EUROPEAN RESEARCH ON CETACEANS - 14

PROCEEDINGS OF THE FOURTEENTH ANNUAL CONFERENCE OF THE EUROPEAN CETACEAN SOCIETY, CORK, IRELAND

2-5 APRIL 2000

EDITORS: P. G. H. EVANS, R. PITT-AIKEN AND E. ROGAN

EUROPEAN RESEARCH ON CETACEANS - 14

Proceedings of the Fourteenth Annual Conference
of the European Cetacean Society,
Cork, Ireland
2-5 April 2000

Editors: P. G. H. Evans, R. Pitt-Aiken and E. Rogan

Date of Publication: December 2000
Place of Publication: Rome, Italy

CONTENTS

INTRODUCTION

The Fourteenth Annual Conference of the European Cetacean Society was held at University College Cork in Ireland between 2nd and 5th April 2000. It was attended by just under 400 people from 31 countries.

The theme this year was "Cetaceans in the Ecosystem: Defining Critical Habitat", and speakers invited to give keynote addresses to this theme included: Phil Hammond on "The Foraging Distribution & Behaviour of Grey Seals and Humpback Whales: Practical lessons for determining critical habitat", Bob Kenney on "Defining Critical Habitat in a critically endangered baleen whale species: the right whale to study?", and Mike Fedak on "Using GIS to explore environmental relationships with the tracks of recently weaned southern elephant seal (*Mirounga leonina*) pups from Macquarie Island". In addition to these, there were 36 other talks and 118 posters.

Both preceding and subsequent to the Conference, there were workshops on the following themes: methods for investigating stock structure in cetaceans; studies on beaked whales; the application of new techniques of radio telemetry; the Irish Whale & Dolphin Sanctuary; and a student workshop on planning, presenting and publishing scientific research.

The Society is very grateful to the Conference Organiser, Emer Rogan of the University of Cork's Zoology Department, and her trusty team of local helpers, Fidelina Butler, Debbie Chapman, Richard Fitzgerald, Simon Ingram, Mick Mackey and Sinead Murphy, as well as Greg Donovan who with Emer organised the Scientific Programme, and Roland Lick who played an important role in the organising of registration and membership fees.

We also gratefully acknowledge the following bodies for their generous sponsorship of the conference (in alphabetical order): Aquaculture Development Centre (UCC), Bord Fáilte (Irish Tourist Board), Bord Iascaigh Mhara, Dúchas (the Heritage Service), Environmental Protection Agency, Fyffes plc, International Whaling Commisson, Irish Water Resources Ltd, Marine Institute, Statoil Exploration (Ireland) Ltd, The Heritage Council, University College, Cork, and Vantage Wholesale.

A Conference Scientific Committee was chaired by Greg Donovan and also comprised Peter Evans, Jaume Forcada, Phil Hammmond, Christina Lockyer, and Nick Tregenza. The following persons have reviewed abstracts: Alex Aguilar, John Baker, John Bannister, Peter Best, Arne Bjørge, David Borchers, Doug Butterworth, Phil Clapham, Chris Clark, Greg Donovan, Peter Evans, Jaume Forcada, Jonathan Gordon, Phil Hammond, Lex Hiby, Rus Hoelzel, Paul Jepson, Toshio Kasuya, Finn Larsen, Robin Law, Christina Lockyer, Tony Martin, Giuseppe Notarbartolo di Sciara, Todd O'Hara, Adrian Raftery, Toni Raga, Randall Reeves, Peter Reijnders, Emer Rogan, Usula Siebert, Paul Thompson, and Nick Tregenza.

Contributions have been arranged broadly by subjects, and within subjects, they are arranged alphabetically. All abstracts were subject to a review process and represent all those submissions which were accepted for the conference. Extended summaries have been edited to improve clarity and to maintain a uniformity of presentation. For the benefit of contributors to future Proceedings, instructions are given at the back of this volume. Please follow the guidelines carefully; most contributors have not followed them closely and this creates much extra work for the editors.

A very great deal of effort has gone into the editing and production of these Proceedings. In this connection, I should like to thank my co-editors Rebecca Pitt-Aiken and Emer Rogan for their invaluable help at all stages of its production. Rebecca efficiently re-formatted contributions and helped with the editing; Emer prepared the short abstracts, editing those for clarity. Finally, I should like to thank Giancarlo Lauriano of ICRAM in Rome for overseeing the printing of the Proceedings.

Peter G.H. Evans

CRITICAL HABITAT

DO HARBOUR PORPOISES USE FAVOURED HABITATS AROUND THE COAST OF WALES, UK, FOR CALVING AND NURSING YOUNG CALVES?

M. E. Baines and S. J. Earl

Nekton, Newport Business Park, Newport, Pembrokeshire, SA42 0LT, UK

The regular use of certain habitats for calving and nursing young calves has been well established for some cetacean species. Recently, it has been suggested that harbour porpoises favour an area off the North Sea coast of Germany for calving. This has important implications for the identification of protected areas and the conservation of this species. Sightings data are examined for evidence of specific habitats around the coast of Wales, UK, that are favoured by porpoises when calving and nursing young calves.

Two data sets were extracted from the regional cetacean sightings database: (1) all records of porpoise sightings without any measure of observer effort, (2) data collected during systematic shore-based monitoring of key coastal study sites. At the onset of the calving season in May, 90% of sightings of calves in Wales were from the vicinity of Ramsey and Skomer Islands, in June this proportion declined to 70% and in July to 60%. The proportion of calves recorded by systematic watches was significantly higher at Ramsey Island than at Strumble Head, although relatively high numbers of porpoises were counted at Strumble. The mean proportion of calves recorded at Ramsey during June and July was 18%, which compares favourably with the proportions recorded off the islands of Sylt and Amrum in Germany. We conclude that there is evidence that certain habitats off the coast of Wales are favoured by porpoises at this critical period in their life-cycle. However, confirmation of this finding and estimation of the extent of such favoured areas requires further dedicated surveys.

DEVELOPING SUSTAINABLE WHALE-WATCHING:
DEFINING CRITICAL HABITATS FOR DOLPHINS AND DOLPHIN TOUR BOATS

S. D. Berrow[1] and B. Holmes[2]

[1]*Shannon Dolphin Project, Merchants Quay, Kilrush, Co. Clare, Ireland*

[2]*Hydraulics and Maritime Research Centre, Model Farm Road, University College, Cork, Ireland*

To develop sustainable exploitation of a wildlife population requires information on the ecology of the target species and the behaviour of the relevant industry. A commercial whalewatching industry targeting bottlenose dolphins *Tursiops truncatus* started in the Shannon estuary, Ireland in 1993 and has expanded to seven dolphin-watching vessels by 1999. Defining the critical habitats of both the dolphins and the dolphin-watching vessels is essential for proper management of the resource.

In this study we describe: (1) the utilisation of the Shannon estuary by dolphins; (2) the preferred locations for dolphin-watching vessels; (3) seasonal changes in these variables; and (4) assess the level of overlap and potential interactions between the two. The Shannon estuary has been nominated as a Special Area for Conservation (SAC) for dolphins and this information is an important component of the management plan for the SAC.

A LOW-COST METHOD TO DETERMINE BATHYPELAGIC AND SEASONAL OCCUPANCY OF FIN WHALE *BALAENOPTERA PHYSALUS* IN THE BAY OF BISCAY

T. M. Brereton[1] and A. D. Williams[2]

[1]*Biscay Dolphin Research Programme, c/o 20 Mill Street, Puddletown, Dorchester, Dorset, DT2 8SH, UK* [2]*Biscay Dolphin Research Programme, 6 Manor Way, Lee-on-Solent, Hampshire, PO13 9JH, UK*

INTRODUCTION This paper presents new information on the distribution and seasonal abundance of fin whales *Balaenoptera physalus* at the south-eastern limit of their North Atlantic range, from a preliminary analysis of sightings data collected under the Biscay Dolphin Research Programme (BDRP) between 1995 and 1998. BDRP is a voluntary marine research and conservation organisation, sponsored by P&O Portsmouth and affiliated to Sea Watch Foundation.

Fin whales are widespread throughout the world's oceans (Gambell, 1985), but have declined considerably in the 20th Century as a result of intensive whaling activity (ICES, 1995). Owing to their rapid rate of decline (presumed more than 50% over three generations), fin whales are classified as "endangered" on the IUCN's (International Union for the Conservation of Nature) Red List (Baillie and Groombridge, 1996), and thus are a high priority species in global conservation terms. The largest fin whale populations occur in the Southern Hemisphere, with smaller numbers in the North Atlantic and North Pacific (Gambell, 1985). The species is widely distributed in the North Atlantic, occurring from the Gulf of Mexico (Jefferson & Schiro, 1997) and Mediterranean Sea northward to the edge of the arctic (IWC, 1992). The population structure of fin whales in the North Atlantic is the subject of considerable conjecture. It is convenient to adopt a simple east/west North Atlantic population subdivision, although following much debate in the early 1990's, seven separate populations/stock units were identified by the International Whaling Commission (IWC), on the basis of genetic and other evidence (Donovan, 1991). The seasonal movements of fin whales in the North Atlantic are equally complex and variable (Christensen *et al.*, 1992). Migrations between cool, high latitude pack ice edge summer feeding grounds and low latitude winter mating/calving grounds are well known from some populations (Clark 1995), whilst in others inshore-offshore, east-west dispersal and year-round residency occurs. The true picture is obscured, because of the inevitable localised/patchy nature of sampling effort, and because the majority of survey work is carried out in the summer months.

Fin whales in the Bay of Biscay form part of the British Isles-Spain-Portugal ('Iberian') population/stock. Population estimates from this area have been carried out largely through IWC North Atlantic Sightings Surveys (NASS) during the summer months off the Iberian coast (e.g. 1984, 1987, 1993). Best recent population estimates have been in the order of 5-8,000 animals (Goujon, 1995), representing around 10-20% of the total Atlantic estimated population (Bérubé & Aguilar, 1998). There has been little offshore study of this population in the winter months, and seasonal movements and distributions are poorly understood.

In 1995, BDRP launched a year-round survey programme of fin whales in the eastern Bay of Biscay. The aims were two-fold: (1) to generate new information on distribution and abundance of fin whales in this under-sampled region (east of main NASS transect surveys), and (2) to contribute to our understanding of seasonal movements of this species in the eastern North Atlantic.

METHODS Monthly, year-round surveys of fin whale were undertaken in the Bay of Biscay, from the P&O Portsmouth cruise-ferry, the Pride of Bilbao, which sails between Portsmouth, England and Bilbao, Spain. On each (four-day) trip, effort-based cetacean surveillance work was carried out by a team of three experienced volunteer observers, using standard survey methods developed for commercial ferries and other 'platforms of opportunity' by the Cetacean Group of the Mammal Society (Evans, 1995). Recording was made from a fixed position on the bridge of the ship, at a height of 32 m and speed of 15-22 knots. Both sightings and effort data were collected. The latter enabled the number of sightings to be scaled to recording effort and the calculation of relative frequency and abundance to detect change. The ferry follows a set route, but the course alters at times, and in total, effort-related sightings data were obtained from 16 International Council for the Exploration of the Sea (ICES) grid cells, between 3-6°W and 43.5-49°N. Between 1995 and 1998, thirty-eight (four day) survey trips were made with 19,994 km of trackline searched in good conditions (up to sea state three with good visibility) and approximately 30,000 km overall.

RESULTS **Detection rates**: The bridge of the Pride of Bilbao provides an extraordinary viewpoint from which to observe large cetaceans, and it proved possible to locate rorqual whale blows at distances of more than eight kilometres. Analysis of collated effort data for all Biscay indicated that fin whale detection (sightings) rates were not negatively correlated with sea state (r=0.26, n=7, p=0.62). However, practical experience suggested that fin whales became noticeably less visible in sea state 5 or more, as whale blows dissipate quickly and surfacing animals become difficult to locate. The lack of correlation is more likely due to inclusion of inshore waters in the analysis, which were confirmed as highly significantly calmer (t=4.91, d.f. 190, p<0.0001) and yet largely absent in fin whales.

Overall distribution: Over the survey period, 106 definite fin whale sightings (Figure 1) totalling 334 animals were made (median group size 2-3). A further 26 possible sightings were made, but fin whales were under-recorded due to identification problems with the frequently recorded sei whale *Balaenoptera borealis*. The majority of fin whale sightings were of individuals or pairs (mother and calf); although feeding groups of up to 20 were recorded during the summer months (Table 1).

Spatial distribution & abundance: Less than 60% of the ferry route had water depths of 1,000 m or more, but these areas accounted for more than 99% of fin whale sightings (Figure 1). Sightings were evenly distributed across water depths of between 1,000 m and 4,000m, with no evidence to suggest the species was associated with the initial slope of the continental shelf-edge (water depth 200-1,000m). The highest fin whale relative abundance estimates were recorded between 45-45.5°N by 3-5°W with an extremely high maximum value of 82 animals per 1,000 km of search effort, recorded in ICES cell 45°N by 4°W.

Seasonal distribution and movements: There were occasional records of fin whale in all months except January, which was very under-recorded as the survey vessel is largely out of service. However, more than 90% of fin whale sightings were made between May and October. The highest sightings rates were made in mid-summer and the lowest rates in mid-winter (sightings rate/1,000 km effort in sea state four or less, 9.3 from June-August, compared with 1.4 from December-February; Table 1). July and August were the peak months, and accounted for 64% of all fin whale sightings, yet only 22% of total search effort (4,450 km).

There was some evidence to indicate a southerly movement of fin whales towards the end of the summer, following the period of peak occupancy in Biscay. In August (the peak sightings month), 70% of fin whale sightings were made north of 45°N, whilst in October less than 40% of sightings were made north of this latitude. This association between the highest proportion of fin whale sightings occurring at more northerly latitudes in the summer, but with more southerly latitudes in the autumn was highly significant (Yates corrected Chi^2=7.75, p<0.01)

DISCUSSION Results from the first three years of BDRP survey work highlight the importance of the eastern Bay of Biscay for fin whales. The species is widely distributed throughout bathypelagic (1,000-4,000m) offshore waters, but extremely rare elsewhere, confirming (1) the significance of bathymetry as a key factor limiting distribution, and (2) the relative unimportance of the shallower slopes (200-1,000 m) of the highly productive Celtic-Biscay shelf-edge as a factor determining local distribution. This restriction to deep waters (beyond 1,000 m) contrasts with the distribution of fin whales in other parts of the Atlantic, for example the western North Atlantic where the summer range of fin whales is mainly between 41°20'N and 51°00'N, from shore seaward to the 1,000 fathom contour (Mitchell, 1974). Off the eastern United States in the winter, fin whales are frequently recorded in coastal areas such as river mouths where fish and other prey may be abundant. However, the distribution of fin whales in eastern Biscay is generally consistent with the species' frequent preference for mixing zones (e.g. continental shelf-edge slopes) between coastal and oceanic waters. In Biscay, it seems that the deep water lower slopes are more important than the shallower upper slopes of the Celtic-Biscay shelf-edge.

Evidence from a number of studies suggests that the distribution of fin whales outside the breeding season is largely determined by prey availability (e.g. Ingebrigtsen, 1929). Northern krill (*Meganyctiphanes norvegica*) is known to be a key shelf-edge food source for fin whales, for example in the central/eastern North Atlantic (Rørvik *et al.*, 1976), and in associated submarine canyons off the eastern United States and the eastern Mediterranean (Hain *et al.*, 1992, Mussi *et al.*, 1999). In the eastern Bay of Biscay, fin whales were widely recorded in deeper waters off the shelf break during the surveys, so the significance of northern krill in the diet cannot be assumed. However, between 45.5°N and 46.5°N of north Biscay, there are numerous submarine inlets (canyons?) adjacent to the deep water lower slopes of the shelf-edge, where tuna are often abundant on surveys, and primary productivity and krill abundance is likely to be high. Fish are known to form an important part of the diet of some fine whales populations. A number of potential prey species including anchovies and sardines occur in great seasonal abundance in eastern Biscay (P. Cermeno *pers. comm.*) and may act as key food sources seasonally.

The Biscay survey data provide some evidence to indicate a southerly movement of part of the population in the autumn away from the Celtic-Biscay shelf edge. It is unclear whether this suspected southerly movement represents

(1) a distinct migration between feeding and breeding grounds; (2) an offshore movement to the deep waters of the central North Atlantic, or (3) a more localised movement. It is unlikely that the Biscay population has a reverse, long-distance northerly movement at other times of the year, as there is considerable evidence to indicate fin whales off Iceland and Spain are from separate genetic populations (IWC, 1992). Of the small numbers of fin whales recorded in northern Biscay towards the end of the autumn, it is unclear whether these animals are residents or perhaps immigrants from other populations. Kellogg (1929) has suggested that fin whale stocks may be stratified, with the summer feeding grounds of some fin whales being occupied during the winter by whales which have spent the summer further north. Definition of a precise population (or metapopulation) structure for fin whales in the Bay of Biscay and at a North Atlantic scale requires further survey and research.

BDRP surveys confirmed that fin whale densities in some ICES grid cells in the central parts of the Bay of Biscay were extremely high. Aside from habitat quality factors, this may in part reflect the extraordinary good viewing platform provided by the survey vessel, which in turn may make direct abundance comparisons with other survey vessels problematic. Fin whales were seen in group sizes of up to 20 during the summer months in Biscay. Such large group sizes are normally indicative of aggregated feeding behaviour (Mizroch *et al.*, 1984), and it therefore seems highly likely that the majority of fin whales use the eastern Bay of Biscay as a (post-calving) feeding ground.

In conclusion, the survey work of BDRP has generated important new up-to-date information on fin whales in the Bay of Biscay, highlighting the valuable contribution that volunteers (low cost) and commercial ferry companies can make to our understanding of whale distribution and ecology.

ACKNOWLEDGEMENTS We would like to thank the staff of P&O Portsmouth particularly Penny Guy, and the Entertainment's crew of the Pride of Bilbao for supporting the Project, and Rolf Williams, Paula Bates, Helen Williams, Lisa Browning, Robin Plowman, and Russel Neave, amongst others in collecting the data.

REFERENCES

Baillie, J. and Groombridge, B. (eds.). 1996. *IUCN Red list of Threatened Animals*. IUCN, Gland, Switzerland.

Bérubé, M. and Aguilar. A. 1998. A new hybrid between a blue whale, *Balaenoptera musculus*, and a fin whale, *B. physalus*: frequency and implications of hybridization. *Mar. Mamm. Sci.*, 14: 82-98.

Christensen, I., Haug, T. and Øien. N. 1992. Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. *ICES Journal of Marine Science*, 49: 341-355.

Clark, C. W. 1995. Application of US Navy underwater hydrophone arrays for scientific research on whales. *Rep. int. Whal. Commn*, 45: 210-212

Donovan, G. P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn* (special issue 13): 39-68.

Evans, P. G. H. 1995. *Guide to the identification of whales, dolphins & porpoises in European seas*. Sea Watch Foundation, Oxford.

Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pp. 171-192. In: *Handbook of marine mammals*, Vol. 3. (Eds. S. H. Ridgway and R. Harrison.). Academic Press, London.

Goujon, M., Forcada, J. and Desportes, G. 1995. Fin whale abundance in the eastern temperate North Atlantic for 1993. *Rep. int. Whal. Commn*, 45: 287-290.

Hain, J. H. W., Ratnaswamy, M. J., Kenney, R. D. and Winn. H. E. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. *Rep. int. Whal. Commn*, 42: 653-669.

Ingebrigtsen, A. 1929. Whales caught in the North Atlantic and other seas. Rapports et Procès- verbaux des réunions, *Cons. Perm. Int. L'Explor. Mer*, Vol. LVI. Høst & Fils, Copenhagen. 26pp.

IWC. 1992. Report of the comprehensive assessment special meeting on North Atlantic fin whales. *Rep. int. Whal. Commn*, 42: 595-644.

IWC. 1995. Report of the Scientific Committee. *Rep. int. Whal. Commn*, 45: 53-221.

Jefferson, T. and Schiro, A. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. *Mammal Rev.*, 27: 27-50.

Mitchell, E. 1974. Present status of Northwest Atlantic fin and other whale stocks. Pp. 108-169. In: *The Whale Problem: A Status Report* (Ed. W. E. Schevill). Harvard University Press, Cambridge, MA.

Mizroch, S. A., Rice, D. W. and Breiwick, J. M. 1984. The fin whale, *Balaenoptera physalus*. *Mar. Fish. Rev.*, 46(4): 20-24.

Mussi, B., Miragliuolo, A., Monzini, E., Diaz Lopez, B. and Battaglia, M. 1999. Fin whale feeding grounds in the coastal waters of Ischia. Pp. 330-335. In: *European Research on Cetaceans - 13.* (Eds P. G. H. Evans, J. Cruz and J. A. Raga). Proceedings of the ECS Annual Conference, Valencia, Spain.

Rørvik, C.J., Jónsson, J., Mathisen, O. A. and Jonsgård, Å 1976. Fin whales, *Balaenoptera physalus* (L.), off the west coast of Iceland distribution, segregation by length and exploitation. *Rit Fiskideildar*, 5: 1-30.

Table 1: Seasonal frequency, relative abundance and group size of fin whale in the Bay of Biscay 1995-1998 (n=101 sightings of 313 animals in good/fair weather - sea state 4 or less and good visibility)

Seasonal (quarterly) period	No sightings	No. animals	No. km effort	No. sightings per 1000 km	No. animals per 1000 km	Median group size	Modal group size	Max. group size	Mean group size
Winter (Dec-Feb)	3	7	2123	1.4	3.3	2	N/A	4	2.3
Spring (Mar-May)	7	35	5958	1.2	5.9	3	2	15	5.0
Summer (Jun-Aug)	64	198	6888	9.3	28.7	2	1	16	3.1
Autumn (Sep-Nov)	27	73	5026	5.4	14.5	2	1	20	2.7

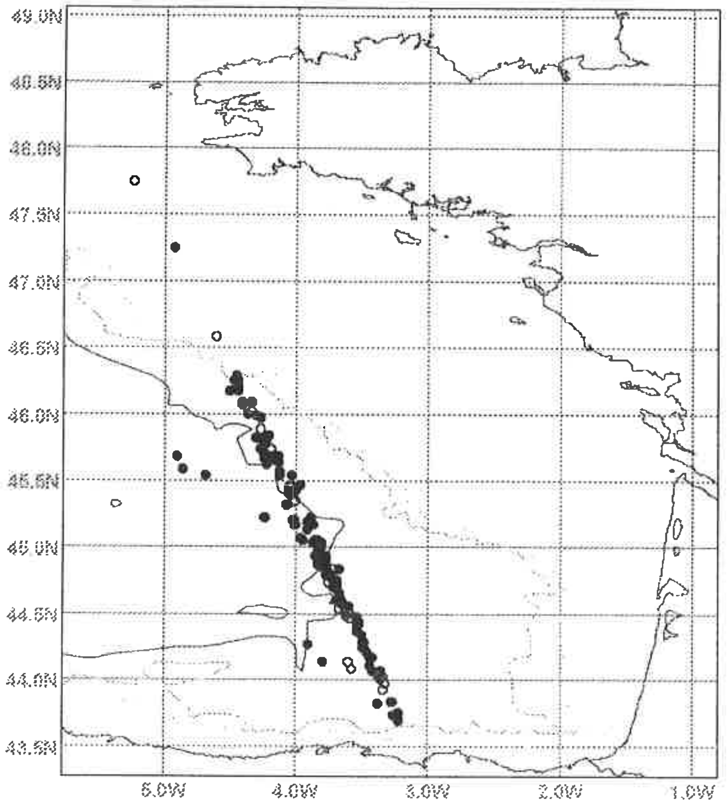


Figure 1 Fin whale sightings in the Bay of Biscay, recorded from the Pride of Bilbao ferry, 1995-98. Closed circles represent definite sightings, open circles possible sightings. Depth contours presented from right to left are 200 m (dashed line), 1000 m and 4000 m.

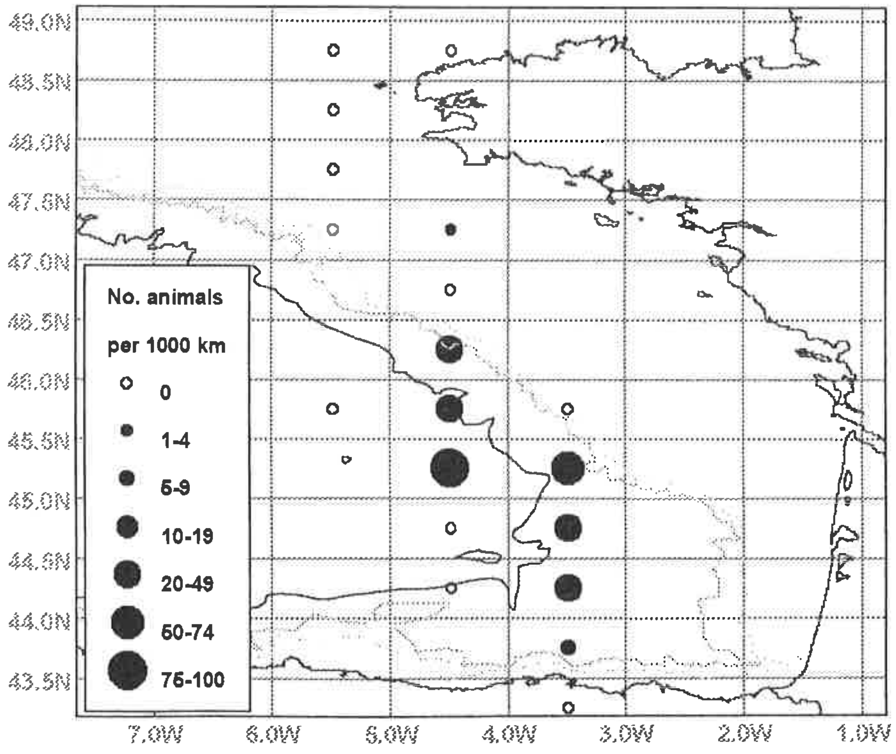


Figure 2 Relative abundance of fin whale in ICES grid cells of the Bay of Biscay sampled by the Pride of Bilbao ferry 1995-98. Depth contours presented from right to left are 200 m (dashed line), 1000 m and 4000 m.

HABITAT VARIABILITY AND SITE FIDELITY OF THE RISSO'S DOLPHIN IN THE NORTHWESTERN MEDITERRANEAN: DEFINING A HOME RANGE FOR A NOMAD

C. Casacci[1] and A.Gannier[2]

[1]*Groupe de Recherhce sur les Cétacés, Villa Aurélia 13,*
741 chemin des Moyennes Bréguières, 06600 Antibes, France
[2]*Centre de Recherche sur les Cétacés, Marineland, 307 avenue Mozard, 06600 Antibes, France*

INTRODUCTION A photo-identification catalogue aims to evaluate and study a particular population, on the basis of recognisable animals. Since 1988, photographs of Risso's dolphins (*Grampus griseus*) from the western Mediterranean are collected by the groupe de Recherche sur les Cétacés. Past analysis of survey results and short-term (1-2 years) results of photo-ID work have so far provided a coherent picture of the Risso's dolphin habitat in the Northwestern Mediterranean where the species can be regarded as a year-round resident (Bompar, 1997), with a strong affinity for the continental slope (Gannier and Gannier, 1994; Gannier, 1998) and some degree of site fidelity both during a summer season and between different years (David and Di-Méglio, 1999).

However, several sightings occur off the usual slope habitat, and require a different interpretation. We use here comprehensive data for the 1988-99 period to shed new light on the species habitat and residency. Surveys took place with small boats (9-12 m) with the same basic sighting protocol; they were random with respect to the Risso's dolphin known distribution.

MATERIALS AND METHODS Risso's dolphins were photographed from a 9 m sailing ship, using colour slides. Attempts were made to photograph both sides and the lower flanks of each animal. Particularly distinctive scars and markings or pigmentation patterns on the sides of the animals were documented. These were coded in relation to their shape, and angle. The most common marks were: L, linear scars; LL, double linear scars, rails; T, spot; C, circular scars; N, nick; R, rake; E, notch; TR, triangle, as in Gannier and Gannier (1997).

The location of these marks on the dolphins were recorded by dividing the body into nine areas, four on each side: dorsal fin (right: Δd / left: Δg); head to the blow hole (right: 1d / left: 1g); flank, from blow hole to dorsal fin (right: 2d / left: 2g); peduncle, from dorsal fin to flukes (right: 3d / left: 3g).

This arrangement allowed for a precise description of the location of the markings and classification of the records. Ideally, all of the above nine areas should be photographed for each dolphin. However, only one view is in some case sufficient to identify a Risso's dolphin when the mark is particularly characteristic. For each animal, an identikit is drawn.

The pigmentation is defined by a colour scale from black to white. Likewise, the density of marks is described on a scale from 1 (no marks) to 5 (body covered of marks) differentiating body and dorsal fin.

Finally, dolphin photo-identifications were given a quality index: *, * *, * * *, according to their increasing reliability. The more areas of the dolphin that are photographed, the higher the quality index would be. With a quality score of " * ", re-identification of the animal could be difficult because photographs were either of too poor quality or too few were taken to enable a subsequent match. With a quality score of " * * ", the dolphin is identifiable, with a sufficient set of pictures, and pigmentation patterns are documented. However, the animal might not be identifiable during subsequent re-sightings. Individuals with a quality score of " * * * ", possess one or many patterns were particularly distinctive, and would certainly be recognised if seen again, regardless of which part of the dolphin is photographed.

RESULTS From 33 sightings, 22 have been documented with photo-ID work (Table 1). Survey results show that 18% of the sightings are located over a depth in excess of 2500 m, and more than 50 kilometres from the 200 m isobath, i.e. off the usual slope habitat of this species.

In our photo-ID catalogue of 113 individuals, 56 animals have received a good or very good quality index, meaning they are very likely to be re-identified if photographed.

There are two long-term (>4yrs) re-sightings (Table 2):

- dolphin 93149 i1 (18/08/1993) was re-identified in 1998, as 98099 i2 (08/08/1998), less than 10 km from its initial position (number **2** on map).
- individual 93163 i1 was re-identified twice at different times (September 1993 and July 1997) and different locations (43°31.2N; 7°10.3E and 42°56.7N; 5°29.2E, number **3** on the map).

Another individual 93163 i3 who was in the same group as individual 93163 i1 was re-identified twice at different times (September 1993 and July 1994) and different locations (43°31.2N; 7°10.3E and 43°32.5N; 7°140E, number **4** on the map). It is interesting to observe that among the dolphins identified on the first occasion, none was re-sighted again with dolphins 93163 i1 or 93163 i3. However, only three individuals were identified with a good or very good quality score during sighting 93163.

DISCUSSION The question of the stability of characteristic marks used for identification receives two interesting answers, with dolphins re-identified after 4 and 5 years. The use of such marks in the photo-identification of *G. griseus* is therefore a very useful tool even for long-term studies.

From the examples of individuals 93149 i1 and 93163 i1, we observe that Risso's dolphins appear to have some sort of long-term (inter-annual >3 years) site fidelity, as suggested by David and Di-Méglio (1999). This also confirms that particular sites along the continental slopes are favoured by this species, probably for trophic reasons. This habitat use may be called a " nomad " strategy, as animals are seen across a wide range but may actually feed in only several particular places.

How does that relate to out-of-range sightings, i.e. sightings obtained far from the usual slope range of Risso's dolphin? The " outlier " sightings may be schools travelling from one major feeding region to another, or schools engaged in a delicate phase of the biological cycle (parturition), or temporary excursions from the main feeding region, for trophic reasons. Given that *G. griseus* are year-round residents in the northwestern Mediterranean Sea (Gannier, 1998b; Bompar, 1997), " outliers " cannot be explained by migrating schools from a wintering site to a summer feeding area. However, Risso's dolphins are common across all the western Mediterranean, and also in the Ionian Sea, and groups travelling from one part of the basin to another may well take the shortest route, through the open sea, rather than moving along the continental slope.

CONCLUSIONS Risso's dolphins have an extensive distribution range in western Mediterranean, in contrast to a habitat centred on continental slope waters. Risso's dolphin pigmentation marks show remarkable stability, enabling long-term studies to be continued. Results on long-term recaptures suggest multi-year site fidelity, probably linked with good foraging opportunities.

ACKNOWLEDGEMENTS We thank the Ministère de l'Environnement and the Conseil régional de Provence Alpes Côte d'Azur for having funded this study.

REFERENCES

Bompar, J. M. 1997. Winter presence of Risso's dolphins, *Grampus griseus*, in the western part of the Ligurian Sanctuary. Pp. 164-166. In: *European Research on Cetaceans- 11*. Proc. 11th Ann. Conf. ECS, Straslund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

David, L. and Di-Méglio, N. 1999. First results of summer movements of Grampus griseus (Cuvier, 1812) in the northwestern Mediterranean Sea. Pp. 189-194. In: *European Research on Cetaceans - 13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Gannier, A. 1998a. Les cétacés de Médierranée nord-occidentale: nouveaux résultats sur leur distribution, la structure de leur peulplement et l'abondance relative des différentes espèces. *Mésogée* 56: 3-19.

Gannier, A. 1998b. Variation saisonnière de l'affinité bathymétrique des Cétacés dans le bassin liguro-provençal. *Vie et Milieu* 48 (1): 25-34.

Gannier, A. and Gannier, O., 1994. Abundance of *Grampus griseus* in the northwestern Mediterranean. Pp. 99-102. In: *European Research on Cetaceans - 8*. Proc. 8th Ann. Conf. ECS. Montpellier, France, 2-5 Mar, 1994. (Ed. P. G. H. Evans) European Cetacean Society, Lugano, Switzerland. 288pp.

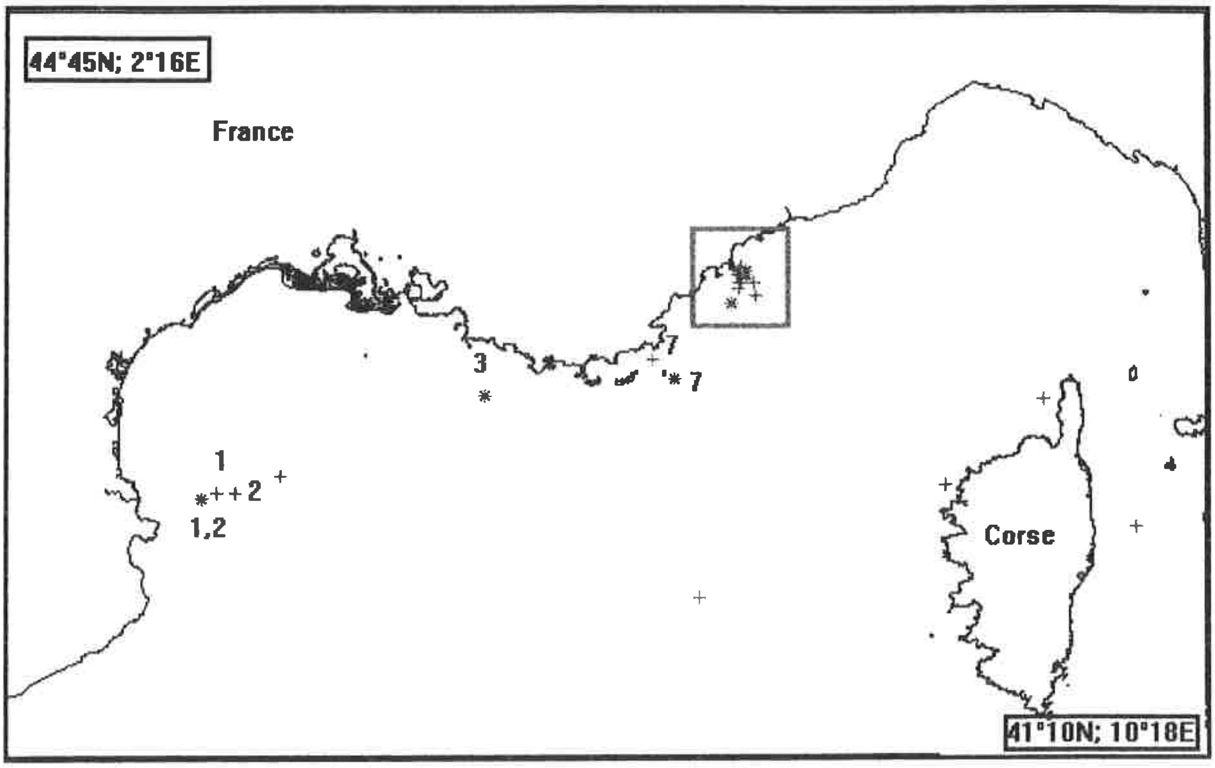
Gannier, A. and Gannier, O., 1997. Photo-identification of fin whales in the Western Mediterranean: the French catalogue. Pp. 119-121. In: *European Research on Cetaceans - 11*. Proc. 11th Ann. Conf. ECS, Straslund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Table 1. Photo-ID groups: number and quality score index.

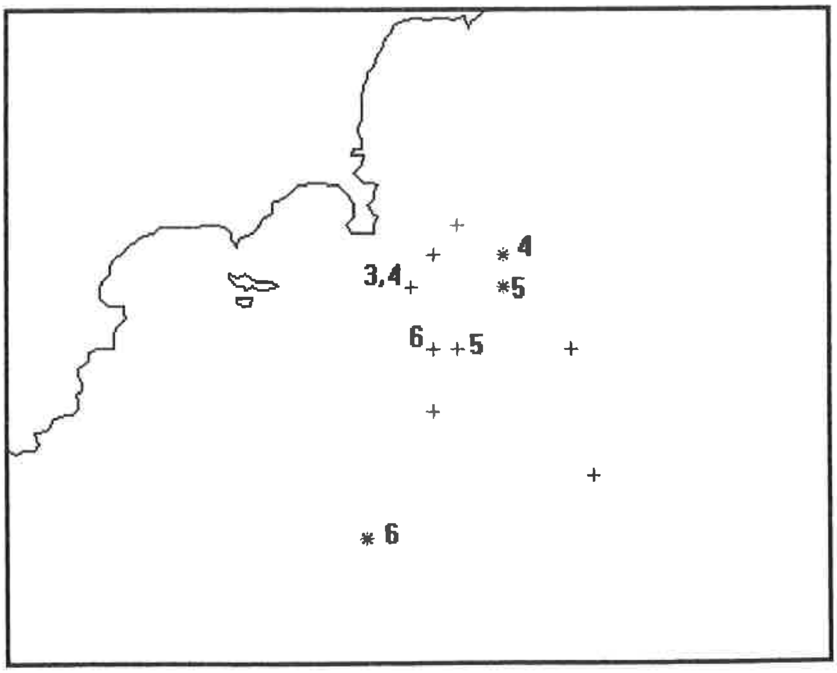
Date	Photo-ID group	Number of photo-ID animals	Quality score (number)
19/08/1988	88019	5	* (3) , * * (2)
14/07/1989	89016	5	* (5)
30/10/1989	89095	1	*
26/02/1991	91003	1	*
11/08/1991	91059	9	* (2) , * * (6) , * * * (1)
12/08/1991	91060	15	* (6) , * * (7) , * * * (2)
27/06/1993	93015	1	*
03/08/1993	93100	3	* (2) , * * (1)
17/08/1993	93143	1	* *
18/08/1993	93149	2	* * (2)
01/09/1993	93163	3	* * (2) , * * * (1)
10/07/1994	94011	2	* (1), * * (1)
08/08/1995	95144	6	* (1) , * * (5)
16/08/1995	95154	6	* (4) , * * (2)
04/07/1996	96003	1	* *
26/07/1996	96083	5	* (2) , * * (3)
26/07/1996	96085	2	* (1) , * * (1)
08/07/1997	97032	5	* (4) , * * * (1)
05/08/1997	97106	3	* (2) , * * (1)
17/06/1998	98001	15	* (8) , * * (7)
08/08/1998	98098	5	* (3) , * * (2)
08/08/1998	98099	17	* (10) , * * (6) , * * * (1)

Table 2. Recaptured animals and localisation. Each photo-ID group is represented by a number.

Photo-ID animal	Recapture	Map index
91059 i3	91060 i6	5
91059 i4	91060 i7	5
91059 i5	91060 i8	5
91059 i6	91060 i9	5
91059 i7	91060 i10	5
93149 i1	98099 i2	2
93163 i1	97032 i1	3
93163 i3	94011 i2	4
95144 i3	95154 i2	7
96083 i1	96085 i1	6
96083 i5	96085 i2	6
98098 i1	98099 i6	1
98098 i3	98099 i7	1



Map 1: Localisation of the resightings
+ sightings
* resightings



BOTTLENOSE DOLPHIN FEEDING HABITAT UTILISATION IN THE INDIAN RIVER LAGOON, FLORIDA

D. M. Clement[1] and J. G. Morris[2]

[1]*University of Otago, Dept of Environmental Science, PO Box 56, Dunedin, New Zealand*
[2]*Florida Institute of Technology, 150 W. University Blvd., Melbourne, FL 34946, USA*

Atlantic bottlenose dolphins *Tursiops truncatus* in the Indian River Lagoon (IRL), Florida, were surveyed to assess habitat preference and feeding utilisation while also determining possible correlations with known dolphin fish prey species. The study sites were chosen based on three criteria: habitat type, daily boat survey accessibility, and high occurrence of feeding activity. Thirty-two feeding sites were surveyed and seined between February 1997 and November 1997.

Dolphin utilisation and feeding within the four surveyed habitat types were independent of seasonality, but demonstrated possible trends. Dolphins frequented both tributary mouth and shoreline habitats more in the spring and summer months while spoil islands had more feeding occurrences in the fall. Group size was significantly associated with habitat during all three seasons (Spring: $Chi^2 = 70.620$; Summer: $Chi^2 = 13.173$; Fall: $Chi^2 = 70.143$). Larger groups of dolphins occurred and were observed feeding more often during the spring and fall seasons than during summer, especially along spoil island habitats. The number of feeding occurrences was significantly correlated with known dolphin prey species of standard lengths greater than 10 cm in both the spring ($r = 0.564$) and fall ($r = 0.439$). Finally, specific "feeding hotspots" or dolphin site affinities occurred within the IRL. Some sites were seasonally flexible while others were maintained throughout the year.

Results of this study suggest that resident bottlenose dolphins may prefer feeding habitats that are seasonally dependent upon specific species that are more abundant or larger in size. The IRL, whilst being one of the most diverse estuaries, is heavily impacted by humans. Its shorelines have suffered wetland and mangrove destruction, salt marsh alterations, and coastline siltation. Removal or loss of preferred prey resources could potentially alter the bottlenose dolphin utilisation of specific habitats as well as the IRL as a whole.

ISSUES CONCERNING CETACEANS IN THE STRAITS OF GIBRALTAR

R. De Stephanis[1], N. Pérez Gimeno[2], E. Roussel[3], R. Laiz Carrión[2],
M. Martínez Serrano[2], J. Rodríguez Gutiérrez[2], P. Bárcenas Gascón[2],
E. Puente González[2], A. Maya Vílchez[2], P.Beaubrun[3], and M. Fernández-Casado[1]

[1] *firmm®España, Pedro Cortés nº3, Tarifa (Cádiz), 11380, Spain, (e-mail: renaud_stephanis@yahoo.com)*
[2] *Facultad de Ciencias del Mar, Universidad de Cádiz, Polígono Río San Pedro S/N,*
Puerto Real, Cádiz 2510, Spain
[3] *Ecole Pratique des Hautes Etudes, U.M. II, Bp 94, Place Eugène Batallion,*
34095 Montpellier CEDEX 5, France

INTRODUCTION The Straits of Gibraltar is the only natural communication channel between the Mediterranean and the Atlantic. Recent studies highlight the presence of various cetaceans species in these waters (Fernández-Casado *et al.*, 1999).The present study puts forward four factors to explain the possible environmental problems: a) it is the second greatest area in the world with respect to maritime traffic; b) the growing whale watching activity; c) its relevant fishing activities; and d) its geopolitical problems.

METHODOLOGY The data used in this study come from sightings carried out within two different campaigns: one from whale watching platforms and another from ferries connecting Algeciras (Spain) with Ceuta (North Africa) (See Table 1 and Fig. 1). In both cases, the species were identified, the number of individuals determined, and their initial reaction to the vessel recorded (when at least one animal from the group got close to the vessel it was regarded as an attraction; when the animals clearly went away, it was considered as an avoidance, and when no change in behaviour was detected as an indifference). Regarding the whale watching activities, data were obtained from campaigns carried out on one of the platforms as well as through interviews to those involved at the different ports where the activity is carried out.

RESULTS AND DISCUSSION **Maritime Traffic** The Straits of Gibraltar is the second busiest maritime route in the world (Gárate J., *pers. comm.*). The importance of the maritime traffic, 75% of the national and international volume, has an obvious relevance in this area (Table 2). On the other hand, potentially hazardous substances are carried through the Straits on a daily basis, and it is quite usual for big vessels to clean their deposits when crossing the area of study. In addition, they could be causing a strong noise pollution. Records from 1999 are shown in Table 2. Using data collected in sightings carried out from ferries, the following results are obtained (Tables 3-4):

- The proportions of attraction for the groups with calves and those without calves are quite similar. As calves have been only sighted in groups of small dolphins, it can mean that regular transport lines are not perceived as a danger by these cetaceans, which is consistent with what Angradi *et al.* (1993) have found for striped dolphins *Stenella coeruleoalba* in the Tyrrhenian sea.
- The interspecies comparison (Fig. 2) allows one to distinguish two categories of proportion of reaction to the boat, with small dolphins on the one hand and medium-sized odontocetes on the other hand. In the first category, striped dolphins are more attracted by the boat than common dolphins *Delphinus delphis* in this part of the Straits, whereas Sagarminaga and Cañadas (1998) observed in the Alboran sea an opposite situation, with much higher proportions of attraction (67.82 %) for common dolphins.
- With respect to activities, attraction was low when travelling, close to the average while feeding and resting, and high when socialising. These differences may reflect the importance of the state of the animals for the attraction.
- Finally, we can see that cetaceans have focused on one ferry (Ciudad de Ceuta) (Fig.3) which appeared to have the finest streamlined hull of the three used for observations. One can guess that this boat, producing a greater stem wave, will be more attractive for the cetaceans to "play".

Whale-Watching The Gibraltar Straits is a key location for the development of whale watching. Whilst in 1999, five vessels were devoted to this activity, it is foreseen that by summer 2000, that will increase to eight.

As can be seen from Fig. 4, in 48% of the sightings, cetaceans showed attraction. In 336 cases, the behaviours could be recorded. These data should be looked at with caution, due to the ambiguity when interpreting behaviours. In the analysis of the different species, only the positive reactions to the vessels have been taken into consideration, this being the behaviour of the striped and common dolphin, whilst the long-finned pilot whales *Globicephala melas* and bottlenose dolphins *Tursiops truncatus* behaved quite similarly (See Fig. 5) Interesting also is that striped dolphins are also more attracted by the boat than common dolphins. There is a clear interaction between whale watching vessels and the animals which would require more detailed research of the potential impacts both in the short and long term (IFAW, 1995; Martín and Montero, 1993)

Fisheries The area under study has an intense commercial and fishing activity. The total fishing fleet located in the ports of the area comes to a total of 750 vessels. It is worth highlighting four fishing methods : purse-seine netting, long liner, gill-netting and madrague: (Fig. 6). The area where the fishing activities take place should also be taken into consideration (Fig. 7).

Although the effect of this activity on cetaceans is still to be determined, it seems quite clear that such a high concentration in such a restricted area as the Straits of Gibraltar, directly affects the marine mammal populations.

This becomes obvious with the various sightings of killer whales *Orcinus orca* carried out by the *Firmm* foundation in the Straits. During the period July - August 1999, a group of nine killer whales was observed around 45 long liners, devoted to the fishing of tuna fish. Once the fishermen have trapped the tuna, killer whales grab them either in the water or whilst they are being lifted to the ships. As a reaction, fishermen throw objects to repel them. It should also be noted that some of the fishing equipment widely used in the area (gill netting and purse-seine netting) produce by-catches (perrsonal observation, and Fernandez Lopez, *pers. comm.*).

Geopolitical The area under study is located at an important strategic point where interests from several nations meet together. The waters are under the sovereignty of Spain and Morocco, and in addition the British colony of Gibraltar makes the geopolitical situation even more complicated.

Moreover, there are three firing ranges as well as traffic of all types of military vessels (including submarines both at the surface and submerged), which can result in potential problems for cetaceans (Frantzis and Cebrian, 1998; Rendell and Gordon, 1996; Tyack and Clark, 1998).

CONCLUSIONS The Straits is crossed on a daily basis by many vessels amongst which there are fast ferries which are a clear threat for the conservation of cetaceans in the area not only because of the noise pollution but also for the possibility of collisions, etc. Lower ferries did not appear to be of relevance for small dolphins, but they can play an important role in the presence of lager cetaceans.

Some fisheries and cetaceans compete in the Straits for the same resource; this interaction is causing direct harm to the animals, especially on the killer whale, as well as a reduction in the availability of their food. The interaction between the whale watching vessels and cetaceans is quite clear.

All the above findings show that there is a need for a management plan in the area. From a global viewpoint, the negative effects should be minimised, taking into account that any activity in this area will affect the other socio-economical interests. The effectiveness of such a plan would be conditional upon an agreement of the different countries involved in the Straits.

ACKNOWLEDGEMENTS I would first like to thank Erika and Mercedes for their help. From the University of Cadiz: I thank Sara, Diego, Barragan, Macias, Cañavate, Alfredo, Rafa, and Ramón. I should also like to thank Tarifa Trafico and specially J. Gárate. And finally, thanks to all the volunteers and crew of *firmm España*.

REFERENCES

Angradi A. M., Consiglio C. and Marini L. 1993. Behaviour of striped dolphins (*Stenella coeruleoalba*) in the central Tyrrhenian Sea (Mediterranean Sea) in relation to commercial ships. Pp. 77-79. 1993. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Fernández-Casado, M, de Stephanis R., Ploner, R, and Vargas, F. (in press) Aproximación al estudio de las poblaciones de las diferentes especies de cetáceos en el Estrecho de Gibraltar: resultados preliminares"IV jornadas de la flora, fauna y ecología del campo de Gibraltar, Tarifa (Cádiz).

Frantzis, A. and Cebrian, D. 1998 A rare, atypical mass stranding of Cuvier's beaked whales. Cause and implications for the species' biology. Pp. 332-333. In: *European Research on Cetaceans -12*. Proc. 12th Ann. Conf. ECS, Monaco, 20-24 Jan, 1998. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

IFAW, Tethys Research Institute and Europe Conservation 1995. *Scientific aspects of managing whale watching*. Montecastelo workshop report, 30 March-4 April de 1995. Ed. IFAW. 40pp.

Martín, V. and Montero R. 1993. *Estudio de impacto que provocan las embarcaciones en la población de calderones residentes en las aguas del SO de Tenerife*. Informe inédit

Rendell, L. E. and Gordon, J. C. D. 1996: Vocal responses of long-finned pilot whales (*Globicephala melas*) to military sonar pulses. Pp. 69-71 In: *European Research on Cetaceans - 10*: Proc. 10th Ann. Conf. ECS, Lisbon, Portugal, 11-13 Mar, 1996. (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

Sagarminaga R. and Cañadas A. 1998. A comparative study on the distribution and behaviour of the common dolphin, *Delphinus deplhis*, and the striped dolphin, *Stenella coeruleoalba*, along the southeastern coast of Spain. Pp. 175-181. In: *European Research on Cetaceans - 12*. Proc. 12th Ann. Conf. ECS, Monaco, 20-24 January 1998 (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Tyack, P. L. and Clark, C. W. 1998. Quick Look, Phase II, Playback of low frequency sound to gray whales migrating past the central California coast, January, 1998. Unpublished report, Department of Biology, Woods Hole Oceanographic Institute, Woods Hole, MA 02543, USA.

Table 1: Methods of Study

	Campaigns	
	Whale-watching Platform	Sightings from Ferries
Vessels	9 m length, sighting from 280* cm 7 m length, sighting from 290* cm	99.5 m length, sighting from 1300 cm*
Dates	25 April to 31 October 1999	7 March to 26 May 1999
Observers	1-2	1 with binoculars 7x50
Number and duration of transects	271 trips of 2h 06 min	122 trips of 1h05 min
Type of transects	Random at an average speed of 6-7 knots , always with <4 Beaufort	Following the Algeciras-Ceuta line at an average speed 15-16 knots always with sea <4 Beaufort.

* *Average height of eyes with respect to the sea level*

** *Observations carried out from the ferries : " Ciudad de Ceuta", " Ciudad de Algeciras" and "Bahía de Ceuta", with similar characteristics.*

Table 2: Records of maritime traffic through the Strait (Source:Tarifa Tráfico tower control)

GIBREP'S* (E-W)	53336
Ferries (N-S)	13473
EAV** (N-S)	17047
Total no. of identified vessels	83856

* Merchants, Petrol tankers and Container ships.

** High speed vessel.

Table 3: Proportions of attraction by the ferries on cetaceans according to several parameters, in the Eastern part of the Strait

attraction	presence of calves		per species			
	with	without	Pilot whales	Bottlenose dolphin	Common dolphin	Striped dolphin
No. of sightings	77	145	5	8	41	28
% of attraction	32.5	29.8	0	12.5	29.3	39.0

Table 4: Proportions of attraction by the ferries on cetaceans according to several parameters, in the Eastern part of the Strait

attraction	per activity				per model of ferry		
	Travelling	Feeding	Resting	Socialising	Ciudad de Algeciras	Bahia de Ceuta	Ciudad de Ceuta
No. of sightings	104	39	21	38	61	24	137
% of attraction	16.3	28.2	33.3	65.8	19.7	20.8	36.5

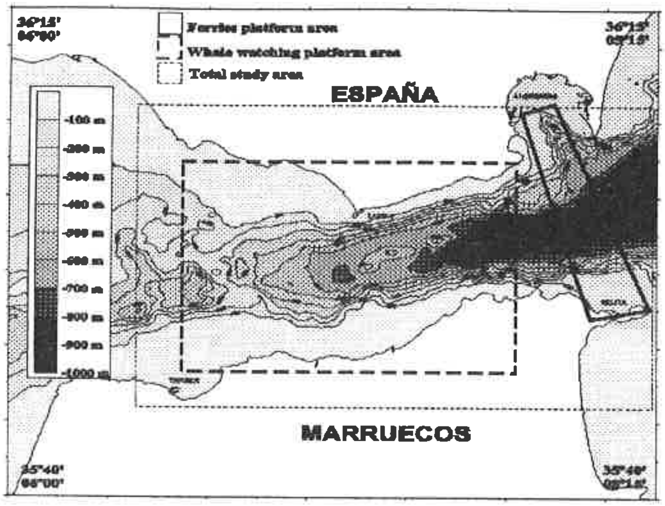


Fig. 1: Study areas

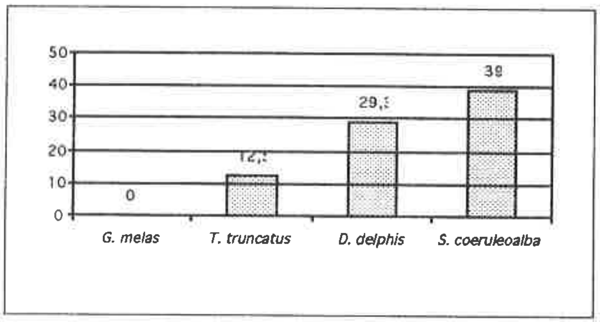


Fig. 2. Attraction to ferries per species (in percentage)

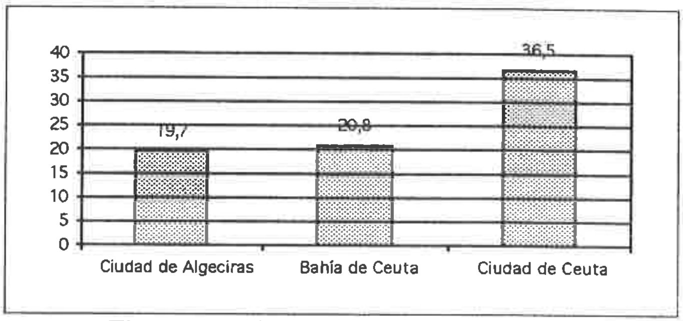


Fig. 3. Attraction per ferries (in percentage)

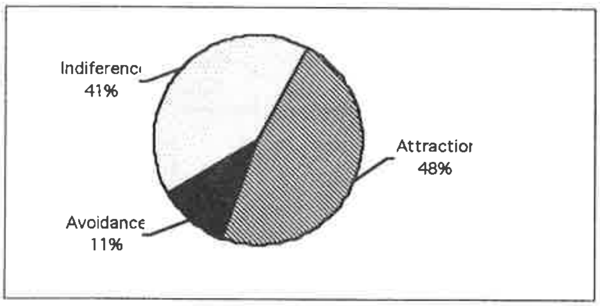


Fig. 4. General reactions to whale watching boats (in percentage)

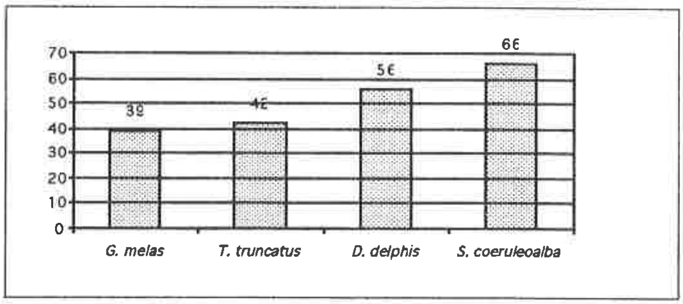


Fig. 5. Attraction to whale watching boats per species (in percentage)

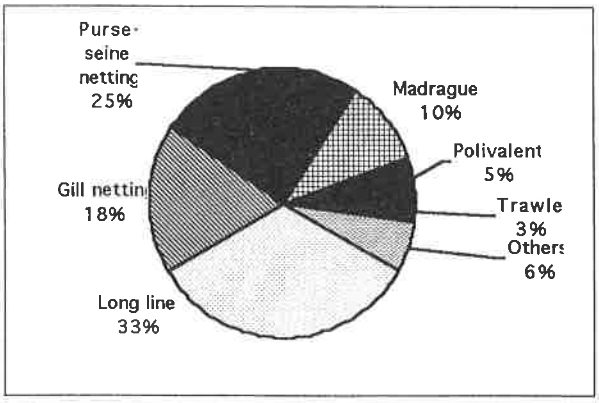


Fig. 6. Fishing arts

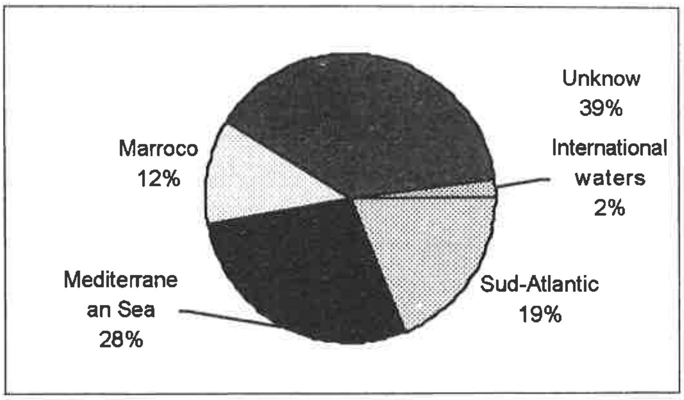


Fig. 7. Fishing areas

UNDERWATER VOCALISATIONS
FOR ASSESSING SPERM WHALE HABITAT

V. Drouot[1], A. Gannier[2] and J. Goold[3]

[1] *GREC, 741 chemin des Moyennes Bréguières, villa 13, 06600 Antibes, France*
[2] *Centre de Recherche sur les Cétacés, Marineland, 306 avenue Mozart, Antibes*
[3] *Institute of Environmental Science, University of Wales, Bangor, LL57 2UW, UK*

INTRODUCTION Sperm whales are known to feed mainly on mesopelagic squids. It is generally assumed that sperm whales use echolocation to scan the environment and detect prey. During a prolonged dive, sperm whales produce clicks at a fairly regular rate, typically between one and two clicks per second, in long sequences (Gordon, 1987; Goold and Jones, 1995). Within these long sequences of clicks, the click production rate do sometime increase, to create distinct sequences of rapid and increasing clicks termed 'creaks'. Creaks are thought to be produced when sperm whales are investigating prey, and could thus be indicative of feeding attempts (Goold, 1999; Gordon, 1987). In this study, we focus on creak detection to determine indices of sperm whale feeding activity, in an attempt to define sperm whale habitat use.

MATERIALS AND METHODS The platform was a 12 metre motor-sailer with a 80HP diesel engine. A dual channel towed hydrophone was used in 1997 and 1999 (IFAW type) and a mono towed hydrophone in 1998 (MAGREC HP30/MT). A high-pass filter (MAGREC) was added to remove excessive noise. Either a Sony WMD 6 analogue recorder or a Sony TCD 7 DAT were used for the recordings. Surveys were conducted during summer 1997, 1998, and 1999. Four distinct regions of the Mediterranean were investigated: the North-western basin, the South-western basin, the Tyrrhenian Sea, and the Ionian Sea. Each region was divided into sampling boxes where zig-zag cruise tracks were defined. The acoustic sampling consisted of 1- minute listening every 2 miles along the transect to detect the characteristic sperm whale clicks. Recordings were performed systematically when sperm whales were detected. Only recordings from diving sperm whale were taken into account. The recordings were analysed aurally, by playing the tape in real time, to identify and count the creaks. Consecutive positive acoustic samples were grouped together into acoustic sequences, which are the sampling unit used for analysis. The creak rate (i.e. the number of creaks per minute per whale) was calculated for each acoustic sequence:

Creak rate= creak nb / (d×n)
where d is the recording duration and n is the number of individuals)

When more than three individuals were heard simultaneously, it became difficult to determine the number of individuals clicking.

Analysis was performed by stratifying the study area into two strata : the continental slope (between 200 m and 2,000 m contour) and the open-sea (>2,000 m contour).

For each region, the creak rate was compared to the mean Acoustic Relative Abundance Index (ARAI), which is the percentage of positive acoustic station (where sperm whales were heard) over the total number of station performed along the transects (Gannier and Drouot, 1999).

RESULTS From the recordings performed over the three surveys, 5 hours 30 mins were used to count creaks, with an average recording duration of 18 mins per acoustic sequence.

Creaks were always included in long click sequences emitted by diving sperm whales, while they were never heard from animals at the surface. Creaks are characterised by a sudden increase in click rate, up to 10-20 clicks per second, and they are followed by a gap of three seconds or more. We calculated that on average a sperm whale produced creaks at a rate of 0.27 (SD= 0.295) per minute. The production of creaks was irregular. In some recording sessions, no creak was heard, while in others the creaks were relatively clustered, with up to 1.24 creaks produced per minute per whale in one dive from the Lion Gulf.

Offshore/ Continental slope
Over the continental slope, the creak rate fitted a normal distribution (Anderson Darling Test, p=0.059), with a mean of 0.31creak/min/whale (Table 1). Creak rates typically range from 0.1 creak/min (25% of the samples) to 1

creak/min (5% of the samples) and only 15% of the acoustic sequences do not include creaks. In the open-sea recordings, 50% of the acoustic sequences do not include creaks, and the remaining samples feature 0.2 to 0.4 creak per min. Thus, it appears that creaks were more frequent in recordings performed over the continental slope than in the open-sea, although this difference was not significant statistically.

Comparison between different basin
We notice a trend for creak production rate (per whale) to increase in regions of enhanced sperm whale abundance. Particularly the regions showing the highest sperm whale relative abundance, the Provence coast, the Lion Gulf and the Balearic Sea, had high feeding indices (Table 2). Conversely, low creak rates were found in regions of low relative abundance, such as the Tyrrhenian Sea and the Alboran Sea. However, the relationship between the feeding index (i.e.: creak rate) and relative abundance was not statistically significant (Pearson correlation).

DISCUSSION The trend for the creak production rate to be higher over the continental slope is consistent with the fact that many species of squid are found in dense concentrations over the continental slope, at depth between 200 and 2000 metres (Clarke, 1979). Unfortunately, no stomach content is available from Mediterranean sperm whales so that foraging activity cannot be directly related to the ecology of a particular cephalopod species. Nevertheless, species such as *Todarodes sagittatus* and *Histioteuthis bonelli*, which are known to be part of the sperm whale diet in the Azores (Clarke, 1958), and off South Africa (Clarke, 1966), have been caught on the slope in the Mediterranean (Mangold-Wirz, 1963). Many other studies in other parts of the world have suggested a habitat preference of the sperm whale to continental slope waters (Jaquet and Whitehead, 1996; Gannier, 1998; Hooker *et al*, 1999).

The fact that creaks were not heard from whales at the surface and were always included in regular click sequences from diving whales is consistent with the hypothesis that they are produced during feeding dives, while investigating prey (Gordon, 1987). Assuming a creak equal to one squid eaten, the average rate of 0.27 creak/min corresponds to 389 squids eaten in one day (24 h). These results are credible, since Clarke's (1987) calculations suggested that a sperm whale may eat an average of 2,000 cephalopods within 1 and 2.5 days.

The enhanced feeding activity in regions of high abundance of sperm whales suggests that whales tend to aggregate in area where they find good foraging conditions. Thus, the Provence coast, the Lion Gulf and the Balearic Sea, would meet the feeding requirements to sustain relatively high abundance of sperm whales. Unfortunately, knowledge on the distribution and ecology of cephalopods in the Mediterranean are too scarce too draw any conclusion. However, these regions are known to be relatively productive (Jacques and Treguer, 1986) and could benefit from the general westerly current transporting higher levels of the food chain. Other studies have found a positive correlation between sperm whale abundance and enhanced productivity (Jaquet and Whitehead, 1996) but links from primary production to cephalopod species remain to be defined.

CONCLUSIONS The results support the earlier paradigm about sperm whale preference for continental slope waters. The positive relationship between sperm whale abundance and the creak rate strongly suggests that feeding success might be an important factor influencing sperm whale distribution. Further effort should be put into improving the methodology for creak counting since this study shows that creak rate could provide a good indicator of sperm whale habitat use.

ACKNOWLEDGEMENTS We thank Marineland and the Conseil Régional de Provence Alpes Cote d'Azur for funding this study.

REFERENCES

Clarke, M. R. 1956. Sperm whales of the Azores. *Discovery Reports*, 28: 237-298.

Clarke, M. R. 1966. Review of the systematics and ecology of oceanic squids. *Adv. Mar. Biol.*, 4: 91-300.

Clarke, M. R. 1979. The head of the sperm whale. *Sci. Amer.*, 240 (1): 106-117.

Clarke, M. R. 1987. Cephalopod biomass-estimation from predation, Pp. 221-237. In: *Cephalopd Life Cycles* (Ed. P. Boyle).

Gannier, A. 1998. Les cétacés de Méditerranée nord-occidentale, nouveaux résultats sur leur distribution, la structure de leur peuplement et l'abondance relative des différentes epèces. *Mésogée*, 56: 3-19.

Gannier A. and Drouot, V. (1999). Relative abundance and distribution of sperm whale in the western and central Mediterranean Sea. Pp. 227-231. In: *European Research on Cetaceans -13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Goold, J. C. 1999. Behaviour and acoustic observations of sperm whale in Scapa Flow, Orkney Islands. *J. Mar. Biol. Ass. U.K.*, 79: 541-550.

Goold, J. C. and Jones, S. E. 1995. Time and frequency domain characteristics of sperm whale clicks. *J. Acoust. Soc. Am.*, 98 (3): 1279-1291.

Gordon, J. C. 1987. *The behaviour and ecology of sperm whales off Sri Lanka*. PhD thesis, Darwin College, University of Cambridge. 346pp.

Hooker, S. K., Whitehead, H. and Gowans, S. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. *Conservation Biology*, 13 (3): 592-602.

Jacques, G. and Treguer, P. 1986. La Méditerranée occidentale.in *Ecosystèmes pélagiques marins*, Masson Ed., Paris. 243pp.

Jaquet, N. 1996. How spatial and temporal scales influence understanding of sperm whale distribution: a review. *Mammal Rev.*, 26 (1): 51-65.

Jaquet, N. and Whitehead, H. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. *Mar. Ecol. Prog. Ser.*, 135(1-3): 1-9.

Mangold-Wirz, K. 1963. Biologie des Cephalopodes benthiques et nectoniques de la mer Catalane. *Vie et Milieu* (Suppl.), 13: 1-285.

Table 1. Creak rate (nb creak/min/whale) calculated over the continental slope and off shore (>2,000 m contour)

Creak rate	No.	Mean	St. Dev.	SE	Min	Max
Open-sea	14	0.2258	0.3348	0.0895	0	1.2353
Continental slope	20	0.3091	0.2674	0.0598	0	1.0

Table 2. Mean Acoustic Relative Abundance Index (ARAI) for regions where creak rates were calculated

Region	Mean ARAI (%)	Mean Creak Rate (creak/min/whale)	N acoustic sequence
Provence	20.04	0.26	12
Lion Gulf	33.41	0.38	7
Centre Northwestern	12.1	0.23	1
West Corsica	7.65	0.44	1
Baleares	18.11	0.38	6
West Sardinia	7.92	0.157	1
Alboran Sea	1.18	0.03	1
North Tyrrhenian	0.01	0.18	1
South Tyrrhenian	1.25	0.16	2
West Greece	13.1	0	2

USING GIS TO EXPLORE ENVIRONMENTAL RELATIONSHIPS WITH THE TRACKS OF RECENTLY WEANED SOUTHERN ELEPHANT SEAL (*MIROUNGA LEONIA*) PUPS FROM MACQUARIE ISLAND

M. Fedak and B. McConnell

NERC Sea Mammal Research Unit, Gatty Martine Laboratory, University of St Andrews, Fife KY16 8LB, UK

Elephant seal pups leave the breeding beaches unaccompanied by experienced animals. They travel thousands of kilometres during their first few months, searching for food, but without the benefit of previous experience. It seems likely, therefore, that they may use innate rules to interpret environmental features which might direct them to concentrations of prey. We thus examined the tracks of 30 pups over two seasons in relation to a set of environmental features, including magnetic heading, ocean currents (both at the surface and diving depths, sea surface temperature, ice cover and patterns of primary productivity (as determined from Sea WiFs images).

We initially examine the simple notion that the animals travelled on a constant magnetic heading. We then added to this the effect of current speed and direction, both at the surface and 100m depth (near mean diving depth) and generated tracks over a range of swimming speeds to compare with actual tracks. We then added features of sea surface temperature, ice cover and chlorophyll concentrations to see if an relationships of these features to the tracks could be detected.

While GIS is an essential tool in data exploration and hypothesis generation, new methodologies are necessary to establish the statistical significance of supposed associations, This poses a particular problem for marine mammal studies in that animals are not likely to be randomly distributed at any time because they necessarily show seasonal cycles of convergence (breeding and mould) and dispersal (foraging). Within these constraints, simple "diffusive" models are not likely to be adequate to generate underlying null distributions, complicating test of significance of relationships. New approaches to model developing distributions could facilitate understanding of both the distributions of marine mammals in relation to environmental characteristics and the clues they use to guide them to food.

EFFECTS OF HYPOXIA ON HABITAT QUALITY FOR BOTTLENOSE DOLPHINS IN THE NEUSE RIVER, NORTH CAROLINA

D. P. Gannon, L. A. Eby and A. J. Read

Duke University Marine Lab, 135 Duke Marine Lab Rd., Beaufort, NC 28516, USA

We examined how habitat quality varies temporally and spatially within the Neuse River estuary, North Carolina, for bottlenose dolphins (*Tursiops truncatus*). Anthropogenic eutrophication in the Neuse watershed produces summer episodes of hypoxia and anoxia. We tested the hypotheses that hypoxia influences habitat quality of the Neuse River for bottlenose dolphins by (1) displacing prey from portions of the habitat, and (2) decreasing prey growth rates, leading to reduced prey size. Our methods included analysis of stomach contents from 71 stranded dolphins; two years of monthly trawl and water quality surveys (temperature, salinity, and dissolved oxygen); vessel surveys of dolphin distribution (103 survey days over two years); focal animal sampling (50 follows over two years); and caging experiments to measure the effect of hypoxia on fish growth rates. Spot, croaker, and pinfish dominated trawl catches. Most fish caught in the estuary were young-of-the-year, and mean fish length increased for all prey species throughout spring, summer, and fall. Dolphin prey composition was similar to that of the trawls, but dolphins selected prey at the upper ends of the length-frequency distributions of trawl catches. Regardless of water quality and fish distribution, dolphins showed a strong affinity for the shoreline. The downstream portion of the study area experienced less hypoxia, had significantly larger fish, and was used more often by dolphins than the upstream area. Dolphins also exhibited behaviours consistent with feeding significantly more often in the downstream area. Caging experiments showed that growth rates of croaker were significantly lower under hypoxic conditions relative to well-oxygenated conditions. Based on these data, we cannot conclude that hypoxia causes loss of habitat to bottlenose dolphins in the Neuse River. However, hypoxia does diminish habitat quality by reducing the growth rates of dolphin prey.

IS CRITICAL HABITAT A USEFUL CONCEPT FOR MANAGEMENT OF SPERM WHALES AND OTHER PELAGIC OFFSHORE CETACEANS?

J. Gordon[1, 2], L. Steiner[1] and T. Lewis[2]

[1]*IFAW, 1a Howard Street, Oxford, OX4 3AY, UK*
[2]*WILDCRU, Department of Zoology, South Parks Road, Oxford, OX1 3PS, UK*

Critical habitats are usually envisaged as geographic areas that are essential for the long-term health and viability of particular animal populations. They may require special management or protection. This notion has its roots in terrestrial conservation where it is a concept that can be readily applied. It can become increasingly difficult to implement, and arguably less useful for management, as one moves offshore in the marine environment. Important habitat parameters for pelagic oceanic species may depend on oceanographic processes that show little geographic predictability at the spatial scales at which habitats are usually managed. Using new photo-identification and acoustic survey data from the Azores, we have investigated the extent to which critical habitat areas for sperm whales can be identified within the archipelago, and how geographically-based management could promote their conservation. There were no indications of discrete areas of high abundance, of specific sensitive areas (e.g. calving or nursing grounds) or of preferred areas for particular individuals or groups. However, sperm whales were generally most abundant in certain depth ranges (~1,500-2,500 m) and there were indications that different components of the population preferred certain water depths (e.g. calves were relatively abundant between 750-1,750 m). We do not know what elements of the habitat in these regions are important for the sperm whales within them, or what, if anything, managers could do to improve or protect these habitats. In this case, geographically based management may not offer very focused protection but, if this approach were to be applied, these data suggest that certain "depth corridors" should be protected. It is important that regulators should appreciate that for some species, critical habitat approaches to management may be less effective, and for these, it is essential that regulatory mechanisms to support alternative management strategies should be enacted.

THE FORAGING DISTRIBUTION AND BEHAVIOUR OF GREY SEALS AND HUMPBACK WHALES: PRACTICAL LESSONS FOR DETERMINING CRITICAL HABITAT

P. S. Hammond, B. J. McConnell, P. T. Stevick, J. Matthiopoulos, P. Lovell and M. A. Fedak

Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, St Andrews,
Fife KY16 8LB, UK

The ability to determine key areas of habitat is crucial for making informed decisions about the conservation of marine mammals and the management of activities impacting them, as well as for understanding their ecology and predicting the effects of environmental change. Success depends on scientists working with managers to provide information that helps inform conservation objectives.

In this presentation, the role of the scientist is illustrated through studies of two species that differ in techniques of data collection, type of information obtained, and methods of analysis. In the North Atlantic, humpback whales forage in high latitude feeding areas in summer and migrate to common breeding areas in the West Indies in winter. They have been studied extensively using photo-identification and (more recently) genetic markers. Matches between encounters provide information on movements within and between seasons. Many thousands of individuals have been identified over a period exceeding 20 years, but most are represented by only one or two sightings. Results show a strong tendency for individual humpbacks to return to feed in the same general region but that finer scale structuring is also evident. Re-sightings between years are most common at a scale of tens of kilometres and are not unusual up to 200 km. But exchange between areas separated by greater than 600 km is rarely seen. Local shifts in distribution in response to changes in prey availability are known to occur.

Grey seals spend part of their lives on land, during the breeding season and at other times. Their detailed foraging behaviour at sea on trips from these haul-out sites has been studied around Britain using satellite-relay data loggers (SRDLs), generating a large quantity of data but on a relatively small number of individuals. To extract the maximum value from these extensive data, tools for exploration and analysis have been developed. The computer software MAMVIS allows behavioural data to be visualised in a 3-D environment, giving insights not possible through other media. Mathematical / statistical models are used to synthesise information on the haul-out and foraging behaviour of individuals, and to extrapolate the spatial distribution of the population. Central to understanding habitat use in this method is the separation of accessibility from preference. Results show that individual grey seals may make long distance movements but that they mainly forage in particular areas within 50 km of haul-out sites. Overall, the population forages widely over shelf waters around northern Britain but individuals may have peculiar and consistent patterns of behaviour. Foraging 'hot spots' to which many animals return repeatedly year after year are evident; in some areas these can be characterised by physical characteristics of the seabed.

What these results tell us about determining critical foraging habitat depends in part on the conservation objectives: e.g. to maintain current or regain historical population size or range; or to protect a number of 'flagship' areas. But they do suggest that different strategies may be needed for these two species. The humpback whale population shows considerable spatial structuring and fidelity to feeding regions at a scale of hundreds of kilometres but shifts in distribution in response to prey availability at a smaller scale. This suggests that it may be desirable to designate several entire large feeding areas to maintain population range or size. For grey seals, it is possible that much smaller areas of critical foraging habitat could be defined. These could be based on some combination of current preferences for foraging areas at sea, physical characteristics of the seabed in some areas, and even the location of haul-out sites.

DEFINING CRITICAL HABITAT AREAS FOR BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) RESIDENT IN THE SHANNON ESTUARY, IRELAND AND CONSERVATION MANAGEMENT IMPLICATIONS

S. N. Ingram and E. Rogan

Department of Zoology & Animal Ecology, University College Cork, Lee Maltings, Prospect Row, Cork, Ireland

Understanding habitat use is essential in effective conservation management of marine mammal populations. This study examined habitat use by bottlenose dolphins resident in the Shannon estuary, a proposed Special Area of Conservation under the European Habitats directive. Standardised boat surveys were used to collect data on the distribution and habitat use of dolphins in a 150km^2 area of the outer estuary.

Between July 1996 and August 1998, 45 boat surveys were conducted, resulting in 166 encounters with dolphin groups. Harmonic mean analysis of the spatial distribution of these groups identified two core habitat areas encompassing $45\ \text{km}^2$ of the outer estuary. The distribution of sightings was non random with respect to depth ($p<0.01$) and slope ($p<0.05$) and dolphins exhibited preferential use of areas with the greatest depth (>30 m), steepest benthic slope and fastest tidal currents ($2.5\ \text{ms}^{-1}$). These core areas overlapped a busy shipping lane and standardised shore watches were used to record interactions of dolphins with boats in the largest of these core areas (40km^2) at the estuary mouth. Vessels were present in 65% of shore-watch scans with a maximum of five boats recorded during a single scan. Dolphin-watching vessels accounted for 38% of all boat traffic and were involved in 62% of dolphin-boat interactions. Large transiting ships represented 12% of the total shipping traffic recorded during the study, and these vessels accounted for 23.5 % of the total recorded interactions between boats and dolphins.

The Shannon is one of Ireland's busiest waterways and transports over ten million tonnes of shipping per annum. The potential effects of increased boat activity and dolphin-watching operations on the dolphin population is discussed together with the importance of understanding habitat use in conservation management plans.

DEFINING CRITICAL HABITAT IN A CRITICALLY ENDANGERED BALEEN WHALE SPECIES: THE RIGHT WHALE TO STUDY?

Robert D. Kenney

University of Rhode Island, Graduate School of Oceanography, Bay Campus Box 41,
Narragansett, RI 02882-1197, U.S.A. (E-mail: rkenney@gso.uri.edu)

The right whale (*Balaena glacialis*) may very well be the "right" whale to study in regard to critical habitat research and management, for a variety of reasons - both positive and negative. Geographically disjunct right whale populations inhabit the middle latitudes of the North Atlantic, North Pacific, and Southern Oceans. However, this paper focuses primarily on the western North Atlantic population, which has been the focus of intensive research since the 1970's.

CRITICAL MANAGEMENT NEEDS The principal reason why right whales are currently a focus of habitat research is that there is an immediate management need because of their endangered status. Right whales were the first whale species to be a target of commercial whaling and the first to be seriously depleted. After centuries of whaling, beginning with the Basques in the Bay of Biscay as early as the 11th Century (Aguilar, 1986), they are the world's most endangered large whale species, with Northern Hemisphere stocks the most critically depleted (IWC, 2000a). Currently available data indicate that the western North Atlantic population is the largest surviving northern stock, however at present it includes only about 300 animals (Knowlton *et al.*, 1994; IWC, 2000b; Kraus *et al.*, 2000). Modeling of demographic trends suggests that this population is presently declining, with extinction in the foreseeable future a distinct possibility (Caswell *et al.*, 1999; IWC, 2000b). The status of North Pacific right whales may be worse, however the data are very sparse and uncertain. Because of their critically endangered status, there is a pressing management need to develop a solid scientific understanding of right whale habitat requirements and to provide the highest possible level of protection to those habitats which are essential for their survival.

ACCESSIBILITY Right whales occur during much of their annual migratory cycle relatively close to shore in largely consistent locations (Winn *et al.*, 1986). This makes them more easily accessible for study than many other cetaceans. This is particularly true in the western North Atlantic, where both feeding and calving grounds are in relatively nearshore waters. Even the Great South Channel and Scotian Shelf feeding grounds, which are often referred to as "offshore" habitats, are located in continental shelf waters only 50-150 km from shore. However, since the majority of the population is absent in winter, and some individuals may not be observed for several years at a time (Brown *et al.*, submitted), they may utilize other more offshore wintering and feeding habitats which have yet to be discovered. In Southern Hemisphere right whales, only the calving grounds are nearshore, while feeding likely occurs in pelagic regions (IWC, 2000a).

On the other hand, right whales' use of the same nearshore habitats where human activities are concentrated make them more susceptible to a variety of anthropogenic threats, beginning with early whaling in North Atlantic coastal waters. In western North Atlantic right whales, at least one-third of all mortalities can be definitely attributed to human causes (Kraus, 1990; Knowlton and Kraus, 2000). The most significant source of mortality at present is collision with large ships. Between 1970 and 1999, sixteen right whales were known to have been killed by ships, and two others were last seen with serious and probably fatal injuries. Ship collisions may be less of a mortality factor in other oceans, where right whales spend less time in near-shore habitats or where the level of industrial development is lower, although recent mortalities in the South Atlantic suggest cause for concern (IWC, 2000a; Boersma, 2000).

The second most important human-related mortality factor in western North Atlantic right whales is incidental capture in commercial fishing gear. Since 1970, three right whales are known to have been killed by entanglements, and eight others were seriously injured. Entanglement seems to be very common, but is often not lethal. Over 60% of whales in the western North Atlantic bear scars from entanglement, and some individuals have been entangled two or three times (Knowlton and Kraus, 2000). Entanglement may be more of a threat to younger animals, who might grow into a relatively benign entanglement until it becomes life-threatening.

Other possible impacts which are likely to be more serious in nearshore waters include toxic contaminants, man-made noise, exclusion from habitats by high levels of human activity, and changes in ecosystem structure caused by intensive commercial fishing activity.

DEFINING CRITICAL FEEDING HABITATS Effective management and protection of any population requires protection of their feeding habitats, which in turn requires some understanding of the dynamics of their prey. Right whales are specialists, feeding exclusively on zooplankton, especially on large calanoid copepods such as *Calanus finmarchicus* (Omura *et al.*, 1969; Murison and Gaskin, 1989; Mayo and Marx, 1990; Kenney and Wishner, 1995). A 20-70 tonne predator which feeds on prey the size of rice grains requires prey concentrated in very dense patches in order to feed efficiently (Kenney *et al.*, 1986; Mayo and Marx, 1990). *Calanus* is a widespread, dominant species; it may be the most abundant animal in the North Atlantic and therefore less likely to be negatively affected by human impacts. *Calanus* is also herbivorous, putting right whales at the top of a very short and simple food chain (phytoplankton – copepod – whale). A short food chain lessens the potential impacts from biomagnification of toxic contaminants, and also makes it easier to study and model the ecological interactions in right whale habitats.

We began studying right whale feeding habitats in the early 1980's, with the objective of better understanding their habitat requirements. One of our first conclusions was that right whales are much better zooplankton samplers than oceanographers are—the densest zooplankton concentrations measured in the North Atlantic have been found by sampling near right whales. Our studies culminated in the South Channel Ocean Productivity Experiment (SCOPEX) in 1988 and 1989. SCOPEX was an intensive multidisciplinary oceanographic study of the feeding habitat in the Great South Channel (Kenney and Wishner, 1995). We assumed that right whales selected locations with exceptionally dense patches of zooplankton, and attempted to differentiate among three hypotheses concerning the mechanisms responsible for creating those patches:

- the "upwelling" hypothesis: very high local phytoplankton productivity leads to high zooplankton production via the food chain
- the "advection" hypothesis: oceanographic processes (water mass structure, stratification, currents, tides) interacting with the topography of the ocean floor physically concentrate zooplankton produced over a broader region
- the "swarming" hypothesis: *Calanus*' species-specific behavior patterns cause aggregation into dense patches

The SCOPEX results showed that advection and concentration by physical processes was the primary causative mechanism, with a possible contribution by *Calanus* behavior, but with local biological productivity unimportant. This close connection between oceanography and topography and the development of right whale feeding habitats suggests that the habitats may be more stable and predictable, and therefore more easily protected. The Great South Channel and Cape Cod Bay feeding grounds and the Southeast U.S. calving ground have all been designated as right whale critical habitats under the U.S. Endangered Species Act. Protective measures have been initiated in order to reduce mortality from ship collisions and fishery entanglements. Some protective management measures have also been undertaken in the two known feeding grounds in Canadian waters—Bay of Fundy and Scotian Shelf.

Even though right whale feeding is relatively localised, their prey resource is produced over a much larger region, then transported and concentrated by hydrographic processes. Studies have shown that slope waters beyond the continental shelf are an important source for the *Calanus* populations in the Gulf of Maine and Georges Bank (Bucklin and Kocher, 1996). Management measures designed to protect the habitat where right whale feeding occurs may actually miss nearly all of the region where their prey are produced. In addition, the originally-envisioned simple three-step food chain model is made far more complex by expansion to a much larger area and addition of effects of temperature, current, topography, mixing, and wind.

Finally, the oceans and atmosphere comprise a closely-coupled dynamic system, with atmospheric factors the principal drivers of ocean circulation. The tight linkage of right whale feeding to physical oceanographic phenomena implies a similar close relationship to atmospheric patterns, and also suggests that right whales may be more susceptible than other cetaceans to impacts from global climate change. In an on-going study (Kenney, unpublished), I have found statistically significant correlations between western North Atlantic right whale calving rates and two different decadal-scale atmospheric cycles, the Southern Oscillation and the North Atlantic Oscillation (NAO). The NAO is the principal mode of climate variability in the North Atlantic region, and is a cycle of intensification (positive phase) and lessening (negative) of the winter atmospheric pressure gradient between the Iceland Low and Azores High (Hurrell, 1995). NAO phase correlates with ocean circulation patterns such as the intensity of the Labrador Current and the position of the Gulf Stream (Reid *et al.*, 1998; Taylor *et al.*, 1998). In the early 1990's, there was a shift to a strongly positive NAO regime. This corresponded in time to the shift from growth to decline in the right whale population trend (Caswell *et al.*, 1999; IWC, 2000b), a dramatic increase in inter-birth intervals (Kraus *et al.*, 2000), and abandonment of the summer feeding ground south of Nova Scotia (M.W. Brown, S.D. Kraus, *pers. comm.*). The causative mechanisms have not been demonstrated; however, a likely hypothesis is that changes in atmospheric patterns have altered ocean circulation, affecting the development of dense zooplankton patches and therefore affecting right whale foraging success. An alternative hypothesis is that populations of other species which prey on copepods have increased, reducing the food available for right whales. Human influences have the potential to alter the structure of marine food chains. Commercial fisheries, by removing larger predatory fishes, may allow abundances of smaller fishes to increase, and herring and mackerel stocks in the Gulf of Maine/Georges Bank region are presently very high (K. Sherman, NMFS, *pers. comm.*). It seems unlikely, however, that competitors could be that much more abundant now than they were before whaling began, when the ecosystem was capable of supporting a population of right whales which must have numbered in the thousands.

CONCLUSIONS AND FUTURE DIRECTIONS If right whales are to survive in the western North Atlantic, the most critical measure which needs to be taken is to continue management efforts to reduce, and preferably eliminate, human-caused mortality. Beyond that, habitat studies should continue and expand. Efforts should be undertaken to locate the "missing" whales and any other habitats which they may be using. We must expand our efforts to work with scientists from other disciplines on detailed habitat studies similar to SCOPEX, as well as expanding that sort of research to additional habitats. One intriguing possibility would be an oceanographic and zooplankton study in the waters off Labrador and Newfoundland where Basque whalers took thousands of right whales in the 16th and 17th Centuries to investigate whether those waters still constitute viable right whale feeding habitat. Research has begun toward coupling the SCOPEX results with large-scale oceanographic patterns such as satellite-derived sea surface temperatures to develop predictive models which might help us to locate other undiscovered right whale habitats or to predict habitat shifts with climate or oceanographic changes. It is clear that effective conservation of right whales and other cetaceans requires protection of their habitat, necessitating a broad-scale, multidisciplinary, ecosystem approach.

ACKNOWLEDGEMENTS Much of this research has been conducted by a group of co-operating institutions and agencies which has been loosely organised as the Western North Atlantic Right Whale Consortium. Too many scientists have been involved to mention all of them, but this work would not be possible without all of their efforts. Special mention is due to the late Howard Winn and John Prescott, the prime movers in starting the Consortium. This research has been supported by many sources, including the National Marine Fisheries Service, Minerals Management Service, Canada Dept. of Fisheries & Oceans, National Science Foundation, Marine Mammal Commission, Office of Naval Research, U.S. Army Corps of Engineers, U.S. Navy, state agencies, numerous foundations and other private granting agencies, and the participating members of the Consortium themselves.

REFERENCES

Aguilar, A. 1986. A review of old Basque whaling and its effect on the right whales (*Eubalaena glacialis*) of the North Atlantic. *Rep. int. Whal. Commn* (special issue 10): 191-200.

Boersma, P. D. 2000. Three southern right whales dead along Argentine coast. *Mar. Mamm. Sci.*, 16(2); 511-512.

Brown, M. W., Hamilton, P. K., Kenney, R. D., Knowlton, A. R., Marx, M. K., Mayo, C. A., Slay, C. K. and Kraus, S. D. Submitted. Sighting heterogeneity of right whales in the western North Atlantic. *J. Cetacean Res. Manage.*

Bucklin, A. and Kocher, T. D. 1996. Source regions for recruitment of *Calanus finmarchicus* to Georges Bank: evidence from molecular population genetic analysis of mtDNA. *Deep-Sea Res.*, 43: 1,665-1,681.

Caswell, H., Fujiwara, M. and Brault, S. 1999. Declining survival probability and its implications in the North Atlantic right whale. *Proc. Nat. Acad. Sci.*, 96: 3,308-3,313.

Hurrell, J. W. 1995. Decadal trends in the North Atlantic Oscillation: regional temperatures and precipitation. *Science*, 269: 676-679.

International Whaling Commission. 2000a (in press). Report of the Workshop on the Comprehensive Assessment of Right Whales. *J. Cetacean Res. Manage.* (special issue 2).

International Whaling Commission. 2000b (in press). Report of the Workshop on Status and Trends of Western North Atlantic Right Whales. *J. Cetacean Res. Manage.* (special issue 2).

Kenney, R. D., Hyman, M. A. M., Owen, R. E., Scott, G. P. and Winn. H. E. 1986. Estimation of prey densities required by western North Atlantic right whales. *Mar. Mamm. Sci.*, 2(1): 1-13.

Kenney, R. D. and Wishner, K. F. (eds). 1995. *The South Channel Ocean Productivity EXperiment: SCOPEX. Cont. Shelf Res.*, 15(4/5, special issue): 373-611.

Knowlton, A. R. and Kraus, S. D. 2000 (in press). Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *J. Cetacean Res. Manage.* (special issue 2).

Knowlton, A. R., Kraus, S. D. and Kenney, R. D. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Can. J. Zool.*, 72: 1,297-1,305.

Kraus, S. D. 1990. Rates and potential causes of mortality in North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mamm. Sci.*, 6: 278-291.

Kraus, S. D., Hamilton, P. K., Kenney, R. D., Knowlton, A. R and Slay, C. K. 2000 (in press). Status and trends in reproduction of the North Atlantic right whale. *J. Cetacean Res. Manage.* (special issue 2).

Mayo, C. A. and Marx, M. K. 1990. Feeding behavior of northern right whales, *Eubalaena glacialis*, in Cape Cod Bay, and associated zooplankton characteristics. *Can. J. Zool.*, 68: 2,214-2,220.

Murison, L. D. and Gaskin, D. E. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. *Can. J. Zool.*, 67: 1,411-1,420.

Omura, H., Ohsumi, S., Nemoto, T., Nasu, K. and Kasuya, T. 1969. Black right whales in the North Pacific. *Sci. Rep. Whales Res. Inst. Tokyo*, 21: 1-96.

Reid, P. C., Planque, B. and Edwards, M. 1998. Is observed variability in the long-term results of the Continuous Plankton Recorder survey a response to climate change? *Fish. Oceanogr.*, 7: 282-288.

Taylor, A. H., Jordan, M. B. and Stephens, J. A. 1998. Gulf Stream shifts following ENSO events. *Nature*, 393: 638.

Winn, H. E., Price, C. A. and Sorensen, P. W. 1986. The distributional biology of the right whale, *Eubalaena glacialis*, in the western North Atlantic. *Rep. int. Whal. Commn* (special issue 10): 129-138.

TRACE METAL CONCENTRATIONS IN MARINE TUCUXI (*SOTALIA FLUVIATILIS*, GERVAIS, 1853) IN GUANABARA BAY, BRAZIL: PRELIMINARY RESULTS

J. Lailson-Brito Jr.[1, 2]; M. A. A. Azeredo[2] and M. F. C. Saldanha[3]

[1]*Mestrado em Ciências Ambientais - Universidade Federal Rural do Rio de Janeiro, Seropédica, RJ Brazil, 23851-970*
[2]*Projeto MAQUA – Depto. Oceanografia/Universidade do Estado do Rio de Janeiro. R. São Francisco Xavier, 524/4002E – Maracanã, Rio de Janeiro, RJ, Brazil. 20550-013 (E-mail: maqua@uerj.br)*
[3]*CNPS, EMBRAPA SOLOS, RJ, Brazil, 22460-000.*

The marine ecotype of the tucuxi, *Sotalia fluviatilis*, is found in estuarine areas, bays and inlets and is in constant interaction with human activities. Guanabara Bay, located in Rio de Janeiro state, is visited daily by tucuxi and is the most degraded area of its distribution. The industrial discharges of sewage and process wastes represent a principal source of pollution of the bay. Pollution, destruction of marginal areas, incidental catches and intentional harrassment, constitute direct threats to the conservation of tucuxi in Guanabara Bay. Despite these problems, the species is observed year-round in this area where it feeds, socialises and nurses its young. This study analyses livers and kidneys of seven specimens, from foetus to adult, males and females. The analyses were performed by ICP-AS after concentrated HNO3 digestion. The metals analysed were Fe, Cu, Zn, Mn, Cd and Pb. Parallel certified reference material analysis was performed (DORM2-NRC, Canada). Concentrations (wet weight) varied: livers - Fe (87.85 – 482.00 m g/g), Cu (2.45 – 33.57 m g/g), Zn (30.70 – 126.33 m g/g), Mn (1.05 – 4.00 m g/g), Cd (below limit detection – 0.50 m g/g) and Pb (below limit detection); kidneys - Fe (49.95 – 167.00 m g/g), Cu (2.49 – 5.19 m g/g), Zn (20.23 – 24.75 m g/g), Mn (0.46 – 0.82 m g/g), Cd (below limit detection – 1.79 m g/g) and Pb (below limit detection). Ecotoxicological factors (age, sex, sexual maturity, distribution, etc.) were considered in the interpretation of the results. The concentrations, in general, were lower than for other species, and it is possible that the oceanographic characteristics of the Guanabara Bay may not permit bioavailablility of these elements for long periods.

RIVER DOLPHINS DON'T ALWAYS PREFER RIVERS

A. R. Martin[1] and V. M. F. da Silva[2]

[1]*Sea Mammal Research Unit, Gatty Marine Laboratory, Univ, of St. Andrews, St. Andrews, Fife KY16 8LB, UK*
[2]*Laboratory of Aquatic Mammals, INPA C.P. 478, Manaus, AM 69011-790, Brazil*

We have studied the boto or Amazon river dolphin (*Inia geoffrensis*) for six years in an area of seasonally-inundated rainforest (Várzea) in Brazil, where systems of lakes and channels in dense forest are connected by narrow entrances to the vast river Amazon during the low-water season. At high water, all land disappears and the whole region becomes a turbid inland sea, mostly covered with tree canopy. Potential fish prey are abundant and diverse, concentrating in the smaller waterways during the low-water season and spreading through the forest at high water. The study included an investigation of the seasonal habitat preferences of botos, using visual observations of individually-marked animals (172 freeze-branded), small boat censuses of lake systems, line- and strip-transects of major waterways, and remote sensing of VHF-tagged dolphins (n=54). Results showed marked differences in habitat preference between individuals within seasons and between seasons within individuals. Dolphins were found in major rivers throughout the year, with densities greatest along the banks (~1 per km^2) and lowest in mid-river. Botos occupied lake systems at very high densities (typically ~10 per km^2) during mid-water-level periods, moving into the main rivers at low water and into the flooded forest at high water. Known individual botos were seen in all habitats, but some remained in lake systems almost all year. Dolphins commonly moved >20 km per day within the study area, but sometimes stayed for periods of weeks within small areas (<1 km^2), apparently foraging. We conclude that boto distribution is primarily dictated by the density and availability of fish prey, which in turn is determined by seasonal fluctuations in water level. The density of fish in this region is sufficient to support extremely high densities of these dolphins both in the main rivers and in lake systems, but the latter habitat is preferred for most of the year.

CRITICAL HABITATS OF BLUE WHALES IN THE EASTERN NORTH PACIFIC

B. R. Mate

Oregon State University, Hatfield Marine Science Center, Fisheries & Wildlife, Newport, Oregon 97365, USA

Except for some summer feeding areas off California, the critical habitats, range, and seasonal distribution of the estimated 2,500 eastern North Pacific (ENP) blue whales are poorly understood. Photographic surveys and preliminary radio-tagging efforts have shown some individuals off Baja California, Mexico, in the fall and spring, although the numbers observed off Mexico in any one season account for <5% of the California feeding aggregation. To examine the hypothesis that ENP blue whales migrate to winter breeding and calving areas where they can continue to feed, 32 blue whales were tagged off California with new semi-implantable Argos (satellite-monitored) radio tags during 1998-99. Whales were tracked for up to 241 days. Sea surface temperatures and primary productivity were determined by AVHRR and SEAWIFS satellite images. Tagged blue whales spent prolonged periods in upwelling areas known for dense aggregations of krill, including off Magdalena Bay, in the Sea of Cortez, and near the equator. Whales travelled fast, often over long distances, between such areas. Winter feeding by blue whales contradicts the general consensus that baleen whales fast during their migrations and winter reproduction (like gray and humpback whales). During the summer of 1998, an El Niño year, half of the blue whales seen were emaciated and some tagged whales moved as far north as Oregon. Perhaps due to continued poor feeding conditions in the southern winter range, some whales migrated north into southern California three months earlier than usual in spring of 1999. The summer movements of whales tagged in 1999 (a "normal" La Niña year) were not as wide-ranging as 1998. The movements of tagged whales in association with oceanographic data necessitates a re-assessment of critical habitats and environmental preferences of blue whales in the ENP.

HAUL-OUT BEHAVIOUR IN GREY SEALS:
SITE SELECTION BY PHOTO-IDENTIFIED INDIVIDUALS IN SUMMER

L. Meynier[1], C. Vincent[2] and V. Ridoux[2]

[1]*Laboratoire d'Etudes des Mammifères Marins, Océanopolis, 29 275 brest, France*
[2]*Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, 17 026 La Rochelle, France*

Haul-out sites are critical habitats for pinnipeds, notably grey seals, *Halichoerus grypus*, as they use them for three major functions - resting, reproduction, and moulting. Haul-out behaviour during breeding is characterised by intense socialising, especially in polygynous seals. During summer time, the social constraints are supposed to be reduced. As a consequence, one can expect that the animals could more easily adapt haul-out site selection according to short term changes in the quality of these sites (exposure to weather and sea conditions, human disturbance, etc.). Therefore, on a medium time scale (i.e. during the summer season), this should result in the seals being distributed at random amongst suitable sites of the area. This hypothesis was tested by investigating microsite fidelity of photo-identified female grey seals during the summers 1998 and 1999 at the Molène archipelago, Brittany, France. Twenty-four and 26 field sessions were carried out in 1998 and 1999 respectively, during which, on average, 81-84% of the females on haul-out sites were photo-identified. These individuals were not distributed at random, since any single seal only used a small proportion of available and suitable sites. Additionally, the combinations of sites used by individuals were not determined at random, leading to higher values of overlap coefficient between sites, as calculated from the occurrence of identified seals within pairs of sites. These results are discussed in terms of small-scale abiotic characteristics of haul-out sites, as well as possible social links outside the breeding season.

BREAKING THE SURFACE - A STUDY OF WHALES, DOLPHINS AND DUGONGS IN WEST MALAYSIA

C. Nadarajah

World Wide Fund for Nature Malaysia, No. 49, SS 23/15, Petaling Jaya, Selangor, 47300, Malaysia

There have been extremely limited scientific research or locality records on the marine mammals of West Malaysia since the 1950's (Perrin *et. al.*, 1995). As a result, little is known about the marine mammals that frequent these waters and the habitats they use. As coastal and marine habitats are rapidly being destroyed as a result of economic development, it was imperative to begin preliminary scientific studies on marine mammals and their associated habitats.

A twelve-month project was designed as a pilot study to determine base-line data relating to which species are found in West Malaysia, the habitats they utilise, and the current threats faced by both. Recommendations for future research priorities were also provided by this study.

Five sites along the coastline of Peninsular Malaysia were selected for surveys to be undertaken for this project. In depth interview surveys of fishermen and tour operators were conducted at all project sites. Anecdotal information on species, sightings, strandings, distribution, abundance, threats, bycatch, and fisheries-marine mammal interactions were collected. Boat surveys were also conducted at all project sites to gather data on species composition and habitat use and status.

Species were recorded during the project through strandings, skeletal remains and opportunistic sightings. In total, seven odontocetes (false killer whale (*Pseudorca crassidens*), melon-headed whale *(Peponocephala electra)*, bottlenose dolphin *(Tursiops truncates)*, long-snouted spinner dolphin *(Stenella longirostris)*, Indo-Pacific humpback dolphin *(Sousa chinensis)*, finless porpoise *(Neophocaena phocaenoides)* and Irrawaddy dolphin *(Orcaella brevirostris)* and one sirenian, dugong (*Dugong dugon*) were observed.

Habitats used by marine mammals ranged from open sea to coastal and riverine areas. Coastal and riverine areas were most notably under threat from coastal reclamation and development for tourism and industry, conversion of land for agricultural purposes, and pollution. In-depth interviews conducted with local fishing communities and tour operators revealed a strong presence of marine mammals throughout the study area. Dolphins are frequently sighted and seen throughout the year. Whales, porpoises, and dugongs were less commonly seen. Evidence suggests that whales are seasonal visitors to the waters of Peninsular Malaysia.

The main potential threats to marine mammals in Peninsular Malaysia were identified to include habitat loss and degradation, incidental bycatch in fishing gear, increased fishing effort and depletion of fisheries resources, increased boat traffic, and acoustic disturbance and pollution.

Based on the findings of this project, there is vast potential for future research in this area. It is important that further research into species composition, their habitat utilisation, critical habitats for marine mammals, and their distribution be a priority in West Malaysia. Abundance surveys are also important, but are not an immediate priority. As habitat loss and degradation are the most immediate threats to the coastal species of marine mammals in West Malaysia, it is important that future work focuses on this area and ensures the establishment of "protected areas" or sanctuaries for marine mammals where possible.

Education and awareness must also be a priority of marine mammal conservation in West Malaysia. Awareness about marine mammals and the need to conserve them must be increased amongst the general public, relevant communities, research institutions and government agencies. Capacity building and training should also be a priority within relevant agencies before long-term conservation programmes can be established.

REFERENCE

Perrin, W. F., Leatherwood, S. and Dolar, M. L. L. 1995. The Status of Marine Mammal Research in Southeast Asia. *IBI Reports* (International Marine Biological Research Institute), 5: 213-227.

CONSIDERABLE AMOUNT OF PLASTIC DEBRIS IN THE STOMACH OF A CUVIER'S BEAKED WHALE (*ZIPHIUS CAVIROSTRIS*) WASHED ASHORE ON THE FRENCH ATLANTIC COAST

Eric Poncelet[1], Olivier Van Canneyt[1] and Jean-Jacques Boubert[2]

[1]Centre de Recherche sur les Mammifères Marins, Institut de la Mer et du Littoral,Port des Minimes,
17000 La Rochelle, France (E-mail: poncelet@univ-lr.fr)
[2]Groupe de Recherche et d'Etude des Mammifères Marins de la SEPANSO,1, rue de Tauzia,
33800 Bordeaux, France

INTRODUCTION Man-made marine debris is a growing threat to marine fauna, causing entanglement and incidental ingestion. This latter impact has been documented in cetaceans but also in pinnipeds, sirenians, seabirds, marine turtles, squids and fish (see Laist, 1997 for a review). In this work, we report the outstanding discovery of 33 kg of plastic (wet weight) filling the stomach of a dead Cuvier's beaked whale (*Ziphius cavirostris*) which was washed ashore on the French Atlantic coast. We also review case reports of debris ingestion reported in France since 1972.

Cuvier's beaked whale strandings are rare on the French Atlantic coast (from southwestern France to the tip of Brittany), with 56 case reports from 1972 to 1999 (CRMM unpublished data).

Debris ingestion has been previously reported in this species in the North Atlantic (Virginia, USA) and North Pacific (California, USA), with plastic bags and wrappers, drinking straws and asphalt recovered in stomach contents (data from the Charleston Museum of Natural History, Charleston, S.C., U.S.A. and the Southwest Fisheries Science Center, N.M.F.S., La Jolla, California, U.S.A., reported in Walker and Coe, 1990). Such cases are not rare in marine mammals. According to Laist (1997) and Baird and Hooker (in press), 27 species of cetaceans have been inventoried as victims of foreign object ingestion, with the bowhead whale (*Balaena mysticetus*) and the minke whale (*Balaenoptera acutorostrata*) being the only mysticetes recorded to date. In 1999, Pribanic *et al.* (1999) reported a similar case to the one reported here; a striped dolphin (*Stenella coeruleoalba*) from the Adriatic Sea was found with a stomach full of plastic bags.

THE STRANDING AND THE FINDINGS On 29th January 1999, a dead 4.65 m male *Ziphius* was washed ashore on a beach at Biscarrosse, Landes, southwestern France, Bay of Biscay. Local field operators of the French National Stranding Network alerted the Centre de Recherche sur les Mammifères Marins (CRMM), who is in charge of the management of the National Stranding Network, and staff visited the carcass. The whale was in a moderate state of decomposition (based on the criteria developed by Kuiken and García Hartmann in 1991). The teeth of the lower jaw had not erupted suggesting the whale was physically immature (Heyning, 1989). It was very thin. The skull relief appeared through the skin ("peanut head" condition), as did the dorsal spine, the transverse processes, and the upper ribcage. The blubber layer was 2.8 cm thick on the upper left flank, ca. 20 cm under the dorsal fin. This emaciated condition suggested that the whale probably died from starvation.

The stomach was analysed *in situ*, and the chambers explored and emptied by hand. It was full of plastic debris (see sample description in Table 1) which had a wet weight of 33 kg and a volume of 60 litres, once extracted (the plastic volume must have been a little bit smaller in the stomach due to the compression by the walls). The debris was covered with dark viscous fluids. A few cephalopod and fish remains and nematode parasites were discovered among the debris. Of the extracted plastics, 786 g was randomly collected, cleaned, dried and quantitatively described (Table 1). We identified seven supermarket plastic bags (77.8%), two of which had a Spanish name brand ("El Arbol" and "Eroski"), and two plastic sheets (22.2%). Eight items were translucent and only one was transparent.

Given the humidity rate in the sample and the total wet weight of all of the plastics found in the stomach, we estimated the total dry weight to be 2.81 kg. Using the sample-to-total wet weight ratio and the number of items in the sample, we estimated the whale's stomach contained 378 plastic items.

DISCUSSION Among the 839 cetaceans necropsied on the French coast between 1972 and 1999, there have only been eight reports of plastic ingestion (Table 2) recorded by the CRMM. However, only a proportion of the stomachs were examined for debris ingestion.

It is difficult to understand why animals with acute senses may ingest such inedible objects in the wild. One would expect their echolocation (Walker and Coe, 1990), and tactile and gustatory senses to identify such objects as inedible. In the present case, the stomach was full of plastic debris and it is unlikely that this was the result of a single incidental ingestion. It is more likely that the whale swallowed plastic debris during several weeks or even months. A plastic pellet is thought to require 1-2 years to degrade in the stomach of a seabird (Ainley *et al.*, 1990) and thus the presence of small plastic remains in this whale's stomach suggests that the first incidental ingestion occurred a long time before it died. This behaviour may start in sick and weakened individuals who progressively become unable to catch preferred prey (Kastelein and Lavaleije, 1992) and shift their diet to easy-to-catch but inedible objects in a survival instinct. A vicious cycle may then develop whereby the individual, with growing starvation and weakness, continues to consume inedible items until the stomach is full and the individual dies.

The dark viscous fluids recovered on the debris were possibly digested blood resulting from stomach lining erosion and profuse haemorrhages (Walker and Coe, 1990). According to Sandritter and Thomas (1972), such an erosion may be a cause of death.

Unfortunately, plastic ingestion is more and more frequent in marine fauna. The excessive behaviours reported in Pribanic e*t al.* (1999), and here simply stress the need to prevent debris release in the oceans.

ACKNOWLEDGEMENTS We would like to thank Jean Barrière of the Groupe de Recherche et d'Etude des Mammifères Marins de la SEPANSO for helping during the necropsy, and the administration of the Centre d'Essai des Landes for facilitating our intervention on the stranding.

We are also indebted to Dan Odell for his useful comments on this manuscript, to Damian C. Lidgard for improving the English, and David Laist, Robin W. Baird and Sam Ridgway for providing information on plastic ingestion in aquatic animals.

REFERENCES

Ainley, D. G., Spear, L. B. and Ribic, C. A. 1990. The incidence of plastic in the diets of pelagic seabirds in the eastern equatorial Pacific region. Pp. 653-664. In: *Proceedings of the Second International Conference on the Marine Debris, 2-7 April 1989, Honolulu, Hawaii. Volume I* (Eds. R. S. Shomura and M. L. Godfrey). U.S. Department of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154. 774pp.

Baird, R. W. and Hooker, S. K. In press. Ingestion of plastic and unusual prey by a juvenile harbour porpoise. *Marine Pollution Bulletin.*

Heyning, J.E. 1989. Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. Pp. 289-308. In: *Handbook oj marine mammals. Volume 4: river dolphins and the larger toothed whales* (Eds. Ridgway, S.H. and Harrisson, R.). Academic Press, London, xx + 442pp.

Kastelein, R. A. and Lavaleije, M. S. S. 1992. Foreign bodies in the stomach of a female harbour porpoise (*Phocoena phocoena*) from the North Sea. *Aquatic Mammals*, 18(2): 40-46.

Kuiken, T. and García Hartmann, M. 1991. Proceedings of the first ECS workshop on cetacean pathology: dissection techniques and tissue sampling. *ECS Newsletter*, 17, 1-43pp.

Laist, D. W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pp. 99-139. In *Marine debris. Sources, impacts, and solutions* (Eds. J. M. Coe and D. B. Rogers). Springer-Verlag, New-York, 416pp.

Pribanic, S., Holcer, D. and Miokovic, D. 1999. First report of ingestion by striped dolphin (*Stenella coeruleoalba*) in Croatian part of the Adriatic Sea. Pp. 443-446. In: *European Research on Cetaceans - 13*. Proceedings of the 13th Annual Conference of the European Cetacean Society, Valencia, Spain, 5-8 April 1999 (Eds. P. G. H. Evans, J. A. Raga and J. Cruz). European Cetacean Society, Valencia, Spain, 484pp.

Ridgway, S.H. 1972. Homeostasis in the aquatic environment. Pp. 590-747. In *Mammals of the sea. Biology and medicine* (Ed. S. H. Ridgway). Charles C. Thomas, Springfield, xiv + 812pp.

Sandritter, W. and Thomas, C. 1972. *Manuel et atlas d'anatomie pathologique macroscopique*. France, Masson & Cie, xii + 359pp.

Secchi, E. R. and Zarzur, S. 1999. Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon dentirostris*, washed ashore in Brazil. *Aquatic Mammals*, 25(1): 21-24.

Tarpley, R. J. and Marwitz, S. 1993. Plastic debris ingestion by cetaceans along Texas coast: two case reports. *Aquatic Mammals*, 19(2): 93-98.

Walker, W. A. and Coe, J. M. 1990. Survey of marine debris ingestion by odontocete cetaceans. Pp. 747-774. In *Proceedings of the Second International Conference on the Marine Debris, 2-7 April 1989, Honolulu, Hawaii* (Eds. R. S. Shomura and M. L. Godfrey). U.S. Department of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154, 774pp

Table 1. Quantitative description of the plastic debris sample collected from the stomach contents

Total wet weight:	786 g
Total dry weight:	66.96 g
Humidity rate:	91.48%
Sample / total plastic wet weight ratio:	ca. 2.38%
Number of complete bags or sheets:	9
Lightest complete item:	2.07 g
Heaviest complete items:	10.35 g
Mean dry weight of the complete items:	7.44 g
Weight of small plastic parts:	3.66 g
Total approximate surface:	2.12 m^2

Table 2. Review of the cetaceans stranded on the French coast from 1972 to 1999, and reported to have foreign objects in their stomach

Info. No.	Species	Examination date	Department	Approx. position	Sex	Length (cm)	Foreign object description	Observer
I 1235	*Kogia breviceps*	03/02/84	Charente Maritime	46°00'N 01°19'W	Female	185	Plastic bags in the stomach	A. Collet
I 1262	*Grampus griseus*	14/03/84	Var	43°11'N 05°40'E	Male	ca. 250	Over 1 kg plastic remains in the stomach	J. Besson
I 3205	*Physeter macrocephalus*	14/04/89	Corsica	41°22'N 08°76'E	Female	730	16 m² plastic cover in the stomach	D. Viale
I 4151	*Globicephala melas*	24/07/91	Gironde	45°16'N 01°10'W	Female	394	31 plastic bags and sheeting in the forestomach, and algae (*Fucus vesiculosus*, *Fucus serratus*, *Himanthalia elongata*), total wet weight = 1,740 g	A. Collet
I 4798	*Stenella coeruleoalba*	30/12/92	Var	43°13'N 06°39'E	Male	199	One 400-cm² plastic bags and the stick of 1 cotton stick in the forestomach	J.-M. Bompar
I 7918	*Ziphius cavirostris*	30/01/99	Landes	44°22'N 01°16'W	Male	465	Ca. 33 kg plastic bags and sheets in the stomach	O. Van Canneyt, E. Poncelet, J.-J. Boubert, J. Barrière
I 8171	*Globicephala melas*	19/04/99	Charente Maritime	45°52N 01°16'	Male	578	Monofilament fishing line in the forestomach	E. Poncelet, K. Le Coq, O. Van Canneyt, G. & C. Ansleme
-	*Globicephala melas*	05/15/99	Landes	?	Male	535	Ca. 6 kg of plastic bags in the stomach	A. Dewez

INTERACTION BETWEEN DOLPHINS AND ARTISANAL GILLNET FISHERY: METHODS OF FISHERY AND DAMAGE SAMPLING

M. E. Quero[1], G. Chiofalo[2], S. Datta[2], A. Di Natale[1], P. Y. Dremière[3] and D. Goodson[2]

[1]*Aquastudio, Via Trapani 6, 98121 Messina, Italy*
[2]*Elec. & Elec. Eng. Dept., Underwater Acoustics Group, Loughborough University, Loughborough, LE11 3TU, UK*
[3]*Ifremer, Laboratoire de Technologie des pêches, 1 Rue Jean Vilar, B. P. 171, 34203 Sète, France*

INTRODUCTION Project "ADEPTs" is a European Commission DGXIV supported two-year study of small-scale (artisanal) fisheries where dolphin predation on nets reportedly causes serious economic damage. Although such cetacean interaction problems appear widespread throughout the Mediterranean (Northridge and Di Natale, 1991, Di Natale, 1992, Di Natale and Notarbartolo, 1994), this investigation concerns different locations in Sicily (Fig. 1): the Island of Favignana, Archipelago of Egadi Islands (Fig. 2), and comparative investigations in Catania (Fig. 3). Moreover, ADEPTs partners are carrying out some informative inquiries in France.

The long-standing complaints from local fishing communities of damage caused to their fishing nets by dolphins, was confirmed in a preliminary survey undertaken in Sicily during 1994-95 (Chiofalo and Quero, 1999), and it appears that a predation driven interaction between dolphins, mainly *Tursiops truncatus*, and specific set net gear fisheries does exist. Some dolphins have apparently learned to prey upon fish enmeshed in small-scale trammel-net and monofilament gillnets.

OBJECTIVES The main tasks of the project are: 1) to develop appropriate methods and tools to investigate 'opportunistic' feeding behaviour of cetaceans interacting with fishing nets; 2) to quantify the damage to the fishing nets; to develop and test new technology, including low power and possibly interactive acoustic devices in an attempt to displace dolphins from the immediate vicinity of these nets; and 3) to establish that such devices, if they should prove to be effective, do not have adverse side effects on the fishery itself, e.g. by reducing catch rates.

MATERIALS AND METHODS The fishery activity has been sampled from fishing boats, following the usual fishery rhythms. In order not to influence in any way the habits of fishermen, it has been decided not to dictate preferences either on the choice of fishery field, or on the range of time spent at sea. Total number of individuals, number of individuals per species, total height, and height per species has been taken for each trial, together with the characteristics of gear technology as a monitoring of the catch rates. Fishermen are asked to use active deterrents on random days during a week. Fishery sampling is carried out with and without pieces on the nets, in order to have comparable data. Damage sampling is based on measurements of the damaged surface and on photographic documentation. During fishery trials, dolphn' sightings are logged and documented by photographs and videos; acoustic contacts are recorded.

The mitigation technology and acoustic observation methods that are being developed and tested in this study are reported in a separate paper (see Chiofalo *et al*, this vol.).

DISCUSSION This research, originally planned as a 2-year study, is actually carrying out the field observations in Favignana and Catania, trying to find all the necessary adaptations to fit the information required with the current fishing activities, without modifying any parameter of the fishery itself.

This preliminary period provided a first set of information, concerning the relevant differences between the two study areas (Figs. 2 and 3), gear used (photos 1 and 2), fishery catches (photos 3 and 4), damage (reportedly caused by bottlenose dolphins, photos 5 and 6), the effects of PICE's, the behaviour of both dolphins and fishermen, and the level of interaction and various environmental data, such as the current anthropogenic impact on the areas.

As a matter of fact, the two areas are basically quite different: Favignana is a Marine Protected Area, with a very low ambient noise in winter (it is predicted to increase in summer, with the tourist activity); dolphins seem quite used to patrol the area around the Egadi three islands, with an adaptive strategy to forage themselves picking up fishes and cephalopods from a range of fishing net gear (trammel nets, bottom set nets, drifting nets, purse-seines). The fishermen were accustomed to react in a strong way in the past, but actually, due to a strict regulation and to a better sensitivity, they are now frequently claiming for the serious damage reported.

In Catania, the fishing ground taken into consideration is quite close to the commercial harbour, with a higher ambient noise level and several anthropogenic activities taking place. The fishermen are using drift-nets, set nets and occasionally trammel nets, with a different catch composition from Favignana. The interaction with dolphins is quite frequent and the fishermen sometimes use small fire-works to reduce the problem; as a consequence, dolphins are more used to "noises".

According to these preliminary observations, a comparative study, possibly with different kinds of experimental acoustic deterrents, will be carried out in the coming months.

ACKNOWLEDGEMENTS All the partners of project "ADEPTs" would like to thank the fishermen community in Favignana and Catania, the Coop. "Gente di Mare'91" in Catania and the Municipalities of Favignana and Catania for their hospitality and collaboration.

REFERENCES

Di Natale A, 1992. Impact of large pelagic fishery on cetaceans in the Italian Seas. *Boll. Mus. Ist. biol.* Univ. Genova, 56-57: 87-112.

Di Natale A. and Notarbartolo di Sciara G., 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean Sea and of the cetacean bycatch. *Rep. Int. Whal. Commn.* (special issue 15): 189-202.

Northridge, S. and Di Natale, A., 1991. *The environmental effects of fisheries in the Mediterranean.* Report to the European Commission's Directorate General Environment, Nuclear Safety and Civil Protection, Brussels. Pp. 1-44.

Chiofalo G. and Quero M. E. In press. "Interazione tra piccola pesca costiera e cetacei nell'Isola di Favigna (Arcipelago delle Is. Egadi). XXX SIBM, Vibo Valenzia, Italy.

Fig 1 Map of Sicily and ADEPTs sampling field marked.

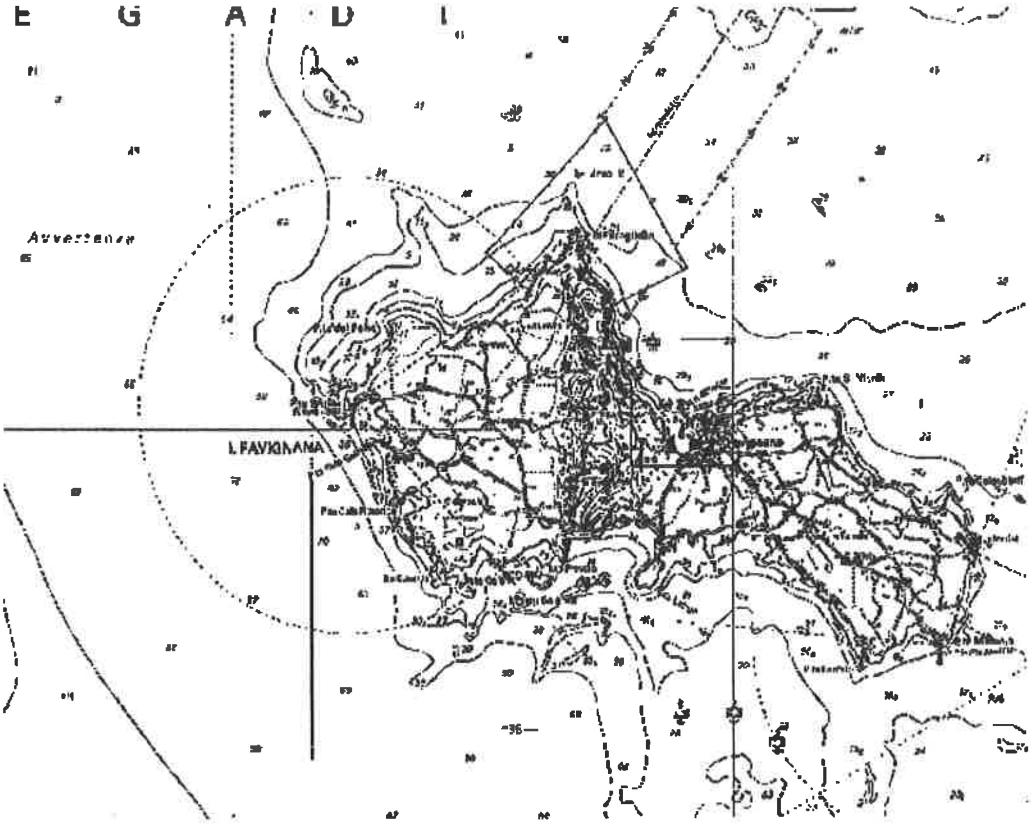


Fig 2 Map of the Island of Favignana (Egadi Islands, Trapani, Italy)

Fig 3 Map oh the harbour of Catania (Italy)

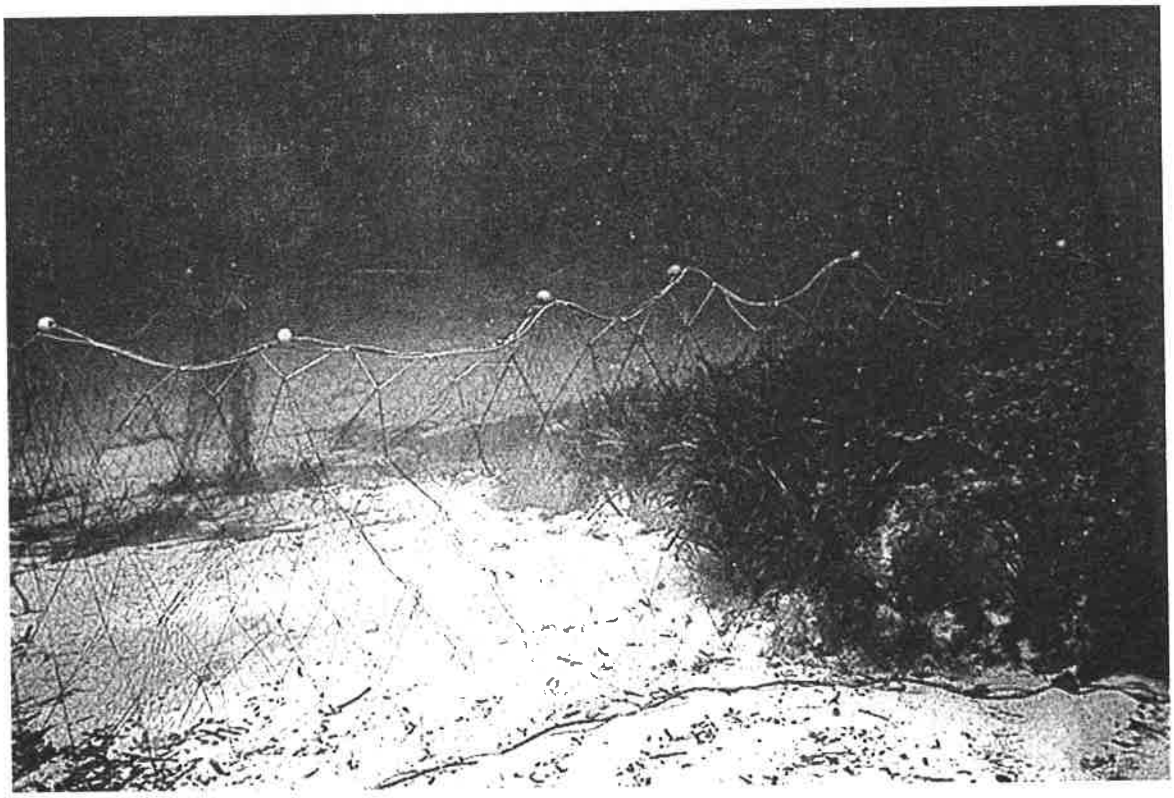


Photo 1 Fishing gear in Favignana (Trammel-Net)

Photo 2 Fishing gear in Catania ("Menaide" Gill-Net)

Photo 3 Favignana's fishery

Photo 4 Catania's fishery

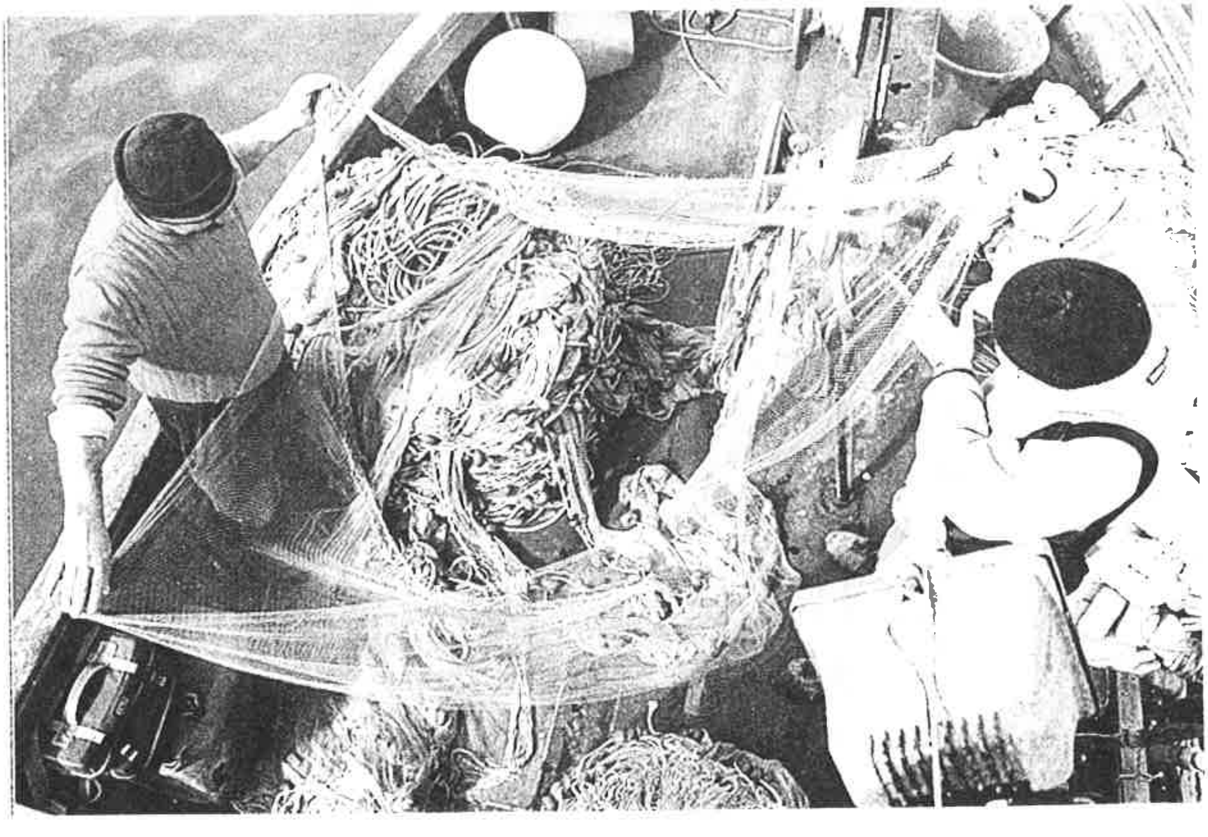
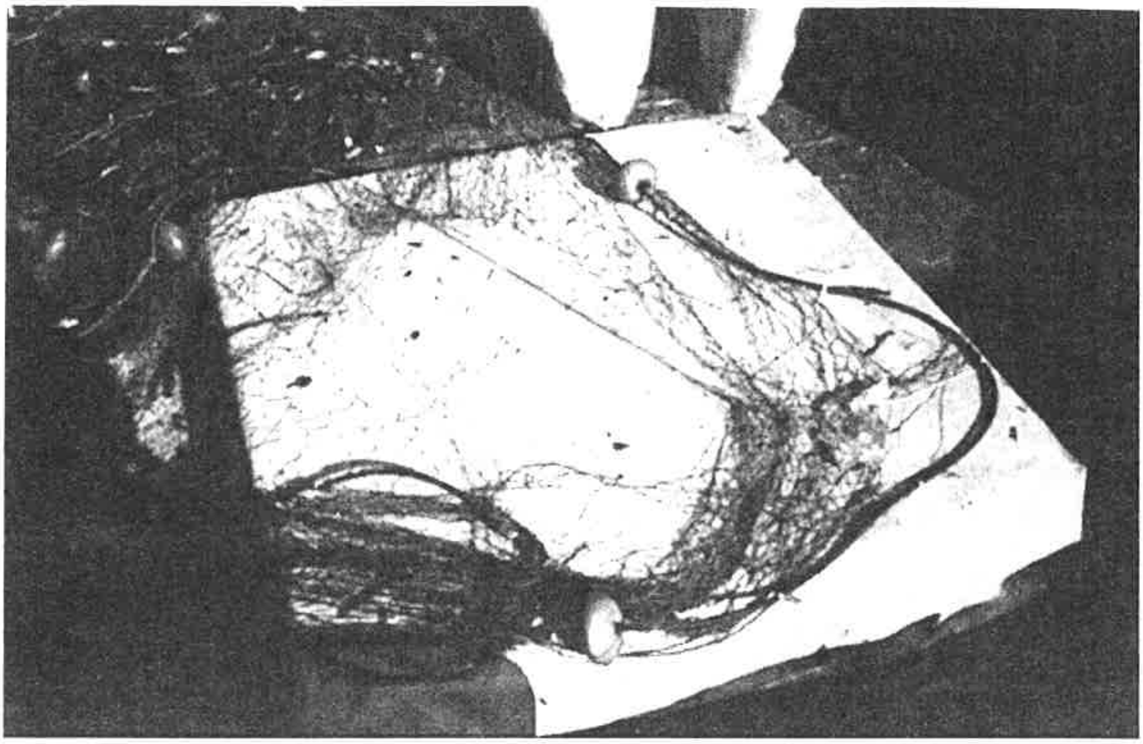


Photo 6 Catania's damages



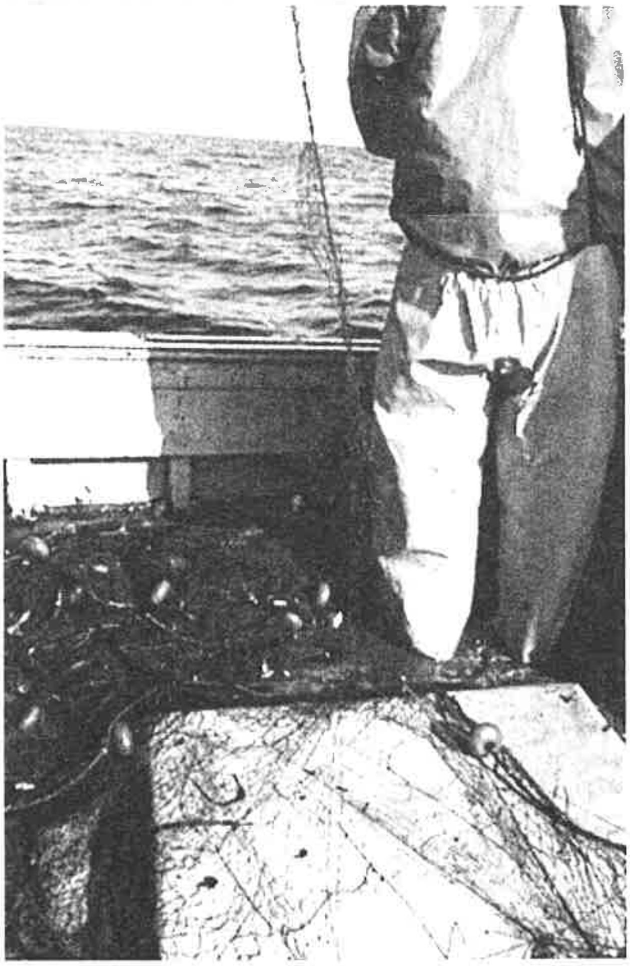


Photo 5 - Favignana's damages

LONG-TERM USE, DIFFERENTIAL RESIDENCE TIME AND SITE EXPLOITATION BY MINKE WHALES

U. Tscherter and E. M. N. Lynas

ORES Centre for Coastal Field Studies, Postfach 756, CH-4502 Solothurn, Switzerland
(E-mail: utscherter@enviroweb.org)

INTRODUCTION The 200 km^2 Laurentian Channel headwaters area of the St. Lawrence estuary (Figure 1) is a terminal point in the feeding migration of blue, finback, humpback, and minke whales. Its dominant bathymetric feature is a drowned U-shaped valley running in from the Gulf. Mean tidal range in the region is 4 m with currents of 3 m.s^{-1} at peak flow. Internal tides propagate seaward in waves of ~60 km length (El-Sabh, 1979). Ingram (1975) has recorded internal, interfacial waves up to 80 m high, and up to six oceanographic fronts (convergent flow) in each semi-diurnal tidal period in the confluence zone. At the human level, the area is bisected by transoceanic shipping lanes. It supports a modest crab fishery. It is a national marine park with growing recreational appeal, and since the mid-1980's has an extensive and well-developed whale watching industry. For a number of years we have studied the breathing and foraging ecologies of the area's four rorqual species. In 1999, we selected the minke whale as the object of further study: concentrating on area use and site exploitation, number and distribution in time and space. We are motivated to explore the short-term and long-term effects of shared habitat use between whales and humans.

METHODS Work in the study area was carried out (weather permitting) from mid-July until early October using two inflatable craft. On the basis of previous experience photo-tagging was not attempted during rain or in wind speeds greater than 15 knots. Each boat worked independently with subjects *ad libidum*. Either boat could call on the other for help in covering large aggregations of animals (>10). We used Nikon 90FX cameras with Nikon 300 mm automatic fixed focal lenses and Fuji 36 x 35 mm RM 100 - 1000 professional film set at 200 ASA, with shutter speeds between 1/500^{-s} - 1/1000^{-s}. Photo-tags were made as close to 90^0 as possible at 50 m or less and were matched using the senior author's dorsal-fin edge marks (DEM) system. We assumed that we had adequately covered an aggregation when individuals previously photo-tagged on both sides were encountered randomly a third or fourth time. Location, GPS position (taken on the dive puddle), and time were recorded for each subject tagged, together with: 1) a description of associated behaviour, 2) proximity to conspecifics, other species, marine vessels, and whale watching craft, and 3) prevailing weather, sea, and oceanographic conditions. Where possible, fifteen-minute sequences of blow data were recorded on identified subjects for use in log-survivorship analysis of foraging behaviour.

RESULTS During 52 on-water work days, we identified 195 individual minke whales. Comparison with historical records revealed that ~10% of these had used the area for up to 14 prior seasons consecutively, and of the total, 73% had been recorded in at least one other season since 1995, indicating major medium-term to long-term use and familiarity with the area. One photo-tagged individual had originally been recorded in 1978 and had not been recorded in any of the years in between. Mean days residence per whale was 2.1 (SD = 2.3; range = 1-17; n of identified daily sightings = 410). Of 70 individuals resident on more than one day, ~10% were recorded in the area on four or fewer consecutive days, and <0.1% were recorded on more than four consecutive days. One hundred and twenty five whales were recorded only once.

In general, the distribution of foraging animals followed the steep depth contours between 25 m - 100 m downstream on both sides of the Channel where interfacial wave induced convergent flow is most common (Figure 1). In the confluence area, small (3 - 5) to large (> 20) aggregations of minkes foraged near Solotons and along oceanographic fronts as they formed: dispersing as the frontal flows themselves dispersed. Banks and reefs in the confluence area, off downstream river mouths and over glacial moraine shelves, particularly, were alternate regularly-used foraging sites.

Intra-Specific Site Exploitation No direct evidence of inter-specific or intra-specific foraging competition was recorded. However, plotted foraging sites (defined by a GIS 1500 m diameter buffer zone surrounding the GPS position on the first dive puddle), suggest some degree of site selection and/or tenacity among a number of long-term area users (see Figures 2 - 4). We have stereotyped this and two other types of use below (Table 1) as spatially and/or temporal distinct, and involving long-term and/or short-term users. Among the latter category, we found no evidence that animals used different sites differently, based upon single versus multi-season residence.

Numbers of individuals identified daily ranged from one to 29, and increased across the season from July to October. Area use, as defined by the most frequent and most concentrated daily numbers (70% of individuals identified), was greatest from mid-August to early October. Highest daily numbers occurred for the most part on either side of spring tide peaks. All animals when recorded were foraging as opposed to travelling or resting. So, presumably, prey abundance was proportional to the number of animals in the area. Runge and Simard (1990) suggest that krill are delivered to the headwaters by the lunar tide from the open gulf. Numbers predicted (R^2) by tide height in each tidal cycle were not significant, except in one instance (values for p ranged from 0.477 to 0.020). These results support our general working hypothesis that activity, particularly surface foraging activity, is related to complex lunar and internal tidal amplitudes, and is not simply a linear function of tide heights, or time of day. Surface foraging off river mouths and reefs was more frequently observed in July and late September/October: feeding sites well clear of commercial vessels and large whale watching craft. Otherwise, it was most prevalent downstream along coastal interfacial *slicks* (convergent flows): sites more accessible to whale watching craft of all sizes. In the Saguenay confluence region, surface foraging activity along fronts correlated perfectly with entrapped zooplankton prey items (*Calanus* sp., *Meganyctiphanes norvegica* and *Thysanoessa raschi*) visible to the naked eye, together with predatory fish (*Mallotus villosus*), and was not recorded at all when prey items were not visible, although foraging activity was taking place at near-surface depths (Lynas, 1997). Energy expenditure, as a function of air intake (blow) rates, by whales foraging at the surface (84^{-h}, SE = 2.26, n = 35) was greater than those foraging at depth (70^{-h} and 69^{-h} SE = 2.6 and 3.26; n = 17 and 20).

DISCUSSION **Estimated Area Use and Prey Biomass Removed** In 52 net days of observation, we recorded 410 day-residences. Assuming daily distribution (type and quantity) was the same throughout a standard 120 day feeding season, then the estimated number of whales using the area for one day only per season is 288, and the estimated total number of whales (single and multiple day residents) using the channel headwaters during 1999 is 436 individuals. Making the same assumptions and converting to single users, conservatively the area could support 947 minke whales for one day's feeding per season, or almost eight individuals for a 120-day season each. We estimate the area prey biomass thus removed by minke whales alone at 229.4 tonnes, calculated at 4% of bodyweight^{-d} (Sergeant, 1963, Ohsumi, 1979) using a mass-length ratio of $0.0161\text{x}L^{2.854}$ (Ohsumi, 1979). Average daily consumption derived from Sergeant's data is 0.24 tonnes (SD = 0.04, n of animals = 25) per individual. It remains to be discovered how productive the area is relative to contagious segments of the total feeding grounds utilised by St. Lawrence minke whales.

People and Whales The high rate of single day visits found during our study suggest that negative aspects of commercial shipping, recreational boating, and whale watching activities will have a minimal effect on the animals using the area. The same would apply to POP point sources or heavy concentrations of human and industrial waste discharge. However, if similar perturbations apply in contiguous habitats throughout the population's feeding range, then the effect(s) would be inescapable for the majority of individuals. Regulators should seek to determine the number of such habitats throughout the population's feeding range.

Pulse-like increases and decreases across the season suggest that high residence numbers are a function of prey density. Regardless of the removal mechanism (intra-specific, inter-specific, or human competition) when prey density declines, the number of residents declines (SL profiles) as whales move elsewhere. Again, the high degree of individual mobility found in this study between contiguous habitats also has implications for abundance estimates based on sighting probability models. Clearly where animals are likely to be as spatially and temporally mobile as the vessels conducting the survey, considerable care is needed to avoid double counting individuals.

No doubt the headwaters area is a critical habitat for minke whales, given that members of the species are never absent from the area daily during the feeding season (personal observation since 1978). Nevertheless, it seems that few individuals, depend on it in anything like a major way. The heaviest daily exploitation recorded (17 days residence time), extrapolated to a 120-day season, is only 48 days (or ~ 1/3) of an individual's annual food requirement, and a total of 125 individuals neither stayed nor returned to the area following a single visit. Given these data, a major question is what factors contribute to, and distinguish, casual versus prolonged use within a season and between seasons, and in what way does this differ from other contiguous areas of the Canadian East Coast stock's feeding home range?

REFERENCES

El-Sabh, M. I. 1979. The lower St. Lawrence estuary as a physical oceanographic system. *Naturaliste can. (Rev. Ecol. Syst.)*, 106: 55-73.

Ingram, R. G. 1985. Frontal characteristics at the head of the Laurentian Channel. *Naturaliste can. (Rev. Ecol. Syst.)*, 112: 31-38.

Lynas, E. M. N. 1997. Log survivorship analysis of temporal ventilating units and dive depth in three species of rorqual whales. In: *FR22-96. Field Report to the Ministry of Fisheries and Oceans (Quebec): Whale research activities in the St. Lawrence Estuary 1996* (Eds. E. M. N. Lynas *et al.*,). Pp. 23-30.

Ohsumi, S. 1979. Feeding habits of the minke whale in the Antarctic. *Rep. int Whal. Commn.* 29: 473-476.

Sergeant, D. E. (1963). Minke whales, *Balaenoptera acutorostrata* Lacepede, of the Western North Atlantic. *J. Fish. Res. Board Can.*, 20(6), 1489 - 1504.

Runge, J. A., and Simard, Y. 1990. Zooplankton of the St. Lawrence estuary: The imprint of physical process on its composition and distribution. In: *Oceanography of a large-scale estuarine system--the St. Lawrence*. (Eds. M. I. El-Sabh, and N. Silverberg). Springer-Verlag, New York. *Coastal and Estuarine Studies*, 39: 298-320.

TABLE 1: Stereotypical Intra-Specific Site Exploitation

Pair Type	Term of Use		Spatial Dimension		Temporal Dimension	
	Short	Long	Overlap	Distinct	Overlap	Distinct
Complementary 1	-	X	X	-	-	X
Complementary 2	X	X	X	-	X	-
Contrasting	-	X	-	X	X	-

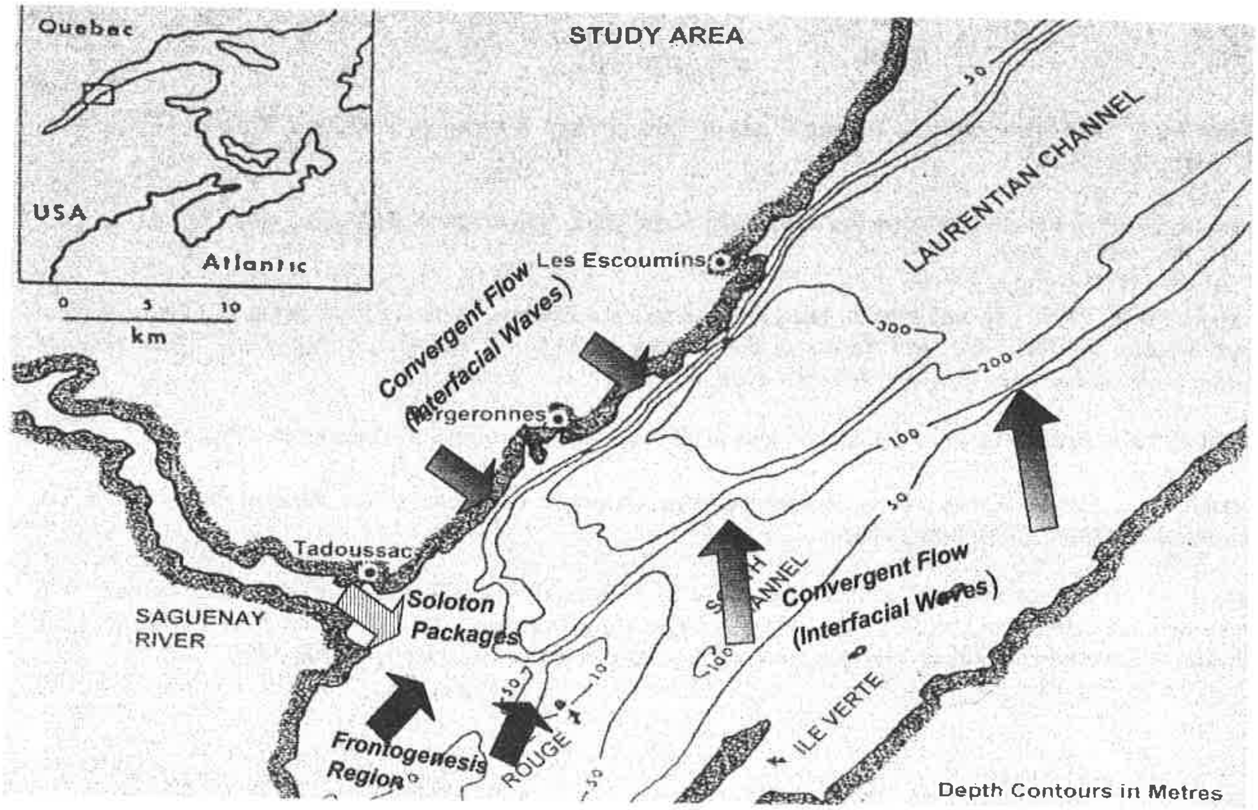
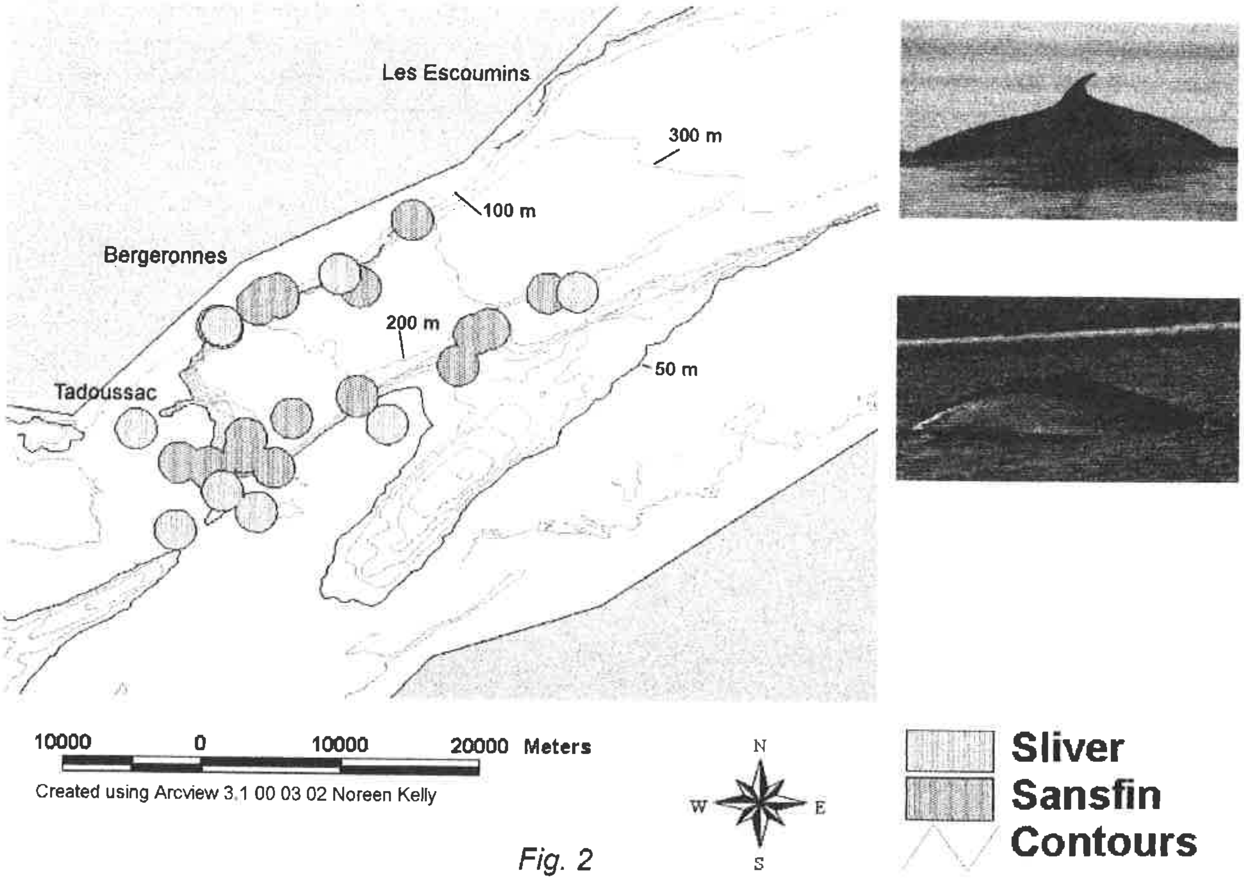


Fig. 1

Site Exploitation (Complementary Long-Term Use)



Created using Arcview 3.1 00 03 02 Noreen Kelly

Fig. 2

Site Exploitation (Contrasting Long-Term Use)

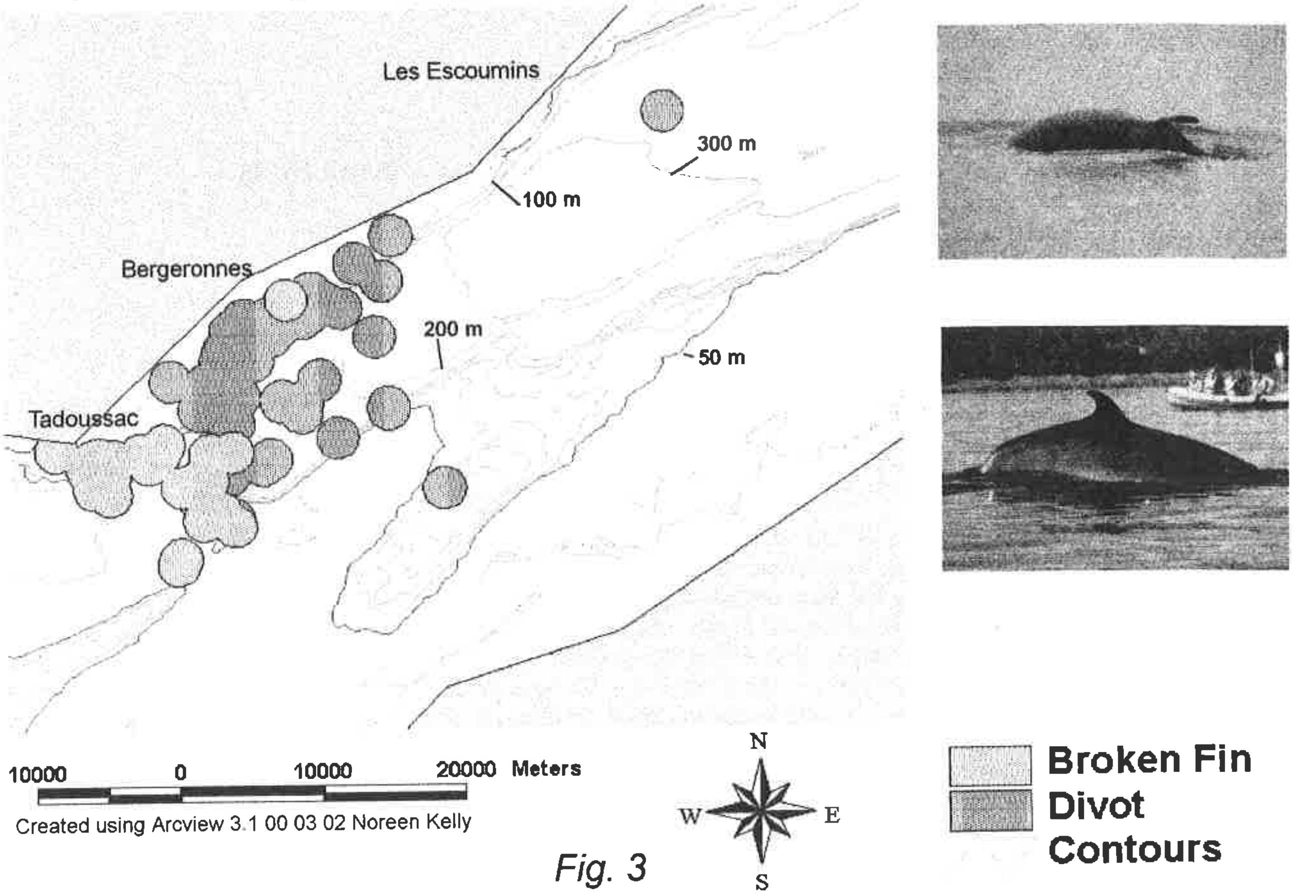


Fig. 3

Site Exploitation (Complementary Short & Long-Term Use)

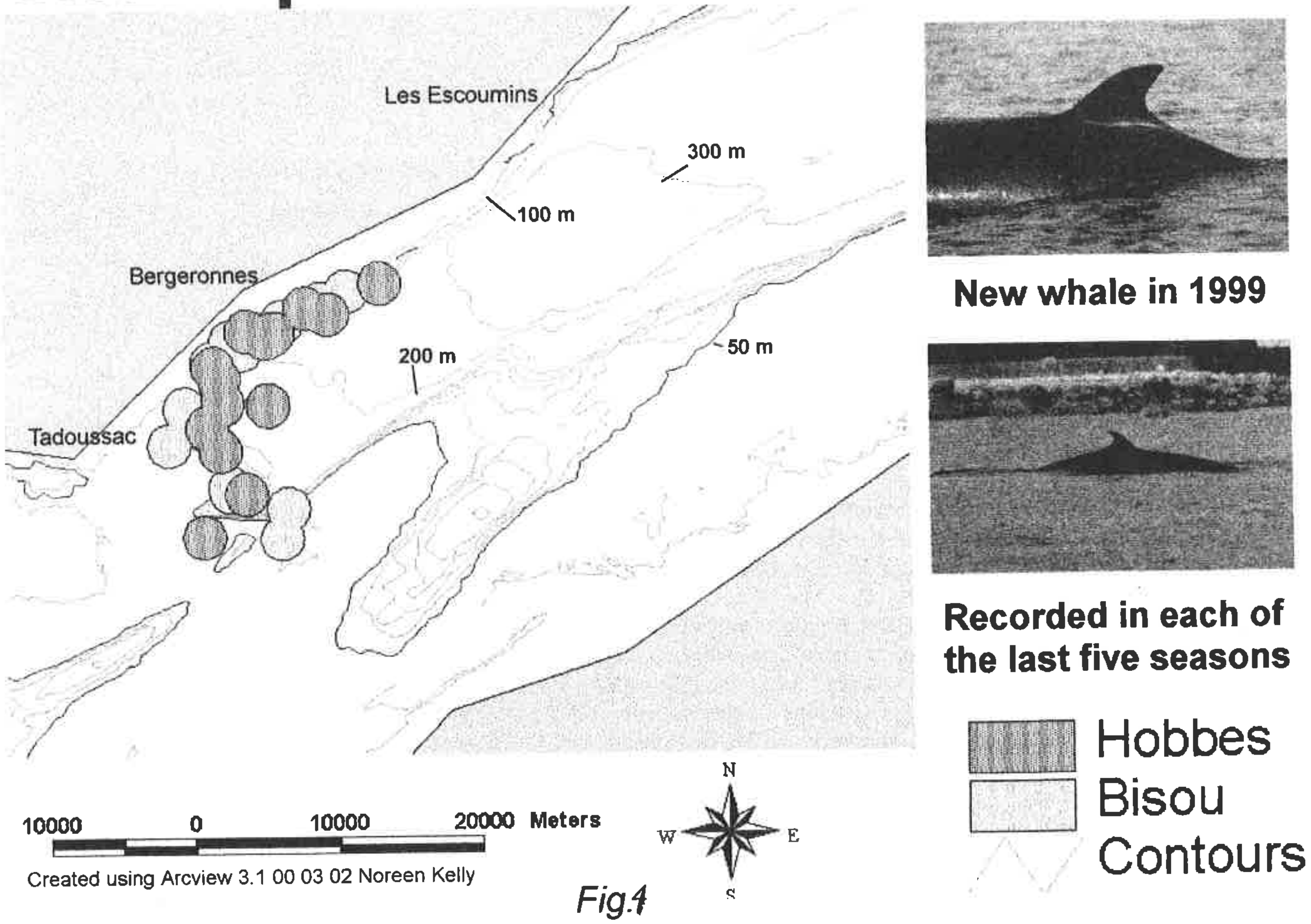


Fig.4

COMPARATIVE DISTRIBUTION AND HABITAT USE BY SEALS AND DOLPHINS IN A COASTAL ECOSYSTEM

P. M. Thompson[1], K. Grellier[1], G. D. Hastie[1], B. Wilson[2] and P. S. Hammond[2]

[1]*Lighthouse Field Station, Department of Zoology, University of Aberdeen, Cromarty, Ross-shire, IV11 8YJ, UK*
[2]*NERC Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews,*
St Andrews, Fife, KY16 8LB, UK

Many coastal areas contain populations of both seals and dolphins, but the factors affecting their habitat use are generally considered in isolation. Here, we compare the distribution of resident populations of harbour seals and bottlenose dolphins in the Moray Firth, NE Scotland, and explore similarities and differences in the habitat use of these two species under identical environmental conditions. Radio-tracking and TDR studies of seals have shown that individuals regularly use favoured foraging areas within 75km of haul-out sites, and that their choice of foraging habitat is constrained by the need to come ashore. The distance at which seals forage from haul-out sites is related to body size and reproductive status. Thus, foraging areas at different distances from the coast may support groups of animals that differ in age-structure. Boat based photo-ID studies have shown that groups of dolphins are also found in several predictable areas. However, these are not areas typically used by seals, and the areas favoured by the two species differ in their habitat characteristics and likely prey populations. The differential use of habitats by these two species is discussed in relation to differences in their reproductive biology, social structure and foraging behaviour. For both species, seasonal and inter-annual changes in distribution have also been observed, highlighting the dangers of using short-term studies to identify habitat requirements and protected areas for these species.

PRELIMINARY INSIGHTS INTO THE ONTOGENY OF HABITAT USE IN YOUNG GREY SEALS, *HALICHOERUS GRYPUS*

C. Vincent[1], B. MacConnell, M. A. Fedak[2] and V. Ridoux[3]

[1]*Laboratoire d'Etudes des Mammifères Marins, Océanopolis, 29 275 Brest, France*

[2]*Sea Mammal Research Unit, Gatty Marine Laboratory, Univ. of St Andrews,*
St Andrews, Fife, KY16 8LB, UK

[3]*Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, 17 026 La Rochelle, France*

Most studies of the movements and habitat use in phocid seals have concentrated on adults. However, the distribution of the young holds also particular interest. Most phocids have a brief nursing period, which ends at weaning when the mother abandons her pup on shore with other naïve animals. How do the young seals develop the foraging patterns of adults? We examined behaviour and movement patterns of ten young grey seals, *Halichoerus grypus*, at three temporal and spatial scales: individual dives (minutes and 100's of metres), intermediate (days and 10's of km), and larger scale movements (months and 100's of km) using Satellite Relay Data Loggers that monitored movements, activities and dives. These seals could be classified into three categories of age. Four were found live stranded at 0.5 to 2 months of age, rescued and set free on the coasts of Brittany, France, at 7 months old with no experience at sea (group 1). The other six were caught at haulout sites in Brittany, fitted with the transmitters and released immediately. Of these, three were estimated to be 1-3 years old (group 2) and the others 4-5 years old (group 3). All showed tracks of distinct distance and duration, using diverse haul-out and foraging areas throughout the Channel and the Celtic sea. Adult-like dive patterns tended to get established within the first weeks at sea. Repeated movement patterns operating at intermediate scales (alternate feeding bouts and resting periods) remained unclear in group 1 but were more visible in groups 2 and 3. Large-scale routines, implying the repeated use of sites located several hundreds of km apart, only appeared in individuals of group 3.

ASSOCIATION OF THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) WITH THE WESTERN IRISH SEA FRONT

Caroline R. Weir[1] and Susan H. O'Brien[2]

[1]*Seabirds and Cetaceans, Joint Nature Conservation Committee, Dunnet House, 7 Thistle Place,*
Aberdeen, AB10 1UZ (E-mail: weir_c@jncc.gov.uk)
[2]*Present address: Institute of Zoology, Zoological Society of London, Regent's Park, London, NW1 4RY*

INTRODUCTION On the European continental shelf, seasonal warming of the sea surface in areas of deep water results in stratification of the water column into an upper warm layer and a cooler lower layer. The western Irish Sea front develops as a seasonal oceanographic feature at the interface between thermally stratified water in the deep western Irish Sea and mixed water in the shallow eastern Irish Sea (Simpson & Hunter, 1974). The position of the front extends between the southern end of the Isle of Man and Dublin, Republic of Ireland (Fig. 1), but shifts daily over several kilometres through tidal advection and strong winds.

At the interface of the front, nutrient-rich mixed water combines with warmer, nutrient-impoverished stratified water to result in an enhanced level of primary production, and concentrations of zooplankton, euphausiids, fish eggs and larvae including sprat (*Sprattus sprattus*) and Atlantic herring (*Clupea harengus*). Concentrations of seabirds occur in the area (Begg & Reid, 1997), and an association of cetacean species with frontal systems in the Irish Sea has been suggested for common dolphins (*Delphinus delphis*) at the Celtic Sea front (Goold, 1998), and harbour porpoises (*Phocoena phocoena*) at the Irish Sea and Celtic Sea fronts (Jones, 1984). We report here on the distribution of the harbour porpoise relative to physical water properties in the Irish Sea, during August 1998.

METHODOLOGY Between 1st and 10th August 1998, a dedicated survey to collect oceanographic, seabird and cetacean distribution data was carried out from the M.V. *Loyal Mediator* in the central Irish Sea. The cruise track covered an area between latitudes 53°10'N and 54°15'N, and longitudes 4°20'W and 6°20'W (Fig. 2). An intensive study of the temporal and spatial movements of the front was made on 10th August by running five repeat transects across the front between approximately 53°24'N 5°16'W and 53°34'N 5°36'W. Standard techniques for counting seabirds were used (Webb & Durinck, 1992), and information on cetaceans was collected throughout the survey. An undulating CTD (Conductivity Temperature Density) aquashuttle (*Chelsea Instruments*) was towed behind the vessel to collect data on sea temperature, salinity and chlorophyll concentration (a measure of primary productivity) between the sea surface and approximately 50 m depth. The vessel's position, course and speed were continuously recorded from the Global Positioning System (GPS), and environmental variables such as sea state, wind speed and visibility were recorded every 90 minutes or when a notable change in conditions occurred.

DATA ANALYSIS Cetacean data collected during the survey are presented as an index of relative abundance. Since the detection rate of porpoises is reduced as sea state increases (Palka, 1995), data collected in a sea state greater than 3 have been excluded from the analysis. Maps were produced using Dmap for Windows (Morton, 1995). Oceanographic data collected with the CTD aquashuttle were analysed using a stratification index (SI) (B. Scott, *pers. comm.*) which compares values of salinity, sea temperature, and density in the upper ten metres of water with those from depths below 45 metres. Isopycnic water has SI values approaching 0, stratified water has a lower surface density giving SI values greater than 0.5, whilst intermediate values indicate the location of the front.

RESULTS A total of 1,280 km (384 km^2) survey coverage was achieved during eight days of survey (Fig. 3). The position of the Irish Sea front was easily identified using data collected by the aquashuttle. Mixed water was characterised by low chlorophyll concentrations and uniform temperatures and stratified water by an obvious thermocline, and concentrated chlorophyll. The surface expression and upwelling of the thermocline was apparent by steep horizontal temperature gradients (Fig. 4). Salinity remained relatively unchanged across the front. The southern part of the front shifted considerably over several kilometres during the survey period.

During the survey, a total of 69 sightings were made of 164 harbour porpoises. The highest abundance of porpoises was recorded in the region of the Irish Sea front, with the greatest concentrations observed in the immediate area of the front (Fig. 5). There were only two individuals in stratified water in the north-west region of the study area. A total of 57 sightings (147 individuals) occurred during dedicated crossings of the southern region of the front on 10th August. During the 12 sightings throughout the rest of the Irish Sea, porpoise group size had ranged from one to three individuals, and no juveniles had been recorded. In the region of the front on 10th August, group size ranged from one to six animals, and calves were recorded in 50% of the aged groups (Fig. 6).

On 10th August, five consecutive transects were run across the Irish Sea front. No porpoises were sighted during the first transect. A total of 13 animals recorded during the second and third transects were on the mixed side of the front. The majority of porpoises were recorded during the fourth and fifth consecutive transects (n=114). A further twenty individuals were sighted in the south-west area of the frontal region, while steaming towards Dublin after the transects. Of the 114 individuals recorded on the final two transects, 81.4% of these animals were in mixed water or in the region of upwelling, with SI values of less than 0.3. The distribution of harbour porpoises in relation to the front was similar in each transect, and that from the fifth transect is shown in Fig. 7. Porpoises are situated predominantly over mixed water with a homogeneous temperature and chlorophyll concentration. Harbour porpoise sightings were strongly linearly related to stratification index values ($R^2 = 0.505$, $P < 0.0001$) (Fig. 8). Porpoises therefore appeared to be preferentially using the mixed side of the front.

DISCUSSION The harbour porpoise was shown during the present survey to occur more frequently in the vicinity of the southern Irish Sea front than in other areas of the central Irish Sea. In particular, porpoises favoured the mixed side of the front rather than stratified water. The distribution of greatest porpoise abundance corresponds with previous findings of the distribution in the peak abundance of species of zooplankton (White, 1988), which are consistent with a southward density-driven flow of water along the western side of the Irish Sea. This current of increased productivity, in addition to the Irish Sea front, may explain the distribution of porpoises shown in this study. Harbour porpoises are small, metabolically active animals, and require a daily intake of about 13% of their body weight in food (Evans, 1987). The aggregation of harbour porpoises in the region of the Irish Sea front may therefore be the result of enhanced productivity and availability of food resources within a relatively small, spatial area, making the region an energetically efficient place to forage.

ACKNOWLEDGEMENTS Although space restricts individual acknowledgements, many thanks are due to all sponsers of the JNCC Seabirds at Sea Phase 5 programme of work. Nigel Harding assisted with computer programs. Ciarán Cronin, Peter Evans, Jim Reid, Rob Robinson, Beth Scott, Mark Tasker, and Andy Webb provided comments on earlier drafts. Many thanks to Rowena White for providing help with this paper during and since the Conference. Thanks to Steve Newton, Claire Pollock, Sam Taylor and Andy Webb for collecting data during the survey. Also, thanks are given to the captain and crew on board M.V. *Loyal Mediator*.

REFERENCES

Begg, G. S. and Reid, J. B. 1997. Spatial variation in seabird density at a shallow sea tidal mixing front in the Irish Sea. *ICES Journal of Marine Science*, 54: 552-565.

Evans, P. G. H. 1987. *The natural history of whales and dolphins*. Christopher Helm, London, 343 pp.

Goold, J. C. 1998. Acoustic assessment of populations of common dolphin off the west Wales coast, with perspectives from satellite infrared imagery. *Journal of the Marine Biological Association of the United Kingdom*, 78: 1353-1364.

Jones, P. H. 1984. Cetaceans seen in the Irish Sea and approaches, late summer 1983. *Nature in Wales*, 3: 62-64.

Morton, A. 1995. *Dmap for windows. A computer program for distribution and coincidence mapping*. Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire SL4 4QR, U.K.

Palka, D. 1995. Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. Paper SC/47/SM26, presented to IWC Scientific Committee, May 1995.

Simpson, J. H. and Hunter, J. R. 1974. Fronts in the Irish Sea. *Nature*, 250: 404-406.

Webb, A. and Durinck, J. 1992. Counting birds from ship. Pp. 24-37. In: *Manual for aeroplane and ship surveys of waterfowl and seabirds* (Eds. J. Komdeur, J. Bertelsen, and G. Cracknell). IWRB Special Publication No. 19, Slimbridge. 37pp.

White, R. G. 1988. *Studies on holoplankton and mesoplankton in relation to fronts*. PhD Thesis, University College of North Wales, Bangor.

On 10th August, five consecutive transects were run across the Irish Sea front. No porpoises were sighted during the first transect. A total of 13 animals recorded during the second and third transects were on the mixed side of the front. The majority of porpoises were recorded during the fourth and fifth consecutive transects (n=114). A further twenty individuals were sighted in the south-west area of the frontal region, while steaming towards Dublin after the transects. Of the 114 individuals recorded on the final two transects, 81.4% of these animals were in mixed water or in the region of upwelling, with SI values of less than 0.3. The distribution of harbour porpoises in relation to the front was similar in each transect, and that from the fifth transect is shown in Fig. 7. Porpoises are situated predominantly over mixed water with a homogeneous temperature and chlorophyll concentration. Harbour porpoise sightings were strongly linearly related to stratification index values ($R^2 = 0.505$, $P < 0.0001$) (Fig. 8). Porpoises therefore appeared to be preferentially using the mixed side of the front.

DISCUSSION The harbour porpoise was shown during the present survey to occur more frequently in the vicinity of the southern Irish Sea front than in other areas of the central Irish Sea. In particular, porpoises favoured the mixed side of the front rather than stratified water. The distribution of greatest porpoise abundance corresponds with previous findings of the distribution in the peak abundance of species of zooplankton (White, 1988), which are consistent with a southward density-driven flow of water along the western side of the Irish Sea. This current of increased productivity, in addition to the Irish Sea front, may explain the distribution of porpoises shown in this study. Harbour porpoises are small, metabolically active animals, and require a daily intake of about 13% of their body weight in food (Evans, 1987). The aggregation of harbour porpoises in the region of the Irish Sea front may therefore be the result of enhanced productivity and availability of food resources within a relatively small, spatial area, making the region an energetically efficient place to forage.

ACKNOWLEDGEMENTS Although space restricts individual acknowledgements, many thanks are due to all sponsers of the JNCC Seabirds at Sea Phase 5 programme of work. Nigel Harding assisted with computer programs. Ciarán Cronin, Peter Evans, Jim Reid, Rob Robinson, Beth Scott, Mark Tasker, and Andy Webb provided comments on earlier drafts. Many thanks to Rowena White for providing help with this paper during and since the Conference. Thanks to Steve Newton, Claire Pollock, Sam Taylor and Andy Webb for collecting data during the survey. Also, thanks are given to the captain and crew on board M.V. *Loyal Mediator*.

REFERENCES

Begg, G. S. and Reid, J. B. 1997. Spatial variation in seabird density at a shallow sea tidal mixing front in the Irish Sea. *ICES Journal of Marine Science*, 54: 552-565.

Evans, P. G. H. 1987. *The natural history of whales and dolphins*. Christopher Helm, London, 343 pp.

Goold, J. C. 1998. Acoustic assessment of populations of common dolphin off the west Wales coast, with perspectives from satellite infrared imagery. *Journal of the Marine Biological Association of the United Kingdom*, 78: 1353-1364.

Jones, P. H. 1984. Cetaceans seen in the Irish Sea and approaches, late summer 1983. *Nature in Wales*, 3: 62-64.

Morton, A. 1995. *Dmap for windows. A computer program for distribution and coincidence mapping*. Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire SL4 4QR, U.K.

Palka, D. 1995. Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. Paper SC/47/SM26, presented to IWC Scientific Committee, May 1995.

Simpson, J. H. and Hunter, J. R. 1974. Fronts in the Irish Sea. *Nature*, 250: 404-406.

Webb, A. and Durinck, J. 1992. Counting birds from ship. Pp. 24-37. In: *Manual for aeroplane and ship surveys of waterfowl and seabirds* (Eds. J. Komdeur, J. Bertelsen, and G. Cracknell). IWRB Special Publication No. 19, Slimbridge. 37pp.

White, R. G. 1988. *Studies on holoplankton and mesoplankton in relation to fronts*. PhD Thesis, University College of North Wales, Bangor.

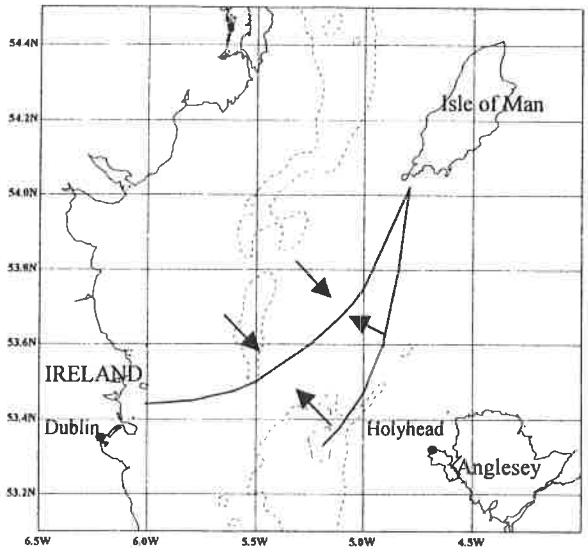


Fig. 1. The survey area showing place names and approximate location of the Irish Sea front
Bathymetry: dot (100m isobath); dotdash (200m isobath)

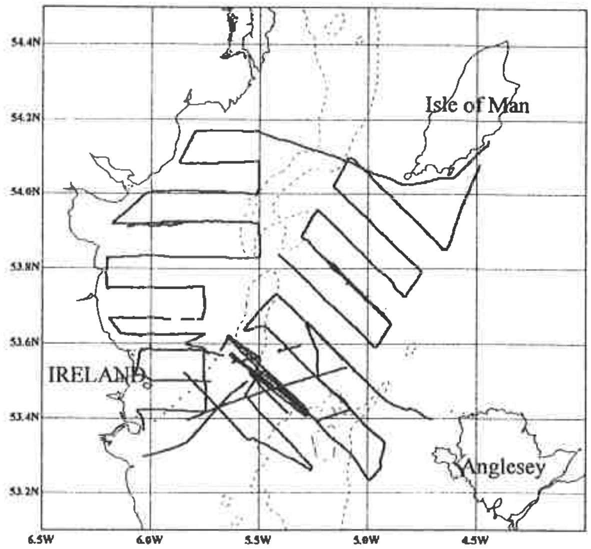
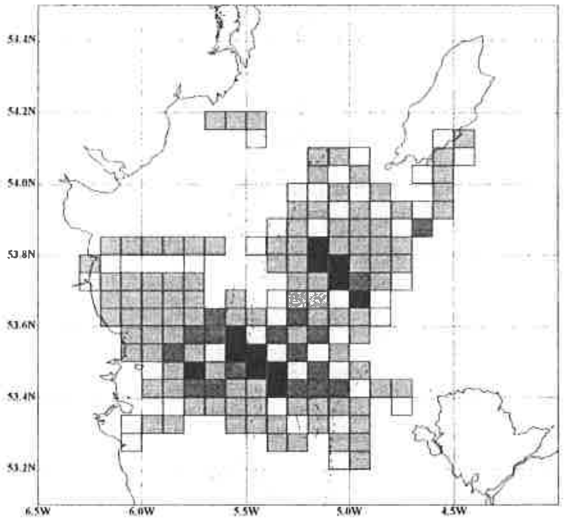


Fig. 2. The cruise track taken during the Irish Sea survey, 1-10 August 1998
Bathymetry: dot (100m isobath); dotdash (200m isobath)



Effort (kms travelled):

☐ 0.01-2.99 ▨ 3.00-9.99 ■ 10.00-19.99 ■ 20.00+

Fig. 3. Distribution of survey effort (less than sea state 3) over the survey area
Bathymetry: dot (100m isobath); dotdash (200m isobath)

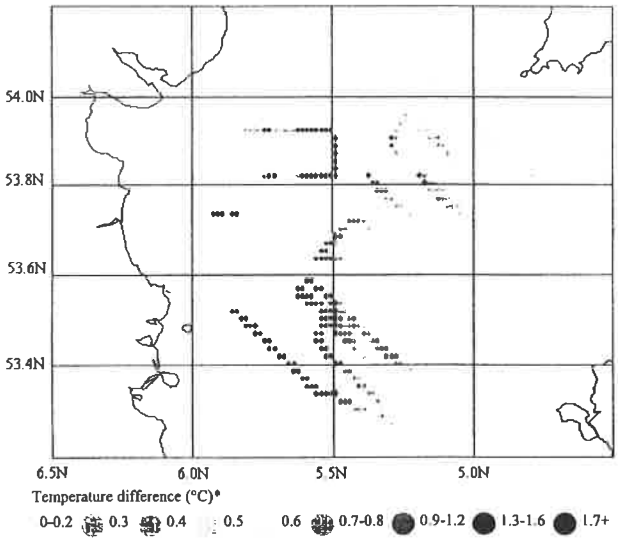


Fig. 4. Distribution of water temperature during survey on 5 August 1998

- Temperature difference represents the difference in average temperature (°C) between the top 10 m of water and that below 30 m depth

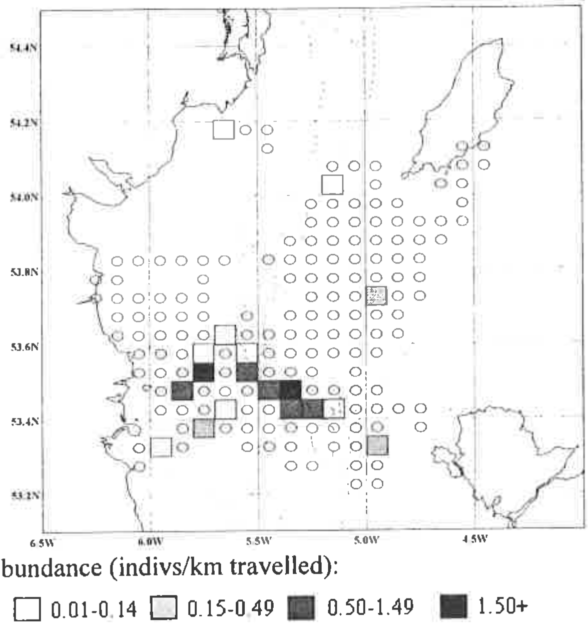


Fig. 5. Abundance of harbour porpoises over the survey area.
Bathymetry: dot (100m isobath); dotdash (200m isobath)

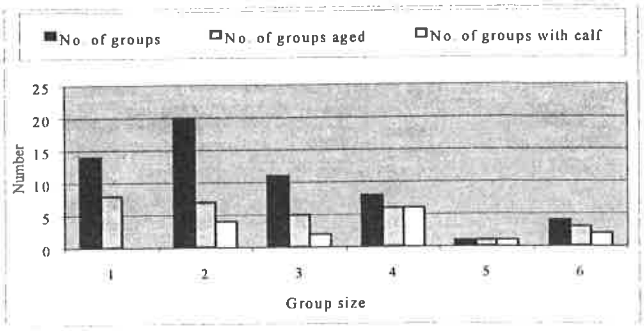


Fig. 6. Group size and composition in the region of the Irish Sea front on 10 August 1998

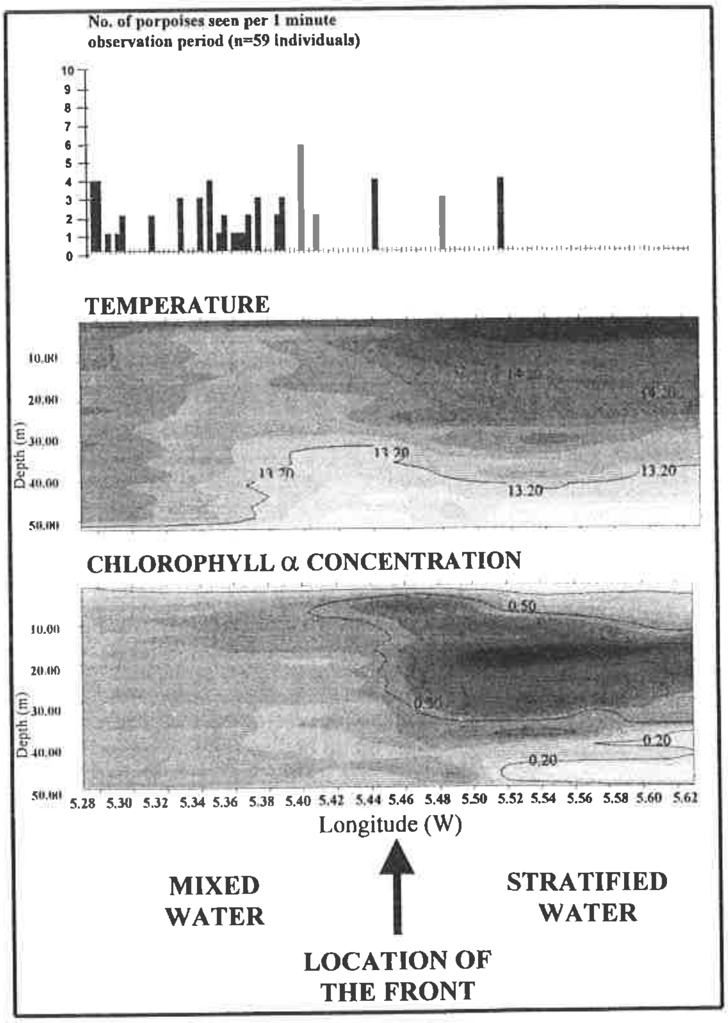


Fig. 7. The number of harbour porpoises recorded over temperature and chlorophyll α profiles, during transect five across the Irish Sea front, August 1998

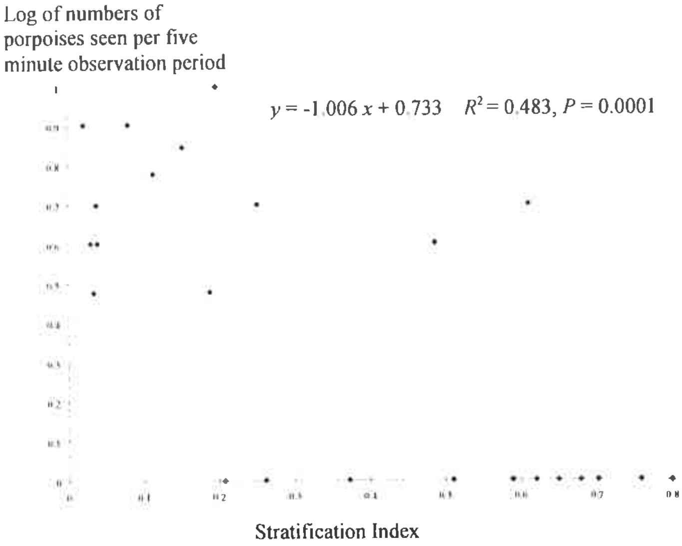


Fig. 8. Regression of number of porpoises recorded against stratification index for transect five

WATCHING PUFFING PIGS FROM SPACE: DEFINING CRITICAL HABITAT USING SATELLITE TELEMETRY

A. J. Westgate, A. J. Read, and T. C. Cox

Duke University Marine Lab, 135 Duke Marine Lab Road, Beaufort, NC 28516, USA

Understanding patterns of habitat use is important for the design of conservation strategies for marine mammals. Using traditional survey data to define critical habitat is problematic because these surveys are restricted both temporally and spatially, and provide only a "snap-shot" of a species' distribution and habitat utilisation patterns. Instead, collection of data from satellite telemetry devices can provide detailed information on three-dimensional habitat utilisation patterns of individual marine mammals. Here we illustrate the utility of using satellite telemetry data to define critical habitat, using the harbour porpoise (*Phocoena phocoena*) as an example.

We tracked the movements of porpoises using two types of satellite telemetry. The first type consisted of simple location-only transmitters which provided daily positions of tagged individuals. The second type consisted of satellite dive recorders which provided data on positions of individuals as well as information on the depth and duration of dives. We attached 18 transmitters to porpoises between August 1995 and September 1999 as they were released from herring weirs in the Bay of Fundy, Canada.

We collected a total of 1,747 tracking days, including 230 days of diving data, from 6 female and 12 male harbour porpoises (four tags were still transmitting as of 21st Nov 1999). Periods of data collection ranged from 26 to 212 days with a mean length of 97.1 ± 47.7 days. Using a Geographic Information System (Arcview, ESRI), we overlaid these positions with data on sea surface temperature and bathymetry. Collection of detailed information on the movements of individual porpoises and integration of these data with quantitative descriptions of habitat has allowed us to understand what physical and biological features shape patterns of habitat use in this species.

ACOUSTICS

VOCALISATIONS OF THE MARINE TUCUXI (*SOTALIA FLUVIATILIS*, GERVAIS, 1853) AND ITS RELATIONSHIP TO BEHAVIOUR

F. Azevedo[1] and S. M. Simão[2]

[1]*Projeto MAQUA – Depto. Oceanografia/Universidade do Estado do Rio de Janeiro. R. São Francisco Xavier, 524/4002E – Maracanã, Rio de Janeiro, RJ, Brazil. Cep:20550-013 (E-mail: maqua@uerj.br)*

[2]*Laboratório de Bioacústica de Cetáceos - DCA/IF Universidade Federal Rural do Rio de Janeiro, Seropédica, RJ Brazil 23851-970*

The bioacoustic aspects of tucuxi, *Sotalia fluviatilis*, have been poorly studied. This study was conducted (11h 30 min) during March 1998 until May 1999, at Guanabara Bay, Rio de Janeiro, Brazil. The bioacoustic system used was flat from 20 Hz to 20 kHz. The behaviour of tucuxi was observed simultaneously. The size of groups ranged between 4 to 50 involving adults, young and calves. 2,154 pulsed sounds and 5,925 whistles were recorded. From the latter, 611 were used only in a semi-quantitative analysis. The whistles were divided into 219 types and their duration lasted between 4 to 852 ms (mean=103.2; SD=81.1), their start frequency ranged from 900 Hz to 18.3 Hz (mean=7.9; SD=2.9), and their end frequency from 400 Hz to 19.1 kHz (mean=13.0; SD=4.5). It was also observed that some whistles contained 11 harmonics and seven inflexion points. The whistles with inflexions between 0 and 1 corresponded to 78.8% of those recorded . The highest ratio/min of whistles was detected during feeding (28.9%), and the smallest during travel (2.9). The foraging and feeding behaviours coincided with 75.2% of the emissions (pulsed sounds and whistles). The frequency variables were the ones with lowest standard deviations, while the duration and inflexions had the highest. The acoustical complexity in terms of the number of inflexions, and the more pronounced presence of vocalisations (pulsed sounds and whistles) during feeding could both be associated with complex co-ordination among individuals of the groups. The analysed vocalisations indicated that *S. fluviatilis* has a varied whistle repertoire, as has been observed in other odontocete species. The variations in whistle acoustic parameters, mainly duration and inflection points, as well as the presence of pulses, could be related to specific activities.

INTERSPECIFIC COMPARISON OF DOLPHIN WHISTLES USING MULTIVARIATE DISCRIMINANT ANALYSIS

O. Boisseau[1], J. Gordon[1,2], O. Chappell[1] and D. Gillespie[1]

[1]*International Fund for Animal Welfare, 1A Howard Street, Oxford OX4 3AY*
[2]*Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS*

The recent development of a real-time whistle detection programme has facilitated the collection and analysis of large numbers of tonal sounds from cetaceans. Linear discriminant analysis was used to classify the whistles produced by eight species of dolphin commonly encountered in the North Atlantic. Out of a total of 34,054 whistles, 55% were assigned to the correct species using this analysis technique. Correct classification of 12.5% whistles would be expected by chance alone. The killer whale and both pilot whale species were readily distinguished from the other delphinid species studied. Whilst previous interspecific comparisons of whistles have relied on labour-intensive manual measurements of parameters, large numbers of whistles may be processed using the whistle detection programme. It is thought that algorithms developed through studies such as this may be incorporated into the software to provide real-time identification of species based on acoustic cues alone. This technique may even be used to identify the behavioural state of the animals.

THE DEVELOPMENT OF A BIVOCAL SIGNATURE WHISTLE IN A BOTTLENOSE DOLPHIN CALF

Elke Bojanowski[1], Frank Veit[2] and Dietmar Todt[1]

[1]*Institut für Verhaltensbiologie, FU-Berlin, Haderslebener Str. 9, 12163 Berlin, Germany*
(E-mail: ebojanow@zedat.fu-berlin.de)
[2]*International Laboratory for Dolphin Behaviour Research, Dolphin Reef Eilat, Israel*

INTRODUCTION Bottlenose dolphins (*Tursiops truncatus*) are well known for their outstanding acoustic capabilities, especially concerning sound production. The majority of their vocalisations can be broadly assigned to two sound categories: narrow-band whistles, and short broad-band pulsed sounds, the latter containing echolocation clicks as well as communicative signals. Vocalisations of both sound categories are used in various social contexts (for a review, see Herman and Tavolga, 1980; Herzing, 1996), and can be combined and imitated spontaneously (*e.g.* Tyack, 1986; Reiss and McCowan, 1993).

Most intensely studied was the so-called signature whistle, an individually specific whistle most dolphin calves develop within their first year of life. Once formed, it remains stable over long periods of time and its frequency contour shows a high degree of stereotypy. Functions assigned to the signature whistle include *e.g.* giving information on identity and location of the individual (Caldwell and Caldwell, 1990).

Nevertheless, processes influencing the development of this individual contour remain largely unknown, just as for other vocalisations in the dolphins' repertoire. Study results support the hypothesis that learning plays an important role in signature whistle development; simple genetic models of inheritance have been rejected as a possible mechanism (for a review, see Sayigh, 1992).

In the course of a long-term study on the ontogeny of acoustic signals in bottlenose dolphins, four calves were recorded throughout at least their first year of life. One calf will be dealt with in detail here, as results raised new questions on (a) the mechanisms involved in the development, (b) functions, and (c) even the morphological structures utilised in the production of bottlenose dolphin signature whistles.

MATERIALS AND METHODS The 'focal calf', a male, was born into a colony of ten bottlenose dolphins in the Dolphin Reef Eilat, Israel (for details on housing conditions, see Bojanowski 1999) in July 1997. A total of 30 hours of underwater recordings were taken between July 1997 and June 1998 with a mobile underwater camera including a hydrophone (Sony CCD-TR3E & Sony MPK-TR3 housing). All analysed whistles (n=993) were assigned to the specific calf by air bubbles released simultaneously to sound production (for this method, see McCowan and Reiss, 1995). The Avisoft program was used to create spectrograms of these whistles. Examples shown here were chosen for their 'typical' visual appearance by one of the authors (E.B.).

RESULTS AND DISCUSSION The whistle contour first developed by the calf showed a marked similarity to the signature whistles of two other individuals of the colony (see Figure 1). This similarity stands in clear contrast to the proposed functions of signature whistles within dolphin groups, which is, for example, broadcasting an individual's identity (see above). At the age of 50 days, the first bivocal whistle was recorded from this calf (see Figure 3, top spectrogram). From the age of 3 months on, the majority of his whistles were bivocal (69.8% = 308 whistles, see also Figure 2, for examples see Figure 3) making them clearly distinctive from all other signature whistles within his colony. Altogether, the share of bivocal whistles increased significantly throughout the first year of life (Spearman's correlation coefficient = 0.779, see also Figure 2).

Two observations make it highly improbable, that morphological irregularities are responsible for this signal structure: (1) From the age of three to twelve months, about 30% of all whistles recorded from the focal calf were not bivocal. (2) In two cases, another calf was recorded producing an imitation of the specific whistle, including the bivocal structure (example see Figure 4; for signature whistle mimicry see Burdin, *et al.*, 1975; Tyack, 1986).

Instead the occurrence of a bivocal signature whistle supports hypotheses by other researchers, that bottlenose dolphins may utilise more than one sound generator for signal production, as stated in numerous publications mentioning simultaneous production of whistles and clicks (e.g. Lilly and Miller, 1961; Evans and Prescott, 1962; Caldwell and Caldwell, 1966), as well as in rare reports on simultaneous whistle production (Kaznadzei *et al.*, 1976; Markov and Ostrovskaya, 1990).

Generally, our results support other studies in finding the individual contour to be typically developed within the first three to four months of life (e.g. Caldwell and Caldwell, 1979, Sayigh, 1992). In no other published study, however, did the structure of a signature whistle change so substantially within this period of time. Instead, there seemed to be a rather gradual development from faint, shaky whistles with little frequency modulation to 'typical' bottlenose dolphin whistles ranging approximately from 4-20 kHz (e.g. Caldwell & Caldwell, 1979; Herman and Tavolga, 1980).

The onset of bivocal whistling in the second month of life of our focal calf marked a decisive change in whistle structure resulting in the individual character of this animal's signature whistle. In an additional 50 hours of underwater recordings stretching over an additional 3 year-period, no other bivocal whistles were recorded from this colony. We cannot totally exclude the possibility, that a sound, natural or artificial, with a bivocal, or similar, structure has been present in the acoustic environment of this calf. But nevertheless we are confident, that, if it occurred at all, it has at no stage been frequently or continuously audible, since recordings of this group have been extensive over the course of 5 years, and especially thorough following the birth of calves. Additionally, we did not find any evidence for any 'teaching' or 'modelling' of whistle contours taking place (in contrast to Sayigh 1992).

It is therefore argued, that processes other than the imitation of signals from the acoustic environment of the dolphins (see e.g. Tyack *et al.*, quoted in Sayigh 1992) were likely to have influenced the development of a bivocal signature whistle, which to our knowledge, was documented for the first time.

It is impossible to know what processes caused the change of structure in the signature whistle of this specific bottlenose dolphin calf. The result may indicate, however, that on a certain level within this organism a decision-making process takes place, leading to the individuality of a dolphin's signature whistle, which in turn points to the biological importance of these individual differences.

On what level and with which underlying rules this process takes place might be impossible to ever assess. In contrast to other acoustically versatile animals, such as certain songbird species, the breeding and raising of large numbers of dolphins under controlled laboratory conditions is, and in fact will, remain impossible due to their slow reproductive rates and development. Indirect evidence from detailed observations and recordings of as many individuals as possible may be the only tools to formulate hypotheses and ideas on certain developmental and learning processes in these mammals.

ACKNOWLEDGEMENTS The first author is supported by a Nafög-scholarship. B.L.A.S. funded technical equipment for the project.

REFERENCES

Bojanowski, E. 1999. Early social development in bottlenose dolphin calves with special reference to the role of adult males. In: *European Research on Cetaceans 12*. Proc. 12th Ann. Conf. ECS, Monaco, 20-24 Jan, 1998. (Eds. P. G. H. Evans & E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

Burdin, V. I., Reznik, A. M., Skornyakov, V. M. and Chupakov, A. G. 1975. Communication signals of the Black Sea bottlenose dolphin. *Soviet Physics Acoustic*, 20: 314-318.

Caldwell, M. C. and Caldwell, D. K. 1966. Intraspecific Transfer of Information Via the Pulsed Sound in Captive Odontocete Cetaceans. Pp. 879-936. In: *Animal Sonar Systems - Biology and Bionics*. (Ed. R. G. Busnel).

Caldwell, M. C. and Caldwell, D. K. 1979. The Whistle of the Atlantic Bottlenosed Dolphin (*Tursiops truncatus*) - Ontogeny. Pp. 369-401. In: *Behavior of Marine Animals, Volume 3: Cetaceans*. (Eds. H. E. Winn and B. L. Olla). Plenum Press, New York & London.

Caldwell, M. C., Caldwell, D. K. and Tyack, P. L. 1990. Review of the Signature - Whistle Hypothesis for the Atlantic Bottlenose Dolphin. Pp. 199-234. In: *The Bottlenose Dolphin*. (Eds. S. Leatherwood and R. R. Reeves) Academic Press, New York & London.

Evans, W. E. and Prescott, J. H. 1962. Observations of the Sound Production Capabilities of the Bottlenosed Porpoise. *Zoologica*, 47: 121-128.

Herman, L. M. and Tavolga, W. N. 1980. The communication systems of cetaceans. Pp. 149-209. In: *Cetacean Behavior: Mechanisms and Functions*. (Ed. L. M. Herman) John Wiley and Sons, New York.

Herzing, D. L. 1996. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis*, and bottlenose dolphin, *Tursiops truncatus*. *Aquatic Mammals*, 22(2): 61-79.

Kaznadzei, V.V., Kreichi, S. A. and Khakhalkina, E. N. 1976. Types of dolphin communication signals and their organization. *Soviet Physics Acoustics*, 22: 484-488.

Lilly, J. C. and Miller, A. M. 1961. Sounds emitted by the bottlenose dolphin. *Science*, 133: 1689 - 1693.

Markov, V.I. and Ostrovskaya, V. M. 1990. Organisation of Communication System in *Tursiops truncatus* Montagu. Pp. 599-622. In: *Sensory Abilities of Cetaceans*. (Eds. J. Thomas & R. Kastelein) Plenum Press, New York,

McCowan, B. and Reiss, D. 1995. Whistle Contour Development in Captive-Born Infant Bottlenose Dolphins (*Tursiops truncatus*): Role of Learning. *Journal of Comparative Psychology*, 109(3): 242-260.

Reiss, D. and McCowan, B. 1993. Spontaneous Vocal Mimicry and Production by Bottlenose Dolphins (*Tursiops truncatus*): Evidence for Vocal Learning. *Journal of Comparative Psychology*, 107(3): 301-312.

Sayigh, L. S. 1992. Development and function of signature whistles of free-ranging bottlenose dolphins, *Tursiops truncatus*. Ph.D. thesis, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, 344pp.

Tyack, P. 1986. Whistle repertoires of two bottlenosed dolphins, *Tursiops truncatus*: mimicry of signature whistles? *Behavioral Ecology and Sociobiology*, 18: 251-257.

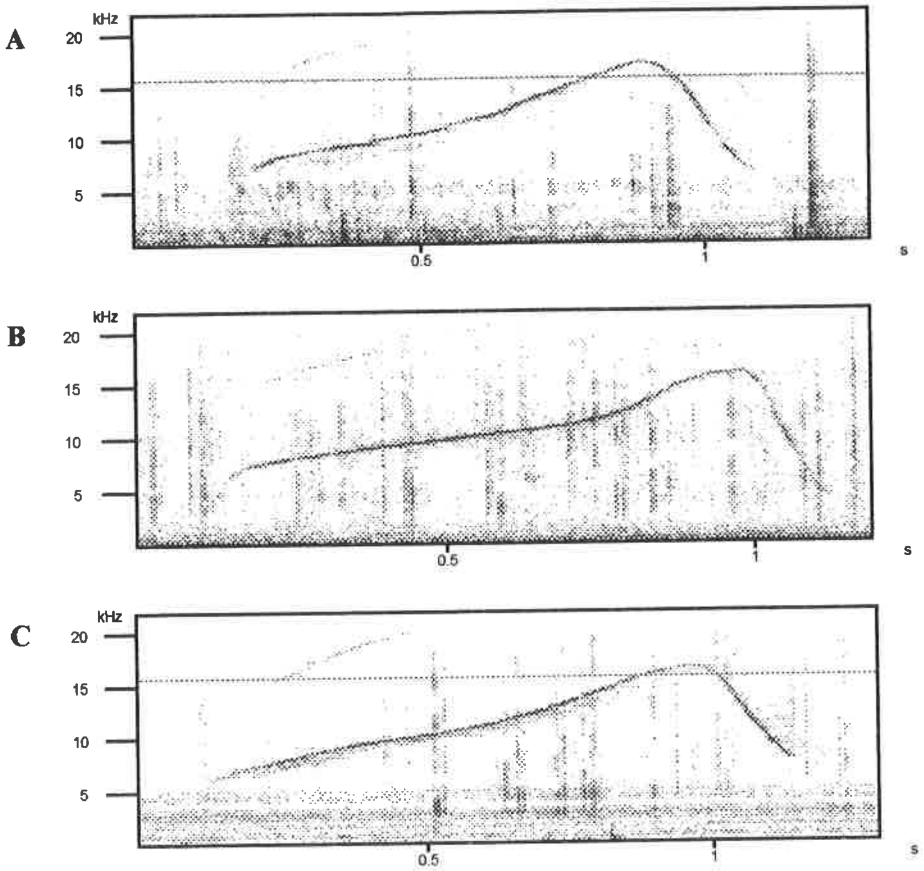


Fig. 1. Examples of individual whistle contours of three dolphins with high degree of similarity. (A) focal calf, (B) juvenile female, (C) male calf of the same age as the focal calf.

Spectrogram settings: FFT-length: 512; Hamming window; Effective filter bandwidth: 111 Hz; Time res.: 5,8 ms; Frame: 100%; Overlap: 50%.

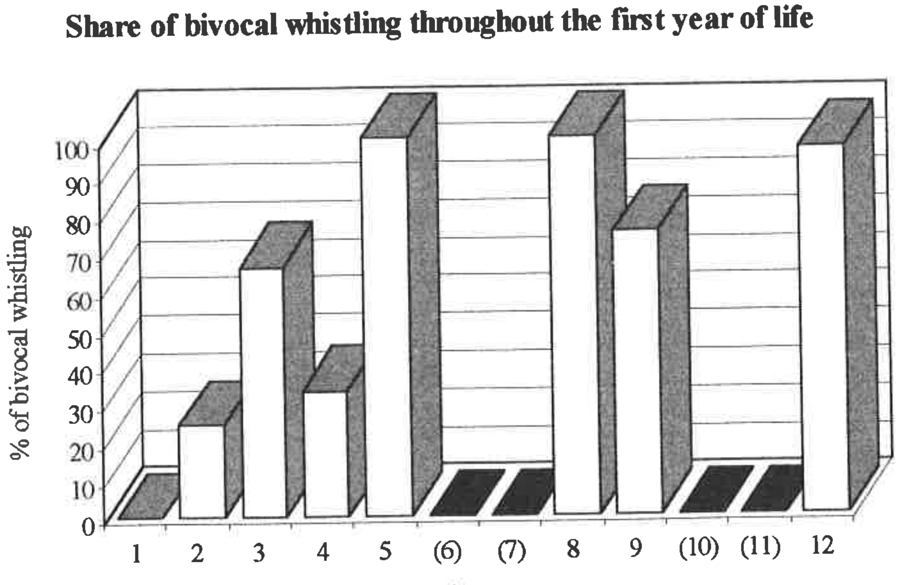


Fig. 2. Share of bivocal whistling in the focal calf throughout its first year of life. Months given in brackets indicate, that no whistles were recorded of, or could unequivocally be assigned to the focal calf.

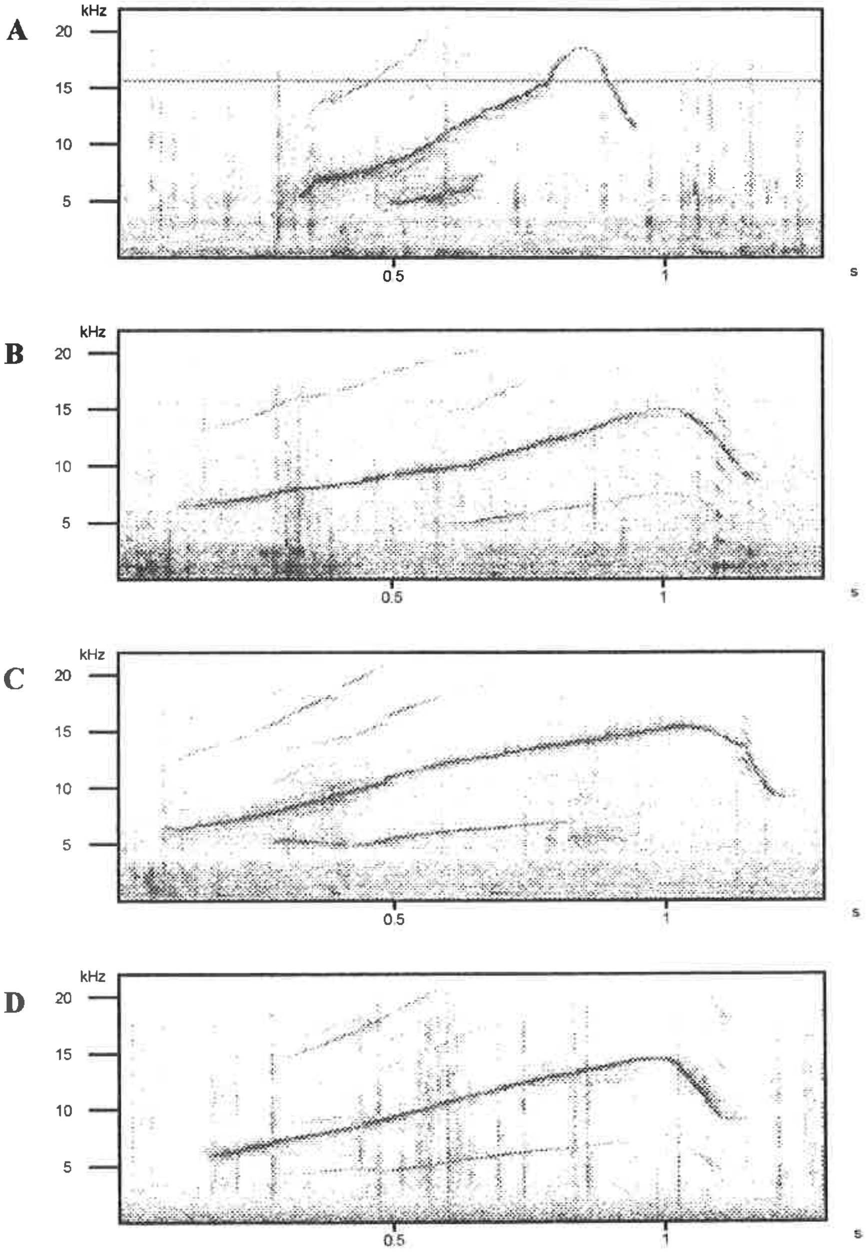


Fig. 3. Bivocal whistles of the focal calf: (A): first bivocal whistle recorded, age: 50 days; (B) + (C): age 6 months; (D): age 1 year. For spectrogram settings, see figure 1.

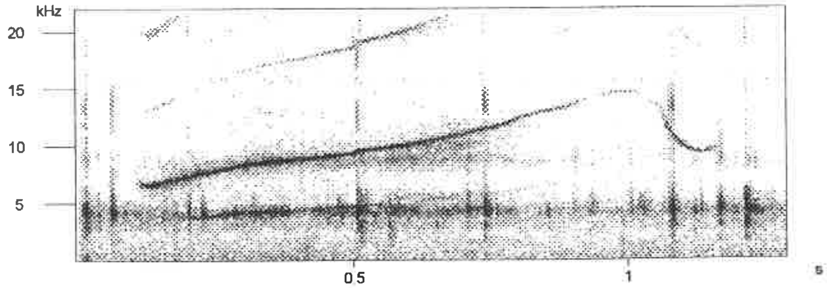


Fig. 4. Imitation of the bivocal signature whistle produced by a male calf (not the focal calf) at the age of approximately 1 year. For spectrogram settings, see figure 1.

SOUND PRODUCTION BY FIN WHALES IN THE CORSICAN-LIGURIAN BASIN, MEDITERRANEAN SEA

J. F. Borsani[1], C. W. Clark[2], and G. Notarbartolo Di Sciara[1]

[1]*Istituto Centrale per la Ricerca Applicata al Mare, Via di Casalotti 300, 00166 Roma, Italy*
[2]*Cornell Laboratory of Ornithology, Cornell University, 159 Sapsucker Woods Road, Ithaca, NY 14850, USA*

Monitoring fin whale vocalisations has proved a valuable tool for understanding whale movements and habitat use in several North Atlantic locations. The potential application of acoustic techniques for fin whale conservation and management in the Mediterranean posed several problems. In particular, in the recently-established Cetacean Sanctuary, there was no available evidence that Mediterranean fin whales engage in extensive vocal activity. Furthermore, the chances of detecting fin whales might be seriously masked by the high levels of shipping noise in the region. To overcome these problems, two pop-up acoustic recording systems were deployed on the bottom of the Corsican-Ligurian basin. These units continuously recorded sounds in the 0-1,000 Hz frequency band for 16-18 days. For the first time, this allowed autonomous recording of fin whale vocalisations with only limited need of a research vessel. All 821 hours of acoustic data were analysed for fin whale "20 Hz" sounds using an automatic detection process. For the period between 31st August to 18th September, 1999, over 3,200 fin whale sounds were detected, including clear cases when a whale approached and passed by the pop-up's location. The basic characteristics of these fin sounds are similar to those from all other fin whale populations recorded throughout the world. However, there are several acoustic features, notably the cadence and pattern of repetition for two note types, that appear distinctive to this population. Recordings using pop-up hydrophones will continue through an entire year to monitor seasonal changes in vocal activity, and possibly migration habits and habitat use within the Sanctuary.

FIRST ACOUSTIC RECORDINGS OF THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) WHISTLES IN NORMANDY WATERS

E. Buchet and C. Warembourg

Groupe d'Etude des Cétacés du Cotentin (GECC), Centre d'Innovation Technologique, rue Louis Aragon, 50130 Octeville, France

In France, acoustics of marine mammals in their natural environment is poorly studied. To date, no study has been made on the Normandy population of bottlenose dolphins (one of the largest in Europe with more than 60 identified individuals). Since 1998, in addition to the population study in the Normano-Breton Gulf, we have developed an acoustic population monitoring programme. During the summers 1998 and 1999, with a tape-recorder (NAGRA) and an omni-directional hydrophone (TR 25 C-frequency response up to 25 kHz), we recorded more than eight hours of signals. All recordings were made from an outboard motor boat. Prospecting effort was over 63 hours, which means a 10% efficacy. At first, we inventoried and classified whistles, which are the most frequent signals used by *Tursiops*. For each whistle, we measured: (1) minimum, maximum and average frequencies; (2) frequency contour; (3) signal duration; and (4) slope changes of the frequency during the signal. A total of 108 whistles were analysed with SBRTA (software developed by G. Pavan). Twenty-two types were created to classify them according to their form and Frequency/Time ratio. The average frequency of the whistles was 4.910 kHz; the average duration was 3.12 s. Ideally, acoustic software will be developed from the inventory of signals in order to improve the population study.

APPLYING ACOUSTIC TELEMETRY TECHNIQUES TO THE INVESTIGATION OF OPPORTUNISTIC FEEDING BEHAVIOUR OF DOLPHINS AROUND FISHING NETS

G. Chiofalo[1], S. Datta[1], A. D. Goodson[1], M. E. Quero[2],
A. Di Natale[2], and P. Y. Dremiere[3]

[1]*Underwater Acoustic Group, Electronic & Electrical Engineering Department,*
Loughborough University, LE11 3TU, UK (E-mail: a.d.goodson@lboro.ac.uk)
[2]*Aquastudio, V. Trapani 6, 98121 Messina, Italy*
[3]*Ifremer, Laboratoire de Technologie des Pêches, 1 Rue Jean Vilar, B.P. 171, 34203 Sète, France*

INTRODUCTION This paper describes the development and practical application of 'sonobuoy' radio telemetry systems to an investigation of damaging interactions between dolphins and artisanal fishing nets. The primary study area, within the Sicilian Egadi Islands Marine Nature Reserve, was selected after formal requests for assistance were received from the local authority and from the fishermen's co-operative. An earlier study (Chiofalo, 1996) confirmed that the reported net damage was largely caused by bottlenose dolphins (*Tursiops truncatus*). As a part of this new study, the nets of a few fishing boats are being equipped with a new acoustic device 'Aquamark 100' to determine if this predation problem can be mitigated. This micro-controller based programmable deterrent transmits a variety of very low power, wideband sounds at randomised intervals (Newborough *et al.*, 1997) of the type shown to be effective in reducing the bycatch of harbour porpoises (*Phocoena phocoena*) in commercial gillnets (Larsen, 1997). Detection of dolphin calls usually precedes any visual sightings of surfacing animals, even in very calm daylight conditions, and the methodology adopted offers major advantages in a fishery frequently operating at night and near dawn. Recordings of dolphin whistles are used to try to identify local individuals, and echolocation behaviour is being analysed to examine foraging activity near to the nets. Tests conducted in the study area indicate that a single hydrophone multi-path ranging technique appears to be practical, and this should provide supplementary data on the underwater movements and proximity of vocalising animals to the fishing nets.

MATERIALS AND METHODS The radio telemetry equipment developed was based on 'life-expired' ASW sonobuoy components (SSQ904 Dowty). The transmitting package consists of a robust plastic cylindrical buoy which incorporates the signal processing electronics and the radio transmitter circuit, together with a rechargeable lead-acid battery. The original circuit boards were modified to increase the upper frequency response from <3 kHz to >15 kHz in order to detect both dolphin whistles and low frequency echolocation components. The circuit's sensitivity to low frequency sea state and shipping noise has also been restricted below 2 kHz. The telemetry package (Fig. 1) is moored using a single anchor and a visible marker buoy with a 'bridle' technique (Fig. 2) which helps to improve the antenna stability and reduces the risk of entangling the hydrophone cable. The radio-receiving equipment consists of two Yaesu FT9600 wideband FM communication receivers connected to the left and right channels of a digital (R-DAT) audio recorder (Fig. 3). The sonobuoy telemetry systems are moored with the hydrophone close to the fishing net being studied. The observer monitors the underwater acoustic activity using portable radio-receiving equipment, either working from the shore or onboard a boat that can stay in the area for the period that the net is set. Recordings of dolphin calls which include resolvable seabed and surface reverberations allow the estimation of both the swimming depth and the range to the vocalising animal.

REVERBERATION RANGING A field experiment, to establish whether the multi-path reverberation technique developed by Lepper *et. al.*, (1997) could be used to estimate the range to a dolphin-like sound source in these shallower water conditions, was carried out in locations where dolphin damage to fishing nets had been previously reported. The tests (Fig. 4) involved a mid-water sound source transmitting a frequency swept signal, simulated a dolphin whistle with a Source Level of 160 dB re 1µPa at 1m. The sound was repeated at intervals for a period of one minute at each of three different transmit transducer depths: 1 m below the surface; mid-water; and 1 m above the seabed. The receiving hydrophone was deployed at 1/3rd of the water depth, and recordings of the signals received were made at 5, 25 and 50 m distances.

ANALYSIS AND CONCLUSIONS Analysis of the R-DAT recorded tapes was conducted at Loughborough University using the spectral analysis software 'SBRTA' developed by Pavan (1996). For a displayed dolphin whistle, the time differences measured between identical parts of the direct path signal and its reverberations were measured with the analyser's cursor. The time delay values measured were then compared with the predicted values obtained from a computer simulation. By matching the predicted and measured time delays, it was possible to establish which reverberation paths were involved at the selected values of depths and ranges (Table 1) and hence determine the actual range to the source. Fig. 5 shows a spectrogram of dolphin whistles recorded by the system in 30 m water depth. At this temporal resolution, the spectrograph display tends to merge the multi-path echoes with the direct path signal. However, by using high resolution analysis methods with good dynamic range digitally recorded data, the individual multi-path components can be separated and measured.

Table 1 illustrates the difficulty of resolving the 1st order reverberation path delays due to the merging of the direct path + multi-path signals in very shallow conditions. The existing computer model has now been revised to include second order reverberation predictions which helps to identify and separate the various paths. Despite the complications introduced by the shallow water limiting conditions and the rather labour intensive analysis approach, it appears that this single hydrophone reverberation method may be expected to generate useful range estimates to support this study.

ACKNOWLEDGEMENTS The authors acknowledge the considerable support for this project provided by the local communities of Favignana and Catania, and they particularly wish to thank all the collaborating fishermen. Thanks to G. Pavan (Pavia University) for the SBRTA software and to Paul Connelly (Loughborough University) for revising the multi-path prediction models; to the RAF (Kinloss) for 'life-ex' sonobuoys; to the Italian Ministero dell'Ambiente Ispettorato Centrale per la Difesa del Mare and the Capitaneria di Porto di Trapani for facilitating this study within the Riserva Marina Isole Egadi. The financial support of the European Commission DGXIV is gratefully acknowledged.

REFERENCES

Chiofalo, G. 1996. Tursiops truncatus: interazione tra piccola pesca costiera e delfini nell'isola Di Favignana, Arcipelago delle Egadi (TP). Degree Dissertation, Dept of Zoology, University of Messina.

Larsen, F. 1997. *Effekten af akustiske alarmer på bifangst af marsvin i garn.* DFU-Rapport nr. 44-97. Danish Institute for Fisheries Research. ISBN:87-88047-56-3.

Lepper, P. A., Kaschner, K., Connelly, P. R. and Goodson, A. D. 1997. Development of a simplified Ray Path Model for estimating the range and depth of vocalising marine mammals. *Proc. Institute of Acoustics - Symposium on Underwater Bio-Sonar and Bioacoustics*, 19(9): 227-234 (ISSN: 0309-8117).

Newborough, D., Goodson, A. D. and Woodward, B. 1997. Micro-controller based deterrents: Acoustic devices to reduce harbour porpoise (*Phocoena phocoena*) incidental catch in gillnets. *Proc. Institute of Acoustics - Symposium on Underwater Bio-Sonar and Bioacoustics*. 19(9): 235-243 (ISSN 0309-8117).

Pavan, G. 1996. A real *time FFT spectrographic display for bioacoustics*. International Bioacoustic Council Symposium (XV IBAC 96). 24-26 Oct. Pavia, Italy.

Table 1 - Comparison between data obtained from the reverberation ranging test on the fishing ground and theoretical data obtained from the computer model.

		Sea Test Results (Delayed arrival times)		Rx Depth 12m	Water Depth 20m
Range	Tx Depth	1st Path(ms)	2nd Path(ms)	3rd Path(ms)	4th Path(ms)
5	1	12.60 ♠	27.20 ♠	40.6	55.7
5	10	9.00 ♣	22.30 ♣	35.6	49.3
5	19	13.10 ♦	24.00 ♦	39.9	51
25	1	8.90 ♥	22.58 ♥	34	48.7
25	10	5.91 ♠	16.58 ♠	30	41.6
25	19	8.41 ♣	17.80 ♣	32	43
50	1	5.00 ♦	14.90 ♦	24.5	38.2
50	10	3.00 ♥	9.60 ♥	20.1	31.5
50	19	5.58 ♠	13.08 ♠	25.75	36.1
		Multi-Path Simulation		Rx Depth 12m	Water Depth 20m
Range	Tx Depth	1st Surface Path (ms)	1st Seabed Path (ms)	2nd Surface Path (ms)	2nd Seabed Path (ms)
5	1	1.26 ...	10.53 ...	11.88 ♠	26.82 ♠
5	10	11.76 ...	9.11 ♣	22.56 ♣	25.28 ...
5	19	15.62 ♦	1.16 ...	26.48 ♦	16.97 ...
25	1	0.59 ...	6.50 ...	7.52 ♥	20.20 ♥
25	10	5.63 ♠	3.92 ...	13.98 ...	16.30 ♠
25	19	9.50 ♣	0.42 ...	18.68 ♣	10.57 ...
50	1	0.32 ...	3.86 ...	4.52 ♦	13.85 ♦
50	10	3.14 ♥	2.12 ...	8.74 ♥	10.45 ♥
50	19	5.71 ♠	0.22 ...	12.42 ♠	6.45 ♠

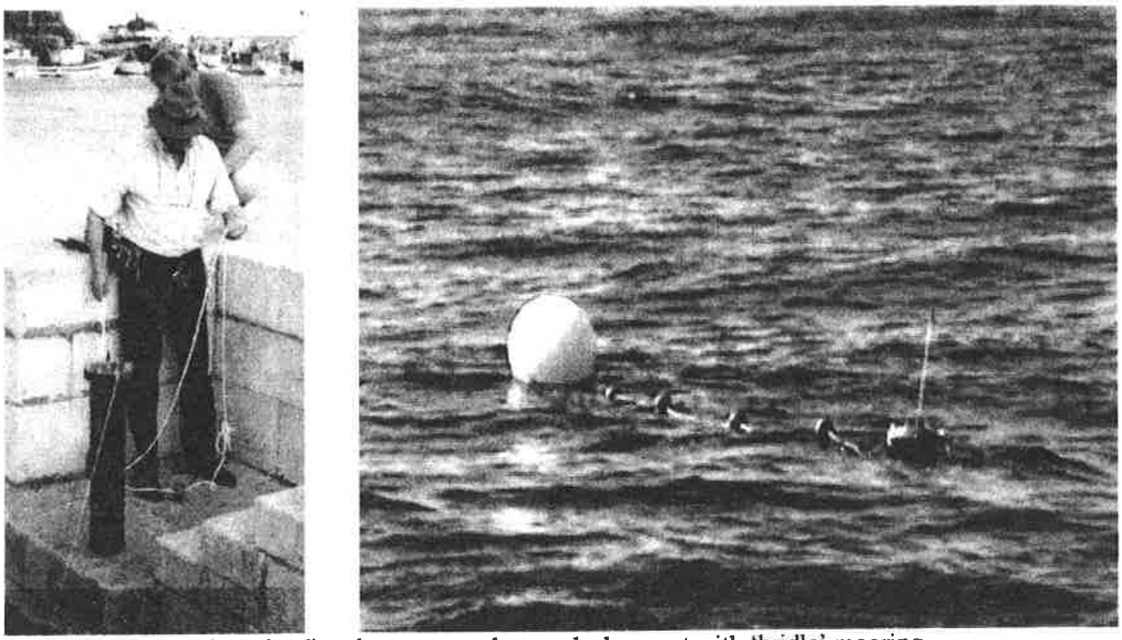


Fig. 1 Re-packaged radio telemetry sonobuoy - deployment with 'bridle' mooring

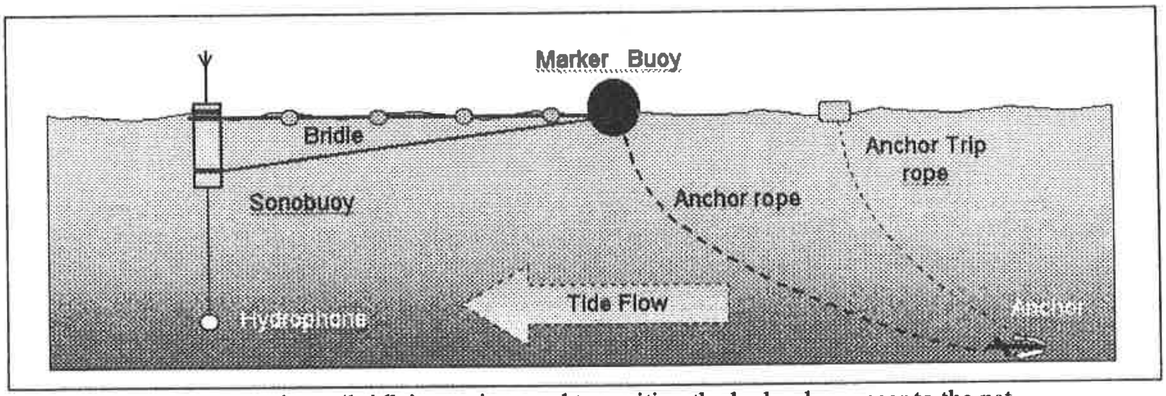


Fig. 2 Sonobuoy 'bridle' mooring used to position the hydrophone near to the net

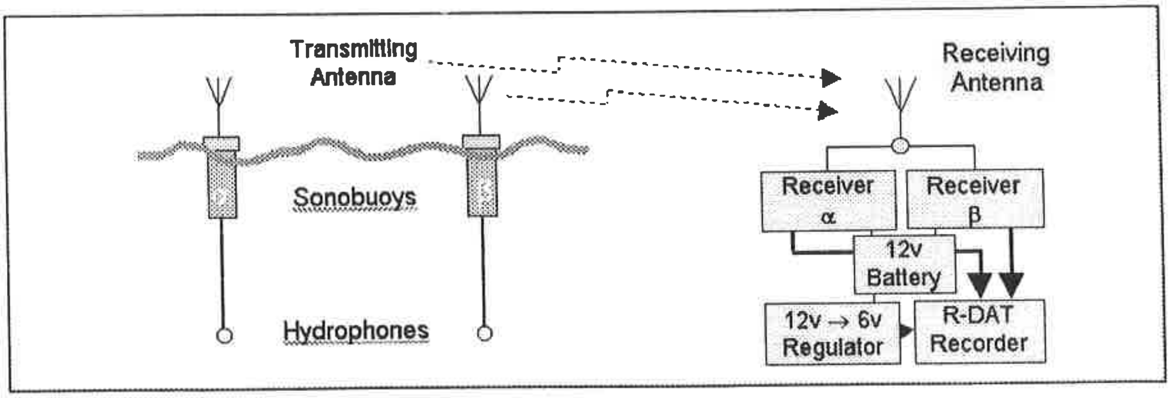


Fig. 3 Sonobuoy radio telemetry system

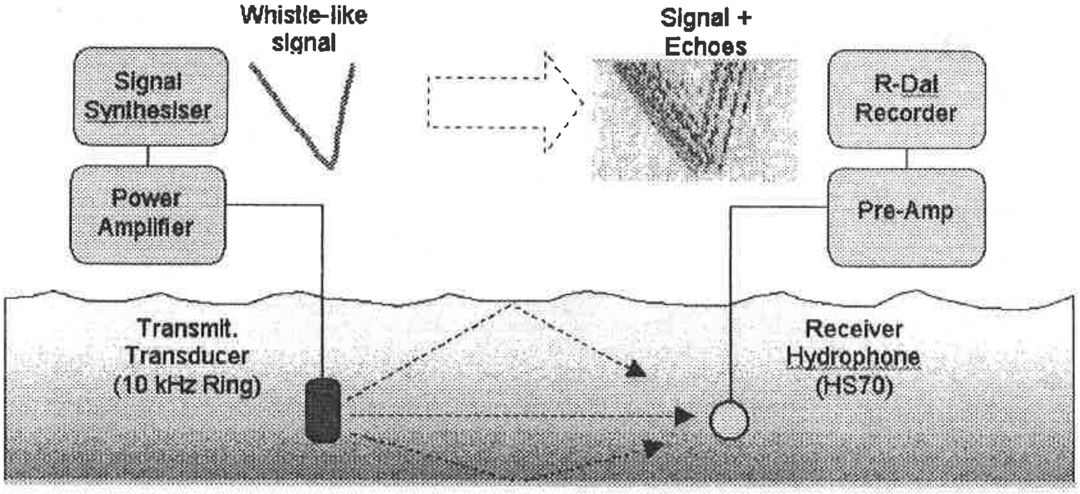


Fig. 4 Reverberation Ranging Tests - The inset spectrogram shows that clear multi-path echoes were received. The direct path plus 1st and 2nd order reflections from the surface and bottom are clearly detectable.

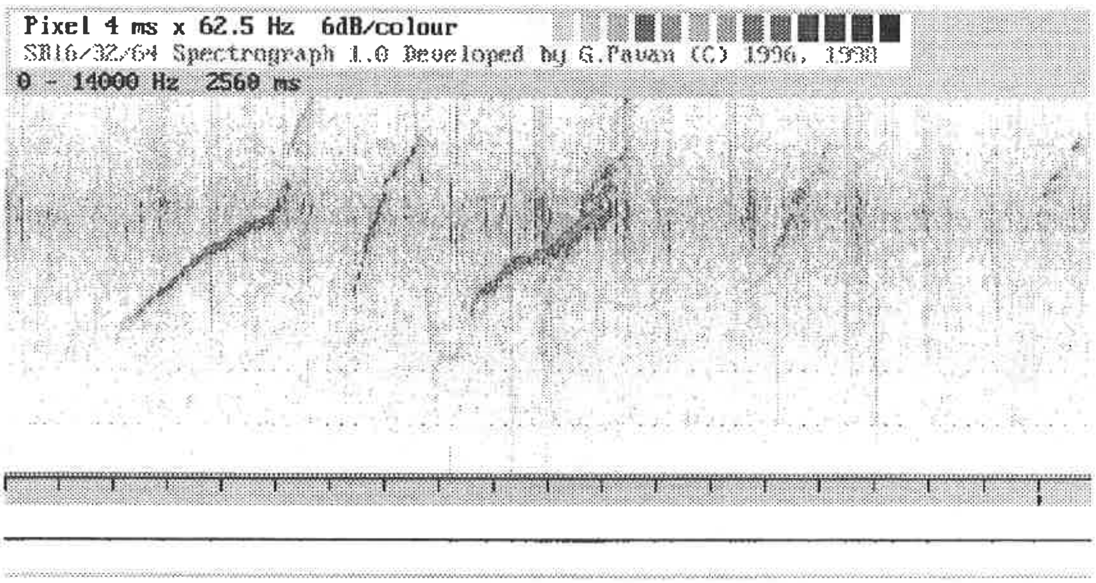


Fig. 5 Spectrogram of dolphin whistles with 3+ animals present.
At this resolution the multi-path echoes tend to merge with the direct path signal.

THE EVOLUTION OF THE ACOUSTIC AND SOCIAL BEHAVIOUR IN AN ARTIFICIAL COMMUNITY OF DOLPHINS

S. Ciaramitaro[1], M. Azzali[1], S. Catacchio[1], M. Jones[2], R. Simoni[1], and A. Ruggeri[1]

[1]*National Research Council, Inst. Of Marine Fishery Res., 60100 Ancona, Italy*
(E-mail: elettronica@irpem.an.cnr.it)
[2]*Palablù of Gardaland, Verona, Italy*

INTRODUCTION The problems we chose to cover in this paper are: what are the transient acoustic and social behaviours of dolphins, coming from different places and forced to live together in a new tank? How much time do they need to adjust to changes in the physical and social environment, to form an acoustic group, and to find a social harmony? Palablu, the new dolphinarium created in Gardaland in the March 1997, offered a unique opportunity to study this type of problems. The three dolphins put initially into the Palablu, came from different pools, and at the beginning neither socialised nor used their sonar. Their acoustic and social behaviour have been surveyed since June 1997, also in relation to the arrivals of other dolphins (January 1999, June 1999). Here the results of the first 28 months of this study are reported.

MATERIALS AND METHODS In the first 19 months (June 1997 - December 1998), the subjects of the study were three free-born dolphins (*Tursiops truncatus*): a male, Robin (about 19 years old), and two females, Violetta and Betty (about 17 years old), coming from different pools. In the following 5 months (January - May 1999), the subjects were four *Tursiops*, following the arrival from Tenerife dolphinarium (Octopus Park) of Amada, a free-born and about 34 years old female. In the last 4 months, the subjects of this study were seven *Tursiops*, following the arrival from Octopus Park of a family composed of Squeak, a free-born and 27 years old female, Hector, a free-born and 30 years old male, and their offspring, Teide, a captive-born and 2 years old male.

Two data set were collected and processed during the 28 months of this study: acoustic and ethological data. Acoustic data (i.e. the sonar signals emitted by each dolphins) were collected in sessions of three consecutive days per month. Sonar signals were recorded from a Bruel & Kjaer 8105 hydrophone onto a wide-band recorder (30 Hz-300 kHz), and synchronised with video images recorded from an underwater camera through the comments of the experimenter. Generally in each session, two hours of acoustic and video data were acquired. In each session, two standard trials were carried out:

Free trials, without target. During these experiments, the hydrophone was positioned two metres depth and three metres far from the pool wall. The sonar signals were collected on different occasions: while dolphins were swimming freely during the day and sometimes during the night; when they were involved in training; and sometimes during the exhibitions. It is assumed that dolphins, during these trials, used their sonar to interact w3ith each other.

Trials with targets. During these experiments, targets, different in shape, dimensions and materials were suspended from the hydrophone with a nylon twine, about 5 cm long. The hydrophone was lowered in the pool, at different positions and depths. In some trials, only one dolphin at a time was allowed to approach the target. In other trials, all the dolphins could move around and ensonify the target. It is assumed that dolphins, during these trials, used their sonar to acquire acoustic information on the objects, and probably to share objects information through echoes.

Moreover, in the first months of the research, when Robin, Violetta and Betty seemed to be unnaturally silent and to take no interest in the targets, sonar signals at 45 kHz were produced artificially from the hydrophone. These signals seemed to stimulate mostly Betty to use its own sonar. Ethological data were collected in a session of three hours per week. They were based on the "Focal Animal Sampling" method. The data presented in this paper refer only to the number and duration of the interactions between the members of the community. They are used as a measure of the level of socialisation of the single dolphins and of the community.

Sonar signals were analysed in the laboratory. First, the pulses were attributed to dolphins using the comments registered onto the audio channels of both the wide band recorder and the camera.

The signals of uncertain origin were discarded. Then the identified signals (around 3,500) were digitised at an effective sampling rate of 5.12 sample per µs. Lastly, the signals were processed using MATLAB m-file language. The data presented in this paper are four parameters, extracted by each pulse: the first and the second moment in time, that represent respectively the centre of gravity and the Gabor time width of the signal; the first and second moment in the frequency, that represent respectively the centre of gravity and the Gabor bandwidth of the spectrum (Azzali *et al.*, 1998).These four parameters are used to plot in the time-frequency plane a schematic spectrogram (i.e. a rectangle) of the group of sounds emitted by each dolphin in a chosen period. The union (⋃) of the spectrograms of every dolphin is called the spectrogram of the community in the chosen period. The intersection (⋂) of the spectrograms of all the community's dolphins, if it is not empty, represents the set of sounds that are used by all the members of the community. The value of this intersection is assumed as a measure of the acoustic integration of the community in the chosen period.

RESULTS The acoustic activity of Robin, Violetta and Betty from June 1997 to September 1999 is represented respectively in Figures 1, 2, and 3. On this basis the 28 months of study can be divided into four periods.

First period (June 1997 - October 1998): The three dolphins were unnaturally silent (total number of recorded signals: 250 in 54 hours of recording) and did not socialise. The most silent of the group was Robin (Fig. 1), who emitted few sonar signals with a large band and at a particularly high frequency (average bandwidth: 100-150 kHz). The trend of Violetta's acoustic activity and the number of her signals were similar to those of Robin (Fig. 2). However, Violetta used a different band of the spectrum, shifted to lower frequency (average bandwidth: 50-80 kHz). Betty was the most active of the group (Fig. 3), alternating months of blank silence with months of sonar emissions. The average bandwidth of Betty's sonar signals was from 75 to 110 kHz (35 kHz). The schematic spectrogram of the community is shown in Figure 4. The union of the spectrograms of Robin, Violetta and Betty is pretty large (1.4), but the intersection is empty (i.e. no acoustic overlap). The average socialisation of the three dolphins was estimated around 2%. The three dolphins usually ignored each other and occupied different areas in the pool.

Second period (November and December 1998): The acoustic activity of all three dolphins exploded suddenly and unexpectedly (total number of recorded signals: 500 in 8 hours of recording); however, the socialisation remained low. The most active dolphin was Robin who emitted up to 70 sonar signals per hour, characterised by a wide band, as in the first period, but shifted to lower frequencies (bandwidth: 75-125 kHz). Violetta emitted about 25 signals per hour with an average bandwidth of 50 kHz (between 60 and 110 kHz), wider than in the previous period. Betty emitted up to 40 sonar signals per hour with an average bandwidth of 60 kHz (between 40 and 125 kHz), about twice as wide as in the first period. The schematic spectrogram of the community is represented in Figure 5. The union of the spectrograms of Robin, Violetta, and Betty is 0.834 (40.4% smaller than in the first period), but the intersection is wide: 0.204. This means, following our assumptions, that in the months of November and December the dolphins created an acoustic group. However, the level of socialisation of the single dolphins (Fig. 5) and of the community as a whole (5.3%, Table 1) remained low .

Third period (January - May 1999): With the arrival of Amada (10th January), there was a great increase in social interaction among the four dolphins, and a consolidation of the acoustic nucleus in the spectrograms characterised this period. Amada integrated easily and quickly into the small community. The acoustic activity of Robin, Violetta, and Betty remained high, in spite of the arrival of Amada. The total number of recorded signals was 800 in 16 hours of recording. On average, each dolphins emitted about 20 sonar signals per hour. No more silent sessions, as in the first period, occurred. The schematic spectrogram of the community is represented in Figure 6. The union of the spectrograms of Robin, Violetta, Betty and Amada is 0.99 (19% wider than in the second period), and the intersection is 0.064 (69% smaller than in the second period). In this period, the level of socialisation both of the single dolphins (Fig. 7) and of the community (47.7%), increased considerably with respect to the two previous periods.

Forth period (June - September 1999): The arrival of a family of three dolphins, the fluctuation of social interactions and of acoustic activity among the seven dolphins, and the corroboration of the common nucleus in the spectrograms, characterised this period. The acoustic activity of Violetta, Betty, and Amada decreased after the arrival of the three dolphins (on average, they emitted around 10 sonar signals per hour). Robin, Hector, and Squeak were more active: they emitted around 20 signals per hour. Teide, the offspring of Squeak and Hector, was the most active of the group, emitting on average 70 sonar signals per hour. In total, the recorded sonar signals were 1,850 in 8 hours of recording. Therefore, the acoustic activity differed among the members of the community, much more than in the previous periods. The schematic spectrogram of the community is represented in Figure 8. The union of the spectrograms of the seven dolphins is 1.2 (21% wider than in the second period) and the intersection is 0.043 (37% smaller than in the second period). Therefore, the common nucleus in the spectrograms decreased but was not lost for the arrival of the three dolphins. In this period, the level of socialisation, as the acoustic activity, was different in the different members of the community (Fig.9). Robin and Hector had the lowest level of socialisation (around

10%), whilst Teide had the highest (more than 40%). On average, the level of socialisation of the community was estimated to be 26.5%.

CONCLUSIONS The conclusions from this study are:

The acoustic activity between our three dolphins, coming from different dolphinaria, and forced to live together, did not improve progressively in the time, but showed sudden bursts, after 18 months of common life in almost total silence. Since then, the dolphins have regularly used their sonar.

During the two months of acoustic outburst, the three dolphins changed the acoustic features of their signals, shifting the frequencies so as to form a common nucleus (i.e. the intersection of dolphin spectrograms was not empty, as in the previous period).

The socialisation arose from a very low (5.3%) to a high level (47.7%) only two months later than acoustic outburst.

The common nucleus in the dolphin spectrograms showed some changes following the arrival of new dolphins, but did not disappeared.

These results suggest that sonar signals may be used by dolphins as a form of communication, and that probably there is some relationship between acoustic and social behaviour.

ACKNOWLEDGEMENTS Many thanks go to the Palablu staff, and in particular to Martin Jones, Monica Acciai., Daniel Barros, Valeria Redivo, and Simon Ede, for their help during acoustic and ethological sessions. This research was supported by Gardaland.

REFERENCE

Azzali, M., Garbati, P. and Impetuoso, A. 1998. Similarity among sonar signals collected from small communities of dolphins (*Tursiops truncatus*). Pp. 246-255. In: *Proceedings of the Fourth European Conference on Underwater Acoustics*, vol. 1 (Eds. A. Alippi and G. B. Cannelli). CNR-IDAC, Rome, Italy.

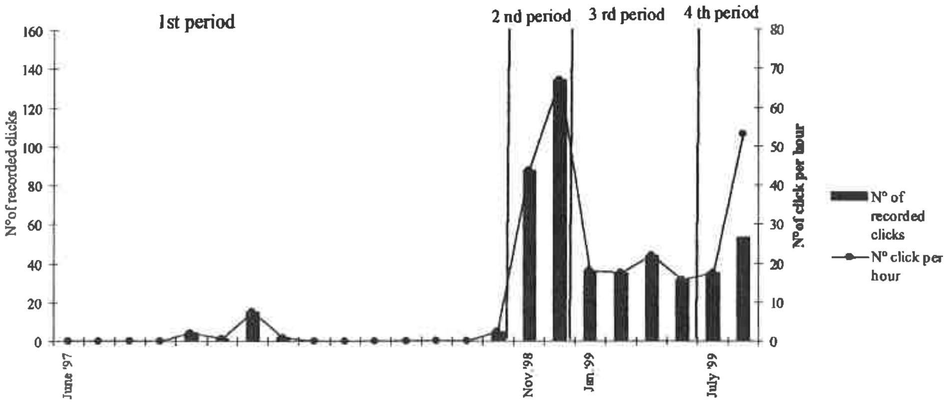


Fig. 1 Acoustic activity of Robin

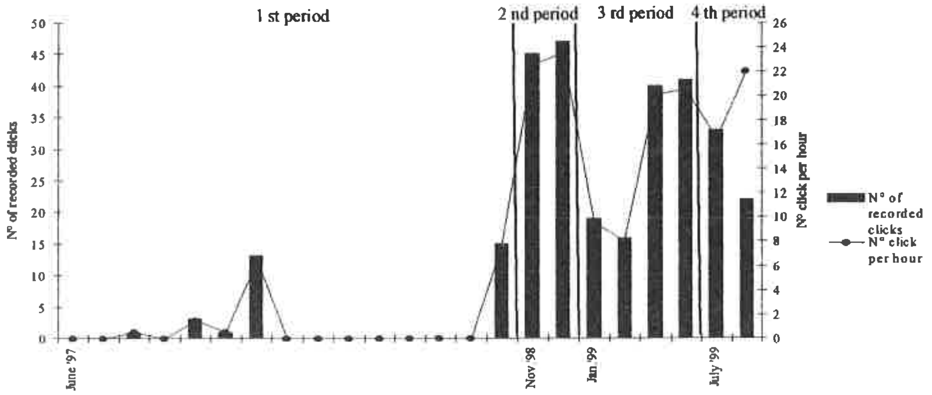


Fig. 2 Acoustic activity of Violetta

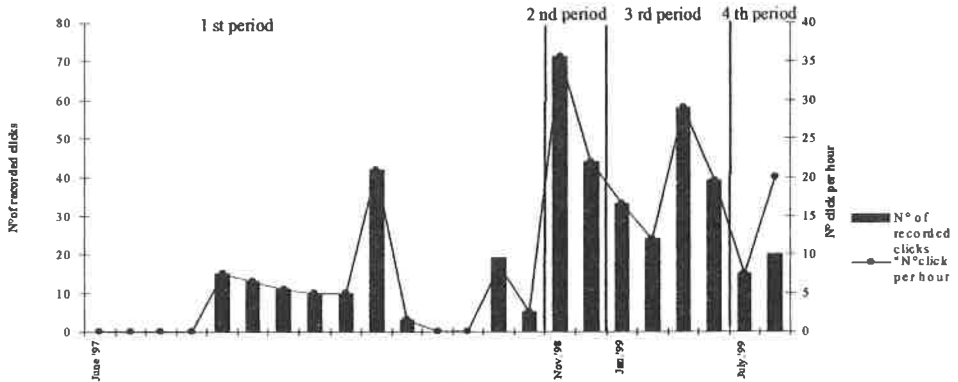


Fig. 3 Acoustic activity of Betty

Table 1

	N° of dolphins	Identified signals	Union (∪) of spectrograms x 10^{-3}	Intersection (∩) of spectrograms x 10^{-3}	Level (%) of socialisation
27 sessions June'97- Oct.'98	3	250	1400	0	2
4 sessions Nov.'98-Dec.'98	3	500	834	204	53
8 sessions Jan.'99- Apr.'99	4	800	990	68	47,7
4 sessions July'99-Sept.'99	7	1850	1200	43	26,5

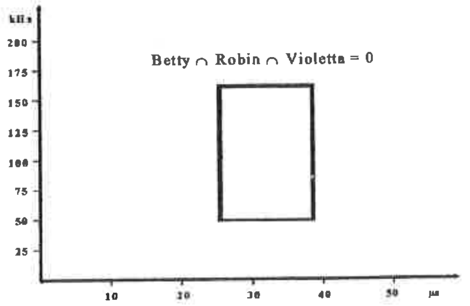


Fig. 4 First period: spectrogram of the community. In this period no physical interactions were observed

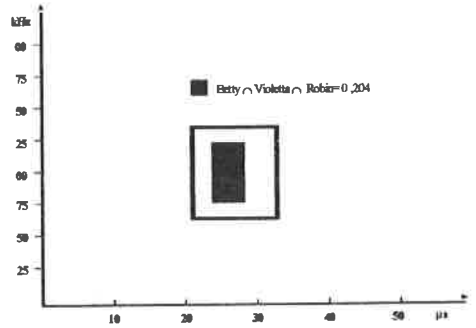


Fig.5 Second period: spectrogram of the community

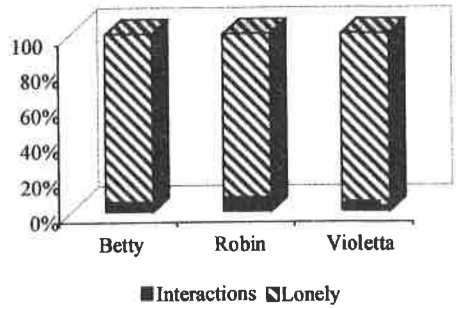


Fig. 6 Second period: socialisation of single dolphins

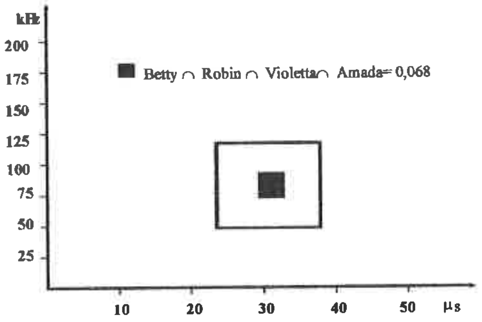


Fig. 7 Third period: spectrogram of the community

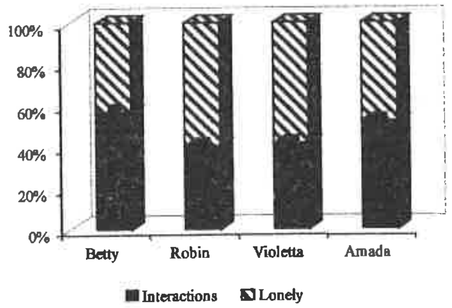


Fig. 8 Third period: socialisation of single dolphins

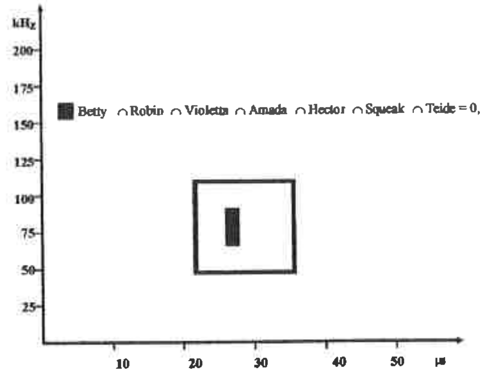


Fig. 9 Fourth period: spectrogram of the community

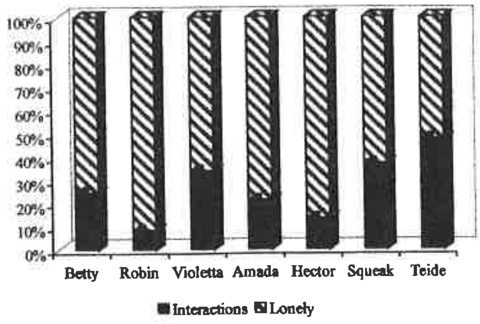


Fig. 10 Fourth period: socialisation of single dolphins

VOCALISATIONS OF WHITE WHALES (*DELPHINAPTERUS LEUCAS*) SUMMERING AROUND SVALBARD, NORWAY

J. Karlsen[1], A. Bisther[2], C. Lydersen[3], K. Kovacs[4], and T. Haug[5]

[1]*Norwegian College of Fishery Science, N-9037 Tromsø, Norway*
[2]*University of Gothenburg, S-45034 Fiskebäckskil, Sweden*
[3]*Norwegian Polar Insistute, N-9296, Norway*
[4]*Norwegian Polar Institute, N-9296 Tromsø, Norway*
[5]*Norwegian Institute of Fisheries and Aquaculture, N-9291 Tromsø, Norway*

Vocalisations of free-ranging white whales were recorded in Van Keulenfjorden, Svalbard, in August 1997. The aim was to describe the repertoire of discrete call types, and to compare the results with analyses of white whale calls from other areas in the Arctic. Despite considerable effort, and the presence of whales in the area, recordings of vocalisations were only achieved on two occasions.

During several recording attempts, when whales were visually followed, they were silent. However, when vocalising pods were encountered, they emitted many signals (total number of calls recorded was approximately 4,000). Whistle calls were analysed in the frequency range 0-20 kHz and categorised into contour types.

Preliminary results suggest 17 contour types, which is similar to the repertoire sizes of other white whale populations (range: 19-35 call types). Mean frequency for the whistle contour types ranged from 2.9-13.7 kHz; mean duration ranged from 0.14-1.96 s. Contour types differed significantly between behavioural activities. A comparison with whistles recorded from Somerset Island, Canada, in August 1995, revealed similarities in a number of relatively unmodulated contour types. Svalbard white whales also produced a number of different contour types that consisted of both a pulsed and a whistle component.

INFORMATIONAL AND MECHANICAL INTERACTIONS BETWEEN ECHOLOCATING DOLPHINS (*TURSIOPS TRUNCATUS*) AND OBJECTS AND HUMAN BEINGS AS TARGETS

S. Manoukian[1], M. Azzali[1], R. Tizzi[2]

[1]*National Research Council, Inst. Of Marine Fishery Res., 60100 Ancona, Italy*
(E-mail: elettronica@irpem.an.cnr.it)
[2]*Delfinario Rimini, Lungomare Tintori 2, 47900 Rimini, Italy (E-mail: dolphins@iper.net)*

INTRODUCTION Current opinion is that sonar signals are used by dolphins to perceive the environment. They can choose which sonar signal (click) to use to investigate a target. Dolphins can vary intensity, frequency, and bandwidth of a click, and consequently its informational content, according to the characteristics of the target. However, during the last 20 years, the work of biologists, psychologists and neurophysiologists seems to suggest that these ultrasonic pulses have some characteristics able to cause positive effects in the interaction with human beings (Cole, 1994; Nathanson, 1995; Birch, 1997). If so, by changing some physical parameters of the targets and keeping the others constant, we can observe if the dolphins actually change the way in which they use their own sonar to obtain more or less detailed information in order to recognise the object in question or, in front of human beings, to try to interact with them.

The aim of this study was to demonstrate that the acoustic behaviour of these animals is highly influenced by the characteristics of the target they ensonify. If this assumption is correct, the characteristics of dolphins' sonar pulses might considerably change according to whether the target is an inanimate object or a human being able to produce some kind of interaction. Precisely these last clicks could have some physical parameters that may cause biological, physiological and psychological effects on humans.

MATERIALS AND METHODS The subject of the study was a community of six bottlenose dolphins *Tursiops truncatus* housed in the Rimini's Dolphinarium (Table 1). Measurements of the echolocation signals were carried out, changing in each task the physical characteristics of the target that the dolphins had to ensonify (Table 2). These parameters (material and shape) had been selected in order to move gradually from objects to human beings. From objects in Plexiglas, almost completely transparent to the sight, we have moved towards objects hidden from sight inside a fibreglass blister (transparent to ultrasounds but not to sight in order to simulate the human body), to objects directly detectable to sight, till to human beings. Acoustic emissions were recorded using a Bruel & Kjaer 8105 Hydrophone, positioned at least 1 m below the water surface, a Bruel & Kjaer charge amplifier 2626, and an analogue wide band recorder (0.03 Hz - 300 kHz). Sonar signals were monitored with a digital oscilloscope HP 54520A. All the dolphins were accustomed to the presence of the hydrophone and the experimenters. The sonar signal emitted in the presence of the trainer - who sent the dolphins one by one near the target - were easily attributed to the transmitters. Instead, during the free tasks, all the animals were free-swimming and each pulse has been attributed to a dolphin using the comments registered by an operator onto the audio channel of the wide band recorder and the images from an underwater camera. All pulses of uncertain origin have been discarded. Immediately after each session, sonar pulses were digitised at an effective sampling rate of 5.12 sample per 1 μs, much higher than the Nyquist sampling rate. The feature extractor and the classifier of each set of clicks of a dolphin have been developed using MATLAB m-file language. In this study, we used two parameters extracted from the time moments, two parameters extracted from the frequency moments - as described in Azzali *et al.* (1998) - and, finally, the energetic and informational content of sonar pulses. Even though the observations have been conducted on all the six dolphins of Rimini's community, in this paper we report only the results obtained from one of the animals - the adult female named Beta - who showed the greatest responsiveness to target changes.

RESULTS Table 2 indicates all the tasks we performed during the period of research, the working conditions (with or without the trainer), and three typical parameters of sonar pulses. (All the data are averaged on the total number of clicks per task; the number of the clicks varies between some hundreds, during the free tasks, and some tens, during the tasks with the trainer. The intensity is measured at the target. The uncertainty principle is defined as the product between the mean value of the sonar pulse duration (P.D.) and bandwidth (P.E.), both calculated following Gabor. $P.D.xP.E.\geq 1/4\pi \cong 0.0796$.) Each task is represented by the click's profile and the correlated spectrum. As shown in Figure 1, Beta's wave shapes show a gradual changing of their profile while we move from objects to human beings. From the standard profiles that we observe during the tasks involving an inanimate target, they move to more complex and unusual ones in front of persons. The dolphin changes the manner in which it uses its own sonar to analyse the targets in front of it, probably because it tries to receive more adequate information necessary for their identification.

With "objects" hidden from sight (such as the cylinder in the blister or the inner structures of the human body), Beta uses a wider bandwidth that affects the value of the uncertainty principle. This "acoustic window" will allow it to receive a higher amount of information.

With respect to the intensity distribution, in most of the tasks, more than 50% of the intensity is concentrated in a 50-150 kHz frequency range, often reaching values over 80% (Table 3 and Fig. 2). In front of targets detectable at sight, a large amount of the intensity moves to a 25-50 kHz frequency range. In the presence of human beings, the situation is more complex and the intensity distribution depends on the portion of the body that the dolphin is examining. In fact, the presence of skull bones might account for the change that we can observe in intensity distribution. A large amount of the intensity is reflected from the bone structure (Figure 3); only three very thin bands - around 10 kHz, 65 kHz and 130 kHz - can easily cross over this barrier and directly interact with the central nervous system.

CONCLUSIONS The results indicate that:

1) Although each individual of Rimini's community seems to have a personal method in using the sonar, all the dolphins show more complex wave profiles with a higher informational content and a greater quantity of energy in front of human beings (Fig. 1).

2) The dolphin uses a wider "acoustic window" while it is ensonifying objects hidden from sight. This allows it to receive a greater quantity of information, but, on the other hand, at the same time by no means a negligible amount of background noises.

3) If the target is immediately perceptible through sight, or the analysis has to be performed through some thickness of material, the range of click frequencies shifts to the lower one to provide coarser information, in the first working condition, or to ensure higher penetration, in the second one (Fig. 2).

4) Finally, the dolphin seems to change its sonar behaviour according to the acoustic and biological characteristics of the different parts of the body. Lower frequencies are usually used for soft tissue such as the belly - that present a smaller attenuation coefficient α - and higher frequencies for bones such as in the head and legs - with a higher α. Instead of an insuperable barrier, the human skull could function like a filter: it allows the complete transmission of three critical bands around 10 kHz, 65 kHz and 130 kHz that could directly interact with the central nervous system (Fig. 3).

ACKNOWLEDGEMENTS The authors acknowledge the support provided by the staff of Rimini's dolphinarium.

REFERENCES

Azzali, M., Garbati, P. and Impetuoso, A. 1998. Similarity among sonar signals collected from small communities of dolphins (*Tursiops truncatus*). Pp. 247-255. In: *Proceedings of the Fourth European Conference on Underwater Acoustics* vol. 1. (Eds. A. Alippi and G. B. Cannelli). CNR- IDAC, Rome, Italy.

Birch, S. 1997. *Dolphin-Human interaction effects.* (Ed. by Bioelectronics Group, Dept. Of Electrical & Computer Systems Engineering). Monash University, Caulfield Campus, Melbourne, Australia. http://web.access.net.au/%7Ediverse/interspecies/Reports.htmd/dol-hum.html

Cole, D. M. 1995. Neuro-electrical effects of human-dolphin interaction and Sono-Chemical Hypotheses. *First International Symposium on Dolphin Assisted Therapy, Cancun Mexico, 8-10 September, 1995,* http://www.aquathought.com/idatra/symposium/95

Nathanson, D. 1995. Dolphin Human Therapy: A professional association dedicated to helping disabled children. *First International Symposium on Dolphin Assisted Therapy, Cancun Mexico, 8-10 September, 1995,* http://www.aquathought.com/idatra/symposium/95

Table 1 – Bottlenose dolphins (*Tursiops truncatus*) housed in the Rimini delphinarium

Name	Sex	Birth Date	Provenience	Residence in captivity
Speedy	M	1970	Adriatic Sea	17 years
Alfa	F	1979	Gulf of Mexico	9 years
Beta	F	1981	Gulf of Mexico	9 years
Sole	M	05/03/1993	Rimini Delphinarium	captive-born (Alfa x Speedy)
Luna	F	05/12/1995	Rimini Delphinarium	captive-born (Alfa x Speedy)
Blue	F	26/06/1997	Rimini Delphinarium	captive-born (Beta x Speedy)

Table 2 - The different tasks with their working condition and three typical parameters of the sonar pulses

N° OF TASK	TARGET	WORKING CONDITIONS	CLICK INTENSITY (W/m²)	UNCERTAINTY PRINCIPLE	GABOR BANDWIDTH (kHz)
1	Copper sfere	With trainer	27.412	0,2	22,2
2	Only hydrophone	Free task	16.651	0,2	35,3
3	Plexiglas cylinder	With trainer	15.041	0,2	35,7
4	Plexiglas sfere	With trainer	23.078	0,2	38,6
5	Plexiglas cylinder within the fiberglass blister	With trainer	2.512	0,4	41,8
6	Child with hydrophone on the leg	Free task	**20.884**	**0,4**	**34,5**
7	Adult human being with hydrophone on the belly	Free task	**9.103**	**1,0**	**66,3**
8	Adult human being with hydrophone on the head	Free task	**33.540**	**0,8**	**53,4**

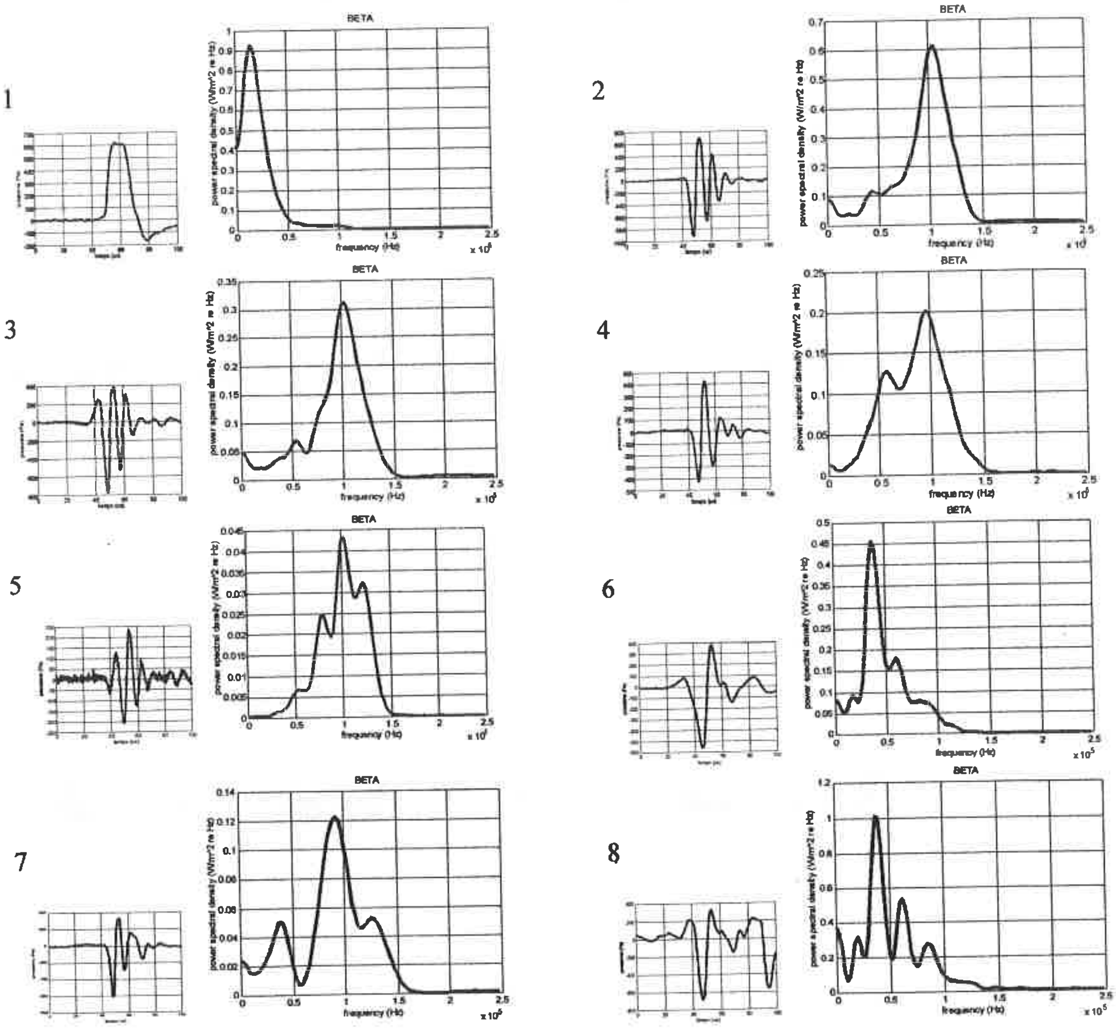


Fig. 1 - Sonar pulses' profiles and spectra of Beta for each task

Table 3 - Intensity distribution measured at the target for the different tasks

N° OF TASK	TARGET	% of Intensity within the range 0-25 kHz and >6.0 cm	% of Intensity within the range 25-50 kHz and 3.0-6.0 cm	% of Intensity within the range 50-150 kHz and 1.0-3.0 cm
1	Copper sfere	57,23	35,78	6,81
2	Only hydrophone	1,24	4,37	93,87
3	Plexiglas cylinder	0,77	7,14	91,42
4	Plexiglas sfere	0,94	14,06	84,67
5	Plexiglas cylinder within the fiberglass blister	0,15	2,23	94,97
6	Child with hydrophone on the leg	**14,21**	**43,56**	**41,84**
7	Adult human being with hydrophone on the belly	**10,06**	**70,48**	**16,26**
8	Adult human being with hydrophone on the head	**17,87**	**37,46**	**47,23**

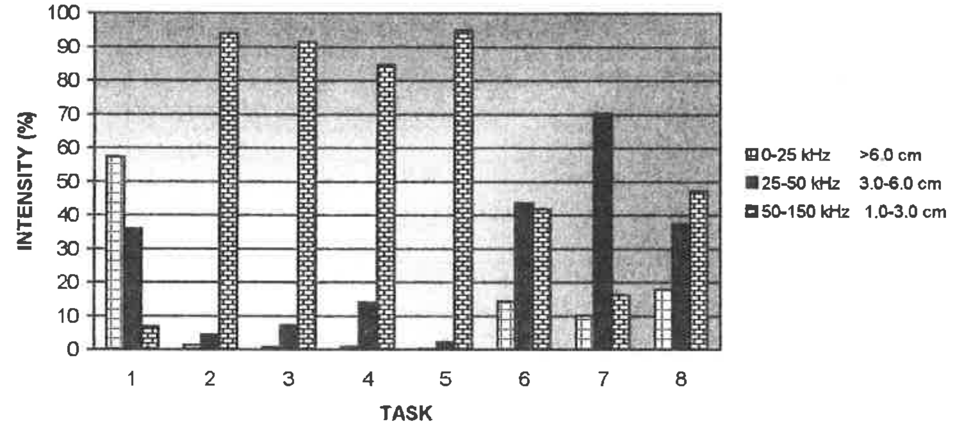
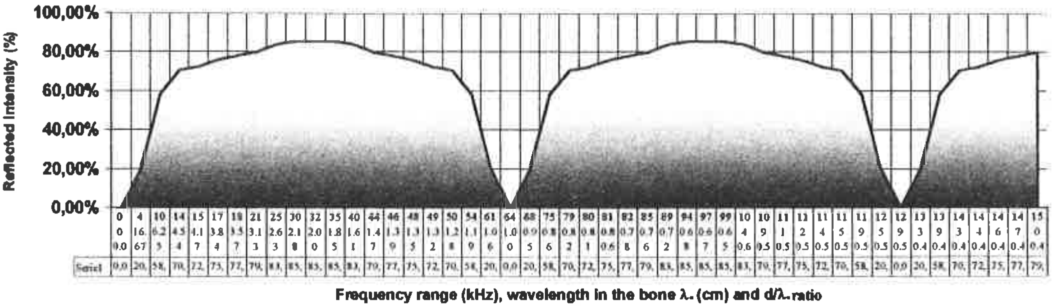
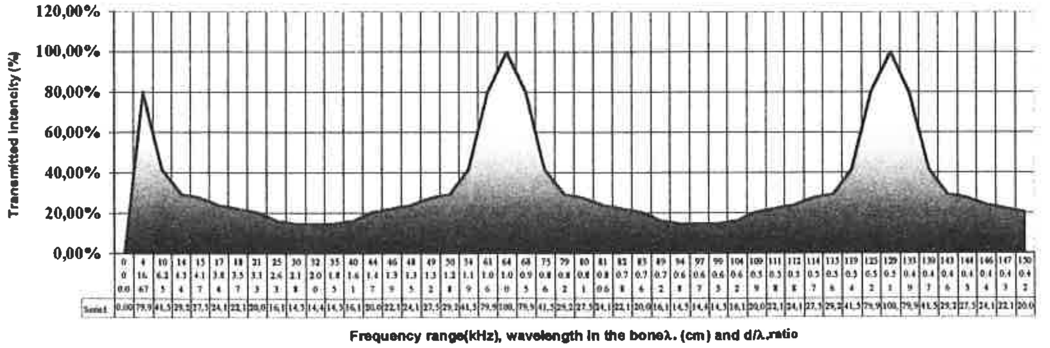


Fig. 2 - Intensity distribution measured at the target



REFLECTED INTENSITY (%)



TRANSMITTED INTENSITY (%)

Fig. 3 - Interaction between the sonar pulses and the human skull. Reflected (on the top) and transmitted (on the bottom) intensities (%) have been calculated using water impedance (about $1.54 \times 10^5 g/cm^2 s$), bone impedance (about $7.80 \times 10^5 g/cm^2 s$) and the thick *d* of the human skull (about 0.5cm).

VARIABILITY OF TEMPORAL AND SPECTRAL CLICK CHARACTERISTICS OF SPERM WHALES (*PHYSETER MACROCEPHALUS*)

V. Teloni[1], W. M. X. Zimmer[2], C.Fossati[1], M.Manghi[1], G.Pavan[1,3], M. Priano[1]

[1]*Universita' di Pavia, V.le Taramelly 24, 27100 Pavia, Italy (E-mail: vteloni@cibra.unipv.it)*
[2]*Saclant Undersea Research Centre, V.le San Bartolomeo 400, 19138 La Spezia, Italy*
[3]*Dipartimento di Urbanistica, IUAV, Ca' Tron, Santa Croce 1957, 30135 Venezia, Italy*

INTRODUCTION Sperm whales, while deep diving, are known to produce loud, impulsive or transient-like sounds at various repetition rates. In the last few years, CIBRA (Centro Interdisciplinare di Bioacustica e Ricerche Ambientali) of the University of Pavia has carried out several research cruises in the Mediterranean Sea, and has collected acoustic data during multiple dive cycles of sperm whales. For four photo-identified individuals, a total of more than 33 hours of acoustic tracking has been analysed to determine the variability of their click characteristics. All data sets were recorded in deep water with bottom depth exceeding 900 m.

MATERIALS AND METHODS An automatic Real Time Click Detector was developed to analyse the data. First, the data are normalised with respect to the background spectrum to enable the detection of clicks independent of their spectral content. The detection algorithm takes this normalised signal as input and sequentially decides the presence or absence of a transient signal. The method applied is called the Sequential Probability Ratio Test and provides as output the start and stop time of each possible sperm whale click (Abraham, 2000). In a separated step, the individual detection is classified interactively as sperm whale clicks, bottom echoes, or false alarms. The basic criterion for this classification is that the Inter Click Interval (ICI) behaves in a regular and predictable way, at least over short time periods. As usual, the ICI is defined by the time separation between the onset of two consecutive clicks. Currently, the detection algorithm is limited to strong and somewhat slow sperm whale clicks, so called "regular clicks". The algorithm will be modified in the future to detect weak and fast sperm whale 'creaks'.

RESULTS To compare the sperm whale click characteristics among the four different individuals, a complete dive cycle was selected for each and analysed in more detail.

Inter Click Interval The ICI as function of dive time for each of the four sperm whales is compared in Fig. 1. Common to all four individuals is that their click patterns start off very deterministically with small variations from a general trend, followed, after a couple of minutes, by larger variations around a 'mean' ICI value. This indicates that at the beginning of a dive, where we expect the animals to dive downwards, they have no need to vary the click sequence randomly, but follow a more deterministic click scheme. Whether this click scheme is pre-programmed or environmentally dependent cannot be deduced from these limited sets of data. For example, while all four sperm whales show a different initial click pattern, only the click scheme of individual SW0695 clearly indicates a decreasing ICI while the animal dives downwards and approaches the bottom.

To describe the statistics of the Inter Click Interval, histograms of the ICI and its variation are compared. The histograms of the ICI (Fig. 2, left side), confirm that the overall variation of the ICI is significant and may not be symmetric around a most likely ICI value. In particular, the histograms for individuals SW0994 and SW0695 indicate the presence of more than one peak or 'preferred' ICI. The histograms of the time difference between consecutive Inter Click Intervals (Fig. 2, right side) describe the relative variation of the ICI. All histograms show maximal values around zero indicating that the probability of two consecutive ICI values being equal is very high (André and Kamminga, 1999). Since the histograms are symmetric around zero, one may further deduce that the number of situations where the ICI is increasing in time is equal to the number where the ICI is decreasing. The interpretation of these observations is clear: while in the long term, there are wide variations possible, in the short term, all individuals click at some almost constant rate. This is consistent with the description of the term 'regular sperm whale click' and may be used as its definition.

Inter Pulse Interval To analyse the Inter Pulse Interval (IPI) as a function of dive time, all detected sperm whale clicks were processed with a Cepstrum technique (Pavan *et al.*, 1997; Goold, 1996). Fig. 3 shows the delay of various pulse arrivals within each click for all clicks made during a single dive of individual SW0697. Clearly visible as a strong decreasing line is the time difference between a sperm whale click and the echo from the surface, which depends on the depth of the receiving hydrophone, the depth of the sperm whale, and their relative distance. The horizontal line at 6.3 milli-seconds corresponds to the IPI, which is fairly constant over the whole dive and very weak. When investigating the Cepstrum carefully, one recognises some random peaks or high values before the IPI value. This indicates that the IPI is really the upper boundary of what looks like a set of very weak peaks. This is consistent with the general understanding that the IPI is generated by internal reflections of the frontal sac, and therefore measures the size of the sperm whale head, but there may be other pulses between the primary pulse and the reflection from the frontal sac. (Norris and Harvey, 1972; Gordon, 1991; Goold and Jones, 1995).

Fig. 4 compares the results from the Cepstrum analysis for all four individuals. On the left side is a zoom of the Cepstrum analysis around the IPI presented as intensity plot and on the right side is the corresponding average value. The weak peaks in the averages correspond to the IPI values of the different animals. This figure confirms that the IPI is not always easy to measure and only indicates an upper limit to the possible internal reflections of the primary pulse.

SUMMARY The variation of the Inter Click Interval and the Inter Pulse Interval have been analysed for four different sperm whales. During the dive, the ICI obeys two different schemes. In the first phase, while the animal is diving downwards and approaches the bottom, the ICI is very regular and more deterministic. In the second phase, while the animal is foraging, irregular sequences and large variations characterise the ICI scheme. However, in the short term the ICI is always predictable, i.e. changes of click interval are usually small and vary continuously.

The IPI is constant over the entire dive and may be considered a characteristic of the individual animal. Also, the presence of random reflections before the IPI indicates that the complex structure of sperm whale clicks is not completely understood

ACKNOWLEDGEMENTS The CIBRA work is in part supported by ONR Grant N00014-99-1-0709.

REFERENCES

Abraham, D. A. 2000. *Passive Acoustic Detection of Marine Mammals*. SM-351, SACLANT Undersea Research Centre, La Spezia, Italy.

André, M. and Kamminga, C. 1999. Rhythmic dimension in sperm whale echolocation click trains: identification and communication? Pp. 226-234. In: *European Research on Cetaceans - 13*. Proc. 13th Ann.Conf. ECS, Valencia,Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Clarke, M. R. 1978. Structure and proportions of the spermaceti organ in the sperm whale. *J. Mar. Biol. Ass. UK*, 58: 1-17.

Goold J. C. and Jones S. E., 1995. Time and frequency domain characteristics of sperm whale clicks. *J. Acoust. Soc. Am.*, 98(3): 1279-1291.

Goold J. C., 1996. Signal processing techniques for acoustic measurement of sperm whale body lengths. *J. Acoust. Soc. Am.*, 100 (5): 3431-3441.

Goold J. C., Bennell J. D., and Jones S. E., 1996. Sound velocity measurements in spermaceti oil under the combined influences of temperature and pressure. *Deep-Sea Research J.*, 43(7): 961-969.

Gordon, J. C. D. 1991. Evaluation of a method for determining the length of sperm whales *Physeter catodon* from their vocalizations, *J. Zool.*, London, 224: 310-314.

Norris, K. S. and Harvey, G. W., 1972. A theory of the function of the spermaceti organ of the sperm whale *Physeter catodon*. Pp. 397-417. In: *Individual Orientation and Navigation* (Eds. S. R. Galler, K. Schmidt Koenig, G. J. Jacobs and R. E. Belleville), NASA Spec. Publ. 262.

Pavan, G., Priano, M., Manghi, M., and Fossati, C., 1997. Software tools for real-time IPI measurements on sperm whale sounds. *Proc. Underwater Bio-Sonar and Bioacoustics Symposium. Proc. I.O.A.*, 19 (Pt 9), Loughborough, UK: 157-164.

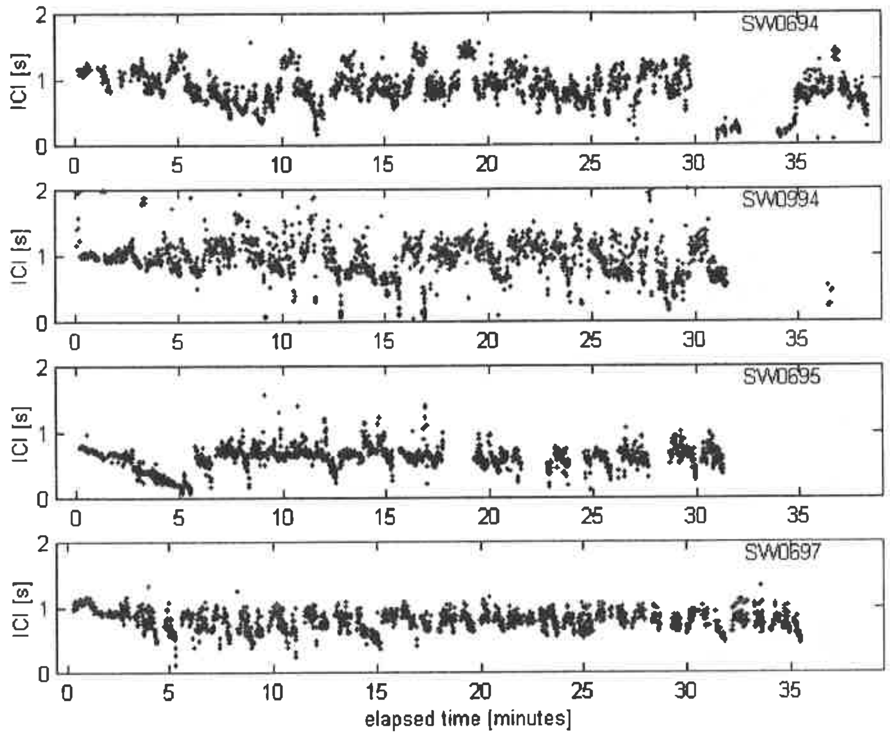


Fig. 1: Inter Click Interval values as function of dive time. For each of the analysed data sets a single complete dive has been selected

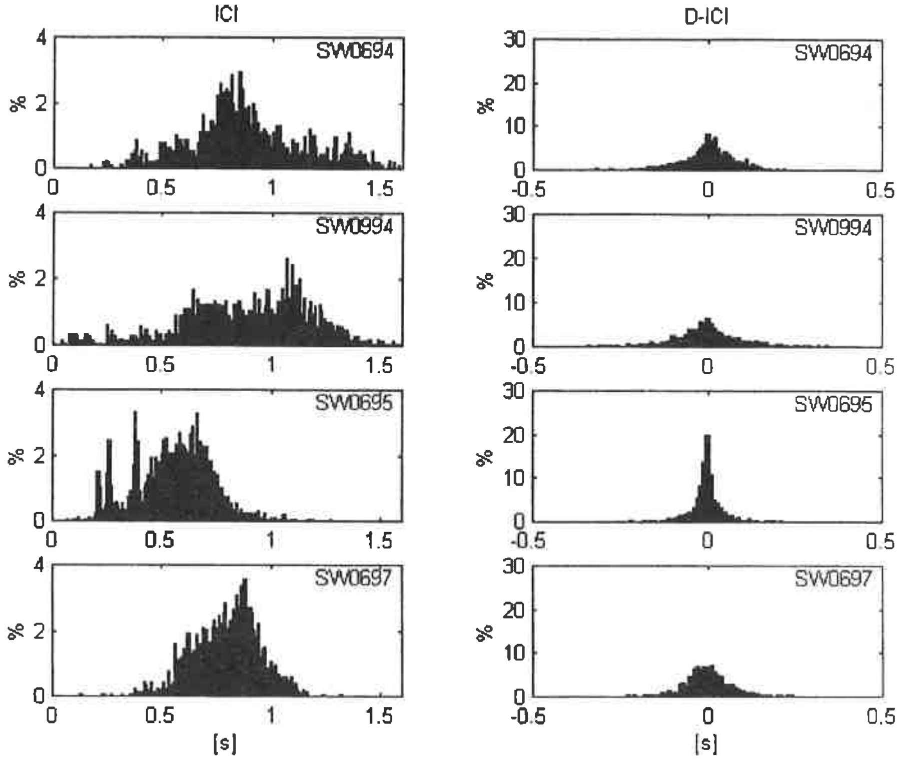


Fig. 2: Inter Click Interval statistics for all four sperm whales. The left side shows the histograms of all ICI values for the selected dive. The right side shows histograms of the variation of the ICI during the dive

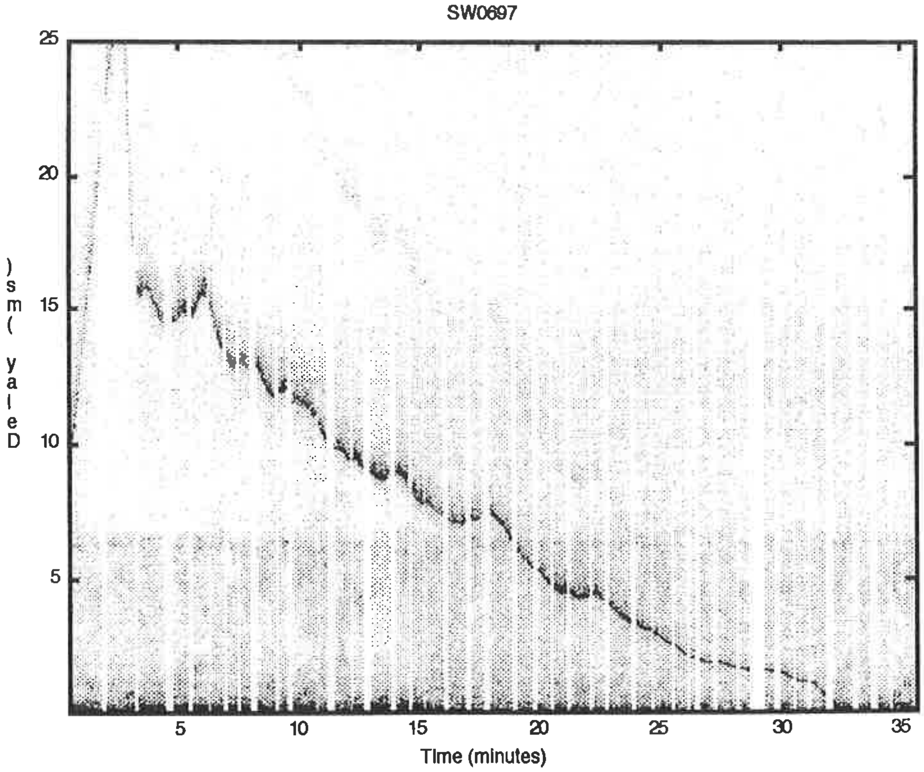


Fig. 3: Cepstrum analysis for individual SW0697 as function of dive time

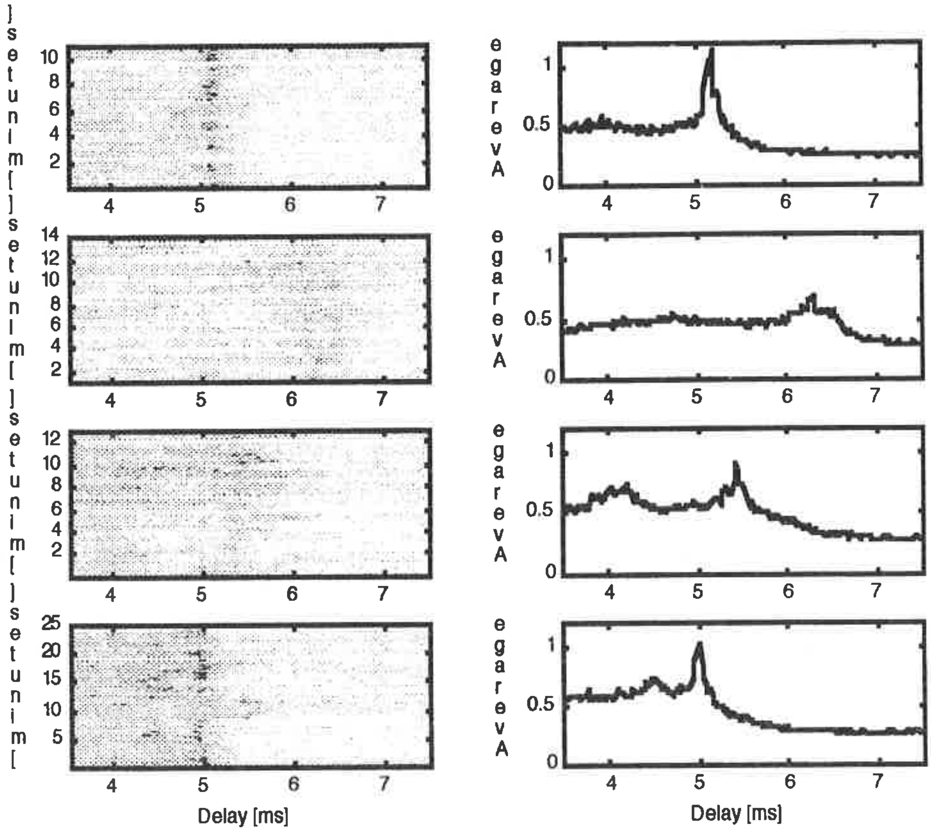


Fig. 4: Inter Pulse Interval Comparison. The left side show the results from the Cepstrum analysis around the IPI. The right side show the corresponding average values

USING ECHOES IN ORIENTATION
WHY ARE ODONTOCETES AND BATS SOMETHING SPECIAL?

Jakob Tougaard

Centre for Sound Communication, Odense University, Denmark (E-mail: jakob.t@biology.sdu.dk)

INTRODUCTION Toothed whales (Odontoceti) are, together with microchiropteran bats, famed for their echolocation abilities. Other terrestrial vertebrates, such as the megachiropteran bats of the genus *Rousettus*, and some birds such as the oilbird (*Steatornis caripensis*) are known to have echolocation abilities as well. From time to time, it has been suggested that marine mammals other than odontocetes may possess echolocation abilities also. A comparison of the two most advanced systems (bats and odontocetes) may reveal common specialisations. This knowledge should be useful for evaluating echolocation in other animals.

Echolocation The auditory system of mammals and birds can be said to be pre-adapted to echolocation, since these systems in general possess several features necessary for orientation using echoes. An important role of the auditory system is to passively acquire information about the surroundings based on sound from close and distant sources. From the partial degradation of the signals through attenuation and multipath reflections, the listener can gain much knowledge about the surroundings. This process is referred to as *auditory scene analysis* (Bregman, 1990) or passive sonar (Urick, 1983). From this passive system there is only a small step to the deliberate production of sounds for generating echoes. Crude orientation is possible as demonstrated by humans navigating and avoiding large obstacles in complete darkness simply by listening to the echoes of their own footsteps or clapping hands. This form of navigation is echolocation in its broadest sense and conforms with the use of the term by Donald Griffin, who introduced the word (Griffin, 1958). For a more restricted definition of echolocation, see Schusterman *et al.* (2000). This crude form of echolocation is a good starting point for the evolution of more advanced systems, as seen in the animals we normally refer to as echolocators. These animals use signals better suited for the task, and often have modifications of the sound emitting and receiving structures.

Comparison between odontocetes and bats What we might call a true biosonar is present in odontocetes and microchiropteran bats. These biosonars allow for navigation and foraging without the aid of other sensory modalities. Both systems are characterised by a number of specialised adaptations. Some of these specialisations are related to sound production and hearing in air or water (medium-specific), whereas others are related to the sonar itself (sonar specific). The latter may be identified by comparing the two independently evolved systems, one from air and one from water. These adaptations are likely to be general, and knowledge of these can thus be helpful when judging whether a given (third) group of animals possess biosonar capabilities comparable to that of odontocetes and microbats. The adaptations are divided into three categories: the sonar signals, hearing, and sound production.

SONAR SIGNALS Sonar signals needs to fulfil certain basic requirements in order to be useful. Their wavelength should be of comparable size or shorter than the dimensions of the objects of interest in order to generate sufficiently strong echoes. The signals should be sufficiently intense in order to overcome transmission loss through the medium, and thus generate audible echoes from objects at relatively long distances. Finally, signals should have a time-frequency structure that allows for reliable timing of the signal relative to the echo, making measurements of target distance possible. Bat and odontocete signals share these features to varying degrees (Table 1). The clicks of odontocetes are optimally suited for both ranging (short duration) and detection (high intensity). Bats on the other hand are likely to be limited in detection because constraints of the medium (air) reduce the physically possible source levels below the optimal. They may have compensated for this by increasing the duration of the signals (increasing the signal *energy*) while maintaining temporal resolution by means of a frequency modulation of the signal. Bats generally also have a larger repertoire of signal types, using longer narrowband signals for detection and shorter broadband signals for ranging. Odontocetes on the other hand have generally very stereotyped sonar signals.

HEARING The hearing of bats and odontocetes does not differ drastically from that of other mammals in most respects, such as absolute sensitivity, frequency discrimination, critical bandwidths, etc. On one central point, however, is a radical difference seen between bats and dolphins on the one hand, and mammals in general on the other. This is temporal processing. Here is seen what is probably the single most important biosonar adaptation in the auditory system: the ability to accurately measure the delay between sound emission and return of the echo.

Brainstem/midbrain anatomy Both the inferior colliculus and the lateral lemniscus are greatly hypertrophied in odontocetes and microbats. This is significant, since especially the nuclei of the lateral lemniscus plays a central role in temporal processing of sounds. Bats have a separate sub-division of cells in the lateral lemniscus for extraordinary precise coding of stimulus arrival time (Covey and Casseday, 1991). Odontocetes seem to have a similar sub-division, although only described anatomically (Zook *et al.*, 1988).

Temporal processing Bats and dolphins display a remarkable form of temporal integration for echolocation stimuli. Two or more signals arriving within a critical time window are apparently completely summated and both contribute to detection. Other signals arriving outside this interval are ignored, or at least play no role in determining detection thresholds. This integration time is around 260 ms in bottlenose dolphins (Au *et al.*, 1988); and ranges from 220 ms in the false vampire bat, *Megaderma lyra* (Wiegrebe and Schmidt, 1996) to 2.4 ms in the big brown bat, *Eptesicus fuscus* (Surlykke and Bojesen, 1996). This form of integration is in contrast to humans where the second click of a pair always adds to the detectability of the signal, independent of click separation (Viemeister and Wakefield, 1991). The role of this form of temporal processing is not clear. It could be imagined, however, that this would act as a form of temporal filter allowing the animal to focus attention on a single echo and ignore echoes arriving later, thus exploiting the unique *a priori* knowledge of the received signal that an active echolocator has.

SOUND PRODUCTION The mechanisms of sound production in bats and cetaceans are entirely different. These differences, however, are likely to have their origin in differences in the media. What they share is the ability to efficiently produce high intensity sounds and radiate them with high directionality out in front of the animal.

Cetaceans The sounds are produced in the nasal plug complex and radiated out through the melon, a unique lipid-filled structure only found in odontocetes. The main function of the melon is believed to be impedance matching to the aqueous medium (Au, 1993). The highly complex sound generation apparatus probably reflects the difficulties of producing series of short, high-intensity sounds in water.

Micro-bats The sounds are produced in the larynx as in mammals in general, and radiated out through either the mouth (e.g. Vespertillionidae) or the nose (e.g. Rhinolophidae).

EXCEPTIONS No rules come without exceptions and there are important ones to the general picture described above.

Porpoises (family Phocoenidae) and dolphins of the genus *Cephalorhynchus* These small odontocetes share several unique features. Compared to other odontocetes, their signals are extremely narrowband, generally of high frequency and with substantially lower source levels than the odontocetes (Fig. 1). Not only do these two groups share many similarities in their signals, their morphology and biology are also remarkably similar. It is not clear, however, why they produce such different signals, but it is tempting to relate this to their specialised lifestyle: They are the most coastal of odontocetes and feed near the bottom often in shallow waters. The biosonar of an odontocete feeding close to the bottom is likely to be limited by background clutter echoes rather than by the background noise, as are sonars in open water (Urick, 1983). Increases in the source level do not help improve the signal to clutter ratio since clutter increases with the source level as well and there is thus little selective pressure on these animals to use high intensity signals. The animals may instead have resorted to using narrow bandwidth signals, which, associated with as yet undescribed narrow auditory filters, could overcome the loss in sensitivity caused by the lower source level.

Gleaning bats and horseshoe bats Bats, which hunt for prey hovering above the ground or in front of the vegetation, face similar clutter problems as the porpoises and the Cephalorynchid dolphins. Their sounds are also comparatively less intense than arial hawking bats (Neuweiler, 1990). Many gleaning bats seem to have overcome the clutter problem by resorting to passive listening for prey generated sounds. An extreme specialisation to clutter is seen in the horseshoe bats (*Pteronotus parnellii* and genus *Rhinolophus*). They use unusually long sonar signals, and have divided the signal into two functionally separate parts. The main part is a long part of extremely constant frequency, which serves the purpose of determining velocity of targets, through a measurement of the Doppler shift of the returning echo. At the end of the signal a "traditional" downward FM-sweep is added, used for timing and hence target distance assessment.

Changes prompted by prey reactions Echolocating bats are faced with a counter-pressure on the design of their signals, due to the fact that many of their insect prey can hear the bat's echolocation signals (see Miller and Surlykke, 2000, for review). Some bats seem to overcome this problem, at least partially, by decreasing the intensity of their signals. Although the bat suffers by a decreased detection distance, the loss in detection distance for the insect is larger and a decrease in source level is thus still beneficial to the bat in relative terms (Surlykke, 1988). Although it has been demonstrated that some fishes are able to detect odontocete sonar signals (Astrup and Møhl, 1993; Mann *et al.*, 1998), the nature of the possible predator-prey interactions is not known, and it is not clear whether similar selection pressures as in the bat-moth system are operating. See Astrup (1999) for a discussion of this topic.

CONCLUSION Odontocete whales and microchiropteran bats share several unique features in their auditory and vocal systems, providing adaptations for efficient sonar systems. These features can be considered a checklist for judging whether a given animal possesses echolocation capabilities matching a true biosonar. None of the other groups of known echolocators seem to fulfil these criteria and neither do some of the groups, which from time to time have been suggested to posses echolocation abilities, such as baleen whales, seals and penguins (e.g. Poulter, 1963; Renouf and Davis, 1982). While these groups may use simpler forms of echolocation in orientation, it seems unlikely that they possess true biosonar capabilities comparable to that of cetaceans and bats.

ACKNOWLEDGEMENTS This work was supported by the Danish National Research Foundation, Centre for Sound Communication.

REFERENCES

Astrup, J. and Møhl, B. 1993. Detection of intense ultrasound by the cod *Gadus morhua*. *J. Exp. Biol.*, 182: 71-80.

Astrup, J. 1999. Ultrasound detection in fish - a parallel to the sonar-mediated detection of bats by ultrasound-sensitive insects? *Comp. Biochem. Physiol., A* 124: 19-27.

Au, W. W. L. 1993. *The sonar of dolphins*. Springer Verlag, New York. 277pp.

Au, W. W. L., Moore, P. W. B. and Pawloski, D. A. 1988. Detection of complex echoes in noise by an echolocating dolphin. *J. Acoust. Soc. Am.*, 83: 662-668.

Bregman, A. S. 1990. Auditory scene analysis. Perceptual organization of sound. MIT press, Cambridge. 792pp.

Covey, E. and Casseday, J. H. 1991. The monaural nuclei of the lateral lemniscus in an echolocation bat: parallel pathways for analyzing temporal features of sound. *J. Neurosci.*, 11: 3456-3470.

Griffin, D. R. 1958. *Listening in the dark*. Yale University Press, New York. 413pp.

Mann, D. A., Lu, Z., Hastings, M. C. and Popper, A. N. 1998. Detection of ultrasonic tones and simulated dolphin echolocation clicks by a teleost fish, the American shad (*Alosa sapidissima*). *J. Acoust. Soc. Am.*, 104: 562-568.

Miller, L. A. and Surlykke, A. 2000. How some insects detect and avoid being eaten by bats. The tactics and counter tactics of prey and predator. *BioScience* (in press).

Neuweiler, G. 1990. Auditory adaptations for prey capture in echolocating bats. *Physiol. Rev.*, 70: 615-641.

Poulter, T. C. 1963. Sonar signals of the sea lion. *Science*, 139: 753-755.

Renouf, D. and Davis, M. B. 1982. Evidence that seals may use echolocation. *Nature*, 300: 635-637.

Schusterman, R. J., Kastak, D., Levenson, D. H., Reichmuth, C. J. and Southall, B. L. 2000. Why pinnipeds don't echolocate. *J. Acoust. Soc. Am.*, 107: 2256-2264.

Surlykke, A. 1988. Interaction between echolocating bats and their prey. Pp. 551-566. In: *Animal sonar. Processes and performance*. (Eds. P. E. Nachtigall and P. W. B. Moore) Plenum Press, New York. 862pp.

Surlykke, A. and Bojesen, O. 1996. Integration time for short broad band clicks in echolocating FM-bats (*Eptesicus fuscus*). *J. Comp. Physiol. A*, 178: 235-241.

Urick, R. J. 1983. Principles of underwater sound. McGraw-Hill, New York. 423pp.

Viemeister, N. F. and Wakefield, G. H. 1991. Temporal integration and multiple looks. *J. Acoust. Soc. Am.*, 90: 858-865.

Wiegrebe, L. and Schmidt, S. 1996. Temporal integration in the echolocating bat, *Megaderma lyra. Hear. Res.*, 102: 35-42.

Zook, J. M., Jacobs, M. S., Glezer, I. and Morgane, P. J. 1988. Some comparative aspects of auditory brainstem cytoarchitecture in echolocating animals: Speculations on the morphological basis of time-domain signal processing. Pp. 311-316. In: *Animal sonar. Processes and performance.* (Eds. P. E. Nachtigall and P. W. B. Moore) Plenum Press, New York. 862pp.

Table 1. Comparison of general characteristics of bat and odontocete sonar signals.

	Odontocetes	Micro-bats
Intensity	Very high (>220 dB re. 1mPa; >5000 W/m^2 at 1m)	High (>100 dB re. 20 mPa; >0.01 W/m^2 at 1m)
Directivity	Very high (–3dB beamwidth 10°–15° or better)[1]	High (–3 dB beamwidth 20°–40°)[2]
Frequency	High (10–150 kHz) Most often broadband	High (10–200 kHz) Narrowband or broadband
Time/frequency structure	Very short duration signals, (50-200 ms) Very stereotypical within species	Short duration signals (1 -20 ms) Highly regular FM-sweeps, constant frequency signal or both) Signals vary considerably

Notes: 1) Hartley, D. J. 1992. *J. Acoust. Soc. Am.*, 91: 1120-1132.
2) Au, W.W.L. 1993. The sonar of dolphins, Springer Verlag, New York.

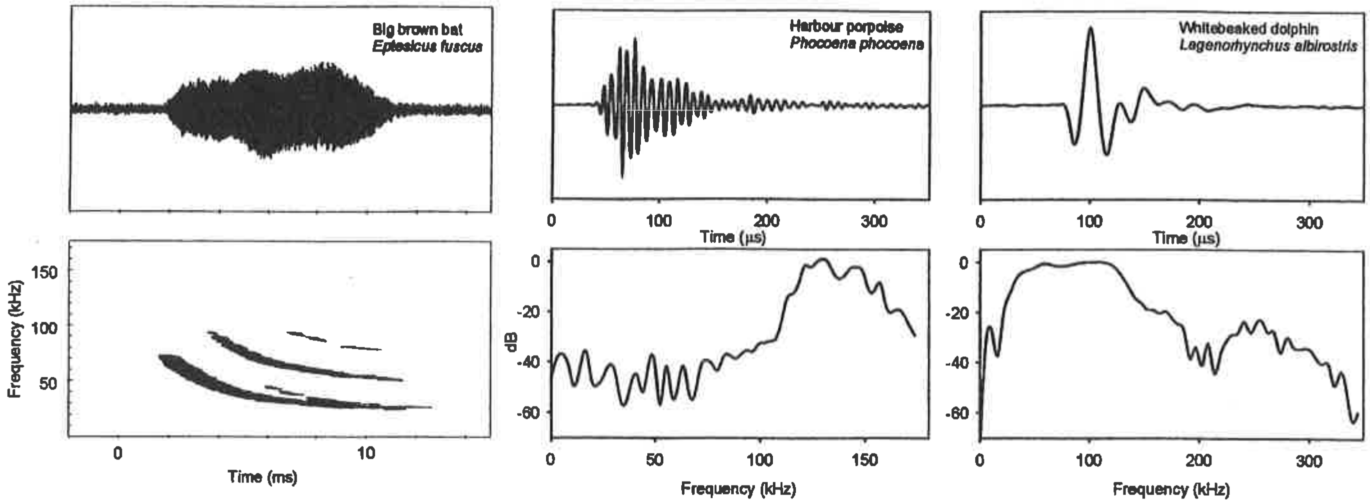


Figure 1. Sonar signals of the big brown bat (left), harbour porpoise (middle) and whitebeaked dolphin (right). Top row shows signals, bottom row shows spectrogram (bat; FFT size 512, Hann window) or powerspectra (odontocetes) of the signals. Bat signal courtesy of Lee A. Miller. White-beaked dolphin signal courtesy of Marianne Rasmussen.

FISH CATCH AND ECHOLOCATION BEHAVIOUR OF THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*)

U. V. Verfuss[1,2,3], L. A. Miller[2] and H.-U. Schnitzler[3]

[1]*Fjord & Belt Centre, Margrethes Plads 1, 5300 Kerteminde, Denmark, Germany*
[2]*Center for Sound Communication, Odense University, 55, Campusvej, 5230 Odense, Denmark*
[3]*Dept. of Animal Physiology, University of Tuebingen, Auf der Morgenstelle 28, 72076 Tuebingen, Germany*

This study concerns the echolocation behaviour of harbour porpoises (*Phocoena phocoena*) when catching fish. Hopefully, a better knowledge of their echolocation behaviour will assist in finding ways of reducing by-catch. Synchronised video and high frequency sound recordings of porpoises during prey capture were made under controlled conditions in low and high clutter environments. The behaviour was correlated with the sound production. Two video cameras allowed for three-dimensional reconstruction of the catch, showing predator/prey interaction. The experiments were conducted with two trained porpoises kept in a semi-natural environment at the Fjord & Belt Centre, Denmark.

Click trains produced in low cluttered environment show at least two different stages: a 'far stage', in which the porpoise approaches the fish up to around 1 m, followed by a 'near stage', where the porpoise closes on the prey. In the beginning of the 'far stage' the click interval is rather variable around 80 ms. As the porpoise approaches the target, the click interval decreases to around 50 ms. The decrease is linear with distance in most cases, which indicates range locking behaviour. During 'near stage', the click interval decreases rapidly to around 1.5 ms, where it can be stable over more than one hundred clicks. The behaviour and echolocation pattern indicate that the porpoises focus on their prey, especially within the last metere before capturing the fish.

We thank the following organisations and people for their co-operation, assistance, suggestions and financial support: the Fjord & Belt Centre, especially the trainers Sabrina Labberté and Kirstin Anderson, Dr. Geneviève Desportes, Dr. Mats Amundin, Deutscher Akademischer Austauschdienst e.V., Bundesamt für den Naturschutz, Stiftung Landesgirokasse Stuttgart, Gesellschaft zum Schutz der Meeressäugetiere e.V., Deutsche Umwelthilfe, and the Danish National Research Foundation.

BEHAVIOUR

EVIDENCE OF VIOLENT INTERACTIONS BETWEEN BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) AND OTHER CETACEAN SPECIES IN NW SPAIN

J. M. Alonso[1], A López[1, 2], A. F González[1], and M. B. Santos[3]

[1]*Instituto de Investigaciones Marinas-CSIC, c/ Eduardo Cabello, 6, 36208, Vigo, Spain (E-mail: jmalonso@iim.csic.es)*
[2]*Coordinadora para o Estudio dos Mamíferos Mariños, CEMMA, Apdo. 156, 36380, Gondomar, Spain (E-mail: cemma@arrakis.es)*
[3]*University of Aberdeen, Department of Zoology, Tillydrone Avenue, Aberdeen AB24 2TN, UK (E-mail: m.b.santos@abdn.ac.uk)*

INTRODUCTION Violent interactions between cetacean species have been described poorly (Dufalt and Whitehead, 1995), and mainly report attacks of bottlenose dolphins on harbour porpoises (Ross and Wilson, 1996, Jepson and Baker, 1998). The bottlenose dolphin inhabits the coastal waters of Galicia and shares this habitat with 13 other cetacean species. This paper describes the first evidence of bottlenose dolphin attacks on harbour porpoise on the Galician coast, and the first example of such attacks on a striped dolphin.

MATERIALS AND METHODS All cetaceans stranded in the Galician coast (NW Spain) were studied by the technical staff of the Instituto de Investigaciones Marinas (IIM-CSIC) and CEMMA following the protocols of Kuiken and Garcia-Hartmann, (1991). Only cetaceans in stages from 1 to 3 were considered to evaluate inter-species interactions. The total number of cetaceans observed was 212 (20% of the total number). Skin wounds produced by bottlenose dolphin tooth-rakes are evaluated according to Lockyer and Morris, (1990). Internal damage produced by bottlenose dolphin attacks are evaluated according to a modification of the guide made by Jepson and Baker (1998).

RESULTS Traumatic injuries showing signs of violent interactions were present in five stranded specimens from four cetacean species (Fig. 1): two harbour porpoises (*Phoconea phocoena*), one common dolphin (*Delphinus delphis*), one striped dolphin (*Stenella coeruleoalba*), and one humpback whale calf (*Megaptera novaeangliae*).

All of them had teeth marks in the skin corresponding to the size and spacing of bottlenose dolphin (*Tursiops truncatus*) teeth. In two cases, these marks were accompanied by important internal damage. These lesions most likely caused the death of the animals. Marks of bottlenose dolphin teeth on the tail stocks and the flippers of a common dolphin, a second harbour porpoise, and the humpback whale calf were not accompanied by internal damage.

DISCUSSION AND CONCLUSIONS Tooth marks on the tail stocks and the flippers are often caused by members of the same species while trying to keep a sick member of the group afloat. Explanation for the violent attacks between the bottlenose dolphins and other cetacean species described remains unclear. This is the first evidence of such attacks on the Galician coast and the first example of an attack on a striped dolphin.

REFERENCES

Dufault, S. and Whitehead, H. 1995. An assessment of changes with the tissue in the marking patterns used for photo-identification of individual sperm whales. *Mar. Mamm.Sci.*, 11(3): 335-343.

Ross, H. M. and Wilson, B. 1996. Violent interactions between bottlenose dolphins and harbour porpises. *Proc. Roy. Soc.* London, 263: 283-286.

Jepson, P. D. and Baker, J. R. 1998. Bottlenose dolphins *(T. truncatus)* as a possible cause of acute traumatic injuries in porpoises (*P. phocoena*).*Vet.Rec.*, Nov 28, 1998.

Kuiken, T. and Garcia-Hartmann, M. 1991. Cetacean Pathology: Dissection techniques and tissue sampling. Proceedings of the first ECS workshop, ECS Newsletter, No. 17 (special issue): 1-39pp.

Lockyer, C. H. and Morris, R. J. 1990. Some observations on wound healing and persistence of scars in *T. truncatus*. *Rep. int. Whal. Comm* (special issue 12): 113-118.

Figure 1. Species involved in violent attacks and lesions described on them.

Description of lesions	*Phocoena phocoena* male 106 cm	*Phocoena phocoena* male 140 cm	*Delphinus Delphis* male 163 cm	*Stenella coeruleoalba* female 146 cm	*Megaptera novaengliae* male 460 cm
Teeth marks in caudal fin	-	+	+	+	+
Teeth marks in the carcass dorsal area	+	-	-	+	-
Teeth marks in the carcass ventral area	-	-	+	+	-
Deep and sharp teeth marks	+	+	-	-	-
Haemorrhages of subcutis and in muscular post-cephalic area	+	-	-	+	-
Haemorrhages in ms. semispinalis, and anterior portion of ms. multifidus and longisimus dorsi	+	-	-	+	-
Both scapulae torn in the internal direcction	+	-	-	+	-
Fractures of thoracic vertebrae and intervertebral disks	-	-	-	+	-
Fractures of ribs	+	-	-	+	-

BEHAVIOUR OF A SOLITARY, "SOCIABLE" BOTTLENOSE DOLPHIN IN SOUTHERN ITALY

G. Barbieri and G. Bearzi

Tethys Research Institute, Viale G.B. Gadio 2, 20121 Milano, Italy (E-mail: giovibi@tin.it)

INTRODUCTION The behaviour of a solitary male bottlenose dolphin (*Tursiops truncatus*) nicknamed "Filippo" was regularly observed in 1999 near Manfredonia, Italy (southern Adriatic Sea). The dolphin - first reported in the area around 1996 – became increasingly "sociable" towards humans, and by November 1997, started to interact regularly with our species. From spring 1998, Filippo settled in the harbour of Manfredonia, where he can be predictably sighted.

MATERIALS AND METHODS Observations were opportunistically conducted from the wharf or from small boats, based on a 3-min behavioural sampling routine. No interaction whatsoever occurred between the dolphin and the observer. Behavioural data were collected from January to September 1999 for a total of 113 h 30 min. A total of 103 h 27 min of observation were conducted while Filippo was in the port, where he seemed to spend most of the day, and particularly the afternoon, from autumn to spring. Another 10 h 33 min focused on the behaviour in open waters, in the harbour's proximity, where the dolphin usually moved following boats or trying to interact with humans (including swimmers and professional scuba-divers). The dolphin seemed to "reside" within a range of 10 km of coastline, and was never observed nor reported farther away or offshore.

Five behavioural states were defined for the purpose of this study: Resting, Milling, Feeding, Interacting/Feeding and Interacting. These behavioural states were defined *a posteriori*, based on standardised behavioural variables and events. Consistent behavioural states resulted in a combination of three basic variables: movement pattern (lethargic, regular or frantic), occurrence of a target at surface (boats, swimmers, floating objects, people interacting with the dolphin from a boat), and occurrence of events suggestive of feeding behaviours. As obvious feeding at surface was observed on rare occasions, we considered as feeding-related behaviours including mud on rostrum (Rossback and Herzing, 1997), tailstock dives, flukes-up dives, and surface rushes (Shane 1990, Bearzi *et al.* 1999).

RESULTS The behaviour in and out of the port differed significantly ($c^2=769.2$, df=5, $p<0.001$).

Resting was the most frequent behaviour (78.5%) in port, and it was never observed out of port. Conversely, interacting with boats and humans was relatively infrequent (16%) in port, while it was the most frequent behaviour (65.9%) out of port. Feeding and Interacting/Feeding totalled 27.0% of the time spent out of port, and 1.3% in port.

Overall, "playful" interactions accounted for 20.5% of the total observation time, while "feeding-related behaviour" (*i.e.*, Feeding and Interacting/Feeding) totalled 3.7%.

Close proximity to a "target" was recorded during 94.3% of the total observation time, as shown in Fig. 2. Boats represented by far the favourite target. Resting in close contact to a moored boat was the most typical behaviour (71.1% of the time). Moving boats were chosen as target 20.6% of the time, while interactions with people on a boat (*e.g.*, petting the dolphin), human swimmers, or floating objects were occasional (1.1%, 0.8%, and 0.7%, respectively).

CONCLUSIONS Overall, the dolphin seemed to spend a remarkable proportion of his time budget resting and interacting with humans and boats. Activities suggestive of foraging were comparatively rare. The remarkable proportion of time spent either resting or interacting with humans and boats, as compared to foraging, may reflect ease of finding prey in Filippo's bizarre "critical habitat". However, the behavioural budget may change farther away from the port or at night, stressing that the study area must be further extended to match the whole dolphin's movement range.

As shown in Fig. 2, Filippo spent a very high proportion of his time in close proximity to a "target" (particularly a large speedboat consistently used by Filippo during Resting). This may indicate the need for some sort of "social surrogate" (Lockyer, 1990).

Interactions with boats and humans may represent a threat if unregulated, due to the dolphin's "reckless" behaviour. Interactions with people may habituate the dolphin to inappropriate behaviours including begging for food. Moreover, interactions with swimmers may be harmful to the latter. As Filippo offers remarkable opportunities for public awareness and education initiatives, and a valuable subject for ongoing studies focusing on behaviour, genetics, and toxicology, management measures must be taken to prevent damage to both the dolphin and people. Waiting for appropriate national legislation, a "code of conduct" to regulate interactions with humans was disseminated in collaboration with local authorities.

ACKNOWLEDGEMENTS We are grateful to Elena Politi for insightful comments and backing. Roberto Murgo and the Lega Navale of Manfredonia offered logistic assistance and invaluable backing to this project, and – together with the *Capitaneria di Porto* of Manfredonia – did their best to keep the dolphin safe. Members of the "Adventure Club" (Foggia) and Pasquale Sdanga provided support and friendly advice since the beginning of the study. Nautica Mazzone (Mattinata) kindly offered nautical assistance.

REFERENCES

Bearzi, G., Politi, E. and Notarbartolo di Sciara, G. 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Marine Mammal Science*, 15(4):1065-1097.

Lockyer, C. 1990. Review of incidents involving wild, sociable dolphins, worldwide. Pp. 337-353. In: *The bottlenose dolphin.* (Eds. S. Leatherwood and R. R. Reeves). Academic Press, San Diego.

Shane, S. H. 1990. Behavior and ecology of the bottlenose dolphin at Sanibel Island, Florida. Pp. 245-265. In: *The bottlenose dolphin.* (Eds. S. Leatherwood and R. R. Reeves). Academic Press, San Diego.

Rossbach, K. A. and Herzing, D. L. 1997. Underwater observations of benthic-feeding bottlenose dolphins (*Tursiops truncatus*) near Grand Bahama Island, Bahamas. *Marine Mammal Science*, 13(3):498-503.

Table 1. Observation time (min) during 1999

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
411	492	567	1,308	1,470	--	1,662	--	906

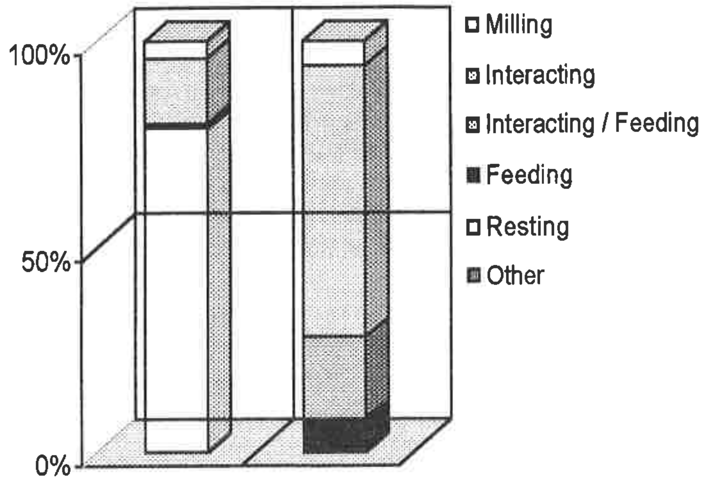


Fig. 1. Total behavioural budget

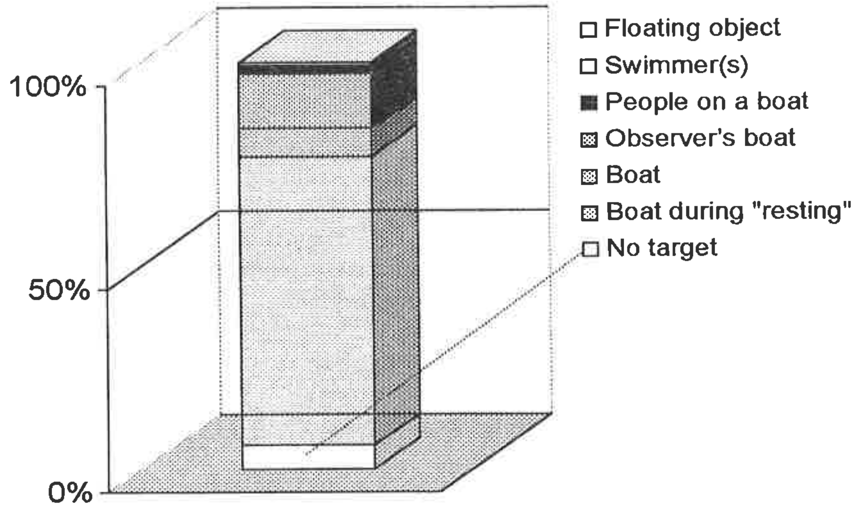


Fig. 2. Dolphin target

RARE REPORT OF A BOTTLENOSE DOLPHIN FORAGING IN THE VENICE LAGOON, ITALY

G. Bearzi and S. Ferretti

Tethys Research Institute, Viale G.B. Gadio 2, 20121 Milano, Italy (E-mail: bearzi@tin.it)

INTRODUCTION Although it is known that bottlenose dolphins (*Tursiops truncatus*) can be found in coastal lagoons and estuarine waters throughout the world (Leatherwood and Reeves, 1983), it is unusual to observe the species within the labyrinthine Venice lagoon water system. In recent times, live bottlenose dolphins entering these inshore waters were rarely reported (Rallo, 1976, 1979; Centro Studi Cetacei, 1990, 1991). Whether these events were more frequent in the past is not known. Trois (1894) reported that short-beaked common dolphins caught in the inner lagoon channels used to be frequently brought to the fish market, while this was claimed to happen only occasionally with bottlenose dolphins.

The reported observation – however anecdotal – sheds light on the possible reasons that occasionally bring dolphins into northern Adriatic Sea inshore waters, and stress that careful behavioural observations must be carried out by experienced personnel prior to organising rescues.

MATERIALS AND METHODS On 27th March 1998, an adult bottlenose dolphin entered and left the Venice lagoon water system. The dolphin behaviour was observed from a small inflatable craft for a total of 3 hours, between 13:45-16:45 h, until the dolphin voluntarily headed for open waters. Recorded information included surface activity, swimming directionality and speed, boat disturbance, presence of potential prey, and the continuous timing of surfacing intervals. Water depths corresponding to dolphin locations - never exceeding 9 m - were obtained by means of a nautical map 1:50,000, and then arbitrarily subdivided in two categories: <5 m and >5 m.

Based on combinations of objective variables, behavioural activities could be categorised as follows:

TRAVEL (T): consistent directionality and speed of movement.

FEEDING (F): obvious feeding activities near the surface, visible prey (small unidentified fish), irregular headings within a given location, belly-up fish pursuing, feeding rushes.

POSSIBLE FEEDING (PF): no consistent directionality, irregular headings within a given location, occasional presence of fish.

DISTURBANCE (D): occurrence of boat harassment (due to human attempts to force the dolphin to leave the lagoon) that may have affected dolphin behaviour.

OTHER (O): any behaviour that did not fit in the previous categories.

Ad libitum behavioural data, recorded on a constantly-running tape recorder, were subdivided into 55 standard 3-min samples (Bearzi *et al.*, 1999). The behaviour could not be consistently recorded during the remaining 15 min. A total of 209 surfacing events recorded on tape (every time the dolphin surfaced to breath) were timed *a posteriori* with a dedicated software package (Ferretti, 1999), accounting for 208 inter-blow intervals.

RESULTS Dolphin reported positions and observed movements are shown in Fig. 1.

Mean dive duration was 46 sec (SD=27.9, N=208, range 3-246 sec). The respiration pattern was characterised by short (<1 min), non-clustered surfacing intervals, as could be expected in shallow waters (<10 m). Twenty-eight percent of the inter-blow intervals lasted 1-30 sec, 57% between 31-60 sec, and 15% were longer than 60 sec.

The behavioural budget, as based on the percentage of 3-min samples for each activity, is shown in Fig. 2. Possible feeding and travel covered most of the total sample. Feeding-related activities increased in shallow waters (Fig. 3), where the dolphin was repeatedly observed taking advantage of the muddy shores and shoals to trap fish.

CONCLUSIONS The dolphin appeared to be in good physical condition, and repeatedly engaged in feeding-related activities, particularly in the very shallow waters of narrow lagoon channels. The animal seemed to orient well in the Venice lagoon, where it appeared to be relatively "at home" (an interviewed fisherman claimed that a dolphin - possibly the same individual - was seen in the same area on the day before). Behavioural observations were consistent with the hypothesis of "natural", deliberate behaviour, while rescue operations improvised to "save" the animal by forcing it to leave the lagoon seemed to represent inappropriate and risky harassment (one helicopter, several speedboats, a fire-brigade ship and personnel including divers were mobilised).

In recent times, it is often assumed that any dolphin entering the Venice lagoon (or other closed water systems) is a stray. This may not always be germane. The reported observations suggest that bottlenose dolphins – the commonest cetaceans in the northern Adriatic Sea (Bearzi *et al.*, this volume) - may at times deliberately enter relatively closed water systems to engage in opportunistic foraging forays.

Despite the presence of fishing gear in the area, the dolphin was never observed in its proximity, indicating that the animal was not engaging in opportunistic behaviours that may result in gear damage.

ACKNOWLEDGEMENTS Sebastiano Bruno assisted with data collection. The Venice Customs (*Guardia di Finanza*) kindly provided logistic support, insightful coordination and the inflatable boat used for the observations. We are grateful to Luca Mizzan (Venice Natural History Museum), the Venice Port Pilots, and Sgt. Colella (*Capitaneria di Porto*) for reporting relevant information. Thetis SpA offered further logistic support.

REFERENCES

Bearzi, G., Politi, E. and Notarbartolo di Sciara, G. 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Marine Mammal Science*, 15(4): 1065-1097.

Centro Studi Cetacei. 1990. Cetacei spiaggiati lungo le coste italiane. III. Rendiconto 1988. *Atti Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Milano*, 130(21): 269-287.

Centro Studi Cetacei. 1991. Cetacei spiaggiati lungo le coste italiane. IV. Rendiconto 1989. *Atti Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Milano*, 131(27): 413-432.

Ferretti, S. 1999. Comportamento respiratorio dei delfini comuni (*Delphinus delphis*) e tursiopi (*Tursiops truncatus*) osservati nelle acque della Grecia Ionica. Degree in Biological Sciences thesis. University of Milan, Italy. 157pp.

Leatherwood, S. and Reeves, R. R. 1983. *The Sierra Club handbook of whales and dolphins*. Sierra Club Books, San Francisco. 302pp.

Rallo, G. 1976. Avvistamento di un *Tursiops truncatus* (Montagu) nella laguna di Venezia. *Lavori Soc. Ven. Sc. Nat.*, 1: 50-51.

Rallo, G. 1979. I Cetacei dell'Adriatico. *WWF Veneto*, 12: 3-4.

Trois, E. F. 1894. Elenco dei Cetacei dell'Adriatico. *Atti R. Ist. Veneto Sc. Lett. Arti* 5(7). 6pp.

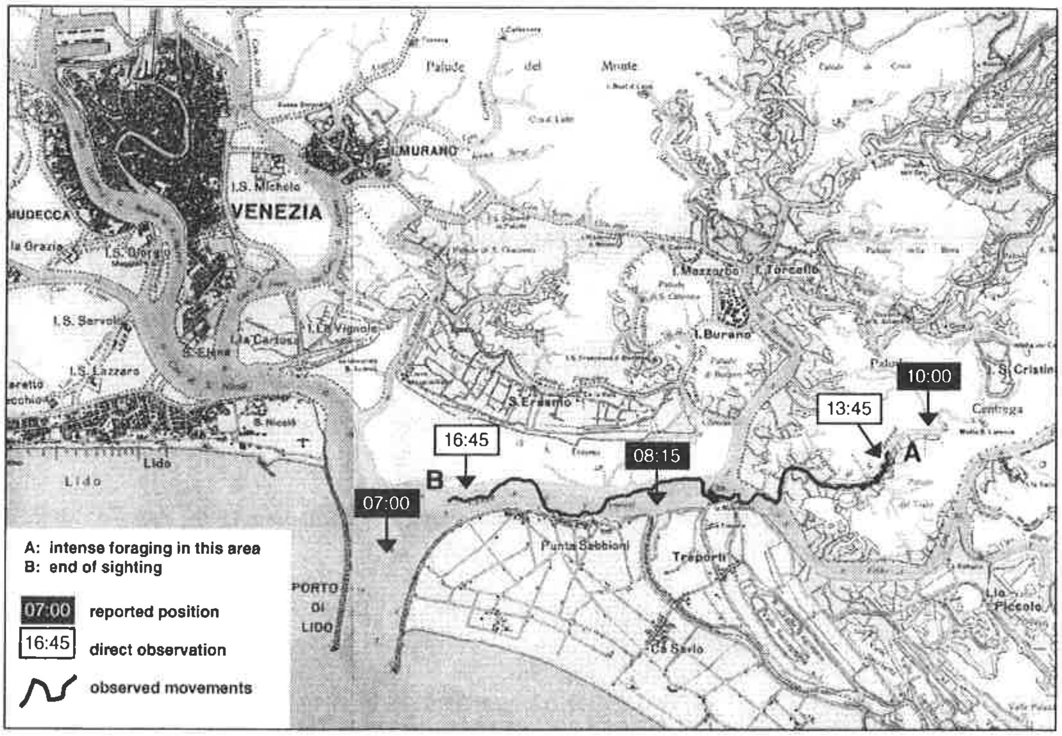


Fig. 1. Bottlenose dolphin reported positions and observed movements in the Venice lagoon.

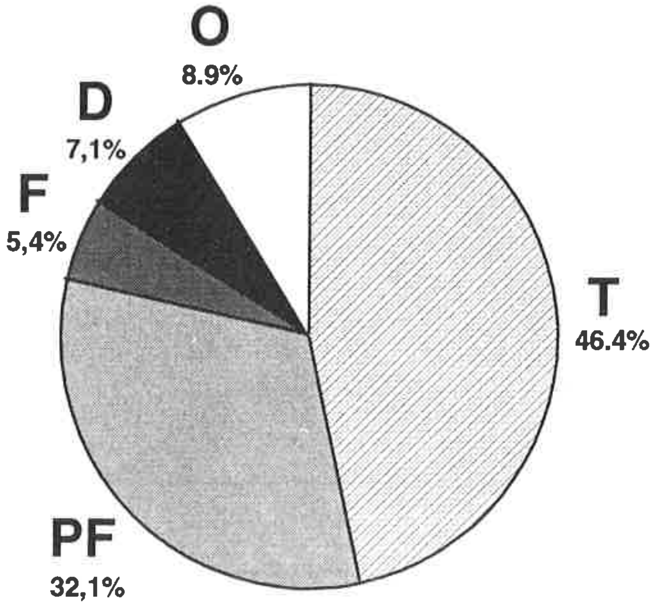


Fig. 2. Total behavioural budget. T = Travel, PF = Possible feeding, F = Feeding, D = Disturbance, O = Other.

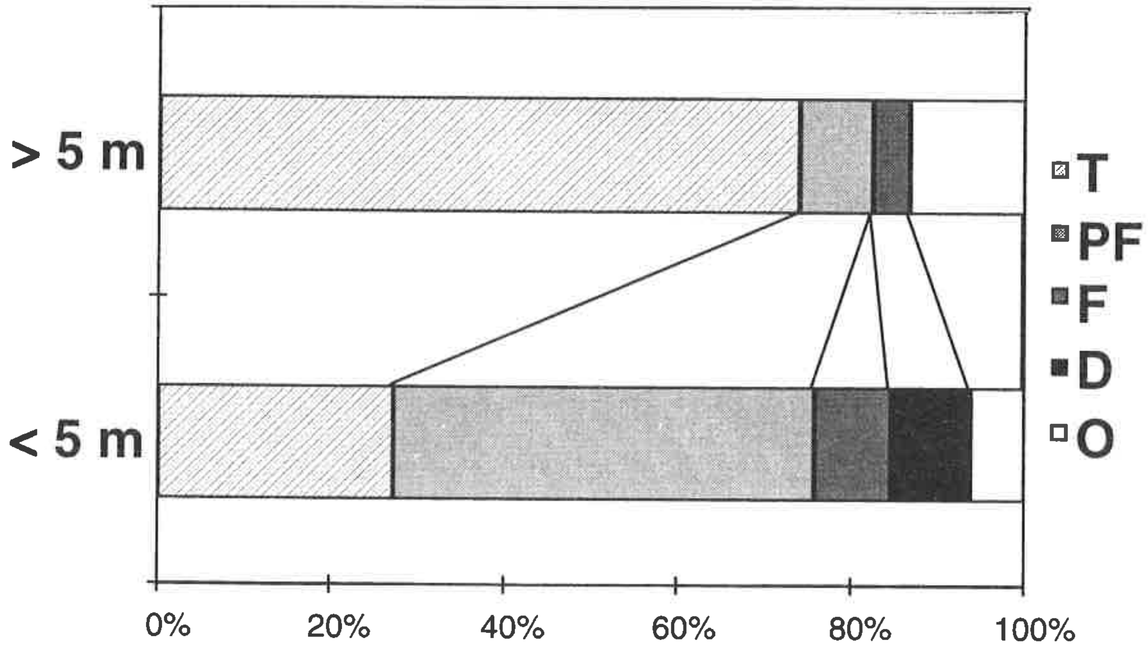


Fig. 3. **Behavioural budget relative to water depth.**
T = Travel, PF = Possible feeding, F = Feeding, D = Disturbance, O = Other.

SUMMER ACTIVITY PATTERNS OF CETACEANS IN THE LIGURIAN SEA SANCTUARY AND THEIR DIURNAL VARIATION

S. Bourreau[1], A. Gannier[2], and S. Laran[1]

[1]*Groupe de Recherche sur les Cétacés, Villa Aurelia 13, 741 chemin des Moyennes Bréguières, 06600 Antibes, France*
[2]*Centre de Recherche sur les Cétacés, Marineland, 307 avenue Mozart, 06600 Antibes, France.*

Activity patterns of six cetacean species were studied in the Ligurian Sea by analysing data from dedicated surveys. Field surveys took place from boats of 9 or 12 metres length every summer during the 1989-98 period with the same sighting protocol; passive acoustics have been in use since 1990. The activity was determined by observing surface cues, diving cycles, and by underwater listening (odontocetes). Frequencies were obtained for each activity class as the ratio of the number of sightings recorded in the given activity to the total number of sightings. The analysis was restricted to sightings of over 3 minutes duration, obtained at close range with good sea state (Beaufort 3 or less). Diurnal variations of patterns were gained by stratifying data into four time periods (6-10am, 10am-2pm, 2-6pm, 6-10pm). The sperm whale and the bottlenose dolphin were observed frequently feeding (respectively F=94% and F=64%). Socialising was rarely observed for the fin whale (F=4%), but occurred commonly (range 23-28%) for delphinids known to breed in summer, such as the striped and Risso's dolphins, and the pilot whale. Socialising peaked during the afternoon for all delphinids. Resting was frequent for the fin whale (38%) and the pilot whale (40%), and less frequent for Risso's dolphin (F=21%) and striped dolphins (F=11%). Fin whales and pilot whales tended to feed early in the morning; they were observed to rest frequently during the afternoon; and to resume feeding activity from late in the afternoon. Activity pattern analyses are useful when dealing with impact studies. They can be used to minimise human-induced disturbance during activities such as whale-watching, or to better evaluate collision risks in the case of fast ferry traffic.

GROWING UP SPOTTED: PATTERNS IN ASSOCIATION RELATED TO AGE AND GENDER IN SPOTTED DOLPHINS (*STENELLA FRONTALIS*) LIVING IN THE BAHAMAS

B. J. Brunnick and D. L. Herzing

This study contrasts age and gender differences in the social organisation of a population of free ranging spotted dolphins inhabiting the Bahama Banks. A total of 1,284 sightings, from between 1986 and 1997, were included in this study. Employing the half weight index, coefficients of association (COA) were determined for pairings of 81 females and 90 males. Values were compared between years, and age classes, for evidence of gender specific patterns and maturational change. Spotted dolphin calves had very close relationships with their mothers during the first few years of life. However, association values between female calves and their mothers declined significantly, first at year two, and again, with the largest drop when the calves became juveniles. At that time, associations with other dolphins were related to age and gender. Older females have a fluid fission-fussion relationships with each other, depending on individual reproductive state. Associations among adult females were fluid across all age classes. Relationships between adult females and males varied depending on the age class of the male. In contrast to female mother/calf relationships, associations of male calves with their mothers remained consistent for the first two years, with the first significant drop in COA values at year three. Like females, however, there was a significant change in this relationship when the males became juveniles. At that time, they began to form associations with other males of the same age, many of which developed into long lasting alliances. Associations between males and females during the juvenile years were not as strong and did not build into consistent relationships. For young adults, relationships between genders were dependent on maturity and reproductive status. As adults, these relationships became fluid, while single gender associations continued to be strikingly different for males and females.

SARDINIAN WILD BOTTLENOSE DOLPHINS:
AN INTERPRETATION OF SURFACING INTERVALS

M. Casale

ICRAM, Istituto Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare
Struttura Tecnico Scientifica, 30015 Chioggia, Venezia, Italy (E-mail: mkcasal@tin.it)

INTRODUCTION The observation of cetaceans in their natural environment is often limited to their surfacing intervals. During these brief intervals, researchers must be able to collect as much information as possible on the species investigated. For a few years, attention has been paid to the intervals occurring between two consecutive surfacings and researchers have even been able to define a few patterns of surfacing intervals. Moreover, some scientists have tried to relate the series of surfacing intervals to the activities of the cetaceans observed. For example, Watson and Gaskin (1983) in the harbour porpoise *Phocoena phocoena* found two different types of surfacing intervals, one associated with their travelling behaviour, the other to feeding. In the former case, dives were all of very short duration, while in the latter several extended dives were spaced out by many short-duration dives. Similar researches have been carried out on the bottlenose dolphin *Tursiops truncatus*, both from a strictly physiological viewpoint (e.g. Verwey, 1975) and a behavioural one (e.g. Lockyer and Morris, 1986, 1987).

The work reported here shows the results of the analysis of surfacing intervals of *Tursiops truncatus*. A population belonging to the above-mentioned species was studied in north-eastern Sardinian waters (Fig. 1) between July 1991 and October 1994. The aim of that research was to gain information on their ecology and behaviour (Consiglio *et al.*, 1992; Marini *et al.*, 1995; Casale, 1997). The analysis of surfacing intervals was performed according to the method employed by dos Santos *et al.* (1990) on bottlenose dolphins living in the Sado river estuary area (Portugal). Afterwards, an attempt was made to compare the results of the two studies, and find out a relationship between surfacing intervals and the type of behaviour observed.

MATERIALS AND METHODS The observations were carried out from both fixed land stations and the sea. In the latter case, an inflatable boat (4.5 m of length equipped with 25-HP-engines) and fishing vessels belonging to the Golfo Aranci fleet were employed. The following instruments were used during the observation session: i) 12x50 binoculars; ii) telescope on tripod with a 20-60 zoom; and iii) portable audio recorder.

The method used for collecting data concerning behaviour consists of recording the sighting operations throughout their duration (Altman, 1974). The dive times during the sightings of a few specimens were collected only for specimens which presented clear marks such as notches or depigmented parts on the dorsal fin.

RESULTS The analysis of dive times has shown the presence of the three basic patterns found by dos Santos and his collaborators (Fig. 2): **(A)** sequence of variable surfacing intervals, rarely longer than 30 sec; **(B)** prolonged dives, longer than 30 sec, are clearly distinct from the shorter ventilation sequences. In its turn, pattern **B** can be subdivided into three subpatterns: **(B_1)** prolonged dives alternated with ventilation sequences consisting of several short-duration-dives; **(B_2)** prolonged dives alternated with ventilation sequences consisting of relatively long dives; **(B_3)** prolonged dives alternated with a single surfacing; and **(C)** Surfacing intervals are irregular, although periods of prolonged dives exist.

During the whole period of the research, the total recording of diving times consisted of 4.44 hours. The overall amount of all dives is 643, subdivided into 76 sequences (a sequence is defined as the group of the series of prolonged dives added to the ventilation sequences). From these data, only the sequences in excess of 180 sec, or those including at least 10 measures, were then selected. Eventually, 61 sequences (N= 61) were employed, made up of 497 dives of 3.18 hours in total duration. From these sequences, the parameters reported in Table 1 were calculated. Comparing the values of Table 1 to those found by dos Santos (Table 2), one may note the following differences:

1. the mean duration of submergences of pattern $\mathbf{B_1}$ is lower than that found by dos Santos;
2. the mean duration of dives and the mean number of surfacings per ventilation sequence of pattern $\mathbf{B_1}$ is much higher to that found in Portuguese bottlenose dolphins;
3. for each surfacing pattern, the mean duration of ventilation sequences of Sardinian bottlenose dolphins is nearly twice that of Portuguese specimens.

The **B$_3$**-type sequence, though not reported in Table 2, was observed in the Sardinian dolphins as well as in the Portuguese specimens; however, dos Santos preferred to ignore it because of the very limited amount of data available to him.

From the analysis of the bottlenose dolphin activities (Fig. 3), at the very moment when their diving times were detected, it may be noted that:

1. patterns **A** and **B$_3$** were recorded only during the feeding;
2. almost all the sequences of type **B$_1$** were detected while the bottlenose dolphins were involved in clear travel behaviour;
3. pattern **B$_2$** was equally noticed both during feeding and milling;
4. pattern **C** presented mainly travel activities and, to a lesser degree, milling and feeding activities near trawl-fishing nets (the third here defined as behaviour P).

From Fig. 4 (which shows the relationship between the sea-tract depth and the pattern for surfacing intervals), it is possible to notice that most of the sequences observed were recorded in areas deeper than 20 metres. The only exception is represented by the pattern **B$_2$**, observed at a depth inferior to 10 metres. This pattern was recorded only during a night sighting of a specimen which was feeding close to a trammel net located near the coastline.

DISCUSSION By comparing the results obtained by dos Santos and his collaborators, one could state that the environmental features strongly affect the times of diving sequences. Indeed, while the Sardinian bottlenose dolphins live in a wide marine environment, marked by quite rapidly deep bottoms (Fig. 1), those analysed by dos Santos live in an estuary-type area, marked by rather shallow sandy and muddy bottoms. Therefore, it is likely that the Sardinian dolphins make longer dives for certain types of activities, thus increasing their related surfacing intervals. This is what could occur, for example, during the dives where C-type sequences are recorded, associated with activities of both travel and feeding on trawl-fishing nets, or during the dives with **B$_1$**-type sequences, associated with activities of travel only.

The activities carried out by bottlenose dolphins, at the very moment that dive times are detected, often differ from what is reported by other authors (e.g. Watson and Gaskin for harbour porpoise). It must be considered that in some cases it was quite difficult to deduce the real activity of the species, during the sighting operations carried out both from the land (the great distance between observers and animals) and from the sea (the presence of the inflatable boat might have somehow affected their behaviour). Then, it is possible to conclude that, although a certain relationship between surfacing intervals and specific behaviour patterns can be observed, similar to what dos Santos and his collaborators noted, this relationship is not very clearcut. In any case, further comparisons of the studies carried out on other populations of bottlenose dolphins in other areas would help us to investigate this subject.

REFERENCES

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour*, 49: 227-262.

Casale, M. 1997. *Ecologia ed etologia di Tursiops truncatus (Cetacea, Odontoceti) nelle acque della Sardegna nord-orientale.* Tesi di Laurea in Scienze Naturali, Univ. Padova. 125pp.

Consiglio, C., Arcangeli, A., Cristo, B., Mariani, L., Marini, L., and Torchio, A. 1992. Interactions between bottle-nosed dolphins, Tursiops truncatus, and fishery along North-eastern coast of Sardinia, Italy. Pp. 35-36. In: *European Research on Cetaceans – 6.* Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 Feb, 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Dos Santos, M. E., Xavier, P. and Lazaro, A. 1990. Measuring surfacing intervals in free-ranging bottle-nosed dolphins. Pp. 82-85. In: *European Research on Cetaceans – 4.* Proc. 4th Ann. Conf. ECS, Palma de Mallorca, Spain, 2-4 Mar, 1990. (Eds. P.G.H. Evans, A. Aguilar & C. Smeenk). European Cetacean Society, Cambridge, UK. 140pp.

Lockyer, C. and Morris, R. J. 1986. The history and behaviour of a wild, sociable bottle-nosed dolphin (Tursiops truncatus) off the north coast of Cornwall. *Aquatic Mammals*, 12: 3-16.

Lockyer, C. and Morris, R. J. 1987. Observations on diving behaviour and swimming speeds in a wild juvenile Tursiops truncatus. *Aquatic Mammals*, 13: 31-35.

Marini, L., Consiglio, C., Arcangeli, A., Torchio, A., Casale, M., Cristo, B., and Nannarelli, S. 1995. Socio-ecology of bottlenose dolphins, Tursiops truncatus, along the north-eastern coast of Sardinia (Italy): preliminary results. Pp. 139-141. In: *European Research on Cetaceans - 9*. Proc. 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 Feb, 1995. (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Kiel, Germany. 302pp.

Verwey, J. 1975. *The cetaceans Phocoena phocoena and Tursiops truncatus in the Marsdiep area (Dutch Wadden sea) in the years 1931-1973.* Netherlands Institute for Sea Research. Publikaties en Verslagen, No. 1975-17a/b.

Watson, A. D. and Gaskin, D. E. 1983. Observations on the ventilation cycle of the harbour porpoise *Phocoena phocoena* (L.) in coastal waters of the Bay of Fundy. *Can. J. Zool.*, 61: 126-132.

Table 1. Parameters calculated for sardinian bottle-nosed dolphins sequences
(*) Surfacing rate: number of surfacings per minute.

Surfacing patterns	Tot. N° of sequences	Tot. duration of sequences	N° of submergences	Duration of submergences (sec.)	N° of dives	Mean duration of dives (sec.)	N° of ventilation sequences	Mean N° of surfacings per vent. seq.	Mean duration of vent. seq. (sec.)	Surfacing rate (*)
A	2	5,2 min.	35	*Mean:* 8,97" *Range:* 2" – 36" *St. d.:* 7,13	-	-	-	-	-	6,73
B_1	30	99,0 min.	279	*Mean:* 21,29" *Range:* 2" – 309" *St. d.:* 43,42	31	122,39" *St. d.:* 72,76	36	6,89 *St. d.:* 4,19	59,64" *St. d.:* 46,45	2,82
B_2	2	10,2 min.	16	*Mean:* 38,31" *Range:* 17" – 98" *St. d.:* 22,32	3	79,33" *St. d.:* 19,01	3	4,33 *St. d.:* 2,52	125,0" *St. d.:* 82,53	1,57
B_3	1	9,1 min.	5	*Mean:* 109,0" *Range:* 35" – 185" *St. d.:* 62,79	5	109,0" *St. d.:* 62,79	-	-	-	0,55
C	26	67,6 min.	162	*Mean:* 25,04" *Range:* 3" – 167" *St. d.:* 22,31	32	59,5" *St. d.:* 29,03	28	4,64 *St. d.:* 4,76	76,86" *St. d.:* 84,15	2,40

Table 2. Parameters calculated for portuguese bottle-nosed dolphins sequences (dos Santos, 1990)
(*) Surfacing rate: number of surfacings per minute.

Surfacing patterns	Tot. N° of sequences	Tot. duration of sequences	N° of submergences	Duration of submergences (sec.)	N° of dives	Mean duration of dives (sec.)	N° of ventilation sequences	Mean N° of surfacings per vent. seq.	Mean duration of vent. seq. (sec.)	Surfacing rate (*)
A	5	19,2 min.	96	*Mean:* 11,92" *Range:* 3" – 35" *St. d.:* 6,6	-	-	-	-	-	5,27
B_1	24	209,2 min.	313	*Mean:* 38,01" *Range:* 3" – 258" *St. d.:* 53,8	89	107,36" *St. d.:* 58,6	64	4,56 *St. d.:* 2,7	38,81" *St. d.:* 29,4	2,29
B_2	3	16,6 min.	28	*Mean:* 35,46" *Range:* 13" – 138" *St. d.:* 30,6	6	83,50" *St. d.:* 37,5	5	4,4 *St. d.:* 2,7	73,8" *St. d.:* 63,8	1,87
C	5	39,84 min	103	*Mean:* 23,15" *Range:* 4" – 128" *St. d.:* 21,15	25	51,0" *St. d.:* 27,2	20	3,8 *St. d.:* 3,3	40,37" *St. d.:* 45,3	2,72

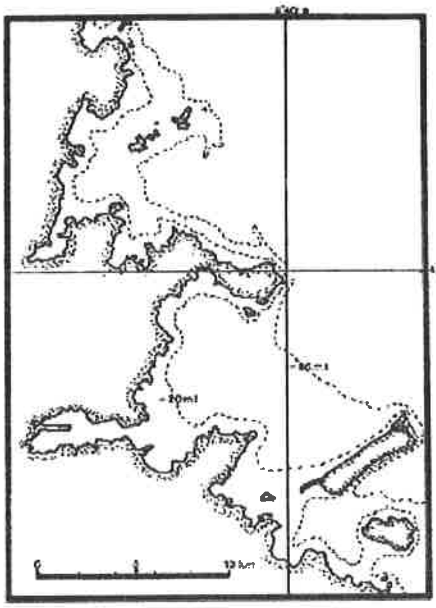


Fig. 1. The study area

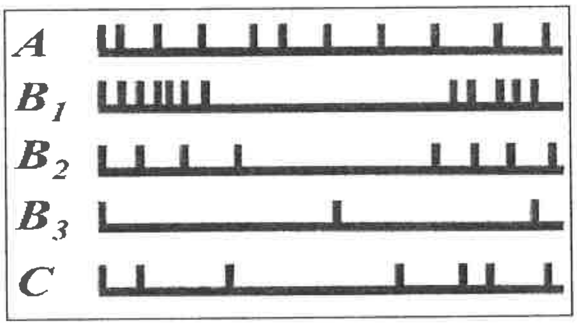
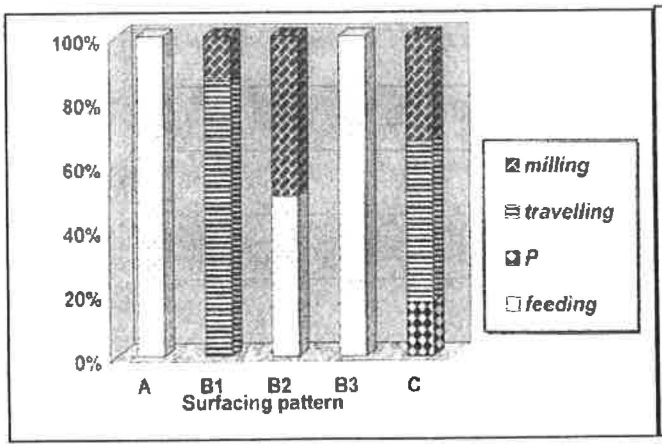


Fig. 2. Surfacing patterns according to dos Santos *et al.* (1990)



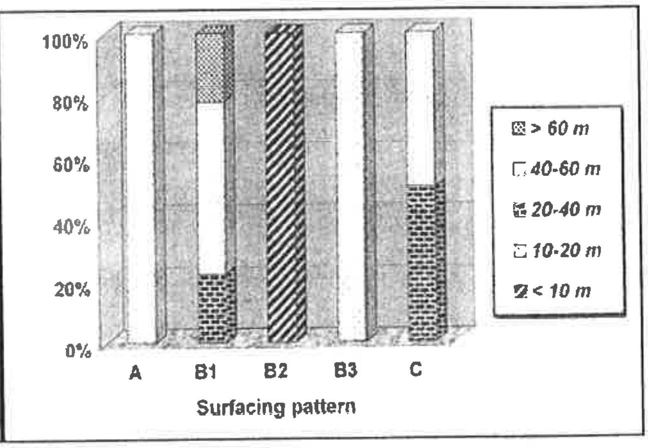


Fig. 3. Surfacing patterns & behaviours

Fig. 4. Surfacing patterns & depth

BEHAVIOUR OF COMMERSON'S DOLPHINS AND PRELIMINARY INFORMATION OF THE EFFECT OF BOATS IN WATCHING ACTIVITIES

M. A. Coscarella, S. L. Dans, S. N. Pedraza, and E. A. Crespo

Centro Nacional Patagónico, Blvd. Brown s/n, 9120 Puerto Madryn, Chubut, Argentina

Preliminary results have been obtained on the behaviour of Commerson's dolphins which have recently been targeted by the dolphin-watching industry. Data were gathered at Bahía Engaño, northern Patagonia, between February 1998 and June 1999, from a 21 m high cliff. Scan sampling methodology was applied every half an hour. Behaviour was classified as travelling, milling, co-operative feeding, resting, socialising, or undefined. Photo-ID was used to identify individuals and total size of the herd involved. Interactions with boats were also studied.

Dolphins were sighted in 31 out of 147 scans. The mean group size was 2.12 individuals (SD=1,77), with a maximum of 20 individuals. The dolphins seem to display a daily pattern of movement, arriving in the area during the morning, being more abundant during noon and the first hours of the evening and moving away at dusk. The highest number of animals in the area was recorded between 12:00 and 16:00 h. The number of animals in the area also increased after February, reaching a peak in May. As far as is known, these dolphins are in the study area during winter while during summer they are not.

Behaviour scan samples were performed on 135 groups. The main activities were milling (36%) and travelling (31%), followed by socialising (10%), co-operative feeding (7%), and resting (6%). The undefined behaviours were recorded in 10% of the scans. Birds were present and interacting with dolphins when feeding. By means of photo-ID at least 22 dolphins were identified and some were resighted. The number of individuals in the area could be no less than 130 dolphins. Interactions with the boat were studied on board the vessel or from the cliff. On the basis of the present information, the dolphins seem to socialise often in the presence of the boat (1-80 individuals) and not all of them are involved in the interactions.

BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) USING AN UNDERWATER TOUCHSCREEN IN A COGNITIVE TASK: ROLE OF SOCIAL CONSTRAINTS ON THE LEARNING PROCESS

F. Delfour

Earthtrust, 25 Kaneohe Bay Drive, HI 96734, USA
Present address: 13 imp. Marfaing, 31400 Toulouse, France

INTRODUCTION Dolphins have the capability of fine visual discrimination (Nachtigall, 1986); they possess highly developed cognitive structures to classify, store, organise, interpret and manipulate auditory information (Herman *et al.*, 1994). Moreover, in a social context, constraints on learning (social facilitating and/or inhibiting) act on the expression of an acquired behaviour (Bond and Titus, 1983).

In our study, we investigated the dolphins' ability to perform a complex cognitive task when information arrived through two different sensory modalities (visually and auditory), and we examined the significant role of some social constraints on the learning process.

MATERIALS AND METHODS **Subjects:** three 30-year-old female bottlenose dolphins (Sea Life Park, Hawaii): Puna ; Iwa (*Tursiops truncatus*) and Laukani (*Tursiops gilli*).

Experimental set-up and procedure: the touchscreen monitor, connected to a Power Mac 8100AV computer, displayed the visual signals ("targets"). In order to display the auditory signal, the computer was connected to an audio-amplifier and to a piezo film on the tank window. The dolphins' behaviours were videotaped by a Minolta S-VHS Series V-2000 video camera and they were recorded by a Panasonic AG-1960 S-VHS VCR. To use the touchscreen, the dolphins rubbed their rostrum against the screen. Four grey geometrical forms were associated with four auditory signals (Table 1). The dolphins passively listened to one tone for 3 sec long while the associated visual signal was presented in the centre of the touchscreen. The dolphins had 5 sec (starting at the end of the auditory presentation) to touch the inside part of the target (the active part). If the subject failed, the screen turned black for 3 sec and was inactive; if the dolphin succeeded: it got a reward for 3 sec long (a coloured ball and/or a fish and/or the target moving on the screen). Later on, 2, 3 and 4 targets (in 3 dimensions) were presented. Each session lasted 30 minutes.

We examined the time spent in front of the apparatus, the scores obtained by each dolphin, the priority to get to the touchscreen, and the number of approach/retreat in dyadic contact.

RESULTS **Association visual forms / auditory signals**
a. Time spent in front of the touchscreen: the three dolphins were present throughout the entire experiment, but they did not spend the same amount of time in front of the touchscreen. Puna spent the longest time, then Laukani, and the last one was Iwa (Kruskall-Wallis test, df = 2, H = 22.99, p = 0.0001). We distinguished five different steps (I to V) (Table 2). The three dolphins spent the same amount of time in front of the apparatus from I to V (Friedman's test not significant). Iwa started to come at session 8.

b. Scores of right, wrong, and missed answers per hour for each dolphin: Laukani got the greatest score of right answers per hour, then Puna and Iwa (Kuskall-Wallis's test, df = 2, H = 51.68 and p = 0.0001) (Fig. 1). Puna showed the greatest score of wrong and missed answers, then Laukani and Iwa (Kuskall-Wallis's test, df = 2, H = 23.01 and p = 0.0001; df = 2, H= 62.27, p = 0.0001).

Role of social constraints on the learning process
a. In front of Laukani, Puna displayed 40 retreat items and Iwa 61; this female displayed 16 retreat items in front of Puna.

b. Number of times a dolphin initiated a session: Laukani : 47 times, Puna: 16 and Iwa: 9. However, Iwa never initiated a sequence of sessions.

DISCUSSION Dolphins show very impressive auditory capabilities and fine visual discrimination (Nachtigall, 1986). However, their underwater acuity is best at near viewing distances (1 m or less) (Herman, 1986). Moreover, dolphins appear to make judgments about relations which are either the same or different (Herman *et al.*, 1994), to be able to classify objects according to relative size or shape (Kastak and Schusterman, 1992; Pack and

Herman, 1995; Schusterman and Gisiner, 1988). However, the precise nature of these mental representations remains elusive. The three dolphins seemed to demonstrate an ability to associate a visual form with an auditory signal. However, we need some further analysis to assert that they learned that complex cognitive task and developed a generalised rule about the relationship between the auditory and visual (Herman, 1986). The learning process of the task appeared to be quickly accomplished by each dolphin, according to the high scores of right answers at the begin of each experiment, but we may wonder if the missed and wrong answers were sufficiently negative for the dolphins to be considered as negative reinforcement.

Even if no sex differences and no kinship relationships existed in that group, we noticed some kind of dominance relationships (Tayler and Saayman, 1972): a particular female (Laukani) determined the social structure (Caldwell and Caldwell, 1972) and displayed subtle gestures of threat (Johnson and Norris, 1986).

In a learning task with a unique experimental procedure, the subjects seemed to differently experience the situation according to their social relationships. Laukani, the alpha female, had priority access to the apparatus. Moreover, she did not seem to require a long time exposure to answer correctly. Puna spent the longest time in front of the touchscreen and proportionally got few correct answers. Even if Iwa passively learned from her conspecifics and waited for them to leave to practice, she got correct answers.

CONCLUSIONS The high scores of correct answers tend to demonstrate an ability of the dolphins to associate an auditory signal obtained by passive listening with a visual signal presented on an underwater touchscreen. However, further analysis are required to understand the learning process developed by each dolphin in such a complex cognitive task when information arrives through two different sensory modalities. Then, it appears that in a unique experimental situation, each subject individually experiences the situation according to its own social status.

ACKNOWLEDGEMENTS We would like to thank B. Megessier who created all the programs we used, and Dr R. Chalmeau for his helpful comments. We are grateful to Earthtrust and Sea Life Park (Hawaii).

REFERENCES

Bond, C. F. and Titus, L. J. 1983. Social facilitation: a meta analysis of 241 studies. *Psychology Bulletin*, 94: 265-292.

Caldwell, M. C. and Caldwell, D. K. 1972. Behavior of marine mammals. Pp. 419-465. In: *Mammals of the sea: biology and medecine*.(Ed. S.H. Ridgway). Thomas, Springfield, IL.

Herman, L. M., 1986. Cognition and language competencies of bottlenosed dolphins. Pp. 221-252. In: *Dolphin cognition and behavior: a comparative approach.* (Eds. R. J. Schusterman, J. A. Thomas and F. G. Wood). Lawrence Erlbaum Associates, London.

Herman, L. M., Pack, A. A. and Wood, A. M. 1994. Bottlenose dolphins can generalize rules and develop abstract concepts. *Marine Mammal Science*, 10 (1): 70-80.

Johnson, C. M. and Norris, K. S. 1986. Delphinid social organization and social behavior. Pp. 335-346. In: *Dolphin cognition and behavior: a comparative approach.* (Eds. R. J. Schusterman, J. A. Thomas and F. G. Wood). Lawrence Erlbaum Associates, London.

Kastak, D. A. and Schusterman, R. J. 1992. Comparative cognition in marine mammals: a clarification on match-to-sample tests. *Marine Mammal Science*, 8: 414-417.

Nachtigall, P. E. 1986. Vision, audition and chemoreception in dolphins and other marine mammals. Pp. 79-113. In: *Dolphin cognition and behavior: a comparative approach.* (Eds. R. J. Schusterman, J. A. Thomas and F. G. Wood). Lawrence Erlbaum Associates, London.

Pack, A. A. and Herman, L. M. 1995. Sensory integration in the bottlenosed dolphin: immediate recognition of complex shapes across the senses of echolocation and vision. *Journal of Acoustical Society of America*, 98 (2): 722-733.

Schusterman, R. J. and Gisiner, R. 1988. Artificial language comprehension in dolphins and sea lions: the essential cognitive skills. *The Psychological Record*, 38: 311-348.

Tayler, C. K. and Saayman, G. S. 1972. The social organization and behavior of dolphins (*Tursiops aduncus*) and baboons (*Papio ursinus*): some comparisons and assessments. *Annals Cape Providence Museum of Natural History*, 9: 11-49.

Table 1. Associations of geometrical forms with auditory signals

Visual signal	circle	square	triangle	cross
Size (cm)	14	13	13 x 13	14 x 4
Auditory signal (kHz)	6	7	8	9

Table 2. Lengths of time spent in front of touchscreen in relation to visual forms

Experiment	Sessions	Number of visual forms	Size	Location on the touchscreen
I	1 to 6	1	Big	Centre
II	7 to 16	1 & 2	Big	Quadrant(s)
III	17 to 27	1 & 2	Small	Quadrant(s)
IV	28 to 35	1 & 2 in 3D	Small	Quadrant(s)
V	36 to 42	3 & 4 in 3D	Small	Quadrants

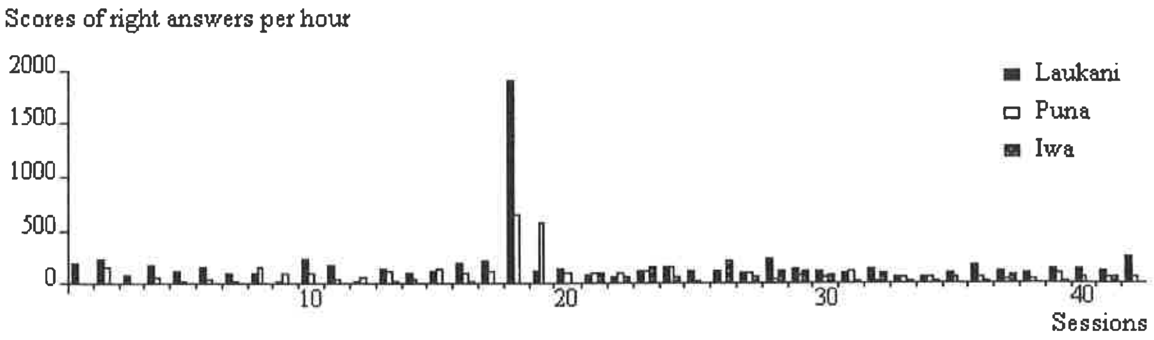


Figure 1. Success scores for each of the three dolphins

RESPIRATION PATTERNS OF FIN WHALES (*BALAENOPTERA PHYSALUS*) OFF ISCHIA ISLAND (SOUTHERN TYRRHENIAN SEA, ITALY)

B. Díaz López[1], B. Mussi[2], A. Miragliuolo[2], D. Chiota[3] and L. Valerio[3]

[1]*CEMMA, Aldea Nova 82, 15220 Ames-A Coruña,, Spain*
[2]*STUDIOMARE, v. D'Abundo 82, 80075, Forio d'Ischia (Na), Italy (e-mail: studiomare@pointel.it)*
[3]*WWF Italia Oasi Blu, C.P. 45, 04028 Scauri (Lt), Italy*

INTRODUCTION: The fin whale (*Balaenoptera physalus*) is an oceanic cetacean, which is found in every ocean of the world. It is the most common large cetacean inhabiting the Mediterranean Sea (Jefferson *et al.*, 1993; Leatherwood *et al.*, 1983). Previous surveys carried out in the Archipelago Campano area (Mussi *et al.* 1997, 1998, 1999) pointed out that the sightings of fin whale are generally higher during summer months. A similar situation occurs in the Liguro-Provençal basin, where the population of fin whale congregates during the summer (Aguilar, 1985; Zanardelli *et al.*, 1992; Relini *et al.*, 1992; Jahoda *et al.*, 1993; Nortarbartolo di Sciara *et al.*, 1993; Forcada *et al.*, 1993). The area of study of our research is that part of the Tyrrhenian Sea embracing the islands of Ischia, Procida and the mainland coast, surveying particularly the submarine canyon of Cuma (Pennetta *et al.*, 1998). This area, of about 35 square miles, is smaller than the Ligurian one.

The breathing behaviour of whales seems to be influenced by the presence/absence of boats. The study of respiration patterns of fin whale could be a useful method to investigate the disturbing effect caused by approaching vessels (Jahoda *et al.*, 1993, 1996; Notarbartolo di Sciara *et al.*, 1996).

In the summer, we observed that the level of boat traffic in the study area is high as a consequence of the proximity of the land and the increase of tourism.

METHODS: The Archipelago Campano has been the object of a long-term study (1991-99) on cetaceans (Mussi *et al.*, 1997, 1998, 1999). The observations of this research were carried out during the summer of 1997 and 1998. The surveys were conducted on board the long sail-boat "Barbarian" (15 m.), fully equipped for high-sea navigation. The routes were chosen to optimise the sightings, and were determined daily on the basis of previous sightings. No trip was performed in conditions greater than Sea State 5 (Beaufort). The survey covered an area of about 35 square miles.

All data were recorded for the longest time possible, until visual contact with the whales was lost either due to the distance becoming too great, or because of poor weather conditions. To avoid potential ambiguities due to contiguous surfacing of indistinguishable individuals, respiration times were recorded only from lone whales. The observers collected the data in seconds, using digital stopwatches. Observations consisted of uninterrupted bouts, from sunrise to sunset, in fine weather conditions. The observation period consists of continuous breathing and diving cycles, from the first time the whale is observed until it disappears. A dive time is defined as an interval between two breaths lasting longer than 36 seconds. A surfacing time is defined as the time the fin whale swims on the surface. The surfacing rate is defined as the number of surfacings per whale in an hour. A cycle is defined as a dive followed by a surfacing time. Only complete dive-surfacing cycles were considered for the analysis (Jahoda, *et al.*, 1993). For each record of the surfacing rate, the observation period was at least 30 minutes (Friis, *et al.*, 1992). Respiration patterns were related to different behavioural states. "Indifference" and "Investigating" were chosen to point out the different attitude of the fin whale. We say that a fin whale is indifferent if it is observed at a distance of more than 100 metres from the boat: the whale is not affected at all by the presence of vessels, and continues swimming with a speed of 1-3 knots. We say that a fin whale is investigating if it is observed at a distance of less than 100 metres from the boat: the whale shows interest in the vessels and swims around in a milling fashion with a speed <1 knots. We characterised four different behavioural categories: indifferent diving (INDD), indifferent surfacing (INDS), investigating diving (INVD), investigating surfacing (INVS). We also identified two parameters: indifferent surfacing rate (INDSR) and investigating surfacing rate (INVSR).

RESULTS: During the whole period of research, 159 diving/surfacing cycles were timed from fifteen lone whales for a total of 19 hr. 26 min of net observation, corresponding at a mean of 39 minutes per whale. Fin whales spent 25.01% of their time at the surface (sum of surfacing times) and 74.98% diving (Figure 1). The value of diving/surfacing medium times are respectively 283.57 sec. diving (SE 11.007) and 110.08 sec. surfacing (SE 7.082). A significant difference in surfacing time was found for the two kinds of behaviour "investigating" and "indifferent" of the fin whales (Student t-test, $p < 0.01$) (Figures 2, 3, & 4). On the contrary, no difference emerges from dive time analysis nor from the values of the two parameters INDSR/INVSR (Student t-test, p >0,05). The surfacing rate changes with the trophic behaviour during the day: during our observations, the surfacing rate was higher at daybreak than during daytime, showing a little change at sunset (Figure 5). The direct study of the whale's behaviour with the observation of convoluted courses, circle swimming, bubble production, and defecation episodes suggested a foraging activity during these hours (Mussi *et al.*, 1999).

CONCLUSIONS: The outcome of our research indicates that the whale respiration patterns vary according to a number of external stimuli, including the influence of the proximity of vessels and their trophic behaviour. The surfacing rate could depend on the area of observation, and the day-time, and is related to the behaviour of the fin whale. This species, in this area, has a high level of "curiosity" towards boats, and this takes the animals close to them, resulting in them staying longer on the surface than the "indifferent" one. This kind of behaviour influence could be considered "positive" because it increases the surfacing time. The whales spend more time at the surface than those observed by other researchers working in the Italian seas. In that case, the presence of vessels could be considered "negative" because the surface time diminishes and the swimming speed increases (Nortarbartolo di Sciara *et al.*, 1996). A negative influence was observed as well by other researchers studying the bowhead whale *Balaena mysticetus* in the Beaufort Sea (Richardson *et al.*, 1985). The novelty that our research brings to light is that there are two kinds of behaviour of the fin whale towards vessels: "positive" and "negative". We observed that the whales spent much more time on the surface at daybreak (Figure 5), which is probably associated with the vertical diurnal migrations of euphausiid prey (Friis *et al.*, 1992; Relini *et al.*, 1992; Mussi *et al.*, 1999). In future research, the study of "indifferent" whales should be recorded from longer distances to obtain more objective results in order to compare the different levels of human influence.

ACKNOWLEDGEMENTS: Studiomare and WWF Oasi Blu funded the research. Thanks go also to C.E.M.M.A. Many people contributed to the success of this research: special thanks go to Stanislao Migliaccio, Bettina Büttgen, and Michela Muzzi. We wish to thank also the anonymous referees for their valuable suggestions and contribution to the final draft of the manuscript. Kodak furnished the films. Finally, many thanks to Oberon and DS Telematica.

REFERENCES

Aguilar, A. 1985. *Biología y dinámica poblacional del rorcual común, Balaenoptera physalus en las aguas atlánticas ibéricas*. Ph.D thesis, Univ. de Barcelona. 487pp.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X. and Aguilar, R. 1993. Distribution and abundance of fin whales in the Western Mediterranean Sea during the summer. Pp. 128.131. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Friis, L. W., Pedersen, J. U., Rebsdorf, M. and Skytte, E. 1992. Fin whale, *Balaenoptera physalus*, surfacing rates in west Geenland. Pp. 90-94. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P.G.H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Gannier, A. and Gannier, O. 1993. The winter presence of the fin whale in the Liguro-Provençal Basin: preliminary study. Pp. 131-135. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Gili, J. M., Murillo, J. and Ros, J. 1989. The distribution pattern of benthic Cnidarians in the Western Mediterranean. *Sci. Mar.* 53 (1): 19-35.

Jahoda, M. and Nortarbartolo di Sciara, G. 1993. Respiratory patterns of fin whales summering in the Ligurian Sea. Pp. 237-241. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Jahoda, M., Airoldi, S., Azzelino, A., Biassoni, N., Borsani, J. F., Cianfanelli, L., Lauriano, G., Nortarbartolo di Sciara, G., Panigada, S., Vallini, C. and Zanardelli, M. 1996. Behavioural reactions to biopsi-darting on Mediterranean fin whales. Pp. 43-48. In: *European Research on Cetaceans - 10*: Proc. 10th Ann. Conf. ECS, Lisbon, Portugal, 11-13 Mar, 1996. (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

Jefferson, T. A., Leatherwood, S., and Webber, M. A. 1993. *FAO species identification guide. Marine mammals oj the world.* Rome, FAO. 320pp.

Leatherwood, S., Reeves, R. R. and Foster, L., 1983. *The Sierra Club Handbook of Whales and Dolphins.* Sierra Club Books. San Francisco. 303pp.

Marini, L., Consiglio, C., Angradi, A. M., and Sanna, A., 1991. Preliminary results of the firs year of a sightings survey of cetaceans in the Central Tyrrhenian Sea. Pp. 22-25. In: *European Research on Cetaceans - 5.* Proc. 5th Ann. Conf. ECS, Sandefjord, Norway, 21-23 Feb, 1991. (Ed. P. G. H. Evans). European Cetacean Society, Leiden, The Netherlands. 132pp.

Marini, L., Consiglio, C., Maria, A., Sanna, A., and Valentini, T., 1992. Cetacean sighting campaign in the Central Tyrrhenian Sea : Results of the second year of activity. Pp.66-69. In: *European Research on Cetaceans - 6*: Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 Feb, 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Marini, L., Consiglio, C., Catalano, B., Valentini, T., and Villetti, G. 1996. Aerial behaviour in fin whales, *Balaenoptera physalus*, in the Mediterranean sea. *Marine Mammal Science*, 12 (3): 489-495.

Mussi, B., Miragliuolo, A., and Battaglia, M. 1997. Cetacei nell' arcipelago delle isole Pontine e Campane. Pp. 157-167. In: *Atti del 5° Seminario Internazionale di Studi sull'Ecosistema marino.* Gaeta, Napoli, Ustica, Italia. (Ed. L. Valerio), Oasi Blu del WWF, Gaeta, Italia. 286pp.

Mussi, B., Miragliuolo, A., and Battaglia, M. 1997. Osservazioni sul comportamento di *Stenella coeruleoalba* (Meyen, 1833) nell'arcipelago Pontino – Campano, *Tirreno Centro Meridionale. 3° Convegno Nazionale sui cetacei, Abstracts. 5-6 Dicembre 1997, Napoli, Italia. Centro Studi cetacei della Società Italiana di Scienze Naturali.*

Mussi, B., Gabriele, R., Miragliuolo, A., and Battaglia, M. 1998. Cetacean sightings and interacion with fisheries in the Archipelago Pontino-Campano, South Tyrrhenian sea, 1991-1995. Pp. 63-65 In: *European Research on Cetaceans - 12.* Proc. 12th Ann. Conf. ECS, Monaco, France, 20 –24 January 1998. (Editor P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Mussi, B., Miragliuolo, A., Monzini, E., Diaz Lopez, B. and Battaglia,, M. 1999. Fin whale, *Balaenoptera physalus*, feeding ground in the coastal waters of Ischia (Archipelago Campano). Pp. 330-335. In: *European Research on Cetaceans - 13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Nortarbartolo di Sciara, G., Forcada, J., Acquarone, M. and Fabbri, F. 1993. Population estimates of fin whales and striped dolphins summering in the Corso-Ligurian Basin. Pp. 135-139. In: *European Research on Cetaceans - 7*: Proc. 7th Ann. Conf. ECS, Inverness, 18-21 Feb, 1993 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Nortarbartolo Di Sciara, G., Bérubé, M., Zanardelli, M. and Panigada, S. 1995. The role of the Mediterranean in fin whale ecology: insight trhough genetics. Pp. 218-219. In: *European Research on Cetaceans - 9.* Proc. 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 Feb, 1995 (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Kiel, Germany. 302pp.

Nortarbartolo di Sciara, G., Jahoda, M., Biassioni, N. and Lafortuna, C. 1996. Reactions of fin whales to approaching vessels assessed by means of a laser rangefinder. Pp. 38-43. In: *European Research on Cetaceans - 10*: Proc. 10th Ann. Conf. ECS, Lisbon, Portugal, 11-13 Mar, 1996. (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

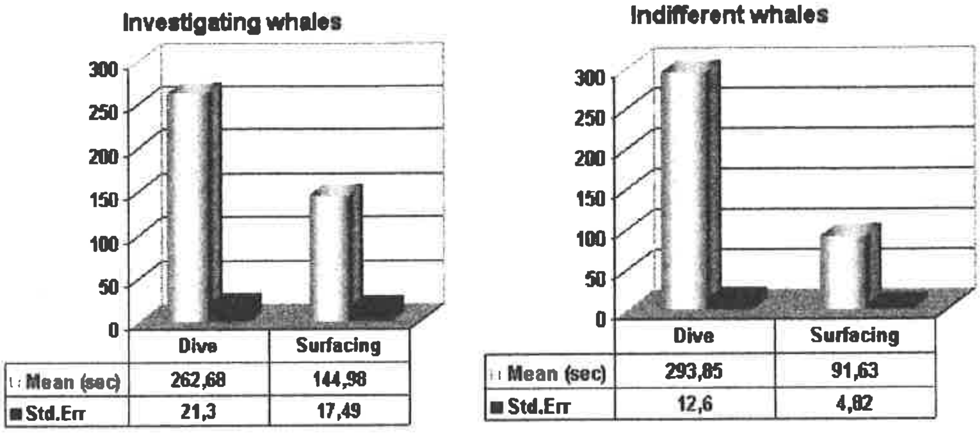
Relini, L.O. and Giordano, A. 1992. Summer feeding of the fin whale, *Balaenoptera physalus*, in the Liguro-Provençal Basin. Pp. 134-138. In: *European Research on Cetaceans - 6.* Proc. Sixth Ann. Conf. ECS, San Remo, Italy. (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England.

Relini, L.O., Relini, G., Cima, C., Palandri, G., Relini, M., and Torchia, G. 1994. *Meganyctiphanes norvegica* and fin whales in the Ligurian Sea: new seasonal patterns. Pp. 179-183. In: *European Research on Cetaceans - 9.* Proc. 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 Feb, 1995 (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Kiel, Germany. 302pp.

Richardson, W. J., Fraker, M. A., Würsig, B., and Wells, R. S. 1985. Behaviour of bowhead whales *Balaena mysticetus* summer in the Beaufort Sea: reactions to industrial activities. *Biol. Conserv.*, 32(3): 195-230.

Zanardelli, M., Nortarbartolo Di Sciara, G., and Jahoda, M. 1992. Photo-identification and behavioural observation of fin whales summering in the Ligurian Sea. Pp. 86-90. In: *European Research on Cetaceans - 6*: Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 Feb, 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Fig. 1 Temporal distribution in the dive-sufacing cycle



Investigating whales

	Dive	Surfacing
☐ Mean (sec)	262,68	144,98
■ Std.Err	21,3	17,49

Indifferent whales

	Dive	Surfacing
☐ Mean (sec)	293,85	91,63
■ Std.Err	12,6	4,82

Fig. 2, 3 Whales' behaviour

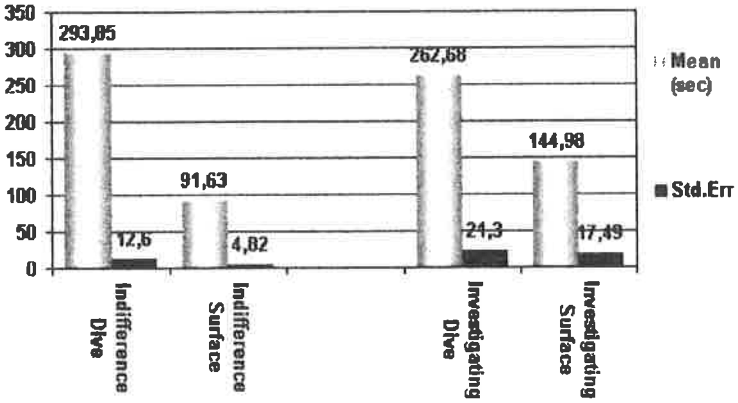


Fig. 4 Dive-surfacing lengths in different behaviouralstates

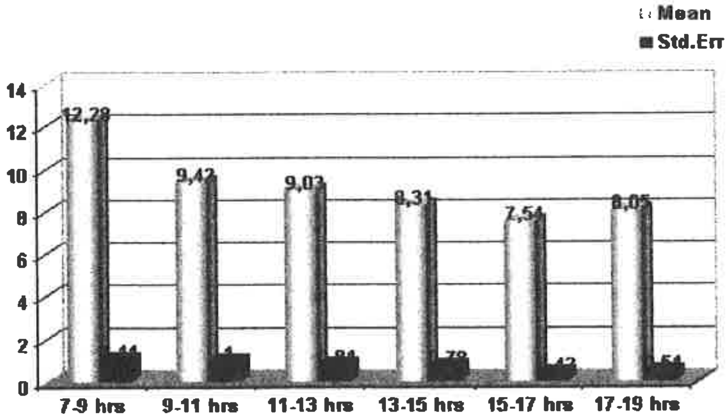


Fig.5 Surfacing rates during the day

A COMPARATIVE APPROACH OF THE MOVEMENT PATTERNS AND ORIENTATION OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) AND BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE NORTH-EASTERN ALBORAN SEA

J. A. Fayos, A. Cañadas and R. Sagarminaga

ALNITAK, Universidad Autónoma de Madrid, Nalón 16, E-28240 Hoyo de Manzanares, Madrid, Spain

INTRODUCTION The continental shelf of the coast of Almería has been highlighted as an important breeding ground for several species of cetacean prey. The region is known to concentrate the highest levels of ichthyoplankton in the Alboran Sea, induced by the oceanographic phenomena related to the inflow of Atlantic waters through the Strait of Gibraltar, as well as local physiography.

Two species of cetaceans are regularly observed in this area, the bottlenose dolphin (*Tursiops truncatus*) and the common dolphin (*Delphinus delphis*). Movement patterns of both species have been compared with the topography to determine if they are related to these movements, and as a means of identifying important habitats for these two species listed as vulnerable by the Spanish Ministry of Environment.

METHODOLOGY Data from 265 sightings of common dolphins and 108 of bottlenose dolphins between 1992 and 1999 were analysed. One hundred and twenty-four and 83 of these sightings, respectively, had data of long visual tracks of the animals, which were used for the analysis.

The research area was divided into eight sub-areas for the analysis. A first division was made taking into account the depth. In this way, three ranges were considered: 0 – 200 m, 201 – 500 m and 501 – 1000 m depth, named respectively A, B and C. Each of these depth ranges was in turn divided into 2 to 3 sub-areas with similar orientation of the isobaths (Table 1). The area A3 was not considered in the analysis due to the small sample size of tracks. For bottlenose dolphins, an extra area was considered, which for the common dolphins was included in area B1. This was the Seco de los Olivos, an underwater mountain with the higher encounter rate for this species. For this area, being a rounded mountain, we calculated the angles of the four sides of a diamond shaped figure drawn over the mountain, and reduced it to two mean directions. In this way the distribution was quadrimodal; hence, we transformed it into an unimodal distribution by adding or subtracting the appropriate number of degrees equally to both the physiography and to the orientations of the dolphins.

Circular statistics was used to test the significance of the orientation patterns during the movements of the dolphins: the Rayleigh test for randomness was used to verify statistical evidence of directionality, being H_0 that the sampled population is uniformly or randomly distributed around the 360°. If H_0 is rejected by this test, we may conclude that there is a mean population direction. The v test was used to verify if the dolphins were oriented in the same direction as the depth contours, which were considered the expected mean direction (Batschelet, 1981; Zar, 1984).

For each area and species, the mean angle (ϕ), the data dispersion (r) and the mean angular deviation (s) of the orientations were calculated. As the distribution of the data was bimodal for each direction (for example, the dolphins can be swimming to the east or to the west), we transformed it to unimodality in order to apply the statistical analysis. This was done by duplication of the data: each data was multiplied by 2, and to those angles between 180° and 360°, 360° were subtracted. The mean angle obtained in this way (ϕ_2) was then divided by 2, so that $\phi_1 = \phi_2 / 2$ (for the samples between 0° and 180°), and $\phi_1 + 180°$ (for the samples between 180° and 360°).

RESULTS AND DISCUSSION Results obtained for both species are shown in Table 2 (for common dolphins) and Table 3 (for bottlenose dolphins).

Delphinus delphis In areas A1 and A2, corresponding to the shallowest depth range (0 to 200 m), the results showed that the dolphins had a highly significant directionality, and that they were highly significantly oriented in the same direction as the depth contours. Their favourite prey, small pelagic fish such as sardines, usually concentrate over the continental shelf and the first section of the continental slope. The dolphins are probably tracking the area using the bottom topography as landmarks in their orientation, especially when they are searching for their prey. Even in very long tracks, they seemed to orientate on some occasions exactly as the bottom topography did.

In areas B1 and B2, which correspond to the next depth range (200 to 500 m), their directionality was also significant, but not so much as in areas A, but they were still highly significantly oriented in the same direction as the physiography.. Area B3 had a much more complex physiography, with the depth contours not being as straight as in the other areas. Thus, the results are difficult to analyse here, although in the map it can be seen that, again, most of the tracks close to the line of 200 m were following this depth contour. Areas C1 and C2 (corresponding to the deepest depth range considered in this study: from 500 to 1000 m) did not show any directionality, and the values of *u* were much smaller, giving lower significance to the orientation in relation to the bottom topography.

In shallow waters up to around 300 m, common dolphins could be using the bottom topography as a landmark for their orientation in search of their prey inhabiting those areas. In deeper waters, they are probably not searching for food, or at least for these small pelagic fish, and hence they would not need to track over specific depth ranges, using other mechanisms or clues for their orientation.

Tursiops truncatus The bottlenose dolphins showed a highly significant directionality in three areas: A1, Seco de los Olivos, and B2, whilst in areas B3 and C2, the directionality was significant but not as much as in the previous three areas. There was no statistical evidence of directionality in areas A2, B1 and C1. At the same time, the dolphins were highly significantly oriented in the same direction as the depth contours (*u* value) in all areas with the exception of C1 (not significant), the Seco de los Olivos being the area with the highest significance.

The favourite prey of this species is demersal fish inhabiting the continental shelf and slope, and the Seco de los Olivos area has been highlighted as an important feeding ground for it (Cañadas *et al.* in press). Bottlenose dolphins are therefore probably using also the bottom topography as a landmark for their orientation, especially when searching for food, as their prey are directly related to this topography, not only around the Seco de los Olivos, but also in other areas with the appropriate depth (up to around 300 m).

The lack of directionality in area A2 could be due to the fact that two main directions were tracked in this area: most tracks between the depth contours of 100 m and 200 m (the continental shelf edge) were parallel to them, whilst in shallower waters from 0 to 100 m, they were perpendicular. The tracks between 100 and 200 m are responsible for the high *u* value in this area. In areas C1 and especially in B1, the lack of directionality could be due to the influence of the proximity of the Seco de los Olivos, as the dolphins were probably navigating towards that area. This is probably the reason why area C1 was the only one with a non significant *u* value.

This species seems to orientate with the bottom topography even in deep waters, where it is very unlikely that they are searching for food, or at least for their most common demersal prey. Thus, they are probably using the bottom physiography as landmarks for their orientation during most of their displacements, even when they are not searching for food.

CONCLUSION From these results, we can conclude that physiography, which is considered in some cases to be related to cetacean distribution due to aggregation of prey, could also be playing an important role as a landmark for cetacean orientation. More research will be conducted to investigate the orientation patterns of these and other species in the area, with a deeper insight into the behavioural states and other parameters that could be influencing the orientation.

ACKNOWLEDGEMENTS We would like to thank to all the volunteers on board the research vessel *Toftevaag*, and especially to those from the Earthwatch Institute, for their help both financial and with the data collection. We are also very grateful to Dr. Joaquín Ortega for his teachings and advice on circular statistics, to Dr. Javier de Miguel for his advice, and to María Ovando, Manuel Fernández-Casado and Renaud de Stephanis for their help in the preparation of the data.

REFERENCES

Cañadas, A., Sagarminaga, R., García, S. and Marcos, P. 1999. Cetacean distribution with respect to the physiography of the Alboran sea. Pp. 175-179. In: *European Research on Cetaceans – 13.* Proceedings of the 13th Annual Conference of the European Cetacean Society, 5-8 April 1999, Valencia, Spain. (Eds. P. G. H. Evans, J. Cruz and J. A. Raga). European Cetacean Society, Valencia, Spain. 484pp.

Batchelet, E. 1981. *Circular Statistics in Biology.* Academic Press, New York.

Zar, J. H. 1984. *Biostatistical analysis.* Prentice-Hall International, Inc., New Jersey.

Table 1. Orientation of the isobaths for the seven sub-areas analysed (divided in the two complementary angles: from 0° to 180° and from 180° to 360°)

AREA	Orientation of the isobaths	
	0° – 180°	**180° - 360°**
A1	109.33	289.0
A2	58.11	238.11
B1	100.47	280.47
Seco de los Olivos (direction 1)	124.5	304.5
Seco de los Olivos (direction 2)	40	220.5
Seco de los Olivos	124.5	304.5
B2	67.74	247.74
B3	123.83	303.83
C1	74.34	254.34
C2	102.94	282.94

Table 2. Circular statistics for *Delphinus delphis* (n = sample size; r = data dispersion and significance for the test of Rayleigh; ϕ_1 and ϕ_2 = mean angle of the orientation of the groups tracked for 0°-180° and 180°-360°; $\phi_{0\text{-}1}$ and $\phi_{0\text{-}2}$ = mean orientation of the isobaths for 0°-180° and 180°-360°; u = statistic for the test v.

Delphinus delphis					
Area	***n***	***r* Rayleigh's test**	**ϕ_1 and ϕ_2**	**$\phi_{0\text{-}1}$ and $\phi_{0\text{-}2}$**	***u* v test**
A1	24	$r = 0.466$ $p < 0.005$	$\phi_1 = 102.3$ $\phi_2 = 282.3$	$\phi_{0\text{-}1} = 109$ $\phi_{0\text{-}2} = 289$	$u = 4.712$ $p < 0.0005$
A2	19	$r = 0.602$ $p < 0.001$	$\phi_1 = 65$ $\phi_2 = 245$	$\phi_{0\text{-}1} = 58.1$ $\phi_{0\text{-}2} = 238.1$	$u = 4.765$ $p < 0.0005$
B1	21	$r = 0.348$ $p < 0.10$	$\phi_1 = 90.8$ $\phi_2 = 270.8$	$\phi_{0\text{-}1} = 100.5$ $\phi_{0\text{-}2} = 280.5$	$u = 3.796$ $p < 0.0005$
B2	22	$r = 0.399$ $p < 0.05$	$\phi_1 = 78.7$ $\phi_2 = 258.7$	$\phi_{0\text{-}1} = 67.7$ $\phi_{0\text{-}2} = 247.7$	$u = 4.150$ $p < 0.0005$
B3	11	$r = 0.302$ $p > 0.10$	$\phi_1 = 99.1$ $\phi_2 = 279.1$	$\phi_{0\text{-}1} = 123.8$ $\phi_{0\text{-}2} = 303.8$	$u = 2.456$ $p < 0.01$
C1	18	$r = 0.192$ $p > 0.10$	$\phi_1 = 116.5$ $\phi_2 = 296.5$	$\phi_{0\text{-}1} = 74.3$ $\phi_{0\text{-}2} = 254.3$	$u = 2.261$ $p < 0.025$
C2	9	$r = 0.227$ $p > 0.10$	$\phi_1 = 58.6$ $\phi_2 = 238.6$	$\phi_{0\text{-}1} = 102.9$ $\phi_{0\text{-}2} = 282.9$	$u = 1.711$ $p < 0.05$

Table 3. Circular statistics for *Tursiops truncatus* (n = sample size; r = data dispersion and significance for the test of Rayleigh; ϕ_1 and ϕ_2 = mean angle of the orientation of the groups tracked for 0°-180° and 180°-360°; $\phi_{0\text{-}1}$ and $\phi_{0\text{-}2}$ = mean orientation of the isobaths for 0°-180° and 180°-360°; u = statistic for the test v.

Tursiops truncatus					
Area	***n***	***r* Rayleigh's test**	**ϕ_1 and ϕ_2**	**$\phi_{0\text{-}1}$ and $\phi_{0\text{-}2}$**	***u* *v* test**
A1	7	$r = 0.846$ $p < 0.005$	$\phi_1 = 92.0$ $\phi_2 = 272.0$	$\phi_{0\text{-}1} = 109.3$ $\phi_{0\text{-}2} = 289$	$u = 3.365$ $p < 0.0005$
A2	19	$r = 0.228$ $p > 0.10$	$\phi_1 = 74.3$ $\phi_2 = 254.3$	$\phi_{0\text{-}1} = 58.1$ $\phi_{0\text{-}2} = 238.1$	$u = 2.886$ $p < 0.0025$
Seco de los Olivos	17	$r = 0.544$ $p < 0.005$	$\phi_1 = 133.7$ $\phi_2 = 313.7$	$\phi_{0\text{-}1} = 124$ $\phi_{0\text{-}2} = 304$	$u = 4.273$ $p < 0.0005$
B1	10	$r = 0.337$ $p > 0.10$	$\phi_1 = 83.3$ $\phi_2 = 263.3$	$\phi_{0\text{-}1} = 100.5$ $\phi_{0\text{-}2} = 280.5$	$u = 2.537$ $p < 0.005$
B2	17	$r = 0.834$ $p < 0.001$	$\phi_1 = 81.8$ $\phi_2 = 261.8$	$\phi_{0\text{-}1} = 67.7$ $\phi_{0\text{-}2} = 247.7$	$u = 5.247$ $p < 0.0005$
B3	8	$r = 0.725$ $p < 0.01$	$\phi_1 = 93.2$ $\phi_2 = 273.2$	$\phi_{0\text{-}1} = 123.8$ $\phi_{0\text{-}2} = 303.8$	$u = 3.173$ $p < 0.0005$
C1	9	$r = 0.083$ $p > 0.10$	$\phi_1 = 99.2$ $\phi_2 = 279.2$	$\phi_{0\text{-}1} = 74.3$ $\phi_{0\text{-}2} = 254.3$	$u = 1.164$ $p > 0.10$
C2	10	$r = 0.663$ $p < 0.01$	$\phi_1 = 62.0$ $\phi_2 = 242.0$	$\phi_{0\text{-}1} = 102.9$ $\phi_{0\text{-}2} = 282.9$	$u = 3.165$ $p < 0.0005$

USING DUAL SCALING IN CETACEAN BEHAVIOUR STUDIES: A MULTIVARIATE APPROACH

A. I. Fernández[1], J. M. Gutiérrez[1], R. Mengual[2], D. Verdes[3], A. Méndez[3],
B. C. Marcos[1] and A. Pérez-Ruzafa[1]

[1]*Dpto. de Ecología e Hidrología, Facultad de Biología, Universidad de Murcia, 30100 Murcia, Spain*
[2]*Dpto. de Biotecnología. Area de Biología Celular, Facultad de Ciencias,*
P.O.B. 99, Universidad de Alicante.03690, Alicante Spain
[3] *"Excursiones Marinas y Submarinas". Club de Regatas del Puerto de Mazarrón. Mome I. 30.860, Mazarrón, Murcia, Spain*

Knowledge of the behaviour of cetaceans has added to the relationships they have with their habitats, and is an important requirement to managing them. The use of multivariate analytical techniques would help us improve behaviour studies. Since 1998, whalewatching cruises have been conducted on the Murcia coasts (SE Spain). In 1999, the more frequently sighted species, sorted by the number of sightings, were striped dolphin *Stenella coeruleoalba*, Risso's dolphin *Grampus griseus*, long-finned pilot whale *Globicephala melas*, common dolphin *Delphinus delphis* and bottlenose dolphin *Tursiops truncatus.* During these cruises, behavioural observations were carried out.

Behavioural observations must be considered as categorical data, and as such are difficult to analyse. How to retrieve information from categorical data has been a perennial problem in data analysis. Relationships between group structure and behaviour are difficult to analyse without appropriate analytical techniques.

Dual Scaling is a technique, related to Correspondence Analysis, designed to explore a hidden structure of categorical data. We use Dual Scaling to illustrate some relationships between group cohesion and behaviour on one hand and structure (age) of the groups and response to the vessel by the other.

Our results show that socialising and resting activities in *S. coeruleoalba* are carried out by forming compact groups, and travelling occurs in smaller groups within a bigger one, whilst feeding activities have no relationship with the general group structure. We interpret this last result as group feeding behaviour, which depends on the prey they were feeding upon. In addition, the adult groups, with or without young individuals, are more likely to approach vessels whilst the presence of calves limits this kind of activity.

AN INSIGHT ON THE BIOLOGICAL SIGNIFICANCE OF MIXED GROUPS OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) AND STRIPED DOLPHINS (*STENELLA COERULEOALBA*) IN THE ALBORAN SEA

S. García[1], D. Knouse[1], R. Sagarminaga[2] and A. Cañadas[2]

[1]*ALBORAN, Universidad Autónoma de Madrid, Cantoblanco 28049 Madrid, Spain*
[2]*ALNITAK, Univ. Autónoma de Madrid, Nalón 16, 28240 Hoyo de Manzanares, Madrid, Spain*

INTRODUCTION The Alboran Sea appears to be an ideal research site for studying the magnitude and possible causes of the apparent decline of the common dolphin (*Delphinus delphis*) population in the Mediterranean. One of the hypotheses that has been suggested by several authors is that of the existence of competition between this species and striped dolphins (*Stenella coeruleoalba*) (Viale, 1980; Casinos, 1982). The striped and common dolphins are at present the most frequently encountered species in the Alboran Sea region. The first species is now considered very abundant throughout the pelagic waters of the Mediterranean, whereas the latter is nowadays only seldom observed north of latitude 37° 40' N, which is the northern limit of the research area (Gannier, 1995; Forcada and Hammond, 1998; Cañadas *et al*, 1999).

The aim of this study was to test the hypothesis of a possible competition between the two species by analysing the inter-specific relations between them.

METHODOLOGY Since 1992, Alnitak is carrying out a ship-based survey on populations of cetaceans in the north-eastern section of the Alboran Sea. The research area covers from Cabo de Palos - 36°38'N 0°33'W to Almerimar - 36°20'N 2°55'W. This area was divided into two sub-areas due to their different oceanographic and physiographic characteristics: the Gulf of Vera (north-eastern area, from Cabo de Palos to Cabo de Gata) and the Alboran section (south-western area, from Cabo de Gata to Almerimar). Eight to ten hours per day (30 to 50 nm) were sailed during June, July, August and September from 1992 until 1999, on board the research vessel *Toftevaag*. Data on species, time, and position, oceanographic and meteorological conditions, behaviour, social structure, etc, were taken at sightings. Only encounters during effort were considered. Effort stopped with sea state of 3 (Douglas scale) or more.

In order to gain some insight into the biological significance of the mixed groups, comparisons regarding behaviour, group size, presence of juveniles and calves, and depth were made between mono-specific groups of common and striped dolphins, and among these and mixed groups of both species. We considered five categories for behaviour: feeding, milling, resting, travelling and socialising.

For some of the analysis, the data were homogenised through the calculation of the encounter rates (E.R.) for different areas or depth ranges, both for mono-specific groups and for mixed groups. Four depth ranges were established: 0-200 m, 201-500 m, 501-1000 m, and more than 1000 m. We used the *z* test, Mann-Whitney U test, Kruskal Wallis and chi-square tests for the statistical analysis of data.

RESULTS In these eight years of research, 392 groups of common dolphins, 603 groups of striped dolphins, and 78 mixed groups of both species were sighted.

Comparison between areas

1. The encounter rate for mixed groups in both areas was not significantly different, although there existed a positive tendency for the Alboran section (E.R. Alboran = 0.622, E.R. Vera = 0.336, χ^2=4.7, df=1, n= 54, p>0.05).
2. There was no difference between the encounter rates of striped dolphins between the areas (E.R. Alboran = 3.38, E.R. Vera = 0.16, chi-square test: χ^2=0.4, df=1, n=401, p>0.05; Mann Whitney test: U=191.5, p>0.05).
3. Monospecific groups of common dolphins were highly significantly more abundant in the Alboran section than in the Gulf of Vera (E.R. Alboran = 4.09, E.R. Vera = 1.39, chi-square test: $\chi2$=86.5, df=1, n=294, p<<0.01; Mann-Whitney test: U=105.0, p=0.01).

Comparison among depth ranges

1. Monospecific groups of striped dolphins showed a highly significant difference in distribution among depth ranges, preferring always depths greater than 500 m, and especially greater than 1000 m (chi-square test: χ^2=355.2, df=3, n=398, p<<0.01; Kruskal Wallis test: K=19.693, df=3, p<<0.001).
2. There were no significant differences in distribution per depth for monospecific groups of common dolphins (chi-square test: χ^2=4.2, df=3, n=293, p>0.05; Kruskal Wallis test: K=0.730, df=3, p>0.05).
3. Mixed groups of both species showed highly significant differences in distribution per depth, with all encounters except one in depths greater than 200 m. (χ^2=29.6, df=3, n=54, p<<0.01; Kruskal Wallis test: K=10.228, df=3, p<0.05).

The average depth at encounters of striped dolphins was 959 m (SE ±18.1 m, n=505); for common dolphins, it was 543 (± 26.7, n=308); whilst the average depth for mixed groups was 847 m (±51.9, n=76). Chi-square tests showed a highly significant difference both between the distribution per depth of monospecific groups of striped dolphins and mixed groups (χ^2=19.336, df=3, n=456, p<<0.001), and between monospecific groups of common dolphins and mixed groups (χ^2=26.759, df=3, n=311, p<<0.001).

Differences per group size and presence of calves

1. There were no significant differences between the average group size of common dolphins in monospecific (x=72.6, SD=97.4, n = 289) and mixed groups (x=74.5, SD=110.3, n=75), with a z value of 1.03 (p>0.05).
2. The average group size of striped dolphins in mixed groups (x=71.6, SD=79.3, n=77) was highly significantly larger than in monospecific groups (x=41.0, SD=46.5, n=490), with a z value of 3.35 (p<0.01).
3. The average group size between monospecific groups of striped and common dolphins was highly significantly different (z=4.39, p<<0.01; U=29,505.5, p<<0.01).
4. There were no significant differences between group sizes of striped and common dolphins in mixed groups (z=1.33, p>0.05; U=21,911, p>0.05).
5. No differences in the presence of calves or juveniles were detected between the sightings of monospecific and mixed groups (χ^2=0.159, df=1, p>0.05).

Differences per behaviour

1. There were highly significant differences between the behaviour of monospecific groups of both species and mixed groups. There were more sightings than expected of mixed groups socialising, and fewer feeding, in comparison to monospecific groups (χ^2=16.6, df=4, p<<0.01).

DISCUSSION The results obtained from the analysis of the areas show that striped dolphins are similarly present in both regions, whereas the common dolphin appears more often in the Alboran section. However, it cannot be assumed that the existence of mixed groups depends on the relative abundance of each species in either area.

From the study of the distribution in relation to depth ranges, it can be stated that striped dolphins prefer deeper waters (depth >500 m) whereas common dolphins show no preference in this respect. Mixed groups are more abundant in depths greater than 200 m, which is consistent with striped dolphins having a higher presence in deep waters. However, from the fact that the presence of mixed groups in the 200-500 m range and in deeper ranges is similar, it can be assumed that in this shallower area where striped dolphins are less frequent, this species is more readily associated with common dolphins.

The analysis of the distribution of monospecific and mixed groups in relation to depth also showed significant differences; from these results, we conclude that either the species change their depth preferences in mixed groups or the animals that form mixed groups have chosen unusual depths intentionally for other reasons (prey scarcity, population density, etc.) and that leads them to join the other species.

Another variable studied, group size, was significantly different between monospecific groups, common dolphins having much greater numbers of individuals per group. Mixed groups showed no difference to common dolphin groups in size; however, striped dolphins groups were smaller than these groups. This analysis also shows that there is a similar proportion of both species when they are found together, regardless of the higher number of common dolphins in monospecific groups.

Differences were also found regarding behaviour patterns between mixed and monospecific groups. When the species are sighted together, there is greater social activity, which could mean that these socially complex species communicate intensely with each other. It is also interesting to point out the lower chance of encountering mixed groups feeding than monospecific ones, a fact that could be due to the different feeding habits of both species.

CONCLUSION Although it seems that common and striped dolphins do not form associations by chance, the reasons for it are still not clear. Mixed groups are usually found between species that benefit one another either with protection or with higher efficiency in hunting prey (Baraff, 1998). However, neither of these aspects seems to be the reason for mixed group formation, in this case because predators are not common in the Alboran waters and each species' diet is different (unless scarcity of prey temporarily modified one species' feeding habits). In any case, these results do not support the hypothesis of a possible competition for ecological niche between the two species.

ACKNOWLEDGEMENTS We would like to thank all the volunteers on board the research vessel Toftevaag, and especially those from the Earthwatch Institute in 1999, for their help both financial and with the data collection. We are also very grateful to Dr. Angel Baltanás, Dr. Juan E. Malo, Dr. Begoña Peco, Dr. Javier de Miguel and Dr. Arturo Morales from the Universidad Autónoma de Madrid for their help and valuable advice, and to Pilar Marcos, Ainhoa Pérez-Puyol, Celia Agustí and Dr. Alexandros Frantzis for their comments on different aspects of this work.

REFERENCES

Baraff, L S. and Asmutis–Silvia, R.A. 1998. Long-term association of an individual long-finned pilot whale and atlantic white-sided dolphins. *Marine Mammal Science*, 14(1): 155-161.

Cañadas, A., Sagarminaga, R., García, S. and Marcos, P. 1999. Cetacean distribution with respect to the physiography of the Alboran sea. In: *European Research on Cetaceans - 13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999 (Eds, P. G. H. Evans, J. A. Raga, and J. Cruz) European Cetacean Society, Valencia, Spain. 484pp.

Casinos, A. 1982. Los cetáceos del Mediterráneo. *Mundo Científico*. 16 (2): 714-724.

Forcada, J. and Hammond, P. 1998. Geographical variation in abundance of striped and common dolphins of the western Mediterranean. *Journal of Sea Research*, 68 (1998): 1-13

Gannier, A. 1995. *Les cétacés de Méditerranée nord-occidentale: estimation de leur abondance et mise en relation de la variation saisonnière de leur distribution avec l'ecologie du milieu.* Master Thesis. Ecole Pratique des Hautes Etudes. Montpellier, France.

Viale, D. 1980. Les modifications du peuplement de cétacés de Méditerranée occidentale. *Journées Étud. Systém. Et Biogéogr. Médit.* Cagliari, C.I.E.S.M.

ASSOCIATION PATTERNS OF RISSO'S DOLPHINS (*GRAMPUS GRISEUS*) IN THE NORTH-WEST MEDITERRANEAN

S. Gaspari[1], A. Azzellino[2], S. Airoldi[3], and A. R. Hoelzel[1]

[1]*University of Durham, Department of Biological Sciences, South Road, Durham, DH1 3LE, UK*
[2] *Politechnic University of Milan, Environmental Engineering Department, 20133 Milano, Italy*
[3]*Tethys Research Institute, viale G. B. Gadio 2, 20121 Milano, Italy*

Most delphinids are very social and spend much time in the presence of conspecifics. The proportion of co-occurrence of any two individuals is usually measured by means of association indices. In this study, the Simple Ratio index was used to describe the association patterns in a population of Risso's dolphins in the Northwest Mediterranean Sea. The area is included in the recently declared Cetacean Sanctuary. From 1990 to 1998, 128 individuals were photo-identified. In the present study, only individuals resighted at least three times were considered ($N = 58$). Association indices ($SR \geq 0.5$) showed that about 4% of all possible pairwise interactions between dolphins were observed. Thirty-four percent of the individual associations of dolphins pairs tested, were found to be significantly different ($p < 0.01$) from random distributions derived from a randomisation test (30,000 unrestricted permutations). The overall pattern of associations was weak with few strong associations between individuals lasting over the years. Cluster Analysis outlined the existence of four social groups. These results suggest a fission-fusion society for the considered population, and represent one of the first reports of longterm associations in Risso's dolphins.

EFFECTS OF THE LUNAR CYCLE ON THE FORAGING ECOLOGY OF SUBANTARCTIC FUR SEALS

J.-Y. Georges[1], D. Filippi[2] and C. Guinet[1]

[1] *CEBC-CNRS, 79360 Villiers en bois, France ; (1) LBEM, Université de La Rochelle,*
17042 La Rochelle, France
[2] *LSCE, avenue de la terrasse, 91198 Gif sur Yvette, France*

Lactating subantarctic fur seals breeding on Amsterdam Island, Indian Ocean, feed nocturnally on mesopelagic myctophid fish occurring in deep scattering layers. Prey accessibility varies according to light levels: (1) myctophids show vertical nocturnal migrations, being deeper than the seals' diving capacities during the day, and migrating close to the surface at night, when seals can feed on them; (2) myctophids occur in much lower densities in the upper ocean during nights with a full moon than on nights with a new moon.

During this study, we investigated maternal attendance patterns, diving behaviour, and foraging performances in lactating subantarctic fur seals in relation to the lunar cycle, to assess how subantarctic fur seals respond to cyclic changes in prey availability. Fourier analyses performed on daily census data showed a cyclical lunar rhythm, with the highest number of lactating females ashore during a full moon. Time depth recorder data indicated that fur seals did not dive deeper during a full moon, but performed longer dives than at a new moon. Furthermore, fur seals increased their diving effort (dive frequency, vertical travel distance, and time spent diving) during nights with a full moon compared with nights with a new moon. Individual weighing of pups showed no significant differences in mass gain between pups whose mothers were foraging at sea during a full moon compared with those whose mothers were at sea during a new moon.

This study suggests that changes in maternal attendance and foraging behaviour over the lunar cycle correlate with reduction of prey availability by lunar light. Subantarctic fur seals appear to reduce the foraging costs associated with the predictable, cyclic reduction in relative food availability by (1) synchronising their foraging periods with periods of highest prey availability, and/or (2) by increasing their foraging effort during low food availability periods.

DOLPHIN DIVING BEHAVIOUR: IMPLICATIONS FOR HABITAT SELECTION IN A THREE-DIMENSIONAL ENVIRONMENT

G. D. Hastie[1], B. Wilson[2], L. H. Tufft[1], and P. M. Thompson[1]

[1]*Zoology Department, University of Aberdeen, Lighthouse Field Station, Cromarty, Ross-shire, UK* [2]*NERC Sea Mammal Research Unit, Gatty Marine Laboratory, School of Environmental and Evolutionary Biology, University of St. Andrews, St. Andrews, Fife, KY16 8LB, UK*

Habitat selection by marine mammals must be considered in three-dimensional space, taking account of both the horizontal distribution of animals at the water surface and their vertical distribution within the water column. In NE Scotland, a narrow bay entrance, approximately 55 metres deep, is used intensively by a large proportion of a resident bottlenose dolphin population. Within this area, dolphins are seen significantly more often in the deepest regions. This study aimed to further understand their habitat selection in this deep area using passive acoustic techniques to examine the dolphins' vertical distribution within the water column. Data were collected using a vertical 4-hydrophone array deployed from a motor vessel. Recordings of dolphin vocalisations were made using a 4-track tape recorder. Twenty five-minute samples were collected during the summer of 1999. The vertical distribution of echolocation clicks was used as an index of the distribution of dolphins. The depth of each click was established by calculating the time delays of sound arrival between hydrophones and plotting corresponding hyperbolas. A total of 600 echolocation clicks were localised. Calibration of the array showed that the median error in depth estimation was ±0.63 metres at distances of up to 300 metres from the array. Although clicks were localised at all depths in the water column, there were significantly more within the top 10 metres (Kruskall-Wallis statistic = 69.09. df=5, P=0.000). In 75% of the samples, the deepest click localised was within 15 metres of the seabed. This passive acoustic technique proved an accurate method for studying the depth distribution of dolphin vocalisations. The findings suggest that dolphins spend the majority of their time close to the water surface. Nevertheless, they do appear to consistently travel to depths close to the seabed.

CAN WE PREDICT BOTTLENOSE DOLPHIN BEHAVIOUR?

C. Liret[1], E. Cam[2], and J. Y. Monnat[2]

[1]*Laboratoire d'Etude des Mammifères Marins, Océanopolis, B.P. 411, 29275 Brest cedex, France*
[2]*Laboratoire de biologie animale, UFR Sciences et Techniques, B.P. 809, 29285 Brest cedex, France*

In some studies of animal behaviour, the instantaneous sampling method is used, resulting in daily sequences of activities. These successive observations are interdependent: an animal's activity at time t+1 is influenced by its activity at time t. From this assumption of a Markov process, the hypothesis that animals follow a behavioural model according to different variables is established.

Activity sequences of coastal bottlenose dolphins resident around île de Sein, Brittany, are analysed by estimating the probability of transition from one state to another. The model research has been realised by using SAS procedures. Daily activity patterns of dolphins are influenced by environmental parameters. Tide appears to be a main factor and leads to a behavioural change at defined moments. Moreover, the duration of an activity acts on the probability of transition. The analysis of behavioural sequences appears to be a promising step towards a better understanding of these dynamic relationships with the environment.

AQUISITION OF TEMPORALLY FINELY-RESOLVED DATA ON THE BEHAVIOUR OF FREE-RANGING HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN THE BALTIC: A FIRST ATTEMPT

K. Lucke[1], R. Wilson[2], J. Teilmann[3], G. Desportes[4], F. Larsen[5], D. Adelung[2] and U. Siebert[1]

[1]*Forschungs- und Technologiezentrum Westkueste, Hafentoern, 25761 Buesum, Germany*
[2]*Institut fuer Meereskunde, Abt. Meereszoologie, Duesternbrooker Weg 20, 24105 Kiel, Germany*
[3]*National Environmental Research Inst., Dept for Arctic Environment, Tagensvej 135, 4.,*
2200 Copenhagen N Denmark
[4]*Fjord & Bæltcentret, Margrethes Plads 1, 5300 Kerteminde, Denmark*
[5]*Danish Institute for Fisheries Research, Dept. of Marine Fisheries, Charlottenlund Castle,*
2920 Charlottenlund, Denmark

The development of effective protection measures for harbour porpoises regarding bycatch and habitat depletion depends basically on knowledge of the behaviour and ecology of these animals. The use of satellite telemetry and data loggers currently provides the only direct approach to gather data. On 20th May 1999, a young male porpoise, caught in a pound net in the Inner Danish Waters, was fitted with a self-releasing buoyant unit attached to the dorsal fin. The unit was hydrodynamically shaped and contained a Platform Transmitter Terminal (enabling positional fixes to be obtained via the Argos satellite system) and a data logger recording water temperature, animal swim speed, dive depth, heading and inclination at intervals of 6 s. The system was designed to be released after ca. 14 days corresponding to the time when the logger memory was full.

Numerous position fixes were obtained during the period of deployment. The unit was recovered beached on the island of Anholt (Kattegat, DK) on 10th June 1999. During the period of logging, speed was recorded for the first 40 hours only, after which the sensor (a differential pressure sensor) failed. Other than that, animal activity was consistently recorded for the full logging period.

The porpoise dived almost continuously during this 14 day-period exploiting depths up to 43 m and remaining underwater for up to 100 s. Various dive profiles were exhibited, including 'U', 'V' and 'W' shaped dives as well as many other types. There was a clear relationship between the maximum depth reached during a dive and the following parameters; dive duration, descent duration, ascent duration, time spent during the bottom phase of the dive, descent and ascent rates. The animal tended to dive deeper around dawn and dusk although extensive diving was apparent at all times of the day and night.

SOCIAL STRUCTURE AND MALE PARENTAL CARE IN A LONG FINNED PILOT WHALE (*GLOBICEPHALA MELAS*) POD OFF VENTOTENE ISLAND (SOUTHERN TYRRHENIAN SEA, ITALY)

B. Mussi[1], A. Miragliuolo[1] and B. Díaz López[2]

[1]*Studiomare, 82 via d'Abundo , 80075 Forio d'Ischia, Napoli, Italy (E-mail: studiomare@pointel.it)*
[2]*CEMMA, Aldea Nova 82, 15220 Ames-A Coruña, Spain*

INTRODUCTION: Long-finned pilot whale (*Globicephala melas*) is a rare species in the Mediterranean Sea (Notarbartolo di Sciara *et al.*, 1990; Gannier & Gannier, 1990, 1992; Giordano and Tringali, 1992; Marini *et al.*, 1992; Airoldi *et al.*, 1999), relatively common only in the Alboran Sea (Cañadas and Sagarminaga, 1998) and in the Strait of Gibraltar (Das, 1999). In 1995, we encountered for the first time a free-ranging pod of long- finned pilot whales off the south-western coast of the island of Ventotene in the Archipelago Pontino (Tyrrhenian Sea, Italy). This area has been the object of a longterm study on Cetaceans since 1991. From 1995 to 1999, we observed, every year, this single stable pod of long-finned pilot whales that seems to be seasonally resident off Ventotene island (Mussi *et al*, 1997, 1998)

METHODS: The observations were carried out on board the "Barbarian", a 15 m sailboat equipped for underwater listening with towed hydrophones (system response 10 Hz, 20 kHz) and underwater vision (underwater Panasonic CCD Camera WV-KS152 anteriorly placed). Audio and video signals are synchronically recorded with a BETACAM support (BETACAM SP Sony). The videos recorded were analysed by a Studio DC10 video bluster which allows one also to collect single shots for further computer image analyses. The audio signal is recorded also on a digital support (DAT Hitachi 88EX). The routes were chosen to optimise the sightings and were determined daily on the basis of previous sightings, particular attention being paid to following the bottom topography and depth profiles. No trip was performed in conditions greater than sea state 5 (Beaufort). Shots were made using automatic cameras with objectives 70-200 mm/f:1-2.8 zoom, Kodak Ektachrome 200 ASA film, with exposure time less than 1/250 sec. Together with weather conditions (sea and wind), the distance from the coast and depth were also recorded. Shots for individual identification were made during all the research period; the features utilised for pod member identification are in accordance with the methods suggested by Shane and McSweeney (1990). All the individuals of the pod have been photo-identified, and for five of them the sex was also determined. The following observations concern photo-identified animals belonging to the same social group.

RESULTS: A total of 148 trips were undertaken, involving 495 hours of navigation. During this period, 44 sightings of long-finned pilot whale were recorded, for a total of 72 hours of direct observations. In 1995, the pod comprised six individuals: three adult males (Cagliostro ~7m length, Santiago ~6.5 m and Enea ~6 m), one adult female (Señora ~5.5 m), one juvenile female (Emma ~3 m; estimated age: 5 years), and one immature of unknown sex (Pan ~2.5 m; estimated age: 1-2 years). In 1996, Enea disappeared and was never sighted again. The pod is led by the largest male, the "pilot" Cagliostro, as observed in other social groups of this species (Amos *et al.*, 1993). The mean number of members of the group observed at any one time was 4.7. The sightings occurred from June to October, with a peak in September, when the animals occurred for four successive days. Long- finned pilot whales were followed for periods that varied between 10 mins and 357 mins (average 123 mins, ±79.9 SD). Sightings were located within a relatively small area (3 km^2), mainly between 500 and 700 m depth (average depth 663.6 ±96.6 m, range 150/800); the average distance from the nearest coast (Ventotene island) was 7.8 km (±1.6 SD; range 2.1/12.6).

In this area, the local fisherman used to fish with a traditional tool called "palma", which consists of several palm tree leaves, moored on the bottom, floating at about 1 m from the water surface. The shelter and shadows conditions due to the "palma" attract many fishes, such as *Naucrates ductor, Coryphaena hippurus, Engraulis encrasicholus,* and cephalopods (e.g., *Todarodes sagittatus)*. These organisms, on the other hand, attract larger pelagic predators such as sharks (*Scyliorhinus stellaris, Hexanchus griseus,* and *Oxinotus centrina*), tuna fish (*Thunnus* sp.), sword fish (*Xiphias gladius*), manta rays (*Mobula mobular*) and sunfish (*Mola mola*), as well as cetaceans such as striped dolphin *Stenella coeruleoalba,* bottlenose dolphin *Tursiops truncatus* and Risso's dolphin *Grampus griseus.* Fin whales (*Balaenoptera physalus*) and sperm whales (*Physeter macrocephalus*) have also been recorded in this area. During the early morning hours, the long-finned whales were feeding with fast swimming behaviour and long and deep dives (>4 mins, Heimlich-Boran & Heimlich-Boran, 1990) recognisable by the strong bending of the tail flukes. Resting behaviour was characterised by slow swimming, synchronous breathing, and passive drifting into the current. These behaviours were interspersed with social interactions between pod members as evidenced by modular whistles. The animals showed strong signs on the head, on the dorsal fin, and tail flukes (Bloch *et al.*, 1993). Adult males suffered from abrasions and scars caused by conspecific encounters. However, such abrasions changed or disappeared rapidly, and were not suitable as photo-identification features.

In June 1999, we had a newborn in the pod.

Literature data on population genetics of this species (Amos, 1991, 1993) revealed that pods contain related individuals, and that males are rarely the fathers of the calves they accompany. It is unknown also if adult males stay with the original, native pod, or live apart and move from one pod to another. Due to the fact that field observations of this species are limited, it is still unclear how adult males may help and interact with their relatives.

Our direct observations in 1999 suggest that Cagliostro, the largest adult male (the "pilot"), was taking constant care of the young, Pan (now 5-6 years-old), isolating him from the rest of the pod. On the other hand, the two females and the smaller male of the group were taking care of the newborn, in such a way that it was impossible to approach the juvenile closer than 100 m distance. While the boat was approaching, the animals were diving and emerged far from the boat itself. At the same time, the pilot Cagliostro and the young Pan apparently tried to divert our attention from the other members of the group, by following the back of the boat and crossing its route and anterior part with spyhopping and breaching. Observations with the underwater camera indicated the strong dependence of Pan upon the pilot Cagliostro, which apart from encouraging him into fast swimming (like a mother), was protecting him by placing him between the juvenile and the boat.

CONCLUSIONS: The opportunity to perform direct and continuous "*in situ*" observations on a wild pod of long-finned whales off Ventotene island, confirmed the temporal stability of social groups in this species. The evident interaction between the pilot and the youngest member of the pod brings new insight on the role of adult dominant males in the complex social structure of *Globicephala melas*. In fact, this behaviour may represent a form of "baby sitting" aimed at avoiding Pan's extended suckling or to prevent disturbance to the newborn. Probably this behaviour may act also as a kind of "teaching" from the oldest member of the pod to the juvenile.

AKNOWLEDGEMENTS: We would like to thank Maria Cristina Gambi (Stazione Zoologica "A. Dohrn", Naples) for her valuable comments upon the text, and her assistance. Special thanks also go to Pippo Cappellano and Marina Cappabianca for the underwater video equipment, and to Donatella Chiota for the preparation of this poster. Thanks go to Kodak, Oberon, Ds Telematica and Mandara.

REFERENCES

Airoldi, S., Azzellino, A., Nani, B., Ballardini, M., Bastoni, C., Notarbartolo di Sciara, G., and Sturlese, A. 1999. Whale watching in Italy: results of the first three years of activity. P.153-156 In: *European Research on Cetaceans – 13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 April 1999 (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Kiel, Germany. 484pp.

Amos, B., 1993. The social structure of pilot whale pods in the Faroe Islands: genetic insights. P.11 In: *European Research on Cetaceans – 7.* Proc. 7th Ann. Conf. ECS, Inverness, Scotland, 18-21 February 1993 (Ed P. G. H. Evans). European Cetacean Society, Cambridge, England. 306pp.

Bloch, D., Zachariassen, M., and Zachariassen, P. 1993. Some external characters of the long finned pilot whale off the Faroe Islands and comparisons with the short-finned pilot whale. *Rep. int. Whal. Commn.* (special issue 14): 117-135.

Cañadas, A. M. and Sagarminaga, R. 1998. Is the Alboran sea a region of special importance for long-finned pilot whale (*Globicephala melas*) in the Mediterranean? Pp.136-142 In: *European Research on Cetaceans – 12* Proc. 12th Ann. Conf. ECS, Monaco, France 20-24 Jan 1998 (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Das, A. 1999. Long-finned pilot whales, *Globicephala melas*, in the Strait of Gibraltar – a preliminary study. Pp. 183-188. In: *European Research on Cetaceans – 13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 April 1999 (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Gannier, A. and Gannier O., 1990. Cetacean sightings in the Mediterranean sea: second report. P. 39. In: *European Research on Cetaceans – 4*. Proc. 4th Ann. Conf. ECS, Palma de Mallorca, Spain, 2-4 March 1990 (Eds. P. G. H. Evans, A. Aguilar and C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

Gannier, A. and Gannier O., 1992. Northwestern Mediterranan survey: 4th annual report. Pp. 56-60. In: *European Research on Cetaceans - 6* Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 February 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Giordano, A. and Tringali M., 1992 Presence and individual recognition of long-finned pilot whale, *Globicephala melas*, in the Liguro-provençal basin. Pp. 103-104. In: *European Research on Cetaceans – 6*. Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 February 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Heimlich-Boran, J. R. and Heimlich-Boran, S. L., 1990. Occurence and group structure of short finned pilot whales, *Globicephala macrorhynchus*, off the western cost of Tenerife. Canary Islands. Pp. 102-104. In: *European Research on Cetaceans – 4*. Proc. 4th Ann. Conf. ECS, Palma de Mallorca, Spain 2-4 Mar, 1990. (Eds. P. G. H. Evans, A. Aguilar and C. Smeenk). European Cetacean Society, Cambridge, UK. 140pp.

Marini, L., Consiglio, C., Maria, A., Sanna, A., and Valentini, T., 1992. Cetacean sightings programme in the central Tyrrhenian sea: results of the second year of activity. Pp. 66-69. In: *European Research on Cetaceans - 6* Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 February 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Mussi, B., Miragliuolo, A., and Battaglia M., 1997. Cetacei nell' arcipelago delle isole Pontine e Campane. Pp. 157-167. In: *Atti del 5° Seminario Internazionale di Studi sull'Ecosistema marino*. Gaeta, Napoli, Ustica, Italia. (Ed. L. Valerio), Oasi Blu del WWF, Gaeta, Italia. 286pp.

Mussi, B., Gabriele, R., Miragliuolo, A., and Battaglia, M., 1998. Cetacean sightings and interacion with fisheries in the Archipelago Pontino-Campano, South Tyrrhenian sea, 1991-1995. Pp. 63-65. In: *European Research on Cetaceans -12*. Proc. 12th Ann. Conf. ECS, Monaco, France, 20 –24 January 1998. (Editor P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Notarbartolo di Sciara, G. *et al*., 1990. Distribution and relative abundance of cetaceans in the central Mediterranean sea. Pp. 41-43. In: *European Research on Cetaceans - 4* Proc. 4th Ann. Conf. ECS, Palma de Mallorca, Spain, 2-4 March 1990 (Ed P. G. H. Evans, A. Aguilar and C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

Shane, S. H. and McSweeney, D., 1990. Using photo-identification to study pilot whale social organisation. *Rep. int. Whal. Commn.* (special issue 12): 259-263.

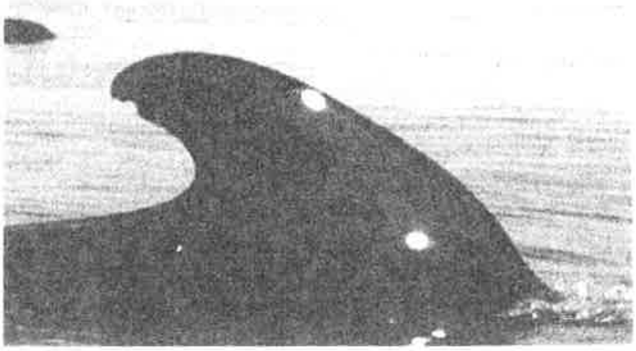


Fig. 1 Cagliostro dorsal fin

Fig. 2 Santiago dorsal fin

Fig. 3 Enea dorsal fin

Fig. 4 Senora dorsal fin

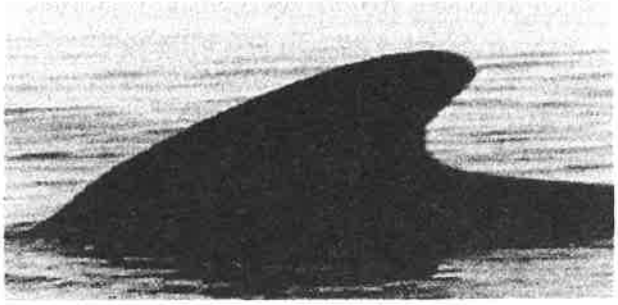


Fig. 5 Emma dorsal fin

Fig. 6 Pan dorsal fin

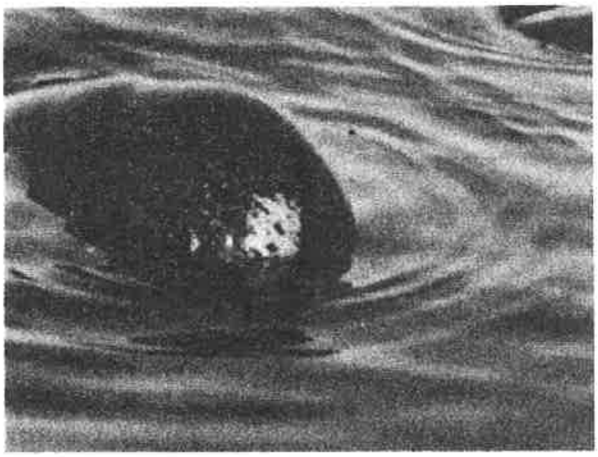


Fig. 7 Abrasion on the head of the whale

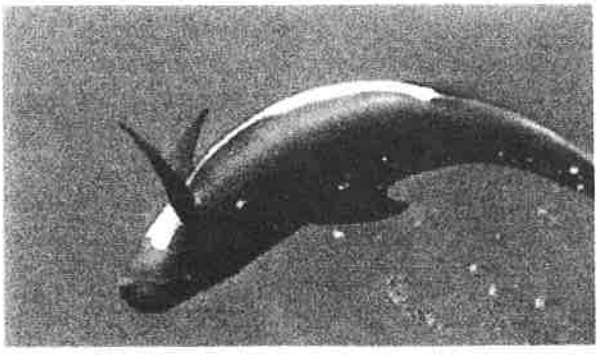


Fig. 8 Emma bow-riding

ASSOCIATIONS OF SPINNER DOLPHINS (*STENELLA LONGIROSTRIS*) IN MOOREA, FRENCH POLYNESIA

M. Oremus, A. Cottier, and M. M. Poole

10, rue des Vanneaux - 17180 Périgny. France

The question of social life among animals has intrigued biologists for centuries. In dolphins, this social life has not been studied in many species. We know for a long time that many spinner dolphin populations (*Stenella longirostris*) hunt during the night and rest in the daytime near the coasts of islands. Then, individuals split into groups whose composition changes regularly.

A longterm survey of the population around Moorea island (French Polynesia) using photo-identification techniques has enabled us to collect a large data set. This study proposes to determine if dolphin associations form longterm associations. We used presence/absence information of 21 dolphins easily identifiable within 135 groups observed between 1988 and 1990. A strong coefficient of association (CoA), ($P>0.5$) existed between individuals of a given pair after the first animal had been identified, representing approximately 13% of all coefficients. These associations were not found between the same dolphins between years. Nevertheless, the same pair consistently gave the highest coefficient, with a CoA of 0.97 in 1989. It is also interesting to note that no pair produced a coefficient lower than the average for three successive years.

These results show no evidence of active avoidance between pairs of animals. Even though specific pairwise associations have been identified, we know that these associations are not permanent. Now, it remains to be understood the significance and function of these associations in the context of social behaviour.

HOW DO STRIPED AND COMMON DOLPHINS SHARE THE EASTERN PART OF THE STRAIT OF GIBRALTAR FOR A SEASON?

E. Roussel and P. Beaubrun

Ecole Pratique des Hautes Etudes, U.M.II, B.P. 94, Place Eugène Bataillon, 34095 Montpellier Cedex 5, France

INTRODUCTION The probable decline of the common dolphin's (*Delphinus delphis*) range in the western Mediterranean (Aguilar, 1991; Notarbartolo di Sciara, 1993; Gannier, 1995) has led in recent years to an increase in studies comparing some aspects of its ecology to that of striped dolphin (*Stenella coeruleoalba*) (Sagarminaga and Cañadas, 1995; Sagarminaga and Cañadas, 1998; Garcia *et al.*, this volume). Both species are known to be the essential components of the cetacean population in the eastern part of the Strait of Gibraltar (Hashmi, 1998), where they are still frequent and abundant. This work has been undertaken to give as broad a picture as possible of the way they live in this particular area, in order to suggest several possible and interesting areas for further study.

METHODS Sightings have been made from 17th March to 26th May 1999 from three ferries of a similar kind between Algeciras (Spanish coast) and Ceuta (Moroccan coast), using a line-transect method across the eastern part of the Strait at a constant speed of about 15 knots. The sole observer was placed at a visual height of 13 metres above the surface and covered a visual angle of 120°. Each of the 122 crossings was 15.5 nm long and had a mean duration of 65 mins (SD=3.5). For each sighting, position, species, number, presence of calves, activity (divided into four categories: travel, rest, feeding and socialisation), and the heading of travelling animals were noted. Simultaneously were also noted: the hour of the day, moon phase and tide, wind force and direction, and surface current boundaries. The direction and strength of current was then deduced from the original water mass and the period of the tide, with 3-hour periods covering the complete cycle of tides, according to Stanley *et al.* (in Rey, 1983).

RESULTS We made 118 sightings of striped dolphin (1,243 individuals, mean group size=11, SD=13), 41 of common dolphin (858 individuals, mean group size=21, SD=31) and 11 of mixed groups (559 individuals). Unfortunately, the latter would have required a detailed study, too long to be included in this analysis. Some differences can be deduced from the peaks of arrivals per crossing (Figure 1): whereas striped dolphins were seen very regularly over the entire period, common dolphins arrived in mid-April in larger groups but were sighted less frequently. Although large peaks for both species tend to occur on the same days in relation to moon phases (see Beaubrun and Roussel, this volume), we can observe here a slight shift when looking at a finer temporal scale (several crossings were made the same day). The analysis of presence in relation to daytime allowed us to analyse this on an hourly basis (see Figure 2: when no activity could be recorded for common dolphins at a given hour, it means that they were absent at this time). A similar phenomenon is seen along the breadth of the Strait, with respect to spatial variation (Figure 3): if some areas of the Strait were preferred by both species (middle and counter-currents under the black bands), slight shifts of one nautical mile were observed inside these areas. Furthermore, the distribution of common dolphins is irregular compared with that of striped dolphin. Figure 4 illustrates these phenomena across the Strait in relation to moon phases: each map of this sequence represents the situation during a fortnight that began at new and full moon. One can see how the distribution of striped dolphins changed as common dolphins arrived, with the exception of the canyon of Algeciras. The respective positions of each species evolved progressively to reach the classical gradient with depth that is well known along open coasts; in other words, at first, striped dolphins occurred on their own and occupied the whole width; then common dolphins arrived, passing near the Spanish coast and in the middle of the Strait where both species stayed together for about a month; finally, striped dolphins remained in deep water, while common dolphins moved closer to the shore, over the slope.

Comparing behaviours, when the two species were close to one another, they differed in the regularity with which they be exhibited a spectrum of activities at any given time of the day (Figure 2). For both species, travelling can occur all the day, rest is more frequent in the morning, in contrast to social activities, and feeding is likely to happen early in the morning, at midday, and late in the evening. On the other hand, common dolphins exhibited much less varied behaviour at any moment in time than did striped dolphins. Similar results were found for activities in relation to moon phases. The response to environmental parameters while travelling differed entirely between the two species (Table 1). If the link between the course taken by common dolphins and the direction of the current is obvious, striped dolphins tend to react in the opposite way. A similar result may occur in relation to wind, if further studies are made on this topic. In addition, striped dolphins showed a greater attraction to ferries than common dolphins (see De Stephanis *et al.*, this volume).

CONCLUSIONS First of all, the Strait of Gibraltar appears to be a good area to characterise and compare the ecology of both species, not only for its high density of dolphins but also because of its well-marked environmental parameters inducing quite clear responses of cetaceans. For both species, moon phases (probably through the different tide cycles) seemed to be the most important factor influencing their presence and behaviour. It has been possible to assess temporal variation in their arrivals that may coincide with a fortnightly cycle for common dolphins, and with a weekly cycle for striped dolphins, both tide cycles being known to play a major role in the current circulation of the Strait (Wang, 1993; Bryden *et al.*, 1994). Within the day, the discontinuous presence of common dolphins made us think of possible daily movements, maybe for feeding in the most productive parts of the Strait (Rubin *et al*, 1997a, b; Gomez-Perez, 1998). If so, these movements should be of a small scale according to the relatively short periods of absence. On the other hand, the regular presence of striped dolphins suggests a stable population, at least in spring. Furthermore, with respect to travelling, common dolphins were found to be dependant on currents, whereas striped dolphins swam mostly against the current. Anyway, small dolphins showed a similar range of activities, at the same hours of the day or with respect to moon phases, even if these were a little more extended at any given time for striped dolphins.

As a consequence, the closeness of these species is evident when we consider broad levels of time and space. But a finer level of analysis has revealed slight shifts in their distribution, and differences in their habitat use. In our opinion, these differences suggest that striped dolphins have many opportunities to move into this area and to react to external factors, while common dolphins show marked, and well-defined responses. Associated with the cohabitation of the two species that we observed during six weeks fieldwork, and documented by Fernandez-Casado *et al.* (this volume) for the western part of the Strait during summer, our results do not as yet suggest any trophic competition, as Sagarminaga and Cañadas (1998) have found in the Alboran Sea. Hence we believe that this difference in adaptability to ecological conditions between the two species is of primary importance in the apparent decrease observed in the range of common dolphins in northern areas of the western Mediterranean.

ACKNOWLEDGEMENTS We would like to thank the companies Trasmediterranea and Euroferries, Firmm España® and Alnitak Project for their support.

REFERENCES

Aguilar, A. 1991. Calving and early mortality in the western Mediterranean striped dolphin, *Stenella coeruleoalba*, *Can. J. Zool.*, 69(5): 1408-1412.

Bryden, H. L., Candela, J. and Kinder, T. H. 1994. Exchange through the Strait of Gibraltar. *Prog. Oceanogr.*, 33: 201-248.

Gannier, A. 1995. *Les Cétacés de Méditerranée nord-occidentale : estimation de leur abondance et mise en relation de la variation saisonnière de leur distribution avec l'écologie du milieu.* Ph. D. Thesis, Ecole Pratique des Hautes Etudes, Montpellier. 438pp.

Gomez-Perez, F. 1998. *Distribucion espacial del microplancton en el Estrecho de Gibraltar en condiciones estivales. Tesis de Licenciatura*, University of Cadiz, Spain. 180pp.

Hashmi, D. D. K. 1998. Cetacean movements through the Strait of Gibraltar. P. 75. In: *European Research on Cetaceans*-12. Proc 12th Ann. Conf. ECS, Monaco, 20-24 January, 1998 (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Notarbartolo di Sciara, G. 1993. Cetacei del Mediterraneo. Contributi del Centro Linceo Interdisciplinare « Beniamino Segre » *N.86 XIX Seminario sulla Evoluzione Biologica e i grandi problemi della biologia*: 39-52.

Rey, J. C. 1983. El paso del atun rojo, *Thynnus thynnus*, a traves del estrecho de Gibraltar y su relacion con la hidrologia. Esquemas de migracion. *Bol. Inst. Esp. Oceanogr.* 1(1): 85-94.

Rubin, J. P., Cano, N., Arrate, P., Garcia Lafuente, J., Escanez, J., Vargas, M., Alonso-Santos, J. C. and Hernandez, F. 1997a. El ictioplancton, el mesozooplancton y la hidrologia en el golfo de Cadiz, estrecho de Gibraltar y sector noroeste del mar de Alboran , en julio de 1994. *Inf. Tec. Inst. Esp. Oceanogr.*, 167: 44.

Rubin, J. P., Cano, N., Rodriguez, V., Blanco, J. M., Jimenez-Gomez, F., Rodriguez, J., Garcia Lafuente, J., Echevarria, F., Guerrero, F., Escanez, J., Hernandez-Guerra, A. and Chbani, M. 1997b. Relaciones del ictioplancton con la hidrologia, biomasa fitoplanctonica, oxigeno disuelto y nutrientes, en el Mar de Alboran y estrecho de Gibraltar. *Publ. Espec. Inst. Esp. Oceanogr.*, 24: 75-84.

Sagarminaga, R. and Cañadas, A. 1995. Studying a possible competition for ecological niche between the common dolphin, *Delphinus delphis*, and the striped dolphin, *Stenella coeruleolba*, along the southeastern coast of Spain. Pp. 114-117. In: *European Research on Cetaceans - 9*. Proc 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 February, 1995 (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Cambridge, England. 302pp.

Sagarminaga, R. and Cañadas, A. 1998. A comparative study on the distribution and behaviour of the common dolphin, *Delphinus deplhis*, and the striped dolphin, *Stenella coeruleoalba*, along the southeastern coast of Spain. Pp. 175-181. In: *European Research on Cetaceans - 12*. Proc 12th Ann. Conf. ECS, Monaco, 20-24 January, 1998 (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Wang, D.P. 1993. The Strait of Gibraltar Model: internal tide, diurnal inequality and fortnightly modulation. *Deep-Sea Research*, 40(6): 1187-1203.

Table 1. Responses of both species to current and wind direction (expressed as % of individuals)

		Current direction		Wind direction	
Species	Headings	to the East	to the West	to the East	to the West
Common dolphin	350°-160°	89.3	10.7	71.4	28.6
	170°-340°	10.6	89.4	34	66
Striped dolphin	350°-160°	17.1	82.9	23.7	76.3
	170°-340°	67.4	32.6	55.4	44.6

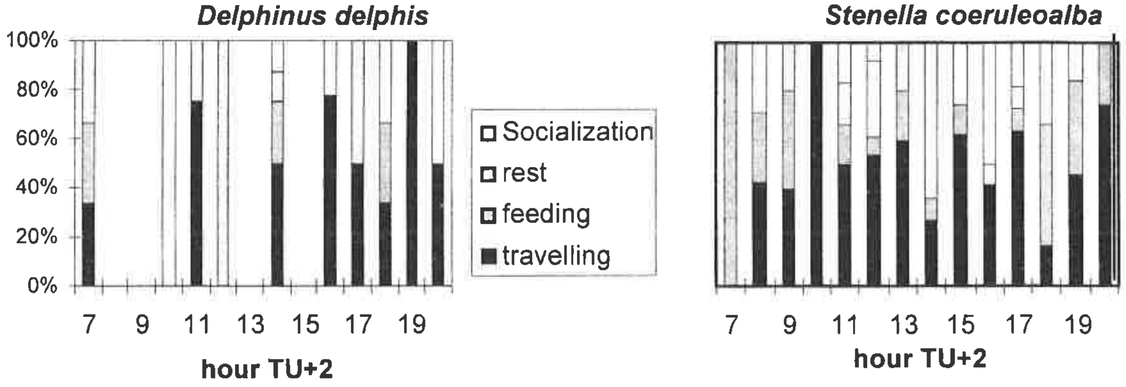


Fig. 2. Proportion of activities according to the time of the day

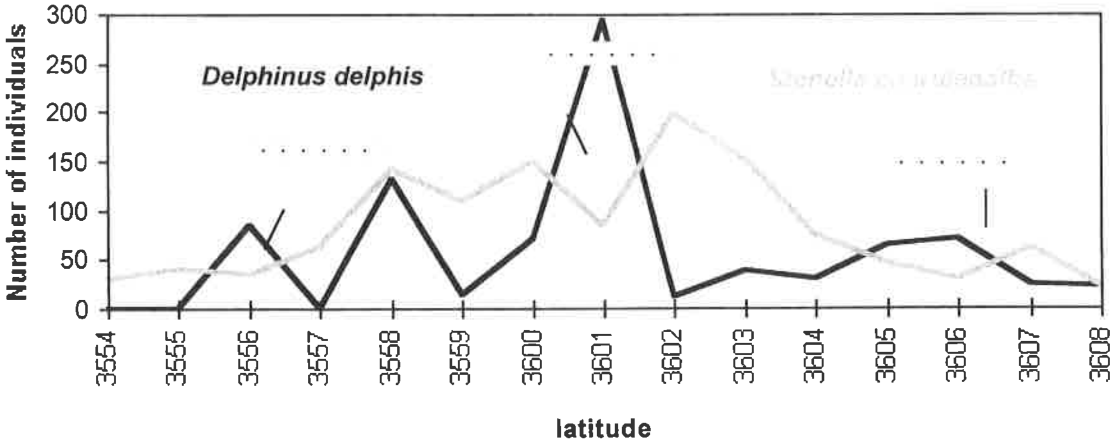


Fig. 3. Distribution of both species along the Strait width (shifts are shown by black arrows)

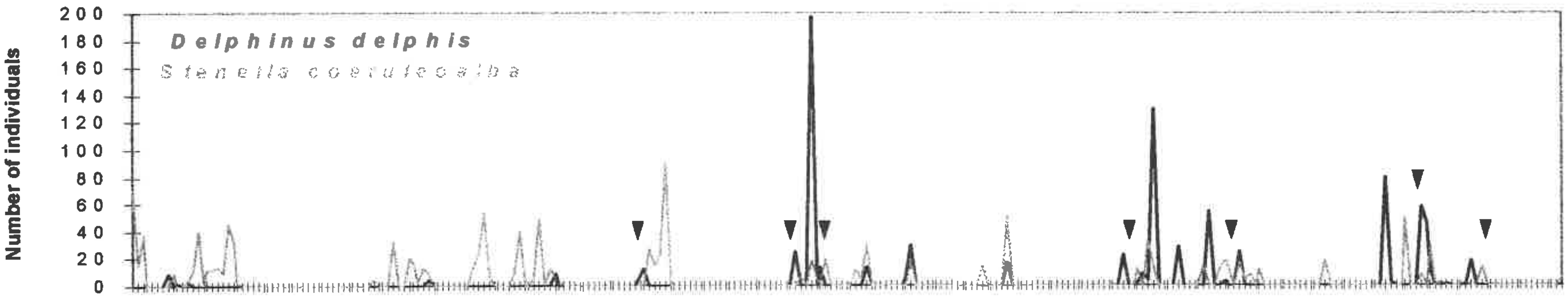


Figure 1 : Peaks of arrivals of both species per crossing along the study period (shifts are shown by black arrows).

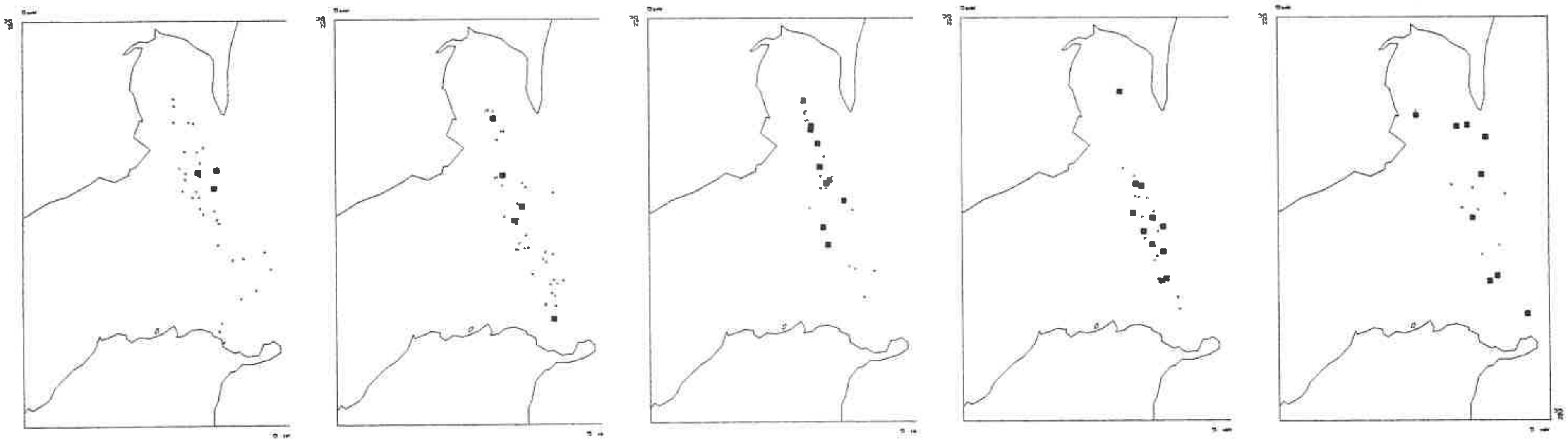


Figure 4 : Fortnightly distribution in the Strait of common dolphins (black circles) and striped dolphins (grey points) during spring 1999.

THE DEVELOPMENT OF PLAY BEHAVIOUR IN A BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) CALF

R. Tizzi[1,2], A. Castellano[3] and D. S. Pace[1]

[1]*OCEANOMARE Onlus, Via delle Gondole 109, 00121 Roma, Italy*
(E-mail: dpace@mail.telethon.it; oceanomare_onlus@yahoo.com)
[2]*Delfinario di Rimini, Lungomare Tintori 2, 47900 Rimini, Italy (E-mail: dolphins@iper.net)*
[3]*Dept. of Science & Technology, University of Torino, C.so Borsalino 54, 15100 Torino, Italy*

INTRODUCTION Play is an important component of the developmental sequence in many mammals and birds, and often is defined as activity not directed towards the satisfaction of a utilitarian need. Investigators attribute a wide range of functions to play behaviour (Bekoff, 1984; Martin & Caro, 1985), including aiding the process of growth and development, learning about the environment, practicing adult activities, and establishing social relationships (Bekoff, 1988, 1992). All have in common that, as a result of playing when young, the individual is better able to perform some form of useful behaviour later in life.

Different species play in different ways and over different periods of time, and it is important to realize that these structural differences may reflect a heterogeneity of function. Aquatic mammals such as cetaceans seem to exhibit play during their whole life and this appears to be inextricably linked to cultural learning (Norris and Dohl, 1980; Gewalt, 1989; Bel'kovich *et al.*, 1991).

The aim of the present work is to report data on a systematic observational study focussed on the development of play behaviour in one female bottlenose dolphin born at Rimini Dolphinarium (Italy).

METHODS The subject of the study was a newborn female bottlenose dolphin (*Tursiops truncatus*) housed in the Rimini Dolphinarium, Italy (Table 1). "Blue" was born in the pool on June 26th, 1997. Mother-calf pair was constantly observed from birth to 52 weeks of age. Focal animal sampling (Altmann, 1974) sessions lasting 30 minutes were carried out for the calf according to a decreasing temporal schedule.

Observation times were randomised among 3-hr periods and balanced for equal representation within a week and at different times of day (observational phase: from 08:00 to 20:00 h). A total of 170 hrs were recorded for the calf. A specific ethogram was first set up and then used for observations. Nine displays related to social-play, seven to object play, and four to bubble-play, were selected from the catalogue and then analysed (Table 2). Total and monthly mean frequency and duration were scored for all these behavioural categories, by means of a video camera and Observer 3.0 software. Frequencies were analysed by mixed-model factorial ANOVA.

RESULTS All the behavioural displays, related to the three main categories of play studied in this work, showed a positive relationship between frequency and duration. Social displays with other young animals were the most frequent play behaviours seen (72%), whereas the object ones showed higher duration values (49%) during the whole study (Fig. 1).

Some significant monthly variations in frequency ($F=23.95$; $gdl=2$; $p<0.0001$) and duration ($F=2,87$; $gdl=2$; $p<0.005$) were found between the three main categories, providing evidence of different developmental patterns possibly due to individual maturation (Fig. 2). In particular, it has been noted that social-play appeared two weeks after the birth, whilst bubble-play and object-play became visible only after one and two months respectively. However, bubble-play and object-play showed some similarities in their ontogenetic profile, displaying specific approach sequences in which observational periods were followed by acts of "manipulation" involving the rostrum.

As for the different displays related to each play category, "chase" (duration 68%) and "leap" (frequency 31%) were the most highly represented into the social-play context as well as "mouth" (both duration and frequency over 30%) and "bite" (both duration and frequency over 50%) had the higher occurrence during object-play and bubble-play sessions respectively (Fig. 3).

DISCUSSION AND CONCLUSION It is important to note that the three main categories of play followed a definite order in their appearance. In fact, social play was the first to be recorded, showing its presence only a few weeks after birth. As reported in the literature, a function of play can be to establish social relationships with peers and adults. Some of these may be pure affiliations, whereas others could be related to the establishment of dominant-subordinate relationships and to the tactics used in intra-specific competition. Blue showed play interactions mainly with the other young animals hosted in the pool, underlying the development of a strong social bond with them. Social play with the adults was recorded only a few times during the first year of the calf's life.

Bubble-play and object-play appeared one month and two months respectively after birth, showing some similarities in the approaching/interaction phases. According to Defran and Pryor (1980) and Pace (2000), when captive adult and young bottlenose dolphins are given free opportunity to interact with objects in their tank, they generally spend a considerable amount of time manipulating them with fins, or carrying them on their rostrum. It could be argued that such observations relating to the different times of appearance of the three play categories may find their possible explanation in more general features of social, sensory, and motor maturation, depending on the changing capabilities of the developing organism. Play behaviour may perform critical roles in growth and development, through the use of muscles and co-ordinated movements. The manner and degree of the influence of play actions on maturation of specific muscle groups, as well as the sensory and motor nervous system remains to be clarified. Some observational studies provide preliminary evidence in this regard (Miller and Byers, 1991; Bekoff, 1992). Data from these studies highlight the likely importance of play behaviour during development, and suggest another function of play - gaining information about the environment. This would be particularly true of diversive play as an orientational-investigational activity. By exploring and manipulating objects found in the surrounding environment, young animals accumulate specific information that may prove useful later in life. However, examining the types and amounts of play actions may provide information on developmental use of certain displays according to similar patterns from other functional context.

In conclusion, this work described the development of play in one captive bottlenose dolphin calf. The study was limited by the small sample size, but seems to reflect the learning flexibility and behavioural versatility of the young dolphins.

ACKNOWLEDGEMENTS We thank Rimini Dolphinarium their owners and trainers for the logistic support, the observers who shared with us many hours at the underwater windows, and Cristiana Balducci, Tiziana Chieruzzi and Mascia Gabaldo who also participated in the hard "Observer work".

REFERENCES

Altmann, J. 1974. Observational study of behavior: Sampling methods. *Behaviour,* 49: 227-267.

Bekoff, M. 1984. Social play behavior. *BioScience,* 34: 228-233.

Bekoff, M. 1988. Motor training and physical fitness: possible short- and long-term influences in behavior. *Develop. Psychobiol.* 20: 85-99.

Bekoff, M. 1992. Time, energy and play. *Anim. Behav.*, 44: 981-982.

Bel'kovich, V. M., Ivanova, L. B., Kozarovitsky, L. B., Novikova, E. V. and Kharitonov, S. P. 1991. Dolphin play behavior in the open sea. Pp. 67-77. In: *Dolphin Societies: Discoveries and Puzzles.* (Eds. K. W. Pryor and K. S. Norris). University of California Press, Berkeley and Los Angeles. 397pp.

Defran, R. H. and Pryor, K. W. 1980. The behavior and training of cetaceans in captivity. Pp. 319-362. In: *Cetacean Behavior: mechanisms and functions.* (Ed. L. M. Herman). Krieger Publishing Company, Malabar, Florida. 461pp.

Gewalt, W. 1989. Orinoco-Freshwater-dolphins (*Inia geoffrensis*) using self-produced air bubble "rings" as toys. *Aquatic Mammals*, 15(2): 73-79.

Martin, P. and Caro, T. M. 1985. On the functions of play and its role in behavioral development. *Adv. Study Behav.*, 15: 59-103.

Miller, M. N. and Byers, J. A. 1991. Energetic cost of locomotor play in pronghorn fawns. *Anim. Behav.*, 41: 1007-1013.

Norris, K. S. and Dohl, T. P. 1980 The structure and functions of cetacean schools. Pp. 211-261. In: *Cetacean Behavior: mechanisms and functions.* (Ed. L. M. Herman). Krieger Publishing Company, Malabar, Florida. 461pp.

Pace, D. S. 2000. Fluke-made bubble rings as toys in bottlenose dolphin calves (*Tursiops truncatus*). *Aquatic Mammals*, 26(1): *in press.*

Table 1. Subject (*) and social contest in the Rimini Dolphinarium

Name	Sex	Birth Date	Location	Residence in captivity
Speedy	M	1970	Adriatic Sea	17 years
Alfa	F	1979	Gulf of Mexico	9 years
Beta	F	1981	Gulf of Mexico	9 years
Sole	M	05/03/1993	Rimini Dolphinarium	captive-born (Alfa x Speedy)
Luna	F	05/12/1995	Rimini Dolphinarium	captive-born (Alfa x Speedy)
*Blue	F	26/06/1997	Rimini Dolphinarium	captive-born (Beta x Speedy)

Table 2. Behavioural categories

DEFINITION	REFERENCE
Social Play	
Swim (fast)	The usual mode of swimming or normal swimming posture (Renjun et al., 1994)
Chase	In varied form, but characteristicaly when chasing is in progress the animals swim inverted at high speed just below the surface (Saayman et al., 1973)
Push	Pushing with the beack, the side or ventral part another animal (Pilleri, 1986)
Contact	Any behaviour which involved physical contact between two animals (Nelson & Lien, 1994)
Tail slap	Flukes raised above the surface and ventral/dorsal side slapped downward, usually making a loud, percussive sound (Shane, 1990)
Breacking	Swimming quickly underwater, lifts itself out of the water on an angle so that the caudal peduncle and the tail remain underwater (Pilleri, 1986)
Leap	Entire body clears the water, exit and enter head first (Shane, 1990)
Slap	Jumping out of the water with an angle about 45°, half of the body is out of the water, then the animal drops against the surface of the water, lands on its side or its back producing slash and noise (Martinez & Klinghammer, 1995)
Object Play	
Transport	Transporting an object by using the outside of the beak, the flippers or the melon (Denkinger, 1996)
Push	Pushing or pulling an object with the beak (Denkinger, 1996)
Circle	Swimming around objects (Denkinger, 1996)
Play water	Spit water, bite the water (von Strait, 1996)
Mouth	Play with a number of different toys [...] carried in the mouth (Renjun, 1994)
Rub	Dolphin rubs head, side or other areas of the body on objects (Tizzi, 1995)
Throw	Play with a number of different toys [...] thrown above the surface of the water (Renjun, 1994)
Bubble Play	
Interest	The animals show interest for the bubble movements and follow it up to the water surface without touch it (Pace, 2000)
Push	The animals gently push the bubble without disrupt it (Pace, 2000)
Bite	The animals bite the bubbles to break off it (Pace, 2000)
Through	The animals pass through the bubbles to break off it (Pace, 2000)

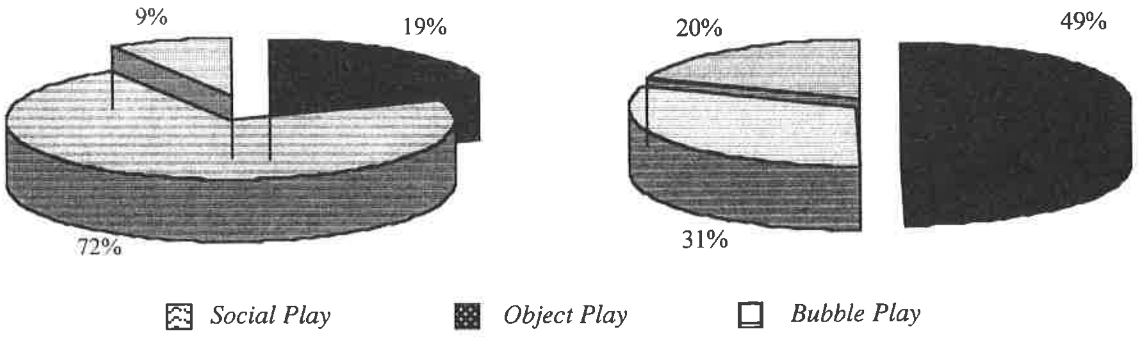


Fig. 1 . Total frequency and duration of play behaviours during the whole study

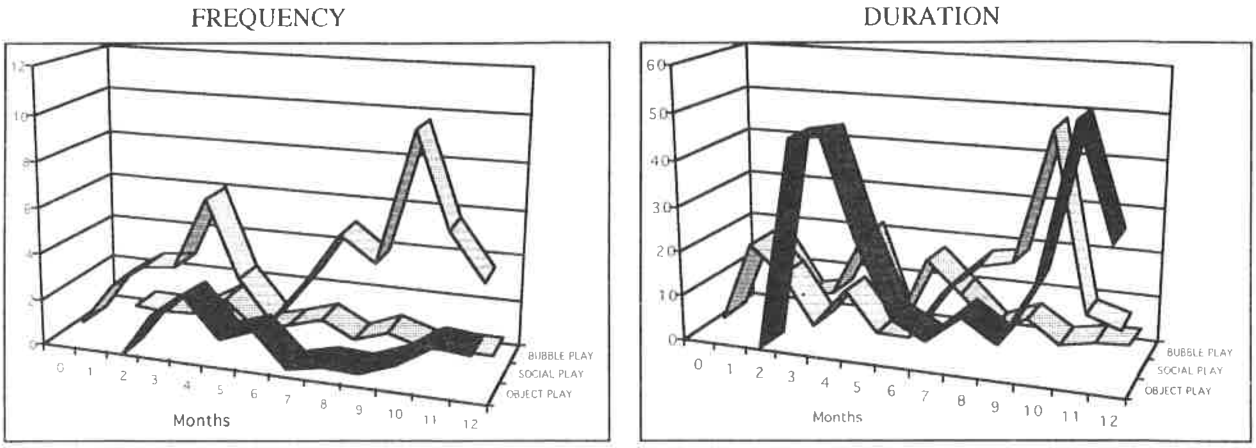
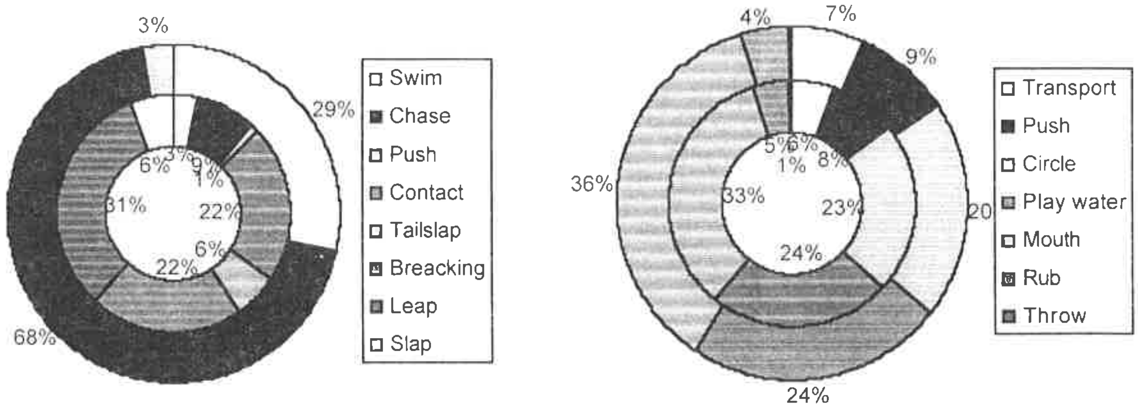
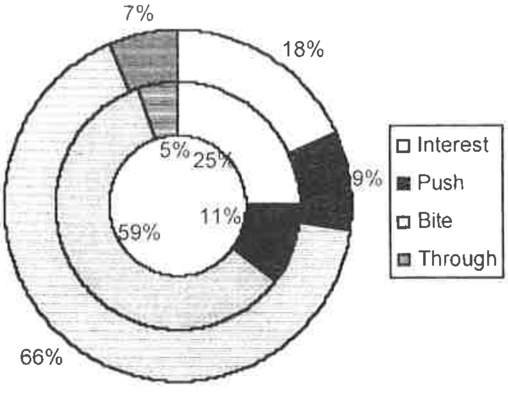


Fig. 2. Monthly trend of play behaviours [mean frequency and duration (seconds)]



a) Social Play

b) Object Play



c) Bubble Play

Fig. 3. Total frequency and duration of the behavioural displays for each main play category
External ring = duration; Internal ring = frequency

DOLPHINS SPONTANEOUSLY COMPREHEND SIGNS

A. Tschudin[1], J. Call[2], and R. Dunbar[3]

[1]*Department of Experimental Psychology, University of Cambridge, Cambridge CB2 3EB, England, UK*
[2]*Max-Plank Institute for Evolutionary Anthropology, D-04103 Leipzig, Germany*
[3]*ESRC Research Centre in Economic Learning and Social Evolution, School of Biological Sciences, Nicholson Building, University of Liverpool, Liverpool L69 3BX, UK.*

Little work had been done on the spontaneous comprehension of communicative signs in animals. This capacity is of interest as it may be informative about the animal's understanding of the signaller's behaviour. Pointing and gaze following are the major types of behaviour that have received attention in such studies.

Our study investigated whether or not six captive bottlenose dolphins were capable of using human pointing, directed gaze and replicas to select one of two objects. In the first instance, the study replicates findings by Herman *et al.* (in press) of pointing in dolphins. Gaze following and use of replica have not previously been documented for dolphins. Four dolphins comprehended pointing, five followed gaze and two could use the replica, in some cases after extended trials. Analysis of blocks of trials indicates no apparent learning effects, at least for pointing and gaze following. Our findings suggest that dolphins can spontaneously comprehend different communicative signs. Their performance at signal comprehension appears to be better then any of the great apes tested by Tomasella *et al.*, (1997). The potential significance of such findings for comparative and social cognition are discussed.

A QUANTITATIVE STUDY OF THE BEHAVIOUR OF KILLER WHALES (*ORCINUS ORCA*) IN NORTHERN NORWAY

F. Ugarte[1], T. Simila[2], B. Wilson[3], and P. Van der Gullik[4]

[1]*Rom C-201, NFH, University of Tromso, 9037 Norway*
[2]*Box 181, Straumsjoen, 8475 Norway*
[3]*Sea Mammal Research, University of St Andrews, Scotland KY16 8LB*
[4]*The Whale Centre, 8480 Andenes, Norway*

The aim of this study was to create an objective description of the behaviour of Norwegian killer whales at a time when their main prey is over-wintering herring (*Clupea harengus*). Data were collected from a 10 m cabin cruiser during November 1997 in Kvæfjord, Nordland. Behavioural observations were made in 10- minute sample periods where specific individual behaviours, activity (feeding, travel-foraging, resting or socialising), group geometry, blow rates, time and position were recorded. After observing the behaviour, the area around the whales was sampled with an echo-sounder to obtain data on topography and availability of prey.

Observations made during 62 encounters with killer whales were analysed. The median dive sequence for individuals consisted of a series of 4.5 blows separated by 18-second intervals and a 78-second dive between series. The breathing synchronisation was inversely related to the distance between individuals, and was lowest during socialising. The amount of blows per individual per minute was related to speed and was highest during feeding.

A cluster analysis showed that: 1) travelling whales often move in straight lines, with all individuals heading in the same direction and in a line abreast, 2) some individuals float while resting, 3) socialising is characterised by physical contact, rolling, spy-hopping, and individuals floating, and 4) feeding is associated with lob-tailing, arch dives, no formation, birds following, back and forth and non-directional movement. Group activity was not affected by the presence of cod, large herring schools, or herring in deep water. All feeding encounters involved small schools of herring in the upper 15 m of the water column.

This study supports the hypothesis that the depth of herring schools is an important factor determining the availability of herring as killer whale prey, and that the size of herring schools is an important factor affecting killer whale feeding behaviour.

CONSERVATION & MANAGEMENT

CONSERVING CRITICAL HABITATS FOR THE MEDITERRANEAN MONK SEAL IN GREECE THROUGH THE CREATION OF A NETWORK OF PROTECTED AREAS

S. Adamantopoulou, K. Anagnostopoulou, P. Dendrinos, S. Kotomatas, N. Labadariou,
V. Pipinis, G. Stroufliotis, E. Tounta, and V. Zavras

MOm / Hellenic Society for the Study and Protection of the monk seal 18 str. Solomou, Athens, GR-10682, Greece

The fact that Greece hosts the largest population of the critically endangered Mediterranean monk seal, *Monachus monachus*, necessitates the concentration of conservation efforts in this country. Until recently, research and conservation activities have been conducted mainly in the N. Sporades Islands, where a National Marine Park is already established, and in the Ionian Sea. However, recent data from a National Information Network indicates that the species is widely distributed and that several breeding populations may exist.

Based on this evidence, three strategically located island complexes (Kimolos, Karpathos, Fournoi) were selected in order to promote the establishment of a network of marine protected areas for the conservation of the species. In each area, the coastline was surveyed regularly in order to identify all resting and breeding monk seal shelters Furthermore, basic population parameters were recorded for a 3-year period.

The results obtained from this work are: Kimolos: 24 seal shelters were identified (including nine breeding areas), where a population of 25-40 animals was estimated to live in the area, reproducing with a birth rate of six births per year. Karpathos: 14 shelters were identified (two breeding), while the population was estimated to be 10-20 animals, reproducing with a rate of 2-3 births per year. Fournoi: 24 shelters were identified, the population was estimated to be 5-10 animals, reproducing at a rate of at least one birth per year.

The above data were evaluated in order to determine the most critical habitats and to formulate appropriate management proposals for the protection of the species. These proposals were integrated into specific zoning plans that provide also for the conservation of other important species and habitats, the regulation of human activities (fisheries, farming, tourism), and the promotion of the sustainable development in each area.

FAST FERRIES IMPACT ON CETACEAN IN CANARY ISLANDS: COLLISIONS AND DISPLACEMENT

N. Aguilar[1], M. Carrillo[2], I. Delgado[1], F. Díaz[1] and A. Brito[1]

[1]*Dept. of Animal Biology (Marine Sciences), Faculty of Biology, La Laguna University,*
Avda. Astrofisico Fco, Sánchez, La Laguna, Tenerife, Spain
[2]*Tenerife Conservacion, C/Tabaiba 34, Club 2, Los Gigantes, Tenerife, Islas Canarias, Spain*

In the Canarian archipelago, fast ferries started to operate in April 1999. There are two different types: (1) catamaran-type with 40 knots medium speed, operating in the channel between Tenerife and Gran Canaria; (2) monohull-type with 30 knots medium speed, operating in the channel between La Gomera andTenerife. At least seven individuals from a minimum of four cetacean species have died due to fast ferries (*Balaenoptera* sp. probably *B. edeni*, *Physeter macrocephalus*, *Ziphius cavirostris* and a medium sized animal, probably *Globicephala macrorhynchus*). Data are provided by trusted casual observers, and stranded specimens with heavy cuts. Other cetacean species, or smaller animals such as turtles, may also have suffered collisions but do not strand due to the strong currents in these regions. In addition, communities of the protected seagrass *Cymodocea nodosa* are being impacted.

Dolphin displacement is thought to occur, possibly due to acoustic pollution produced by the catamaran fast ferries. In the channel between Gran Canaria andTenerife, a year-round population of bottlenose dolphins showed changes in distribution pattern, as indicated by the reduction in sightings in their usual area (Agaete), coincident with the commencement of the fast ferry operations in the area. Between La Gomera and Tenerife, there is a resident population of short-finned pilot whales and bottlenose dolphins. In addition, both channels are crossed by many migratory species, some as the endangered northern right whale (*Eubalaena glacialis*). The whole archipelago, and in particular the two channels that are covered by fast ferries, can be considered as a very sensitive area for cetaceans. Part of both channels have been declared Natura 2000 areas (Special Areas of Conservation) because of the presence of *Tursiops truncatus* and loggerhead turtle (*Caretta caretta*) populations. Islas Canarias form a critical habitat for a number of cetacean species. Collisions and displacement due to fast ferries should not be permitted. The precautionary principle should be invoked, and the archipelago should be declared a marine sanctuary.

FAST FERRIES AND CETACEAN COLLISIONS: EVIDENCE & SOLUTION(S)

M. André[1], E. Degollada[1,2] and A. Fernández[1]

[1] *Marine Mammal Conservation Research Unit, Department of Morphology, School of Veterinary Medicine*
University of Las Palmas de Gran Canaria, 35416 Arucas, Gran Canaria, Spain
[2] *Dept. Anatomy, Veterinary Fac., Autonomous University of Barcelona, 08193 Bellaterra, Spain.*

Collisions between cetaceans and shipping have become a major threat to marine mammal conservation in recent years. The recent introduction of fast ferries in areas of intense shipping seems to have worsened the problem of unfortunate encounters. A case study in the Canary Islands is presented, showing evidence of the negative impact that fast ferries may induce through acoustic pollution, leading to possible hearing loss, and great difficulties for cetaceans to avoid imminent collisions. The use of acoustic deterrents has been shown to be inefficient in the medium term on populations already highly tolerant of noise. An efficient and benign solution to the problem is discussed. This could include the development of a passive sonar system which would detect the cetacean acoustic signals and transmit continuously and in real time, the position and movements of the individuals crossing a "security acoustic highway" in areas of intense shipping.

PRE-IMPACT BASELINE STUDIES ON CETACEANS AND THEIR MOST IMPORTANT PREYS IN THE ADRIATIC SEA

M. Azzali[1], G. Rivas[2], A. Modica[2], M. Luna[1], C. Farchi[1], L. Giovagnoli[1] and
S. Manoukian[1]

[1]*C.N.R.-I.R.P.E.M, Largo, Fiera della Pesca, 60125 Ancona, Italy*
[2]*CEOM S.C.p.A., Viale della Libertà 37, 90139 Palermo, Italy*

INTRODUCTION Some areas of the Adriatic Sea will be affected by activities associated with the oil and gas exploration industry in the immediate future (Azzali M., 1999). Noise and loud sounds such as oil drilling and seismic surveys can elicit detrimental effects on a wide range of aquatic animals (Turnpenny *et al.*, 1994), ranging from marine mammals (Ketten 1995) to small pelagic fish (Wiley *et al.*, 1981) some of which are of economic importance to humans. However, these effects will remain controversial without pre-impact data. This paper presents pre-impact baseline studies carried out in the Adriatic from 1988 to 1998 on marine mammals and small pelagic fish. The aims of these studies are:

- To identify 'hot spots" of the Adriatic Sea where marine mammals and small pelagic fish have been found to congregate;
- To estimate the potential risk levels in those areas;
- To provide a data base to evaluate in the immediate future the short- and long-term effects on aquatic animals of the oil activity that is beginning in some areas of the Adriatic.

MATERIALS AND METHODS Two synoptic surveys were conducted from July to October in the Adriatic, each year since 1988: one on small pelagic fish, and the other on marine mammals. The Adriatic waters from the Italian coast to the Mid-Line, and from Trieste to Brindisi (around 16,000 square nautical miles) were covered by the R/V Salvatore Lo Bianco with a zigzag grid (around 2,000 nautical miles), as shown in Figure 1. Data on small pelagic fish (sardines, anchovies, sprat, and other pelagic species) were collected and processed using acoustic technology and methodology (Azzali M. *et al.*, 1997). Marine mammals were monitored visually by trained personnel, during the acoustic surveys.

Thanks to an agreement between CNR - IRPEM and "ADRIATICA" company, naval officers on the liners have reported since 1988 the sightings of cetaceans, collected with the same methodology used on the R/V Salvatore Lo Bianco. These liners cross the Adriatic regularly, all year round, on the same routes (Fig. 1).

Two types of data set, originated by acoustic and visual surveys, were stored and processed: a spatial data base and a temporal data base.

The temporal data base on cetaceans and on small pelagic fish was represented in the form of a time series from 1988 to 1998, and cross-correlated in the form of phase plane trajectories.

The spatial data base was represented on a raster map, consisting of an array of grid cells (each elementary cell is one square mile). The values of each cell (i.e. fish data, marine mammal data) were aggregated in square blocks of 30x30 elementary cells (Fig. 2). In each block, the following numerical data were calculated: 1) the number of sightings of all cetaceans as a whole and per species, measured either all year round, or from May to October (summer period), or from November to April (winter period); and 2) the mean fish biomass (in tons) measured from July to October. The resulting spatial distributions of marine mammals and of small pelagic fish were cross-correlated. Moreover, each spatial distribution was compared with a uniform distribution, taken as a reference to classify the level of risk of each block. If the difference in a block was higher than 50% (lower than 50%) with reference to the uniform distribution, then the risk of the block was classified high (low). Otherwise, the risk was classified medium. The blocks at high risk are considered "hot spot" areas. This analysis applies to all the Adriatic sea and, in particular, the areas of interested for oil activities as outlined in Figure 2.

RESULTS The temporal variability of the number of cetacean sightings, and of small pelagic fish biomass are shown in Figures 3 & 4 per species, and in Figures 5 & 6 as a whole.

The number of cetaceans visually surveyed from 1988 to 1998 (Fig. 5) changes significantly between several hundreds (years 1990 and 1995) and few dozens (years 1988 and 1998). However, dolphin species composition seems to be relatively constant (Fig. 3). Bottlenose dolphins are the most abundant and the most variable species: the percent of sightings ranging between 80% (years 1988, 1994 and 1995) and 45% (years 1990, 1991 1996 and 1998) of the total. The percent of striped dolphin sightings fluctuates from 20% (years 1988, 1989, 1994 and 1995) to 30% of the total. In the same period, the pelagic biomass as a whole seems to be relatively stable (Fig.4), but its composition (Fig. 4) shows large changes that involve sardines (from 20% of the total in 1998, to 75% in 1988) and anchovies (from 5% of the total in 1988, to 65% in 1998). Figure 7 shows an attempt to plot in the phase plane the data presented in Figures 5 and 6. There is no simple relationship between dolphins and their prey. The plot appears to have a double loop trajectory. However, the interpretation of this plot requires at least the addition of humans as predators, who interact significantly with both fish stocks and dolphins, and probably further ecological and biological data.

The spatial distribution of cetaceans as a whole, surveyed from 1988 to 1998, is shown in Figure 8. In total, the sightings of dolphins (excluding Risso's dolphins) were 301, and the number of dolphins sighted was estimated at 3,754 individuals (on average eight sightings, or 100 individuals per block of 30x30 nautical miles). The spatial distribution of pelagic biomass as a whole, averaged between 1988 and 1998, is shown in Figure 9. The total biomass was estimated as 783,628 tons in a sampled area of 15,747 square nautical miles (an average of around 46,000. tons per block). Regarding dolphins, the potential risk level in a period of one year is represented in Figure 10. In the blocks where more than 12 sightings were made, the risk was estimated high, while the risk was estimated low in blocks with less than four sightings. Similar maps of risk were calculated for the periods May-October and November-April. The potential risk for the pelagic biomass is represented in Figure 11. In the blocks where the pelagic biomass was more than 63 t/nm^2, the risk was estimated to be high, while the risk was estimated to be low in the blocks with a biomass less than 39 t/nm^2. The spatial correlation between the number of sightings of dolphins and the small pelagic fish biomass is represented in Figure 12. There is no substantial difference in considering the number of dolphins (graph at the top of Fig. 12) or in the number of sightings (graph at the bottom of Fig. 12). The blocks 1, 3 and 8 in the North Adriatic (see Fig. 2) are at a high level of risk for both the dolphins and their prey.

Spatial distributions of dolphins per species and per periods of year are represented in Figure 13. The potential level of risk is estimated on the basis of the number of dolphin species that were found in each block. The highest level of risk is attributed to the blocks (indicated with the letter C in Fig. 13) inhabited by three species: bottlenose dolphins, striped dolphins, and common dolphins. The blocks where only bottlenose dolphins were found (as indicated with the letter A in Fig. 13) were considered at the lowest level of risk. Comparison between the maps of Figure 13 shows that striped dolphins tend to aggregate into the Central Adriatic, and bottlenose dolphins to move to the south in winter. The mean number of individuals in a herd, per species, is reported in the Table associated with Figure 13. Both striped dolphins and bottlenose dolphins form larger herds in winter (respectively, 10.6 and 17.8 individuals per herd) than in summer (respectively, 9.2 and 13.6 individuals per herd). On the contrary, the herds of common dolphins are larger in summer (11.3 individuals per herd) than in winter (5.6 individuals per herd).

CONCLUSIONS The map of Figure 14 is used as a mean to summarise the "hot blocks" in Adriatic and the type of risk in each block. The blocks at high risk for dolphins are:

- 16 all year round (blocks: 1, 3, 5, 8, 19, 20, 21, 23, 27, 41, 42, 43, 44, 45, 48, 49)
- 5 in winter (blocks: 12, 15, 21, 22, 35) and only one in summer (block: 2).
- Three blocks are considered at high risk only for the sporadic presence of rare (for Adriatic) species (blocks: 17, 36, 46). Two blocks are considered at high risk only for small pelagic fish (blocks: 6, 25). The total number of "hot blocks" in the Adriatic is 27 out of 50.
- With regard to the seven blocks of interest for future oil activity (blocks: 16, 17, 20, 24, 28, 29, 33), three are considered at high risk: block 20 for dolphins all year round, block 28 for dolphins only in winter, and block 17 for the presence of rare species.

ACKNOWLEDGEMENTS This research was supported by ENI, Explorations & Productions Division AGIP. The authors would like to thank "ADRIATICA" Shipping Company for their assistance in the collection of data on cetaceans.

REFERENCES

Azzali, M. 1999. *Evaluation of the compatibility between oil activity and migratory courses of cetaceans in some areas of Middle Adriatic* (in Italian). Consultancy Report N.5014-A180-1/99.July 1999. 17pp.

Azzali, M., Cosimi, G. and Luna, M. 1997. *The biomass, the structure of aggregations and the geographical distribution of Anchovy and Sardine populations in South Adriatic, assessed with acoustic methodology* (in Italian). Research Report for Italian Ministry of Agriculture and Forestry. May 1997. 57pp.

Ketten, D. R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Pp. 391-409. In: *Sensory System of Aquatic Mammals* (Eds. R. A. Kastelein, J. A. Thomas and P. E. Nachtigall). De Split Publishers, Werden, The Netherlands.

Turnpenny, A. W. H. and Nedwell, J. R. 1994. *The effects on Marine Fish, Diving Mammals and Birds of Underwater Sounds Generated by Seismic Surveys.* Consultancy Report FCR 089/94. Oct. 94. 40pp.

Wiley, M. L., Gaspin. J. B. and Goertner, J. F. 1981. Effects of underwater explosions on fish with a dynamic model to predict fish kill. *Ocean. Sci. Eng.*, 6: 223-284.

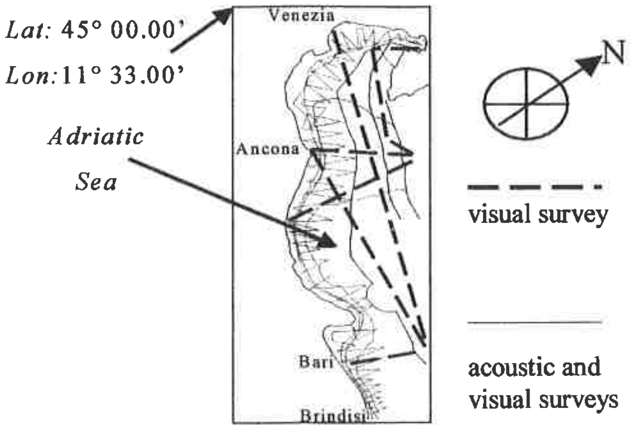


Fig.1 Tracks of acoustic and visual surveys

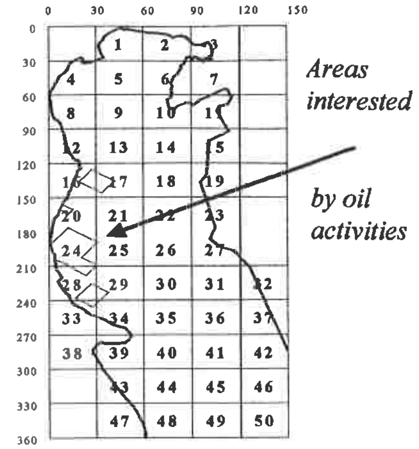


Fig.2 Raster map. Acoustic and visual data are stored in 50 blocks

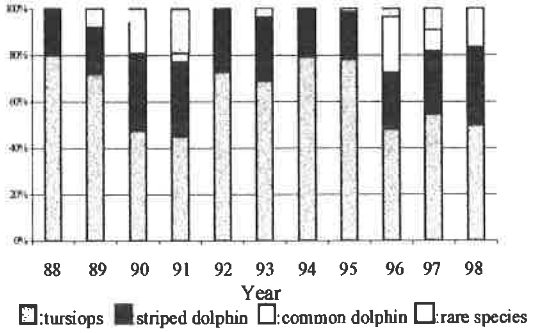


Fig.3 Number of sightings per species as function of time

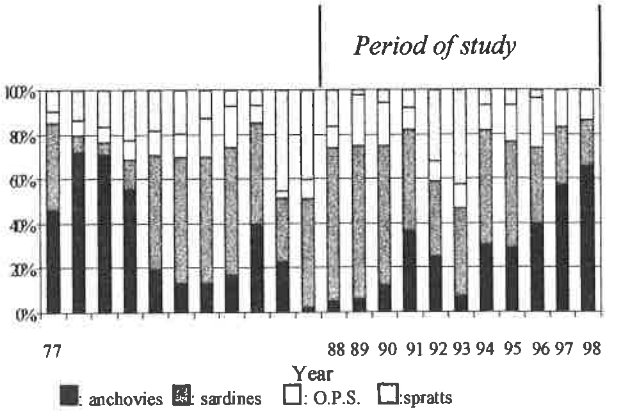


Fig.4 Fish biomass per species as function of time

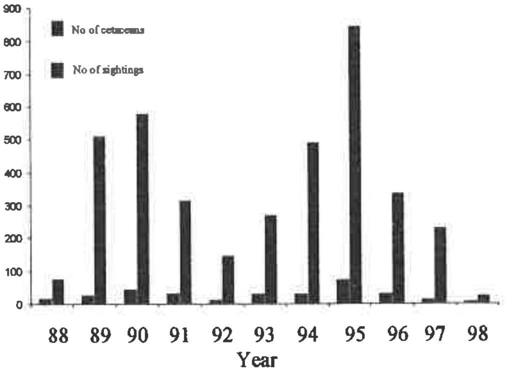


Fig.5 Sightings&cetacean number as function of time

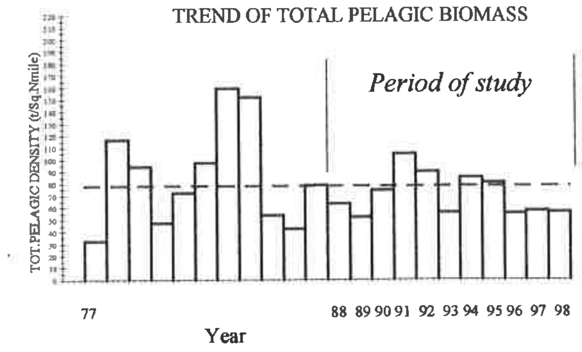


Fig.6 Biomass of small pelagic fish as function of time

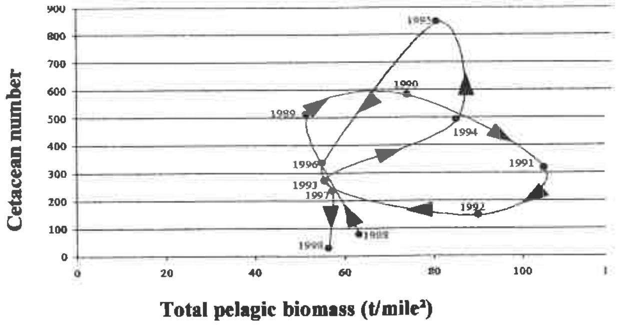


Fig.7 Oscillations of the predator (cetaceans) and prey (small pelagic fish) populations

● Winter period
(Nov.-Apr.)
Sightings No:69

▫ Summer period
(May.-Oct.)
Sightings No:232

○ Sperm whale

● Risso's dolphin

▨ Fin whale

Species		year	summer	winter
Dolphin	Sightings	301	☐ 232	○ 69
	Indiv. No	3754	2494	1260
Sperm whale	Sightings	○ 4	3	1
	Indiv. No	16	15	1
Fin whale	Sightings	▨ 3	1	2
	Indiv. No	15	13	2
Risso's dolphin	Sightings	● 6	4	2
	Indiv. No	19	16	3

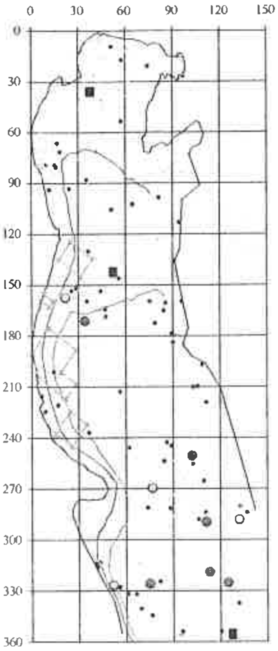


Fig.8 Spatial distribution of sightings from 1988 to 1998

Biomass of small pelagic fish averaged between 1988 and 1998

▩ Density between 63 and 135 t/mile²

▨ Density between 39 and 63 t/mile²

☐ Density between 19 and 39 t/mile²

Tot. Pelagic biomass: 783,628 t
Mean density: 49.8 t/mile²
Surveyed area: 15747 mile²

Biomass composition:

Anchovies: 28%

Sardines: 46%

Spratts: 12%

Other Pelagic Species: 14% (O.P.S.)

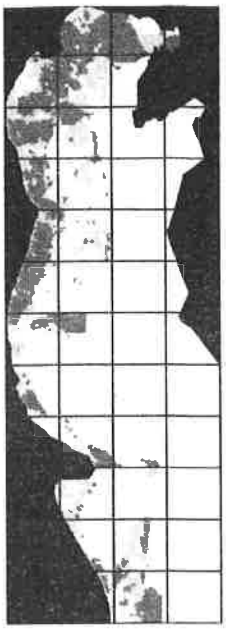
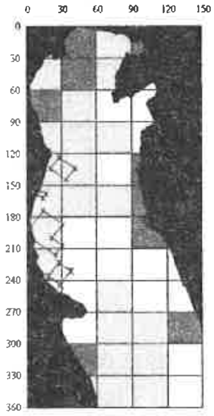


Fig.9 Spatial distribution of pelagic biomass averaged from 1988 to 1998



Level of risk:

▩ high

▨ mean

☐ low

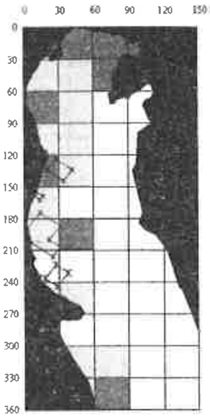


Fig.10 Risk level for cetaceans

Fig.11 Risk level for small pelagic fish

Block Number	Density (t/mile²)	Sight Number	Individ Number
30	18.7	0	0
29	20.3	2	12
40	22.6	7	86
35	26.8	5	31
21	29.7	6	143
28	30.2	5	79
33	30.5	0	0
39	32.5	2	9
43	34.4	10	112
13	38.0	5	49
34	38.2	1	4
17	40.1	11	70
24	43.3	4	31
38	43.5	0	0
44	43.9	7	122
20	51.1	6	60
47	51.9	2	5
9	54.7	10	118
12	56.2	3	142
5	62.0	14	[illegible]
4	65.6	7	29
16	[illegible]	3	132
3	67.4	[illegible]	[illegible]
8	[illegible]	50	647
48	71.3	10	113
2	77.5	8	131
1	84.1	31	[illegible]
25	110.9	0	0
6	[illegible]	4	47

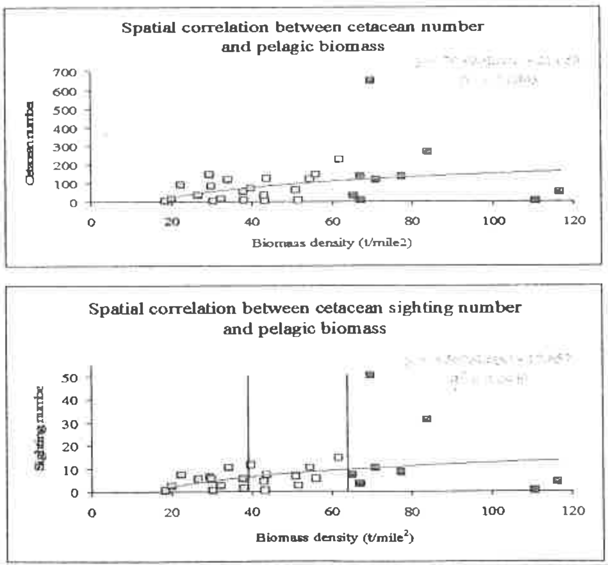
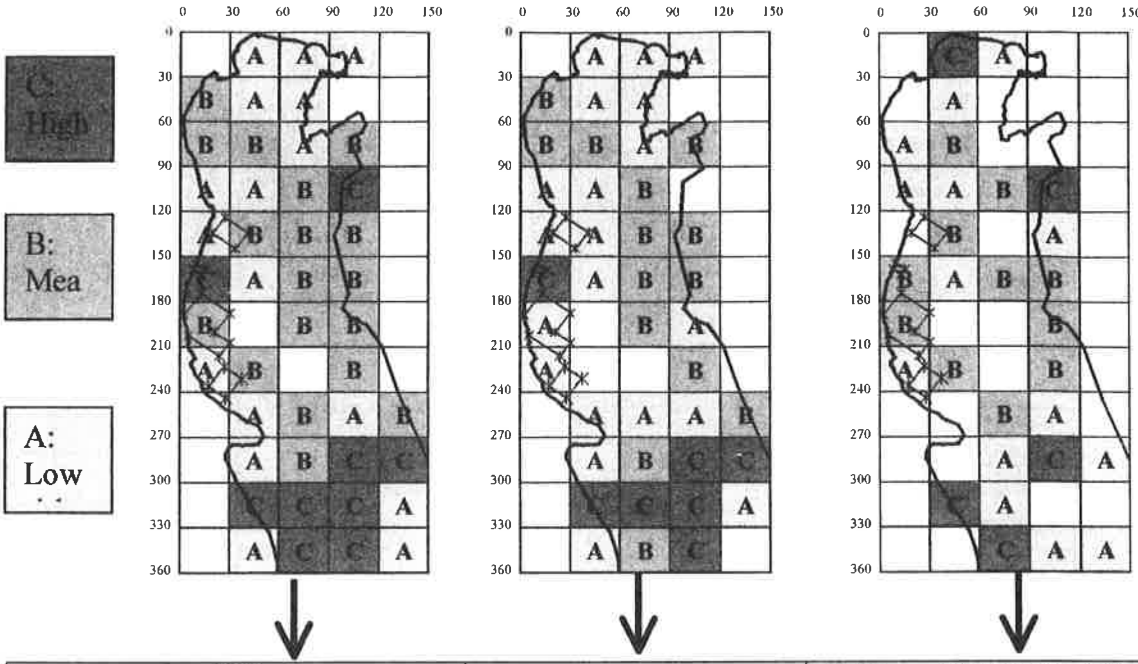


Fig.12 Spatial correlation between number of dolphins (top) or of sightings (bottom) and the pelagic biomass



Species	Yearly					During summer period (May-October)					During winter period (November-April)				
	Herd number	Herd features				Herd number	Herd features				Herd number	Herd features			
		No (max)	No (mean)	St.Dev	Total individ.		No (max)	No (mean)	St.Dev	Total individ.		No (max)	No (mean)	St.Dev	Total individ.
Delphinidi (not identified)	38% (110)	155	12.9	22.7	1417	45% (100)	100	11.2	18.4	1118	13% (10)	155	29.9	46.3	299
Tursiops	39% (111)	110	15.2	22.8	1686	30% (70)	100	13.6	19.5	955	55% (41)	110	17.8	27.7	731
striped dolphins	17% (50)	50	9.7	9.9	487	14% (31)	50	9.2	10.3	285	26% (19)	30	10.6	9.5	202
Common dolphins	6% (17)	25	9.6	7	164	11% (12)	25	11.3	6.1	136	6% (5)	20	5.6	8.1	28
Total	100% (288)				3754	100% (213)				2494	100% (75)				1260

Fig.13 Potential risk in different blocks of the Adriatic evaluated on the basis of species number: (left) all year round, (middle) in summer, (right) in winter. The herd composition per species and in the three different periods is reported in the table.

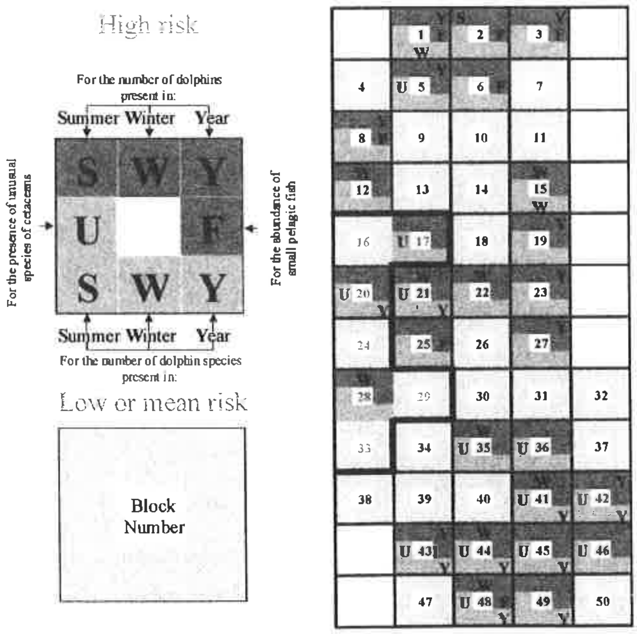


Fig.14 The hot blocks of the Adriatic sea and the type of risk in each block.

NEW DATA ABOUT DOLPHINS IN TUNISIA: INTERACTION BETWEEN DOLPHINS AND FISHERY CRAFT

Ben Naceur Lofti

Institut National des Sciences et Technologies de la Mer,
29 Rue général Khéreddine Pacha le Kram 2025 Tunis, Tunisia

As direct competitors with man because they share the same biological resource needs, dolphins are accused of numerous damaging effects. Fishermen accuse them of destroying their nets, stating that this has brought heavy economic losses in fishery production, repair costs, and new engine purchases. In Tunisia, the problem is so important that the fishermen requested radical intervention in order to reduce the number of these marine animals. To help in this problem, a mechanical wave generator was developed in June 1993 that was able to perturb the echolocation system of the dolphins. This machine, called a "dolphin tube" was put on sale in the national market and its utilisation gave some satisfactory results for numerous fishermen. However, it would be pretentious to say that the problem is definitively solved. Technical improvements still have to be made, taking into account the actual state of dolphin populations: species diversity, distribution, abundance, diet, behaviour, etc. Literature about cetaceans in the region generally refer only to strandings or to accidental captures. They do not give sufficient information about the ecology and behaviour of the species. For these reasons, we have conducted a study. This kind of approach, even with its imperfection linked to the non-scientific nature of the data and the subjectivity of the answers, can make a real contribution to new knowledge about the composition, relative abundance, distribution, and behaviour of the delphinids in the region, and about their impact on fisheries on the northern coasts of Tunisia.

DOLPHIN TOURISM: A TOOL TO CONSERVE THREATENED MARINE MAMMALS AND CRITICAL HABITATS IN EAST AFRICA?

P. Berggren

Department of Zoology, Stockholm University, S-106 91 Stockholm, Sweden

Marine mammals in the East African region suffer from direct and indirect takes as well as habitat degradation due to anthropogenic activities. Dugongs recently became extinct in Tanzania and only a few animals remain in Mozambique and Kenya. Since 1998, the potential for dolphin tourism to protect threatened marine mammals and their habitats has been investigated in Menai Bay, Zanzibar. Dolphins are still hunted for consumption as well as for bait in certain fisheries. During the latest recorded hunt in 1994, 23 dolphins were harpooned and used locally. In the same year, a dolphin tourist initiative began with local boats taking tourists to watch and swim with the dolphins. Since this initiative no direct takes of dolphins have been recorded in the Menai Bay area. About 150 bottlenose (*Tursiops truncatus*) and 50 humpback (*Sousa chinensis*) dolphins have been identified in the Menai Bay during photo-ID surveys in 1998 and 1999. Repeated sightings of known animals indicate that small resident populations of these species are present year round. The lack of reported takes of dolphins since the advent of dolphin tourism suggests that this may be a useful means of affording much needed protection to the animals in the region. However, in order to make this a sustainable resource, it needs to be managed closely. To facilitate future conservation and management of marine mammals in the region, comprehensive education and research programmes are essential. Guidelines and regulations for tour operators need to be developed and enforced alongside teaching materials for tourists, guides, and local communities. In conclusion, historical and present hunt records along with current population data indicate that responsibly managed dolphin tourism may be an approach that could be developed elsewhere in East Africa where dolphin conservation is still very much in its infancy.

LEGAL PROTECTION OF CETACEANS IN WATERS OF EUROPEAN STATES: AN OVERVIEW

V. Bou

Institute of International Law, School of Law, Campus Tarongers s/n, 46022 Valencia, Spain

From a legal perspective, the protection of whales in Europe is achieved through the combination of two different kinds of international treaties. First, international treaties of worldwide scope and application, that is, international treaties that apply all over the world, including all European seas (such as the UN Convention on the Law of the Sea; the International Convention for the Regulation of Whaling; the Convention on the Conservation of Migratory Species of Wild Animals; and the Convention on International Trade in Endangered Species of Wild Fauna and Flora). Second, regional treaties or regulations that only apply to particular European seas (such as the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas; the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area; the Convention on the Conservation of European Wildlife and Natural Habitats; the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean, etc). A global overview of all of these is given.

PRIORITISING CETACEAN SPECIES FOR PROTECTIVE MEASURES IN THE EASTERN NORTH ATLANTIC

P. G. H. Evans

Sea Watch Foundation, 11 Jersey Road, Oxford 0X4 4RT & Dept. of Zoology, Univ. of Oxford, South Parks Road, Oxford 0X1 3PS, UK

With limited resources available for conservation research and monitoring, and for implementation of protective measures, it is necessary to prioritise which species should receive first attention. This approach has been at the core of all major wildlife and habitat conservation agreements, both at national and international levels. The EU Species and Habitats Directive, for example, places the bottlenose dolphin *Tursiops truncatus* and harbour porpoise *Phocoena phocoena* in a special annex. In this case, emphasis was given to two species for which special concern had been expressed as a result of apparent declines in population size and/or range. However, other factors arguably could be used in a prioritisation procedure, yielding a different set of species. These include: (1) the vulnerability of the species in terms of recoverability from any adverse human activity due to its life history parameters; (2) its sensitivity through specific habitat requirements; and (3) the population size and dispersion pattern of the species. Two alternative schemes (termed the 'conservation cube' approach and the 'two-block' approach) are tested to see which species would be selected by either method. Information on status (absolute or relative abundance), distribution (including extent, and dispersion patterns), and life history (for example, longevity and reproductive rates) are used in this process, and different weighting procedures are examined. The results of the two approaches differ primarily with respect to levels of uncertainty, the 'conservation cube' approach emphasising potential vulnerability to human interference, and the 'two-block' approach giving greater weight to actual evidence for population decline and endangerment. Also considered is the importance for any species of the area covered by that legislative instrument relative to its overall global range - should species endemic to the North Atlantic, e.g. Sowerby's beaked whale, white-beaked dolphin, be given higher priority over those with wider distributions?

PHOTOGRAPHIC AND STRANDINGS DATA HIGHLIGHTING THE PROBLEM OF MARINE DEBRIS AND CREEL ROPE ENTANGLEMENT TO MINKE WHALES (*BALAENOPTERA ACUTOROSTRATA*) AND OTHER MARINE LIFE IN SCOTTISH WATERS

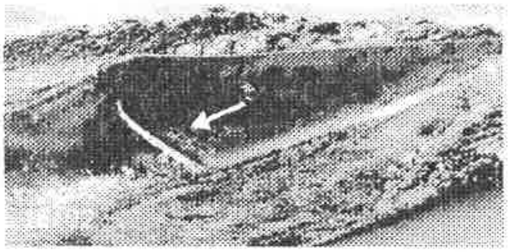
A. Gill[1], R. J. Reid[2], and B. R. Fairbairns[3]

[1]*Hebridean Whale and Dolphin Trust, 28 Main Street, Tobermory, Isle of Mull, Argyll PA75 6NU, UK*
(E-mail: agillm@aol.om)
[2]*SAC Veterinary Science Division, Drummondhill, Stratherrick Road, Inverness IV2 4JZ, UK*
[3]*Sea Life Surveys, Ledaig, Tobermory, Isle of Mull, Argyll PA75 6NU, UK*

Since 1990, the Hebridean Whale and Dolphin Trust and Sea Life Surveys have been conducting a photo-identification study of the local population of minke whales (*Balaenoptera acutorostrata*) in the coastal waters of the Isle of Mull, Scotland. A catalogue of 74 individual whales has been established which show that minke whales return to this area year after year and are summer residents. During the summer months, the whales are actively feeding and through the photo-identification project it is becoming apparent that some of the whales are affected by marine debris.

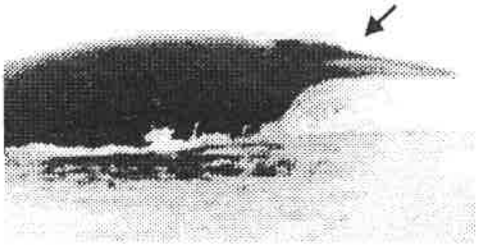
Nine of the recognised whales show evidence of accumulating marine debris. Two whales, photographed in May 1997 and May 1999, have plastic packing strips wrapped around their rostrums. These plastic strips have become trapped in the baleen in the upper jaws and appear to be cutting into the whale's skin. Another whale, photographed in September 1999, has a white scar thought to be caused by a packing strip or twine.

Photographs of minke whales which have packing strips caught around their mouths.



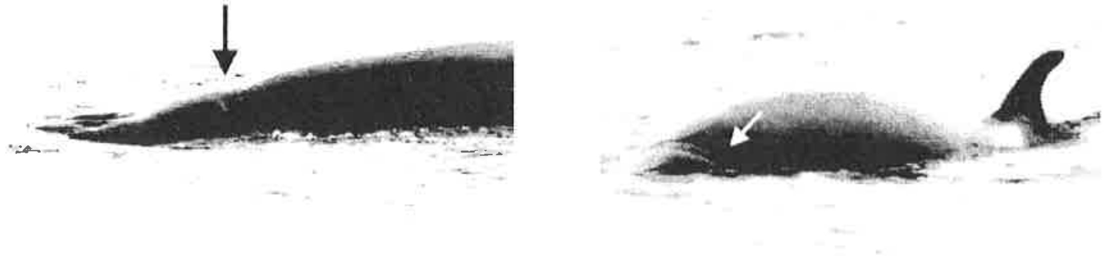
Three minke whales appear to have evidence of creel ropes wrapped around their heads. Two of the whales, photographed in August 1994 and September 1998, have large circular notches in their rostrums along the ridge. These notches appear to be caused by ropes wrapped around their rostrums, and the size of the notch would suggest that it is a thick rope such as those used for creels.

Photographs to show large notches in the rostrums of minke whales



One whale, photographed in September 1998, has obviously had a thick rope wrapped around its head and the twist of the twine can be seen in the scar.

Photographs to show a minke whale that has had a thick rope caught around its head.



Two other whales in the catalogue have marks on the tips of their mouths which look to be caused by a physical abrasion of some sort and 1 whale has scars around its flank. Again these are probably caused by marine debris.

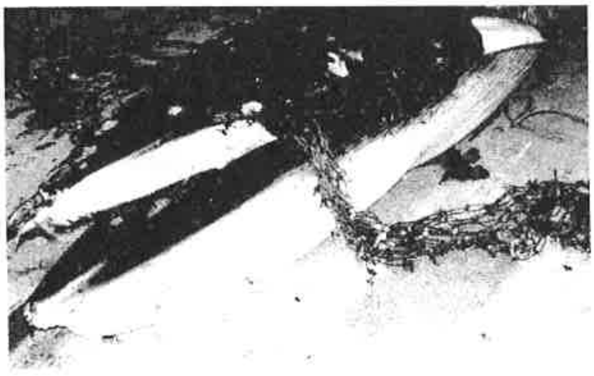
Photograph to show a minke whales with marks on its mouth and one with a scar around its flank.

A minke whale was encountered in May 1999, but not photographed, whose head was completely covered in green trawler netting. This netting was accumulating seaweed and other debris and the whale was clearly distressed, finding it difficult to breathe properly.

The Scottish Agricultural College (SAC) Veterinary Division, in Inverness, co-ordinates and investigates marine mammal strandings on the coast of Scotland. Since 1992, 70 minke whale strandings have been recorded. Post mortems have been carried out on 15 of these and at least seven were believed to have died from entanglement in creel ropes and one caught in fishing net.

The photographs below are of a young male minke whale found near Inverness in July 1993. The photographs show that the net is trapped at the back of the mouth, behind the baleen plates and that the ends are frayed.

Photograph to show frayed fishing net caught in the mouth of a young minke whale.



This would suggest that the whale has been carrying this piece of netting for a while which is also supported by the fact that there are goose barnacles (*Lepas anatifera*) on the net.

Photograph to show goose barnacles on the net

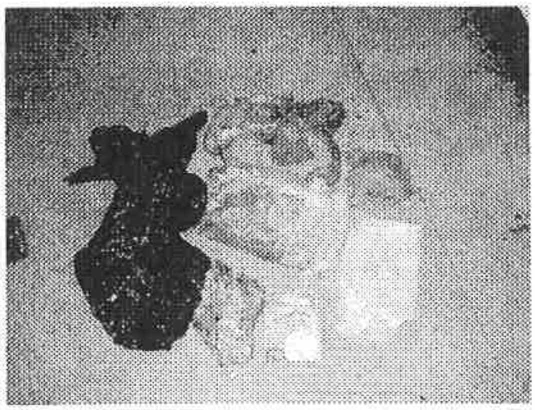
The erosions at the back of the mouth also suggests that the net has been there for some time. Therefore, it appears that this whale picked up this piece of net as floating debris.

Since 1992, 19 stranded leatherback turtles (*Dermochelys coriacea*) have been recorded and at least seven of these died as a result of entanglement in creel ropes.

Photograph to show a turtle entangled in creel ropes found in Northwest Sutherland in October 1993.

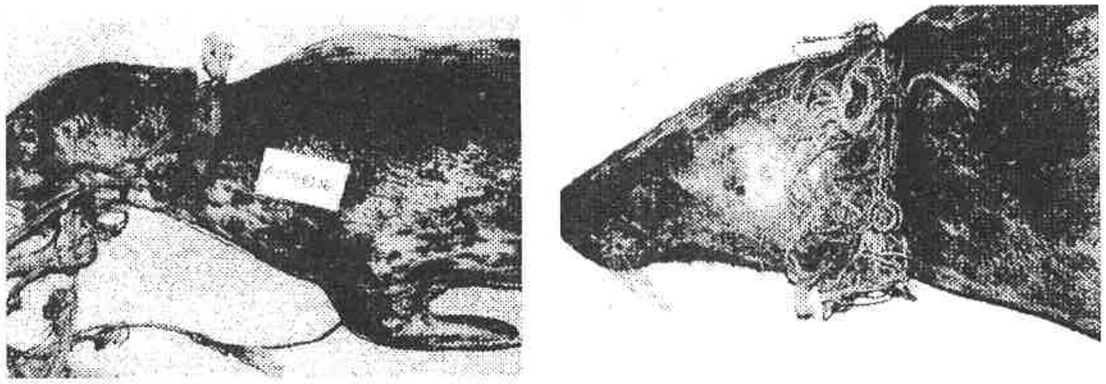
Plastic bags and other debris were recovered from the alimentary tracts of some of these turtles. Turtles will often mistake plastic bags for jellyfish.

Photograph to show the alimentary tract contents of a leatherback turtle.



In addition, two seals with collars of netting have been recorded. One of these was a young female grey seal found near Dornoch, Sutherland in September 1996, and the other a young grey seal found in Shetland in January 1993. Both of these seals were found dead and the post mortems showed the collars to have caused their deaths.

Photographs to show collars of netting around seals



DISCUSSION The evidence presented here is from the coastal waters of Scotland. Globally, an estimated one million birds and 100,000 marine mammals and sea turtles die each year from entanglement in, or ingestion of, plastics (Laist, 1997). Plastics pose a particular threat to the marine environment because they float on the surface of the sea or within the water column and can be transported for many miles. They also persist for many years and even when they break down, they are present as strands in the sand (MCS UK Action Guide, 1999). It has been estimated that 6.4 million tonnes of plastics are thrown off ships every year (MCS, 1993/94). Plastics are the most commonly sighted debris floating at sea (Dahlberg & Day, 1985) and constitute the majority of debris found on beaches in the UK (Center for Marine Conservation, 1998; Tidy Britain Group, 1995; Peck, 1995) and around the world (Center for Marine Conservation, 1998, Willoughby, *et al.*, 1997; Uneputty & Evans, 1997; Frost & Cullen, 1997; Haynes, 1997; Garrity & Levings, 1993).

Turtles are particularly prone to marine debris as they often mistake plastic debris as food, especially plastic bags. In a survey in the Bay of Biscay, plastic bags accounted for up to 95% of the total debris in sub-surface tows (Galgani *et al.*, 1995).

Beachwatch is a practical environmental initiative organised by the Marine Conservation Society (MCS) to monitor litter on Britain's beaches, and they found that nearly 70% of litter found on UK beaches is made up of persistent plastics. The amount of plastic on the beaches, and the levels of litter overall on the west coast of Scotland, exceeds the United Kingdom average and includes the highest levels of fishing debris, sewage related debris, shipping waste, and medical waste (Tyler and McHattie, 1998).

International laws prevent the dumping of persistent plastics, including fishing gear, at sea. These laws include the *International Convention for the Prevention of Pollution from Ships, 1973*, known as MARPOL (73/78) and implemented in the UK in 1988 through the *Merchant Shipping Regulations 1988* and the *London Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972* (London Convention). Nationally, the littering of public places is prohibited by the *Environmental Protection Act, 1990.* These laws, however, have not been effective in reducing the problems of marine debris to date. More emphasis needs to be placed on determining the sources of litter, providing adequate means of disposal at public sites and ports, encouraging recycling, and educating those persons creating litter on the harmful effects on wildlife.

The photo-identification and strandings programme allows us to continue to monitor the situation regarding the entanglement of marine animals in plastics and creel ropes in Scottish waters.

REFERENCES

Dahlberg, M. L and Day, R. H. 1985. Observations of man-made objects on the surface of the North Pacific Ocean. In: *Proceedings of the Workshop on the Fate and Impact of Marine Debris.* (Eds. R. S. Shomura and H. O. Yoshida).

Frost, A. and Cullen, M. 1997. Marine Debris on northern New South Wales beaches (Australia):, Sources and the role of beach usage. *Marine Pollution Bulletin*, 34(5).

Galgani, F., Burgeot, T., Bocquene, G., Vincent, F., Leaute, J. P., Labastie, K., Forest, A., and Guichet, R. (1995). Distribution and abundance of debris on the continental shelf of the Bay of Biscay and in Seine Bay. *Marine Pollution Bulletin*, 30(1).

Garrity, S. D. and Levings, S. C. 1993. Marine debris along the Caribbean coast of Panama. *Marine Pollution Bulletin*, 26(6).

Haynes, D. 1997. Marine Debris on continental islands and sand cays in the far northern section of the Great Barrier Reef marine park, Australia. *Marine Pollution Bulletin*, 34(4).

Laist, D. 1997. Impacts of Marine Debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: *Marine Debris: Sources, Impacts and Solutions* (Eds. J. Coe & D. B. Rogers), Springer Verlag Series on Environmental Management.

MCS. 1999. *Marine Conservation UK Action Guide.* (Eds. G. Brina and S. Pollard). Marine Conservation Society, Ross-on-Wye, UK.

MCS. 1994. Marine Conservation Society, 1993/1994. *Marine Conservation*, 3(1). Winter 1993/1994.

Tyler, P. and McHattie, A. 1998. *The Minch Project. Beach Litter Survey. September 1998.* West Highland Free Press.

Peck, R. D. 1995. *Seasonal composition, distribution and abundance of man-made products on Anglesey shore lines.* BSc Thesis. University of Wales, Bangor.

Tidy Britain Group. 1995. *Marine Litter Research Programme.* Stage 7 Report.

Uneputty, P. A. and Evans, S. M., 1997. Accumulation of beach litter on islands of the Pulau Seribu archipelago, Indonesia. *Marine Pollution Bulletin*, 34(8).

Willoughby, N. G., Sangkoyo, H. and Lakaseru, B. O., 1997. Beach Litter: An increasing and changing problem for Indonesia. *Marine Pollution Bulletin*, 34(6).

SPATIAL & INTERSPECIES VARIABILITY OF MERCURY ACCUMULATION IN SMALL CETACEANS

L. Holsbeek[1], K. Das[2], C. Joiris[1], C. Gascard[1] and J.-M. Bouquegneau[2]

[1]*Laboratory for Ecotoxicology, Free University, Brussels, Belgium*
[2]*Servive of Oceanology, University Liège, Liège, Belgium*

The toxicity of Hg compounds, their bioaccumulation and biomagnification in the food web, constitutes a long-standing health hazard for toothed dolphins. The problem relates to neurotoxic and mutagenic monomethylmercury (MMHg). Models suggest that conversion of a small fraction of the Hg flux in oceans into organomercurials can account for elevated Hg levels in marine top predators. Cetacean tissue (liver) levels increase dramatically with age but are considered non-harmful after being detoxified and stored in a selenium-mercury granulate (thiamanite) form. The demethylation and accumulation of Hg was studied in a series of small cetaceans ranging from the Atlantic to the Black Sea area. The general hypothesis was that, given the higher daily energy demand and relative food intake, Hg accumulation in smaller species (harbour porpoise; North Sea average MMHg intake 35 μg/kg.day) would exceed the one for medium-sized odontocetes (20 μg/kg.day).

Regional differences were obvious: Hg concentrations were an order of magnitude lower for the Black Sea dolphins due to a permanent stratification of the water mass. However, no interspecies differences in Hg accumulation patterns were found: after standardisation for age, Hg detoxification and accumulation follows a similar pattern for small and medium-sized species. Whether this is due to differences in trophic position, open ocean to coastal habitat preference, or other factors remains debatable. Although binding to selenium is widely considered an effective defence mechanism against cellular MMHg damage, it seems to be triggered at a threshold concentration. More importantly, less than 1% of the assimilated MMHg finally ends up as HgSe granules, 99% being eliminated through other pathways. This leads to the conclusion that selenium only offers a partial protection to MMHg exposure, and that Hg cannot be excluded as a continuous threat to odontocete populations.

ECOLOGY AND INTERACTIONS WITH FISHERIES OF BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) IN NW SPAIN

A. López[1], B. Santos[2], A. F. González[1], A. Guerra[1] and G. Pierce[2]

[1]*Instituto de Investigaciones Marinas, CSIC. Eduardo Cabello 6, E-36208 Vigo, Spain*
[2]*University of Aberdeen, Dept. of Zoology, Tillydrone Avenue, Aberdeen AB24 2TN, UK*

INTRODUCTION Interactions between bottlenose dolphins and fisheries have been recorded in Galicia since the XVIII century (Filgueira & Fortes, 1995) and, consequently, for many years the species was hunted. The study of stranded animals offer us the unique opportunity to analyse causes of death. This paper deals with the analysis of bottlenose dolphins (*Tursiops truncatus*) stranded in NW Spain and, in particular, evidence of interactions with fishing gear.

MATERIAL AND METHODS Strandings in Galicia are recorded by the non-profit organization CEMMA in collaboration with the Instituto de Investigaciones Marinas (CSIC, Vigo). The strandings network involves collaboration between researchers, public institutions, and members of the public, and includes regular coastal surveys. Additionally, contacts with fishermen were made in order to get information on interactions between *T. truncatus* and fisheries.

Signs of interaction with fishing gear were identified based on a modified version of Kuiken's protocol (Kuiken, 1996). Diagnostic signs include mutilation of fins, cuts, ropes around the tail, and net markings. Stomach contents of 21 bottlenose dolphins (collected from December 1990 to August 1995) were analysed [data taken from Santos *et al.* (1997)]. Fish otoliths and bones and cephalopod beaks were identified using reference collections and guides (Clarke, 1986; Härkönen, 1986; Pérez-Gándaras, 1986; Watt *et al.*, 1997).

RESULTS A total of 138 bottlenose dolphins, including four recorded by-catches, were collected on the Galician coast between 1990 and 1998. This represents an annual average of 13 animals (1.2 per month). The majority (80%) of these records were from the area of coastline between Malpica and Cape Silleiro.

Males comprised 60% of the animals studied and had an average length of 270 cm. The average length for females was 240 cm. Around 22% of the animals presented signs of interactions with fisheries. If we exclude animals in poor condition (for which signs of by-catch could not have been seen), the figure could increase to 35%. Analysis of gonads suggests that females and males reach sexual maturity at around 270 cm and 300 cm total length respectively.

Seventeen prey species belonging to eleven families were identified in the stomach contents. Male bottlenose dolphins appear to take a wider variety of prey species than females, but in both cases blue whiting (*Micromesistius poutassou*) and hake (*Merluccius merluccius*) were the main prey eaten (Santos *et al.*, 1997).

DISCUSSION As many as 35% of the animals stranded could have died as a result of interaction with fishing gear. This percentage could increase if we consider that some gear do not produce external marks in carcasses. Most incidental catches seem to occur off the continental shelf. The parts of the study area where groups of bottlenose dolphins are present in coastal waters were not the areas with the highest incidence of strandings.

Bottlenose dolphins stranded on the Galician coast had been eating a wide variety of prey, consistent with opportunistic predation. Both blue whiting and hake are fished commercially and are of considerable economic importance, which places bottlenose dolphins in direct competition with fishermen. The various sources of evidence listed above, and the presence of teeth marks of large sharks on some of the carcasses, suggest that strandings, as well as by catches, are mainly from an offshore population.

REFERENCES

Clarke, M. R. (Ed.). 1986. *A handbook for the identification of cephalopod beaks.* Clarendon Press, Oxford.

Filgueira, X. and Fortes, M. X. 1995. *Epistolario do Padre Sarmiento.* Consello da Cultura Galega. Santiago de Compostela.

Härkönen, T., 1986. *Guide to the otoliths of the bony fishes of the northeast Atlantic.* Danbiu ApS, Hellerup, Denmark.

Kuiken, T., 1996. Review of the criteria for the diagnosis of by-catch in cetaceans. Pp. 38-43. In: *Diagnosis of by-catch in cetaceans, Proceedings of the Second ECS Workshop on Cetacean Pathology.* (Ed. T. Kuiken). ECS Newsletter 26 (Special Issue). European Cetacean Society, Saskatoon, Saskatchewan, Canada.

Pérez-Gándaras, G., 1986. *Estudios sobre los cefalápodos ibéricos: sistemática y bionomía mediante el estudio morfométrico comparado de sus mandúbulas.* PhD Thesis, Universidad Complutense de Madrid, Madrid, Spain.

Santos, M. B., Pierce, G. J., González, A. F., and López, A., 1997. Dieta do arroás (*Tursiops truncatus*) en Galicia [Diet of bottlenose dolphin (*Tursiops truncatus*) in NW Spain]. *Eubalaena*, 10, 30-39.

Watt, J., Pierce, G. J., and Boyle, P. R., 1997. *A guide to the identification of North Sea fish using premaxillae and vertebrae.* Co-operative Research Report No 220, International Council for the Exploration of the Sea, 231pp.

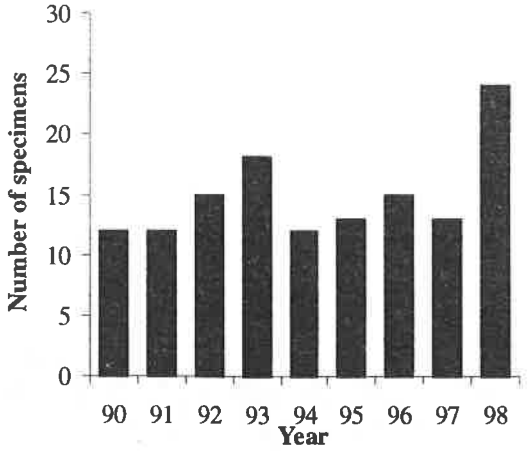


Fig. 1. Annual strandings from 1990 to 1998

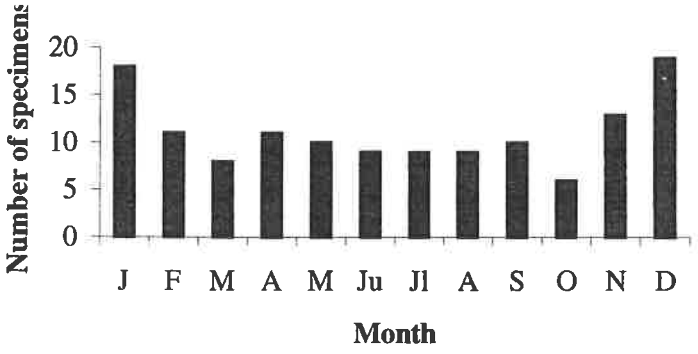


Fig. 2. Cumulative monthly strandings from 1990 to 1998

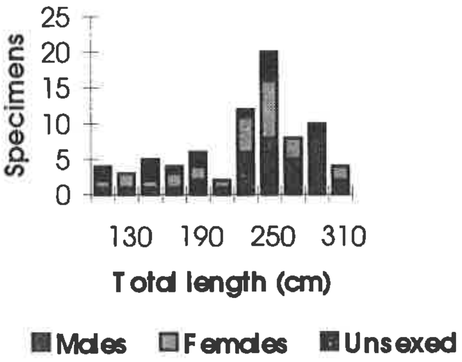


Fig. 3. Percentage of animals by size groups

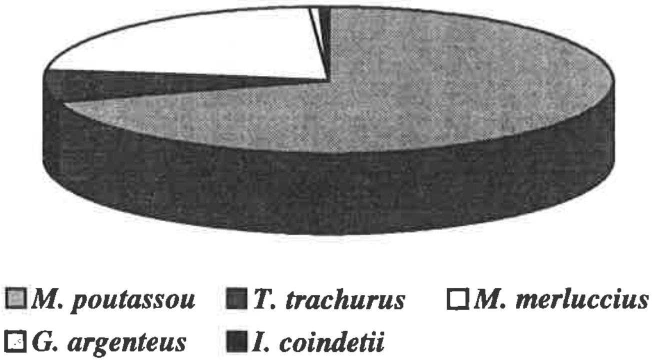


Fig. 4. Diet of females

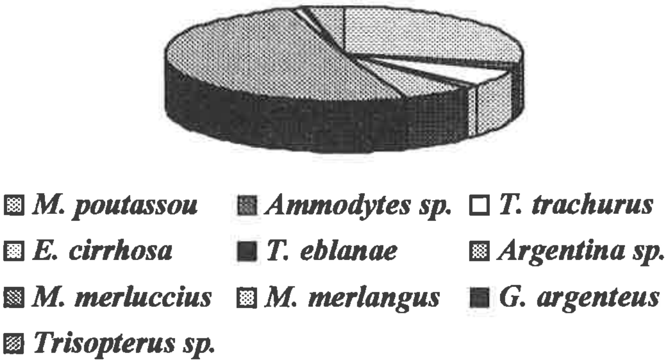


Figure 5. Diet of males

IS THE AGREEMENT ON THE CONSERVATION OF SMALL CETACEANS OF THE BALTIC AND NORTH SEAS (ASCOBANS) MEETING ITS CONSERVATION OBJECTIVES?

H. McLachlan

RSPCA, Causeway, Horsham, West Sussex, RH1 1HG, UK

In 1992, the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was signed and the first meeting of the Parties was held in 1994. The Agreement was created in response to concern for the status of small cetaceans in the Baltic and North Seas. Parties were convinced that the vulnerable and largely unclear status of these cetaceans merited immediate attention. By ratifying ASCOBANS, Parties agreed to co-operate to achieve and maintain a favourable conservation status for small cetaceans in the Agreement area. A conservation and management plan was agreed, as were more specific objectives. This paper reviews reports of the Meeting of the Parties, Advisory Committees and Parties' national reports, and asks whether ASCOBANS is achieving the conservation objectives agreed to date. The mitigation of incidental capture of cetaceans in fisheries is used to illustrate how Parties are meeting their commitments in one important area addressed by the Agreement. This issue was used as it is widely agreed to be the most significant threat to small cetaceans globally. Despite the identification of unacceptable levels of bycatch in the Agreement area, of the seven long-standing Parties, only one has drawn up a conservation strategy for bycatch reduction in its jurisdiction. No Party has yet implemented comprehensive measures to reduce bycatch. The paper finds that, with respect to bycatch reduction, Parties are failing to meet the undertakings they have agreed to date. The paper concludes that, overall, while some progress has been made, ASCOBANS is failing to achieve its stated conservation objectives. Moreover it offers that a solution may lie in Parties affording a higher priority to implementing ASCOBANS commitments, and suggests that researchers require greater awareness of the Agreement, its objectives, and the obligations it places on Parties.

HARBOUR PORPOISE BYCATCH IN UK GILL AND TANGLE NET FISHERIES

S. Northridge and P. S. Hammond

Sea Mammal Research Unit, Gatty Marine Laboratory, Univ. of St. Andrews, St Andrews, KY9 1JB, UK

This study examined the level of cetacean bycatch in British gillnet and tangle net fisheries in the North Sea and Hebridean waters. Observers were placed on 41 vessels from 29 landing places between April 1996 and November 1999. Over 4,000 net hauls were observed. Details of soak time, net length, location, water depth, bottom type and net characteristics were recorded for each net hauled. Any cetaceans found entangled in the nets at the time of hauling were identified and recorded. Where feasible, they were also measured and sexed, and teeth and other samples (including whole carcasses) were returned to port for subsequent analysis. All cetaceans observed in nets were harbour porpoises. Fishery metiers were typified based on the declared target species of each haul and the sea-area of the fishery. Twelve target species and 14 metiers were identified. Of these, eight had positive cetacean bycatch rates associated with them. The observed mean fishing effort (net km.hours) per day at sea within each metier was assumed to be an unbiased measure of daily fishing effort for all UK vessels operating within the same metier. Using official landing statistics for all UK registered vessels, every fishing trip, or group of trips, that had been recorded using gill nets during 1996, 1997 and 1998 was allocated to a metier. This allocation was based on the composition of the recorded landings compared with the observed landings in known-metier trips. Recorded effort (days-at-sea) was used to estimate total net km.hours within each metier. Observed porpoise bycatch rates within each metier were then used to extrapolate estimates of total bycatch in each metier, and these were combined to provide overall estimates of porpoise bycatch in UK North Sea and Hebridean static net fisheries. Overall catch rates were similar to those described in studies in adjacent regions.

THE POSSIBLE IMPACTS OF MILITARY ACTIVITY ON CETACEANS IN WEST SCOTLAND

E. C. M. Parsons[1], I. Birks[2], P. G. H. Evans[3], J. C. D. Gordon[4], J. H. Shrimpton[1] and S. Pooley[1]

[1]*Hebridean Whale and Dolphin Trust, 28 Main Street, Tobermory, Isle of Mull, Argyll PA75 6NU, UK*
[2]*Sail Gairloch, Tigh-na-Bruach, Strath, Gairloch, Ross-shire IV21 2BT, UK*
[3]*Sea Watch Foundation, 11 Jersey Road, Oxford OX4 4RT, UK*
[4]*3 Alma Terrace, Newport-on-Tay, Dundee DD6 8HZ, UK*

INTRODUCTION The waters of western Scotland are one of the most important cetacean habitats in Europe with 24 species recorded from the region (Parsons *et al.*, 1999) ranging from the harbour porpoise in coastal waters to the blue whale and other mysticetes in offshore waters. The region is also a major area for military exercises and activities (Figure 1) including:

- submarine exercises;
- torpedo testing;
- firing ranges; and
- training exercises.

SUBMARINE EXERCISES There are several submarine exercise grounds off the west coast of Scotland including areas of the Firth of Clyde, Sea of Hebrides and the Minches (Figure 1). A summary of the amount of submarine activity in the various regions of western Scotland is presented in Table 1. The concern, with respect to cetaceans and submarine traffic, is the latter's use of sonar. Several studies have voiced concern over the potential impacts of sonar use upon cetaceans. Vonk and Martin (1989), Simmonds and Lopez-Jurado (1991) and Frantzis and Cebrian (1999) have all suggested that the testing of sonar may have caused a mass stranding of Cuvier's beaked whales in the Canary Islands and the Ionian Sea. Moreover, sperm whales and long-finned pilot whales have both demonstrated changes in vocal behaviour in response to the use of military sonar (Watkins *et al.*, 1985; Rendell & Gordon, 1999).

Sonar systems usually emit short pulses of sound and are designed to focus as much energy as possible in narrow ranges of direction. Simple sonar systems target this sound in just one direction, although more complicated systems may emit beams of sound in multiple directions. Frequencies commonly used by sonar systems and their source levels are summarised in Table 2. However, the exact acoustic frequencies and sound sources of military sonar are usually classified, and some systems may use frequencies which are lower or louder than the summarised data. In addition to sonar, submarine-to-submarine communications systems are also a substantial source of submarine sound: 5-11 kHz at source levels of 180-200 dB (Richardson *et al.*, 1995). Table 3 summarises the range of acoustic frequencies used by cetaceans occurring in the Hebrides. These data clearly show that military sonar uses frequencies that cetaceans would be sensitive to. Considering the high source levels of military sonar, the possible impact of these systems upon cetaceans is, therefore, substantial.

TORPEDO TESTING The Ministry of Defence British Underwater Test and Evaluation Centre (BUTEC) is situated near the Kyle of Lochalsh in the western Highlands (Figure 1). The waters adjacent to BUTEC are used as a torpedo testing range. Some 130 squares miles of the Sound of Raasay are considered to be a danger area to shipping because of the use of explosives in this region. However, this area is also an important habitat for cetaceans, notably the harbour porpoise and, on occasions, the northern bottlenose whale.

Torpedoes have been documented to be a cause of cetacean mortality. Gardner (1996) stated that during hostilities between British and Argentine forces in the 1982 Falkland's conflict "a large number of whales were attached by torpedoes and depth chargers". Therefore, the use of torpedoes on the BUTEC range would not only be expected to disturb cetaceans but could also be physically damaging to individual animals in many cases.

FIRING RANGES A missile firing range is situated on the island of South Uist, which fires ordinance westwards out to sea. The west coast of South Uist receives a large number and variety of cetacean strandings every year, suggesting that the adjacent waters possess a diverse cetacean population (Sheldrick, 1989; Bones & Maclennan, 1994a,b). Military artillery produce noise levels in excess of 180 dB. However, the main impact of the South Uist range would not be acoustic disturbance as such, but the potential of physical trauma from falling and fragmenting ordinance.

Live-firing exercises also occur in the waters of western Scotland. These exercises are restricted to the southern approaches to the Firth of Clyde and Cape Wrath - a known area of high cetacean abundance. Apart form the direct physical injury caused by live ordinance, they are substantial sound sources producing broadband frequencies at a source level in excess of 270 dB. Such sound sources could cause auditory damage to cetaceans at distances of several kilometres from the sound source and could cause disturbance to cetaceans at a distance of tens of kilometres.

MILITARY TRAINING EXERCISES Since 1946, NATO has conducted the Joint Maritime Course (JMC) military training exercise in coastal waters and in deeper waters to the north and west of Scotland. The JMC occurs three times a year in March, June, and November. Military jets, submarines, warships (including minesweepers and sub-hunters), landing craft, power boats and sonobouys are utilised during these exercises. The noise levels produced by the various craft used in these exercises are listed in Table 4. Many of the exercises involve the use of active sonar, the impacts of which have been discussed above. In 1998, concerns were voiced by tour operators running cetacean-watching trips near the Small Isles and Gairloch. The tour operators had noted a marked decrease in cetacean sightings for the duration of the JMC. When sightings data were plotted for the two commonest cetacean species occurring in these regions (minke whale, *Balaenoptera acutorostrata*, and harbour porpoise, *Phocoena phocoena*) this decrease was clearly visible (Figures 2-9). A subsequent analysis of minke whale sightings data demonstrated that the decrease observed in 1998 was statistically significant (ANOVA on log transformed data: $F=4.6$; $p<0.005$).

DISCUSSION The amount of military activity in western Scotland is considerable, and so the potential for lethal and sub-lethal impacts upon cetacean populations in this region is high. Due to the classified status of much military activity in this area, and equipment used (especially sonar), it is impossible to determine precise impacts on cetaceans without input from the UK Ministry of Defence (MOD). Concerns over the impacts of military activities upon cetaceans in West Scotland, in particular the impacts of the 1998 JMC, led to the formation of a joint agency forum to discuss these concerns. The forum consisted of representatives of the MOD, Scottish Natural Heritage (Scotland's statutory body with responsibility for nature conservation), environmental NGOs, and concerned wildlife tour operators. As a result of this forum, a code of conduct for military vessels in the vicinity of cetaceans was produced (Table 4), and a more open forum for discussion created. However, as yet, very little progress has been made to address the real issues of concern. To date, no research has been undertaken to evaluate the impacts of military activities upon cetacean populations in the Hebrides, and cetacean conservation bodies in the UK should consider this issue a priority.

REFERENCES

Bones, M. and Maclennan, D. 1994a. Cetacean strandings in the Western Isles in 1992. *Hebridean Naturalist*, 12: 47-50.

Bones, M. and Maclennan, D. 1994b. Cetacean strandings in the Western Isles in 1993. *Hebridean Naturalist*, 12: 51-54.

Evans, P. G. H. and Nice, H. 1996. *Review of the Effects of Underwater Sound generated by Seismic Surveys on Cetaceans*. Report to UKOOA. Sea Watch Foundation, Sussex. 50pp.

Frantzis, A. and Cebrian, D. 1999. A rare mass stranding of Cuvier's beaked whales: cause and implications for the species biology. 1999. Pp. 332-335. In: *European Research on Cetaceans -12*. Proc. 12th Ann. Conf. ECS, Monaco, 20-24 Jan, 1998. (Eds. P.G.H. Evans & E.C.M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

Gardner, W. J. R. 1996. *Anti-submarine Warfare*. Brassey's Sea Power Series, London.

Parsons, E. C. M., Shrimpton, J., and Evans, P. G. H. 1999. Cetacean conservation in Northwest Scotland: perceived threats to cetaceans. In: 1999. Pp. 128-133. In: *European Research on Cetaceans -13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Perry, C. 1998. A review of the impact of anthropogenic noise on cetaceans. *Paper presented to the Scientific Committee at the 50th Meeting of the International Whaling Commission, 1998.* SC/50/E9.

Rendell, L. E. and Gordon, J. C. D. 1999. Vocal responses of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. *Marine Mammal Science*, 15: 198-204.

Richardson, W. J., Greene, C. R., Malme, C. I., and Thomson, D. H. 1995. *Marine Mammals and Noise*. Academic Press Inc, San Diego, USA.

Simmonds, M. and Lopez-Jurado, L. F. 1991. Whales and the military. *Nature*, 337: 448.

Sheldrick, M. C. 1989. Stranded whale records for the entire British coastline, 1967 - 1986. *Investigations on Cetacea*, 22: 298-329.

Vonk, R. and Martin, V. 1989. Goosebeaked whales *Ziphus cavirostris* mass strandings in the Canary Isles. Pp. 73-77. In: *European Research on Cetaceans - 3* Proc. 3rd Ann. Conf. ECS, La Rochelle, France, 24-26 Feb, 1989. (Eds. P. G. H. Evans and C. Smeenk). European Cetacean Society, Leiden, The Netherlands. 132pp.

Watkins, W. A., Moore, K. E. and Tyack, P. (1985). Sperm whales acoustic behaviour in the Southeast Caribbean. *Cetology*, 49: 1-15.

Table 1. Naval activity in the Hebrides during 1998
(NB. Figures are in ship days and high figures reflect multiple vessel exercises)

LOCATION	SUBMARINE ACTIVITY	SURFACE ACTIVITY
Rona North	52 days	45 days
Rona South	52 days	209 days
Rona West	59 days	2 hours
Raasay	58 days	543 days
Tiumpan	46 days	6 hrs
Stoer	38 days	6 hrs
Shiant	48 days	41 days
Ewe	40 days	34 days
Portree	--	195 days
Trodday	55days	1 day 1 hour
Lochmaddy	59 days	2 hours
Dunvegan	76 days	1 day 1 hour
Ushenish	60 days	1 day
Neist	63 days	8 days
Canna	33 days	--
Bracadale	33 days	--
Rhum	9 hours	--
Sleat	--	219 days
Barra	56 days	--
Hawes	44 days	3 hours 29 minutes
Tiree	47 days	3 days
Ford	75 days	5 days
Boyle	72 days	4 days
Place	77 days	6 days
Staffa	34 days	3 days
Eigg	9 hours	2 hours 30 mins
Colonsay	33 days	2 days
Mull	22 days	156 days
Sound of Jura	6 days	17 days
Linnhe	--	30 days
Blackstone	51 days	16 days
Mackenzie	36 days	3 days
Orsay	80 days	9 days
Islay	57 days	9 days
Otter	81 days	26 days
Gigha	30 days	35 days
Earadale	24 days	20 days
Kintyre	70 days	12 days

Source: C. Wheatley, MOD Conservation Officer *pers. comm.*

Table 2. The acoustic properties of active sonar systems (Richardson *et al.*, 1995; Perry, 1998)

SONAR TYPE	FREQUENCY RANGE (KHZ)	AV. SOURCE LEVEL (dB re 1 uPa/1 a)
Search and surveillance	2-57	230+
Mine & obstacle avoidance	25-200	220+
Weapon mounted sonar	15-200	200+
Low Frequency Active Sonar (LFAS) used by NATO	0.25-3.0?	230+

Table 3. Acoustic frequencies utilised by cetaceans occurring in the Hebrides (Evans & Nice, 1996)

SPECIES	SOUND TYPE	FREQUENCY RANGE (kHz)	DOMINANT FREQUENCIES (kHz)
Harbour porpoise	pulses	41.0	--
	clicks	<100-160	125-140
White-beaked dolphin	squeals	--	8.0-12.0
Risso's dolphin	whistles	--	3.5-4.5
	rasp/pulse burst	0.1- 8.0+	2.0-5.0
Common dolphin	barks	--	<0.5-3.0
	whistles	4.0 -16.0	--
	chirps	--	8.0-14.0
	clicks	10.0-110	26, 90, 110
Bottlenose dolphin	barks	0.20-16.0	--
	whistles	0.80-24.0	3.5-14.5
	clicks	0.10-300	15.0-130
Killer whale	whistles	1.50-18.0	6.0-12.0
	pulsed calls	0.50-25.0	1.0-6.0
	clicks	0.10-80.0	12.0-25.0
Long-finned pilot whale	whistles	0.50-8.0	1.6-6.7
	clicks	0.10-18.0	--
Atlantic white-sided dolphin	whistles	--	6.0-15.0
Northern bottlenose whale	whistles	3.0-16.0	--
	clicks	0.5-26.0+	--
Sperm whale	clicks	0.10-30.0	2.4, 10-16
Minke whale	down sweeps	0.06-0.13	--
	moans, grunts	0.06-0.14	0.06-0.14
	ratchet	0.85-6.00	0.85
	clicks	3.30-20.0	less than 12
	thump trains	0.19-2.0	0.1-0.2
Fin whale	moans	0.03-0.75	0.02
	chirps, whistles	1.5-5.0	1.5-2.5
	clicks	10-31	--
	rumble	0.01-0.03	--
	constant call	0.02-0.04	--
Sei whale	pulses	2.5-3.5	3
Northern right whale	tonal moans	0.03-1.25	0.16-0.50
	pulses	0.03-2.20	0.05-0.50
Blue whale	moans	0.012-0.39	0.16-0.25
	clicks	6-8, 21-31	6-8, 25
Humpback whale	song	0.03-8.0	0.12-4.0
	components	0.02-1.80	0.035-0.36
	moans	0.12-1.90+	--
	grunts	0.10-2.0	--

Table 4. MOD guidelines for minimising cetacean disturbance
(Source: Appendix 14 to Annex A to Operations Plan 73701, Exercise Northern Light 99, Dated 15 June 99)

The sea areas off the North West of Scotland, the Minches and the Sea of Hebrides are known cetacean breeding grounds, the principal mating season for these marine mammals falls within the period July-September. Units operating in these areas during this period should, where possible, observe the following guidelines when encountering cetaceans-
a. On encountering cetaceans, continue on your intended route making progress at a slow, steady, no wake speed. This will present predictable movements and thus minimise the risk of disturbance to, or collision with, the animals. Avoid erratic movements or sudden changes in course and speed.
b. To minimise the risk of disrupting mother-calf bonds give cetaceans with young a wide berth and avoid coming between a mother and calf.
c. Allow groups of cetaceans to remain together. Proceeding slowly on a steady course will enable cetaceans to remove themselves from the path of a vessel as a group. Avoid deliberately passing through, or between, groups of cetaceans.
d. On sighting cetaceans, fast planing vessels should gradually slow down to a slow, no wake speed. A suggested speed is less than 5 knots. Wait until well clear of cetaceans before resuming speed.
e. Be aware of, and attempt to minimise, possible sources of noise disturbance.

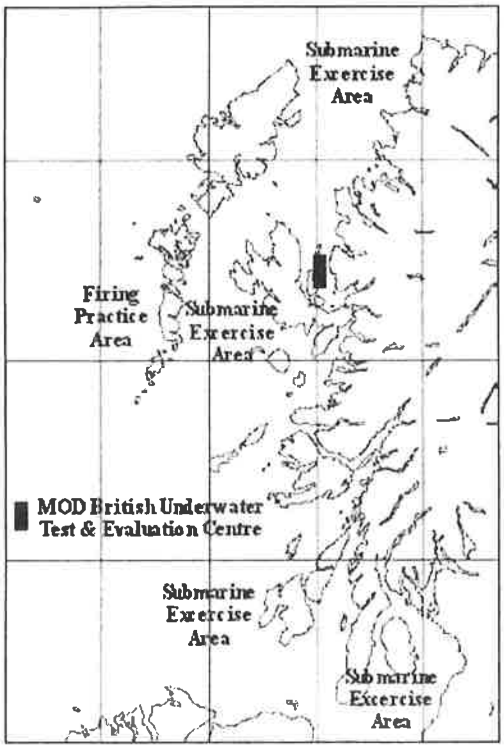


Figure 1. Map of the Hebrides showing areas of naval activity.

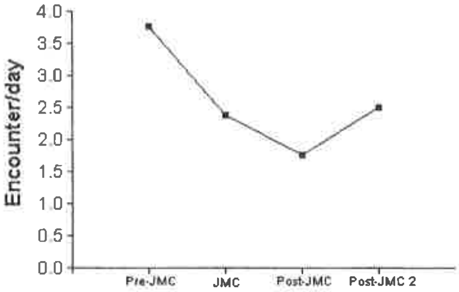


Figure 2. Minke whale sighting rates near the Small Isles before, during and after the 1999 Joint Maritime Course (JMC).

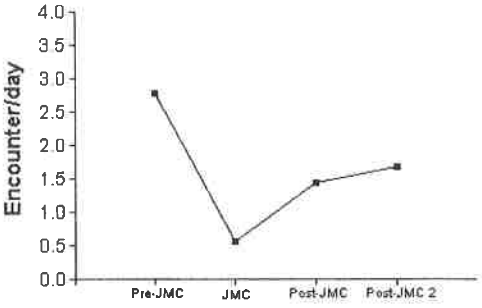


Figure 3. Minke whale sighting rates near the Small Isles before, during and after the 1998 Joint Maritime Course (JMC).

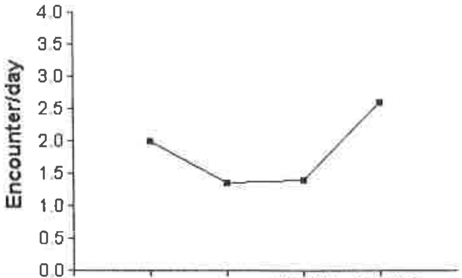


Figure 4. Minke whale sighting rates near the Small Isles before, during and after the 1997 Joint Maritime Course (JMC).

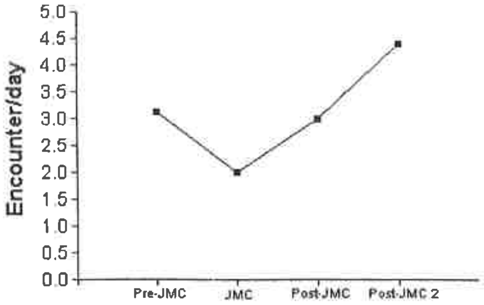


Figure 5. Porpoise sighting rates near the Small Isles before, during and after the 1999 Joint Maritime Course (JMC)

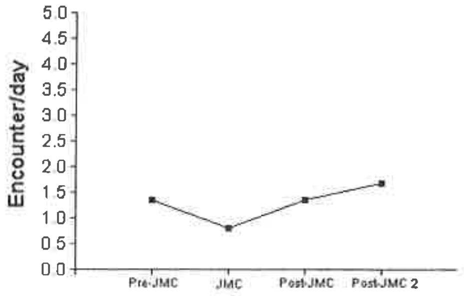


Figure 6. Porpoise sighting rates near the Small Isles before, during and after the 1998 Joint Maritime Course (JMC).

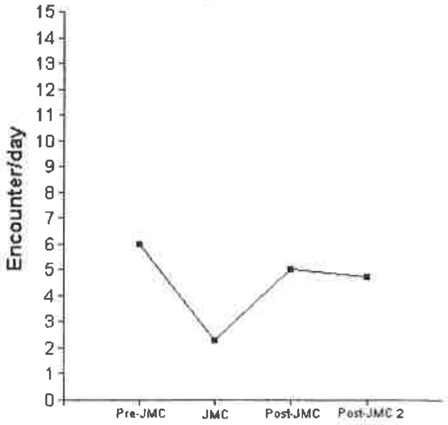


Figure 7. Porpoise sighting rates in Gairloch before, during and after the 1999 Joint Maritime Course (JMC).

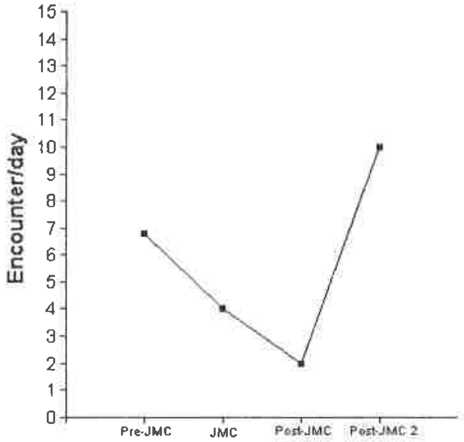


Figure 8. Porpoise sighting rates in Gairloch before, during and after the 1998 Joint Maritime Course (JMC).

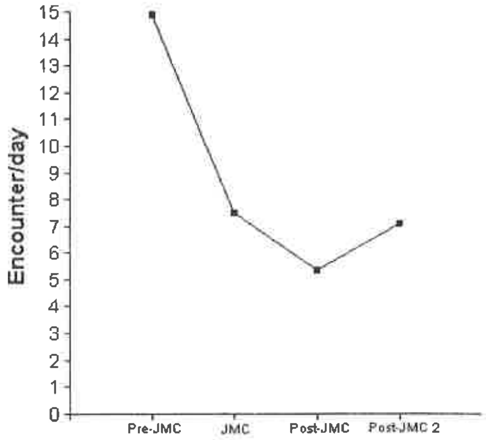


Figure 9. Porpoise sighting rates in Gairloch before, during and after the 1997 Joint Maritime Course (JMC).

THE EFFECTS OF ACOUSTIC POLLUTION ON THE CETACEANS OF THE ALBORAN SEA (SPAIN)

A. Pérez[1], A. M. Cañadas[2], R. Sagarminaga[2] and G. San Martín[3]

[1]*ALBORAN, Faculty of Sciences, Universidad Autónoma de Madrid,*
Cantoblanco E-28049, Madrid, Spain
[2]*ALNITAK, Nalón 16, E-28240 Hoyo de Manzanares, Madrid, Spain*
[3]*Laboratory of Marine Biology, Faculty of Sciences, Universidad Autónoma de Madrid,*
Cantoblanco E-28049, Madrid, Spain

The Alboran Sea is home to eight species of cetaceans, and is also subjected to an enormous amount of vessel traffic, including fishing fleets, pleasure craft and a high volume of commercial ships (accounting for 20% of the world maritime traffic). This study aimed to determine the effects of the acoustic pollution produced by maritime traffic on the small cetaceans of the area. Two different methodologies were used. Boat-based visual survey in which the type and number of ships and cetaceans were recorded; and acoustic surveys involving monitoring a towed hydrophone, every twenty minutes and noting the intensity (on a scale of 0-5) of cetacean sounds and ship noise. The results of the visual survey demonstrated that cetaceans in the Alboran area do not completely avoid contact with passing vessels However, there is a negative correlation between cetacean sounds (clicks and whistles) and ship noise (Pearson correlation coefficient=0.5, p=0.005). This could either be interpreted as a response by small cetaceans to shipping noise, or as ship noise masking the analyst's ability to detect clicks and whistles. In either case, the effect on dolphins and pilot whales could be the same: their ability to explore their environment through sound production and reception could be greatly reduced, in the first case because they may be do not produce sounds, and in the second case because they could fail to receive them. Noise is an important, though often overlooked, habitat parameter. High levels of man-made noise may reduce the value of habitats for cetaceans, and regulating this may be an important component of critical habitat management.

EVIDENCE OF MAN-MADE INJURIES ON MEDITERRANEAN FIN WHALES

G. Pesante, M. Zanardelli and S. Panigada

Tethys Research Institute, Viale G.B. Gadio 2, I-20121 Milano, Italy

INTRODUCTION The problem of collisions between cetaceans and boats affects both odontocetes and mysticetes world-wide, and can represent a serious threat to these marine mammals. Mediterranean fin whales (*Balaenoptera physalus*) regularly concentrate during their feeding season in the Corso-Ligurian basin (Zanardelli *et al.*, 1998), and have to deal with a very high level of boat traffic, especially during the summer months (Notarbartolo di Sciara and Gordon, 1997). Commercial, fishing, military and pleasure vessels may collide with the animals, causing damages of different seriousness, from sublethal wounds to fatal ones.

Photo-identification studies, together with the analysis of records from cetacean stranding networks, help in determining the incidence of this problem, emphasising the need for precautionary measures in order to minimise mortality and incidents.

MATERIALS AND METHODS Study area. The study area includes the offshore waters of the western Ligurian Sea between Imperia (Italy), the French Riviera, and the Island of Corsica. This area lies in a wider region, characterised by high productivity, recently declared by Italy, France, and Monaco Principality an International Sanctuary for Cetaceans (Fig. 1).

Study period and techniques. A long-term photo-identification study was conducted between 1990 and 1999 during the summer months. Pictures were taken from auxiliary sailing vessels using a 35 mm reflex camera equipped with a 100-300 mm zoom.

Catalogues of identified fin whales were analysed in order to evaluate the presence of man-made injuries on their body.

RESULTS Out of twenty-two animals (5.8%) of the total sample of 380 identified whales that presented scars or marks of various origin, fifteen whales (4% of the total sample) were cleary affected by man-made injuries. Scars or marks were determined by:

1- collisions with boats, reported for 15 whales (68.2% of the injured whales). These animals were divided into categories:

- 9 (60%) showed wounds from collisions with boats' hulls. Only one whale presented a non cicatrised cut (Fig. 2), the others had well healed over scars or cut dorsal fins;
- 4 (26.7%) had propeller scars, clearly recognisable from multiple, parallel and evenly spaced cuts;
- 2 (13.3%) lost half of their flukes (Fig. 3).

2- uncertain causes, occurring on 7 whales (31.8%):

- 6 animals presented white spots, light and almost circular stains that can be natural markings or old scars; since spots are found frequently near the dorsal fin, the whale's body's most exposed area, the collision hypothesis seems convincing (Fig. 4);
- 1 whale showed an aberrant dorsal fin, a genetic anomaly, or the consequence of a ship strike.

CONCLUSIONS This level of man-made injuries on Mediterranean fin whales represents a source of concern, considering also that it may be underestimated, since photo-identification studies of fin whales only focus on the dorsal fin and on the right side of the animal, while scars in other parts of the body would remain undetected. Furthermore, these data regard only surviving animals while records from the Italian Stranding Network reported, over a 12-year period, a total number of nine fin whales killed because of boat-strikes (Centro Studi Cetacei, 1987, 1988, 1990, 1991, 1992, 1994, 1994 bis, 1995).

A compelling cause of concern may be represented by high-speed boats, operating in the Sanctuary area since 1996. At present, there are five companies operating fast ferries in the Ligurian Sea; these ships, reaching speeds of 40 knots, daily cross this area, that during summer has the highest density of fin whales in the Mediterranean Sea. Considering the low calf production of mysticetes, and the reproductive segregation of Mediterranean fin whales

(Bérubé *et al.*, 1998), estimated at around 3,500 individuals (Forcada *et al.*, 1996), precautionary management plans are required in order to reduce human caused mortality and accidents.

ACKNOWLEDGEMENTS We are grateful to all Tethys' collaborators who helped in collecting pictures of fin whales. Many thanks to Albert Sturlese and Barbara Nani for their collaboration in the photo-identification research. Special thanks to Portosole, Sanremo, Italy, for support and hospitality. The eco-volunteers supported our research cruises onboard of *"Gemini Lab"*. Thank you to Giovanni Bearzi for helpful comments and suggestions.

REFERENCES

Bérubé, M., Aguilar, A., Dendanto, D., Larsen, F., Notarbartolo di Sciara, G., Sears, R., Sigurjönsson, J., Urban-Ramirez, J. and Palsboll, P. 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus* (*Linnaeus* 1758): analysis of mitochondrial and nuclear loci. *Mol. Ecol.*, 7: 585-599.

Centro Studi Cetacei. 1987. Cetacei spiaggiati lungo le coste italiane. I Rendiconto 1986. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 128(3-4): 305-313.

Centro Studi Cetacei. 1988. Cetacei spiaggiati lungo le coste italiane. II Rendiconto 1987. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 129(4): 411-432.

Centro Studi Cetacei. 1990. Cetacei spiaggiati lungo le coste italiane. IV Rendiconto 1989. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 131(27): 413-432.

Centro Studi Cetacei. 1991. Cetacei spiaggiati lungo le coste italiane. V Rendiconto 1990. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 132(25): 337-355.

Centro Studi Cetacei. 1992. Cetacei spiaggiati lungo le coste italiane. VI Rendiconto 1991. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 133(19): 261-291.

Centro Studi Cetacei. 1994. Cetacei spiaggiati lungo le coste italiane. VIII Rendiconto 1993. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 135(II): 437-450.

Centro Studi Cetacei. 1994 bis . Cetacei spiaggiati lungo le coste italiane. IX Rendiconto 1994. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 135(II): 451-462.

Centro Studi Cetacei. 1995. Cetacei spiaggiati lungo le coste italiane. X Rendiconto 1995. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat.* Milano., 136(II): 205-216.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X. and Aguilar, R. 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean sea during the summer. *J. Zool. Lond.*, 238: 23-34.

Notarbartolo di Sciara G. and Gordon, J. 1997. Bioacoustics: a tool for the conservation of cetaceans in the Mediterranean Sea. *Mar. Fresh. Behav. Physiol.*, 30: 125-146.

Zanardelli, M., Panigada, S., Airoldi, S., Borsani, J. F., Jahoda, M. and Notarbartolo di Sciara, G. 1999. Site fidelity, seasonal residence and sex ratio of fin whales (*Balaenoptera physalus*) in the Ligurian Sea feeding grounds. In: *European Research on Cetaceans* - 12. Proc. 12th Ann. Conf. ECS, Monaco, 20 - 24 Jan, 1998. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

FIRST STEPS FOR A RECOVERY PLAN FOR THE VAQUITA: THE REPORT OF THE INTERNATIONAL COMMITTEE FOR THE RECOVERY OF VAQUITA (CIRVA)

L. Rojas-Bracho[1], A. Díaz de León[2], O. Ramírez[2], A. Jaramillo-Legorreta[1] and H. Pérez-Cortés[3]

[1] *Programa Nacional de Investigación y Conservación de Mamíferos Marinos, Instituto Nacional de la Pesca – CRIP Ensenada., A.P. 1306 – 222769, El Sauzal de Rodriguez, BC, México*

[2]*Instituto Nacional de la Pesca, Pitágoras 1320, Col. Sta. Cruz Atoyac, México*

[3]*Insituto Nacional de la Pesca, Pitágoras, CRIP La Paz, Km. 1 Carretera Pichilingue, La Paz, BCS, México*

The mandate of the International Committee for the Recovery of Vaquita (CIRVA) is to develop a recovery plan for *Phocoena sinus* based on the best available scientific information, which contemplates and considers the socio-economic impacts of any necessary regulations. During the first meeting of CIRVA, in 1997, we reviewed the biology and analysed the risk factors. The Committee agreed that the immediate risk factor for the survival of vaquita are gillnets. The second meeting of CIRVA in 1999, reviewed and analysed work carried out in response to the recommendations of the first meeting. The most important activity was the joint Mexican-US population survey in summer 1997 using three research vessels and covering the entire potential area of vaquita distribution. The survey resulted in an estimate of 567 (CV=0.51, 95%CI 177–1073). CIRVA also discussed the unusual age structure in the sampled bycatch (lack of 3–6 year-old animals), and evaluated the hypothesis concerning age and sex segregation. Other subjects such as fisheries development, fisheries management and socio-economic aspects of the Upper Gulf were also discussed. More importantly, potential mitigation measures were analysed, including acoustic deterrents, season/area closures, gear restrictions, and marine protected areas. CIRVA concluded that only about 600 vaquita are left, and that the species is critically endangered. To prevent extinction, bycatch of vaquitas must be reduced to zero as soon as possible. It was recognised that protective measures would have significant economic and social impacts on residents of the Upper Gulf, and that it was not possible to implement full protection immediately. CIRVA therefore recommended that gillnet fishing in the area inhabited by vaquitas be removed in three stages, starting with large-mesh gillnets.

THE VAQUITA: CONSERVATION ACTIONS OR EXTINCTION?

K. A. Tolley[1] and S. S. Heppell[2]

[1]*Institute of Marine Research, Marine Mammal Division, 5817 Bergen, Norway*
[2]*U.S. E.P.A., Western Ecology Division, Corvallis, OR 97333 USA*

The vaquita (*Phocoena sinus*) has one of the smallest ranges of all cetaceans and recent estimates suggest it numbers less than 600 individuals. Endemic to the upper Gulf of California, this species is critically endangered due to incidental mortality in fishing gear. Although this species is clearly at risk, no plans to mitigate bycatch are currently in place. To investigate the possible effects of bycatch, we estimated population growth rates with an age-based matrix model. Many vital rates for this species were not available, so we incorporated a range of vital rates for natural mortality and reproduction in the model. Using various scenarios, we generated baseline estimates for the annual rate of population growth, l. We then incorporated recent estimates of bycatch rates to determine whether the species could sustain even a minimal level of anthropogenic mortality. In each scenario of the model, the population growth was negative when bycatch was incorporated, even when some of the most optimistic values of vital rates were utilised. The severity of the population decline depended on the level of bycatch mortality and which age classes were affected. In spite of the uncertainty regarding the vital rates, the results from this model demonstrate that the vaquita population will dwindle in the presence of any level of bycatch. Therefore, the survival of this species depends upon development and effective implementation of a management plan which eliminates all bycatch.

POTENTIAL IMPACT OF FAST FERRIES ON WHALE POPULATIONS
A SIMPLE MODEL WITH EXAMPLES FROM THE CANARY ISLANDS

N. Tregenza[1], N. Aguilar[2], M. Carrillo[3], I. Delgado[2], F. Díaz[2], A. Brito[2] and V. Martin[4]

[1]*Institute of Marine Studies, University of Plymouth, Plymouth, PL4 8AA, UK*
(E-mail: nick@chelonia.demon.co.uk)
[2]*Dept. of Animal Biology (Marine Sciences) Faculty of Biology, La Laguna University,*
Canary Islands, Spain (E-mail: naguilar@ull.es)
[3]*Tenerife Conservacion, C/Tabaiba 34, Club 2, Los Gigantes, Tenerife, Canary Islands, Spain*
[4]*Sociedad para el estudio de los Cetáceos en el Archipiélago Canario, Canary Islands, Spain*

INTRODUCTION Since the start of fast inter-island ferries in the Canary Islands, fatal ferry/cetacean collisions, and strandings of cetaceans with collision damage, have been observed (Aguilar, N. 1999). As part of a wider investigation of this problem, we describe a simple spatial model of collision risk and examine its relevance and implications for cetacean populations in the Canary Islands.

To model collision risk, we make five assumptions:

1. the body of the whale can be represented on the sea surface as a line of the same length as the whale.
2. the whale's orientation relative to the direction of travel of the ferry is random.
3. the whale does not tend to move into or out of the ferry's path, actively or passively.
4. ferries do not avoid whales.
5. the ferry transect has an overall density of whales that is the same as some overlapping area from which a survey has given the density estimate used.

To quantify the number of cetaceans at risk from a specific ferry, we require measurement of six parameters:

L	whale length, m
T	percentage of whale time at surface.
W	damaging width of the ferry in metres. This is taken as the waterline width.
P	whale density as animals per sq. km. in a survey area including the ferry transect.
D	length of ferry transect that is within survey area, km.
Y	transects by the ferries each year.

A vessel will sweep a strip of sea as wide as the vessel, putting at risk all whales whose centres lie within that strip. In addition, the vessel may strike whales whose centres lie outside the strip defined by the width of the vessel. If whales are randomly orientated, they will present to the approaching ferry an average 'target size' of 0.64 * whale's length. (0.64 being the mean value of cosines 0-90deg). Half of this may be added to each side of the strip defined by the width of the vessel to give a 'collision strip width'. From the length of the ferry transect, a 'collision area' for each ferry trip can then be derived - (W+ 0.64L)*D/1000 sq km. The mean number of whales in the collision area and at the surface will be T*P giving a total for annual collision risk of (W + 0.64L)*D*T*P*Y/10. This can be related to the size of the population mixing through the area of the ferry route, to derive an individual and population risk. A Windows 95 version of this calculator can be downloaded from www.chelonia.demon.co.uk.

Ferry service frequencies and routes were obtained from published timetables and descriptions of the boats provided by the operators. Large whales at risk were assessed by an observation program conducted by the Cetacean Sighting Net. This used a strip transect assessment of large whales identified simply as visible blows by the ferry crew over a period of 16 days. The crew estimated a strip width of 1.5 km.

Pilot whale densities were estimated from a study of the range and population size of resident short-finned pilot whales *(Globicephala macrorhynchus)* in the Canary Islands.

RESULTS **Fast ferries in the Canary Islands** Two vessel types are in use both using water jet propulsion systems (internal turbines).

Modelling Large whales in the Gran Canaria/Tenerife channel. These are mainly sperm whales (André, 1998) so we have used a value of 14 m for their length. The fraction of time spent at or near the surface used is 30%. (Watkins *et al.*, 1981, 1984; Whitehead *et al.*, 1992; Joyce *et al.*, 1990). Population density in the channel was assessed as 0.0028 (95% CI 0.0019 – 0.0037) large whales/sq. km (Aguilar, *pers. observ.*). The channel is also used by other migratory species, including the blue whale, *(Balaenoptera musculus)*, fin whale *(B. physalus)*, humpback whale *(Megaptera novaeangliae)*, and the endangered northern right whale *(Eubalaena glacialis)* (Aguilar, 1999).

The ferry transect is 67.6 km long and the calculation is performed for each hull independently. This allows for some whales to travel between the hulls without collision.

Using these parameters the model gives seven large whales at the surface each year that will have part of their body in the path of the hull of a fast ferry in the Gran Canaria/Tenerife channel.

The orientation of sperm whales relative to the direction of travel of the ferry is usually random, but in spring and autumn the ferry transect is perpendicular to a migratory pathway through this channel. This could increase the risk by about 50% at such times. During daylight, and especially when the sea is calm, ferries can avoid big whales, but we have seen sperm whales close to the bow without moving out of the ferry route.

Short-finned pilot whales in the Tenerife/La Gomera channel. Montero and Martín, in 1993, identified 500 individual short-finned pilot whales using a range of 180 sq. km including the Tenerife/La Gomera channel. Half of these animals were believed to reside almost exclusively within the range identified giving a density of 1.5 resident pilot whales/sq..km. The same authors report behavioural data indicating that the whales spend 34% of their time at the surface, with median submergence times in the day of only 15 seconds. At night they make longer dives. We have used a length of 4 m for these whales.

Using these parameters, the model gives, for both ferries combined, 469 resident short-finned pilot whales at risk of being struck by a fast ferry in the Tenerife/La Gomera channel. Using the estimated population size, each resident pilot whale is at risk of 1.7 strikes each year.

With this species also, the whale's orientation relative to the direction of travel of the ferry is not random, as pilot whales generally travel in a line parallel to the coast.

DISCUSSION The incidence of injury will differ from the risk calculated in relation to the validity of the assumptions on which it is based.

Assumptions :

1 Using a static linear model of a whale could overestimate risks if the effect of water flow around the hull affects injury risks, either by displacing the animal or drawing it towards water intakes. In the case of hydrofoil borne craft (not operating here), these effects seem less likely.

2 Ferries crossing migratory pathways between islands could have up to 56% higher risks; whales orientating away from noisy ferries would have lower risks.

3 Avoidance reactions by whales must be the key element in determining collision risk, but little data are available on this at present..

4 Species with a highly visible blow might often be avoided by ferries in daylight, but not in darkness.

5 Density estimates need to be used with respect to their confidence ranges in the relevant location.

A significant threat to populations is considered to be presented by anthropogenic mortality estimates of only 1 or 2% per annum. The model of how often a whale will lie in the path of a ferry gives surprisingly high numbers, especially for short-finned pilot whales. If only 1% of instances where pilot whales lie in the path of a ferry were to prove fatal, the 2% mortality level for the population would have been exceeded. The model indicates only those encounters in which a static whale would have been struck or violently displaced by the passing hull. A much larger number of whales must take appropriate avoiding action to reduce the potential strike rate because no behavioural response can be precisely confined to these most critical situations. Such avoiding behaviour must include females and calves, and whales involved in a range of behaviours that may have high priority to the whale, if it is to be sufficiently consistent to achieve a collision rate low enough to be insignificant.

CONCLUSIONS The model used here indicates that unless avoiding action by short-finned pilot whales is very consistent and effective, the population in the Canaries is at risk of extinction from collisions with fast ferries.

There is an urgent need for rigorous objective measurement of collision rates to be made in parallel with local density and behavioural measurement.

REFERENCES

Aguilar, N. and Brito, A. 1999. The Canary Islands Cetacean Sighting Net, II. Pp. 149-152. In: *European Research on Cetaceans -13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

André, M. 1998. *Cachalotes en Canarias*. Thésis doctoral de la Universidad de Las Palmas de Gran Canaria.

Martín, V. and Montero, R. 1993. *Estudio del impacto que provocan las embarcaciones en la población de calderones shortfines (Globicephala macrorhynchus) residentes en aguas del suroeste de la isla de Tenerife*. De.: Consejería de Transportes y Pesca del Gobierno de Canarias.

Joyce, G., Sigurjönsson, J., and Vikingsson, G. 1990. Radio tracking a minke whale (*Balaenoptera acutorostrata*) in Icelandic waters for the examination of dive-time patterns.

Watkins, W. A., Moore, K. E., Wartzok, D., and Johnson, J. H. 1981. Radio track of finback (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales in Prince William Sound, Alaska. *Deep-Sea Research*, 28A (6): 577-588.

Watkins, W. A., Moore, K. E., Sigurjönson, J. Wartzok, D. and Notarbartolo di Sciara, G. 1984. Fin whale (*Balaenoptera physalus*) tracked by radio in the Irminger Sea. *Rit Fiskideildar*, 8(1): 1-14.

Whitehead, H., Brennan, S. and Grover, D. 1992. Distribution and behaviour of male sperm whales on the Scotian Shelf, Canada. *Can. J. Zool.*, 70: 912-918.

Table 1 Fast ferry services in the Canary Islands

Start date	Vessel	Hull width	Speed Nm/h	Route	Trips / year
4/99	Catamarans	7m x 2	40	Tenerife / Gran Canaria	3964
6/99	Monohull	14.4	30	La Gomera / Tenerife	2642
Early 2000	Catamaran	7m x 2	40	La Gomera / Tenerife	1982

GROWTH OF WHALE WATCHING IN SPAIN. THE SUCCESS OF THE PLATFORMS IN SOUTH MAINLAND. NEW RULES

E. Urquiola[1] and R. de Stephanis[2]

[1]*SECAC, Society for the Study of the Cetaceans in the Canary Archipelago, Apartado de Correos 404;-10198, Arrecife de Lanzarote, Canarias, Spain (E-mail: Urquiola@cetaceos.com)*
[2]*ESPARTE, Andalucian Society for the Study of the Cetaceans, Apartado de Correos 792, Málaga 29080, Spain*

INTRODUCTION Whale watching is an expanding tourist industry world-wide and Spain is fully aware of this situation. It began in 1991 in the Canary Islands with records of around 40,000 whale-watching tourists in the SW of Tenerife. In 1998, the number reached a million whale visitors in that specific area but since then, the number of boats seems to have stabilised due to the lack of berths in the marinas in the SW of Tenerife. Nevertheless, the activity is still evolving with a lot of changes as the types of boats are turning towards large catamarans as the most effective whale watching vessels from a commercial point of view, because of the specific characteristics of the Canary Islands waters. The activity has increased in other islands such as Gran Canaria with five new whale-watching boats, one more in Lanzarote, and in La Gomera it is expected to grow from the four existing ones.

But the most spectacular growth in the activity in Spain has occurred in the South mainland, specifically in the Andalucian community where, in two years, the number of boats has increased from 6 to 28 and in the next season another 9 are expected. If no effective actions regarding this issue are taken in time, the problems of conservation of cetaceans in the Straits of Gibraltar will become significant.

These problems have made the national environmental ministry aware of the need to elaborate the regulation of whale-watching activities in Spain, a basic rule that covers all the state, and is now ongoing. Still, now the Canaries Government has its own regulation concerning only the Archipelago waters, and since the problem is now becoming a national concern, this basic rule has became not only necessary but urgent.

METHODOLOGY We analysed the development of the activity in Spain, thanks to the data gathered from:

In the Canaries: the Environmental Department of the Canary Government, in order to authorise and control the whale watching activities. Data are taken from the control boat "Calderón", and the parameters registered have included date, time, and position of the boats, and date, time, and position of the species, number of individuals, behaviour and route of the cetaceans.

In South Andalucia: The data are taken from the vessels of Firmm (Foundation for information and research on marine mammals), the "Rajorca", and the "Firmm". The data taken follow the methodologies of the SEC (Spanish Cetacean Society) (Project Protocols Information document, SEC, 1999), and the parameters registered have included date, time, and position of the boats, and date, time and position of species, the number of individuals, behaviour and route of the cetaceans.

In all these cases, data were also collected by visiting directly the whale-watching boats, through questionnaires, in the marinas, enterprises, directly from the tourists, crews, etc.

For a better analysis and due to its large extension (800 km of coast), the area of Andalucia has been divided into three sub-areas (Straits of Gibraltar (A.I), Bahia de Algeciras A(A. II), and the Costa del Sol (A. III)), following the criteria below (See MAP):
- Cetacean availability.
- Meteorological conditions.
- Environmental education.

ANALYSIS OF THE SITUATION- RESULTS

Cetacean sightings (Table I) Taking into account the data collected by the patrol boat in the Canaries, the species which are most frequently seen are the short-finned pilot whales (*Globicephala macrorhynchus*), with an average of 7.4 sightings per effort day (1996 to 1998) and the bottlenose dolphin (*Tursiops truncatus*), with a 0.4 effort day average of sightings, both being present all the year round. However, a total of 13 species were recorded from the control boat "Calderón" between 1996 and 1999 (including various baleen whale species, sperm whales, killer whales, common, spotted, rough-toothed, and Risso´s dolphins). Another seven species were registered in the channel by several investigators, including the endangered right whale and blue whale. In Tarifa, as an example of the species sighted in the south mainland, the data collected from the Firmm España boat show the presence of seven species. Between 30th October 1998 and October 1999, 271 trips of a duration of 2 hr 06 min average (SD=32 min) were made, with a total of 498 sightings. 0.61 long-finned pilot whales were sighted per trip, as well as 0.38 bottlenose dolphins. Common dolphins and striped dolphins, as well as sperm whales, killer whales, and fin whales were also sighted in the area. A total of 1.83 sightings were made per trip. Another four species have been seen in Andalucian waters even though they have not been registered from the Rajorca and Firmm, as is the case of Risso's dolphins *Grampus griseus*, and several *Ziphius*.

Marinas, boats and enterprises (Figs. 1 and 2) In Tenerife, there are four marinas located within 40 km along the coast; they have 51 whale-watching boats belonging to 27 enterprises with capacity for 2,423 passengers.

In Andalucia´s marinas, boats and their capacity are shown in Fig. 3. In 1998, there were only six boats in Andalucia belonging to three enterprises; these data have obviously increased. At the end of 1999, the number was around 28 boats, belonging to 18 enterprises, and the perspective for the summer 2000 is that it could reach 37 boats (27 enterprises). This means that people have recognised the high potential that this activity has in an area where the factors for the success of whale-watching are to be found. (or definitively exist). The comparative development of the number of whale-watching boats is shown in Figs. 1 and 2.

Currently, the types of boats working in Andalucia are similar to those seen in the beginning in the Canaries. Boats used for tourist charters re-convert to whale-watching boats, but the growing knowledge of what is happening in other areas can influence the change to more specific whale-watching boats; nevertheless, we must not forget that the climatic and oceanographic characteristics are not the same in the Straits of Gibraltar (A.I) as in the Canaries, and the former ones must be adapted to higher winds and rougher waters. For the rest of the community (A.I, A.II), the oceanographic conditions suggest a promising future.

The industry - Factors and Data

1) Whale-watching in the Canaries is carried out all year round with small fluctuations in intensity, an average of 86% of the days are suitable for the activity. In Andalucia, the activity is now developed between June and October. However, there is the possibility of expanding the activity all year round. Currently, some boats have begun the activity in winter in the area I (Gibraltar Straits).
2) In both cases, the Canary Islands and Andalucia, the whale-watching areas are close to very important tourist destinations (more than four million per year in the Canaries; 14 million in Andalucia), and the activity is concentrated in areas of easy access for most vessels.
3) The presence of resident communities of cetaceans close to the marinas is the principal factor of success of all Spanish areas: short-finned pilot whales and bottlenose dolphins in the Canaries and long-finned pilot whales, striped and common dolphins in Andalucia. We must not forget that there are many other migratory species easily seen in both areas, such as sperm whales, several *Balaenoptera* species, common and striped dolphins in the Canaries; also spotted dolphins, and killer whales in the Straits of Gibraltar.
4) The frequency of cetacean sightings is high in both cases: 95% in the Canaries and 87% in the Straits of Gibraltar, which means that the objective of the visitors is almost guaranteed.

Conservation Whale-watching could be a threat for cetacean conservation if it is not developed in the correct way, and also because of possibly exceeding the capacity of the areas (mainly in the Canaries and Andalucia). Other potential conservation threats in the area include heavy traffic from sport vessels, regular vessel routes, the fast ferries, the alteration of the coastline through the construction of artificial beaches and housing estates, and marine pollution from the various outfalls.

In the Straits of Gibraltar, for example, the number of merchant ships crossing the area is greater than 80,000 per year, so that the whale-watching activity becomes saturated. The fisheries industry is also having an effect, and there are delicate geo-political problems due to the confluence of three sovereign states in the same area.

The three main objectives to pursue would be:

1) The development of actions geared towards the reduction of the threatening factors.
2) Creation of a Programme for the Management of Natural Resources, in the form of establishing marine protected areas or similar schemes with rules such as the above-mentioned whale-watching decree, mainly in the most sensitive areas such as the channel located between the islands of Tenerife and La Gomera or the Gibraltar Straits.
3) Analysis and assessment of the importance, fragility, distribution, etc. of the resident cetacean populations, focus on whale-watching and especially upon those cetaceans which are not resident but which are unusual such as the genus *Ziphius*.

The new national rule of whale-watching from the environmental ministry is expected to be approved this year and will include a Code of Conduct based on the Precautionary Principle (Leatherwood Principle) for all vessels, leaving to the autonomies the management of the control of the activities.

CONCLUSIONS Whale-watching in Spain is an unstoppable tourist activity and means the use of a natural resource which can have socio-economic benefits for the population that must be balanced with the maintenance of the cetacean populations and their habitat in the most favourable state of conservation, since the balance is fragile and unstable. The contribution to education and scientific knowledge should also not be forgotten.

Whale-watching rules are going to be in place soon for all Spain; applying them in an efficient way is essential to maintain the mentioned equilibrium.

It is obvious that a global approach is required in order to address the problems that surround this activity. Managers, researchers, and operators need to work as a team to find solutions that will ensure that whale-watching will not increase the survival risk of resident populations or of their environment and, therefore, does not alter the basic population parameters nor the usual pattern of use of such habitat. On the other hand, it should be possible to develop and maintain activities for the observation of cetaceans, which are both viable and responsible.

It is necessary to make an approximate estimate of the maximum number of vessels that could be used for the activity without causing a significant impact.

It is also important to diversify into different areas and towards other type of activities that are less intense and more educational, as well as maintaining an effort to have an efficient control, and promote educational and research tasks in the medium and long-term.

From a scientific viewpoint, it is essential to know the biology of the species observed, to understand the characteristics of the operations and of the vessels, and to have an estimate, at least on a preliminary basis, of what the sustainable capacity of this industry could be. Scientific monitoring of cetaceans and their situation is basic.

ACKNOWLEDGEMENTS We thank Vidal Martín, Ricardo Sagarminaga and Ana Cañadas, Jose Antonio Fayos and María Ovando; from the Canaries: the "Calderón" crew (Juan Ramón Padilla and Manuel Louro), the environmental agencies, the environmental Viceconsejeria and Gesplan S.A; and from South mainland: Eva Perez and Luis Sotomayor, Thanks go also to all the volunteers and crew of Firmm España, specially to Katharina Heyer (president) and Manuel Fernandez-Casado (main person responsible for the scientific area), and finally also to Neus Perez Gimeno.

REFERENCES & BIBLIOGRAPHY

B.O.C.(Canarias Oficial Bulletin) n° de 20 de noviembre de 1995. *Decreto 320/1995 por el que se regula la observación de cetáceos en Canarias.*

Heimlich-Boran, J. 1993. *Social organisation of the short finned pilot-whale, with special reference to the comparative social ecology of delphinids.* Ph. D. Thesis. University of Cambridge. 235pp.

Heimlich-Boran, S and Heimlich-Boran, J. 1990. Occurrence and group structure of short-finned pilot whales Globicephala macrorhynchus off the western coast of Tenerife, Canary Islands. Pp. 102-104. In: *European Research on Cetacean - 4.* Proc. 4th Ann. Conf. ECS, Palma de Mallorca, España 2-4 March, 1990.(Eds. P. G. H. Evans, A. Aguilar and C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

IFAW, Tethys Research Institute and Europe Conservation. 1995. *Scientific aspects of managing whale watching. Montecastelo workshop report, 30 March - 4 April de 1995.* Internatonal Fund for Animal Welfare, Crowborough, UK. 40pp.

Martín, V., Montero, R., and Heimlich-Boran, J. 1992. Preliminary observations of the cetacean of the Canary Islands. .Pp. 61-65. In: *European Research on Cetacean - 6.* Proc. 6th Ann. Conf. ECS, San Remo, Italy 20-22 Feb, 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Martín, V. and Montero R. 1993. *Estudio de impacto que provocan las embarcaciones en la población de calderones residentes en las aguas del SO de Tenerife.* Informe inédito

Martín, V. 1996. Diurnal activity patterns and behaviour in the short-finned pilot whale (*Globicephala macrorhynchus*) of the SW coast Tenerife, Canary Islands. In: *European Research on Cetaceans - 10*: Proc. 10th Ann. Conf. ECS, Lisbon, Portugal, 11-13 Mar, 1996. (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

Montero, R. and Arechavaleta, M. 1997. *La Observación de cetáceos de Canarias como actividad turística en Canarias. 1996-1997. Descripción y diagnóstico" e "Impacto de las embarcaciones sobre la población de calderón tropical.* Informes inéditos

SEC. 1999, *Recopilación, Análisis, Valoración y Elaboración de Protocolos sobre las Labores de Obsaervacion, Asistencia a Varamientos y Recuperación de Mamíferos y Tortugas Marinas de las Aguas Españolas..* Ministerio de Medio Ambiente Español. Secretaria General de Medio Ambiente.

Urquiola, E., Sevilla, J., and Iani, V. 1998. The evolution of whale watching in the Canaries after the regulation of 1995: a year of study. In: *European Research on Cetacean - 11.* Proc. 11th Ann. Conf. ECS, Straalsund.Germany March 1997.(Eds. P. G. H. Evans). European Cetacean Society

Urquiola, E., Martin, V. and Iani, V. 1999. Whale watching, pilot whales and bottlenose dolphins in the Canary Islands: a sustainable activity? In: *European Research on Cetaceans -13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Urquiola, E. 1999. Whales and dolphins from Tenerife islands. In: *Teneride y el Mar.* Ed. Cabildo de Tenerife.

Vonk, R. and Martín, V. 1988. First list of odontocetes from the Canary Islands. Second Anual Conference of the European Cetacean Society. Setubal, Portugal. 31-36. Pp 31-36. In: *European Research on Cetaceans -2.* Proc. 2nd Ann. Conf. ECS, Setubal, Portugal 1988. (Ed. P. G. H. Evans). European Cetacean Society, Lisboa, Portugal.

Table 1. Cetaceans observed during whale-watching activities

SPECIES OBSERVED	**In Canary Islands**	**Ex: sightings in one ye in SW of Tenerife (*)**	**In Andalucia**	**Ex: sightings in Tarifa S f Andalucia (**)**
YEAR		1997		1999
Globicephala macrorrhynchus	X	2155		
Tursiops truncatus	X	79	X	104
Delphinus delphis	X	43	X	90
Stenella frontalis	X	21		
Physeter macrocephalus	X	3	X	29
Steno bredanensis	X	2		
Pseudorca crassidens	X	1		
Balaenoptera edeni	X	3		
Balaenoptera borealis	X	8		
Balaenoptera sp.	X	2	X	
Stenella coeruleoalba	X	3	X	95
Grampus griseus	X	1	X	
Ziphius cavirostris	X	1	X	
Orcinus orca	X	2	X	6
Globicephala melas			X	167
Phocoena phocoena			X	
Balaenoptera physalus			X	5
Kogia breviceps			X	
Unknown	X		X	2

* Data taken from the control boat "Calderon" in 1997, we take that year to be the one with more completed effort (263 effort days). The average of sightings by effort-days in pilot whales in SW Tenerife between the years 1996 to 1998 has been 7.5 and 0.5 in bottlenose dolphins.

** Data collected from "Rajorca" and the "firmm" in the firmm España campaign, in the period 15 April-31 October 1999. (In total 569 hours were spent at sea.)

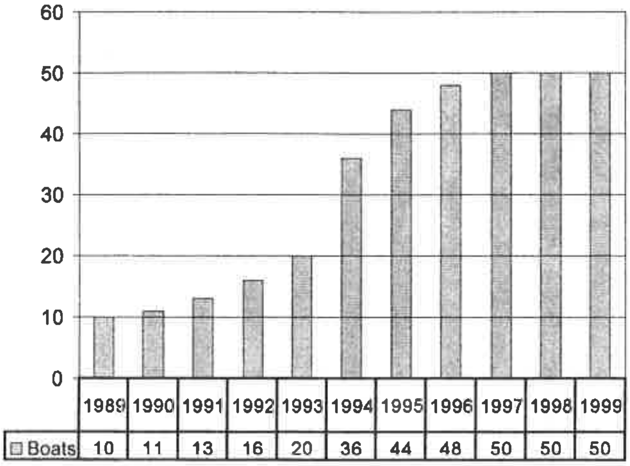


Fig. 1.. N° of Canary Islands boats

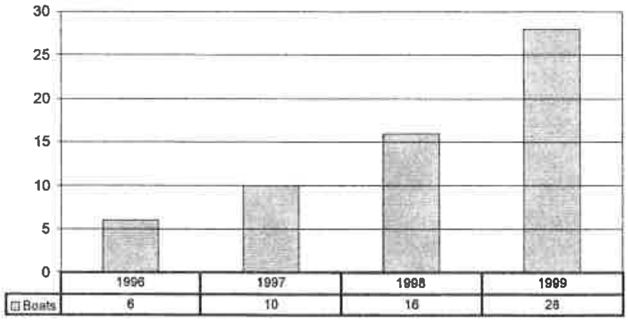


Fig. 2. N° of Andalucia boats

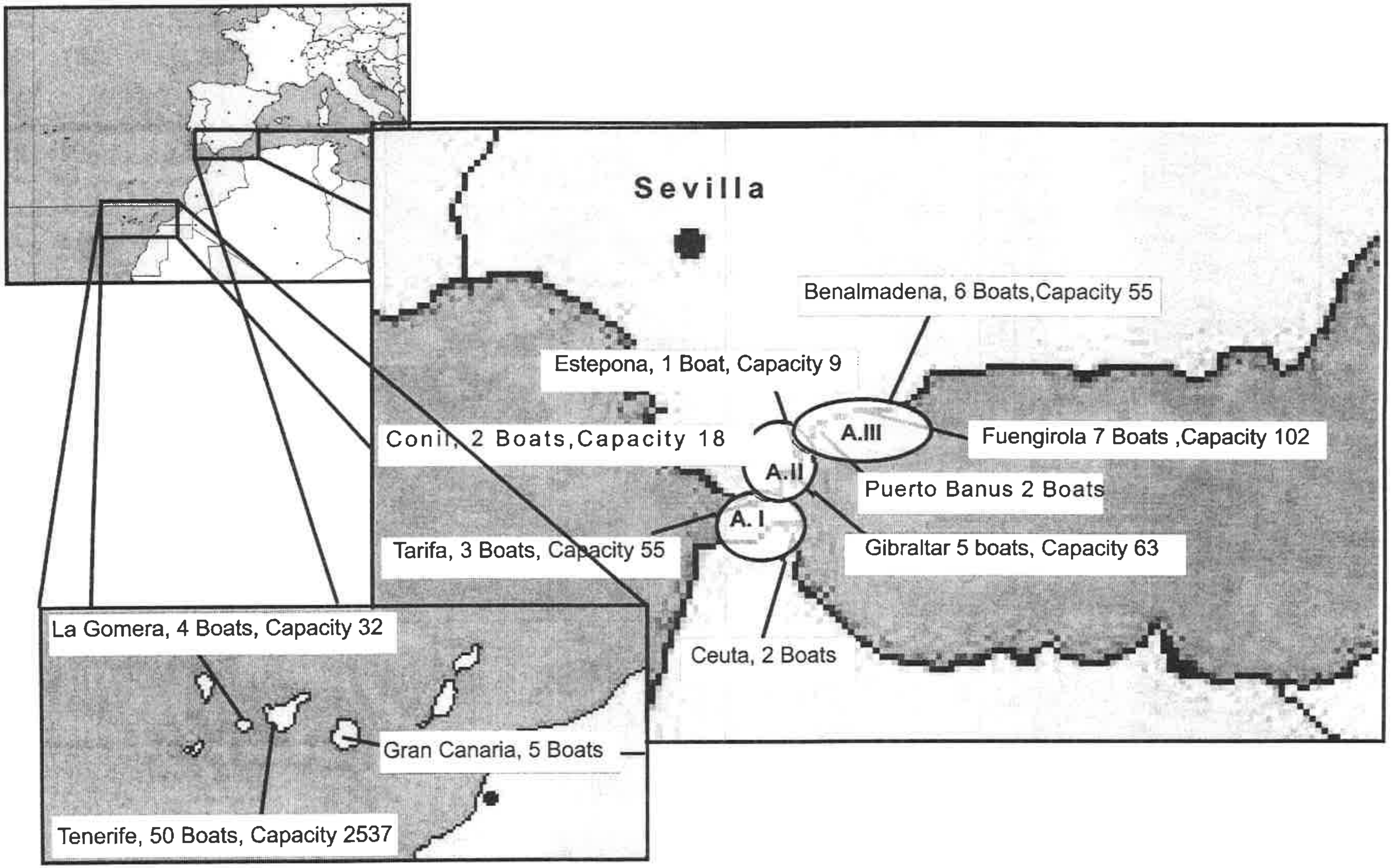

Sevilla
Benalmadena, 6 Boats,Capacity 55
Estepona, 1 Boat, Capacity 9
Conil, 2 Boats,Capacity 18
A.III
Fuengirola 7 Boats ,Capacity 102
A.II
Puerto Banus 2 Boats
A. I
Tarifa, 3 Boats, Capacity 55
Gibraltar 5 boats, Capacity 63
Ceuta, 2 Boats
La Gomera, 4 Boats, Capacity 32
Gran Canaria, 5 Boats
Tenerife, 50 Boats, Capacity 2537

Figure 3. Map

COMPILATION OF 20 YEARS (1980-1999) OF OCCASIONAL CETACEAN SIGHTINGS IN THE BAY OF BISCAY

O. Van Canneyt[1], F. Caurant[2], E. Poncelet[1], A. Collet[1] and V. Ridoux[2]

[1]*Centre de Recherche sur les Mammifères Marins, Institut de la Mer et du Littoral, Port des Minimes, 17000 La Rochelle, France (E-mail: crmm@univ-lr.fr)*
[2]*Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, Institut de la Mer et du Littoral, Port des Minimes, 17000 La Rochelle, France*

The Bay of Biscay has a very rich cetacean fauna. Nevertheless, because of its very broad continental shelf in the north, and the frequent bad sea conditions, scientific surveys cannot be conducted on a regular year-round basis. Therefore, occasional sightings reported by the public and marine authorities are important to determine the distribution of cetaceans in the Bay of Biscay. Data have been collected for the past 20 years and represent more than 1,300 records. A total of 13 species have been recorded (Table 1). French flying customs provide more than 50% of the total number of sightings reported.

We defined two observer categories, the "French customs" and the "other observers" (yachtsmen and fishermen), and compared their sighting distributions for the entire study period. A chi-square test showed that they were significantly different ($\chi\_=73.38$, df=1, $p<0.001$). Further, we assumed that the spatio-temporal observation effort of French customs (observations made from planes) was more homogeneous than for other observers (observations at sea). Thus, we have only used sightings data from the French customs to study the spatio-temporal distribution of cetaceans.

Two categories of cetaceans were defined: small cetaceans (delphinids and porpoises) and large cetaceans (balaenopterids, the sperm whale and the northern bottlenose whale). Variation in the annual frequency of sightings was significantly different between the two categories ($\chi^2=63.22$, df=19, $p<0.001$) (Fig. 1).

Large cetaceans Fig. 1 shows an increase in the number of sightings since 1993 that may suggest an increase in the abundance of large cetaceans in the area. The monthly distribution of sightings shows most large cetacean sightings occurred between June and September (Fig. 2). The majority of sightings (ca. 91%) occurred beyond the continental shelf (Fig. 4). The two aggregations of sightings observed in Fig. 4 may be a reflection of observer effort and/or a heterogeneity in the spatial distribution of large cetaceans.

Small cetaceans There was large inter-annual variation in small cetacean sightings (Fig. 1), and most animals were sighted between June and September (Fig. 3). The spatial distribution of small cetaceans was more scattered with a higher density on the continental shelf (Fig. 5).

These results show the spatio-temporal heterogeneity in the distribution of cetaceans in the Bay of Biscay. To understand the role of marine mammals in the ecosystems, it is very important to relate this heterogeneity to environmental factors such as hydrology and prey availability. The use of GIS software will be essential for cetacean research and management in the Bay of Biscay.

ACKNOWLEDGEMENTS We gratefully acknowledge Dr. Raymond Duguy for the establishment and management of the sighting network from 1980 to 1992, the French Customs (Aeromaritime Surveillance Groups of Mérignac and Lorient), and all yachtsmen, fishermen and marine authorities for having reported their observations. We also thank Emilie Dupaigne, Michel Hayek, Olivier Herlory and Axelle Caillet for data input, and Damian C. Lidgard for improving the English of the manuscript.

Table 1 Species and number of individuals recorded

Small cetaceans	N sight.	Large Cetaceans	N sight.
Delphinidae undet.	252	Balaenopteridae undet.	17
Delphinus delphis	460	*Balaenoptera physalus*	158
Stenella coeruleoalba	24	*Balaenoptera acutorostrata*	10
Tursiops truncatus	64	*Megaptera novaeangliae*	8
Globicephala melas	235	*Balaenoptera musculus*	2
Grampus griseus	7	*Physeter macrocephalus*	36
Orcinus orca	14	*Hyperoodon ampullatus*	1
Phocoena phocoena	34		
Total	**1090**	**Total**	**232**

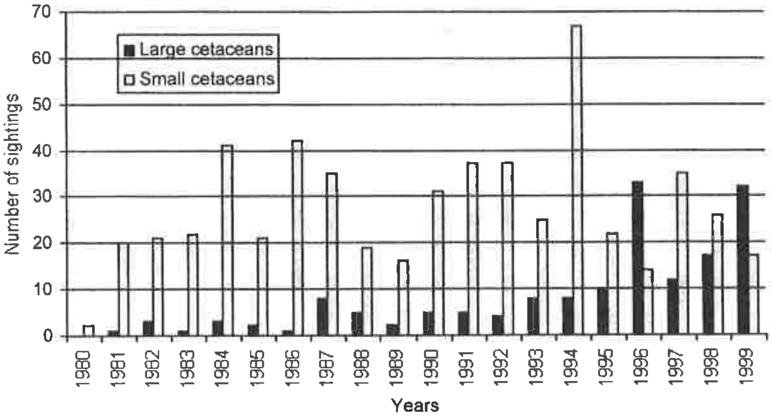


Fig. 1. Annual distribution of French customs' sightings

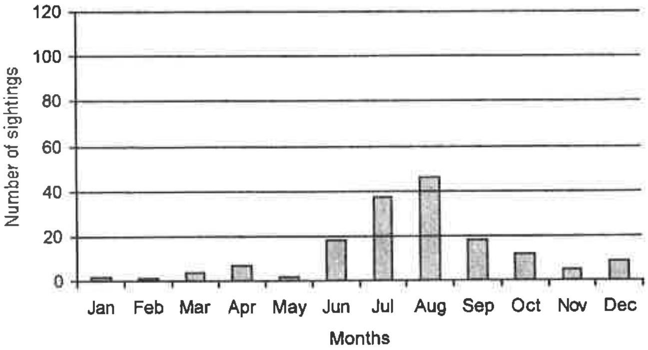


Fig. 2. Monthly distribution of large cetacean sightings by French customs

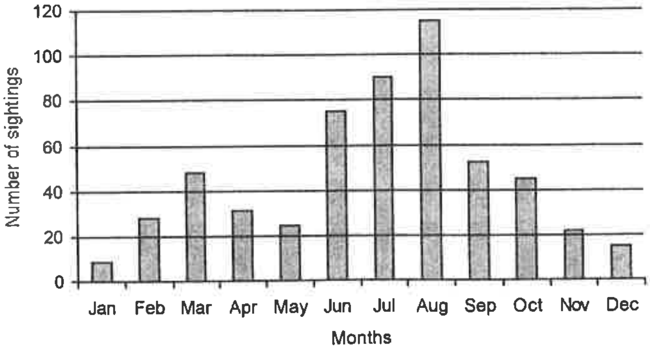


Fig. 3. Monthly distribution of small cetacean sightings by French customs

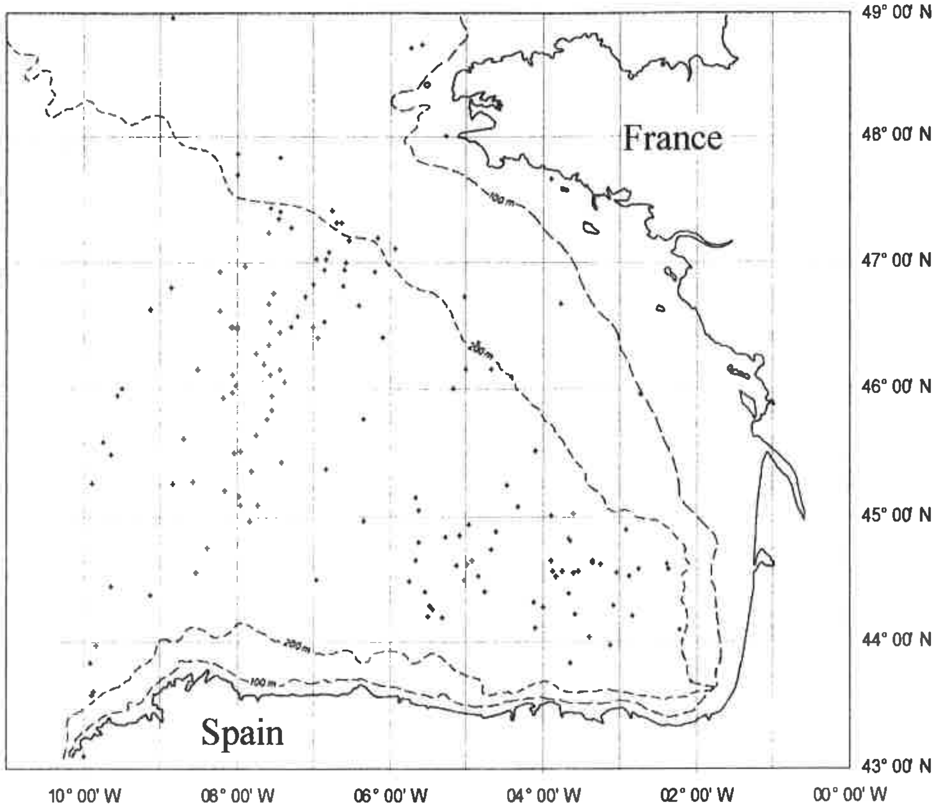


Fig. 4. Distribution of large cetacean sightings reported by the French customs from 1980 to 1999

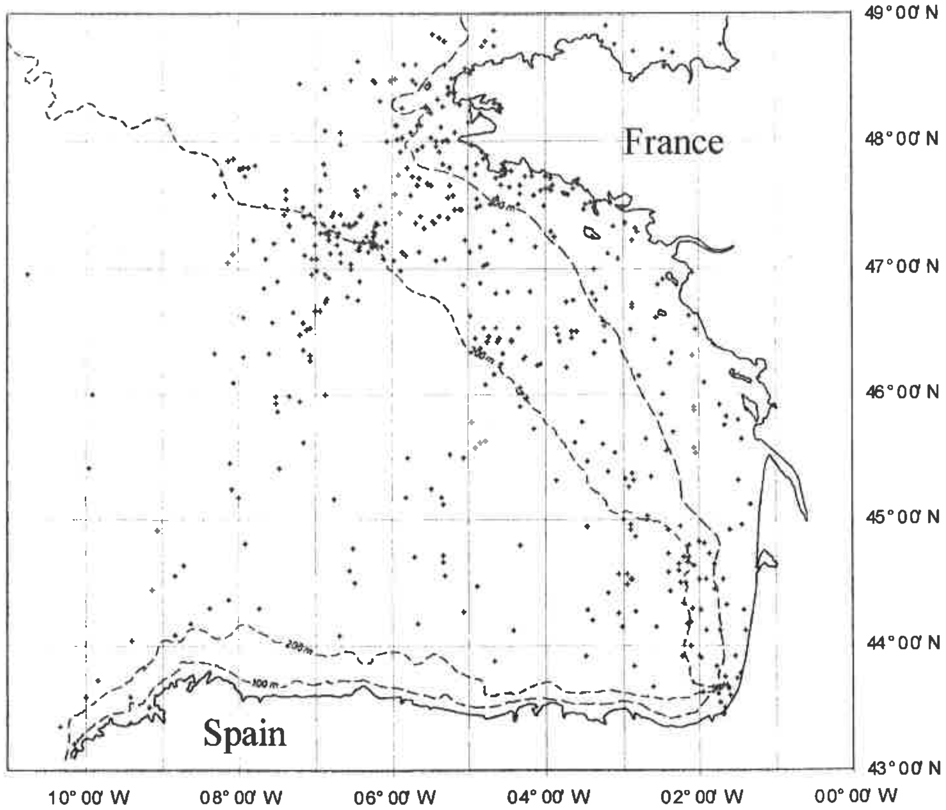


Fig. 5. Distribution of small cetacean sightings reported by the French customs from 1980 to 1999

STRANDING OF A NEW ZEALAND KILLER WHALE (*ORCINUS ORCA*) AND INFORMATION ON POST-STRANDING SIGHTINGS, INCLUDING A PROBABLE BOAT STRIKE OF THE INDIVIDUAL

Ingrid N. Visser[1] and Dagmar Fertl[2]

[1]*The Orca Project, P.O. Box 1233, Whangarei, New Zealand (e-mail: orca@iconz.co.nz)*
[2]*Minerals Management Service, U.S. Department of the Interior, 1201 Elmwood Park Blvd., New Orleans, LA 70123, USA*

A long-term study of orca (*Orcinus orca*) occurring in New Zealand waters has been on-going since December 1992. To date, 117 individuals have been photographically identified using distinctive marks on their dorsal fins, saddle-patches, and eye-patches.

On 14 June 1997, a killer whale was seen in the surf on a beach about two miles to the south of the Mangawhai Harbour, North Island (36° 05.0' S, 174° 36.2' E). The animal appeared to be uninjured externally, except for a few minor wounds. A small sample of loose skin from one of the cuts was collected for genetic analysis. Dorsal fin, saddle- and eye-patch photographs were taken, and body measurements made. On 15 June at 06:00 hrs, preparation began to shift the animal back to the water. Standard whale stranding procedures in New Zealand do not cater for rehabilitation in captivity. Refloating was achieved using specifically designed 'rescue pontoons,' which consisted of a PVC/nylon mat with attachment rings and two inflatable pontoons. At 10:10 hrs, the animal was moved out through the surf after having remained on the beach for an estimated 21 hours. Upon return to the water, the whale began vocalising, which increased during release. Once out in deeper water, the pontoons were deflated and removed. The whale headed in a northerly direction at about three knots.

Photographs of the stranded animal were matched to individual NZ101. On the basis of body measurements made and compared to other killer whale studies (e.g., Bigg, 1982), NZ101 was determined to be a sub-adult. Genetic analyses revealed that NZ101 was a male.

Prior to the stranding, NZ101 had been observed as early as 1996 on six occasions in the north of the North Island; post-stranding, he has since been re-sighted 12 times (as recently as 15 October 1999). During each sighting, NZ101 was observed with at least six other killer whales. NZ6 (adult male) and NZ63 (undetermined age and sex class) were sighted with him on 13 occasions, and NZ4 (adult female) on 12 occasions.

PROBABLE BOAT STRIKE AND WOUND HEALING On 16 October 1998, NZ101's dorsal fin was split from the top to the base of the fin. The wound was red and bleeding, and parallel lines could be seen in front of and to the rear of the dorsal fin. Twenty-seven days later, when he was re-sighted, the dorsal fin had deteriorated, with the leading edge of the cut expanded and showing exuberant granulation tissue, which could be expected from the healing of such a severe or major wound. NZ101 appeared 'sluggish' and was trailing behind the other killer whales present.

On 4 May, 13 May, 4 July and 15 October 1999, NZ101 was again re-sighted. By 4 July (261 days after the initial sighting of the wound), the posterior portion of the dorsal fin had collapsed to the animal's left side and, although collapsed, appeared fairly rigid. The open edges of the wound on the fin had appeared to heal over and were dark in colour like the rest of the skin on the dorsal fin. On 15 October (365 days after the initial sighting of the wound), the fin still remained collapsed and rigid. Behaviour of the whale was more consistent with behaviour prior to the boat strike, in that he was observed to forage benthically for sting rays.

CONCLUDING THOUGHTS It is unknown why this animal stranded, but it is possible that NZ101 stranded while foraging for sting rays in shallow water. The stranding location is adjacent to an area already reported as used extensively for this feeding technique (Visser, 1999). It is also impossible to know if the boat strike was related to the stranding, but this seems unlikely given the time between the incidents.

There is considerable debate over the value and success of refloating stranded individuals. Very few cases exist where systematic efforts have been made to conduct follow-up monitoring of released cetaceans. Successful reintroduction could be assessed on survival and re-incorporation into social groups (Wells, 1998). NZ101 has survived for at least 28 months since his stranding, and has been re-sighted with conspecifics with which he associated prior to the stranding. The possible long-term effects of the boat strike on NZ101's survival chances remain to be seen.

ACKNOWLEDGEMENTS Robin Baird confirmed identification of the animal, pre- and post-stranding, and provided constructive comments on the manuscript. Rus Hoelzel kindly confirmed NZ101's sex from the skin sample. Sam Ridgway assessed photographs of the wound. Prof. J. Craig provided logistical support. Thank you to those who provided information on re-sightings of 'Ben' (NZ101) and to C. Larsen for help in monitoring calls. Thanks to the people of Mangawhai Heads community, Department of Conservation, Project Jonah and the local Iwi who helped rescue 'Ben' including H. Parata, J. Ritchie, J. Berghan, K. Algie, S. Whitehouse, F. Crawford, T. Hardie, G. Gough, B. Woolley, D. & L. Partington, M. Forbes, M. Hollows, D. Williams, T. O'Callaghan, and D. Whitehead. G. Webber provided helicopter assistance for the first author. Support was also received from the Whale and Dolphin Conservation Society, Fleetlease, Yamaha, New Zealand Lotteries Grant Board, Safety at Sea, Dive Log, Naiad, The Interislander, Kaptain Kiwi 2000, Cetacean Society International, Ikelite, Project Jonah, Lion Foundation, PADI NZ and the Ministry for the Environment. Private grants from F. & C. Visser, O. Clemens, C. McLachlan, and W. Inman have supported this research. A permit to conduct this research was issued by the New Zealand Department of Conservation.

REFERENCES

Bigg, M. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. *Reports of the International Whaling Commission*, 32: 655-666.

Visser, I. N. 1999. Benthic foraging on sting rays by killer whales (*Orcinus orca*) in New Zealand waters. *Marine Mammal Science*, 15: 220-227.

Wells, R. S., Bassos-Hall, K., and Norris, K. S.. 1998. Experimental return to the wild of two bottlenose dolphins. *Marine Mammal Science*, 14: 51-71.

USING FIXED ROUTE PLATFORMS OF OPPORTUNITY TO MONITOR MARINE PROTECTED AREAS

A. D. Williams, T. M. Brereton, and R. Williams

(1,2,3) Biscay Dolphin Research Programme, 6 Manor Way, Lee-on-Solent, Hampshire, PO13 9JH, England, UK

Since August 1995, the Biscay Dolphin Research Programme has travelled aboard the P&O Portsmouth cruise-ferry, *MV Pride of Bilbao*, undertaking a cetacean research programme. The vessel travels a fixed route and speed, twice a week, from Portsmouth in southern England to Bilbao in northern Spain. Each month, a team of three experienced observers travel on the vessel and carry out cetacean surveillance work using a line transect sampling method. Data are recorded during systematic watches, which adopt standard recording methodology developed by the UK Mammal Society Cetacean Group (now Sea Watch Foundation) for effort-based cetacean recording (by volunteers) on platforms of opportunity.

Between August 1995 and May 1999, 44 monthly trips were undertaken, with 21,000 km of trackline searched in good - fair weather (sea state four or less and good visibility), and approximately 33,600 km overall. Survey effort has produced over 1,000 sightings of 10,000 animals, from 20 species located in 16 ICES grid cells of the Bay of Biscay.

This unique dataset provides much new information on the distribution, relative abundance, behaviour, population structure, breeding and habitat selection of cetaceans in the Bay of Biscay. Scientific data of this type are vitally important: (1) to ensure that effective and rational conservation and resource exploitation policies are implemented in the Bay of Biscay; and (2) in any future monitoring of Biscay as a designated cetacean sanctuary or marine protected area. Where marine protected areas occur in offshore areas, it is prohibitively expensive to undertake regular seasonal surveys.

Using relative abundance and distribution data allows for regular checks to be kept and for the early identification of potential problems within an area. Within Europe, a number of these proposed areas fall within the routes of fixed route platforms of opportunity. Without effective and regular monitoring, potentially important trends in cetacean distribution and abundance may be overlooked.

ECOLOGY

SOCIAL ECOLOGY OF RISSO'S DOLPHINS IN THE LIGURIAN SEA: PRELIMINARY RESULTS

S. Airoldi[1], A. Azzellino[1], V. Fadda[1], S. Gaspari[2], B. Nani[1], M. Zanardelli[1],
G. Notarbartolo di Sciara[3] and M. Mariani[4]

[1]*Tethys Research Institute, viale G.B. Gadio 2, I-20121 Milano, Italy (E-mail: sabina.airoldi@iol.it)*
[2]*Department of Biological Sciences, University of Durham, Durham, DH1 3LE, UK*
[3]*ICRAM, via di Casalotti 300, I-00166 Roma, Italy*
[4]*Acquario e Civica Stazione Idrobiologica, viale G.B. Gadio 2, I-20121 Milano, Italy*

INTRODUCTION Data on distribution and social structure of Risso's dolphin (*Grampus griseus*) were collected from 1990 to 1998 in the Corso-Ligurian basin, within the recently-established Cetacean Sanctuary.

MATERIALS AND METHODS Research cruises took place in an area of about 2,400 km^2, approximately comprised between 43°54' N - 42°20' N Lat. and 7°05' E – 9°18' E Long., that enclosed coastal and pelagic waters (Fig.1).

Observations were performed every year from June to October, with a total of about 90,000 km travelled at sea. In 1997 and 1998, research efforts particularly focused on the waters adjacent to the continental slope, where the highest occurrence of Risso's dolphin resulted from the previous surveys. The platforms used were a 19 m-long motor-sailer-boat, a 19 metres long motor-boat and a 11 metres long sailing-boat, all equipped with GPS and cruising at an average speed from 5 to 10 knots. Survey effort, environmental and sighting data were recorded using the LOGGER software (IFAW) running on a GPS-interfaced laptop computer. Position, water depth, distance from the nearest coast, group size and major age classes, were recorded at each sighting. Observation sessions were carried out by at least one trained observer. For calculation of sighting frequencies, data were discarded when wind speed was equal or exceeded three on the Beaufort scale.

Regular photo-identification surveys were conducted only during 1997 and 1998, while in the previous years photographs were taken only on an opportunistic basis. About 4,000 photographs were taken with reflex autofocus cameras, equipped with 80-200 mm f 2.8 zoom lens, and Ektachrome EPR 100 ISO and Fujichrome Provia 100 ISO colour transparency films. Identification of Risso's dolphins was based on natural long-term marks such as nicks, notches and scars (Fadda and Airoldi, this volume) on their dorsal fins.

RESULTS Sighting frequencies, distribution and occurrence in the study area: The sighting frequency (n° of sightings/100 km), observed during the study period under good weather conditions (Beaufort <3), was 0.53.

The depth at encounters ranged from 70 to 2,700 m, with a mean of 937 m (SD=564; mode=1,000 m). Most of the sightings occurred in a depth range of 400-1,000 m, according with other studies in north-western Mediterranean (Fabbri *et al.*, 1992; Cañadas and Sagarminaga, 1996; Gannier, 1998; Di-Méglio *et al.*, 1999; Bonaccorsi and Sacchi, 1999; see also Fig. 2).

Risso's dolphins were sighted 77 times and were photographed in 54 encounters. In total, 154 individuals have been photo-identified: 94 from both sides, 36 from the right and 24 from the left. Only the individuals identified from the right side and both sides were considered for the analyses. A total of 81 individuals (63%) were re-sighted, from 1 to 4 times on different years, while within-season re-sightings ranged from 1 to 8 times (range= 1-11 times, mean=2.8, SD=2). The rate at which individuals dolphins were identified during the study is presented in Fig. 2.

Social structure: The percentage group age composition, recorded during 70 encounters, was: 84.3% adults (N= 681), 8.3% subadults (N= 67), and 7.4% calves (N= 60). Group size ranged from 1 to 70 individuals, with a mean of 12 and a mode of 5 (SD= 12.2). No significant group-size variations were recorded among months over the study period (Kruskall-Wallis, $p>0.05$) and among years (Kruskall-Wallis, $p>0.05$).

Groups with calves (mean=20.5, SD=14.8) were significantly larger than groups without calves (Kolmogorov–Smirnov, $p<0.01$). Groups entirely composed of adults (*i.e.*, without calves and subadults) were the smallest (mean=4.2, SD=3.8) ($p<0.01$) (Table 1).

DISCUSSION AND CONCLUSIONS The distribution of Risso's dolphins with respect to water depth is in agreement with the species' main prey - mesopelagic cephalopods (Podestà and Meotti, 1991; Wurtz *et al.*, 1992).

The re-sighting rate for many animals suggests a high degree of site fidelity during the summer, although the study area surely represents only part of a greater home range. The increasing rate of discovery (curve) (Fig. 2) indicates that only part of the marked individuals frequenting the study area have been photo-identified so far.

Mean group size is similar to one reported in other studies in the Mediterranean (Podestà *et al.*, 1997, David and Di-Méglio, 1999), in the Atlantic (Arnbom *et al.*, 1988, Atkinson *et al.*, 1997) and in the Indian Ocean (Kruse *et al.*, 1991), while it is smaller than the one observed in the Pacific (Kruse 1989; Dohl *et al.*, 1980; Leatherwood *et al.*, 1980). The relatively small group size, compared with the greater Pacific aggregations that may form in response to abundant resources (Norris and Dohl, 1980; Wursig, 1986), may be indicative of more scattered or scarcer food resources in the Mediterranean Sea.

We recommend that winter surveys also be conducted to obtain more information on the yearly distribution and abundance of the Risso's dolphins in the study area, and to highlight their possible year-round residency.

ACKNOWLEDGEMENTS We are grateful to Portosole and Marina degli Aregai that offered logistic support and assistance. Thank you to all the researchers and the students who have contributed to data collection, to Albert Sturlese for his collaboration, and to all the volunteers who helped in the field.

REFERENCES

Arnbom, T., Gordon, J., Martins, H., Santos, R. and Walsh, V. 1988. Individual photographic identification of Risso's dolphin *Grampus griseus* near the Azorean Islands. Pp 39-41. In: *European Research on Cetaceans – 2.* Proc. 2nd Ann. Conf. ECS, Troìa, Portugal, 5-7 Feb, 1988. (Ed. P. G. H. Evans). European Cetacean Society, Lisboa, Portugal. 119pp.

Atkinson, T., Gill, A. and Evans, P. G. H., 1997. Notes on the natural markings on Risso's dolphins (*Grampus griseus*) photographed in the coastal waters around the Eye Peninsula, Isle of Lewis, Scotland. P. 209. In: *European Research on Cetaceans – 11.* Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Eds. P.G.H. Evans, E.C.M. Parsons and S.L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Baumgartner, M. F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the Northern Gulf of Mexico. *Mar. Mamm. Sci.*, 13(4): 614-638.

Beaubrun, P. 1995. *Atlas préliminarie de distribution des cétacés de Méditerranée.* CIESM, Musée océanographique, Monaco. 87pp.

Beaubrun, P., David, L., Di-Méglio, N., Gannier, A. and Gannier, O. 1997. First aerial survey in the north-west Mediterranean – Preliminary results. Pp. 100-103. In: *European Research on Cetaceans – 11.* Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Bonaccorsi, R. and Sacchi, R. 1999. Factors affecting the distribution and pigmentation pattern of Risso's dolphin (*Grampus griseus*) in the Liguro-Provençal Basin during 1990-1998. Pp. 288-294. In: *European Research on Cetaceans – 13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 484pp.

Bompar, J. M. 1997. Winter presence of Risso's dolphin, *Grampus griseus*, in the Western part of the Ligurian Sanctuary. Pp. 164-166. In: *European Research on Cetaceans – 11.* Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Ed. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Cañadas, A. and Sagarminaga, R. 1996. Preliminary results of photo-identification studies on Risso's dolphins (*Grampus griseus*) undertaken during surveys of cetacean distribution and dynamics along the south-east coast of Spain: 1992-1995. Pp. 221-224. In: *European Research on Cetaceans –10.* Proc. 10th Ann. Conf. ECS, Lisboa, Portugal, 11-13 Mar, 1996. (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

David, L. and Di Méglio, N. 1999. First results of summer movements of *Grampus griseus* (Cuvier, 1812) in the North-Western Mediterranean Sea. Pp. 189-194. In: *European Research on Cetaceans – 13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 484pp.

Di-Méglio, N., David, L. and Beaubrun, P. 1999. Spatio-temporal distribution of Risso's dolphin *Grampus griseus* (Cuvier, 1812) in summer in the North-Western Mediterranean Sea. Pp. 195-200. In: *European Research on Cetaceans – 13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 484pp.

Dohl, T. P., Norris, K. S., Guess, R. C., Bryant, J. D. and Honig, M. W. 1980. Cetacea of the Southern California Bight. In: *Marine Mammal and Sea Bird Surveys of the Southern California Bight Area, 1975-1978*, Vol. III, "Investigator's Reports", Part II. PB81-248-71, NTIS.

Fabbri, F., Giordano, A. and Lauriano, G. 1992. A preliminary investigation into the relationship between the distribution of Risso's dolphins and depth. Pp. 146-151. In: *European Research on Cetaceans – 6:*. Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 Feb, 1992. (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Fadda, V. and Airoldi, S. 2000. A note on the persistence of dorsal fin scars on Risso's dolphins photoidentified in Ligurian Sea (this volume).

Gannier, A., Beaubrun, P. and Di-Méglio, N. 1994. Cetacean occurrence in the Gulf of Lion and surroundings. Pp. 87-91. In: *European Research on Cetaceans – 8:*. Proc. 8th Ann. Conf. ECS, Montpellier, France, 2-5 Mar, 1994. (Ed. P. G. H. Evans). European Cetacean Society, Lugano, Switzerland. 288pp.

Gannier, A. 1998. Variation saisonnière de l'affinité bathymétrique des Cétacés dans le bassin Liguro- provençal (Méditerranée occidentale). *Vie et Milieu,* 48, 1: 25-34.

Gill, A., Atkinson, T., and Evans, P. G. H. 1997. Cetacean sightings off the East Coast of the Isle of Lewis, Scotland. Pp. 109-111. In: *European Research on Cetaceans – 11*. Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Kruse, S., Leatherwood, S., Prematunga, W.P., Mendes, C., and Gamage, A. 1991. Records of Risso's dolphins,. *Grampus griseus,* in the Indian Ocean, 1891-1986. Pp. 66-77. In: *Cetaceans and Cetacean Research in the Indian Ocean Sanctuary*. (Eds. S. Leatherwood and G. Donovan). United Nations Environmental Programme, Nairobi, Kenya.

Kruse, S. 1989. *Aspects of the biology, ecology and behavior of Risso's dolphin (Grampus griseus) off the California Coast*. MSc Thesis in Marine Sciences, University of California Santa Cruz. June 1989. 120pp.

Leatherwood, S., Perrin, W.F., Kirby, V.L., Hubbs, C.L., and Dahlheim, M.. 1980. Distribution and movements of Risso's dolphin *Grampus griseus* in the eastern North Pacific. *Fish. Bull.*, 77(4): 951-963.

Norris, K.S. and Dohl, T.P. 1980. The structure and functions of cetacean schools. Pp. 211-261. In: *Cetacean Behavior: Mechanism and functions*. (Ed. L. M. Herman). John Wiley and Sons, New York. 463pp.

Notarbartolo di Sciara, G., Venturino, M., Zanardelli, M., Bearzi, G., Borsani, F. J., and Cavalloni, B. 1993. Cetaceans in the Central Mediterranean Sea: distribution and sighting frequencies. *Boll. Zool.,* 60: 131-138.

Podestà, M. and Meotti, C. 1991. The stomach contents of a Cuvier's beaked whale *Ziphius cavirostris,* and a Risso's dolphin *Grampus griseus*, stranded in Italy. Pp. 58-61. In: *European Research on Cetaceans – 5:*. Proc. 5th Ann. Conf. ECS, Sandefjord, Norway, 21-23 Feb, 1991. (Ed. P. G. H. Evans). European Cetacean Society, Leiden, The Netherlands. 132pp.

Podestà, M., Magnaghi, L. and Gorlier, G. 1997. Sightings of Risso's dolphin in the Ligurian waters. Pp.167-169. In: *European Research on Cetaceans – 11*. Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Würsig, B. 1986. *Delphinid foraging strategies*. Pp. 347-359. In: *Dolphin cognition and behavior: A comparative approach*. (Eds. R. J. Schusterman, J. A. Thomas and F. G. Wood). Lawrence Erlbaum Associates, Hillsdale and London.

Würtz, M., Poggi, R. and Clarke, M. 1992. Cephalopods from the stomach of a Risso's dolphin (*Grampus griseus*) from the Mediterranean. *J. Mar. Biol. Ass. U.K.* 72: 861-867.

Table 1. Group sizes differences in relation to age group composition

Age composition	**mean**	**SD**	**SE**	**n**	**range**	**mode**
All animals	11,5	12,4	1,5	70	1--69	5
Adults only	4,2	3,8	0,7	31	1--20	2
Adults and juveniles	11,4	8,6	2,1	17	3--30	5
Groups with calves	20,5	14,8	3,1	22	3--69	18
Groups without calves	7,5	8,3	1,2	50	1--41	5

Fig. 1. Map of the study area with the core area and Risso's dolphin sightings

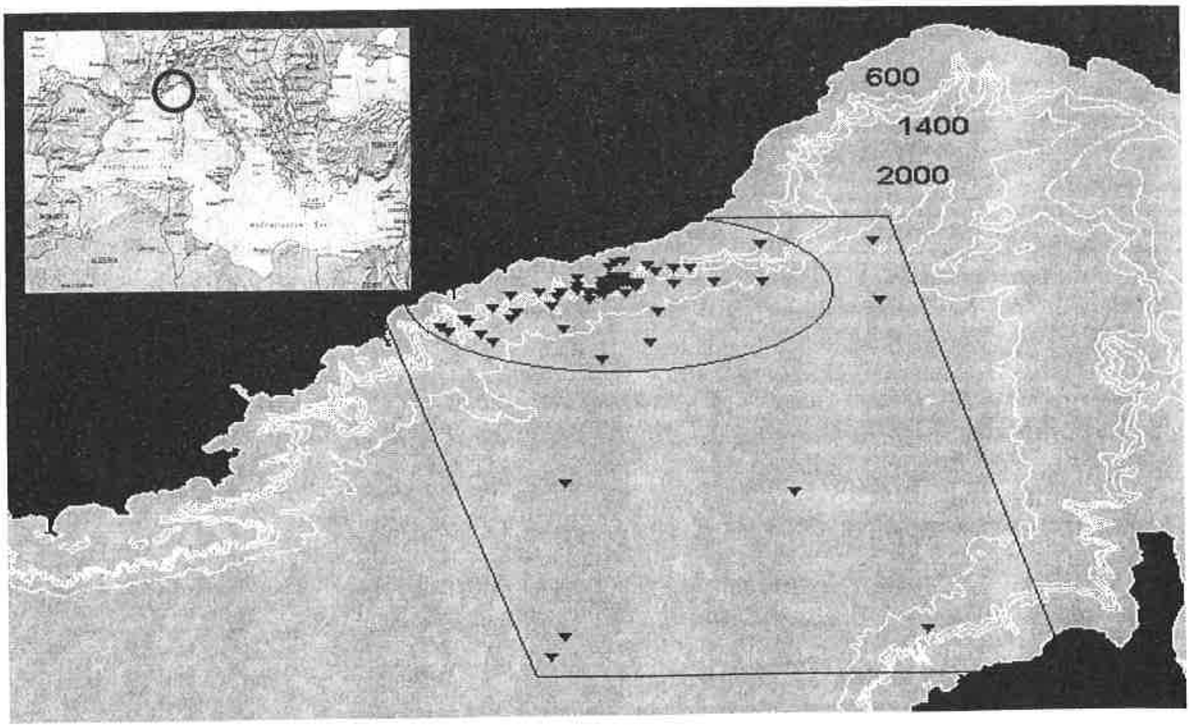
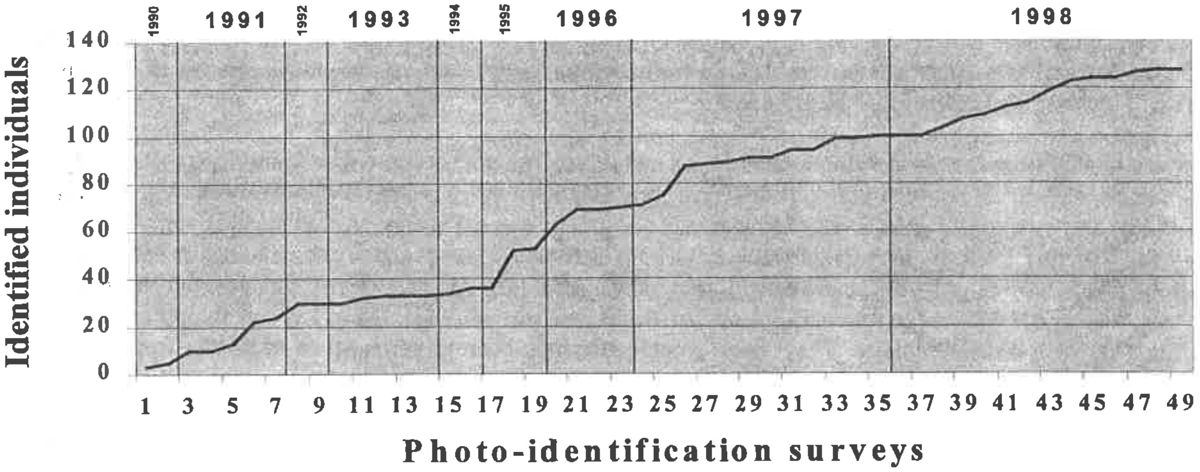


Fig. 2. Cumulative rate of identification of new individuals over time



SEASONAL CHANGES IN ABUNDANCE OF SOUTHERN RIGHT WHALES, *EUBALAENA AUSTRALIS*, AROUND PENINSULA VALDES

E. A. Crespo[1], A. Arias[2], S. L. Dans[1], M. A. Coscarella[1], A. Carribero[3], and S. N. Pedraza[1]

[1]*Centro Nacional Patagónico, Blvd. Brown s/n, 9120 Puerto Madryn, Chubut, Argentina*
[2]*Fundación Vida Silvestre, Argentina*
[3]*Ecocentro Puerto Madryn, Argentina*

Payne and colleagues have carried out long-term studies on southern right whales since the early 1970's. Estimation of population size and other parameters were derived from sighting data based on individual patterns of callosities, and the rate of increase was estimated to be close to 8%.

The objective of this work was to develop a method for monitoring the population which could lead to the study of seasonal changes within and between years. Individuals were classified as: a) mother and calf pairs (MC), b) solitary individuals (SI) and c) breeding groups (BG) considering one female and n-1 males. Aerial surveys were carried out from May to December 1999, flying parallel to the coast at a distance of 500 m and an altitude of 600 feet, between the mouth of Chubut River (42° 30′) and Puerto Lobos (42°). In this way, most of the whales could be recorded because they stay in the 5-10 metres isobath. The first flight was carried out on May 19, and the period between flights ranged between 46 and 39 days. These periods are beyond the average permanence of whales in the area, so ideally during each census new individuals were being recorded.

Only five SI's were counted in May, then the number increased, reaching a maximum of 204 individuals in August. BG's also showed a maximum of 98 individuals involved in breeding activities in August, declining to only six individuals in early November. The number of newborn calves increased from July to September, when a peak of 179 was reached, and then declined. Sexual activity seems to occur earlier in the season than births, which occur mainly from the middle of the breeding season to the end.

MARINE MAMMALS STRANDED ON THE BELGIAN AND DUTCH COASTS: APPROACH OF THEIR FEEDING ECOLOGY BY STABLE ISOTOPE AND HEAVY METAL MEASUREMENTS

K. Das[1], V. Debacker[1], G. Lepoint[1], S. Gobert[1], L. Holsbeek[2], C. R. Joiris[2] and J.M. Bouquegneau[1]

[1]*Laboratory for Oceanology, Liège University B6, B-4000, Liège Belgium (E-mail: Krishna.Das@student.ulg.ac.be)*
[2]*Laboratory for Ecotoxicology, Free University, Brussels, Belgium*

INTRODUCTION The fertile waters of the North Sea represent one major life site for at least three different marine mammal species: the harbour porpoise, *Phocoena phocoena*, the harbour seal, *Phoca vitulina*, and the white-beaked dolphin, *Lagenorhynchus albirostris* (Hammond *et al.*, 1995). Other species like white-sided dolphins *Lagenorhynchus acutus*, sperm whales *Physeter macrocephalus* and fin whales *Balaenoptera physalus* can be sighted or found stranded occasionally but are still considered very rare in the southern part of the North Sea (Camphuysen and Winter, 1995; Hammond *et al.*, 1995). Very few data on marine mammal diet within this area are available (Santos *et al.*, 1999). Stranding data offer a good opportunity for scientists to collect biological data but, in most cases, stranded animal stomach are empty (Jauniaux *et al.*, this volume) and do not allow any trophic comparison between species.

Recently, the use of naturally occurring stable isotopes of carbon and nitrogen has provided complementary data to marine mammal feeding ecology as isotopic ratios ($\delta^{13}C$ and $\delta^{15}N$) are related to those of their diet (*eg*: Hobson and Schell, 1998; Das *et al.*, 2000 ^{b}). Within a food chain, $\delta^{15}N$ and $\delta^{13}C$ typically show a stepwise increase with trophic level with a trophic enrichment value of about $3^{0}/_{00}$ and $1^{0}/_{00}$ leading to high d values in top-predators (reviewed by Michener and Schell, 1994).

Several recent studies have used stable isotope measurements to describe contaminant tranfer in marine ecosystems, but very few have focused on heavy metals (Atwell *et al.*, 1998; Das *et al.*, 2000a). High levels of trace metals such as mercury or cadmium can be measured in marine mammal tissues depending on their trophic position, specific diet and environmental contamination (reviewed by Das *et al.*, 2000b). In order to contribute to the knowledge of North Sea marine mammal ecology, $\delta^{15}N$ and $\delta^{13}C$ as well as mercury (Hg) and cadmium (Cd) have been determined and compared in the tissues of six species beached on Belgian and Dutch coasts between 1990 and 2000: the harbour porpoise, harbour seal, white-beaked-dolphin, white-sided dolphin, sperm whale and fin whale.

MATERIALS AND METHODS The tissues of 36 harbour porpoises, 20 harbour seals, 8 white-beaked dolphins, 2 white-sided dolphins, 4 sperm whales and 3 fin whales found dead along the Belgian coasts between 1994 and 2000 have been sampled and stored until analysis at –20°C. 24 harbour porpoises stranded along the Dutch Wadden Sea coasts between 1990 and 1993 have been added to this study, as well as three sperm whales beached in 1995 on the Dutch coast.

After lipid extraction from the samples using chloroform and methanol rinses, $d^{13}C$ and $d^{15}N$ measurements were performed by mass spectrometry. Total mercury concentration was determined by specific atomic absorption spectrometry; Cd was analysed through induction coupled plasma spectrometry. All metal concentrations are expressed in $\mu g.g^{-1}$ dry weight (dw).

RESULTS AND DISCUSSION **Stable carbon and nitrogen data ($d^{13}C$ and $\delta^{15}N$)** Harbour seals and white-beaked dolphins occupy a higher trophic position than harbour porpoises as suggested from their high muscle $\delta^{15}N$ (Fig. 1). These values are consistent with a piscivorous lifestyle. Sperm whales, fin whales, and white-sided dolphins show very low $d^{13}C$ and $d^{15}N$ values compared with the three above-mentioned species. Their mean $d^{13}C$ values are even lower than those encountered for southern North Sea phytoplankton (POM data from Middelburg and Nieuwenhuize, 1998). The $\delta^{13}C$ depletion observed for sperm whales, fin whales and white-sided dolphins presumably reflect a greater reliance on offshore food. Indeed, stable carbon isotopes have proven most useful in identifying where particular organisms feed, and $\delta^{13}C$ values are typically higher in coastal or benthic food webs than in pelagic food webs (Dauby *et al.*, 1994; Hobson *et al.*, 1997).

Cadmium and mercury levels Sperm whales display the highest renal cadmium level (mean: 258 $\mu g.g^{-1}$ dw, Holsbeek *et al.*, 1999). Cd values are also very elevated for the two white-sided dolphins (88.0 and 88.4 $\mu g.g^{-1}$ dw) while remaining relatively low in white-beaked dolphin, porpoise and seal kidneys (Fig. 2). Sperm whale and white-sided dolphin high concentrations are likely to be diet related, as teuthophagous marine mammals display elevated Cd concentrations in their livers and kidneys (reviewed by Das *et al.*, 2000b). It can be assumed that the two white-sided dolphins can feed on oceanic cephalopods which are known for their high Cd content. This hypothesis is enhanced by their stable isotope values close to sperm whales which mainly feed on oceanic cephalopods (Santos *et al.*, 1999).

Liver mercury concentrations are less heterogeneous. High concentrations can also be encountered in white-sided dolphins and sperm whales while remaining relatively low in the harbour seal. Harbour porpoises and white-beaked dolphins display intermediate values (Fig. 3). Given the high $d^{15}N$ values of harbour seals and white-beaked dolphins, similar elevated Hg values were expected since this metal is supposed to display a bio-amplification process within food chains. Such a relationship was not found due to strong age differences between individuals. Harbour seal Hg concentrations remain low in relation to their juvenile state. Hg tends to accumulate in marine mammal liver during its life span which can lead to highly contaminated old adults (reviewed by Das *et al.*, 2000b).

CONCLUSIONS It appears from this study that despite occasional sightings of sperm whales, fin whales, and white-sided dolphins in the Southern Bight of the North Sea, they feed mainly offshore within the North Atlantic. By contrast, harbour porpoises, harbour seals, and white-beaked dolphins belong to the southern North Sea food web. Both white-beaked dolphins and harbour seals feed on higher trophic level prey than harbour porpoises, but some diet overlap probably occurs between the three species. The high Hg concentrations found in the marine mammals studied reflect a contamination over the whole animal life rather than a bio-amplification process.

ACKNOWLEDGEMENTS The authors are grateful to J. Haelters, T. Jauniaux, J. Tavernier, M. J. Addink and C. Smeenk for providing the samples. We also thank R. Biondo for his valuable technical assistance. K. Das and G. Lepoint received grants from FRIA (Fonds pour la Recherche dans l'Industrie et l'Agriculture). The study was also supported by a grant from the Belgian Office for Scientific, Technical and Cultural Affairs (Contract MN/DD/50).

REFERENCES

Atwell, L., Hobson, K. A., and Welch, H. E. 1998. Biomagnification and bioaccumulation of mercury in an arctic food web : insights from stable nitrogen isotopes analysis. *Can. J. Fish. Aquat. Sci.*, 55: 1114-1121.

Camphuysen, C. J. and Winter, C. J. N. 1995. Feeding fin whales *Balaenoptera physalus* in the North Sea. *Lutra* 38: 81-84.

Das, K., Debacker, V., Pillet, S., and Bouquegneau,, J. M. 2000a. Heavy metals in marine mammals. In: *Toxicology of Marine Mammals,* Taylor and Francis Publishers Washington D.C., USA. (*in press.*)

Das, K., Lepoint, G., Loizeau, V., Debacker, V., Dauby P., and Bouquegneau, J. M. 2000b. Tuna and dolphin associations in the Northeast Atlantic: Evidence of different ecological niches from stable isotope and heavy metal measurements. *Mar. Pollut. Bull.* 40: 102-109.

Dauby, P., Frankignoulle, M., Gobert, S. and Bouquegneau, J. M. 1994. Distribution of POC, PON, and particulate Al, Cd, Cr, Cu, Pb, Ti, Zn and $\delta^{13}C$ in the English Channel and adjacent areas *Oceanologica Acta*, 17: 643-657.

Hammond, P. S., Benke, H., Berggren, P., Borcher, D. L., Buckland, S. T., Collet, A., Heide-Jørgensen, M. P., Heimlich-Boran, S., Hiby, A. R., Leopold, M. F., and Øien, N. 1995. *Distribution & abundance of the harbour porpoise & other small cetaceans in the North Sea & adjacent waters.* European Commission, Life 92-2/UK/027 Final Report October 1995. 240pp.

Hobson, K. A. and Schell, D. M. 1998. Stable carbon and nitrogen isotope patterns in baleen from eastern Arctic bowhead whales (*Balaena mysticetus*). *Can. J. Fish. Aquat. Sci.* 55: 2601-2607.

Hobson, K. A., Sease, J. L., Merrick, R. L., and Piatt, J. F. 1997. Investigating trophic relationships of pinnipeds an Alaska and Washington using stable isotopes ratios of Nitrogen and Carbon. *Marine Mammal Science*, 13, 114-132.

Holsbeek, L., Joiris, C R., Debacker, V., Ali, I. B., Roose, P., Nellissen, J. P., Gobert, S., Bouquegneau, J. M., and Bossicart, M. 1999. *Mar. Pollut. Bull.* 38: 304-313.

Michener, R. H. and Schell, D. M. 1994. Stable isotopes ratios as tracers in marine aquatic foodwebs. Pp. 138-186. In: *Stable isotopes in ecology and environmental science.* (Eds. K. Lattjha and R. H. Michener R.H.). Blackwell Scientific Publications, Oxford, UK.

Middelburg, J. J. and Nieuwenhuize, J. 1998. Carbon and nitrogen stable isotopes in suspended matter and sediments from the Schelde estuary. *Mar. Chem.* 60: 217-225.

Santos, M. B., Pierce, G J., Boyle, P. R., Reid, R. J., Ross, H. M., Patterson, I. A. P., Kinze, C. C., Tougaard, S., Lick, R., Piatkowski, U., and Hernandez-Garcia, V. 1999. Stomach content of sperm whales *Physeter macrocephalus* stranded in the North Sea, 1990-1996. *Mar. Ecol. Prog. Ser.*, 183: 281-294.

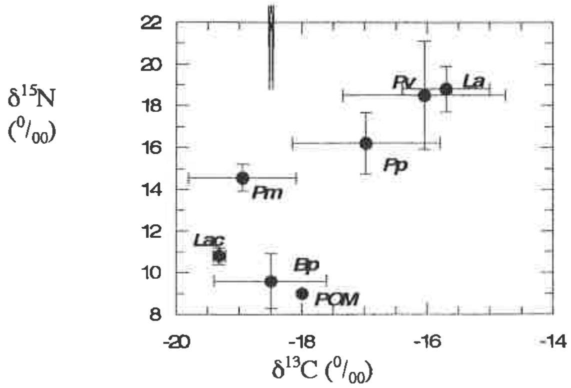


Figure 1. Muscle Isotopic composition of North Sea marine mammals
(*Bp: Balaenoptera physalus, Lac: Lagenorhynchus acutus, Pm: Physeter macrocephalus, Phocoena phocoena: Phocoena phocoena, Pv: Phoca vitulina, La: Lagenorhynchus albirostris,* POM: Particulate organic matter, data from Middelburg and Nieuwenhuize, 1998).

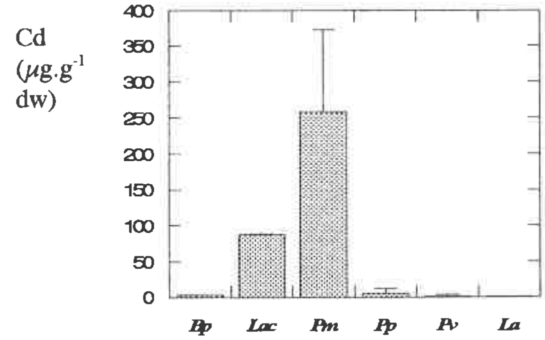


Figure 2. Renal Cd concentrations of North Sea marine mammals

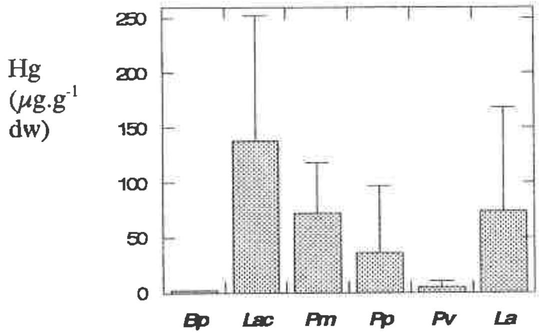


Figure 3. Hepatic Hg concentrations of North Sea marine mammals (nd: not determined)

DISTRIBUTION OF THE FORAGING ACTIVITY OF FEMALE ANTARCTIC FUR SEALS (*ARCTOCEPHALUS GAZELLA*) IN RELATION TO OCEANOGRAPHIC FACTORS AND PREY DISTRIBUTION AT KERGUELEN ISLAND: A TWO-YEAR COMPARISON

L. Dubroca[1], C. Guinet[1], M.-A. Lea[2], Y. Cherel[1], S. Goldsworthy[2], G. Duhamel[3], and J.-P. Donnay[4]

[1]*Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique, 79360 Villiers en Bois, France*

[2]*Zoology Department, Antarctic Wildlife Research Unit, University of Tasmania, GPO Box 252-05 Hobart, Tasmania 7001, Australia*

[3]*Museum National d'Histoire Naturelle, Laboratoire d'Ichtyologie Générale et Appliquée, 43 rue Cuvier, 75231 Paris cedex 05, France*

[4]*Departement de Géomatique, Laboratoire SURFACES, Université de Liege, 7 place du 20 Aout (A1), B4000 Liege, Belgium*

The distribution of the foraging activity of lactating female Antarctic fur seals was investigated at Kerguelen Island in February 1998 and January-February 1999. At that time, fur seals are central place foragers who commute back and forth between foraging trips at sea and the colony where they suckle their pups. Females were fitted with a satellite transmitter combined with a time depth recorder both in 1998 (n=11) and 1999 (n=9). The two sets of data were then combined to locate spatially their diving activity. The fish component of the female diet was determined from the occurrence of otoliths found in scats collected on the breeding colony in 1998 (n=55) and in 1999 (n=55). Oceanographic parameters were obtained simultaneously through direct sampling and satellite imagery obtained on the same spatio-temporal scale. In both years, 20 epipelagic trawls divided along four transects were conducted at night at 50 metres of depth. We then investigated, using Geographic Information Systems, the relationships between the spatial distribution of the diving activity of the females and oceanographic factors: sea surface temperature, surface chlorophyll concentration, prey distribution and bathymetry.

Mesopelagic myctophids were the main prey of the females in both years. The fish species preyed upon by the fur seals represented only 17% of the total number of fishes sampled in trawl nets. However, the diving activity of fur seal females was found to be highly related to oceanographic conditions, fish-prey distribution, and to the distance from their colony in both study years. The change in relationships, according to spatial scale, was also investigated. A probabilistic model was developed, and predicts where females should concentrate their foraging activity according to the oceanographic conditions of the year, and the location of their breeding colonies.

CETACEANS IN SOUTH-EASTERN CRIMEAN COASTAL WATERS: AN EXPERIENCE OF TWO-YEAR OBSERVATIONS

E. B. Gol'din and A. M. Artov

BREMA Laboratory, Simferopol, Crimea 95490, Ukraine

INTRODUCTION The south-eastern coast of the Crimea peninsula including the area between Alushta and Soudak (about 160 km^2) is one of the most interesting places in the Black Sea region. The specific characteristics of climate (precipitation regime and intensity), geological activity, and geomorphological structure (accumulation of weathering products within steep slopes and catchment area of river basins, erosion processes, stone-, mud- and landslides etc) led to the formation of an unusual coastal ecosystem. Short rivers (3.0-16.0 km) running to the sea from low mountains and hills (catchment area is 14.0-76.0 km^2), springs, gorges, temporary brooks and constant mountain mud and stone streams ("sel") bring a lot of organic substance (7.0-16.6%, sometimes about 41.0%, in alluvia and drifts) to the adjoining sea area (B. Gol'din, 1969). These processes promote the enrichment of fish abundance and diversity, attracting cetaceans. The area lying between Alachuk (Andus Valley) and Shelen Rivers, as well as the zone of informants' activity (local people, tourists, frontier guards, etc) between Ulu-Uzen River and Ay-Phoca Cape is the most typical in this sense. So it was chosen for our monitoring so that we could gain some idea of the present status of cetaceans in this part of the Black Sea. Since February 1989, cetacean strandings have been recorded along the coastline by BREMA Laboratory and a monitoring network established here (Krivokhizhin and Birkun, 1999). The present study was undertaken to extend that research .

MATERIALS AND METHODS The observations were carried out monthly from March 1997 to January 1999 in the coastal zone between the mouths of Alachuk (Andus Valley) and Shelen Rivers and adjoining sea area. We also obtained information concerning cetaceans from the more expanded region between Kuru-Uzen and Ulu-Uzen Rivers in the west, and Ay-Phoca Cape in the east, since April 1996 (Fig. 1).

The complex monitoring work included a number of aspects. The main sectors of activity were:

- research of strandings and inspection of dead animals (description, necropsy, collection of samples, etc);
- own observations on living animals in nature;
- collection of relevant information from local people, fishermen, frontier guards, etc;
- results and evaluation of the status of the coastal environment (biotic and abiotic factors, phenology, pollution, etc).

RESULTS AND DISCUSSION Data obtained during 24 months related to both stranding and free-living cetaceans. This material can help provide some idea about the status of cetaceans in the region. Collected information has established the constant presence of two species in coastal waters of South-Eastern Crimea - bottlenose dolphin *Tursiops truncatus ponticus* Barabash-Nikiforov, and harbour porpoise *Phocoena phocoena relicta* Abel (Table 1). During the work, it was necessary to concentrate attention on a specific research area to ensure that observations in the coastal zone (selection of viewpoints, determination of routes, range of informants, questionnaire surveys, etc) could be collected. So there is a need to characterise the region of activity.

General description of research area Low mountain erosive and denuded relief is typical for the south-eastern coast. It was formed on the argillite-aleuric and sandstone flysh bedrocks of the Upper Triassic, Lias, and Dogger age (Tauric series). Numerous submeridianal river valleys, ravines, and gorges are divided by low, gentle hill ranges as the watersheds. The controlled coastal zone is the most recent terrace situated at the foot of a steep slope (25-40°), its altitude not exceeding 200 m (A. Klyukin, 1969; 1971). The main part of the area is a narrow strip of boulder and shingle beach, from 2 to 15 m wide, increasing to 20-40 m in the mouths of rivers, gorges, and erosive narrow gullies, because of the formation of shingle and sandy beaches there. The rest of the research area is covered with beaches of several types: shingle, gravel and shingle, boulder and shingle, boulder, block boulder and detritus (or "wild"), detritus and sandy, sandy ones. The region is a sphere of intensive abrasive and landslidal action now, and this process is continuing. A number of factors can be quite favourable for it. There is domination of the flysh stratum which is very exposed to weathering, and overlays steep slopes with landslide material, development of denudation and abrasion, and heavy shower precipitation, especially in the east part of region (between Uskut and Shelen Rivers and further on to Ay-Phoca Cape). Meanwhile, a low extent of forest covers the river basins (1.0-61.0% in the west part; 0-39.0% in the east part), and an accumulation of mellow weathering products on the slopes of the water catchment area which are very favourable for sel activity, especially in eastern part (B. Gol'din, 1966). The interrelations of exogenous factors create a varied landscape in the coastal zone: the concentration of sel accumulations (formation of spits in river mouth zones and their abrasion), gravitation (land- and mud-slides, scree), abrasion (cliffs, wave-surfing niches, etc). The environmental situation is very important for monitoring. So landslide activity has to be taken into account to form a view about the true rates of stranding. Besides this, a narrow coastline may be covered entirely during a storm weather, and there can be occasions of extremely short-term presence of dead animals on the coast or in the surf zone.

Free-living cetaceans Bottlenose dolphins and harbour porpoises appeared in large numbers (groups of 3-50 individuals) usually from the middle of April until October every year. During May and June, the bottlenose dolphin herds were observed regularly: hunting groups of 3-5 or 10 individuals were near the shore, and the main part of the herd was visible 300 m from the coastline. In July, August, and September, the appearance of bottlenose dolphin herds was recorded near the coast twice a day, early in the morning and at 17:.00-18:00 hrs, during their movement to the east or to the west. Only once have we observed three bottlenose dolphins near Avun Cape in January. The concentration of cetaceans was closely correlated with foraging in spring and autumn for fish (e.g. haarder, *Mugi soiuy*, Basilewsky). In other cases, the appearance of animals was related to human fishing. Thus many bottlenose dolphins occurred in the area during trawling. During this period, informants registered migration, foraging, and play behaviour every day. The most frequent feeding observations of cetaceans was noted in the region of the Kanaka Gorge, mouths of Uskut and Shelen Rivers (bottlenose dolphins), and between Uskut River and Agira Cape in site Kamyshly (harbour porpoise). In September 1997, a bottlenose dolphin herd (about 30 individuals of variable size) was recorded in the region of Agira Cape 150-200 m from the coastline, and these occupied a range of about 500 m east of here during foraging,. The same picture was observed in the region of the mouth of Alachuk River, 400 m from the coastline (on no less than ten occasions).

Strandings or Bycatch During the entire observation period, strandings (or bycatch) were recorded of the following species: common dolphin *Delphinus delphis ponticus* Barabasch-Nikiforov (1), bottlenose dolphin (9), harbour porpoise (4), and unidentified cetaceans (2) at select sites along the coast (regions of Avun, Agira and Ay-Phoca Capes, Uskut River mouth). Bony remains, and carcasses (fresh or at different stages of decomposition), constituted the sample material (Table 1). In all probability, we were informed of all the cases of strandings, or dead cetaceans which appeared on the coastline for a very short time (for example, during storms), because local people, tourists or those engaged in recreational activities could not overlook them and always brought them in. From August 1996 to January 1997, dead animals were not preserved (in some places since April 1996), with the exception of two dead dolphins (species unidentified) in summer 1996 in Ay-Phoca Cape. During 1998, informants did not record any stranding. A comparison of these data with previous results from the same area revealed a number of differences between them. Strandings took place more rarely during the time of our observation than in previous years. There was also a change in the relative importance of the two species amongst strandings. In the earlier years, harbour porpoises dominated the strandings (e.g. 30 harbour porpoises, 4 bottlenose dolphins and 2 common dolphins were recorded by Alexei A. Birkun, Jr. and Sergei V. Krivokhizhin in 1990). These findings raise the question: what may be the cause of increased cetacean mortality in the region - natural factors or bycatch? Two bottlenose dolphins (of nine described) lacked tails, and the others carried some traces of human interference, such as excised parts of the body, etc. This suggests that human activities, particularly bycatch, may be playing an important role in cetacean mortality, and this is in an accordance with the earlier opinion of specialists (Birkun and Krivokhizhin, 1996). The results obtained here show the need for research on the size and distribution of the cetacean populations in the region.

ACKNOWLEDGEMENTS The authors sincerely thank collaborators from the BREMA Laboratory: Dr. Alexei A. Birkun, Jr. for supervising this work, and Sergei V. Krivokhizhin for undertaking four surveys of the research area and for providing very valuable necropsy material. We are also grateful to Pavel E. Gol'din, a student of Tauric National University, for participation in two surveys.

REFERENCES

Birkun, A. A., Jr. and Krivokhizhin, S. V 1996. Cetaceans of the Black Sea: evaluation of the status of communities and problem of their conservation. Pp. 233-245. In: *Crimean Museum*. Tavria, Simferopol. 260pp. (In Russian).

Gol'din, B. M. 1966. Sel streams in the Crimea and measures of their predication. Pp. 82-85. In: *Natural and Manpower Resources of Left-Bank Ukraine and their employment*: Materials of second interdepartmental scientific conference. Vol. 7. Geomorphology. Climate. Soils. Vegetable and Animal Kingdom. (Eds. G. P. Dubinsky and S .I. Medvedev). Nedra, Moscow. 362pp. (In Russian).

Gol'din, B. M. 1969. On the content of organic substances in alluvia of the Crimea rivers. Pp. 321-327. In: *Meteorology and Hydrology*: Informational Bulletin of Geophysical Committee of the Ukrainian SSR, 13. (Eds. S. N.Subbotin *et al.*). Naukova dumka, Kiev. 334pp. (In Russian).

Klyukin, A. A. 1971. Quaternary accumulations and their connection with the relief of the South-Eastern Crimea. Pp. 43-47. In: *Natural and Manpower Resources of Left-Bank Ukraine and their employment*: Materials of third interdepartmental scientific conference. Vol. 10. Physical Geography.(Eds. V. I. Khotkevich *et al.*) Nedra, Moscow. 186pp. (In Russian).

Klyukin, A. A. 1969. Division into districts and typization of sel catchment area. Pp. 72-78. In: *Engineering and geological research of sel*: Bulletine of scientific and technical information. Ser. Hydrogeology and Engineering geology. _ 4. (Eds. A.I.Sheko and A.V.Sadov). Section of scientific and technical information of All-Union Scientific and Research Institute of mineral resources and geological survey. Moscow. 125pp. (In Russian).

Krivokhizhin, S. V. and Birkun, A. A., Jr. 1999. Strandings of cetaceans along the coasts of Crimean peninsula in 1989-1996. Pp. 59-62. In: *European research on cetaceans - 12*: Proc. 12th Annual Conf. ECS Monaco, 20-24 January 1998 (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

Table. Cetaceans in the coastal zone of South-Eastern Crimea (stranding or by-catch)

Cetaceans	Short description	Place and time of discovery	Origin of information
Common dolphin *Delphinus delphis ponticus* Barabasch-Nikiforov	Fresh carcass (immatured)	Agira Cape, January 1997	Frontier guards
Bottlenose dolphin *Tursiops truncatus ponticus* Barabasch-Nikiforov	Male, mummification, without tail	Between Choban Kule Uzen and Shelen Rivers, March 1997	E.Gol'din and A.Artov
	Male, decomposed carcass	Near Alachuk River (2.5 km to the east), May 1997	S.Krivokhizhin
	Male, decomposed carcass, without tail	The surf zone of the sea near a mouth of Uskut River (1.5 km to the west), May 1997	S.Krivokhizhin
	Male, fresh carcass	Near Uskut River, May 1997	Local people
	Mummificated individuals (2)	Near Avun Cape, June 1997	E.Gol'din and A.Artov
	Decomposed carcass	Near the mouth of Shelen River (2.0 km to the west), September 1997	S.Krivokhizhin
	Some fragments: skill, spinal column etc.	at the same place, October 1997	E.Gol'din and A.Artov
	Fragments of spinal column	to the east from Agira Cape, February 1998	
	Female, decomposed carcass	near Agira Cape, October 1998	
Harbour porpoise *Phocoena phocoena relicta*	Two fresh carcasses	In 1.5 km to the west from mouth of Shelen River, April1997	
	Mummification	Agira Cape, July 1997	S.Krivokhizhin
	Mummification	Agira Cape, August 1997	A.Artov
	Some fragments of spinal column	between Choban Kule Uzen and Shelen Rivers, October 1997	E.Gol'din and A.Artov
Unknown species	Carcasses of different stages of mummification	Ay-Phoca Cape, summer 1996	Local people and frontier guards

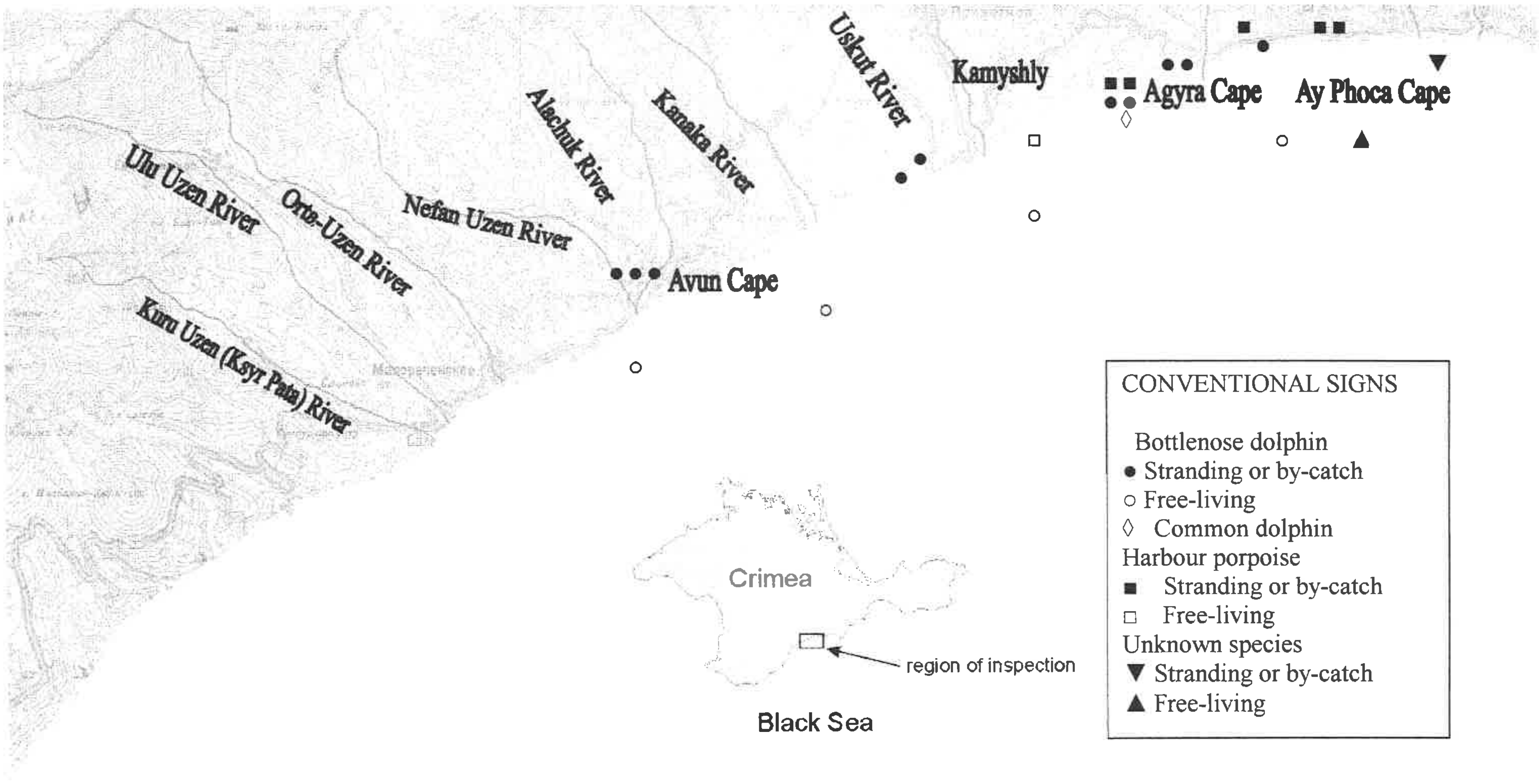


Fig. 1. The research area.

A MULTISPECIES APPROACH TO THE DYNAMICS OF SOME HIGH TROPHIC PREDATORS OF THE NORTHERN AND CENTRAL PATAGONIA MARINE COMMUNITY

M. Koen Alonso, S. N. Pedraza, E. A. Crespo, N. A. García, and S. L. Dans

Centro Nacional Patagónico, Blvd. Brown 3600, 9120 Puerto Madryn, Chubut, Argentina

The objective of this paper is to develop a preliminary multispecies model which allows one to simulate as a whole the dynamics of several high trophic predators of the northern and central Patagonia marine community. The model consisted of several biomass dynamic equations connected by trophic relationships. The prey species included in the model were the Argentine anchovy *Engraulis anchoita*, the Argentine shortfin squid *Illex argentinus*, and the Argentine hake *Merluccius hubbsi*. The high trophic predators considered were the dusky dolphin *Lagenorhynchus obscurus*, the South American sea lion *Otaria flavescens*, and the beaked skate *Dypturus chilensis*. Together with these species, the effect of fishery catches was included in the model. The study covered the period 1968-96. The model was built using discrete equations of the form Bt+1=BteRt where Bt+1 and Bt represent the total biomass of each species in the year t and t+1, and Rt represent the effective rate of biomass increase. The trophic relationships between species were incorporated to Rt of each species by means of the quotient between predator and prey biomasses.

Preliminary results indicate that the model describes reasonably well the dynamics of those species, where there is sufficient information. This model also allows the assessment of the dynamics of these species under different scenarios. Some of the results confirm the critical situation of the Argentine hake stock, suggesting that annual catches higher than 300,000 metric tons produce a collapse of the fishery. Additionally, the annual fluctuations in the anchovy biomass influence the dynamics of the dusky dolphin but they do not affect their population trend. Finally, the population trend of the South American sea lion appears to be influenced neither by the fluctuations of the Argentine shortfin squid biomass nor by the decrease of the Argentine hake stock.

PREY SPECIES OF BLACK SEA CETACEANS

S. V. Krivokhizhin, A. A. Birkun Jr., and J. V. Nessonova

BREMA Laboratory, Simferopol, 95490, Crimea, Ukraine

The stomach contents from 128 stranded and incidentally caught Black Sea cetaceans were examined during the period 1989-99. The cetacean carcasses were represented by 26 common dolphins (*Delphinus delphis*), eight bottlenose dolphins (*Tursiops truncatus*), and 94 harbour porpoises (*Phocoena phocoena*). Food remains were found in 39% of stranded common dolphins, 71% of stranded bottlenose dolphins, 41% of stranded and 85% of by-caught harbour porpoises. Correspondingly, 100%, 83% and 97% of "food-positive" common dolphins, bottlenose dolphins and harbour porpoises contained decomposed fish remains in their stomachs.

Fish remains were identified by means of a reference collection of Black Sea fish otoliths and bones. Five prey species were recognised in the stomachs of *D. delphis*: sprat (*Sprattus sprattus*), anchovy (*Engraulis encrasicolus*), garfish (*Belone belone*), whiting (*Merlangus merlangus euxinus*), and scad (*Trachurus mediterraneus*). Seven fish species were identified in *P.phocoena*: shad (*Alosa pontica pontica*), sprat, anchovy, whiting, pickarel (*Spicara smaris*), gobies (*Gobiidae* gen. sp.), and Far East haarder (*Mugil soiuy*). The last species, introduced into the Black Sea in the 1970s, is a relatively new food object for Black Sea harbour porpoise and bottlenose dolphin (results of visual observations). In addition, some invertebrates were found in a small number of common dolphins (shrimps), bottlenose dolphins (snails and shrimps), and harbour porpoises (oligochaete, molluscs [bivalves], crustaceans [copepods, isopods, amphipods, shrimps, hermit crabs, crabs], and insects [beetles]). Pieces of brown algae, green algae and sand were also recorded. Obviously, sometimes the fragments of mussels and small crustaceans enter porpoise stomachs from swallowed gobies, and the nematode larvae *Contracaecum* spp. probably also appeared from digested fish.

MOVEMENT AND SITE FIDELITY OF INDIVIDUAL GREY SEALS (*HALICHOERUS GRYPUS*) IN THE IRISH AND CELTIC SEAS

D. C. Lidgard[1], O. Kiely[2], E. Rogan[2] and N. Connolly[3]

[1]*Laboratoire de Biologie et Biochimie Marines, Université de La Rochelle, France*
[2]*Dept. Zoology & Animal Ecology, National University of Ireland, Cork, Ireland*
[3]*Coastal Resources Centre, National University of Ireland, Cork, Ireland*

The use of natural markings for studying individuals is an important tool for identifying critical habitat, and understanding their use by individuals. The objective of this study was to determine if individual immature and adult female grey seals show fidelity to, and movement between, key sites along the east and south-east coasts of Ireland to provide a better understanding of site use and population dynamics.

Photo-identification surveys were conducted between June 1996 and September 1998 at haul-out and breeding sites concentrated around the known breeding sites of Lambay Island on the east coast and the Great Saltee on the south-east coast. Images were collected of well-marked immature and adult female grey seals and dedicated computer software used to match like images and create a sighting history for each seal.

Two hundred and forty-four individuals were identified during the study period. Of these, 127 individuals were sighted once and 117 sighted on at least two occasions suggesting some individuals were transient while others appeared to be more resident. Discovery curves suggested that the majority of individuals in the east and south-east coast groups had been photographed, and that both study groups appeared to be closed to immigration. Key haul-out sites that demonstrated site fidelity were St Patrick Island and Lambay Island on the east coast, and the Great Saltee, Coningmore Rocks and Blackrock on the south-east coast. Movement was observed between the majority of study sites within each study group, However, only one individual moved between the east and south-east coast study groups. Some individuals showed evidence of residency within each study group, showing site fidelity to particular haulout sites, while others appeared to be more transient. These data suggest that intraspecific variability exists in grey seal movement patterns, and highlight the importance of key habitats.

SKIN BIOPSIES FOR CELL CULTURES FROM MEDITERRANEAN FREE-RANGING CETACEANS

L. Marsili[1], M.C. Fossi[2], G. Neri[1], S. Airoldi[3], G. Bearzi[3] and S. Panigada[3]

[1]*Department of Environmental Sciences, Siena University, Via Mattioli 4, 53100 Siena, Italy*
(E-mail: marsilil@unisi.it)
[2]*Department of Animal Biology and Marine Ecology, Messina University, Italy*
[3]*Tethys Research Institute, Milano, Italy*

INTRODUCTION Various species of Mediterranean cetaceans have declined dramatically this century. One of the most abundant species until the late 1970s, the common dolphin (*Delphinus delphis*), is now rare in many parts of the basin (Notarbartolo di Sciara and Demma, 1994). Ecotoxicological data on cetaceans are of interest for various reasons, principally because cetaceans do not have sweat and sebaceous glands or gills, so they are a relatively closed system. Recent studies on the metabolic capacity of cetaceans has shown that these marine mammals have a relatively inefficient detoxifying capacity (Watanabe *et al.*, 1989; Tanabe & Tatsukawa, 1992; Fossi *et al.*, 1992; 1997a, 1997b; Fossi & Marsili, 1997). Moreover, the species of cetaceans are thought to have different sensitivities to environmental contaminants, especially organochlorines (OCs), and this may impinge on their vulnerability to these contaminants (Marsili *et al.*, 1996; Marsili *et al.*, 1998). Most studies of contamination and biomarker responses in marine mammals have been conducted using animals killed by hunting, tacitly approving this activity. The development of a series of non-destructive techniques to evaluate biomarker responses and residue levels is strongly recommended for the hazard assessment, protection, and conservation of endangered species of marine mammals (Fossi and Marsili, 1997). A non-invasive sampling method, the skin biopsy, and use of the material obtained to culture fibroblasts, have been developed in this study. In this paper, we present this method for biopsies of Mediterranean specimens of striped dolphin (*Stenella coeruleoalba)*, bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), fin whale (*Balaenoptera physalus*) and Risso's dolphin (*Grampus griseus*).

MATERIALS AND METHODS An epidermal/dermal layer, including a portion of the underlying blubber tissue, was obtained from Mediterranean cetaceans. Sampling was performed in the western Ligurian Sea (striped dolphin, Risso's dolphin, fin whale), in the southern Adriatic Sea (bottlenose dolphin), and in the Ionian Sea off Greece (bottlenose dolphin and striped dolphin).

Sampling method The biopsy dart, a regular aluminium crossbow bolt with a modified stainless steel collecting tip, was used in different ways depending on the species. In the case of fin whale, the dart was fired into the whale with a Barnett Wildcat II crossbow equipped with a 150-pound test bow. In striped dolphin, Risso's dolphin, and bottlenose dolphin, the biopsy was taken by mounting the dart at the end of a two-metre pole. For common dolphin, the dart was fired with either a Barnett Trident crossbow equipped with a 15-pound test bow, or a compressed CO_2 Pneudart gun. Biopsy specimens were taken from the dorsal area, near the dorsal fin, and the upper part of the caudal peduncle. The reaction to sampling varied from a slight start (odontocetes) to no reaction at all (mysticetes).

Culture method The skin sample was stored in sterile medium MEM Eagle Earle's salts w/L-glutamine and Sodium Bicarbonate (Mascia Brunelli, Milan, Italy) + 10% gamma irradiated fetal calf serum (Mascia Brunelli) + 1% MEM Not Essential Aminoacids (NEAA) solution 100X (Mascia Brunelli) + 1% Penicillin/Streptomycin 100X (Mascia Brunelli) + 0.1% Amphotericin B 100X (Mascia Brunelli) at ambient temperature, and was processed within 24 h of collection. In the laboratory, each sample was washed with Earle's balanced salt solution (EBSS) (Mascia Brunelli) containing antibiotic (Penicillin/Streptomycin 100X (Mascia Brunelli) and antimycotic (Amphotericin B 100X (Mascia Brunelli)) solutions. All specimens were handled using sterile techniques. First, the collected tissue was cut into small pieces with curved surgical scissors, placed in 30 mm Petri dishes and incubated with Trypsin-EDTA solution 1X (Mascia Brunelli) for 15 min at 37°C. The biopsy fragments were washed again and then placed in Falcon 25 flasks, moistened with medium. After 24 h at 37°C in an incubator with 5% CO_2, the cultures were covered with 1 ml of medium. Half of the culture medium was replaced every 48 h with fresh medium.

RESULTS Successful cell cultures were obtained from: striped dolphin, bottlenose dolphin, common dolphin, Risso's dolphin, and fin whale. The first fibroblasts were observed after 7-21 days (Fig. 1). Cultures reached 90% confluence in 15-20 days, then were trypsinised, washed and placed in Falcon 50 and 125 flasks, after two and three trypsinisations respectively. The samples grew for over 4 months; however, there were signs of senescence and increased resistance to trypsin treatment. Contamination by micro-organisms is one of the main causes of limited cell viability or slow cell growth. Rapid proliferation of bacteria, yeasts and fungal spores produces an unfavourable environment for the growth of the mammalian cells both by depletion of the available nutrients or for the changes in the pH. The contamination may be introduced into a culture from several routes (Freshney, 1983) but principally is a dormant infection in the sampled specimens. In fact, the most persistent infection was an environmental *Candida* spp. The antimycotic (Amphotericin B 100X) in the medium was inactive against the fungus. Various unsuccessful attempts were made to stop the infection. The antimycotic Canesten 1% (Bayer) was also attempted but the infection proliferated. Against bacterial infection, the cells were washed with Penicillin/Streptomycin 100X, and, surprisingly, the fibroblasts continued to grow, and the confluent layer did not seem to be damaged. We tested also Gentamicina but we notice that this antibiotic damaged the confluent layer.

CONCLUSIONS In conclusion, the main result of this research is the successful growth of fibroblasts from Mediterranean free-ranging cetaceans. In fact, an on-line bibliographic search from 1980 to 1999 showed that the cases of success in preparing epidermic cell cultures from marine mammals are very rare (Mathews *et al.*, 1988; Gauthier *et al.*, 1998). Moreover, there are no good cases published for fibroblast culture obtained from the cetacean specimens used in this study. It is hoped to obtain genetic, biochemical and toxicological information from cultures of fibroblast cells grown from skin biopsy specimens. These data will be valuable for long-term field study of free-ranging cetaceans. In particular, the tissue culture system will allow the study of relationships between contamination and biochemical responses. One of the planned applications of this *in vitro* system which has been developed will be the assessment of interspecies differences in the mixed function oxidase activity (BPMO, EROD, PROD, Cyt.-1A1) activity induced by *in vitro* treatment of various contaminants (DDT, PCBs, PAHs, etc.), added at different concentrations (Fossi *et al.*, submitted).

REFERENCES

Fossi, M. C., Marsili, L., Leonzio, C., Notarbartolo di Sciara, G., Zanardelli, M., and Focardi, S. 1992. The use of non-destructive biomarker in Mediterranean cetaceans: preliminary data on MFO activity in skin biopsy. *Mar. Pollut. Bull.*, 24(9): 459-461.

Fossi, M. C., Marsili, L., Junin, M., Castello, H., Lorenzani, J. A., Casini, S., Savelli, C.,, and Leonzio, C. 1997a. Use of nondestructive biomarkers and residue analysis to assess the health status of endangered species of pinnipeds in the southwest Atlantic. *Mar. Pollut. Bull.* 34(3): 157-162.

Fossi, M. C., Savelli, C., Marsili, L., Casini, S., Jimenez, B., Junin, M., Castello, H., and Lorenzani, J. A. 1997b. Skin biopsy as a nondestructive tool for the toxicological assessment of endangered populations of pinnipeds: preliminary results on mixed function oxidase in *Otaria flavescens. Chemosphere,* 35(8): 1623-1635.

Fossi, M. C. and Marsili, L. 1997. The use of non-destructive biomarkers in the study of marine mammals. *Biomarkers*, 2: 205-216.

Fossi, M. C., Marsili, L., Neri, G., Casini, S., Bearzi, G., Politi, E., Zanardelli, M. and Panigada, S. 2000. Skin biopsy of Mediterranean cetaceans for the investigation of interspecies susceptibility to xenobiotic contaminants. *Mar. Envir. Res.*, (*In press*).

Freshney, R I. 1983. *Culture of animal cells.* Alan R. Liss, Inc., New York.

Gauthier, M. J., Dubeau, H., and Rassart E. 1998. Mercury-induced micronuclei in skin fibroblasts of beluga whales. *Env. Tox. Chem.*, 17(12): 2487-2493.

Marsili, L., Fossi, M. C., Notarbartolo di Sciara, G., Zanardelli, M., and Focardi, S. 1996. Organochlorine levels and mixed function oxidase activity in skin biopsy specimens from Mediterranean cetaceans. *Freshw. Environ. Bull.*, 5: 223-228.

Marsili, L., Fossi, M. C., Notarbartolo di Sciara, G., Zanardelli, M., Nani, B., Panigada, S., and Focardi, S. 1998. Relationship between organochlorine contaminants and mixed function oxidase activity in skin biopsy specimens of Mediterranean fin whales (*Balaenoptera physalus*). *Chemosphere*, 37(8): 1501-1510.

Mathews, E. A., Keller, S., and Weiner, B. D. 1988. A method to collect and process skin biopsies for cell culture from free-ranging gray whales (*Eschrichtius robustus*). *Mar. Mamm. Sci*, 4(1): 1-12.

Notarbartolo di Sciara, G. and Demma,, M. 1994. *Guida dei Mammiferi marini del Mediterraneo*. Franco Muzzio Editore, Padova, Italy. 262pp.

Watanabe, S., Shimada, T., Nakamura, S., Nishiyama, N., Yamashita, N., Tanabe, S., and Tatsukawa, R. 1989. Specific profile of liver microsomal cytochrome P-450 in dolphin and whales. *Mar. Environ. Res.*, 27: 51-65.

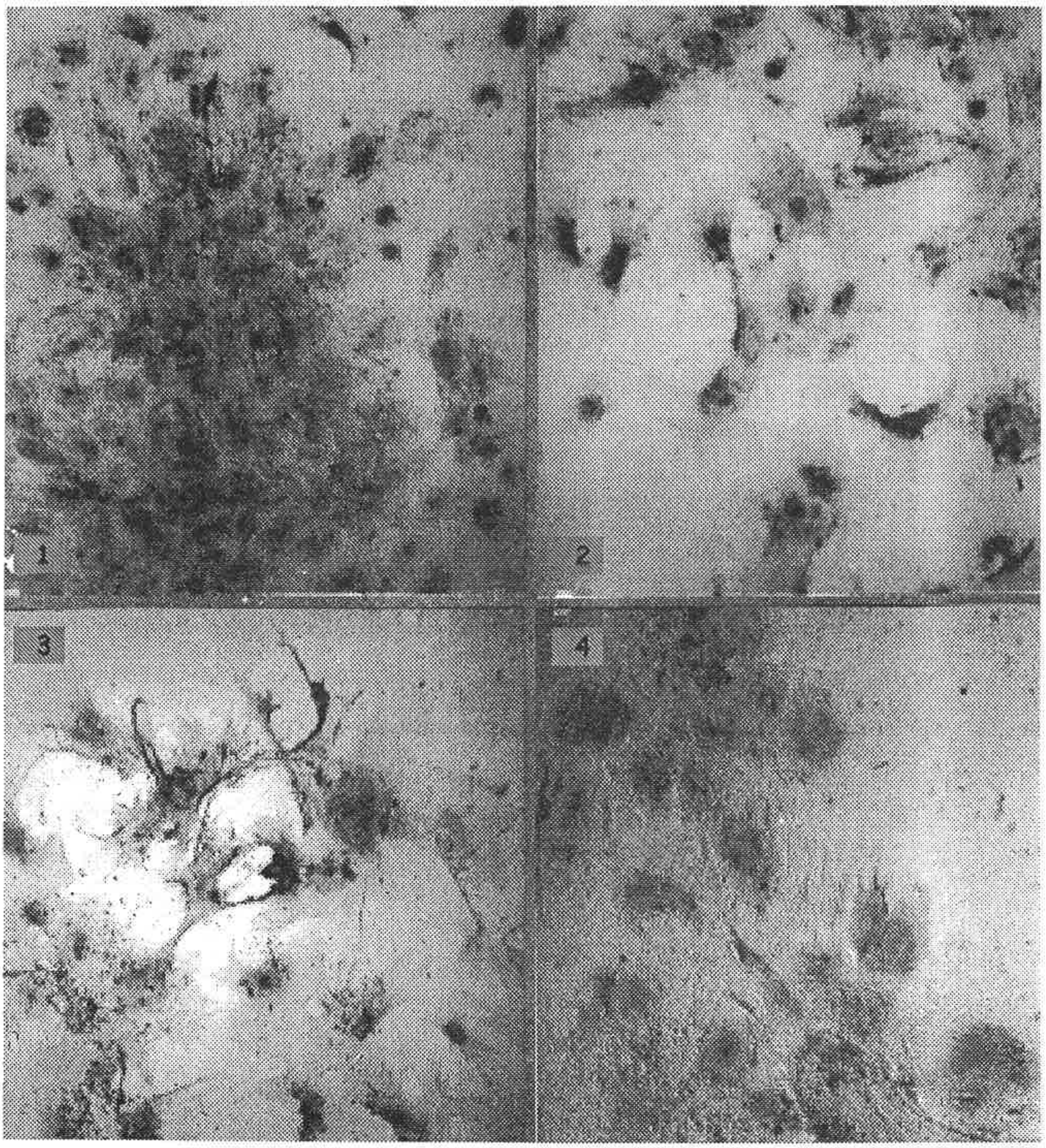


Fig. 1. Fibroblasts of bottlenose dolphin (31.25X) in different areas of the slide. For microscope photos, cells were stained with 0.3% Sudan III and than with Mayer haematoxylin. The photo 4 is in interferential contrast.

EVIDENCE FOR MALNUTRITION IN BOTTLENOSE DOLPHINS PHOTO-IDENTIFIED IN THE EASTERN IONIAN SEA

E. Politi, G. Bearzi and S. Airoldi

Tethys Research Institute, Viale G.B. Gadio 2, 20121 Milano, Italy E-mail: politie@tin.it)

INTRODUCTION A bottlenose dolphin (*Tursiops truncatus*) community has been consistently studied since 1993 in the eastern Ionian Sea coastal waters. The community includes 44 photo-identified individuals showing high levels of site fidelity and sharing the same area with a sympatric community of short-beaked common dolphins (*Delphinus delphis*; Politi, 1998; Politi *et al.*, 1999).

Photographs of identified dolphins showed that several individuals had noticeably poor body condition. As "the lack of sufficient food to maximise reproductive potential may be the most important regulator of population size in animals" (Chapmann and Reiss, 1999), the reported findings may be indicative of the potential threats affecting this coastal bottlenose dolphin community.

MATERIALS AND METHODS The study area, roughly 500 km^2, included the inshore waters surrounding the island of Kalamos, as delimited by the mainland and the islands of Lefkada and Meganisi.

From inflatable craft with outboard engines, we conducted a total of 495 daily surveys from 1993 to 1998, for a total of 22 months spent in the field. Photo-identification was performed using reflex autofocus cameras equipped with 80-200mm f2.8 zoom lenses and Ektachrome EPR 64 ISO or Fuji Provia 100 ISO colour transparency film.

From a catalogue including 2,500 colour slides, a subset of 356 photographs was selected based on sufficient dolphin exposure during surfacing (*i.e.*, visible rib cage).

The subset was then analysed for photo quality, according to appropriate dolphin distance, photo sharpness and contrast. This resulted in a sub-subset of 223 photographs with sufficient quality.

This sample included 106 multiple photographs of identifiable individuals (based on long-term natural marks) and 117 photographs of unidentifiable individuals. Following slide matching, a total of 28 different individuals could be identified. The best photograph for each of these 28 individuals was analysed to evaluate body conditions.

A dolphin was considered as "skinny" if inter-rib spaces were distinctively hollowed in the visible part of the thorax (Fig. 1); as "non-skinny" otherwise

Out of the 28 independently-sampled individuals, 17 (61%) could be classified as "non-skinny" and 11 (39%) as "skinny" (Fig. 2).

CONCLUSIONS The high percentage of individuals showing signs of malnutrition suggests that the community is experiencing feeding-related difficulties.

In the eastern Ionian Sea bottom trawling is seasonally intensive (autumn to spring) and has reportedly reduced local demersal fish resources. Since 1985, it has been acknowledged that the hake in this area has been "heavily overfished", local stocks being largely composed by immature individuals (Papaconstantinou *et al.*, 1985). As bottlenose dolphins in the Mediterranean Sea largely rely on demersal food prey (Voliani and Volpi, 1990; Orsi Relini *et al.*, 1994; Salomon *et al.*, 1997; Miokovic *et al.*, 1999), the species may be negatively affected by local overfishing, particularly as far as trawling fisheries are concerned.

Potential "food-web competition" (Trites *et al.*, 1997) with the sympatric community of short-beaked common dolphins may also occur (Ferretti, 1999). However, this is unlikely to account for the dramatic level of bottlenose dolphin malnutrition recorded in the area, also considering that the two species seem to have rather diverse food preferences and strategies (Ferretti, 1999; Ferretti *et al.*, 1999; Cabras, 2000).

The small size of the bottlenose dolphin community (Politi, 1998) and its degree of genetic isolation (Natoli and Hoelzel, this volume) suggest that this community may have undergone a substantial decline, and may be currently under threat. Critical habitat requirements - particularly as far as prey availability is concerned - must be assessed to ensure the survival of this coastal bottlenose dolphin community.

ACKNOWLEDGEMENTS We are grateful to Sebastiano Bruno, Sabrina Ferretti, Alexandros Frantzis and Ada Natoli for contributing to field data collection.

REFERENCES

Cabras, E. 2000. Il comportamento acustico di due specie di delfini: uno strumento per la valutazione della qualità ambientale. Degree in Environmental Sciences thesis, University of Venice, Italy. 95pp.

Chapmann, J. L. and Reiss, M. J. 1999. *Ecology: principles and applications* (2nd edition). Cambridge University Press, Cambridge. 330pp.

Ferretti, S. 1999. *Comportamento respiratorio di delfini comuni (Delphinus delphis) e tursiopi (Tursiops truncatus) osservati nelle acque costiere della Grecia Ionica.* Degree in Biological Sciences thesis, University of Milan, Italy. 157pp.

Ferretti, S., Bearzi, G., and Politi, E. 1998. Comparing behavior of inshore bottlenose and common dolphins in the Eastern Ionian Sea through focal group surfacing pattern analysis. P. 209. In: *European Research on Cetaceans - 12.* Proc. 12th Ann. Conf. ECS, Monaco, 20-24 Jan, 1998. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

Miokovic, D., Kovacic, D. and Pribanic, S. 1999. Stomach content analysis of one bottlenose dolphin (*Tursiops truncatus*, Montagu 1821) from the Adriatic Sea. *Natura Croatica*, 8(1): 61-65.

Orsi Relini, L., Cappello, M. and Poggi, R. 1994. The stomach content of some bottlenose dolphins (*Tursiops truncatus*) from the Ligurian Sea. Pp. 192-195. In: *European Research on Cetaceans* - 8. Proc. 8th Ann. Conf. ECS, Montpellier, France, 2-5 Mar, 1994. (Ed. P. G. H. Evans). European Cetacean Society, Lugano, Switzerland. 288pp.

Politi, E. 1998. Un progetto per i delfini in Mediterraneo. *Le Scienze*, 360: 64-69.

Politi, E., Airoldi, S., Natoli, A., and Frantzis, A. 1999. Unexpected prevalence of common dolphins over sympatric bottlenose dolphins in eastern Ionia Sea inshore waters. P. 120. In: *European Research on Cetaceans - 12.* Proc. 12th Ann. Conf. ECS, Monaco, 20-24 Jan, 1998. (Eds. P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Valencia, Spain. 436pp.

Papaconstantinou, C., Caragitsou, H., and Panos, T. 1985. Preliminary utilization of trawl survey data for hake (*M. merluccius*) population dynamics from the Western Greek waters. *FAO Fisheries Report*, 345: 87-92.

Salomon, O., Blanco, C., and Raga, J. A. 1997. Diet of the bottlenose dolphin (*Tursiops truncatus*) in the Gulf of Valencia (western Mediterranean). P. 156. In: *European Research on Cetaceans* - 11. Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997. (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

Trites, A. W, Christensen, V. and Pauly, D. 1997. Competition between fisheries and marine mammals for prey and primary production in the Pacif Ocean. *Journal of Northwest Atlantic Fishery Science*, 22: 173-187.

Voliani, A. and Volpi, C. 1990. Stomach content analysis of a stranded specimen of *Tursiops truncatus. Rapp. Comm. int. Mer Médit.*, 32: 238.

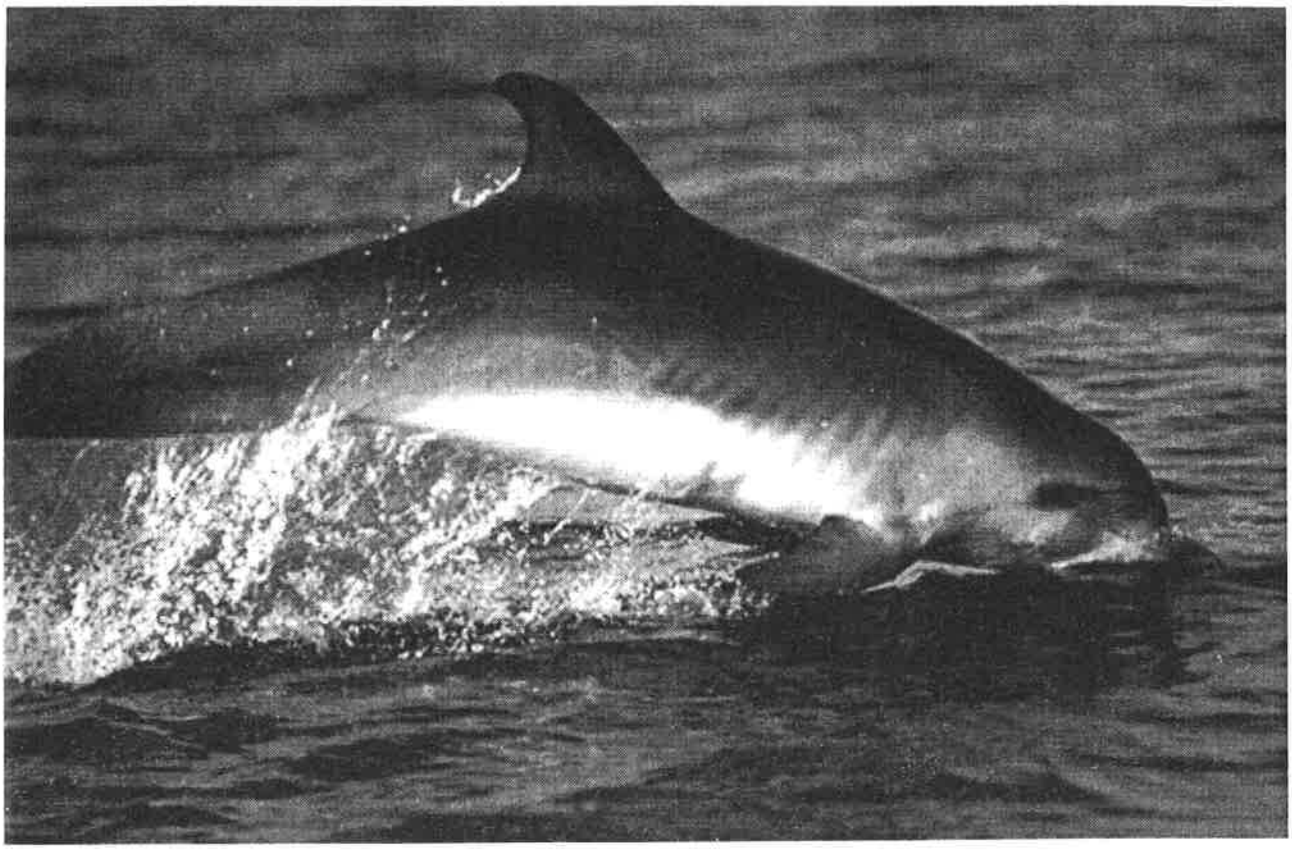


Fig. 1. A bottlenose dolphin considered as "skinny", based on inter-rib spaces distinctively hollowed in the visible part of the thorax

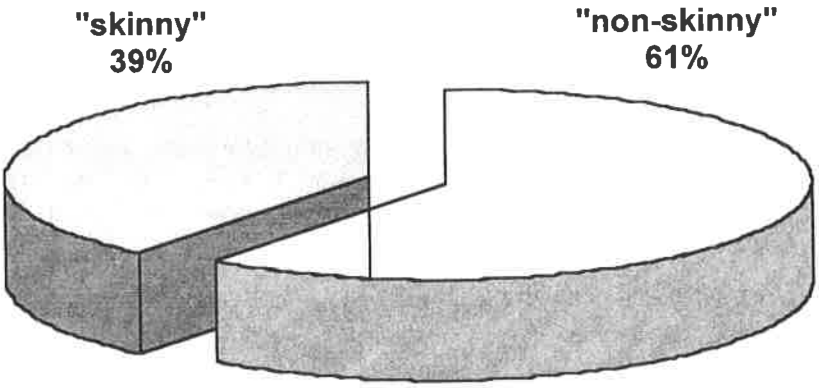


Fig. 2. Proportion of bottlenose dolphins considered as "skinny" and as "non-skinny" out of 28 independently-sampled individuals

INTER-DECADAL VARIATION IN MATERNAL INVESTMENT OF HARBOUR PORPOISES IN THE GULF OF MAINE

A. J. Read

Duke University Marine Lab, 135 Duke Marine Lab Rd., Beaufort NC 28516, USA

The primary prey of harbour porpoises, *Phocoena phocoena*, in the Gulf of Maine is Atlantic herring *Clupea harengus*. In the early 1970s, herring biomass in the Gulf of Maine collapsed to less than 100,000 tonnes due to overfishing. Since that time, herring biomass has increased exponentially, reaching almost 3 million tonnes in the late 1990s. I tested the hypothesis that trends in the maternal investment of harbour porpoises reflect those of their prey and, specifically, that the size of porpoise calves increased between 1970 and 1999. I used the size of calves measured in August as a measure of maternal investment. In August, calves are approximately three months old and still reliant on milk as their primary energy source; their size thus reflects the amount of energy invested by lactating females. Calves were obtained from a research collection in the 1970s, and as bycatch in commercial fisheries in the 1980s and 1990s. The size of calves increased significantly from 93 cm and 16 kg in the 1970s (n = 13) to 106 cm and 25 kg in the 1980s (n = 20), following the trend in herring biomass. Calf size then decreased significantly to 100 cm and 21 kg in the 1990s (n = 18), even as herring biomass continued to increase. Decadal differences in calf size were not caused by changes in the timing of parturition, which was constant over the three decades. The body condition of lactating females, measured by body mass and blubber thickness, did not change between the 1980s and 1990s; no data on maternal condition are available from the 1970s. These results suggest that either fisheries stock assessments do not reflect the true availability of prey, or factors other than herring biomass affect the dynamics of maternal investment in harbour porpoises.

RECENT CHANGES IN THE DISTRIBUTION PATTERN OF KILLER WHALES AND HERRING IN THE COASTAL WATERS OF NORTHERN NORWAY

T. Simila[1], J. C. Holst[2] and I. Røttingen[2]

[1]*Boks 181, 8465 Straumsjoen, Norway*
[2]*Institute of Marine Research, P.O Box 1870, 5011 Nordnes-Bergen, Norway*

Occurrence of killer whales (*Orcinus orca*) in the coastal waters of Northern Norway is related to the presence of their main prey species, Norwegian spring spawning herring (*Clupea harengus*). Since 1990, photo-identification and behavioural studies of killer whales have been co-ordinated with research monitoring the abundance and distribution of herring. This co-operation has offered a unique possibility to study interactions between killer whales and herring. The aim of this study was to document how occurrence and behaviour of killer whales is affected by changes in the distribution pattern of herring. Since 1989, the summer feeding grounds of herring have changed from coastal to oceanic waters, and the occurrence of killer whales has decreased in the study area. Between 1987 and1995, the herring biomass (in 1990-1993, 2.2-3.4 million tons) was dominated by the 1983 year-class which wintered mainly in two sheltered fjords (Tysfjord and Ofotfjord), and an estimated 500-600 killer whales occurred in these fjords from October to January. Since 1996, the wintering biomass of herring has increased substantially, and, in 1998, it was estimated to be 9-10 million tons. This biomass is dominated by 1991 and 1992 year-classes which have chosen a different wintering strategy from the 1983 year-class staying mainly in the exposed Vestfjord area. Since 1996, an estimated 200-250 killer whales which were regularly observed in 1990-95, have not been sighted in the study area. In the old wintering grounds of herring (Tysfjord and Ofotfjord), the whales preferred feeding in shallow waters and areas with underwater seamounts. Such areas are not frequent in the present wintering grounds, and there has been change in the habitat use of feeding and foraging killer whales. This study shows how changes in distribution and abundance of prey species can affect the patterns in occurrence, habitat use, and behaviour of killer whales.

INTER-ANNUAL VARIATIONS IN THE FEEDING PATTERNS OF GREY SEALS *HALICHOERUS GRYPUS* FROM TWO BREEDING COLONIES AS DETERMINED BY BLUBBER FATTY ACID PROFILE ANALYSIS

M. J. Walton and P. P. Pomeroy

Sea Mammal Research Unit, Gatty Marine Laboratory, St Andrews, KY16 8LB, Scotland

Environmentally acquired characters such as fatty acid profiles of blubber may be used to indirectly study factors which are difficult to observe directly, such as stock structure and both foraging and feeding behaviour. Such studies complement other studies using genetic techniques, faecal or stomach content analysis, and satellite telemetry.

In the present study, blubber fatty acid profiles have been used to investigate the feeding behaviour of seals from two breeding sites (the Isle of May and North Rona) over the three years, 1996-98. Blubber biopsies were collected from over 20 seals per site per year and the fatty acid profiles determined by gas chromatography. The seals were branded and many were captured in at least two and sometimes all three years. This allowed inter-annual feeding variations to be studied in individual seals of each colony. Profiles were compared using multivariate statistical procedures (e.g. principal components analysis, discriminant analysis, classification TREES).

The results showed a clear differentiation between the profiles from the two sites in every year studied, implying that the seals have fed at different sites on different prey species. (Without much more information on prey fatty acid profiles, it is not yet possible to identify the individual prey components of the seal fatty acid profiles.) Within each breeding colony, inter-annual differences could be detected although these were much greater in seals from Isle of May than from North Rona.

The results implied that the diet of the seals on Rona varied little between the years studied and as a consequence there was comparatively little change in the fatty acid profiles. In contrast, there appeared to be major differences in the diet of seals on Isle of May, especially between 1997 and 1998. This finding supports data obtained from faecal analysis of seals during the same period.

SIGHTINGS OF BEAKED WHALE SPECIES (CETACEA: ZIPHIIDAE) IN THE WATERS TO THE NORTH AND WEST OF SCOTLAND AND THE FAROE ISLANDS

Caroline R. Weir

Seabirds and Cetaceans Branch, Joint Nature Conservation Committee, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ (E-mail: weir_c@jncc.gov.uk)

INTRODUCTION The Seabirds at Sea Team (SAST) of the Joint Nature Conservation Committee has carried out surveys of seabirds in the waters around Britain and Ireland since 1979. The data resulting from SAST surveys has been added to that from similar seabird surveys carried out in other European countries, to form the European Seabirds at Sea (ESAS) database. Data on marine mammals are collected alongside seabird surveys and the resulting ESAS cetacean database is one of the largest effort-related sightings databases in the north-east Atlantic, containing over 10,000 cetacean records of 17 species. The initiation of SAST and European surveys in offshore waters around Scotland and the Faroe Islands during 1995 to 1999 presented a rare opportunity to observe species of beaked whale at sea. Beaked whales (family Ziphiidae) inhabit deep, offshore waters, where they are normally inaccessible to researchers.

METHODS The study area lies between latitudes 55°N and 65°N, and longitudes 2°E and 15°W (Fig. 1). The region contains shelf waters around Scotland, Iceland and four island groups, the Faroe, Shetland and Orkney Islands, and the Western Isles. The remainder of the study area is composed of deep water, reaching depths of 1,700 m in the Faroe-Shetland Channel, to over 2,000 m in the Rockall Trough and 3,000 m in the Norwegian Basin.

Surveys were carried out from a number of 'platforms of opportunity', using standard methodology for counting seabirds at sea (Tasker *et al.*, 1984; Webb & Durinck, 1992). Cetaceans were recorded opportunistically during the seabird survey whenever they were observed. For each cetacean sighting, the species, number of animals (and age where known), behaviour, direction of travel, and distance from the vessel (transect band) were recorded. The vessel's position, speed and course were recorded or calculated for 10-minute periods using a Global Positioning System (GPS) receiver. Environmental data including wind speed and direction, sea state, swell height and visibility were recorded every 90 minutes, or more frequently if conditions changed. All data from the ESAS database, relating to the defined study area, were included in the production of maps. Survey effort data were calculated as total km^2 survey coverage achieved for each ICES (International Council for the Exploration of the Sea) rectangle (15' latitude by 30' longitude). Maps of survey effort and cetacean distribution were produced using Dmap for Windows (Morton, 1995).

RESULTS A total of 94,347 km^2 survey coverage was achieved in the study area between June 1979 and April 1999. Survey effort prior to 1995 was primarily based along shelf waters of less than 200 m depth, with surveys centred on the North Sea, the west coast of Scotland, and shelf waters around the Faroe Islands (Fig. 2). Since 1995, the emphasis of the surveys has moved to the deep, offshore waters of the Faroe-Shetland Channel, and a high level of survey coverage (>60 km^2 per ICES rectangle) has been achieved along the shelf edge. Coverage has also varied on a seasonal basis; between 1995 and 1999 when dedicated offshore work was carried out, the summer months of June to August received more than double the level of survey coverage than any other season, as a result of longer daylight hours and better weather conditions during the summer months.

Northern bottlenose whale There have been 22 sightings (62 animals) of northern bottlenose whales within the study area; all have occurred since survey work in deep, offshore water commenced in 1995. Within the region, bottlenose whales were associated with deep, offshore waters of over 1,000 m depth (Fig. 3). All sightings of bottlenose whales within the survey area were between March and November, with a peak in both number of individuals and number of sightings during May and June (Fig. 4). Group size also increases during these two months, from an average of 2.8 animals to 3.4 animals (May) and 3.8 animals (June). Animals were recorded north of the Faroe Islands in deep water (>2,000 m) during June and July, and mostly south of the Faroes during the spring and autumn. However, lack of survey coverage at higher latitudes during the other months of the year limits assumptions regarding seasonal migratory movements in this species. During September, three sightings were made over the Rockall Bank in less than 200 m water depth.

Sowerby's beaked whale Sowerby's beaked whale has been positively identified twice within the survey area (Fig. 5). The first sighting occurred on 5 August 1995, when a single un-aged animal was seen in 1,080 m of water to the north-west of the Faroe Bank. The second sighting was recorded on 28 June 1998, when an animal surfaced twice to the south of the Rosemary Bank in 1,700 m water. The close proximity of the animal to the boat (<20 m) allowed a clear view of the head and back, which showed considerable scarring. The position of the teeth half way along the lower jaw, confirmed the animal as an adult male Sowerby's beaked whale.

Unidentified *Mesoplodon* species The majority of beaked whale sightings in the survey area were of animals unidentified to species level. However, the general size and behaviour of the animals and the shape of the head and beak, indicate that these animals belong to the genus *Mesoplodon.* The animals showed considerable variation in colour and morphology; however, all were similar in length (3.5–5 m), had a broad base to the dorsal fin, and had distinctly long and narrow beaks. It was generally considered that the majority of these animals were Sowerby's beaked whales. There have been 26 sightings (74 animals) of unidentified species of *Mesoplodon* within the survey area (Fig. 6), all occurring since the commencement of offshore survey work in 1995. *Mesoplodon* species have been recorded throughout the year except for February and March, when survey coverage along the deep waters of the shelf edge was also low due to bad weather. The number of both individuals and sightings shows a clear peak in the month of August, and this is predominantly due to one cruise in August 1998 which recorded 10 sightings of 39 animals. Group size of *Mesoplodon* species ranged from 1 to 10 animals. *Mesoplodon* species have rarely been recorded further north than 62°30'N, and the centre of their distribution appears to be to the north-west of the Western Isles where 21 of the 26 *Mesoplodon* species sightings have been recorded. This region has a complex seabed topography encompassing a series of ridges and channels. *Mesoplodon* species were not recorded in water of less than 700 m depth within this area, and seemed to associate predominantly with depths of between 700 and 1,200 m (14 sightings). There were four sightings over water depths of between 1,300 and 1,600 m, and three sightings in water depth of over 1,800 m.

CONCLUSIONS Surveys carried out to the north and west of Scotland and the Faroe Islands since 1979 have confirmed the offshore habitat of beaked whale species in this region; whales were sighted in deep waters typically greater than 1,000 m in depth. Despite the occurrence of strandings of Sowerby's beaked whale in the shallow North Sea (Mead, 1989), dedicated surveys within this area have not recorded any beaked whales. While northern bottlenose whales were widely distributed throughout the survey area, species of *Mesoplodon* showed a distribution pattern centred in an area to the north-west of the Western Isles. The distribution of beaked whale species in deep, offshore waters is probably related to that of their prey species, deep-water cephalopods (Mead, 1989; Bloch *et al.*, 1996).

ACKNOWLEDGEMENTS Although limited space prevents individual acknowledgement of all of the companies involved, many thanks go to the Atlantic Frontier Environmental Network (AFEN), and additionally to the Atlantic Margin Group for sponsorship of this work. Thanks also go to our European partners for allowing inclusion of data from the European Seabirds at Sea (ESAS) database. Many thanks to the observers who collected data, and to Ciarán Cronin, Jim Reid, and Sam Taylor for comments on the draft.

REFERENCES

Bloch, D., Desportes, G., Zachariassen, M., and Christensen, I. 1996. The northern bottlenose whale in the Faroe Islands, 1584-1993. *Journal of Zoology, London*, 239: 123-140.

Mead, J. G. 1989. Beaked whales of the genus *Mesoplodon.* Pp. 349-430. In: *Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales.* (Eds. S. H. Ridgway and R. J. Harrison). Academic Press, London.

Morton, A. 1995. *Dmap for windows. A computer program for distribution and coincidence mapping.* Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire SL4 4QR, UK.

Tasker, M. L., Jones, P. H., Dixon, T. J., and Blake, B. F. 1984. Counting seabirds at sea from ships: A review of methods employed and a suggestion for a standardised approach. *Auk*, 101: 567-577.

Webb, A. and Durinck, J. 1992. Counting birds from ship. Pp. 24-37. In: *Manual for aeroplane and ship surveys of waterfowl and seabirds* (Eds. J. Komdeur, J. Bertelsen, and G. Cracknell). IWRB Special Publication No. 19, Slimbridge. 37pp.

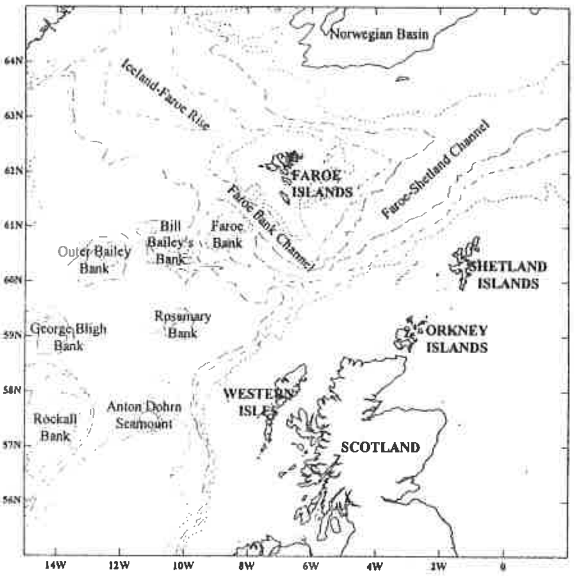
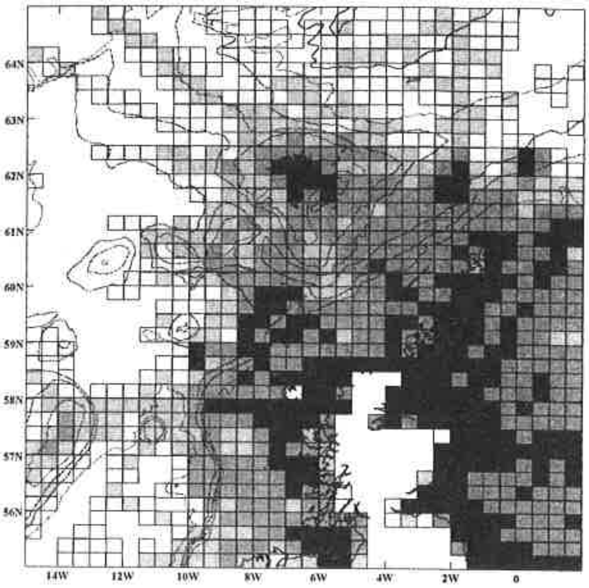


Fig. 1. The study area showing bathymetry and place names

Bathymetry: dot (200 m); dotdash (500 m); dash (1,000 m); dot (2,000 m); solid (3,000 m)



Effort (km² surveyed):

☐ 0.01-9.99 ▨ 10.00-49.99 ■ 50.00-149.99 ■ 150.00+

Fig. 2. Distribution of survey effort, June 1979 – April 1999

Bathymetry: dot (200 m); dotdash (500 m); dash (1,000 m); dot (2,000 m); solid (3,000 m)

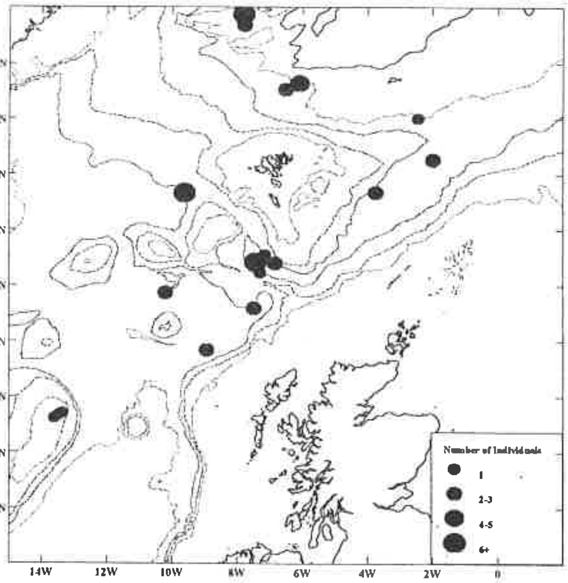


Fig. 3. Location of northern bottlenose whale sightings

Bathymetry: dot (200 m); dotdash (500 m); dash (1,000 m); dot (2,000 m); solid (3,000 m)

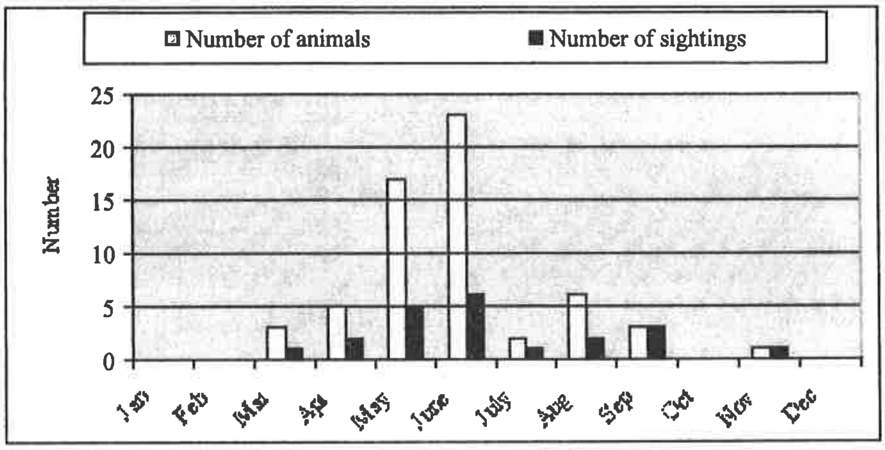


Fig. 4. Seasonal distribution in number of northern bottlenose whales

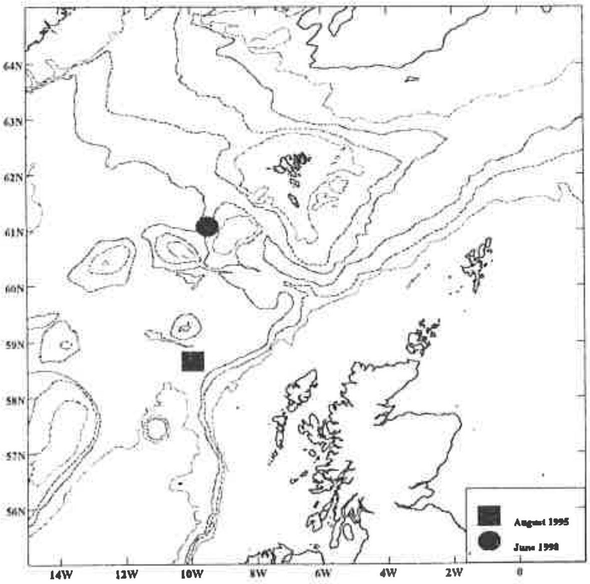


Fig. 5. Location of Sowerby's beaked whale sightings

Bathymetry: dot (200 m); dotdash (500 m); dash (1,000 m); dot (2,000 m); solid (3,000 m)

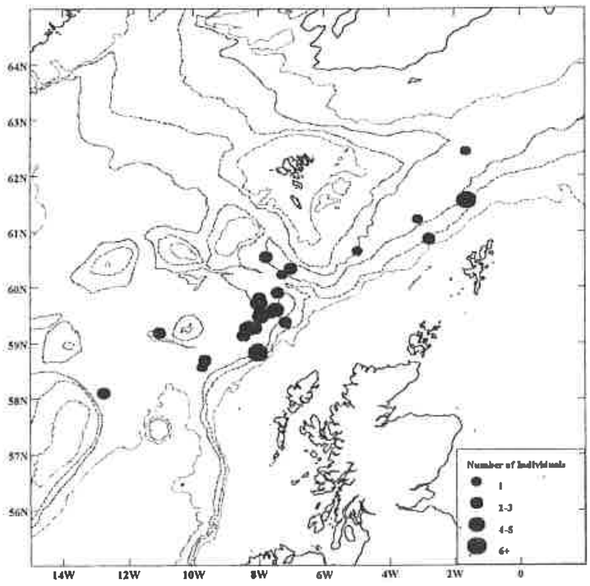


Fig. 6. Location of sightings of unidentified *Mesoplodon* species
Bathymetry: dot (200 m); dotdash (500 m); dash (1,000 m); dot (2,000 m); solid (3,000 m)

LIFE HISTORY

AGE AND GROWTH OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA RELICTA*) FROM THE BLACK SEA AND THE SEA OF AZOV

P. E. Gol'din

BREMA Laboratory, 27-2a R. Luxembourg str., 95000 Simferopol, Crimea, Ukraine &
Dept. of Zoology, Tauric National University, 4, Yaltinskaya str., 95000 Simferopol,
Crimea, Ukraine

During 1997-99, 80 harbour porpoises were sampled from strandings (19) and by-catch (61) along the Black Sea and Azov Sea coasts of Crimea (Ukraine). The standard body length, weight, and girth behind the flippers were measured. The age was determined by counting the number of growth layer groups in dentine (Perrin & Myrick, 1980). For this, paraffin longitudal sections of the teeth 10 μ thick were made, mounted on the slide and stained with Erlich's haematoxylin for 70-100 min. When GLGs were analysed, the age of almost-one-year animals was considered as 1 year. Growth curves for the total sample and both sexes were analysed and approximated by von Bertalanffy, Gompertz and logistic growth formulae, as well as by power and logarithmic dependencies. Multifactor power growth formula was proposed.

Age structure The sample (42 males, 33 females, 5 animals with sex unknown) included animals age 0-13 years (Fig. 1). Mean age was 4.73±1.07 yr in males, and 5.24±1.23 yr in females (P=0.05 in all the calculations); maximum age was 13 yr in males and 12 yr in females. The relatively low value of the maximum age can be explained by the sample size and the prevalence of by-caught porpoises; similar results were obtained for close samples in the Bay of Fundy (Gaskin & Blair, 1977) and West Greenland (Lockyer *et al.*, 1999).

Growth in body length The length at birth is 62-83 cm (mean 73.3±8.3 cm), which corresponds with data from other Atlantic populations (e. g. Lockyer, 1995; Benke *et al.*, 1998;). The mean length of animals 8-13 yrs old (suggested as asymptotic) is 117-152 cm (mean 126.2±10.0 cm) in males, and 127-146 cm (mean 134.4±5.8 cm) in females (the latter are significantly longer). The main increase in body length appears to occur during the 1st year of life – 1-year old porpoises have the mean length of 109.4±3.6 cm, but some females reach 118-120 cm long at the beginning of the 2nd year. After 3 yr, all the animals become longer than 117 cm, and some of them almost reach the asymptotic values in both sexes (the youngest female increases that value at age 4.5 yr, and the youngest male at 6 yr). The maximum lengths of immature animals are 126 cm (male, 2 yr) and 132 cm (female, 3 yr); the minimum lengths of mature animals are 117 cm (male, 9 yr) and 121.5 cm (female, 3 yr). From the 3rd year, the longest females are larger than the longest males, and the 4-6 yr old females are already significantly longer than the males of the same age.

The predictions made by the growth formulae divide into two groups (Fig. 2a, b): 1) Gompertz, von Bertalanffy, logistic – length at birth and the asymptotic values are estimated exactly (in comparison with the empirical ones) or underestimated. The highest values are given by the von Bertalanffy formula, the lowest ones – by a logistic equation, but the differences are insignificant.
2) Power, logarithmic - length at birth and the asymptotic values are not estimated or overestimated. The most exact estimates are made for the ages 1-3 and 6-8 yrs.

Growth in body weight. The mean weight of animals 8-13 yrs old (suggested as asymptotic) is 32-41 kg (mean 37.1±4.3 kg) in males, and 32.5-57 kg (mean 42±7.1 kg) in females (the latter are also significantly heavier). The main increase in body weight seems to take place during the 1st year, the mean weight of one-year old porpoises is 25.81 kg, and the heaviest specimens reach the minimum values of mature animals in both sexes. After 4 yrs, all the porpoises are heavier than 30 kg, after 7 yrs – heavier than 32 kg. The youngest animals reach the asymptotic values at the age of 6 yr (males) and 7 yr (females). The maximum weights of immature animals are 29.5 kg (male, 1 yr) and 34 kg (female, 3 yr); the minimum weights of mature animals are 23.5 and 27 kg (male, 5 yr) and 30 kg (female, 6 yr). Also, as well as during linear growth, from the 3rd year, the heaviest females are larger than the heaviest males, and the 4-6 yr old females are significantly heavier than the males of the same age.

The predictions made by the growth formulae divide into two groups (Fig. 3a, b):

Gompertz, logistic - weight at birth is estimated exactly and the asymptotic values are underestimated. The most exact estimates are made for the ages 4-6 yrs.

Power, logarithmic, von Bertalanffy - weight at birth and the asymptotic values are not estimated or overestimated; von Bertalanffy formula exactly predicts the asymptotic weight. The most exact estimates are made for the ages 1-3 and 6-13 yrs.

The multifactor power formula for body mass calculation was proposed (W – weight, L – length, G – girth, t – age, a, k, b, c – growth constants):

Formula	Sex	n	r^2	a	k±SE	b±SE	c±SE
$W=at^kL^bG^c$	M&F	52	0,8999	0.000548	0.0674±0.0196	1.1061±0.0354	1.2960±0.1698
	Males	26	0.8784	0.001025	0.0864±0.0257	0.8172±0.0420	1.4678±0.2323
	Females	26	0.9064	0.000174	0.0307±0.0342	1.5152±0.0557	1.1156±0.2659

CONCLUSIONS. The main tendencies of the weight and linear growth in the harbour porpoises from the Black Sea basin correspond to that of the species as a whole: the main increase in body size appears during the 1st year of life (some animals reach the minimum size of adult animals already at 1 yr of age, and this makes age estimation based on body length and weight impossible), the body length reaches the asymptotic value (6-9 yrs at the growth curve), and the body weight approaches a plateau only after 10 yrs. Sexual dimorphism in the growth curve starts to occur from sexual maturity (4-6 yr) onwards.

The body size of those animals examined is much smaller than in any Atlantic population. The asymptotic values (Fig. 4) for both sexes are closer to vaquita than to harbour porpoises in the North Atlantic, as is the minimum size of adult animals. The issue of small size in the Black Sea and Azov porpoises and the porpoises in the other regions was discussed in the 1930s-50s (e.g. Kleinenberg, 1956), but a clear explanation was not found. Sixty years ago, the length of adult porpoises was comparable to that of present-day animals in the North Atlantic, but the profound changes in growth took place since that time in animals both in the Black Sea basin and the Atlantic. The current status of the body size in the porpoises examined (that confirms the data on age-length relationships presented by Tanabe *et al.* (1997), can be explained by the impact of hunting until 1966, a decline in abundance and density of the population, or genetic differences in this isolated endemic subspecies. Further research is necessary in these fields.

The Von Bertalanffy formula seems to fit best the growth curves, although the Gompertz formula may describe the linear growth, and the power and logarithmic equations may better apply in certain cases. The proposed multifactor power formula fits very well almost all the data except the "extreme" animals, and may be a good basis for the body mass estimates.

ACKNOWLEDGEMENTS The author thanks his collaborators at BREMA Laboratory, especially Dr. A. Birkun, for their help at all stages of this research, Dr. S. Gilevich - for the advice on age determination, S. Kanishchev – for photo preparation and design, and Drs. C. Lockyer, A. Hohn, and A. Read, who kindly provided me with copies of their works.

REFERENCES

Benke, H., Siebert, U., Lick, R., Bandomir, B., and Weiss, R., 1998. The current status of harbour porpoises *(Phocoena phocoena)* in German waters. *Arch. Fish. Mar. Res.* 46(2): 97-123.

Gaskin, D. E. and Blair, B. A., 1977. Age determination of harbour porpoise *Phocoena phocoena* in the western North Atlantic. *Can. J. Zool.* 55: 18-30.

Hohn, A. A., Read, A. J., Fernandez, S., Vidal, O., and Findley, L. T., 1996. Life history of the vaquita, *Phocoena sinus* (Phocoenidae, Cetacea). *J. Zool., Lond.* 239: 235-251.

Kleinenberg, S. E., 1956. *Mammals of the Black and Azov Seas: experience of research on biology and hunting.* Moscow, USSR Acad. Sci. Publ. House. 288pp. [in Russian].

Lockyer, C., 1995. Investigation of aspects of the life history of the harbour porpoise, *Phocoena phocoena*, in British waters. In: Biology of the Phocoenids. *Report of the International Whaling Commission* (special issue 16): 189-197.

Lockyer, C., Heide-Jørgensen, M. P., Jensen, J. and Walton, M. J., 1999. Life history and ecology of harbour porpoises (*Phocoena phocoena*, L.) from West Greenland. Paper submitted to the NAMMCO International Symposium on Harbour Porpoises in the North Atlantic, held 10-14 September 1999, Bergen-Tromsø, Norway.

Lockyer, C. and Kinze, C. 1999. Status and life history of harbour porpoise, *Phocoena phocoena*, in Danish waters. Working paper submitted to *ICES Working Group on Marine Mammal Habitats*, March 1999, Copenhagen, ICES/WGMMHA/99/WP19. 39pp.

Perrin, W. F. and Myrick, A. C., Jr., (eds), 1980. Growth of Odontocetes and Sirenians: problems in age determination. Report of the workshop / Age determination of toothed whales and sirenians. *Report of the International Whaling Commission* (special issue 3): 1-50.

Read A.J., Gaskin, D.E., 1990. Changes in growth and reproduction of harbour porpoises from the Bay of Fundy. *Can. J. Fish. and Aquat. Sci.* 47(11): 2158-2163.

Tanabe, S., Madhusree B., Öztürk A.A., Tatsukava R., Miyazaki, N., Özdamar, E., Aral, O., Samsun, O., and Öztürk, B., 1997. Persistent organochlorine residues in harbour porpoise (*Phocoena phocoena*) from the Black Sea. *Mar. Poll. Bull.* 34(5): 338-347.

Tsalkin, V. I. 1938. Morphological characteristics of the harbour porpoise in the Black Sea and the Sea of Azov, 1938. *Zoologicheski Zhurnal* 17(4). [in Russian].

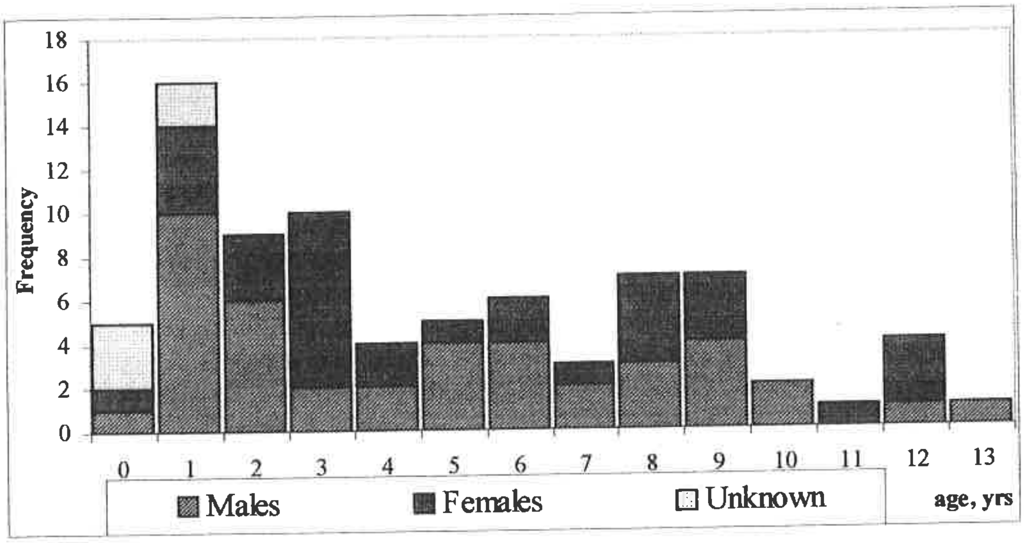


Fig. 1. Age structure of sample

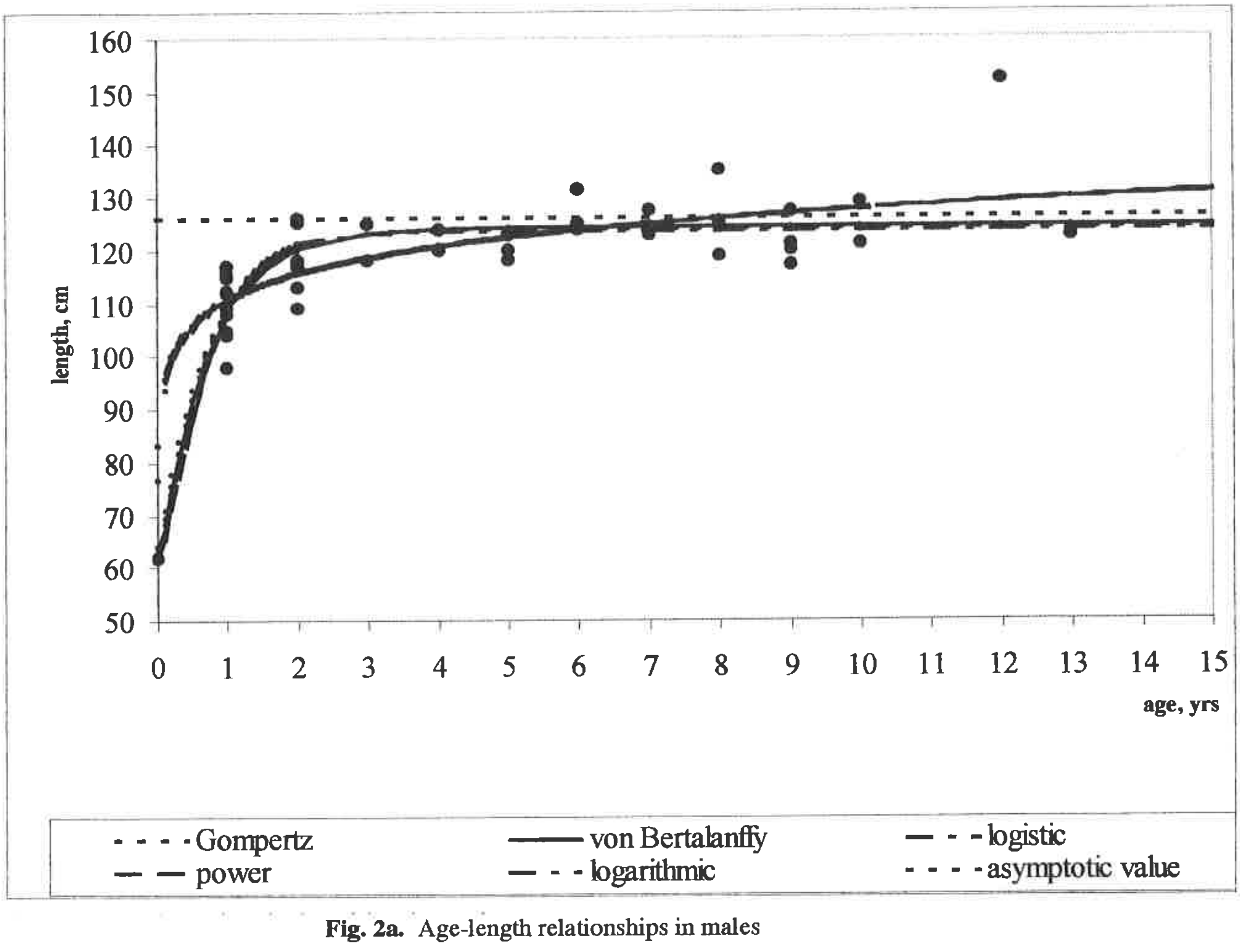


Fig. 2a. Age-length relationships in males

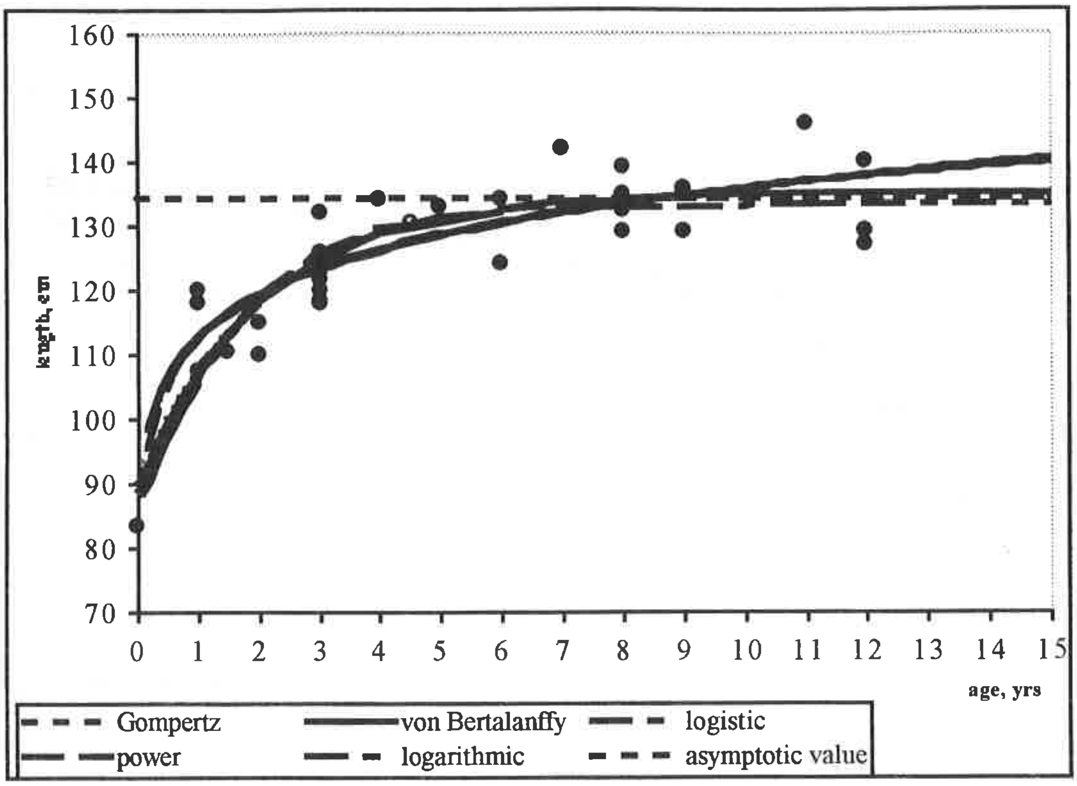


Fig. 2b. Age-length relationships in females

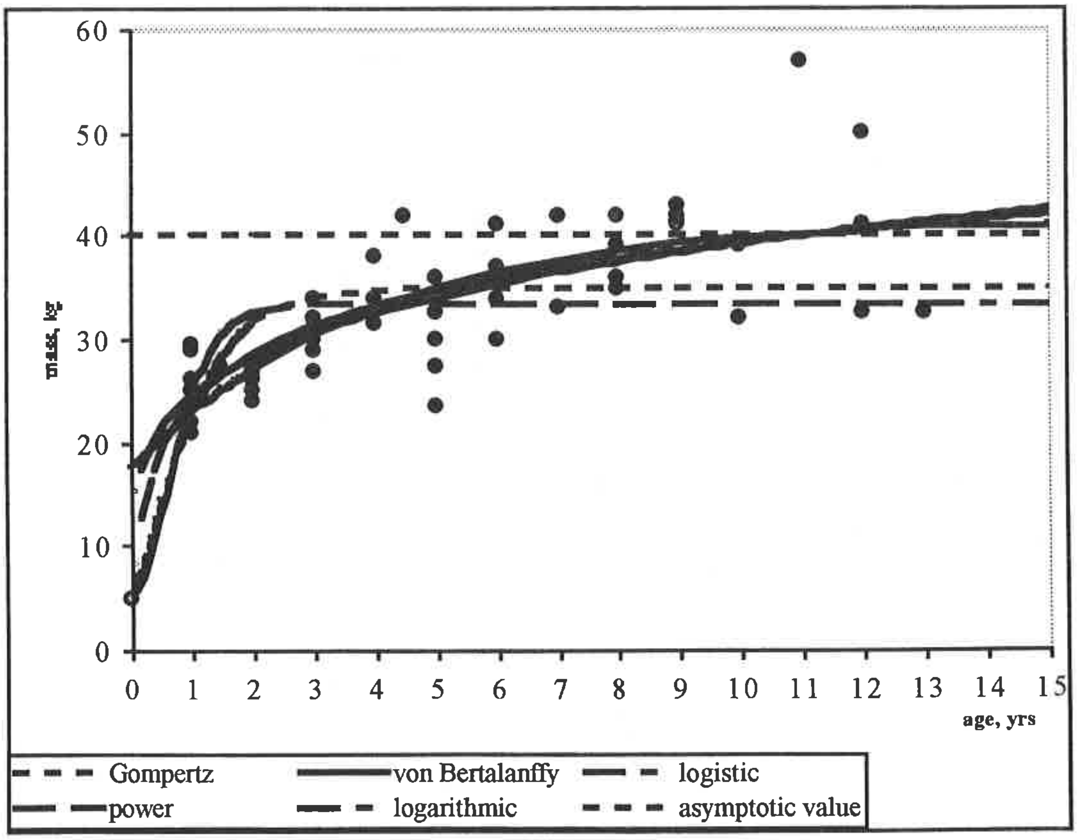


Fig. 3a. Age-weight relationships in both sexes

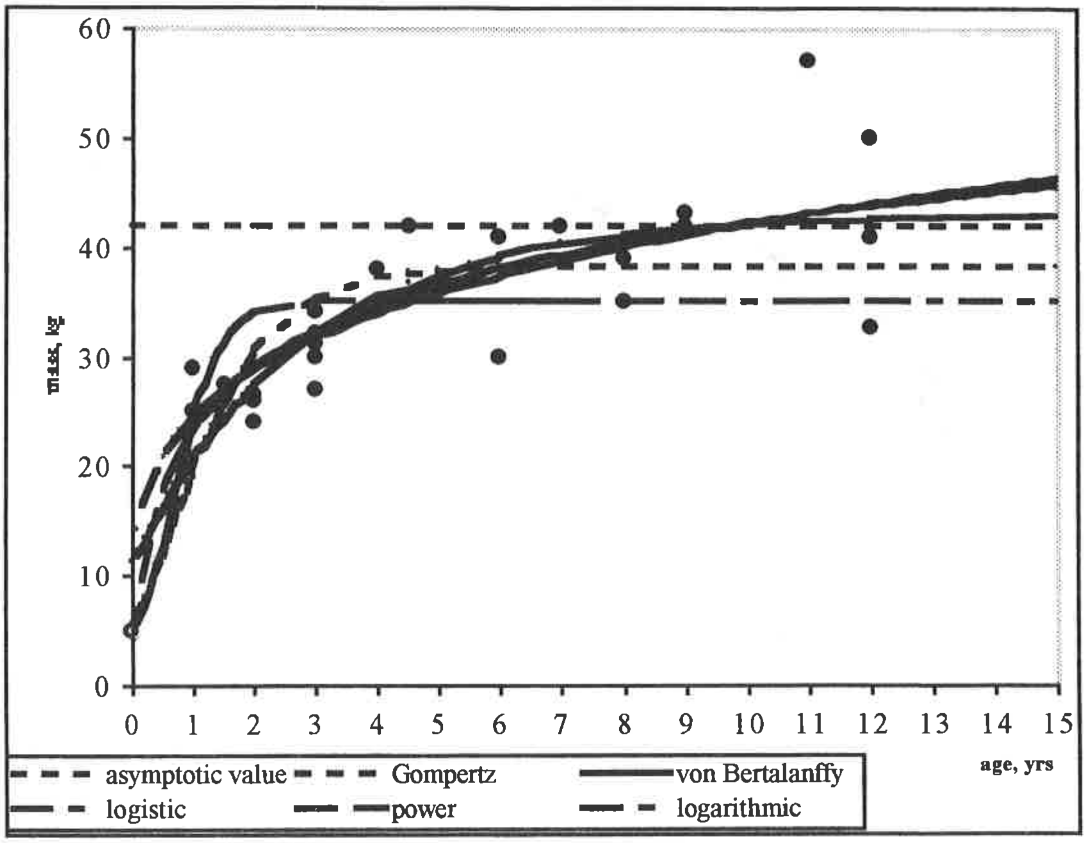


Fig. 3b. Age-weight relationships in females

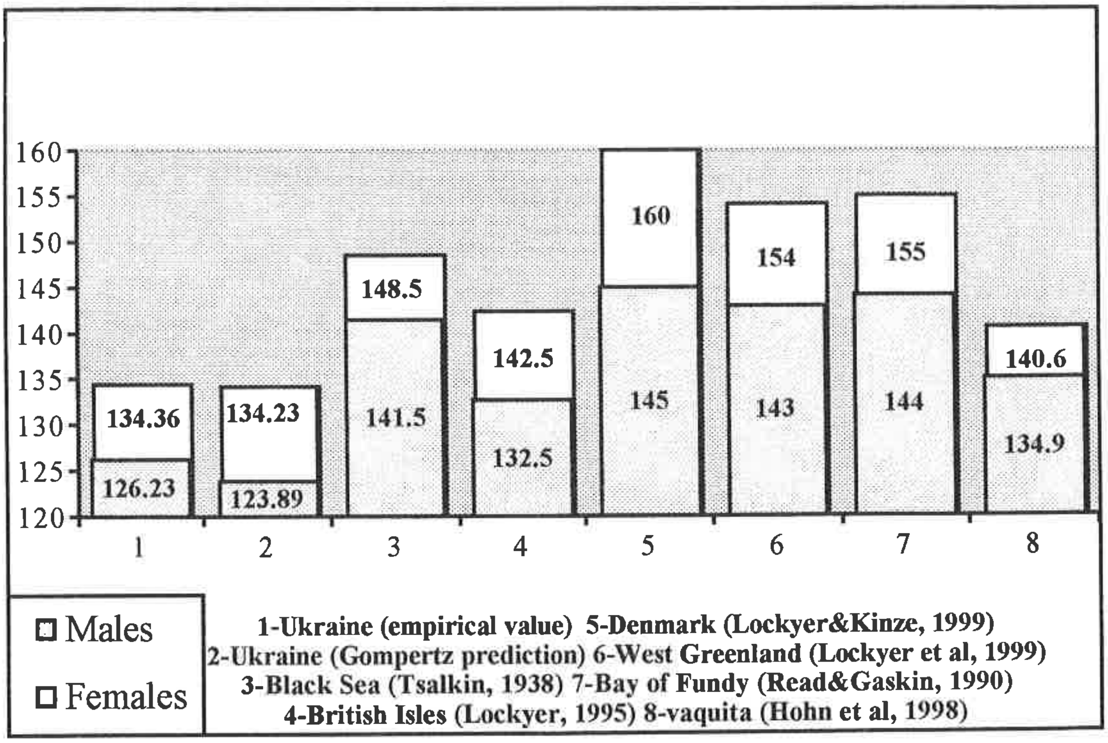


Fig. 4. Asymptotic values of length in harbour porpoises and vaquita (1, 2 – data of this research)

QUANTITATIVE ASSESSMENT OF THE REPRODUCTIVE BIOLOGY OF A SMALL AND GEOGRAPHICALLY ISOLATED BOTTLENOSE DOLPHIN POPULATION

K. Grellier[1], B. Wilson[2], P. S. Hammond[3] and P. M. Thompson[1]

[1] *University of Aberdeen, Lighthouse Field Station, George Street, Cromarty, Ross-shire, IV11 8YJ, UK*
[2] *Sea Mammal Research Unit, Gatty Marine Lab., Univ. of St Andrews, St Andrews, Fife, KY16 8LB, UK*

The population of bottlenose dolphins using the Moray Firth, Scotland has been estimated to consist of 129 individuals, and a population viability analysis model predicts a decline of 5.7% per annum. Here we use photo-identification to quantify three reproductive parameters for this population: length of time calves remain with their mothers, proportion of time calves spend with their mothers, and size of groups in which calves are found, to investigate whether reproductive biology may be limiting this population's viability. Twenty calves born and photo-identified between 1990 and 1997 were objectively assigned mothers by statistical comparison of association indices. The length of time calves remained with their mothers varied but, in several cases, data sets were truncated either because we were no longer able to photo-identify the calf, or because the mother died. The two calves unaffected by these problems remained with their mothers for 7 to 8 years, which is comparatively long for this species. This could be indicative of a long inter-birth interval and therefore a low reproductive rate. In the event of a calf dying within its first few months of life, however, Moray Firth dolphins have shown that they are physiologically capable of reproducing on a 2-year cycle. Within groups, the proportion of time calves spent with their mothers (measured by mean proportion of photographic frames in which the pair appeared together) decreased gradually over the first 7 years of life. This supports the hypothesis that calves maintain close contact with their mothers, but begin making social bonds with other animals as they develop. The size of groups in which calves were found did not change significantly throughout their first 8 years of life. This is the expected pattern if a population is not under predation pressure, which is the case in the Moray Firth.

GROWTH AND SEXUAL DIMORPHISM IN THE COMMON DOLPHIN (*DELPHINUS DELPHIS LINNAEUS*)

S. Murphy and E. Rogan

Dept. of Zoology and Animal Ecology, University College, Cork, Ireland

Growth and sexual dimorphism were described from 90 male and 55 female specimens of common dolphin *Delphinus delphis* stranded along the Irish coastline (24% of sample) or by-caught in fisheries (76% of sample) between 1993-1998. For each dolphin, 20 external measurements comprising linear body lengths, girth measurements, and length and width of fins were recorded, and ages were determined from analysis of growth layer groups in the dentine. The growth rates, growth patterns and sexually dimorphic features were examined for different body length/sex categories or maturity categories. Males ranged in length from 105-231cm and females from 93-216 cm. In growth, both sexes exhibited negative allometry in head measurements, although males exhibited a significantly faster growth rate compared to females in nearly all other measurements especially relating to the lower torso region. The maximum ages of male and female common dolphins recorded were 21 and 16 years, respectively. Sexually mature male dolphins were significantly longer in length than females (p<;0.001) and for all dimorphic characters (using absolute values), males were larger than females in each maturity category. Using proportional values, the degree of sexual dimorphism became more pronounced as the common dolphin becomes both sexually and physically mature. The three girth measurements and three linear body measurements that were proportionally dimorphic in sexually mature individuals included girth around the anus, genital slit and behind the dorsal fin and the tip of rostrum to anus, genital slit, and the outer length of the pectoral fin, respectively. Therefore, male common dolphins had a faster growth rate, grew longer in length and larger in girth than female dolphins. Increased sexual dimorphism in mature dolphins may be due to rapid growth in the relative size of the testes in males, or increased musculature in their lower torso compared to females.

POPULATION PARAMETERS OF THE MEDITERRANEAN STRIPED DOLPHIN (*STENELLA COERULEOALBA*) DERIVED BY STRANDING DATA

L. Orsi Relini, C. Cima, G. Palandri, F. Garibaldi, M. Relini, G. Torchia

Laboratori di Biologia Marina ed Ecologia Animale, DIP.TE.RIS., Università di Genova,
Via Balbi, 5 16126 Genova (E-mail: largepel@unige.it)

INTRODUCTION The striped dolphin *Stenella coeruleoalba* is the most abundant small dolphin of the Mediterranean, in accordance with the fact that its habitat is formed by the offshore waters and is therefore, in terms of area, much more extended than those available for coastal species.

Since the 1980s, the Centro Studi Cetacei (Società Italiana di Scienze Naturali) established a network along the coasts of Italy to recover stranded carcasses of cetaceans for study; from 1986, annual reports are available. In the last eleven years, an average of about 65 *S. coeruleoalba* per year have been recorded in Italy and, in 1991, this figure increased to 329, due to a morbillivirus epizootic. Other occasional stranding data are available for the period 1983-86 (Cagnolaro *et al.*, 1986).

About 700 specimens were sexed and measured according to a standard protocol. On the basis of these data, we illustrate some characteristics of the Mediterranean stock of *S. coeruleoalba*, and compare them with those derived in other Mediterranean (Aguilar, 1991; Calzada *et al.*, 1996, 1997) and oceanic areas (Miyazaki, 1977; Kasuya, 1972).

MATERIALS AND METHODS From the reports of CSC, we have considered numbers of strandings per species and total length of sexed *S. coeruleoalba*, measured from the tip of the lower jaw to the caudal notch. Measures with uncertain notation were discarded.

Length data were arranged in length/frequency distributions with classes of 5 cm: measures were reported to the lower limit of each class. In the length/frequency distributions, relevant Gaussian components were extracted and their age assessed directly or on the basis of literature data. The Von Bertalanffy growth functions were calculated on the basis of the following formulation:

$L(t)=L_\infty-(L_\infty-L_0)\exp^{(-kt)}$ which give evidence to the size at birth (L_0).

RESULTS AND DISCUSSION In Italian records of cetacean strandings (N = 2428 individuals recorded during 13 years), *S. coeruleoalba* is the commonest, representing 45.7% of the total. However, this ratio is overestimated because of the epizootic which occurred in 1990-91. If in the Italian records, these two years are set apart, the percentage of *S. coeruleoalba* of the total number of strandings becomes 40.16%.

A significant portion of stranded animals come from the Ligurian Sea (Fig. 1): about 20% of the total in spite of a stretch of coast totalling just 5% of the Italian coastline. This fact represents a confirmation of the importance of the Ligurian Sea for cetaceans, for which the establishment of an international sanctuary is in progress. In the period autumn to winter, the relative abundance of strandings in the Ligurian Sea reach a maximum (~ 34.4%) and in spring to summer, a minimum of 16.8%. This minimum corresponds to a migration to southern areas of a part of the Ligurian population; Gannier (1998) also noted a spring minimum in the Ligurian Sea, and Marini *et al.* (1996) recorded increased sightings in the Tyrrhenian Sea during spring.

General distribution of sizes and sex ratio The overall length/frequency distribution (Fig. 2) includes a majority of males with a sex ratio 1.25 : 1. Considering the sex ratio per body size (Fig. 3), an increasing trend in female numbers is evident with parity reached at advanced ages.

Season and size of birth If length of the youngest animals (range 80-130 cm TL) is plotted against the date of stranding (Fig. 4), the season of birth becomes evident. In the present study area, i.e. the Central Mediterranean, births occur from July to October, with a maximum in August. This period is indicated also by the results of Aguilar (1991) who noted October as the core of the reproductive season. It is interesting that the season of birth is unimodal, while in the Pacific two or three seasons of birth per year were indicated by Kasuya (1972).

The modal size at birth (90 cm) results from the length/frequency distribution of the period July-October (Fig. 5). It coincides with that indicated by previous studies (Viale and Frontier (1989): 90 cm; Aguilar (1991): 92.5 cm). In the Pacific, size at birth is about 100 cm (Kasuya, 1972; Miyazaki, 1977). In general, individuals from oceanic populations are longer at any given age; for Atlantic *S. coeruleoalba*, Duguy and Robineau (1982) noted that adults are about 20 cm longer than Mediterranean animals.

Growth A Von Bertalanffy growth function (Fig. 6) was calculated for males and females on the basis of the following data:

1) sizes of 0 yr age group individuals: Besides measuring size at birth (90 cm), in a short period after birth it is possible to follow the mean length per month: in the period July –September, we have verified an increment per month of about 4 cm.
2) size at age 1 yr: On the basis of the length/frequency distribution shown in Fig. 5, the age group 1 has a length of 120-130 cm. We have assumed 125 cm for both males and females.
3) size at sexual maturity: In the general length/frequency distribution, a peak is found at 180 cm TL both for males and females. It probably corresponds to increased mortality related to the start of sexual activities (search for a partner, first parturition in females, etc.). Size and age at sexual maturity was calculated at 187 cm and 12.3 years by Calzada *et al.* (1996). In the opinion of Kasuya (1972) and Miyazaki (1977), the mean age of sexual maturity is nine years. We assumed the age indicated by Mediterranean studies.
4) L_∞ = 200 cm for males and 190 cm for females, which is reached at physical maturity (= age 14 yrs in the opinion of Kasuya and Miyazaki; age 13-18 yrs in females, and 15-20 yrs in males, according to Calzada *et al.* (1997). Following the latter, we have assumed 15.5 years for females, and 17.5 for males.

REFERENCES

Aguilar, A. 1991. Calving and early mortality in the western Mediterranean striped dolphin, *Stenella coeruleoalba. Can. J. Zool.*, 69: 1408–1412.

Cagnolaro, L., Cozzi, B., Magnaghi, L., Podestà, M., Poggi, R., Tangerini, P. 1986. Su 18 cetacei spiaggiati sulle coste italiane dal 1981 al 1985. Rilevamento biometrico ed osservazioni necroscopiche. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 127 (I-II): 79-106.

Calzada, N., Aguilar, A., Sørensen, T.B., Lockyer, C. 1996. Reproductive biology of female striped dolphin (*Stenella coeruleoalba*) from the western Mediterranean. *J. Zool. Lond.*, 240: 581–591.

Calzada, N., Aguilar, A., Lockyer, C., Grau, E. 1997. Patterns of growth and physical maturity in the western Mediterranean striped dolphin, *Stenella coeruleoalba* (Cetacea: Odontoceti). *Can. J. Zool.*, 75: 632–637.

Centro Studi Cetacei. 1987. Cetacei spiaggiati lungo le coste italiane. I. Rendiconto 1986. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 128 (3-4): 305-313.

Centro Studi Cetacei. 1988. Cetacei spiaggiati lungo le coste italiane. II. rendiconto 1987. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 129 (4): 411-432.

Centro Studi Cetacei. 1989. Cetacei spiaggiati lungo le coste italiane. III. Rendiconto 1988. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 130 (21): 269-287.

Centro Studi Cetacei. 1990. Cetacei spiaggiati lungo le coste italiane. IV. Rendiconto 1989. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 131 (27): 269-287.

Centro Studi Cetacei. 1991. Cetacei spiaggiati lungo le coste italiane. V. Rendiconto 1990. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 132 (25): 337-355.

Centro Studi Cetacei. 1992. Cetacei spiaggiati lungo le coste italiane. VI. Rendiconto 1991. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 133 (19): 261-291.

Centro Studi Cetacei. 1993. Cetacei spiaggiati lungo le coste italiane. VII. Rendiconto 1992. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano,* 134 (II): 285-298.

Centro Studi Cetacei. 1994. Cetacei spiaggiati lungo le coste italiane. VIII. Rendiconto 1993. *Atti Soc. Ital. Sci. nat. Museo civ. Stor. nat. Milano,* 135 (II): 443-456.

Centro Studi Cetacei. 1994. Cetacei spiaggiati lungo le coste italiane. IX. Rendiconto 1994. *Atti Soc .ital. Sci. nat. Museo civ. Stor. nat. Milano,* 135 (II): 457-468.

Centro Studi Cetacei. 1997. Cetacei spiaggiati lungo le coste italiane. X. Rendiconto 1995. *Atti Soc .ital. Sci. nat. Museo civ. Stor. nat. Milano,* 136 (II): 205-216.

Centro Studi Cetacei. 1997. Cetacei spiaggiati lungo le coste italiane. XI. Rendiconto 1996. *Atti Soc. ital. Sci. nat. Museo civ. Stor nat. Milano,* 137 (I-II): 135-147.

Centro Studi Cetacei. 1998. Cetacei spiaggiati lungo le coste italiane. XII. Rendiconto 1997. *Atti Soc .ital. Sci. nat. Museo civ. Stor. nat. Milano,* 139 (II): 213-226.

Duguy, R. and Robineau, D. 1982. *Guide des mammifères marins d'Europe.* Delachaux & Niestlé, Neuchâtel, Switzerland. 200pp.

Gannier, A. 1998. Les Cétacées de Méditerranée nord-occidentale: nouveaux résultats sur leur distribution, la structure de leur peuplement et l'abondance relative des differentes espèces. *Mésogée,* 56: 3-19.

Kasuya, T. 1972. Growth and reproduction of *Stenella coeruleoalba* based on the age determination by means of dentinal growth layers. *Sci. Rep. Whales Res. Inst. Tokyo,* 24: 57-70

Marini, L., Consiglio, C., Angradi, A. M., Catalano, B., Sanna, A., Valentini, T., Finoia, M. G., and Villetti, G. 1996. Distibution, abundance and seasonality of cetaceans sighted during scheduled ferry crossings in the central Tyrrhenian Sea: 1989-1992. *Ital. J. Zool.,* 63 (4): 381-388.

Miyazaki, N. 1977. Growth and reproduction of *Stenella coeruleoalba* off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst. Tokyo,* 29: 21-48.

Viale, D. and Frontier, S. 1989. Structure de tailles des échouages du dauphin *Stenella coeruleoalba* (Meyen, 1983) sur les côtes françaises de Méditerranée. *Acta Oecologica, Oecol. Gener.,* 10 (3): 295-307.

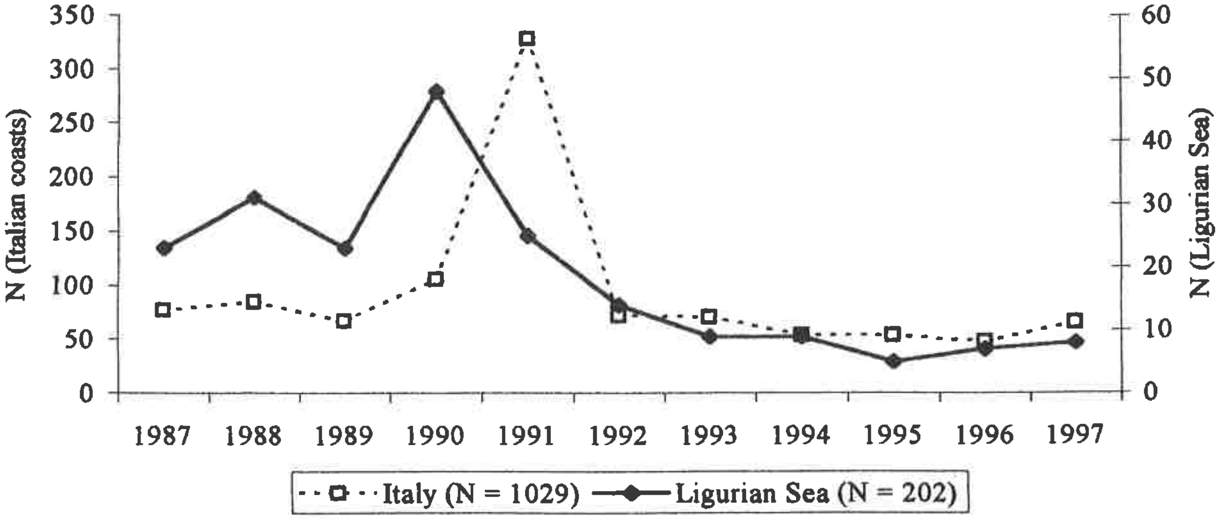


Fig. 1. *S. coeruleoalba*: numbers stranded along the Italian coasts and in the Ligurian Sea

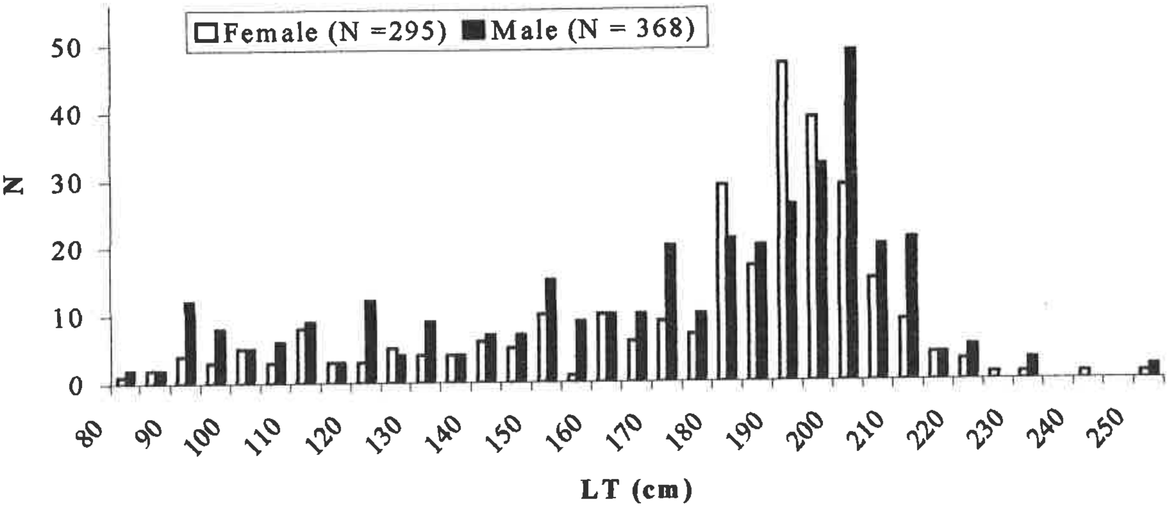


Fig. 2. Length/frequency distribution of *S. coeruleoalba* (only sexed individuals) stranded on the Italian coasts in the period 1983-1997.

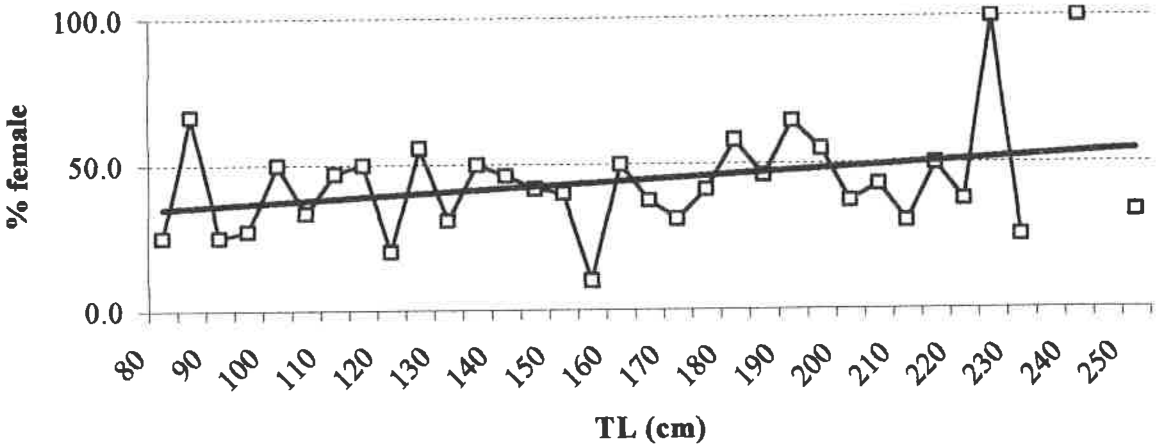


Fig. 3. Increasing trend of female percentage in relation to size

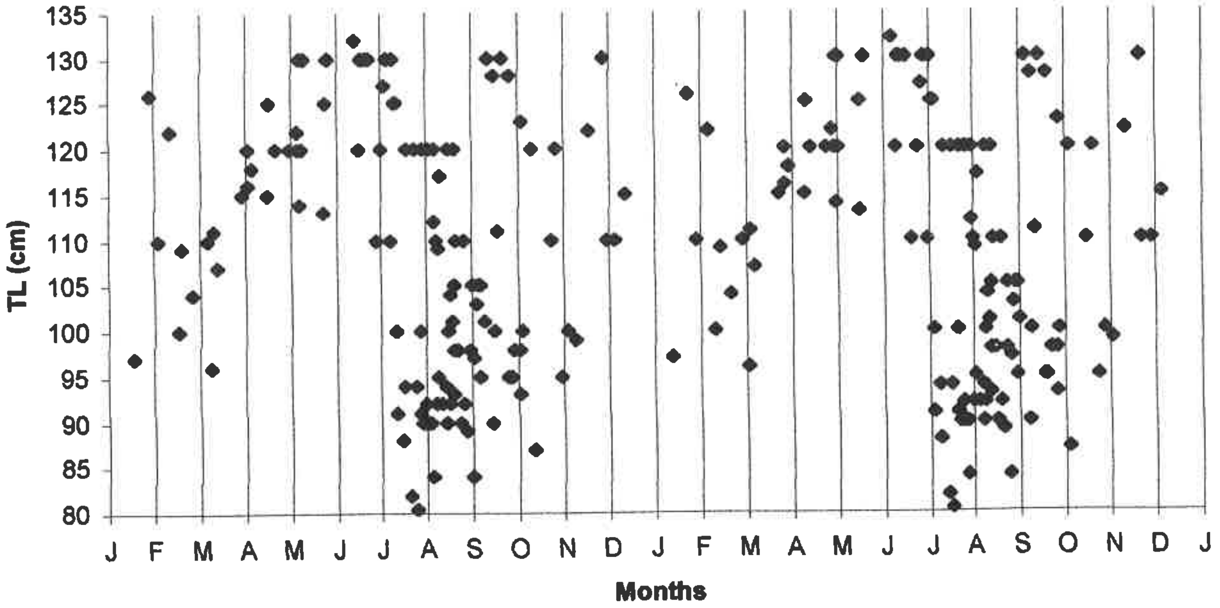


Fig. 4. Size of young individuals in relation to their stranding date

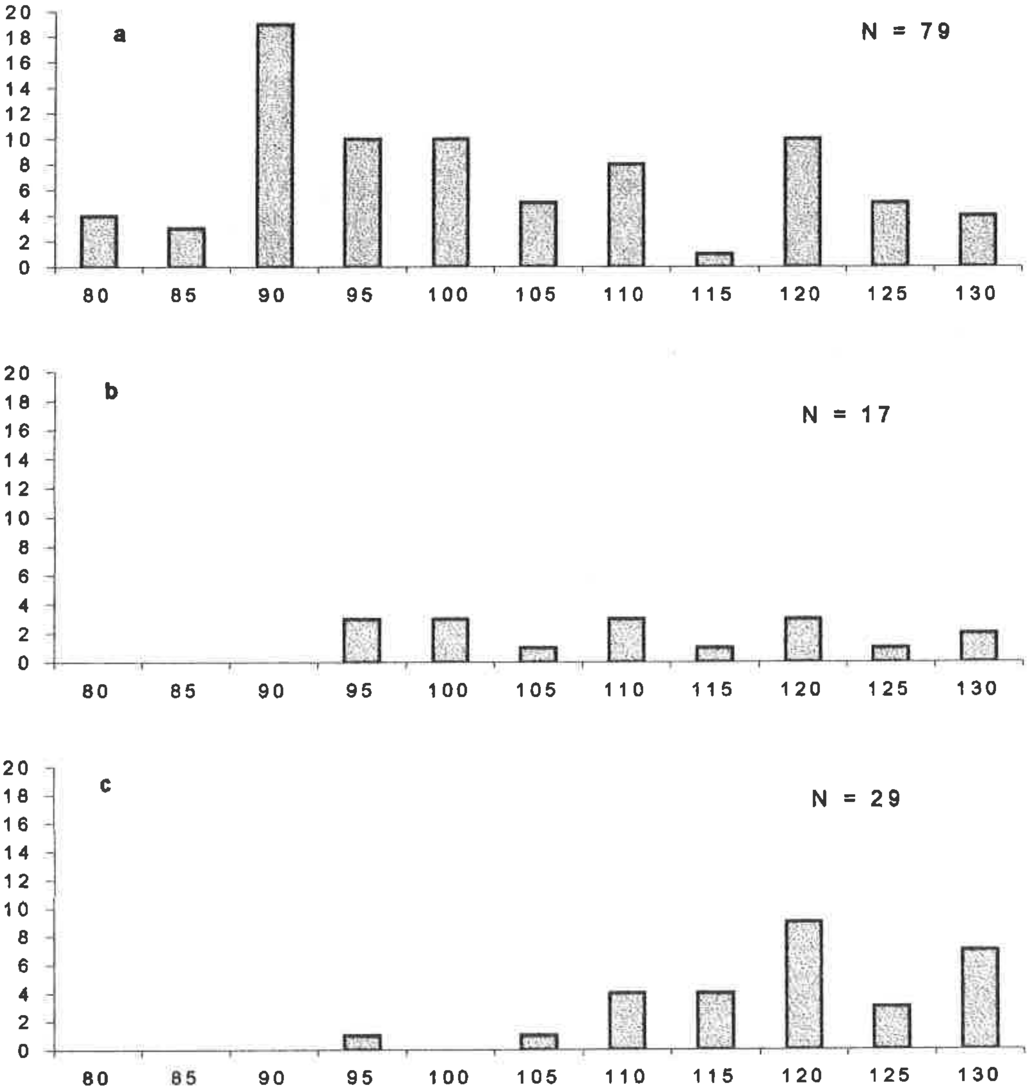


Fig. 5. Length/frequency distributions of calves: a) July-October b) November-February c) March–June

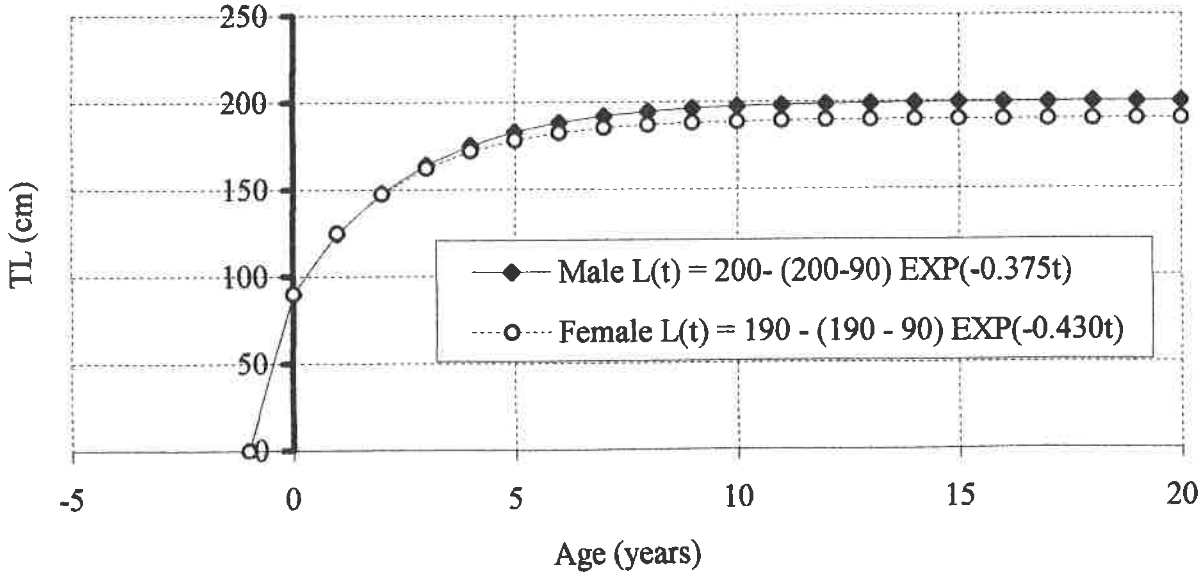


Fig. 6. The von Bertalanffy growth function

MEDICINE, PARASITES & DISEASE

STRUCTURE OF INTESTINAL HELMINTH COMMUNITIES OF *STENELLA COERULEOALBA* FROM THE WESTERN MEDITERRANEAN

C. Agustí, F. J. Aznar, and J. A. Raga

Department of Animal Biology and Cavanilles Research Institute of Biodiversity and Evolutionary Biology, University of Valencia, C/Dr. Moliner 50, 46100 Burjassot, Valencia, Spain

The intestinal helminth communities of 40 Western Mediterranean striped dolphins stranded on Spanish coasts from July to December 1990, were analysed for taxonomic composition and structure. We divided the intestine into 20 equal sections to examine the helminth linear distribution. Five helminth species were found: 3 adult cestodes, *Tetrabothrius forsteri* (Prevalence: 95%; Mean Abundance ± SD: 40.1 ± 50.5; Median Worm: section 2.52), *Trigonocotyle* sp. (12.5; 0.3 ± 0.7; 3.78), *Strobilocephalus triangularis* (30; 2.5 ± 6.0; 19.50); 1 cestode larva, *Scolex pleuronectis* (92.5; [not fully counted]; 19.50); 1 immature acanthocephalan, *Bolbosoma vasculosum* (47.5; 0.9 ± 1.3; 8.55). At the level of the host population, helminth diversity seems to be constrained by host-parasite specificity, i.e., striped dolphins only harbour its own parasites or those acquired from sympatric cetaceans. At the level of individual hosts, mean species richness and mean total abundance were low (1.85 ± 0.86 and 43.8 ± 50.6, respectively). Both a Fager's Recurrent Group Analysis and a Summed Binomial Variance Test indicated that species are independently distributed among hosts. In other words, these communities are species-poor and composed by random subsets of the locally available species. These features seems to result from a low probability of infection that might partly depend on two factors, i.e., the "dilution" of infective stages in the pelagic realm and the widespread movements of the striped dolphins. The habitat selection within the intestine could be primarily accounted for by individual responses of each helminth species. However, we found substantial niche overlap between the pairs *T. forsteri- Trigonocotyle* sp. in the duodenum, and *S. pleuronectis-S. triangularis* in the last section. Even so, their low abundance and co-occurrence probably reduces the likelihood of competitive interactions. We detected potential intraspecific competition in the case of *T. forsteri* because its median worm position did not change, but niche breadth did expand with intensity.

INVESTIGATION ON THE CROSS-REACTIVITY OF SELECTED LEUCOCYTE MARKERS FROM VARIOUS SPECIES FOR THE CHARACTERISATION OF LYMPHOID CELLS IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

A. Beineke[1], U. Siebert[2], A. Wünschmann[1], J. L. Stott[3], and W. Baumgärtner[1]

[1]*Institut für Veterinär-Pathologie, Justus-Liebig-Universität Giessen, 35392 Giessen, Germany*
[2]*Forschungs- und Technologiezentrum Westküste, Universität Kiel, 25761 Büsum, Germany*
[3]*Department of Pathology, Microbiology and Immunology, School of Veterinary Medicine, University of California, Davis, CA 96616, USA*

Immunosuppressive conditions due to bioaccumulated hydrocarbons, including PCB and DDT, are suggested to play a contributing role for mass-mortalities during world-wide morbillivirus-epizootics. Due to the lack of harbour porpoise specific antibodies, leucocyte differentiation antigen markers of dogs, cattle, horses, killer whales (*Orcinus orca*) and man, were investigated for possible cross-reactivities in different lymphoid tissues of the harbour porpoise. Fifteen canine-, 6 bovine-, 1 equine-, 4 killer whale- and 4 human-specific cell surface antigen markers of the immune and hematopoetic system were tested on frozen and paraffin sections of spleen, thymus, lymph node and tonsil of stranded or bycaught harbour porpoises using a standard avidin-biotin-peroxidase technique. Eight out of 30 monoclonal antibodies showed a specific membrane-bound reaction with frozen sections of harbour porpoise lymphoid tissues. CD3e+ cells, recognised by a canine specific monoclonal antibody, were localised in T lymphocyte compartments, including the splenic PALS and mantle layer. In addition, 2 antibodies directed against the killer whale CD2 homologue showed membrane-bound reactions in T cell areas. The anti-equine-pan-leucocyte-marker labeled most lymphoid cells in B and T cell compartments. MHC class II antigen was recognised by a killer whale-, bovine- and canine-specific antibody. The killer whale-specific CD45R marker labelled B and a subset of T lymphocytes. This monoclonal antibody did also cross-react with paraffin embedded tissues, whereas none of the remaining lymphocyte markers showed positive immunoreactivity. Using leucocyte surface antigen markers, it is now possible to evaluate contaminant- or virally-induced impaired immune function in lymphoid organs of harbour porpoises, by immunohistochemistry.

CAUSES OF MORTALITY IN BLACK SEA HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM BULGARIAN, GEORGIAN AND UKRAINIAN WATERS (1997-1999)

A. Birkun., Jr.[1], S. Krivokhizhin[1], A. Komakhidze[2], N. Mazmanidi[2], T. Stanev[3], K. Mikhailov[3],
A. W. Baumgaertner[4], and C. R. Joiris[5]

[1]*BREMA Laboratory, Simferopol, Ukraine*
[2] *Institute of Black Sea Ecology and Fisheries, Batumi, Georgia*
[3]*Institute of Fisheries, Varna, Bulgaria*
[4]*Institute of Veterinary Pathology, Justus Liebig University, Giessen, Germany*
[5]*Laboratory of Ecotoxicology, Free University of Brussels, Brussels, Belgium*

This is the first systematic study on Black Sea harbour porpoise (*Phocoena phocoena*) mortality and pathology monitored simultaneously in three different coastal areas. Within two years (February 1997 - January 1999), 198 dead porpoises were recorded by specialists and voluntary stranding/by-catch networks along Bulgarian (31 cases/355 km), Georgian (22 cases/100 km) and Ukrainian (145 cases/650 km) coasts. 143 cases (72,2%) were represented by animals incidentally caught in bottom-set gillnets for turbot *Psetta maeotica*, and 11 stranded porpoises had lesions potentially related to entanglement in fishing gear. So, incidental catch was determined as a key cause of Black Sea harbour porpoise mortality, particularly in Ukrainian waters off the Crimea (123 definite by-catches). Turbot fishing season (May–June) was recognised as the most risky period relating to high cetacean mortality (54% of all records).

Harbour porpoise males and females, both young and adult, had almost equal rates of entanglement. The presence of pregnant females (with large foetuses), recently pregnant and lactating animals (15, 19 and 50% of the total number of mature females) indicated that the turbot fishing season coincides with porpoise gestation and nursing period. The state of mature male and female gonads (except pregnant individuals) conformed to a breeding period in late spring and early summer. Thus, turbot fishing operations in May–June could be defined as a significant anthropogenic factor of Black Sea harbour porpoise mortality, and limitation on their reproduction output. According to postmortem investigation (104 necropsies), absolutely healthy animals were not recorded. Chronic verminous pneumonia with its complications (99% of porpoises examined) seems to be an important cause of natural mortality. No morbillivirus antigen was detected in the tissues; but more than half of the harbour porpoises tested serologically showed morbillivirus-specific antibody titers, possibly suggesting epizootics in the past and future.

INTERPRETATION OF SKIN LESIONS IN STRANDED CETACEANS

O. Cabezón[1] , E. Obón[1] , F. Alegre[1] , S. Pont[1], and M. Domingo[2]

[1]*Centre de Recuperació d'Animals Marins (CRAM). Camí Ral, 239. 08330 Premià de Mar, Barcelona, Spain*
[2]*Departament de Patologia i Producció Animal de la Universitat Autònoma de Barcelona,*
08193 Bellaterra, Barcelona, Spain

INTRODUCTION Skin lesions are frequent in stranded cetaceans. The origin and nature of these lesions is often difficult to establish. We attempted to classify skin alterations in necropsied small cetaceans stranded on the western Mediterranean coast, from 1994 to 1999. A total of 72 cetacean were necropsied in that time period. Alterations were classified according to the possible or suspected cause such as: viral, parasitic, by-catch induced, behavior interactions, scars and de-pigmentations, post-mortem alterations, and unknown origin.

Viral-induced lesions Poxvirus-induced skin lesions (Baker, 1992; Kennedy, 1990; Sweeney *et al.*, 1975; Van Bressem *et al.* 1999), known as "tattoos", were recognised in six specimens: 1 common dolphin (*Delphinus delphis*), 4 striped dolphins (*Stenella coeruleoalba*) and 1 bottlenose dolphin (*Tursiops truncatus*). Lesions were single in four cases, and multiple in the other two cases. "Tattoos" were located in the anterior body half, especially around the eyes and spiracle. They were composed of a dark line surrounding many small dark points. In unpigmented skin areas, lesions were not so evident.

Parasitic lesions Lesions attributed to external parasites were identified as circular, 1 to 1,5 cm wide, hyperpigmented in light skin, but clearer in dark skin, with a central, deep hole. An inflammatory response is usually evident through the blubber and in the deeper subcutaneous connective and adipose tissue. The most probable cause of these lesions is *Penella* spp. In several cases, the parasite was found still attached to the animal's body, in the centre of similar lesions. Absence of the parasite could be interpreted as expulsion by the inflammatory reaction.

In one subadult striped dolphin, several nodular raised lesions, centrally eroded, with purulent-caseous exudation (skin abscesses) were found especially in the trunk. Ciliated protozoan parasites morphologically similar to *Kyaroikeus cetarius* were found microscopically in the exudate, but this organism is probably a secondary invader (Schulman *et al.*, 1999). A primary cause of the lesion was not identified.

By-catch induced lesions Bycatch induced wounds (Kruiken, 1996) and amputations are seldom found in the area of study. Linear skin ulceration and marks caused by long-standing nets around the trunk were identified cranial to the flippers, often in young dolphins. Focal dark depressions of the skin, without erosion, were interpreted as net knot marks, if other evidence of bycatch was also present.

Pressure lines associated with parturition were observed in a presumably newborn Risso's dolphin (*Grampus griseus*) calf, as rings (between four and five) around the trunk of the animal. These marks should not be confused with marks due to net entrapment.

Behaviour interactions Rake marks (Sweeney, 1975) are easy to recognise and to differentiate from other skin alterations. They usually appear as bands of 3-to-8 parallel lines, straight or with slight undulation, hyperpigmented, with a central light line. Normally, when found, they are healed. If bleeding occurs in parallel lines, it may be difficult to discriminate between interaction marks and injuries caused by being stranded.

Hunting behaviour marks can be observed in the proximity of the beak associated with prey resistance, in particular to cephalopods.

Chronic scars or depigmentation Scars in cetaceans appear as depigmented areas. These marks have variable shapes and sizes as they can be produced by numerous causes. They can result from the healing of a wound or the resolution of a skin disease. The presence of scars in old Risso's dolphins (*Grampus griseus*), as a consequence of their behavioural interactions is well-known.

Post-mortem alterations After death, carcasses of cetaceans are damaged by scavengers, including fish and birds. Eyes are often enucleated and the skin, specially the ano-genital region, shows frequently incisions and cuts.

Perforation of the abdomen and/or ventral trunk may also be present. In these cases, internal organs may be partially or totally absent. Alteration of the skin colour following autolysis is frequently seen on the ventral part of the dolphin's body.

Unknown origin Lesions or alterations of unknown cause have been found in some dolphins. In most cases, these alterations were probably not related to the death of the dolphin or to the diseases found by necropsy, and often these lesions were not investigated further. Forms and pattern of these lesions are often peculiar.

REFERENCES

Baker, J. R. 1992. Causes of mortality and parasites and incidental lesions in dolphins and whales from British waters. *Vet. Rec*, 130: 569–572.

Kennedy, S. 1990.Viral Diseases in Marine Mammals. Pp. 97-113. In *CRC Handbook of Marine Mammal Medicine*. CRC Press. Boca Ratón. FL.USA. 735pp.

Schulman, F. Y. and Lipscomb, T. P. 1999. Dermatitis with Invasive Ciliated Protozoa in Dolphins That Died During the 1987-1988 Atlantic Bottlenose Dolphin Morbilliviral Epizootic. *Vet. Pat*, 36: 171-174.

Sweeney, J. C. and Ridgway, S. H. 1975. Common diseases of small cetaceans. *JAVMA*, 167: 533-540.

Van Bressem, M. F., van Waerebreek, K. and Raga, J. A. 1999. A review of virus infections of cetaceans and the potential impact of morbilliviruses, poxviruses and papillomaviruses on host population dynamics. *Dis. Aquat. Org*, 38: 53-65.

Kuiken, T. 1996. *Diagnosis of by-catch in cetaceans*. Proceedings of the 2nd ECS, workshop on cetacean pathology. Montpellier, France. 1994. ECS newsletter, n° 26 (special issue).

INCIDENCE, PATHOLOGY AND INVOLVEMENT OF *NASITREMA* SP. IN ODONTOCETE STRANDINGS

E. Degollada,[1] M. André,[2], M. Arbelo[2], and A. Fernández[2]

[1]*Dept. Anatomy, Veterinary Fac., Autonomous University of Barcelona, 08193 Bellaterra, Spain*
[2]*Marine Mammal Conservation Research Unit, Department of Morphology, School of Veterinary Medicine, University of Las Palmas de Gran Canaria, 35416 Arucas, Gran Canaria, Spain*

The genus *Nasitrema* (*Trematoda, Digenea*) has been implicated in causing odontocete strandings and death. This trematode, located principally in the paraotic sinuses, has been decribed affecting the ear and the brain. Although considered pathogenic, a thorough description of the resulting lesions is lacking.

The presence and pathological processes of *Nasitrema* sp. in several odontocete species are presented and the involvement of this parasite in strandings is discussed. Routine necropsies are conducted on the cetaceans stranded on the Canary Islands coasts, paying special attention to the parasitism of the otic region. During the last two years, a high percentage of the carcasses examined, of more than four odontocete species, had this trematode present in the paraotic sinuses.

The parasite was found to have caused lesions ranging from mild sinusitis to severe meningo-encephalitis even associated with abscesses affecting the nervous tissues. The latter occurred in an old *Tursiops truncatus* severely infested and showing adult flukes migrating through the eight cranial nerve. The histopathology showed a moderate reaction to both adults and eggs, characteristic of the predominance of round inflammatory cells resulting in neuritis, meningo-encephalitis and malacia. In other cases, with the same lesions, no parasitic forms were found.

The cases observed allow us to discuss the pathogenicity of *Nasitrema* sp. affecting the central nervous system which may imply an equilibrium dysfunction inducing the odontocete to strand. From a pathological perspective, the absence of parasitic forms does not rule out its participation in nervous lesions, thus supporting the present results which clearly indicate a higher incidence of this parasite than reported, mainly because it is overlooked in most necropsies.

ENCEPHALITIS BY A TOXOPLASMA-LIKE PROTOZOAN PARASITE IN A *GRAMPUS*. A HOST-PARASITE RELATIONSHIP WITHOUT KNOWN LIFE CYCLE

M. Domingo[1], E. Obón[2], F. Alegre[2], S. Pont[2], O. Cabezón[2] and E. Degollada[1]

[1]*Departament de Patologia i Produccio Animal, Facultat de Veterinaria, Universitat Autonoma de Barcelona, 08193 Bellaterra (Barcelona), Spain*

[2]*Centre de Recuperació d'Animals Marins de Catalunya (CRAM), 08330 Premià de Mar (Barcelona), Spain*

An adult Risso's dolphin (*Grampus griseus*) was sighted alive near the beach of El Prat (Barcelona, Spain), reintroduced to deep waters, and found stranded and moribund the next morning in a flat sand beach. It died within the first hour after the stranding. It was a 292 cm long, apparently well nourished female specimen. At necropsy, nine copepods (*Penella* spp.) were found attached to the flanks of the animal. No other external lesions were found. Main macroscopic lesions were ulcerative glositis, generalised enlargement of lymph nodes and of spleen, and severe paraotic sinusitis by *Crassicauda grampicola*. Also, adrenal glands were enlarged and showed petechia and congestion at the cut surface. Erosions of the mucosa of the laryngeal appendix and reddish frothy fluid in the trachea were observed in the respiratory system. No ingesta was observed in gastric chambers. The animal was pregnant, with an autolysed 12,5 cm long foetus. Histologically, a granulomatous encephalitis associated with tachyzoites and bradyzoits of a *Toxoplasma*-like parasite was the most prominent finding. Parasites were also found in necrotic foci in adrenal glands. Infection by *Toxoplasma gondii* has been described in apparently normal cetaceans, as well as in morbillivirus infected striped dolphins. This is the first description of *Toxoplasma*-like organisms in a Risso's dolphin. The life cycle of *T.gondii* is terrestrial, with feline species acting as definitive host. Many other warm-blooded animal species can serve as intermediate hosts. Infection may occur either directly from oocysts eliminated by the definitive host or by ingestion of meat of intermediate hosts having bradyzoits or tachyzoits in tissues. Extension of the terrestrial life cycle of *T.gondii* to marine environment has been explained by contamination of coastal waters with *Toxoplasma*-oocysts from feline faeces, and by occasional predation of cetaceans on infected marine birds. No proof or evidence of these links is available.

REFERENCES

Cruikshank, J. J., Haines, D. M., Palmer, N. C., and St Aubin, D. J. 1990. Cysts of Toxoplasma-like organism in an Atlantic bottlenose dolphin. *Can. Vet. J.*, 31: 212-215.

Di Guardo, G., Corradi, A., Agrimi, U., Zizzo, N., Morelli, I., Perillo, A., Kramer, L., Cabassi, E., and Kennedy, S. 1995. Neuropathological lesions in cetaceans found stranded from 1991 to 1993 on the coasts of Italy. *Eur. J. Vet. Pathol.*, 1: 55-57.

Domingo, M., Visa, J., Pumarola, M., Marco, A., Ferrer, L., and Rabanal, R. 1992. Pathologic and Immunocytochemical Studies of Morbillivirus infection in Striped Dolphin (*Stenella coeruleoalba*). *Vet. Pathol.*, 29: 1-10.

Dubey, J. P. and Beattie, C.P. 1988, *Toxoplasmosis of animals and man.* CRC Press Inc. Boca Raton Florida, USA.

Dungworth, D. L. 1993. The respiratory system. Pp. 539-699. In: *Pathology of Domestic Animals.* (Eds. J. V. F. Jubb, P. C. Kennedy and N. Palmer). 4th edition, vol. 2. Academic Press, San Diego, CA.

Frenkel, J. K. 1990. Transmission of Toxoplasmosis and the role of immunity in limiting transmission and illnes. *J. Am. Vet. Med. Assoc.*, 196: 233-240.

Inskeep, W., Gardiner, C. H., Harris, R. K., Dubey, J. P., and Golston, R. T. 1990. Toxoplasmosis in Atlantic Bottle-nosed Dolphins. *J. Wild. Dis.*, 26: 34-38.

Lipscomb, T. P., Schulman, F. Y., Moffett, D., and Kennedy, S. 1994. Morbilliviral Disease in Atlantic Bottlenose Dolphins (*Tursiops truncatus*) from the 1987-1988 Epizootic. *J. Wild. Dis.*, 30 (4): 567-571.

Lipscomb, T. P., Kennedy, S., Moffett, D., Krafft, A., Klaunberg, B. A., Lichy, J. H., Regan, G. T., Worthy, G. A. J., and Tanbenberger, J. K. 1996. Morbilliviral epizootic in bottlenosed dolphins of the Gulf of Mexico. *J. Vet. Diag. Invest.*, 8: 283-290.

Migaki, G., Sawa, T. R., and Dubey, J. P. 1990. Fatal disseminated Toxoplasmosis in a Spinner Dolphin (*Stenella longirostris*). *Vet. Pathol.*, 27: 463-464.

Mikaelian, I, Boisclair, J, Dubey, J. P, Kennedy, S., and Martineau, D. 2000. Toxoplasmosis in Beluga Whale (*Delphinapterus leucas*) from the St. Lawrence Estuary: Two Case Reports and a Serological Surveys. *J. Comp. Pathol.*, 122: 73-76.

INTRACYTOPLASMIC HYALINE GLOBULES IN HEPATOCYTES OF STRANDED CETACEANS: WHAT DOES THAT MEAN?

A. Fernández[1], J. González[1], P. Castro[1], M. Arbelo[1], M. André[1] and E. Degollada,[1, 2]

[1]*Marine Mammal Conservation Research Unit, Department of Morphology, School of Veterinary Medicine*
University of Las Palmas de Gran Canaria, 35416 Arucas, Gran Canaria, Spain
[2]*Dept. Anatomy, Veterinary Fac., Autonomous University of Barcelona, 08193 Bellaterra, Spain*

Eosinophilic cytoplasmic inclusions have been described in many natural and experimentally induced diseases and in several species. These diseases include neoplasias, intoxications, infectious agents, etc (Jubb *et al.*, 1993). In man, alfa-1-antitrypsin (a-1-AT) is, among others, a positive acute phase reactant and an efficient inhibitor of serine proteases, predominantly, leucocyte elastase, which is released by inflammation (Yunis *et al.*, 1968). Acute phase proteins are associated with acute and chronic inflammations, bacterial, viral and certain parasitic infection (Propst *et al.*, 1994). The a-1-AT deficiency (a hereditary condition) results in the presence of faintly eosinophilic, PAS positive cytoplasmic droplets in hepatocytes. Sevelius *et al.*, (1994) demonstrated globular a-1-AT inclusions in hepatocytes endoplasmic reticulum of dogs associated with chronic hepatitis, cirrosis, and in only one case with cholangiohepatitis. In this communication, we demonstrate immuno-histochemically the presence of a-1-antritypsin in cytoplasmic globules in hepatocytes of stranded cetaceans, belonging to different species.

CLOSTRIDIUM PERFRINGENS AS A CAUSE OF DEATH DURING THE RECOVERY OF STRANDED DOLPHINS

E. Fernández

ESPARTE, Victoria Mérida y Piret, 9. 29004 Málaga, Spain

From 1996 to 1998, 23 cetaceans stranded alive along the southern coast of Spain, representing 8.5% of all recorded strandings. Two individual striped dolphins *Stenella coeruleoalba* developed an infectious process caused by *Clostridium perfringens*, which in both cases resulted in their death. Here we present the causes of the strandings, the symptoms detected, the medical treatment, and also the evolution of the infectious process together with its possible causes and the macroscopic and microscopic lesions detected during the necropsy. The first case presented is that of a female measuring 190 cm and weighing 70 kg. The initial diagnosis was of gastroenteritis with a haemorrhage of possible parasite aetiology. Within two days, the dolphin developed a process of muscular rigidity with a strong arching of the body. There was no sign of response to the treatment, and the later necropsy and analysis showed a general infection by *Clostridium perfringens*. In the case of the second dolphin, this was a male measuring 154 cm and weighing 50 kg. This dolphin was found with a strong multisystemic parasitism, which appeared as the probable cause for the stranding of this animal in such a bad state. The animal appeared with its body arched in a similar way to that of the first case described, suggesting a similar infectious process (later confirmed by a diagnosis based on serological tests), which was responsible for the animal's death a few days later. We would like to highlight the threat of this type of infection during dolphin recovery works, and also to propose several preventive measures to avoid it.

MINERAL CONCRETIONS IN KIDNEY TISSUE OF THE ATLANTIC WHITE-SIDED DOLPHIN (*LAGENORHYNCUS ACUTUS*) OF THE FAROE ISLANDS: A WAY OF CADMIUM DETOXICATION?

I. Gallien[1], F. Caurant[1], M. Bordes[2], P. Bustamante[1], and P. Miramand[1]

[1]*Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, Avenue Marillac,*
17042 La Rochelle Cedex, France
[2]*Centre Commun d'Analyses, Université de La Rochelle, 5 perspective de l'Océan, 17000 La Rochelle, France*

The northern sub-polar area appears to be a region where there is cadmium enrichment in the food web. Thus, top predators from this area exhibit high cadmium concentrations in their tissues. With the aim of revealing possible adverse effects, individuals of Atlantic white-sided dolphins from the Faroe Islands have been sampled and their kidneys examined histologically for lesions. Light and electron microscopy revealed signs of abnormalities, which were difficult to relate to the presence of cadmium. Nevertheless, individuals with the highest cadmium concentrations exhibited electron dense mineral concretions in the basal membranes of the proximal tubules. These spherocrystals are made up of numerous strata mineral deposits of calcium and phosphorus, in the centre of which cadmium has been detected with an atomic Ca : Cd ratio of 10. Cd levels in the Atlantic white-sided dolphins off the Faroe Islands were very high compared with similar species from temperate areas, and the presence of these spherocrystals could constitute a way of detoxification for this toxic element in the kidney of such marine mammal species.

ISOLATION AND CHARACTERISATION OF *BRUCELLA* SPP. IN A MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*)

J. Godfroid [1], C. Clavareau[1], M. Tryland[2], V. Wellemans[1], K. Walravens[1], A. Cloeckaert[3]
J-M. Verger[3] and J.-J. Letesson[4]

[1]*Veterinary and Agrochemical Research Center, Brussels, Belgium*
[2] *Norwegian College of Veterinary Medicine, Tromsø, Norway*
[3]*Institut National de la Recherche Agronomique, Nouzilly, France*
[4]*University of Namur, Molecular Biology Unit, Namur, Belgium*

We isolated a noval, unknown *Brucella* species from a minke whale (*Balaenoptera acutorostrata)* that had been caught during commercial hunting off the Norwegian coast of Finnmark in May, 1995. In a serological study, we have found evidence of *Brucella* spp infections in seals but also in whales caught in the North Atlantic. We have cultured spleen and liver samples from a minke whale classified positive by brucellosis serological tests. Cultures on *Brucella*-specific media yielded positive results. Agglutination and biochemical tests were consistent with the diagnosis of a smooth *Brucella* sp. DNA work has shown positive PCR results for the specific *Brucella* 16S-23S Spacer and IS65O1 sequences. RFLP studies based on the IS6501 sequence have shown a unique profile in comparison to those described for *B. melitensis, B. abortus, B. suis, B. neotomae, B. canis* and *B. ovis*. Moreover, Southern Blot analysis, as well as the sequencing of the omp2 locus, have shown a unique characteristic: the minke whale *Brucella* appears to have two copies of the omp2b gene instead of one copy each of the omp2a and the omp2b genes as seen in the other *Brucella* species, except for *B. ovis* which has two genes closely related to omp2a. This is the first description of *Brucella* spp. in rorquals. The minke whale strain is the first known *Brucella* strain that has two copies of the omp2b gene. This new *Brucella* strain is pathogenic in the mouse model and immunogenic in cattle. The isolation of a novel agent which is potentially responsible for reproductive disorders in baleen whales, as well as its potential zoonotic importance, is of concern. Finally, the isolation of *Brucella* spp. in whales, seals, dolphins, and porpoises raises questions regarding the source(s) of infections and the phylogenetic link between the *Brucella* species found in marine mammals and domestic mammals.

FOREIGN BODIES FOUND IN THE DIGESTIVE TRACT OF MARINE MAMMALS IN NORTH-WESTERN SPANISH COAST

A. F. González[1], A. López[1], X. Valeiras[2] and J. M. Alonso[1]

[1]*Instituto de Investigaciones Marinas-CSIC, Eduardo Cabello, 6 – 36208, Vigo, Spain*
[2]*Coordinadora para o Estudio dos Mamíferos Mariños, CEMMA, Apdo. 156 – 36380, Gondomar, Spain*

INTRODUCTION Cases involving foreign bodies into the digestive tract have been reported briefly from captive and wild cetaceans (Greenwood *et al*,, 1976, Beroza *et al*, 1981, Kastelein and Lavaleije, 1992).

Strandings in Galicia (North-west Spain) have been recorded since 1990 by a network of volunteers (CEMMA). A total of 1300 marine mammals have been recorded to date. This paper deals with the cases in which foreign bodies have been found in the digestive tract (comprising mouth, oesophagus, and the three chambers of the stomach) in several species of wild stranded marine mammals.

MATERIALS AND METHODS Cetacean strandings in Galicia were studied following the protocol of Kuiken and Garcia-Hartmann, (1991). The stomach contents were analysed following reference collections of otoliths and cephalopod beaks made for this purpose (Clarke, 1986).

RESULTS Foreign bodies were found in 28 marine mammals comprising 10 species (Table 1). Among them, 27 were found stranded dead along the Galician coast. In just one case, a striped dolphin was found alive with a plastic tube around its nose. This tube was removed and the animal could be released unharmed.

The foreign bodies found included plastic items, fishing nets, feathers, stones, oil balls and hooks. Sand and algae were also considered as foreign bodies. Their localisation along the digestive tract was: mouth 3 cases, oesophagus 7 cases, and stomach 23 cases. The post-mortem entrance was clear only in two cases where sand was present in the mouth.

DISCUSSION AND CONCLUSION Plastic bags could be misidentified with normal compounds of the diet of some odontocetes. However, fishing nets or hooks could be ingested accidentally in association with the diet of these species.

Other hypotheses that have to be taken into account are: inexperience of young animals for feeding, digestive alterations (for instance gastric ulcers) that maintain the stomach chamber full of contents, or neurological problems that produce abnormal perception of potential diet items.

The clinical consequences of ingestion of foreign bodies vary from non-problematic cases (small plastics or stones, sand or algae), moderate problematic cases (physical or chemical effects of hooks or oil) to those that produce the death of the animal. The last ones involved two Cuvier's beaked whale, one striped dolphin and one fin whale with the stomach completely full of plastics, and two bottlenose dolphins with oesophagus and stomach full of fishing net.

REFERENCES

Greenwood, A. G., Taylor, D. C., and Wild, D., 1976. Fibreoptic gastroscopy in dolphins. *Vet. Rec*, June 10, 1978.

Beroza, G. A., Barclay, W. P., McDonall, S. E. and Ott, J. E. 1981. Manual retrieval of a gastric foreign body in an Atlantic bottlenose dolphin. *JAVMA*, vol 179, n°11.

Kastelein, R. A.. and Lavaleije, M. S. S., 1992. Foreign bodies in the stomach of a female Harbour porpoise (*P.phocoena*) from the north sea. *Aquatic Mammals*, 18(2): 40-46.

Kuiken, T. and Garcia-Hartmann, M., (eds) 1991. *Cetacean pathology: dissection techniques and tissues sampling.* Proceedings of the first ECS Pathology workshop, ECS Newsletter (Special Issue), 17: 1-39.

Clarke, M.R. (Ed.). 1986, *A handbook for the identification of cephalopod beaks.* Clarendon Press, Oxford.

Table 1. Numbers with asterisk corresponds to the same animal. S=Stomach, O=Oesophagus, M=Mouth.

	Plastic	Nets	Feather	Oil	Hooks	Stones	Sand	Algae
Balaenoptera physalus (n=1)	1 SO							
Ziphius cavirostris (n=3)	3 S							
Globicephala melas (n=2)	1 S				1* S	1* S	1* S	
Globicephala macrorhynchus (n=1)							1 S	
Grampus Griseus (n=2)	1 S		1* S	1* S				1* S
Tursiops truncatus (n=5)		2,1 SO, OM		1 O	1 S			
Stenella coeruleoalba (n=2)	1, 1 S, M							
Delphinus delphis (n=5)	1 S				1, 1 M, O	1* S	1* S	1 S
Phocoena phocoena (n=4)							2, 1 (SO), O	1 S
Halichoerus grypus (n=3)	1 S		1 S		1 S			

CLINICAL AND PATHOLOGICAL FINDINGS IN A STRIPED DOLPHIN (*STENELLA COERULEOALBA*) DURING A THREE-WEEK REHABILITATION ATTEMPT

C. Hue[1,5], (1), J. Abadie[2], J. M. Alonso[3], T. Chekchak[1], M. F. Menard[4] and S. Pineau[1, 5]

[1]*C.E.R.M.A.M. (Centre Européen de Réhabilitation des Mammifères Marins), Association Le Monde de Gaïa, 65 rue de Vincennes, 93100 Montreuil, France*
[2]*Ecole Nationale Vétérinaire de Nantes, Service d'Histologie - Anatomie pathologique, B.P. 40706, 44307 Nantes Cedex 03, France*
[3] *Instituto de Investigaciones Marinas, CSIC, Eduardo Cabello 6, 36208 Vigo, Spain*
[4]*Institut Départemental d'Analyse et de Conseil, La Chantrerie, Route de Gâchet, B.P. 80603, 44306 Nantes Cedex 3, France*
[5]*G.E.C.C. (Groupe d'Etude des Cétacés du Cotentin), Centre d'Innovation Technologique, rue Louis Aragon, 50130 Octeville, France*

To date, only a few rehabilitation attempts of striped dolphin have been reported. This is the first published case of dolphin rehabilitation in France. On 17 August 1999, a male striped dolphin was found stranded alive on the beach of Armanville (Normandy). After clinical evaluation, members of CERMAM decided to transport the animal to their facilities by helicopter. The dolphin was placed into a pool and a complete clinical examination was performed, including multiple analysis and diagnostic imaging. Blood samples were routinely taken and the behaviour was monitored 24 hours a day. Serology for Brucella and Morbillivirus was also undertaken.

The clinical exploration showed emaciation, dehydration, inability to swim and to maintain itself at the surface, and abdominal pain. Blood biochemistry showed unceasing alteration of some parameters. Serology analysis were slightly positive for Morbillivirus and clearly positive for Brucella. The animal received fluids, antibiotics, vitamins, anthelmintic, anxiolytic agents, and was also treated for gastric ulceration and digestive troubles. Gastric ulceration were confirmed by endoscopy and many parasites were found on the animal.

After two weeks, the clinical picture worsened with colic and respiratory distress. The dolphin died twenty days after the stranding. Necropsy and sample collection were immediately performed. The most significant results were: subcutaneous oedema with extensive degenerative myopathy, gastric retention, hyperacute suppurative necrotizing bronchopneumonia and vascular perturbation. *Staphylococcus aureus* was isolated from respiratory lesions and from lymphatic nodes and was clearly involved in these lesions.

Although the cause of the dolphin's death cannot be accurately determined, an endotoxic shock produced by *Staphylococcus aureus* appears to be the possible primary factor. This was the second time a striped dolphin was maintained for such a long time in Europe. Such attempts provide valuable biological, clinical, and pathological data on this species.

POSTMORTEM EXAMINATION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) STRANDED ALONG THE COASTS OF BELGIUM AND NORTHERN FRANCE FROM 1989 TO 1999

T. Jauniaux, L. Brosens, D. Petitjean and F. Coignoul

Department of Pathology, Veterinary College, University of Liege, Sart Tilman B43, 4000 Liege, Belgium

In Belgium, a multidisciplinary research network (MARIN Marine Animals Research & Intervention Network) involving biologists, toxicologists and veterinary pathologists is in charge of the determination of the cause(s) of death in marine mammals . Animals stranded on the coasts of Belgium and northern France (in association with the Centre de Recherche sur les Mammifères Marins, La Rochelle) are collected, necropsied and sampled for histopathology, bacteriology, virology, parasitology and toxicology. Immunohistochemical investigations especially on dolphin morbillivirus are also performed on formalin-fixed tissues. Since 1989, 43 harbour porpoises (*Phocoena phocoena*) have been examined (11 from France and 32 from Belgium). From 1989 to 1996, only five animals were available for postmortem examination, compared with seven in 1997, eight in 1998 and 23 in 1999. Most of the strandings occurred during winter and early spring, generally after storm periods. Sex ratio was normal and animals were mainly juvenile. The main causes of death were pneumonia, severe parasitism, emaciation, lung edema, and entanglement in fishing gear. Microscopic examination revealed that the main lesions were acute pneumoniae, massive lung edema, enteritis, hepatitis and gastritis. Encephalitis was observed in 2 cases. No evidence of morbillivirus infection was detected. Pneumoniae were associated with bacteria and/or parasites. Most frequently recorded nematode parasites were in the bronchi, arteries and heart (*Pseudalius inflexus* and *Torinurus convolutus*), in the stomachs (*Anisakis simplex*), in the middle ears (*Stenurus minor*) and trematodes in the liver (*Campula oblonga*). Causes of death and lesions were similar to those reported in other countries bordering the North Sea. The reasons for the increasing number of animals examined during the last few years are manyfold. The first is the better and stronger collaboration within the MARIN group which has expanded geographically southward into France. Secondly, the increasing number of stranded porpoises could be due to an increasing number of animals in the southern North Sea.

INFECTIOUS DISEASE MORTALITY IN HARBOUR PORPOISES STRANDED IN ENGLAND AND WALES, 1990-1999

P. D. Jepson[1], J. R. Baker[2], T. Kuiken[1, 3], V. R. Simpson[4], R. C. Deaville[1], and P. M. Bennett[1]

[1]*Institute of Zoology, Regent's Park, London NW1 4RY, UK*

[2] *The Dormie, Berth-ddu, Rhosesmor, Mold, Flintshire CH7 6PS, UK*

[3]*Erasmus University, Institute of Virology, Nl-3000 DR Rotterdam, Netherlands*

[4]*Veterinary Investigation Centre, Polwhele, Truro, Cornwall TR4 9AD, UK*

Between August 1990 and September 1999, 407 standardised postmortem examinations were conducted on harbour porpoises (*Phocoena phocoena*) found stranded around the coastline of England and Wales. The cause of death was established for 304 of these individuals, of which mortality due to infectious disease was diagnosed in 66 individuals. In 16 individuals, fatal septicaemias were diagnosed of which *Streptococcus canis* (n=7), *Salmonella* sp. (n=4) and *Listonella damsela* (n=2) were the most common bacteria isolated. Abscessation of multiple organs were characteristic of most *Streptococcus canis* septicaemias. Chronic granulomatous interstitial pneumonias due to (often heavy) nematode infestations with *Pseudalius inflexus*, *Torynurus convolutus*, and *Halocercus* sp. (n=9), (necro)purulent (broncho)pneumonias due to bacterial infections (n=5), or combinations of these lesions due to both bacterial and nematode infections (n=18) were other common causes of infectious disease mortality. Pulmonary verminous (thrombo)vasculitis was a complicating factor in many of these pneumonias, and in a further two cases, acute fatal pulmonary haemorrhage due to rupture of a parasitised artery was suspected. Only one case of generalised morbillivirus infection (associated with secondary mycotic pneumonia) was recorded during this study. Parasitic gastritis (n=4), suppurative meningo-encephalitis (n=3), mycotic pneumonia (n=2), mastitis (n=1), Clostridial myositis (n=1), non-suppurative meningitis (n=1), gastric (parasitic) stenosis (n=1), necrotising (*Salmonella* sp.) enteritis/peritonitis (n=1) and bacterial hepatitis and peritonitis (n=1) were the other causes of infectious disease mortality.

WINTER OBSERVATIONS AND STRANDINGS OF JUVENILE GREY SEALS (*HALICHOERUS GRYPUS*) IN THE NORTHERN SPAIN DURING 1998 AND 1999

L. Laria[1], A. López[2], G. García-Castrillo[3], J. M. Alonso[4] and AMBAR[5]

[1]*CEPESMA, Coordinadora para el Estudio y Protección de Especies Marinas, Paseo del Muelle,*
3 Luarca, Asturias, Spain, (E-mail: tursion@iim.csic.es)
[2]*CEMMA (Coordinadora para o Estudio dos Mamiferos Mariños) Apartado 165, Gondomar 36380, Spain*
[3]*Museo Marítimo del Cantábrico, San Martín de abajo s/n 39004, Santander, Spain*
[4]*Instituto de Investigaciones Marinas, (CSIC), Eduardo Cabello 6, 36208, Vigo, Spain*
[5] *AMBAR, Karl Marx 15, 4º F. 48950 Astrabudua, Bilbao, Spain*

INTRODUCTION Among the pinniped species studied along the north coast of Spain, the grey seal (*Halichoerus grypus*) is the most frequently recorded (Avellà *et al*, 1993). Although there are no populations established along this coast, the presence of grey seals is reported regularly in the winter months.

MATERIAL AND METHODS Four stranding networks that study marine mammals operate along the north coast of Spain: CEMMA/IIM-CSIC in Galicia, CEPESMA in Asturias, MMC in Cantabria and AMBAR in Euskadi. Alive stranded seals were transported to rehabilitation facilities, while the dead ones were necropsied and analysed. Data on incidental catches were also studied. All data collected were introduced in a data base created by the Seal Working Group of the Spanish Cetacean Society (SEC).

RESULTS A total of 33 grey seals were studied in the north coast of Spain from 1990 to 1997. An increase of records (35 animals) has been observed during the last two years (1998-99) in the same area (see Table 1). Among these records, 11 were observed offshore, 9 stranded alive, 7 stranded dead, and 8 were collected dead as a result of a bycatch. Seven of the animals rescued were successfully rehabilitated in several facilities: the Oleiros Recuperation Centre in Galicia (1), the Marine Fauna Recuperation Centre of Asturias (1), Centre de Recherche sur les Mammifères Marins de La Rochelle (3), and Seal Research and Rehabilitation Center of Pieterburen (2). Malnutrition, extreme weakness, hypothermia, and other pathologies (mainly respiratory and digestive) were the causes of the stranding of these seals.

All the observations and strandings of grey seals have been recorded between December and March. The total length of the animals ranged from 90 to 115 cm, except for one male of 225 cm stranded dead on the Atlantic Galician coast. Capture and observations of grey seals tagged by the University College of Dublin in the north coast of Spain, showed one of the points of departure of these animals.

DISCUSSION AND CONCLUSIONS The weakness of the seals studied (indicating possible long displacements), their length, and the breeding season for this species in the European colonies showed that grey seals arriving in northern Spain are juveniles up to 3 months old (Bonner, 1989a). This temporo-spatial distribution confirms the post-natal dispersion described for this species (Bonner, 1989b). Furthermore, the clear increase of observations of grey seals in the north coast of Spain confirms the clear expansion of this species from their original colonies.

ACKNOWLEDGEMENTS The authors want to thank all the research staff and volunteers of IIM-CSIC and CEMMA (Galicia), CEPESMA (Asturias) and AMBAR (Euskadi). We also want to thank the Spanish Cetacean Society (SEC) for their support to the Seal Working Group.

REFERENCES

Avellà, F., Castells, A., and Mayo, M. 1993. Los Pinnipedos de las costas atlánticas y catábricas de la península ibérica. *Quercus*, 85(1993): 29-34.

Bonner, W. N. 1989a. Grey seal. In: *Handbook of Marine Mammals*. (Eds. Sam H. Ridgway and Richard J. Harrison). Academic Press, London and New York.

Bonner, W. N. 1989b. *The Natural History of Seals*. Christopher Helm, London.

Table 1. Records of Grey seals by autonomous comunities of northern Spain

	1998	**1999**
GALICIA	2	5
ASTURIES	5	9
CANTABRIA	2	2
EUSKADI	5	5

IMMUNOHISTOLOGICAL AND SEROLOGICAL INVESTIGATION OF MORBILLIVIRUS INFECTION IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE BLACK SEA

G. Müller[1], A. Wünschmann[1], W. Baumgärtner[1], A. Birkun[2], A. Komakhidze[3], T. Stanev[4], and C. R. Joiris[5]

[1]*Institut für Veterinär-Pathologie, Justus-Liebig-Universität Giessen, Germany*
[2]*Laboratory of Biotechnological Research in Ecology, Medicine and Aquaculture,*
(BREMA) Laboratory, Simferopol, Ukraine
[3]*Institute of Black Sea Ecology and Fisheries, Batumi, Georgia*
[4]*Institute of Fisheries, Varna, Bulgaria*
[5]*Free University Brussels (VUB), Laboratory of Ecotoxicology, Belgium*

Morbilliviruses have caused a die-off in common dolphins (*Delphinus delphis ponticus*) in the Black Sea in 1994. To further investigate the role of morbilliviruses as a cause of disease and death in harbour porpoises (*Phocoena phocoena*) from this area, blood and tissue samples from 73 stranded or bycaught animals were collected between 1997 and 1999 and investigated for morbillivirus infection.

According to their dental age, cetaceans were grouped into four different age classes (0-1, 1-4, 4-7 and 7-12 years of age). A virus neutralisation assay for detection of porpoise morbillivirus (PMV)-specific antibodies was performed. Due to the cytotoxicity of some sera, only titers of 1:20 or greater were considered positive. For routine histology, brain, lung and splenic tissue were collected. For detection of morbillivirus antigen in lung tissue, immunohistology was performed by using a cross-reactive, polyclonal antibody directed against CDV nucleoprotein and the avidin-biotin-peroxidase technique. Lung tissue from a striped dolphin (*Stenella coeruloealba*) suffering from morbillivirus infection was used as positive control. 52% of all investigated harbour porpoises showed positive porpoise morbillivirus-specific antibody titers.

Grouping the animals according to their age revealed that the majority of animals with positive titers were between 4 and 12 years of age (56 and 79%), whereas in younger animals only 32% (1-4 years) and 33% (< 1 year) were positive. No histological lesions specific for morbillivirus infection were detected, and by immunohistology, all cases were negative for morbillivirus antigen.

The absence of morbillivirus antigen and the lack of characteristic morbillivirus-specific lesions showed that morbillivirus infection was not a major cause of death or illness in the investigated population. However, the serological results are suggestive of a continuous circulation of morbilliviruses among harbour porpoises from the Black Sea, and positive titers in older animals may be remnants from an infection in 1994.

HEAVY METALS IN *TURSIOPS TRUNCATUS* AND *DELPHINUS DELPHIS* BY X-RAY SPECTROMETRY

R. A. Pereira and M. L. Carvalho

Centro de Física Atómica, Faculdade de Ciências, Universidade de Lisboa, Av. Prof Gama Pinto, 2,
1649-003 Lisboa, Portugal

The increase in marine pollution could be the most serious threat to the survival of cetacean populations in many parts of the world. The purpose of this work was to determine heavy metal concentrations in muscle, liver, fat tissue and skin of 15 common dolphins *Delphinus delphis* and bottlenose dolphins *Tursiops truncatus* collected from the Portuguese coast.

The samples were collected during post-mortem examnation, and freeze-dried until further analysis. Prior to analysis, samples were lyophilised and ground in a Teflon mill, to avoid contamination. With the obtained powder, several pellets of each sample were analysed directly by X-Ray Fluorescence Spectrometry. The concentrations for Ti, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Hg and Pb were obtained. The results show that the highest concentrations of Mn, Fe, Cu and Hg are always in liver tissues, Co is similar in liver, skin and muscle, Ni, Rb and Sr are rather constant in all the analysed tissues. Zn and Se are at increased levels in skin tissues.

It is noteworthy that Pb is present in very low concentrations only in skin samples, and As is at elevated levels in fat tissue. These data are discussed and compared with previous studies and measurements made in animals from other populations

PATHOLOGICAL FINDINGS IN HUNTED HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) ORIGINATING FROM WATERS OF GREENLAND

U. Siebert[1], A. Wünschmannm[2], K. Frese[2], M. O. Heide-Jørgensen[3], C. Lockyer[4], G. Müller[2],
W. Baumgärtner[2], and R. Weiss[2]

[1]*Forschungs- und Technologiezentrum Westküste, Christian-Albrechts-Universität zu Kiel, Hafentörn, 25761 Büsum, Germany*
[2]*Institut für Veterinär-Pathologie, Justus-Liebig-Universität Giessen, Frankfurter Str. 96, 35392 Giessen, Germany*
[3]*Greenland Fisheries Research Institute, Marine Mammal Section, Tagensvej 135, Copenhagen N DK-2200, Denmark*
[4]*Danish Institute for Fisheries Research, Dept. of Marine Fisheries, Charlottenlund Castle, 2920 Charlottenlund, Denmark*

The causes for the decline in harbour porpoise populations in German waters have been under investigation since 1991. However, lack of control animals from less polluted waters has hampered interpretation of findings. In order to obtain control data, post mortem examination of eight female and six male porpoises, shot by Inuits in waters around Greenland, was performed. Frozen and formalin-fixed tissues and serum was collected for histological and bacteriological examination.

The age of the animals ranged from 1 to 12 years, as determined by counting of the dental annual growth layers. In general, the body condition of the animals was good. Parasite infestation was the most frequent finding. Twelve animals had nematodes (*Stenurus minor*) in the peribullar cavity. Trematodes (*Orthosplanchus minorovi*) were found in the liver and pancreas of 11 animals, associated with mild to moderate granulomatous inflammation of the bile ducts and pancreatic ductular system. Within the lungs of eight animals were nematodes (*Halocercus* sp.), often associated with mild interstitial granulomatous pneumonia. In the skeletal musculature and mammary tissue of four animals, nematodes (*Crassicauda* sp.) were found, causing mild granulomatous myositis and mastitis. *Sarcocystis* sp. cysts were found in the tongue and skeletal musculature of 2 animals.

Other lesions included mild lymphocytic vaginitis of unknown etiology in four harbour porpoises and thymic microcysts in 12 animals. Bacteriological examination of lung, liver, spleen, kidney and intestine revealed no bacteria considered pathogenic except for a-hemolytic streptococci in the lung of one animal without significant pulmonary lesions.

In conclusion, the health status of the hunted harbour porpoises of the waters of Greenland appeared to be good. The high prevalence of usually mild parasitic infection is to be expected in free-ranging animals.

CLINICAL AND PATHOLOGICAL FINDINGS IN TWO JUVENILE GREY SEALS (*HALICHOERUS GRYPUS)* STRANDED IN ASTURIAS (NORTH COAST OF SPAIN)

A. Solís[1], L. Laria[1], C. Salazar[1], L. C. Suárez[1], A. López[2], and J .M. Alonso[3]

[1]*CEPESMA, Coordinadora Estudio y Protección de Especies Marinas, Muelle, 3 Luarca, Asturias, Spain*
(E-mail: tursion@iim.csic.es)
[2]*CEMMA (Coordinadora para o Estudio dos Mamiferos Mariños) Apartado 165, Gondomar 36380, Spain*
[3]*Instituto de Investigaciones Marinas, (CSIC), Eduardo Cabello 6, 36208, Vigo, Spain*

INTRODUCTION During 1999, nine juvenile grey seals (*Halichoerus grypus*) were found stranded in Asturias (North Spain) by the local network of volunteers (CEPESMA). Two of them were still alive when they were found. This paper describes both clinical cases.

MATERIALS AND METHODS (Clinical procedures) The seals (one male and one female) were transported to a marine animal recuperation centre and a complete clinical exploration were performed (Barnett, 1998). Blood samples were collected regularly for complete haematology and chemistry analyses. Nasal exudates were stained with a Diff-Quick and observed with optical microscopy. A treatment with antibiotics, mucolytics and antiparasitic drugs against respiratory problems was established (see Figure 1). During the first week, the two seals were maintained in a controlled environment facilities. They were put in an outdoor facility a few days later.

A protocol to feed the animals was established: The seals were fed five times per day during the first week with a dose of 250 ml of a multi-milk replacer formula mixed with ground fish (Spotte, 1990). The seals were placed in sternal recumbency, and a lubricated stomach tube (1cm diameter) was passed trough the oesophagus up to the stomach. The two seals began to accept pieces of whole fish and they were fed at a rate of 4-5 kg per day, after the first week. The seals were also fed, in a 30 m^3 pool with live fish, approximately one month later.

RESULTS The two seals (90cm and 14 kg; 110cm and 18 kg) showed the same symptoms: malnutrition, dehydration, and extreme weakness. Both had respiratory distress with continuous mucopurulent nasal and ocular discharge, cough, dyspnea and abnormal auscultation of lung sounds. The respiratory symptoms disappeared after a month of treatment. Blood parameters were into the normal ranges described for this species according to Greenwood *et al.*, (1971).

Both seals had a mean weight increase of 2 kg per week. The female seemed to be less hungry during the last week of rehabilitation and no faeces were found in its recuperation place. This seal was treated with liquid paraffin (see Table 1).

The two seals were released after three months of rehabilitation with 30 (female) and 33 (male) kg of weight. The male reached offshore waters but the female appeared near the first stranding site two days later. The animal died a few hours after the stranding. Necropsy and histopathological analysis showed a pyloric estenosis with a total occlusion of the pyloric pass.

DISCUSSION AND CONCLUSIONS The cases presented represent the first seal rehabilitation attempt of the Asturias stranding network. The causes of the pyloric estenosis diagnosed in the death seal are not clear. However, the over stimulation of the digestive tract with the nutritional plan previously established (4-5 kg per day) appears to act as the primary factor in the death of the seal. Lower doses such as 3 kg/day maximum are recommended for juvenile seals maintained in rehabilitation.

REFERENCES

Barnett, J, 1998. Treatment of sick and injured marine mammals. *In practice*, April 1998, 200-211.

Spotte, S., 1990. Artificial Milks for Unweaned Marine Mammals. In: *CRC Handbook of Marine Mammal Medicine, Boca Raton FL,CRC Press.*

Greenwood, A, G, Ridgway, S. H., and Harrison, R. J, 1971. Blood values in young grey seals. *J.Am.Vet.Med.Assoc.*, 159, 571, 1971.

Lacave, G, 1993. *Diagnostic and Therapeutic methods in Marine Mammals*, Zoo Duisburg, Dec. 4-5.

Stoskopf, M .K., 1990. Marine Mammal Pharmacology. In: *CRC Handbook of Marine Mammal Medicine* (Ed L. A. Dierauf), CRC Press, Boca Raton FL.

Table 1. Drug table.

Drug	Reference	Dose, route and frequency
Enrofloxacine	Lacave, 1993 [4]	5 mg/kg I.M. SID 7 days
Bromhexine	Barnett, 1998 [1]	0’2 mg/kg PO TID
Prazicuantel	Stoskopf, 1990 [5]	10 mg/kg PO
Liquid paraffin	Barnett, 1998 [1]	1 ml/kg/day in divided doses PO

BIOMARKERS OF ENVIRONMENTAL POLLUTION IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN THE NORTH SEA

Rachel Tilley[1,2], Ailsa Hall[1], Graham Kemp[2] and Nick Green[3]

[1] *Sea Mammal Research Unit, University of St. Andrews, St. Andrews, UK (E-mail: ret2@st-andrews.ac.uk)*
[2]*Biomolecular Sciences, University of St. Andrews, St. Andrews, UK*
[3]*Institute of Environmental Sciences, University of Lancaster, Lancaster, UK*

INTRODUCTION In recent years, the physiological and putative ecological effects of environmental contaminants on marine mammals has provoked a great deal of concern (DeLong *et al*, 1973; Jenssen *et al*, 1995; Reijnders, 1986; Ross *et al.*, 1996). Observed physiological effects, correlated with total organochlorine body burdens from captive and field animal studies, have suggested adverse effects to immunocompetence and reproduction in phocids and some cetaceans (Reijnders, 1986; Subramanian *et al*, 1987; Lahvis *et al*, 1995; DeSwart *et al*, 1996; DeGuise *et al*, 1998). More recently, a workshop on Chemical Pollution and Cetaceans, convened by the International Whaling Commission, recommended that the harbour porpoise (*Phocoena phocoena*) be included in the 'Pollution 2000' study on chemical pollutants in cetaceans (Reijnders, 1999a, b).

So far, the majority of information on the exposure and uptake of environmental contaminants by the harbour porpoise has been gained from the measurement of tissue residue levels (Bruhn *et al.*, 1995). However, some contaminants are metabolised and therefore do not bioaccumulate. By investigating an individual's response to exposure using molecular biomarkers, biases introduced from using body burdens as surrogates for exposure can be avoided (Peakall, 1992). The induction of particular liver enzymes, known as cytochrome P450s, which are central to the metabolism of xenobiotics, have been used as biomarkers of contamination in many cetacean species exposed to organochlorines (Goksøyr, 1989; White *et al.*, 1994; Watanabe *et al.*, 1989).

In particular, the subfamily, cytochrome P4501A, has been shown to metabolise certain groups of environmental contaminants, and is detected using the associated mixed function oxygenase (MFO), 7-ethoxyresorufin *O*-deethylase (EROD; Prough *et al*, 1978). Murk *et al* (1994) have previously measured the induction of the P4501A isoenzyme EROD in the liver of a harbour porpoise that had stranded alive in the Netherlands, but later died in rehabilitation.

Many investigations that evaluate the activity of representative cytochrome P450s to detect OC exposure require fresh, internal tissues. Obtaining very fresh samples is difficult, as many countries have now stopped exploiting marine mammals as a resource. Therefore, a small number of samples are obtained from dead animals from strandings, where the cause or time since death is often unknown, and those that are bycaught (McCarthy, 1992). After death, the degradation of proteins and inactivation of enzymes occurs, including cytochrome P450s and their associated MFOs: As a consequence, enzyme activity and cytochrome P450 concentration may be underestimated.

In this preliminary study, data from a bycaught harbour porpoise from the east coast of Scotland demonstrated exposure to environmental pollutants, through the induction of the specific cytochrome P4501A, measured both catalytically and immunochemically. In addition, we have investigated the use of 2-Dimensional gel electrophoresis as a novel method for detecting exposure to environmental pollutants in non-fresh samples.

METHODS Liver samples were obtained from a bycaught harbour porpoise that had been dead for approximately two hours and were placed in liquid nitrogen for transportation to the laboratory for immediate preparation. Liver homogenates were purified by differential centrifugation. The ultra-centrifugation step resulted in a microsomal pellet in which the mixed function oxygensase system is found. Subsequently, the microsomal pellet was used in a cytochrome P450 associated mixed function oxygenase assay, EROD, to determine the presence and activity of one particular cytochrome P450, P4501A, using the method of Prough *et al* (1978).

Immunochemical assays (western blotting) were used to determine whether the anti-trout P4501A primary antibody (courtesy of Dr R. Addison, Institute of Oceanic Sciences, Canada) would cross react with harbour porpoise P4501A, for use in future work and provide further evidence for the existence of the P4501A isoenzyme.

2-Dimensional gel electrophoresis separated the microsomal proteins by their isoelectric point (pI) during isoelectric focusing and by their molecular weight (MW) on 10%T Sodium Dodecyl Sulphate –Polyacrylamide gel electrophoresis (SDS-PAGE).

Concentrations of polychlorinated biphenyls (PCBs) and dioxins were determined in a sample of ventral blubber. Detailed methods used are given in Pomeroy *et al* (1996). Briefly, the congeners were extracted using a Buchi 810 soxhlet apparatus and extracted with hexane for 16h. PCBs were separated from other organochlorines by adsorption chromatography. Twenty-eight congeners were isolated using a Hewlett Packard 5890 gas chromatograph equipped with an autosampler using a 50-m Ultra 2 capillary column.

RESULTS AND DISCUSSION Very few studies have investigated the cytochrome P450-MFO system of the harbour porpoise. An aim of this preliminary study was to elucidate cytochrome P4501A – EROD activity and the cross reactivity of harbour porpoise cytochrome P4501A protein with an anti-trout P4501A. The concentration of accumulated chlorobiphenyl (CB) congeners and dioxins in the blubber were also determined.

The cytochrome P4501A activity obtained using EROD was in the range of other marine mammals, but was higher than in other cetacean species (Table 1). The harbour porpoise from the Netherlands had a 100 fold less activity than the harbour porpoise from this present study (Murk *et al*, 1994). However it is impossible to compare activities from just two individuals from different populations.

Immunochemcial analysis of harbour porpoise liver microsomal protein using anti-trout P4501A antibody revealed two distinct protein bands that cross-reacted with the antibody, suggesting that the cytochrome P4501A isoenzyme is present in this cetacean (Fig. 1). However, a second band at a lower molecular weight also cross-reacted. This could be a degradation product of the P4501A protein, or because the anti-trout antibody is not specific to the P4501A in harbour porpoise. Boon, J.P. (personal communication) detected a protein band from harbour porpoise liver microsomes that cross-reacted with anti-rat P4501A monoclonal antibody; however, several bands were observed when a polyclonal anti- rat P4501A antibody was used.

Cytochrome P450 isoenzymes have been shown to metabolise particular groups of environmental contaminants. P4501A metabolises the coplanar, mono-*ortho* coplanar and although less so, the di-*ortho* coplanar PCBs (Safe *et al.*, 1985).

28 chlorobiphenyl (CB) congeners were measured from the blubber of the harbour porpoise (Fig. 2), which included the ICES seven monitoring CBs: IUPAC numbers 28, 52, 101, 118, 138, 153, 180 (Ballschmiter and Zell, 1980; ICES, 1996). The values obtained were consistent with concentrations obtained from harbour porpoises previously sampled from the east coast of Scotland in 1991, that had been washed or stranded ashore after dying at sea (Wells *et al.*, 1994). The total of five CBs (CB# 118, 153, 138, 170 and 180; five of the seven monitoring CBs) were measured in a harbour porpoise from the Irish Sea sampled during the period 1987-89 (Troisi *et al*, 1998). The total concentration obtained ($6.19\mu g.g^{-1}$) was 2.5 times greater compared to the harbour porpoise from this study ($2.56\mu g.g^{-1}$), for the same five CBs. Different degrees of exposure between geographical areas could provide an explanation. However, a range of biological factors such as age, sex, diet, and reproductive status are known to affect the differential burdens of environmental contaminants in individual animals of the same species, and so it is impossible to make any conclusions from such comparisons. In addition, differential expression of cytochrome P450 isoenzymes in individuals of the same species may also contribute to the different concentrations of CBs in their tissues.

The total toxic equivalents using the WHO-TEFs were measured in the harbour porpoise from the present study (Van den Berg *et al*, 1998). The concentration of mono-*ortho* PCBs > non-*ortho* PCBs > Dioxins (Table 2). This trend could be explained by the greater inducing potencies by non-*ortho* PCBs (and dioxins) of the P4501A isoenzyme, thus suggesting greater metabolism of the non-*ortho* compared to the mono-*ortho* PCBs (Safe *et al*, 1985).

Many cetacean samples are obtained through bycatch or strandings. The latter is often indicative of ill-health, and therefore cytochrome P450 activities obtained are likely to be unrepresentative of the population (McCarthy, 1992). However, 2-Dimensional gel electrophoresis is being explored as a method of monitoring individual hepatic microsomal proteins (Fig. 3). This will then provide an overall view of the expression or down regulation of enzymes and proteins, potentially occurring from exposure to environmental contaminants.

Although this preliminary study was carried out on a single animal, it has provided additional evidence for the existence of inducible cytochrome P4501A isoenzyme in the harbour porpoise. These cross-react with an anti-trout polyclonal antibody. The use of 2-Dimensional gel electrophoresis as a novel tool for monitoring microsomal proteins, for investigating new biomarkers in cetaceans, and for use on slightly degraded samples such as from bycaught and freshly dead stranded animals, shows an initial promise.

ACKNOWLEDGEMENTS This preliminary study was carried out with the financial support of the Natural Environmental Research Council.

REFERENCES

Ballschmiter, K. and Zell, M. 1980. Analysis of polychlorinated biphenyls (PCB) by glass capillary gas chromatography: Composition of technical Arclor- and Clophen- PCB mixtures. *Fresenius Z. Analytical Chemistry*, 302: 20-31.

Bruhn, R., Kannan, N., Petrick, G., Schulzbull, D. E., and Duinker, J. C. 1995. CB Pattern in the Harbor Porpoise - Bioaccumulation, Metabolism and Evidence For Cytochrome-P450 2B Activity. *Chemosphere*, 31: 3721-3732.

DeLong, R. L., Gilmartin, W.G., and Simpson, J.G. 1973. Premature births in Californian sea lions: Association with high organochlorine pollutant residue levels. *Science,* 181: 1168 - 1169.

DeSwart, R. L., Ross, P. S., Vos, J. G. and Osterhaus, Adme. 1996.Impaired immunity in harbour seals (*Phoca vitulina*) exposed to bioaccumulated environmental contaminants: Review of a long-term feeding study. *Environmental Health Perspectives*, 104: 823-828

Goksøyr, A., Andersson, T., Förlin, L., Snowberger, E. A., Woodin, B. R. and Stegeman, J. J. 1989. Cytochrome P450 monooxygenase activity and immunochemical properties of adult and foetal piked (minke) whales, *Balaenoptera acutorostrata.* In*: Cytochrome P450: Biochemistry and Biophysics* (Eds. Taylor , Frances, and Schsier).

ICES. 1996. *Report of the ICES advisory committee on marine pollution*. ICES Co-op. Res. Rep. 135, International Council for the Exploration of the Sea. 82pp.

Jenssen, B. M., Skaare, J. U., Woldstad, S., Nastad, A. T., Haugen, O., Kloven, B., and Sormo, E. G. 1995. Biomarkers in blood to assess effects of polychlorinated biphenyls in free-living grey seal pups. Pp. 607 - 615. In*: Whales, seals fish and man.*(Eds. A. S. Blix, L. Walloe and Ø, Ultang). Elsevier Science.

Lahvis, G. P., Wells, R. S., Kuehl, D. W., Stewart, J. L., Rhinehart, H. L., and Via, C. S. 1995. Decreased lymphocyte responses in free-ranging bottlenose dolphins *(Tursiops truncatus)* are associated with increased concentrations of PCBs and DDT in peripheral blood. *Environmental Health Perspectives*, 103: 67-72.

McCarthy, J. 1992. Biomarkers of toxic exposure in marine mammals. Pp. 192-142 In*: Proceedings oj Mediterranean Striped Dolphins Mortality International Workshop*, Spain.

Murk, A., Morse, D., Boon, J., and Brouwer, A. 1994. In-Vitro Metabolism of 3,3',4,4'-Tetrachlorobiphenyl in Relation to Ethoxyresorufin-O-Deethylase Activity in Liver-Microsomes of Some Wildlife Species and Rat. *European Journal of Pharmacology-Environmental Toxicology and Pharmacology Section*, 270: 253-261.

Peakall, D. 1992. *Animal biomarkers as pollution indicators*. Chapman and Hall, London.

Pomeroy, P. P., Green, N., Hall, A. J., Walton, M., Jones, K., and Harwood, J.1996. Congener-specific exposure of grey seal (Halichoerus grypus) pups to chlorinated biphenyls during lactation. *Canadian Journal of Fisheries and Aquatic Sciences*, 53: 1526-1534.

Prough, R., Burke, M., and Mayer, R. 1978. Direct fluorometric methods for measuring mixed function oxidase activity, p. 372 - 377. In*: Methods in Enzymology*. Vol. 52C (Eds. S. Fleischer and. L. Packer). Academic Press, INC.

Reijnders, P. J. H. 1986. Reproductive Failure in Common Seals Feeding on Fish from Polluted Coastal Waters. *Nature*: 324.

Reijnders, P. J. H., Aguilar, A., Donovan, G. P. 1999a (Eds.). Chemical pollutants and cetaceans incorporating the reports leading to the development of the pollution 2000+ programme. *Journal of Cetacean Research and Management (Special Issue 1)*: 1-273pp.

Reijnders, P. J. H., Donovan, G. P., Aguilar, A., and Bjørge, A. 1999b. Report of the workshop on chemical pollution and cetaceans. *Journal of Cetacean Research Management (Special Issue 1):* 1-42.

Ross, P., DeSwart, R., Addison, R., VanLoveren, H., Vos, J., and Østerhaus, A. 1996. Contaminant-induced immunotoxicity in harbour seals: Wildlife at risk? *Toxicology*, 112: 157-169.

Safe, S., Bandiera, S., Sawyer, T., Robertson, L., Safe, L., Parkinson, A., Thomas, P. E., Ryan, D. E., Reik, L. M., Levin, W., Denomme, M. A., and Fujita, T. 1985. PCBs - Structure-Function-Relationships and Mechanism of Action. *Environmental Health Perspectives*, 60: 47-56.

Subramanian, A. N., Tanabe, S., Tatsukawa, R., Saito, S. and Miyazaki, N. 1987. Reduction in the testosterone levels by PCBs and DDE in Dall's porpoises of Northwestern North Pacific. *Marine Pollution Bulletin*, 18: 643-646.

Troisi, G. M., Haraguchi, K., Simmonds, M. P., and Mason, C. F. 1998. Methyl sulphone metabolites of polychlorinated biphenyls (PCBs) in cetaceans from the Irish and the Aegean Seas. *Archives of Environmental Contamination and Toxicology,* 35: 121-128.

Van den Berg, M., Birnbaum, L., Bosveld, A. T. C., Brunstrom, B., Cook, P. Feeley, M., Giesy, J. P., Hanberg, A., Hasegawa, R., Kennedy, S. W., Kubiak, T., Larsen, J. C., van Leeuwen, F. X. R., Liem, A. K. D., Nolt, C., Peterson, R. E., Poellinger, L., Safe, S., Schrenk, D., Tillitt, D., Tysklind, M., Younes, M., Waern, F., and Zacharewski, T. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives*, 106: 775-791.

Watanabe, S., Shimada, T., Nakamura, S., Nishiyama, N., Yamashita, N., Tanabe, S., and Tatsukawa, R. 1989. Specific Profile of Liver Microsomal Cytochrome-P-450 in Dolphin and Whales. *Marine Environmental Research*, 27: 51-65.

Wells, D. E., Campbell, L. A., Ross, H. M., Thompson, P. M. and Lockyer, C. H. 1994. Organochlorine Residues in Harbor Porpoise and Bottle-Nosed Dolphins Stranded On the Coast of Scotland, 1988-1991. *Science of the Total Environment*, 151: 77-99.

White, R. D., Hahn, M. E., Lockhart, W. L., and Stegeman, J. J. 1994. Catalytic and Immunochemical Characterization of Hepatic-Microsomal Cytochromes P450 in Beluga Whale (*Delphinapterus leucas*). *Toxicology and Applied Pharmacology*, 126: 45-57.

Species	Region	EROD activity (nmol product.min-1.mg protein)	Author
Harbour porpoise	St Andrews Bay, East coast Scotland	5.3	Present study
Harbour porpoise	Netherlands	0.471	Murk et al, 1994
Pilot Whale	Japan	0.042±0.042	Watanabe et al, 1989
Striped Dolphin	Japan	0.191±0.015	Watanabe et al, 1989
Killer whale	Japan	0.612±0.373	Watanabe et al, 1989
Harbour seals	Norfolk, UK	9.6±10	Troisi and Mason, 1997

Table 1. Comparison of the cytochrome P4501A - mixed function oxygenase, 7-Ethoxyresorufin-O-deethylase (EROD) activities from a variety of marine mammals species from different geographical regions

	TEQ/g lipid
Mono-Ortho PCBs	39
Non-Ortho PCBs	9
PCDD/PCDFs	<1
Total TEQ	48

Table 2. Toxicity equivalents of PCBs and PCDD/Fs in the harbour porpoise blubber

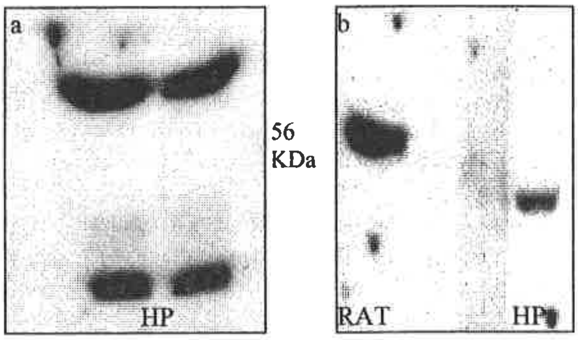


Fig.1. Immunochemical detection of protein bands that cross react with anti-trout P4501A antibody, from harbour porpoise liver microsomes (HP. a; b) and purified rat P4501A1(a). 1b. 2.4pmol rat P4501A1 and 1a; b. 40µg harbour porpoise microsomes.

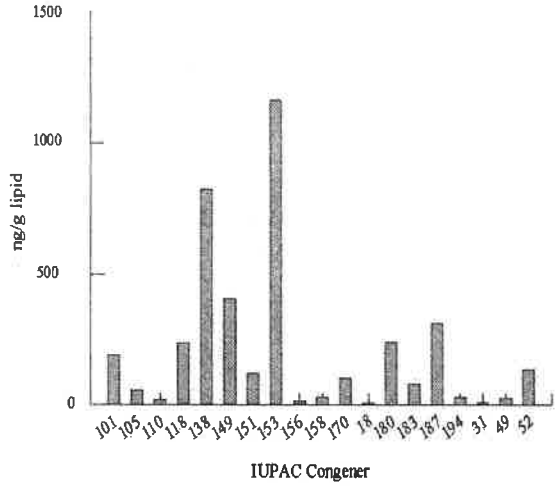


Fig.2. PCB congeners measured in the blubber of the harbour porpoise, including 6 of the 7 monitoring chlorobiphenyl congeners

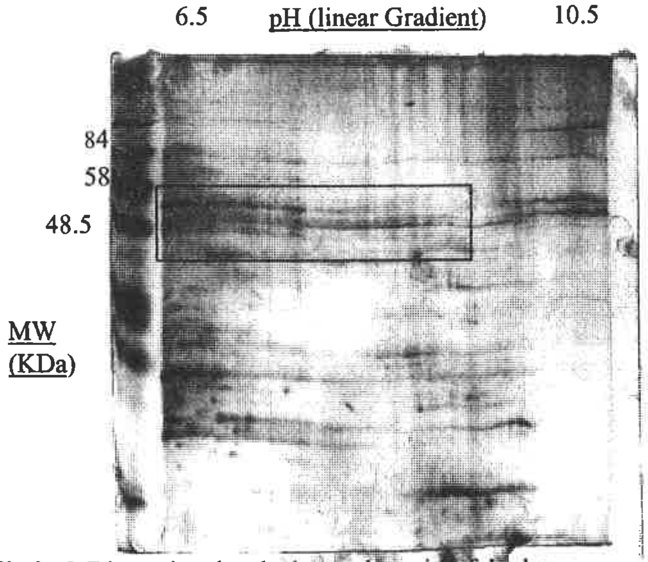


Fig.3. 2-Dimensional gel electrophoresis of harbour porpoise liver microsomes. The area, between 45 and 60Kda, outlined in black represents the location of cytochrome P4501A calculated on the basis of the theoretical pI and MW of a variety of mammals.

IDENTIFICATION AND MOLECULAR CHARACTERISATION OF ß-HAEMOLYTIC STREPTOCOCCI ISOLATED FROM HARBOUR SEALS (*PHOCA VITULINA*) AND GREY SEALS (*HALICHOERUS GRYPUS*) OF THE NORTH AND BALTIC SEAS

A. Vossen[1,2], A. Abdulmawjood[2], Ch. Lämmler[2], R. Weiß[3] and U. Siebert[1]

[1] *Forschungs- und Technologiezentrum Westküste, Christian-Albrechts-Universität Kiel, Büsum, Germany*
(E-mail: vossen@ftz-west.uni-kiel.de)
[2] *Institut für Tierärztliche Nahrungsmittelkunde AG Bakteriologie und Hygiene der Milch, Justus-Liebig-Universität Gießen, Gießen, Germany*
[3] *Institut für Hygiene und Infektionskrankheiten der Tiere, Justus-Liebig-Universität Gießen, Gießen, Germany*

INTRODUCTION The harbour seal (*Phoca vitulina*) is the most common representative of the pinnipeds in the German North and Baltic Seas (Bonner, 1989; King, 1983). The grey seal (*Halichoerus grypus*) is also resident in the Wadden Sea, but in much lower numbers than the harbour seal. Both mammals are present in the Wadden Sea for the whole year (Schwarz and Heidemann, 1994).

Pneumonia, septicaemi, or various other diseases from harbour seals and grey seals are caused by different bacteria and frequently by ß-haemolytic streptococci (Bandomir *et al.*, 1998; Bandomir *et al.*, 1999). In the present study, ß-haemolytic streptococci isolated from various diseases of harbour and grey seals were identified and further characterised by their cultural properties, serologically, biochemically and by molecular analysis.

RESULTS AND DISCUSSION A total of 72 ß- haemolytic bacterial strains were examined in the present study. Sixty-one of these strains were isolated from harbour seals, 11 strains from grey seals. All 72 bacteria appeared to be gram-positive cocci and catalase negative. After cultivation on blood-agar-plates, the bacteria were surrounded by a wide zone of complete ß haemolysis indicating that they could be classified to the genus *Streptococcus* (Lämmler und Hahn, 1993). This genus includes different species with various characteristics.

A further characterisation of the isolates was performed by serogrouping and by determination of biochemical characteristics. For serogrouping autoclaved extracts of the ß-haemolytic cultures were examined by agar gel diffusion. All extracts were tested with specific antisera groups A, B, C, E, G, L, P, U and V. Furthermore, serogroup F was tested by using a commercial grouping system (Streptokokken Identifizierungs Test, Oxoid, Wesel, Germany). Biochemical properties of the bacteria were examined with the commercial testsystem api 50 CH (bioMerieux sa, Nötingen, Germany).

By serogrouping the 72 bacteria, ß-haemolytic streptococci could be differentiated into three serogroups. Sixty-one streptococci could be classified to serogroup F, 8 to serogroup C and 3 to serogroup L. No reactions could be observed with serogroup A, B, E, G, P, U and V specific antisera (Table 1).

The 61 group F and the 8 group C streptococci displayed almost identical biochemical properties. The group F- and group C- streptococci were generally positive in the fructose, glucose, maltose, mannose, N-acetyl-glucosamine and ribose reaction (Table 2), and mostly negative in all the other carbohydrates investigated. The 3 group L streptococcal isolates were uniformly positive in the above mentioned carbohydrates and additionally in the galcatose, glycogen, starch, sucrose and trehalose reaction (Table 2).

According to the results obtained by serogrouping and by biochemical characterisation, the ß-haemolytic streptococci could be separated into two groups. Comparing the above mentioned results with the data given in the literature, the group F and group C streptococci could be identified as *Streptococcus phocae* (Skaar *et al.*, 1994) and the group L streptococci as *Streptococcus dysgalactiae* subspecies *dysgalactiae* Serovar L (Lämmler und Hahn, 1993).

S. dysgalactiae Serovar L had been isolated previously from harbour porpoises. In these animals, group L streptococci caused various pathological processes including bronchopneumonia, septicaemia, pyelonephritis and myocarditis (Swenshon *et al.*, 1998).

S. phocae was first mentioned by Ida Skaar in Norway in 1994. At present, this species has been described in infections of harbour seals, more recently also in infections of fur seals (Henton *et al.*, 1999). The occurrence of *S. phocae* in grey seals is described in the present study for the first time. The appearance of the group F and group C specific group antigen among *S. phocae* had already been described as a common property of this species (Skaar *et al.*, 1994).

To further characterise the species, *S. phocae*, the bacteria were tested for their antibiotic susceptibilities. The determination of antibiotic susceptibility was performed with 20 different antibiotics. All *S. phocae* were uniformly sensitive to clavulanic acid/amoxicillin, bacitracin 0,04 U, bacitracin 10 U, cefacetril, cefotaxime, cefoxitin, clindamycin, erythromycin, minocyclin, ofloxacin, oxacillin, piperacillin 30, penicillin G, trimethoprim/sulfamethoxazole and tetracycline. Most of the strains showed an intermediate reaction to enrofloxacin and gentamicin, but all 69 strains were resistant to kanamycin, nalidixic acid and streptomycin.

A further characterisation of the *S. phocae* isolates was performed by molecular analysis. A molecule most suited for this purpose is the 16S rRNA gene, especially its V2 region (Bentley and Leigh, 1995). The V2 region is a variable but species specific part of the 16S rRNA gene. To determine a species specific part of *S. phocae*, the 16S rRNA gene containing the V2-region was amplified by polymerase chain reaction and sequenced (Medizinische Mikrobiologie, Justus-Liebig-Universität-Gießen, Gießen, Germany). Subsequently, the sequence of the V2-region of *S. phocae* was compared with 31 different V2-regions of other streptococci. The sequences of the other 31 streptococcal species were obtained from the gene databank. The V2 region of *S. phocae* appeared to be unique. The sequencing was performed with the *S. phocae* type strain 8399 H1 (=NCTC 12719) kindly provided by I. Skaar and H. Stenwig, Central Veterinary Laboratory, State Veterinary Laboratories of Norway, N-0033 Oslo, Oslo, Norway. To determine whether there is any sequence variation within the V2 region the 16S rRNA gene of the 69 *S. phocae* of the present investigation was amplified and digested with specific enzymes. The selected enzymes *Ear* I and *Hinc* II cut specifically in the V2 region of *S. phocae.* All *S. phocae* isolates of the present study were digested with *Ear* I and *Hinc* II and revealed a *S. phocae* specific restriction pattern indicating that all 69 *S. phocae* isolates were correctly identified. The *Ear* I specific pattern revealed 3 characteristic DNA bands, the *Hinc* II pattern showed 2 characteristic DNA bands (Fig 1). A large number of control strains of various streptococcal species and serogroups showed no comparable restriction sites for both enzymes.

To further analyse epidemiological relations, the isolates were subjected to macrorestriction analysis of their chromosomal DNA by pulsed field gel electrophoresis. The pulsed field gel electrophoresis allowed a DNA fingerprinting of the bacterial isolates. The chromosomal DNA was digested with rare cutting enzymes and subsequently separated by electrophoresis. When bacteria have the same number and the same size of DNA fragments, these bacteria represent one bacterial clone. One or only a few different DNA fragments represent a close relationship; a large number of different DNA fragments means no relationship (Tenover *et al.*, 1995).

The *S. phocae* strains of the present study were investigated by pulsed field gel electrophoresis using the enzyme *Apa* I. A DNA-fingerprint and a dendrogram of some of the isolates is shown in Fig. 2. According to these results, some of the *S. phocae* isolates represent one bacterial clone. This could be seen for the isolates D, E and F which were all isolated from one animal, and for the isolates B and C which were also isolated from one animal (Fig. 2). In rare cases, single *S. phocae* clones could be found in different animals (strain D, E, F one animal and strain H a second animal). However, most of the *S. phocae* showed no significant relation to each other. This indicates that a number of different bacterial clones were responsible for the various diseases of the harbour and grey seals. This is in contrast to previous studies investigating *S. dysgalactiae* Serovar L isolated from harbour porpoises (Swenshon *et al.*, 1998). In this previous study, only one *S. dysgalactiae* Serovar L clone, or at least closely related clones, seemed to be responsible for the various diseases.

CONCLUSIONS In the present study, *S. phocae* isolated from harbour and grey seals could be identified by cultural, biochemical, and serological properties, and by amplifying and subsequent digestion of the 16S rRNA gene. The latter offers a rapid and reliable identification of the species *S. phocae.* A molecular typing of the bacteria could be performed by pulsed field gel electrophoresis, allowing a further characterisation of the *S. phocae.* This might be useful in epidemiological studies and could help to estimate the virulence of individual bacterial clones of this species.

REFERENCES

Bandomir, B., Marxen, S., Taylor J., Siebert, U., and Adelung, D. 1998. Totfundmonitoring von Robben in Schleswig-Holstein 1998. *Final Report to the Environmental Ministry of Schleswig-Holstein.* 20pp. (in German).

Bandomir, B., Gaethke, U., Siebert, U., and Adelung, D. 1999. Untersuchungen zum Gesundheitszustand von Robben in Schleswig-Holstein 1999. *Final Report to the Environmental Ministry of Schleswig-Holstein.* 15pp. (in German)

Bentley, R. W. and Leigh, J. A. 1995. Development of PCR-Based Hybridization Protocol for Identification of Streptococcal Species. *J. Clin. Microbiol.*, 33: 1296-1301.

Bonner, W. N. 1989. The Harbour (Common) Seal, *Phoca vitulina*. Pp. 83-84. In: *The Natural History of Seals*, 1989. Christopher Helm, London, England. 196pp.

Henton, M. M., Zapke, O. and Basson, P. A. 1999. *Streptococcus phocae* infections associated with starvation in Cape fur seals. *Jl S.Afr.vet.Ass.*, 70: 98-99.

King, J. E. 1983. Northern Phocids. Pp. 72-103. In: *Seals of the world*, 1983. Cornell University Press, Ithaca, New York, USA. 240pp.

Lämmler, C. and Hahn, G. 1993. Streptokokken. Pp. 15-82. In: *Handbuch der bakteriellen Infektionen bei Tieren*, vol. 2. (Eds. H. Blobel und T. Schließer). Gustav Fischer Verlag, Jena, Germany. 141pp. (in German)

Skaar, I., Gaustad, P., Tonjum, T., Holm, B., and Stenwig H. 1994. *Streptococcus phocae* sp. nov., a new species isolated from clinical specimens from seals. *Int. J. Syst. Bacteriol.*, 44: 646-650.

Schwarz, J. and Heidemann, G. 1994. Zum Status der Bestände der Seehund- und Kegelrobbenpopulation im Wattenmeer. Pp. 296-303. In: *Warnsignale aus dem Wattenmeer*. (Eds. J. L. Lozan, E. Rachor, K. Reise, H. Westernhagen und W. Lenz). Blackwell Wissenschafts-Verlag, Berlin, Germany. 387pp. (in German)

Swenshon, M., Lämmler Ch., and Siebert U. 1998. Identification and molecular characterization of beta-hemolytic streptococci isolated from harbor porpoises (*Phocoena phocoena*) of the North and Baltic seas. *J. Clin. Microbiol.*, 36: 1902-1906.

Tenover, F. C., Arbeit, R. D., Goering, R. V., Mickelsen, P. A., Murray, B. E., Persing, D. H., and Swaminathan, B. 1995. Interpreting chromosomal DNA restriction patterns produced by pulsed-field gel electrophoresis: criteria for bactirial strain typing. *J. Clin. Microbiol.*, 33: 2233-2239.

Table 1 Serogrouping of 72 ß-haemolytic streptococci isolated from harbour seals and grey seals

		harbour seal (n=61) and grey seal (n=11) isolates	
		n=72	in %
Serogroup F latex agglutination test		61	84.7
Agar gel diffusion with antisera of group	A	0	0
	B	0	0
	C	8	11.1
	E	0	0
	G	0	0
	L	3	4.2
	P	0	0
	U	0	0
	V	0	0

Table 2 Some biochemical properties determined with the „api 50 CH“

	Group C- and F-Streptococci		L-Streptococci	
	n=69	in %	n=3	in %
Fructose	68	98,6	3	100
Glucose	69	100	3	100
Maltose	68	98,6	3	100
Mannose	67	97,1	3	100
N - Acetyl - Glucosamine	69	100	3	100
Ribose	63	91,3	3	100
Galactose	11	15,9	3	100
Glycogen	17	24,6	3	100
Starch	15	21,7	3	100
Sucrose	12	17,4	3	100
Trehalose	7	10,1	3	100

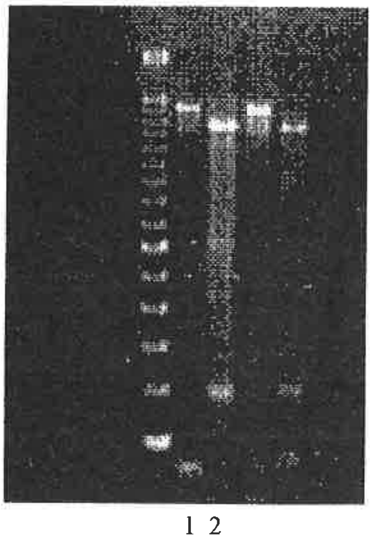


Fig. 1. *S. phocae* specific restriction pattern after digestion of the 16S rRNA gene with the enzyme *Hinc* II; 1: type strain 8399 H1 undigested; 2: type strain 8399 H1 digested with the enzyme *Hinc* II

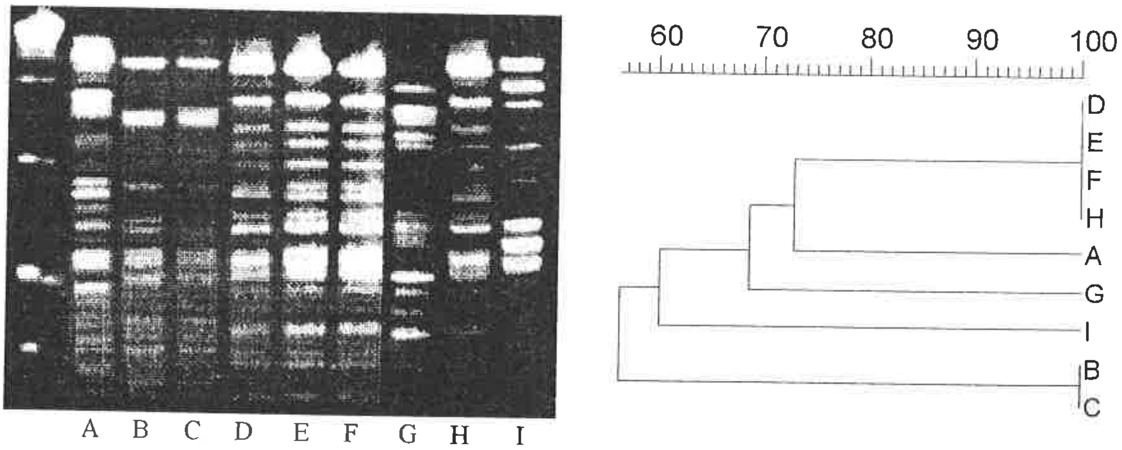


Fig. 2. Pulsed field gel electrophoresis with *S. phocae* isolated from harbour seals of the North Sea using the enzyme *Apa* I (A: harbour seal I, B: harbour seal II, C: harbour seal II, D: harbour seal III, E: harbour seal III, F: harbour seal III, G: harbour seal IV, H: harbour seal V, I: harbour seal VI) and dendrogram

PRELIMINARY RESULTS OF VISUAL LATERALISATION IN THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

S. Yaman[1,2], O. Güntürkün[1], L. von Fersen[3], and G. Dehnhardt[4]

[1]*AE Biopsycholgie, Fakultät für Psychologie, Ruhr-Universität Bochum, 44780 Bochum, Germany*
(E-mail: luukmor@arrakis.es)
[2]*Marineland Mallorca, Garcilaso de la Vega 9, Costa d'en Blanes, 07184 Calviá/Mallorca, Spain*
[3]*Tiergarten Nürnberg, Am Tiergarten 30, 90480 Nürnberg, Germany*
[4]*University of Bonn, Department of Zoology, Poppelsdorfer Schloss, D-53115 Bonn, Germany*

INTRODUCTION Functional hemispheric asymmetries are known since Broca in the 1860's. For a long time, they have been regarded as a uniquely human characteristic. Only in the last decades has there been increased evidence of both structural and behavioural lateralisation in non-human species, especially in birds (von Fersen *et al.*, 1990; Güntürkün, 1997) and mammals (Laska, 1996) suggesting that cerebral functional asymmetries are a fundamental feature of all vertebrate brains. Very little information is available for aquatic mammals (Clapham *et al.*, 1995). Especially for dolphins, scattered findings (Ridgway, 1990, Sobel *et al.*, 1994, Marino, 1997) point to a possible lateral specialisation. Dolphins are ideal for studying cerebral dominance of visual function due of the total decussation of the optic nerve (Ridgway, 1990). Anecdotal reports show a right eye preference in bottlenose dolphins. A recent publication (von Fersen *et al.*, 1999) indeed demonstrated a right eye dominance in visual discrimination tasks, tested with a single subject. Due to the complete crossover of the optic chiasma, a right eye superiority would imply a left hemisphere dominance. The presence of an asymmetry demonstrated in one individual shows that this function can be lateralised in that species, but it does not distinguish between an individual and a population asymmetry. Therefore, we conducted a series of visual discrimination experiments with three individuals of bottlenose dolphin (*Tursiops truncatus*) under monocular conditions. The tested animals had to distinguish between simultaneously presented pairs of different patterns, with one of them always defined to be correct. The number of trials until reaching 85% correct responses with each eye were used as a dependent variable. The present data set revealed a trend towards a right eye superiority with increasing complexity of the patterns to be learned.

MATERIALS AND METHODS Three female bottlenose dolphins named Cindy (19-20 years old), Mery (19-20 years old) and Gambi (7-years old) were subjects in the present study. They are housed together with two other bottlenose dolphins in a 13.5 m x 28 m outdoor pool of 4.5 m depth in Marineland Mallorca (Spain). The experiments took place in a adjacent pool of 4.45 m x 5.70 m and 1.80 m depth where a single animal was separated for each session.

At the start of an experimental session, a (12 cm diameter) rubber eyecup was fixed by suction onto one eye of the subject (Fig. 1b). The animals had to discriminate between simultaneously presented stimuli pairs with different patterns under monocular conditions. They learned successively six pairs of patterns with each eye. The stimuli pairs consisted of 25 x 25 cm white PVC board onto a black pattern was fixed. Each stimulus was mounted into a window of a 1 m^2 white painted board such that a push onto the stimuli flipped it backwards (Fig.1a/c). The white boards with the stimuli were positioned to the left and right of the experimenter with an inter-board distance of 1.50 m. During the discrimination process the experimenter was visually hidden from the subject through a plastic curtain. Each trial started with the animal being positioned at the tip of a 2.50 m target, above water level looking towards the apparatus (Fig. 1). At this viewing distance, dolphins have a high aerial acuity (Herman *et al.*, 1975) for the stimuli. After the positioning of the animal, the experimenter revealed the covered stimuli, and four seconds later, a whistle blow indicated the subject to leave the target and to touch one of the displayed stimuli with its rostrum. Only choices with the stimuli being completely flipped backwards were counted. Correct responses were reinforced with fish. Incorrect choices were followed by correction trials. The left-right positions of the pattern were alternated quasi-randomly (Gellerman, 1933). For each subject, two session per day were conducted, whereby each session consisted of 20 trials. Sessions where a new stimulus was presented took place in 10 trials. A task was considered successful after 85% correct performance in one session (20 trials).

RESULTS An ANOVA was calculated using all six stimulus pairs of all three animals. The parameter used were: *pattern*, *viewing conditions*, and the *interaction* between pattern and viewing conditions. The test revealed a significant difference between the used *pattern* F (5/10) = 7.13; p = 0.004 and a difference for *viewing conditions* (right eye / left eye) with an advantage for the right eye (Fig. 2a-b). The test conducted was a one-tailed ANOVA with F (1/2) = 10.94; p = 0.04. Additionally, the interaction between *pattern* and *viewing conditions* emerged as significant, with F (5/10) = 3.44; p = 0.046. This indicated that the level of faster learning with the right eye depends on the stimulus pattern used.

DISCUSSION The preliminary results reveal a right eye preference, considering all stimulus pairs (*viewing conditions* p = 0.04), but looking at the patterns used, it is obvious that the stimulus pairs were not equal in complexity (Fig. 3.). And indeed, it could be demonstrated that the pattern used had an important effect on the performance and on the lateralisation (*interaction* p = 0.046): The animals need more trials to reach the success criterion, for difficult stimuli than for easier ones. Furthermore, the right eye superiority is more obvious in complex stimuli pairs. Similar results have been found concerning the handedness and manual specialisation of monkeys (Springer and Deutsch, 1993): general reviews of manual laterality show side preferences only at the level of individual asymmetry, and not at the population level. Fagot and Vauclair (1993) suggested that side preferences may appear mainly in tasks where the subjects have to deal with complex testing situations. The results of numerous investigations indeed confirm the findings of Fagot and Vauclair.

These data suggest that bottlenose dolphins might be lateralised at the population level with a right eye / left hemisphere advantage. The tested animals showed a "floor-effect" with little lateralisation for easier stimuli pattern, and a strong lateralisation for more difficult and complex pattern. However, further patterns have to be introduced to see if the right eye superiority is stable over time. But if the left hemisphere dominance for dolphins in visual discrimination tasks can be confirmed, it represents a fundamental deviation from the right hemisphere dominance in terrestrial animals for similar tasks (Hamilton, 1993; Güntürkün, 1997; von Fersen *et al.*, 1999). Thus, the dolphin brain not only developed morphological differences compared with terrestrial mammals, but might also reflect a different functional architecture. Furthermore, the knowledge about hemisphere dominance in different species could represent a fundamental biological principle and help us to understand the evolution of the brain.

ACKNOWLEDGEMENTS The authors would like to thank the *Fundación Marineland Mallorca* to enable the present study at its facility. Furthermore, S.Y. is grateful to the staff of the dolphinaria *Marineland* for their help, their suggestions, patience, and for their friendship. She would also like to thank G. Fernandez (Marineland) for her logistic support and L. Morel for his continuous help. Special thanks go to the staff of the dolphinaria *Zoo Duisburg*, who taught S.Y. the first principles of behavioural training. The project was supported in a part by a Ph.D. grant to S.Y. of the Deutscher Akademischer Austauschdienst (DAAD).

REFERENCES

Clapham, P. J. *et al.* 1995. Do humpback whales exhibit lateralized behaviour? *Animal Behaviour*, 50: 73-82

Fagot, J. and Vauclair, J. 1993. *Manual laterality in non-human primates. The distinction between Handedness and manual specialization.* In: *Left brain-right brain* (Eds. S. P. Springer and G. Deutsch). W. H. Freeman, New York.

Fersen, L., von, and Güntürkün, O. 1990. Visual memory lateralization in pigeons. *Neuropsychologia*,. 28(1): 1-7.

Gellermann, L. W. 1933. Chance orders of alternating stimuli in visual discrimination experiments. *Journal oj Genetic Psychology* 42: 206-208.

Hamilton, C. R. 1993. *Hemispheric specialization in monkeys.* In: *Left brain-right brain* (Eds. S. P. Springer and G. Deutsch). W. H. Freeman, New York.

Herman, L. et al. 1975. Bottlenosed dolphin: double-slit pupil yields equivalent aerial and underwater diurnal acuity. *Science*, 189: 650-652.

Güntürkün, O. 1997. Avian visual lateralization: a review. *NeuroReport.* 8, 6.

Laska, M. 1996. Manual laterality in spider monkeys (*Ateles geoffroyi*) solving visually and tactually guided food-reaching tasks. *Cortex.* 32: 717-726

Marino, L and Stowe, J. 1997. Lateralized behavior in two captive bottlenose dolphins (*Tursiops truncatus*). *Zoo Biology*, 16: 173-177.

Ridgway, S. H. 1990. *The central nervous system of the bottlenose dolphin.* Pp. 69-97. In: *The Bottlenose Dolphin.* (Eds. S. Leatherwood and R. R. Reeves) Academic Press, San Diego, CA.

Sobel, N. *et al.* 1994. Rotational swimming tendencies in the dolphin (*Tursiops truncatus*). *Behavioural Brain Research*, 65: 41-45.

Springer, S. P. and Deutsch, G. 1993 *Left brain-right brain.* W. H. Freeman, New York.

Fig. 1. a) Overview of the testing situation with the apparatus, the stationing device and the position of the dolphin watching towards the revealed stimuli.

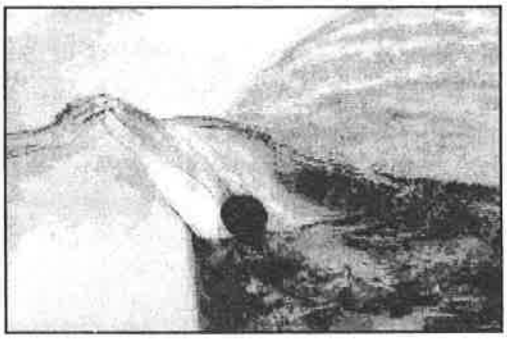


Fig. 1. b) The eyecup was fixed by suction onto it's left eye, while watching with his right eye.

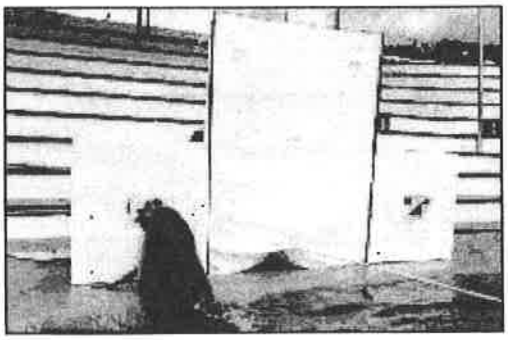


Fig. 1. c) The dolphin leave the target to touch one of the displayed stimuli with its rostrum. Only choices with the stimuli being completely flipped backwards were counted.

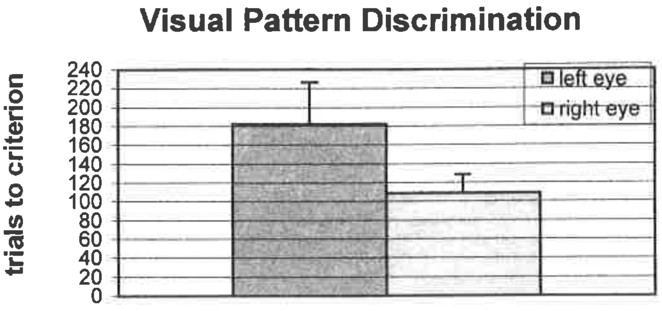


Fig. 2 a)

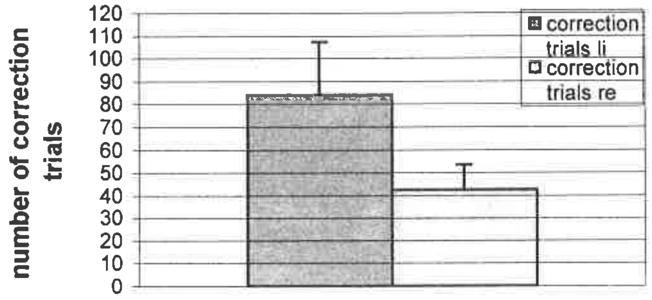


Fig. 2 b)

Fig. 2a-b): (a) Average trials to criterion for all 6 stimulus pairs under monocular conditions, shows a faster learning for the right eye.(b) Average number of correction trials under each monocular condition until reaching criterion (85%). Reveals a better performance for the right eye. Vertical bars depict standard error of mean.

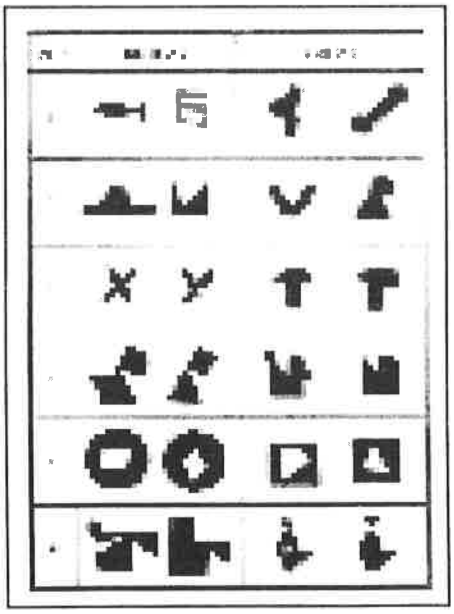


Fig. 3. Example of the pattern used in the present study under monocular conditions

PHYSIOLOGY

THE EFFECTIVENESS OF USING REPRODUCTIVE HORMONE CONCENTRATIONS IN SALIVA TO MONITOR OESTROUS CYCLES IN CAPTIVE FEMALE HARBOR SEALS (*PHOCA VITULINA*) IN BERMUDA

J. Bacon[1] and P. Talbot[2]

[1]*Bermuda College, Department of Natural Sciences, P.O. Box 297, Paget PG BX, Bermuda*
(E-mail: jbacon@ibl.bm)
[2]*Bermuda Aquarium, Natural History Museum and Zoo, P.O. Box FL 145, Smith's FL BX, Bermuda*

Research on a captive female Hawaiian monk seal indicated that estrone sulphate concentrations in saliva could be used to monitor the female's oestrous cycles. To determine if reproductive hormone concentrations in saliva could be used to track oestrous cycles in captive harbour seals, blood and saliva samples were obtained from four female harbour seals in Bermuda during the 1999 reproductive season. The plasma and saliva samples were processed at Cornell University's Central Diagnostic Laboratory, where estradiol 17β concentrations were determined using a radio-immunoassay and estrone sulphate concentrations were measured using an ELISA assay.

Analysis of hormone concentrations from saliva samples suggested that estrone sulphate and estradiol 17β concentrations fluctuated independently of each other. Results for plasma estrone sulphate and estradiol 17β concentrations showed that, although increases in plasma estradiol 17β were accompanied by similar increases in plasma estrone sulphate in two females, significant increases in plasma estradiol 17β were not accompanied by simultaneous increases in plasma estrone sulphate in the other two females. In addition, in three of the seals, plasma estrone sulphate at times increased significantly when there was no increase in plasma estradiol 17β. Comparisons between plasma and saliva estradiol 17β concentrations showed that the marked fluctuations in plasma estradiol 17β concentrations that occurred during the seals' oestrous cycles were not represented by similar changes in saliva estradiol 17β concentrations. Instead, saliva estradiol 17β fluctuated very little even when plasma estradiol 17β increased by 300-500%.

From these results, we conclude that: (1) estrone sulphate concentrations in plasma or saliva may not reliably indicate the onset or the duration of an oestrous cycle, and (2) saliva estradiol 17β concentrations could not be used to monitor the oestrous cycles in Bermuda's captive harbour seals. Furthermore, our results suggest that, although using saliva provides a non-invasive alternative to blood sampling, further research needs to be done in order to determine if saliva oestrogen concentrations can be used to accurately monitor oestrous cycles in phocid seals.

FUNCTIONAL MORPHOLOGY OF THE FACIAL MUSCULATURE OF THE HARBOUR PORPOISE

S. Huggenberger[1], M. A. Rauschmann[2], U. Siebert[3] and H. H. A. Oelschläger[1]

[1]*Dr. Senckenbergische Anatomie (Department of Anatomy), Johann Wolfgang Goethe-Universität, Theodor Stern-Kai 7, 60590 Frankfurt a.M., Germany (E-mail: huggi@stud.uni-frankfurt.de)*
[2]*Orthopädische Universitätsklinik und Poliklinik Friedrichsheim,*
Marienburgstr. 2, 60528 Frankfurt a. M., Germany
[3]*Forschungs- und Technologiezentrum Westküste, Hafentörn 6, 25761 Büsum, Germany*

INTRODUCTION For more than 100 years, the anatomy of the facial complex of the harbour porpoise (*Phocoena phocoena*) has been the subject of scientific research (e.g. von Baer, 1826; Kükenthal, 1893). Although the structure of this region is unique in mammals, little is known about its function. Recent hypotheses imply that sound production occurs in the nasal complex of toothed whales (Curry, 1992; Cranford et al., 1996).

In this contribution, the anatomy and function of the nasal musculature in the harbour porpoise is analysed by means of macroscopic dissection, computer tomography (CT), and magnetic resonance imaging (MR). There are several layers of muscles presumably controlling the nasal passage, the nasal diverticula, and the shape of the melon.

RESULTS AND CONCLUSIONS **Rostral region** The melon of harbour porpoises works as an impedance transformer (Au, 1993), and so the shape of the melon controls the emission of sound (Norris, 1975). Two bilateral muscle complexes of the rostrum are responsible for the modulation of the melon's shape (Fig. 1).

Region of nasal diverticula The soft nasal passage can be closed at different levels independently and a complex of six fan-shaped muscle layers (ml; Table 1 contains a description of the abbreviations) controls the air flow (Fig. 2). The same holds for the entrances to the nasal air sacs. Superficial muscle layers (ml 1, ml 2, ml 3) are responsible for the air flow at the level of the vestibular sacs (VS). Medial to these layers, paired muscles (ml 4, ml 5, ml 6) control the air flow to the complex system of nasal sacs including the premaxillary sacs (PS), nasofrontal sacs (NS), and caudal sacs (CS).

Most prominent is the unilateral nasal plug muscle that opens actively and closes passively (shifted by the surrounding tissue and lateral muscles) the air passages at the level of the dorsal entrance of the bony nares (Fig. 3).

Function of the nasal complex With respect to the epicranial complex, different models of hypothetical sound sources are possible, because the musculature of harbour porpoises operates the nasal complex at all levels. A short comparative description of the nomenclature of the nasal musculature is given in Table 2. The larynx as the potential source for echolocation clicks is implausible. Its role in ultrasound production is also doubted for toothed whales.

Whereas porpoise skulls exhibit only an insignificant asymmetry, the facial morphology is more complicated than in dolphins. Nevertheless, the sound repertoire of harbour porpoises is comparatively restricted, and does not show the complexity seen in the vocalisations of dolphins. Therefore, comparison of different odontocete species could help to understand the basic mechanism of sound production and emission, and to determine the functional characteristics of various structures involved in the porpoise head.

REFERENCES

Au, W. W. L. 1993. *The Sonar of Dolphins*. Springer, New York. 277pp.

Baer, K. E. von 1826. Die Nase der Cetaceen erleutert durch Untersuchung der Nase des Braunfisches *Delphinus Phocoena. Isis (Oken),* 10: 811-847.

Cranford, T. W., Amundin, M., and Norris, K. S. 1996. Functional morphology and homology in the odontocete nasal complex: Implication for sound generation. *J. Morph.*, 228: 223-285.

Curry, B E. 1992. Facial anatomy and potential function of facial structures for sound production in the harbor porpoise (*Phocoena phocoena*) and Dall's porpoise (*Phocoenoides dalli*). *Can. J. Zool.*, 70: 2103-2114.

Kükenthal, W. 1893. Vergleichend-anatomische und entwicklungsgeschichtliche Untersuchungen an Walthieren. *Denksch. Med. Nat. Gesellsch. Jena*, 3: 1-448.

Mead, J. G. 1975. Anatomy of the external nasal passages and the facial complex in the delphinidae (Mammalia: Cetacea). *Smithson. Contrib. Zool.*, 207: 1-72.

Norris, K. S. 1975. Cetacean Biosonar. Pp. 215-235. In: *Biochemical and Biophysical Perspectives in Marine Biology*. (Eds. D. C. Malins and J. R. Sargent) Academic Press, New York.

Table 1. List of abbreviations

CS	caudal sac
CT	computer tomography
lrm	lateral rostral muscle
ml	muscle layer (see nomenclature)
MR	magnetic resonance imaging
mrm	medial rostral muscle
NS	nasofrontal sac
PS	premaxillary sac
VS	vestibular sac

Table 2. Comparison of the nomenclature of the nasal musculature

Citation	Curry (1992)	Mead (1975)
lateral rostral muscle	lateral rostral muscle	lateral portion of M. maxillonasolabialis p.labialis
medial rostral muscle	medial rostral muscle	medial portion of M. maxillonasolabialis p.labialis
nasal plug muscle	nasal plug muscle	plug muscle
muscle layer (ml) 1	superficial facial tendon	M. maxillonasolabialis p. posteroexternus
ml 2	M. maxillonasolabialis p. intermedius	M. maxillonasolabialis p. intermedius
ml 3	M. maxillonasolabialis p. anteroexternus	M. maxillonasolabialis p. anteroexternus
ml 4	M. maxillonasolabialis p. posterointernus	M. maxillonasolabialis p. posterointernus
ml 5	M. maxillonasolabialis p. anterointernus	M. maxillonasolabialis p. anterointernus
ml 6	-	M. maxillonasolabialis p. anterointernus

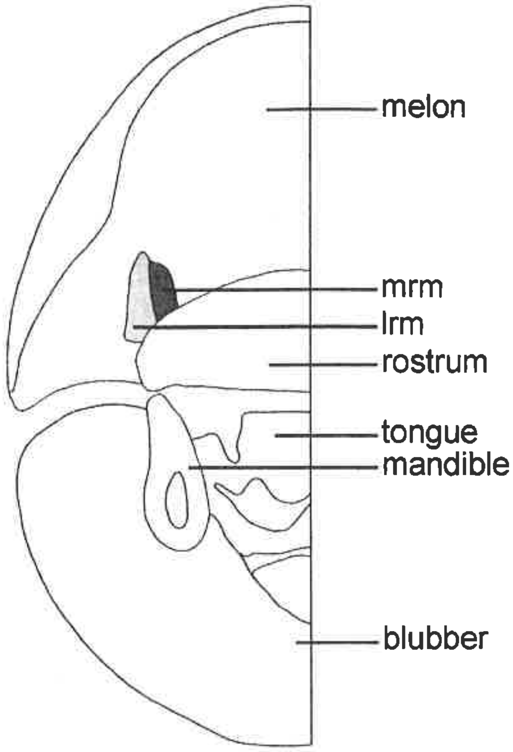


Fig. 1. Reconstruction of a CT scan of the rostral region of a harbour porpoise head (left hand side)

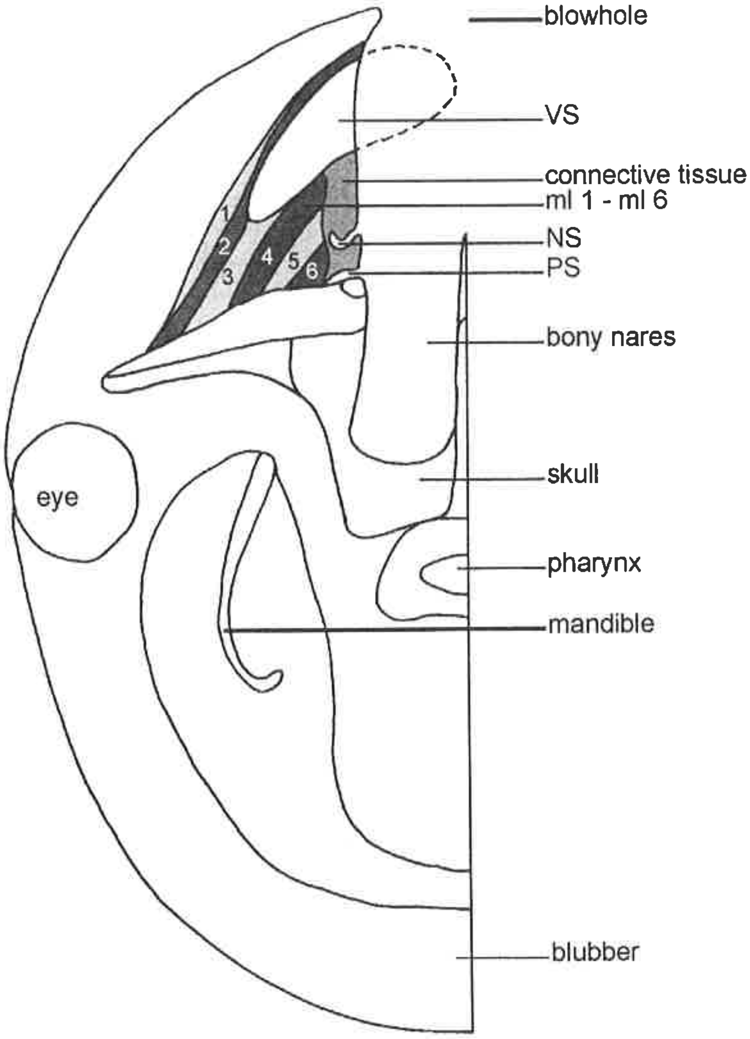


Fig. 2. Schematic reconstruction of the region of nasal diverticula of a harbour porpoise head (left hand side) showing six muscle layers

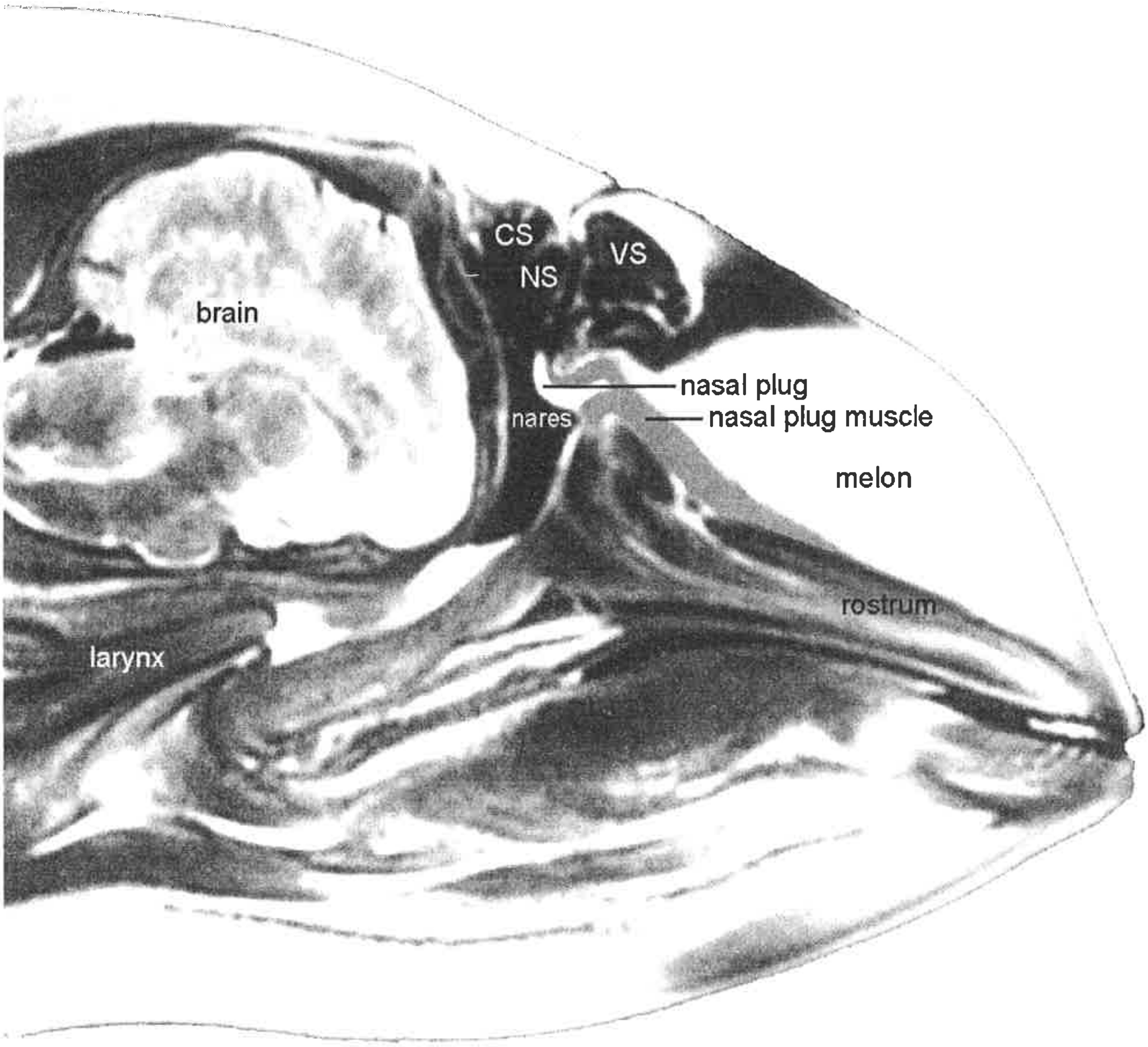


Fig. 3. Reconstructed sagittal MR scan of a harbour porpoise head showing the nasal plug muscle

MORPHOLOGICAL AND BIOCHEMICAL EVIDENCE FOR SELECTIVE LIPID UTILISATION DURING STARVATION IN A SMALL ODONTOCETE, THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*)

H. N. Koopman[1], S. J. Iverson[2] and A. J. Read[1]

[1]*Duke University Marine Laboratory, 135 Duke Marine Lab Road, Beaufort, N.C. 28516, USA*
[2]*Department of Biology, Dalhousie University, Halifax, N.S. B3H 4J1, Canada.*

Harbour porpoises are one of the smallest cetaceans, and thus face severe insulative and energetic challenges. We examined the ways in which harbour porpoises metabolise internal lipid stores by comparing porpoises in two states of body condition: robust animals (n=49) killed incidentally in commercial fishing operations, and emaciated, stranded specimens (n=23) which exhibited sunken epaxial musculature, reduced blubber thickness, and were assumed to have starved to death.

Topographical analysis of blubber thickness distribution, measured at 48-62 body sites, revealed that the thoracic/abdominal blubber of stranded porpoises (mean 11 ± 3 mm) was significantly thinner (reduced by 40%) than that of robust porpoises (mean 19 ± 4 mm), while blubber thickness posterior to the anus did not differ significantly between the two groups. The mean lipid content of thorax blubber was significantly less in starved porpoises (starved 81%; robust 89%), but that of the tailstock blubber was similar to robust animals (starved 76%; robust 78%). Starved porpoises had specifically mobilised long chain polyunsaturated fatty acids of dietary origin (e.g. 18:2n-6, 20:4n-6, 22:6n-3) from their thorax blubber, but not from tailstock blubber. Blubber from all harbour porpoises exhibited fatty acid stratification with two well-defined layers being present. Emaciated porpoises had metabolised more of the inner (metabolic) blubber layer, while making less use of lipids in the outer blubber layer. Starved porpoises also metabolised lipids from axial muscle, but there was little evidence of selective mobilisation of specific fatty acids.

Our data indicate energy storage in harbour porpoises is constrained by small body size and by their limited capacity to draw on lipids in the thoracic outer blubber and the tailstock blubber. The starvation process in small cetaceans likely represents a compromise between the use of blubber lipids for energy and the maintenance of an adequate blubber layer for insulation.

A NEW APPLICATION FIELD FOR A BODY VOLUME ASSESSMENT SOFTWARE

M. R. Rouan[1], C. Vincent[1], and V. Ridoux[2]

[1]*Laboratoire d'Etudes des Mammifères marins, Océanopolis, BP 411, 29275 Brest cedex, France*
(E-mail: mathias.rouan@oceanopolis.com)
[2]*Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, IUT, 15 rue de Vaux de Foletier, 17026 La Rochelle cedex 1, France*

INTRODUCTION The body condition of marine mammals is one of the most necessary data for the understanding of their ecology. But, due to their large size, high mobility and aquatic way of life, this information is often out of reach.

A computer tool, using image analysis and allowing the body volume of different marine mammal species to be estimated, was developed at Oceanopolis. Its validation began on captive common seals (*Phoca vitulina*) and bottlenose dolphins (*Tursiops truncatus*) which were filmed in their pool (La Bernardie *et al.*, 1999; Alvès, 1999), and on several species of dead stranded cetaceans photographed hanging by the tail (Vincent *et al. in prep.*); there were also three cases where the cross-sections of the bodies have elliptic out-lines (Fig. 1b.).

Seals spend extensive periods on the ground to breed, moult, and rest. In this situation, they diverge from the elliptic model having a flat surface in contact to the ground and a rounded surface turned upwards (Fig. 1a.). During periods spent on the ground, they usually fast and have additional energy demands due to either moult or reproduction. Thus, the photogrammetric assessment of body condition should have great potential in this case.

MATERIALS AND METHODS The body of a marine mammal can be considered as a succession of elliptical truncated cones (La Bernardie *et al.*, 1999). For each individual, a volumetric model was built, assuming that the body density is close to 1 (1 L=1 kg), and the total appendix mass is proportional to body mass. This model was constituted as the ellipse-flattening ratio of each cross-section, calculated from a fully lateral and a fully dorso-ventral image of the animal.

The validation of the method was made, comparing the real body mass with the estimated body volume (Vincent *et al. in prep.*). Five new strandings of dolphins (*)allowed us to complete this validation (Fig. 2.). The equation of the linear regression, grouping all available cases, shows that the assessment of the density to 1 kg/L is satisfactory and, moreover, that the correlation between estimated volume and weighed body mass is highly significant (R^2=0.9997).

The study has been conducted on six young grey seals (*Halichoerus grypus*) temporarily held at Oceanopolis seal rescue centre, during the 1998/99 winter.

RESULTS AND DISCUSSION Three questions were raised during the study:

To what extent does an elliptic model, constructed from the width and height of the body cross-sections of a seal resting on the ground, allow the weight of the animal to be estimated? An average model was applied to the dorsal images of six individuals filmed at different dates and different levels of body condition; the same animals were also weighed at the nearest 500 g. The regression slope obtained is very close to one, and the correlation coefficient is highly significant (Fig. 3.). This shows the good reliability of the elliptical model in situations where the cross-sections depart from a truly elliptical shape.

Is there any difference in using dorsal versus lateral images in the calculation of the body volume? The same average model was applied to the same six seals, but this time by using lateral images. Regression results (Fig. 4.) are very close to the previous ones showing that lateral or dorsal images can be used equally.

Can variations in stoutness (or variations in body condition) lead to significant variations in the ellipsoidal flattening ratio and thus make the model unsuited when applied to animal in different body condition?
Three models (corresponding to thin, medium and fat seals), as well as the average model, were successively applied to the same dorsal images of each individual (Fig. 5.).

For every given image, the use of the four different models resulted in estimates that diverged by as little as 2-3% from one another. Consequently, the use of an average species-specific model seems to be fair, whatever the stoutness of the animal. Yet, for some images, the clusters of volume estimates departed from the real body mass by as much as *c.* 8%. This point had already been shown (Vincent *et al. in prep.*) and still raises the problem of the image quantity and quality necessary to have good precision.

CONCLUSION In this study, we showed the reliability of the elliptic model in estimating body volume of seals on land. On average, the loss of area "a" is compensated for by area "b" on the cross-sections of the body (Fig. 6.). Consequently, this opens the use of this tool to monitoring, individually and with minimum disturbance, variations in body condition of breeding seals, thus contributing to studies of the cost of breeding of both males and females, and mass transfer to the pups.

REFERENCES

Alves, C., 1999. Estimation de l'indice de condition chez le grand dauphin, *Tursiops truncatus*, par photogrammétrie. Thèse de Doctorat Vétérinaire, Ecole Nationale Vétérinaire, Maisons-Alfort, 120pp.

La Bernardie, X., de,Vincent, C., Liret, C., and Ridoux V. 1999. Assessing variations in marine mammal body condition by using video image analysis : preliminary tests. In *Wildlife telemetry* (Eds. Y. Le Maho and T. Zorn). Centre d'Ecologie et de Physiologie Energétiques, Strasbourg, 380pp.

Vincent, C., Ridoux, V., La Bernardie, X. de, and Alves, C. (in prep.). Assessment of marine mammal body volume : a new photogrammetric method.

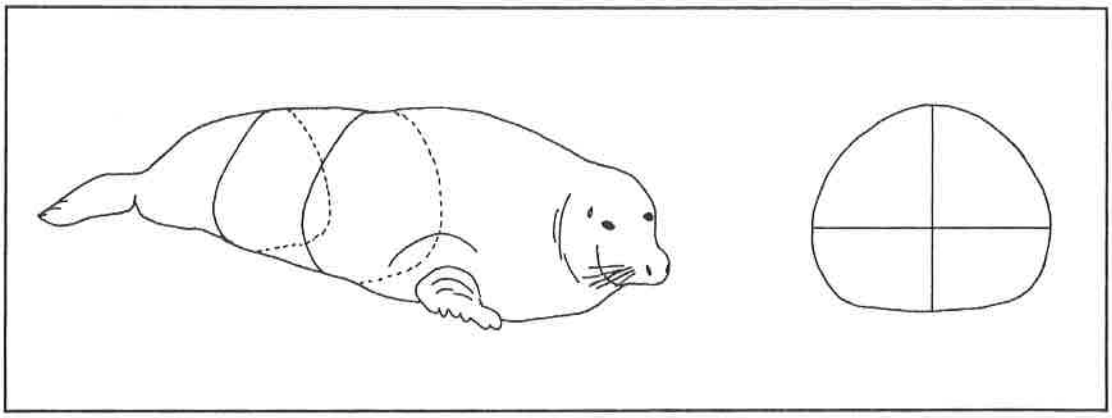


Fig. 1a.

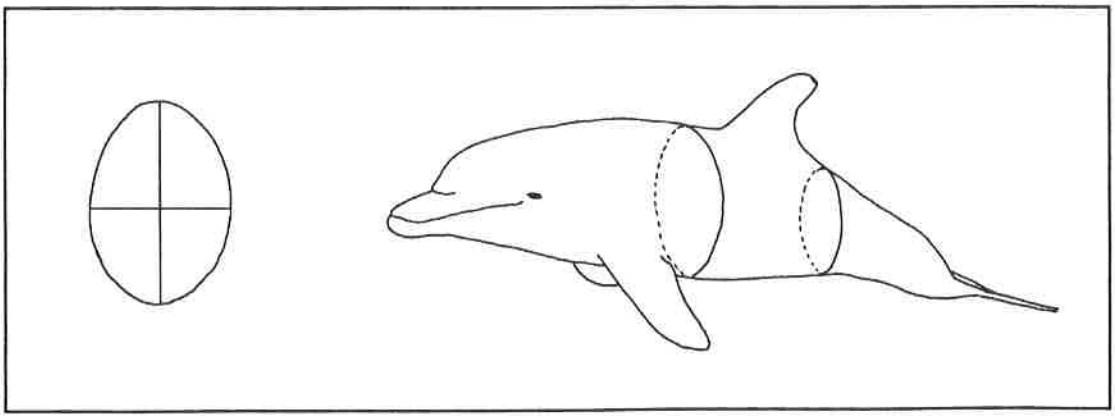


Fig. 1b.

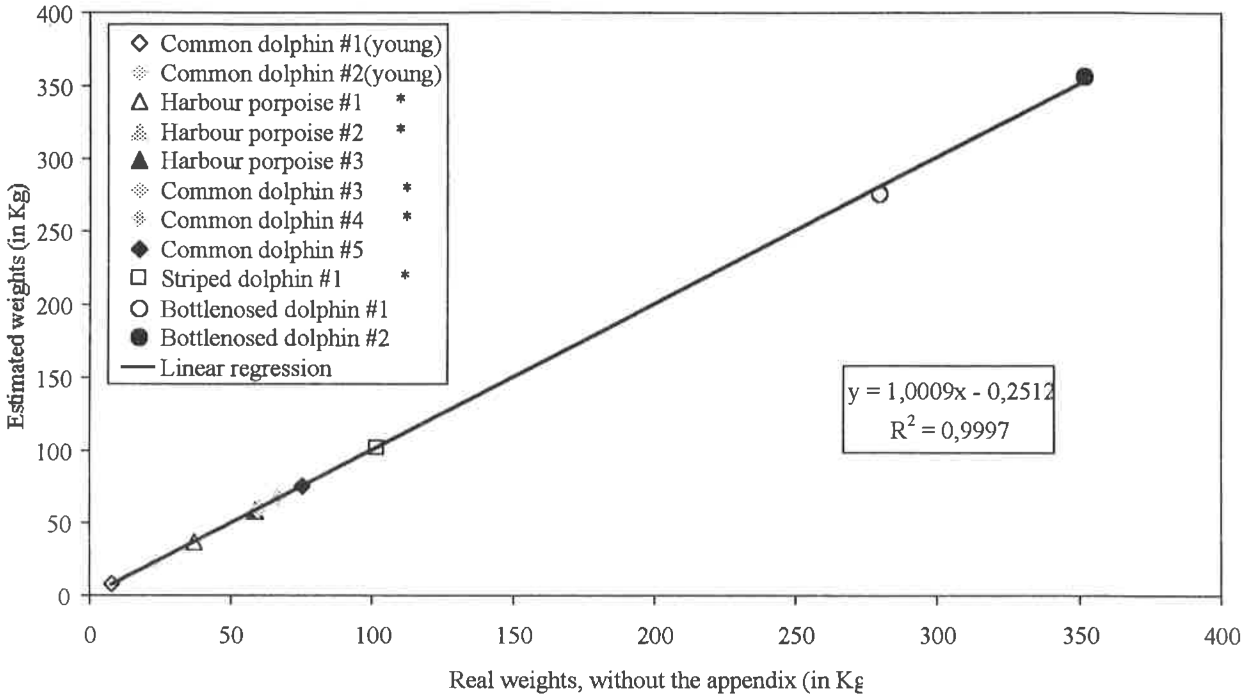


Fig. 2. Linear regression for four stranded cetacean species

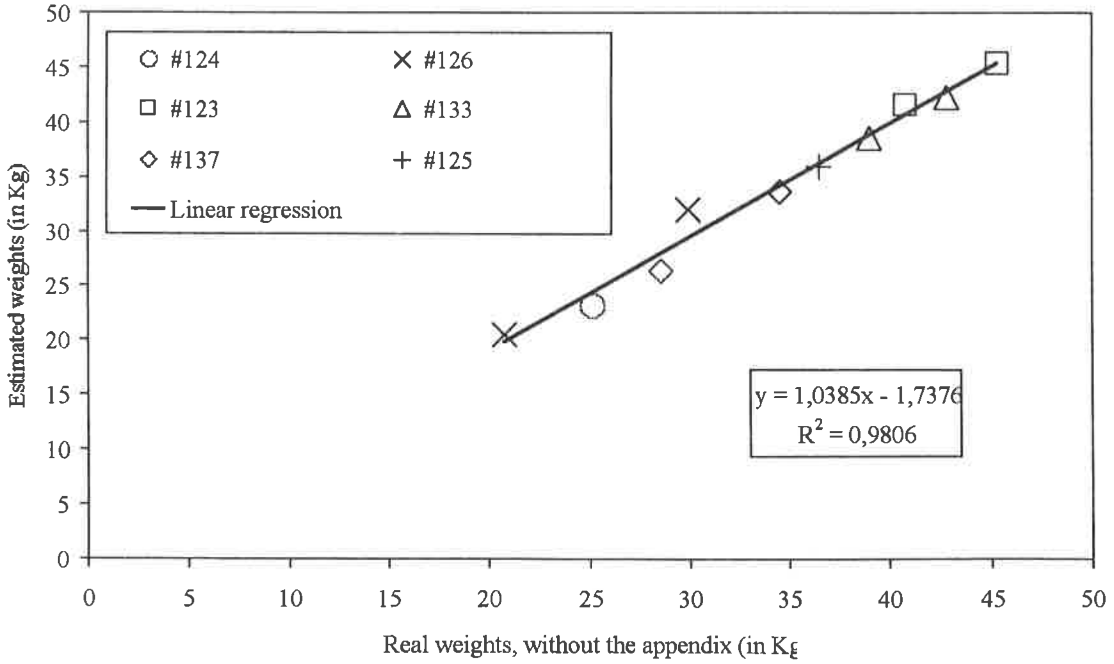


Fig. 3. Weight's assessment of 6 different individuals from dorsal images, with an average model

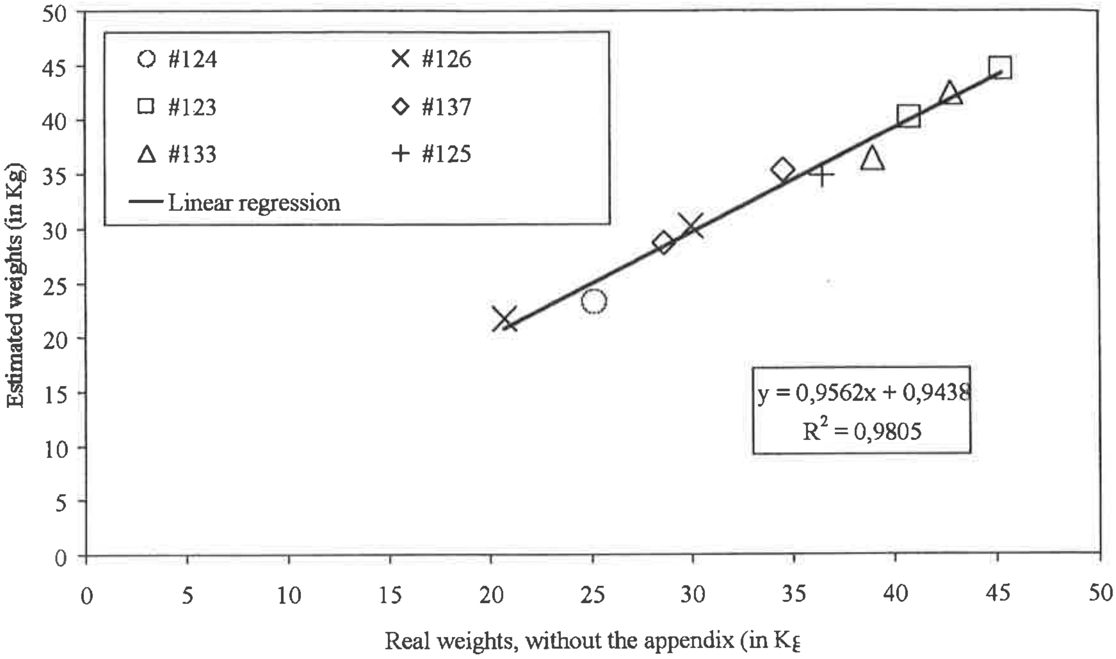
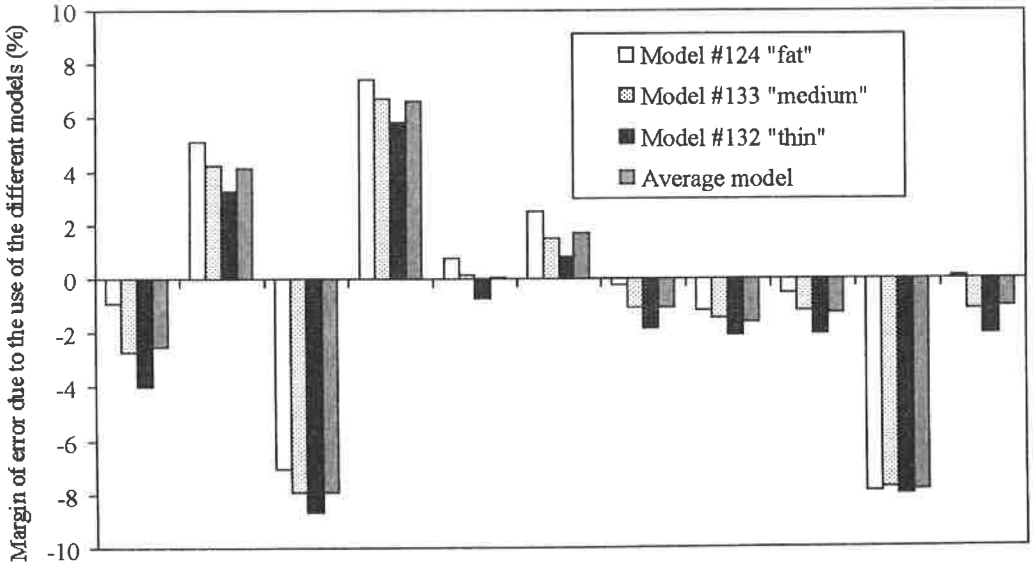


Fig. 4. Weight's assessment of 6 different individuals from lateral images, with an average model



Seals	#137	#132	#137	#126	#123	#123	#126	#125	#133	#124	#133
Real weights	36,00	49,40	29,80	31,20	47,20	42,50	21,60	38,00	44,60	26,20	40,60
Lengths	1,01	1,11	0,93	0,93	1,06	1,02	0,81	0,97	1,02	0,84	0,92
Relatives weights	34,94	36,12	37,05	38,79	39,63	40,05	40,64	41,64	42,03	44,20	52,14

Fig. 5. Comparison of the three models' influence on different individuals

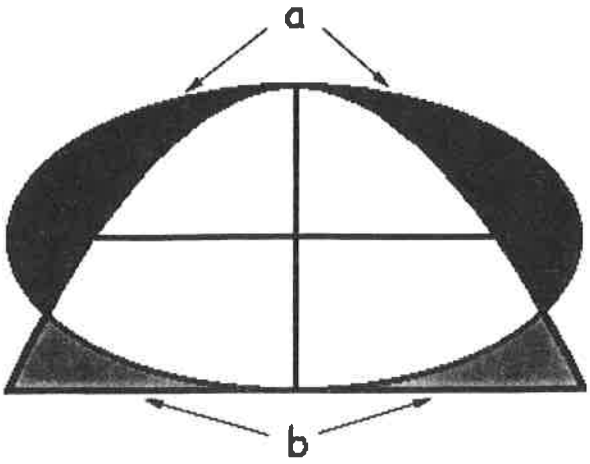


Fig. 6. The loss of area “a” is compensated for by area “b” on the cross-sections of the body

STOCK IDENTITY & DISTRIBUTION

ECOLOGICAL INDICATIONS OF CETACEANS DISTRIBUTION IN THE EASTERN PART OF THE STRAIT OF GIBRALTAR IN SPRING

Pierre Beaubrun and Erwan Roussel

Ecole Pratique des Hautes Etudes, U.M.II, B.P. 94, Place Eugène Bataillon, 34095 Montpellier Cedex 5, France

INTRODUCTION The Strait of Gibraltar has long been considered a critical area by physical oceanographers. The meeting of the Atlantic and Mediterranean water masses brings about very specific and well-marked environmental conditions at this point. Although it is suspected to be of major importance for cetaceans as well, very little is currently known about them in this area. Only two papers (Hashmi and Adloff, 1991; Hashmi, 1998) from the same data set are available, and nothing has been published about their ecology in this particular site. The aims of this study were therefore to collect data from an unexplored season and to analyse it in relation to environmental parameters, with a special emphasis on the possible movements of cetaceans between the Atlantic and the Mediterranean Sea.

MATERIALS AND METHODS Sightings have been made from 17 March to 26 May, 1999, from three ferries of a similar kind between Algeciras (Spanish coast) and Ceuta (Moroccan coast), using a line-transect method across the eastern part of the Strait operating at a constant speed of about 15 knots. The single observer was placed at a visual height of 13 metres above the surface, and covered a visual angle of 120°.

Each crossing was 15.5 nm. long and had a mean duration of 65 minutes (SD=3.5). 122 crossings with a total duration of 132 hours have been made with sea state <3, and 14 have been made with sea state between 3 and 4. Furthermore, and considering the particular sea conditions in the Strait, the Beaufort scale has only been taken as a reference for wind force. For sea state, wave height or quantity of foam have been taken into account in its estimation. This new reference allowed us to observe from wind force 3 up to force 6 during 43 crossings, which represent 32% of the total effort (Table 1).

For each sighting, position, species, number, presence of calves, activity (divided in four categories: travelling, rest, feeding, and socialisation) and headings of travelling animals were noted. Simultaneously the following were also noted: the hour of the day, moon phase and tide, wind force and direction, and surface current boundaries. The sense and strength of current was then deduced from the original water mass and the period of tide, with 3-hour periods covering the complete cycle of tides according to Stanley *et al., in* Rey (1983).

As it is the first work of this type in this area, we gave preference to an extensive approach in order to provide a general picture, instead of focusing on precise localities. For this reason, no statistical analyses have been undertaken.

RESULTS A total of 2,704 individuals (185 sightings) belonging to five species (Table 2) and 380 (38 sightings) unidentified small dolphins were seen. Eleven mixed groups of striped dolphins and common dolphins (559 individuals) and one mixed group of common dolphins and long-finned pilot whales (13 individuals) were seen.

Presence Figure 1 shows the progression of arrivals along the entire period per day and per species. Moon phases are indicated at the same scale. Striped dolphins were regularly present throughout and in abundance. Common dolphins arrived in mid-April, and showed irregular and very high peaks of arrival. Medium-sized cetaceans were seen regularly, but were never abundant. For all species, the main peaks tended to occur in the last days of new and full moon periods.

Behaviour We observed more animals travelling (56% of the total of all species sighted), while resting was the lowest activity in frequency (9%). Feeding occurred for 14% and socialisation for 21% of the total encountered. All activities were noted in small dolphin groups whereas bottlenose dolphins exhibited only two (travelling and feeding), and pilot whales showed no socialisation patterns.

In relation to moon phases (Figure 2), it is possible to observe a development of activities with the moon cycle. This is particularly well illustrated by the regular decrease in travel observed from new moon to second quarter. Socialisation tended to develop in the opposite way, and feeding occurred mainly at first quarter, and, less frequently, at second quarter, i.e. generally at neap tide. Patterns of variation in resting were not so clear, even if they seemed to occur mainly in the second half of the cycle.

Headings of cetaceans Over the entire study period, 90% of all animals were heading to the Atlantic (headings 170-340° according to the Strait axis), and only 10% swam to the Mediterranean. Figure 3 shows the response of common dolphins to current and wind compulsions. Strength of current has been divided into two categories : Atlantic current and counter currents were "normal" when effects of tide currents were weak, and they were intensified when effects of tide currents were strong. We can see that common dolphin movement appears to be dependent on both factors, and the relationship is even clearer for current than for wind. Moreover, there may be an apparent need to take advantage of stronger fluctuations in numbers for this species when it was travelling to the Atlantic.

The particular case of the bottlenose dolphin Although the previous results only apply to observations made with sea state <3, the following results (Fig. 4) take into account observations made with sea state ≥3 also. The ratios presented have been obtained by comparing the latter with the former for sightings, individuals, and the relative contribution to the cetacean population as a whole . Data for pilot whales are too scarce to have any meaning, except for their relative absence. Ratios for small dolphins are much less than one for sightings, about 0.3 for individuals, and about one for the relative contribution. For bottlenose dolphins, on the other hand, they are respectively 5.14, 11, and 36.8.

CONCLUSIONS Firstly, no baleen whales and only one sperm whale were seen during this study. These results are consistent with Hashmi and Adloff (1991), but numbers of bottlenose dolphins and pilot whales were surprisingly low by comparison with that study. In the western part of the Strait, there were high numbers of medium-sized cetaceans at the same time (Fernandez-Casado *et al.*, this volume), and during summer, sperm whales were regularly present (Cañadas *et al.*, this volume). The late arrival of common dolphins could be part of the seasonal migration, as has been highlighted for this species in the Alboran Sea (Sagarminaga and Cañadas, 1995).

Both presence and behavioural activities in the Strait appear to be linked with moon phases, probably through variation in the tides, according to current strength. The relationship between tides and dolphin presence has been documented by Evans (1990) for common dolphin, and by Shane (1990) and Harzen and Brunnick (1995) for bottlenose dolphin. A direct relationship between feeding and moon phases has also been demonstrated for subantarctic fur seal by Georges *et al.* (this volume), whilst Gomez-Perez (1998) has proposed a model of displacement of plankton: in this part of the Strait, plankton aggregates at neap tide and then sinks, to be displaced afterwards by the Mediterranean current. Its aggregation is likely to induce a concentration of the prey of cetaceans that have been found to feed more at neap tide.

Almost all animals were heading to the Atlantic, but there was no evidence that they left the Mediterranean Sea. There is some indication of daily movements amongst small dolphins (see Roussel and Beaubrun, this volume). However, what seems clear is that common dolphins are dependent on currents, and possibly on winds, in their movement patterns. No literature has been found on this precise topic, although Sagarminaga and Cañadas (1998) noted an increase in encounters of striped dolphins in the Alboran Sea with the first westerly storms, which is not the case for this part of the Strait.

The finding that bottlenose dolphins occurred in larger groups in rough seas is surprising. When reviewing past information, this was rarely observed. It cannot be explained in terms of better detection of larger animals (in that case, pilot whales would also have been spotted under relatively rough conditions), nor with sampling error (a total of 136 crossings were made, and ratios are too high). The result suggests that bottlenose dolphins form larger groups when sea state is higher than 3. Reasons for this are not known, since it is generally recommended that observations cease when sea state is higher than 3 (Clarke, 1982; Buckland *et al.*, 1993; Gannier, 1995).

ACKNOWLEDGEMENTS We would like to thank the companies Trasmediterranea and Euroferries, Firmm España® and Alnitak for their support.

REFERENCES

Buckland, S. T., Anderson, D. R., Burnham, K. P. and Laake, J. L. 1993. *Distance sampling: estimating abundance of biological populations.* Chapman and Hall, London. 446 pp.

Clarke, R. 1982. An index of sightings conditions for surveys of whales and dolphins. *Rep. int. Whal. Commn*, 32: 559-561.

Evans, P. G. H. 1990. European cetaceans and seabirds in an oceanographic context, *Lutra*, 33(2): 95-125.

Gannier, A. 1995. *Les Cétacés de Méditerranée nord-occidentale: estimation de leur abondance et mise en relation de la variation saisonnière de leur distribution avec l'écologie du milieu.* Ph.D. Thesis, Ecole Pratique des Hautes Etudes, Montpellier, France. 438pp.

Gomez-Perez, F. 1998. *Distribucion espacial del microplancton en el Estrecho de Gibraltar en condiciones estivales.* Tesis de Licenciatura, University of Cadiz, Spain. 180pp.

Harzen, S. and Brunnick, B. J. 1995. *The bottlenose dolphin of the Sado estuary, Portugal.* Privately published, Lisbon, Portugal. 48pp.

Hashmi, D. D. K. 1998. Cetacean movements through the Strait of Gibraltar. P. 75. In: *European Research on Cetaceans - 12.* Proc 12th Ann. Conf. ECS, Monaco, 20-24 January, 1998 (Eds P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Hashmi, D. D. K. and Adloff, B. B. 1991. Surface frequency of cetaceans in the Strait of Gibraltar. Pp. 16-18. In: *European Research on Cetaceans - 5.* Proc 5th Ann. Conf. ECS, Sandefjord, Norway, 21-23 February 1991 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 131pp.

Rey, J. C. 1983. El paso del atun rojo, *Thynnus thynnus*, a traves del estrecho de Gibraltar y su relacion con la hidrologia. Esquemas de migracion. *Bol. Inst. Esp. Oceanogr.* 1(1): 85-94.

Sagarminaga, R. and Cañadas, A. 1995. Studying a possible competition for ecological niche between the common dolphin, *Delphinus delphis*, and the striped dolphin, *Stenella coeruleolba*, along the southeastern coast of Spain. Pp. 114-117. In: *European Research on Cetaceans - 9.* Proc 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 February, 1995 (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Cambridge, England. 302pp.

Sagarminaga, R. and Cañadas, A. 1998. A comparative study on the distribution and behaviour of the common dolphin, *Delphinus delphis*, and the striped dolphin, *Stenella coeruleolba*, along the southeastern coast of Spain. Pp. 175-181.European Research on Cetaceans - 12. Proc 12th Ann. Conf. ECS, Monaco, 20-24 January, 1998 (Eds P. G. H. Evans and E. C. M. Parsons). European Cetacean Society, Cambridge, England. 436pp.

Shane, S. H. 1990. Behavior and Ecology of the Bottlenose Dolphin at Sanibel Island. Florida. Pp. 245-265. In: *The Bottlenose Dolphin,* (Eds. S. Leatherwood and R. R. Reeves). Academic Press, San Diego, CA.

Table 1. Effort with sea state <3 in relation to wind force

Wind force (Beaufort scale)	0	1	2	3	4	5	6
% of the total effort (n = 122)	8.2	9.7	22.4	27.6	19.4	10.4	2.2

Table 2. Sightings per species

	individuals	sightings	mean group size	standard deviation
striped dolphin (*Stenella coeruleoalba*)	1243	118	11	13
common dolphin (*Delphinus delphis*)	858	41	21	31
bottlenose dolphin (*Tursiops truncatus*)	15	8	2	1
pilot whale (*Globicephala melas*)	15	5	3	1
sperm whale (*Physeter macrocephalus*)	1	1	x	x

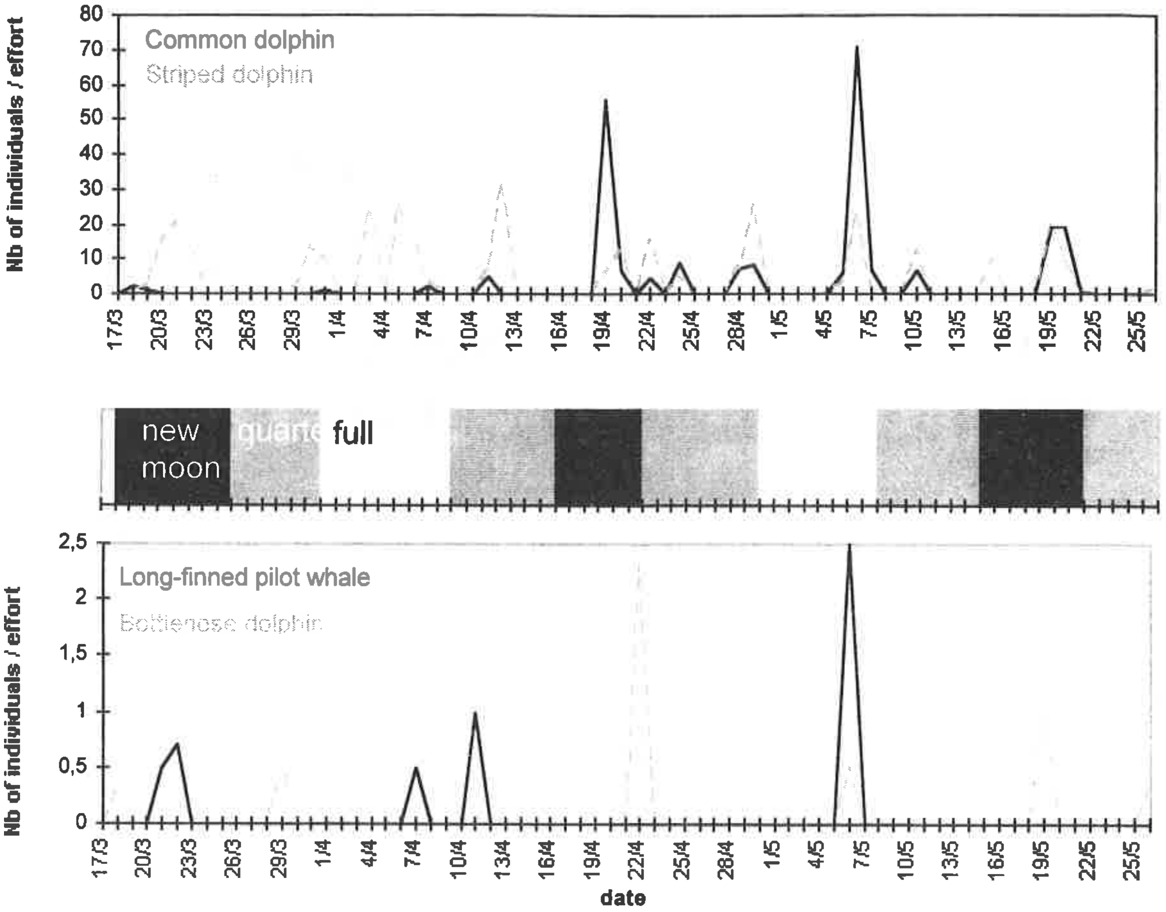


Fig. 1 . Arrivals of cetaceans between 17/3 and 26/5/99 in the eastern part of the Straits.

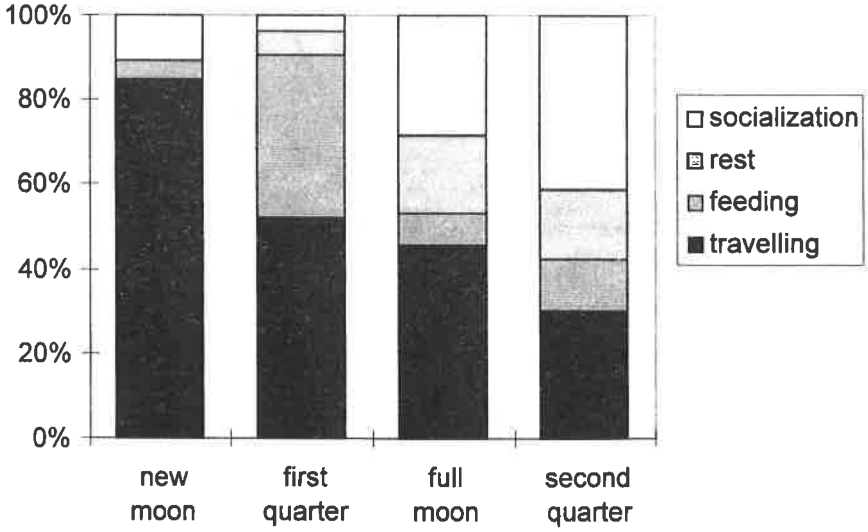
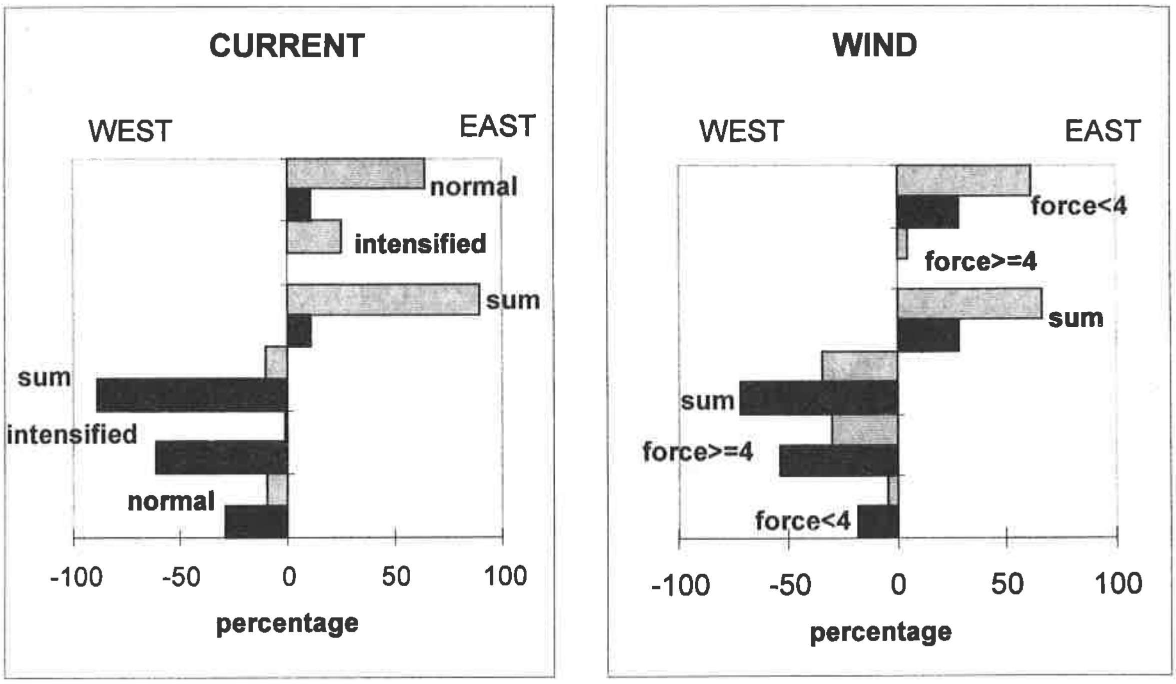


Fig 2. Activities of all cetaceans in relation to moon phases



animals heading 170°-340° animals heading 350°-160°

Fig. 3. Response of common dolphins to current and wind compulsions while travelling.

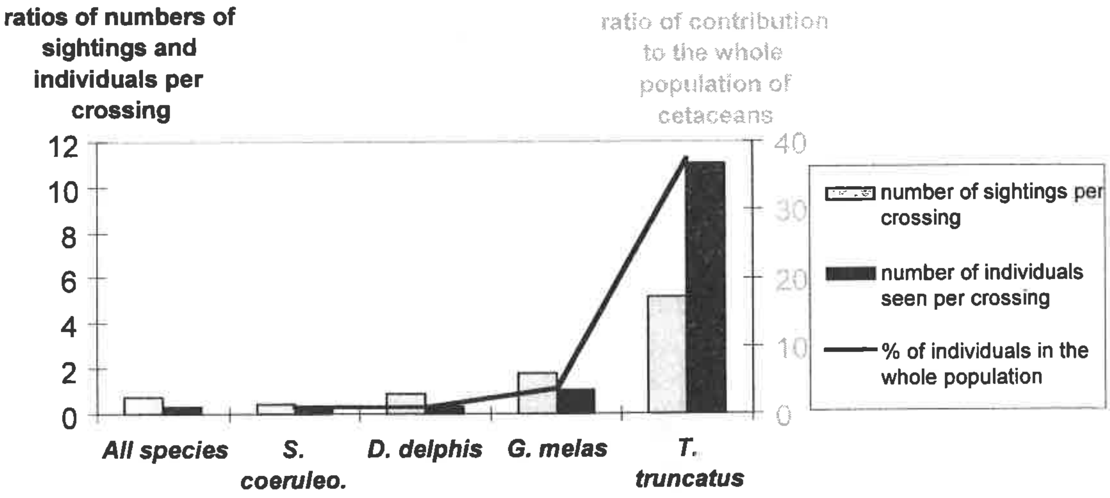


Fig. 4. Comparison of observations between sea state <3 and sea state >3.

SPATIAL ANALYSIS OF MARINE MAMMALS STRANDINGS ALONG THE GALICIAN COAST (NW SPAIN) AS REVEALED BY A GEOGRAPHIC INFORMATION SYSTEM

J. M. Bellido[1], G. J. Pierce[1], M. B. Santos[1], A. Lopez[2], A. Guerra[2], and A. Gonzalez[2]

[1]*Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TN, UK*
[2]*Instituto de Investigaciones Marinas, Vigo, Spain*

This poster examines the potential use of GIS to describe and understand patterns in strandings of marine mammals on European coasts, focusing in the first instance on strandings on the coast of Galicia, NW Spain. The first aim was to map locations of reported strandings and bycatches along the coast and to describe the spatial and temporal pattern of strandings events. Secondly, by overlaying environmental data (e.g. bathymetry, substrate, currents, SST) and fishery data, we aim to identify factors which can explain the concentration of strandings in particular times and places.

The area under study comprised the region 41.30°-44.30°N and 5.30°-10.00°W. Overlay of coverages of available environmental variables is used in a visual analysis of putative links between strandings and environmental conditions, e.g. factors which might favour transport of dead animals onto the shore or directly contribute to live strandings. The present poster aims to extend the use of this tool in the study fields by showing some preliminary applications, and then suggesting some potential uses of GIS applied to cetacean studies.

SPERM WHALES (*PHYSETER MACROCEPHALUS*) AT THE GATES OF THE MEDITERRANEAN SEA

A. Cañadas[1], M. Fernández-Casado[2], R. de Stephanis[2] and R. Sagarminaga[1]

[1]*ALNITAK, Universidad Autónoma de Madrid, Nalón 16, E-28240 Hoyo de Manzanares, Madrid, Spain*
(E-mail: alnitak@cetaceos.com)
[2]*FIRMM ESPAÑA, Pedro Cortés, 3, E-11380 Tarifa, Cádiz, Spain*

INTRODUCTION Sightings of sperm whales (*Physeter macrocephalus*) have been reported throughout the Mediterranean in the past (Raga *et al.*, 1985; Duguy, 1989; Notarbartolo di Sicara *et al.*, 1993). However, very little is known about the abundance, distribution, social structure and migration patterns of this species in both the western and eastern basins of this sea. Until now, scientific research around the Strait of Gibraltar had been very scarce, and very few sperm whale records had been reported (Universidad de Barcelona, 1998; Roussel, 1999). During the nineteenth century, before the whaling stations of the area of the Strait of Gibraltar started their hunting, big schools of sperm whales were reported along the south-western coast of Spain and Portugal (from Cabo San Vicente to the Strait) (Clark, 1887). Studies based on bio-acoustics of the species have suggested that there could be a "Mediterranean" population of sperm whales (Notarbartolo di Sciara and Gordon, 1996). The degree of isolation of this "Mediterranean population" from the Atlantic has become an important matter of concern as the species has in recent years been victim of an apparently important bycatch of pelagic drift-netting operations (Lázaro and Martín, 1999), and it has been suggested that its population has been declining over the last decades (Viale, 1980; Bayed and Beaubrun, 1987).

AIMS The main aim of this study was to analyse the importance of the Strait of Gibraltar as a barrier for the migration of sperm whales in and out of the Mediterranean. In order to achieve this, we have focused on:

- The passage of sperm whales through the Strait of Gibraltar.
- The analysis of the natural bottleneck of Gibraltar.
- The human factors which can increase the bottleneck effect of Gibraltar.

METHODS Ship-board surveys have been conducted in waters around the Strait of Gibraltar and the eastern Alboran Sea. Three thousand seven hundred and twelve nautical miles (6,875 km) have been sailed in the Gibraltar region and contiguous Atlantic region onboard a ten metre motor-boat in 1999, whilst 14,087 nm. (26,145 km) have been sailed in the eastern Alboran Sea region from 1992 to 1999. The visual survey in the last region was assisted by acoustic surveying carried out with a towed array hydrophone since 1997. Data were recorded on number of individuals sighted, estimated size, initial cue and activity, contact position, depth, climatic parameters, sea state, associated species, and human activities. During encounters, the research platform approached the animals carefully and slowly from behind in order to be within range to take a photograph of the fluke at the moment of diving. Photographs were taken perpendicularly to the plane of the fluke when it was closest to the vertical position. Photographs were used to create a photo-identification catalogue, which could allow matching with individuals found in the eastern Alboran research site.

RESULTS AND DISCUSSION **The Natural Bottleneck of the Gibraltar Strait.** The only possible contact for cetacean populations of the Mediterranean with Atlantic populations is through the Strait of Gibraltar. For a species such as the sperm whale, several aspects of this Strait strike us as being possible obstacles for the passage of individuals in and out of the Mediterranean. The first obstacle we find is the physiography of the Strait. A cross section and map of the area reveals how narrow and shallow the Strait is for a pelagic species preferring deep waters. It is only 14 km wide and the area with depths greater than 500 m is only 7 km wide. The presence of sperm whales in the area tells us, however, that this obstacle in itself does not completely prevent these animals from transiting through the Strait.

The Whaling Stations at the Strait. A human activity that might have contributed to the isolation of the sperm whale in the Mediterranean basin is the whaling that was carried out until 1963 at the Gibraltar Strait, by two whaling stations: Getares in Algeciras (Spain) and Benzou in Morocco. The statistical records, although incomplete, clearly show the unsustainable exploitation of this factory that started with a very important number of catches at the beginning of the century (Table 1), but was forced to shut down a few decades later due to the depletion of whales in the area (Bayed and Beaubrun, 1987;Valdés, *pers. comm.*)

Sightings at both ends of the Alboran Sea. Table 1 shows the records of individuals sighted in the Strait of Gibraltar, and Table 2 shows the sightings in the eastern Alboran Sea. Twenty-nine sightings of sperm whale were reported in the area of the Strait of Gibraltar, with 33 animals (27 sightings of single individuals and two sightings of three individuals) from April to October 1999. On the eastern section of the Alboran Sea, 18 encounters were recorded with 23 animals (17 sightings of lone individuals and one sighting of six animals). The Strait of Gibraltar region does not offer ideal conditions for searching sperm whales. It is a very windy area and maritime traffic is intense, making levels of acoustic pollution very high. Whereas in the Alboran region the survey ship was using a hydrophone to detect sperm whale sounds, in the Gibraltar area, acoustics was not used. Despite this, and the generally bad sea state in Gibraltar, sperm whales have been sighted regularly here during this survey, making us think that they might not be as scarce here as generally believed. Also in the eastern section of the Alboran Sea, sperm whales were encountered, although not as frequently as in the Gibraltar area, probably due to its bottleneck effect, giving a greater chance to encounter the animals present in such a narrow area. In both areas, most of the sightings (89.7% in the Strait of Gibraltar and 94.4% in the eastern Alboran Sea) were treated as separate sightings of lone individuals; although on some occasions, another specimen was observed afterwards not far away from the first animal, indicating that maybe some of them comprised small groups in dispersed formation. At the same time, all the acoustic detections of sperm whales in the eastern region were of lone whales, except for the sighting of six animals. In this case, a lone animal was firstly detected; followed by two others after some hours of tracking; until, finally, there were clicks of several animals, just prior to spotting the group blowing on the surface.

The size of most animals (for which a length estimation could be made) in the Strait of Gibraltar was estimated at more than 11 m (83.3%). In the eastern Alboran section, 94.4% of the animals were longer than 12 m (88.9% were longer than 14 m), and only one was between 10 and 11 m (5.6%). No calves have been observed. The fact that the animals were estimated to be larger in the eastern section than in the Strait of Gibraltar could possibly be due to two reasons: either the method of estimation, being quite subjective (comparing the size of the whale with the size of the research boat), and varying depending on the observer, or the animals encountered in the area of the Strait are truly smaller than those in the eastern section (i.e. juveniles or sub-adults staying in the Strait, and older animals using larger areas in the Alboran Sea). The first reason may not apply since one sperm whale sighted simultaneously by the two research teams sailing together was estimated by both teams as of the same length.

On the other hand, all sightings in both areas, except one in the eastern Alboran Sea and one in the Strait of Gibraltar, consisted of feeding animals. All were making long dives, with short periods of blowing in between, and, in deep waters, the depth range of the encounters in the area of the Strait was 500-730 m (this being the maximum depth of the research area) (x=618, SD=72.65, n=27), and in the eastern Alboran Sea it was 550 to 1700 m (x=999 m, SD=319.67, n=19). The exception in the eastern region was a very big male of around 16 to 18 m found in the company of a small group of striped dolphins. This whale was not clicking, and seemed to be resting on the surface or at a couple of metres below, with the striped dolphins jumping constantly beside and over the whale. The animal in the area of Gibraltar that was not feeding, was observed travelling at an average speed of 4 knots.

CONCLUSIONS Results from these first sureys indicate that the sperm whale is present in the Alboran Sea and especially around the Strait of Gibraltar and on either side. The fact that most animals encountered were alone and larger than 11 or 12 m, could indicate that these animals are mainly juveniles or sub-adults and some adult males, and possibly some adult females without calves, feeding in the area. Thus, this seems to be an important feeding area for the species, and possibly also an important area for migration. More effort will be put in coming seasons to assess if the sperm whales are using the Alboran Sea and the Strait of Gibraltar only as feeding grounds, or also as a migration path between the Atlantic and the Mediterranean Sea. It seems clear that intensification of research in this region and throughout the Mediterranean should be considered a priority in the context of cetacean conservation. A phylo-geographic study of this species is urgently required in order to analyse the problem of a possible genetic isolation of the sperm whale in the Mediterranean. On the other hand, a general Mediterranean acoustic survey appears to be the only way to assess the size of this population and its present conservation status.

ACKNOWLEDGEMENTS We would like to thank Dr. Rus Hoelzel, The Mediterranean Sperm Whale Group, Earthwatch Institute and Earthwatch volunteers, FIRMM España (staff and volunteers), ALNITAK assistants, Guardia Civil del Mar and Aduanas for their help. We would also like to specially thank Jonathan Gordon, Douglas Gillespie, Tim Lewis, and Peter Evans for their support and technical help. We are also very grateful to Tarifa Tráfico, and in particular to Javier Gárate, and Felipe Valdés.

REFERENCES

Bayed, A. and Beaubrun, P. C. 1987. Les mammifères marins du Maroc: Inventaire préliminaire. *Mammalia*, 51(3): 437-446.

Cabrera, A. 1925. Los grandes cetáceos del Estrecho de Gibraltar, su pesca y explotación. Trabajos del Museo Nacional de Ciencias Naturales. *Serie Zoológica*, 52.

Clark, H. 1887. The whale fishery. In: *The Fisheries and Fishery Industries of the United States, Washington*; (Ed. G. B. Goodge). section V, vol. II: 3-218.

CZCS Tarifa, 1999. *Memoria anual 1999.* Salvamento Marítimo, Centrode Tarifa (Tarifa Tráfico).

Duguy, R. 1989. Les mammiferes marins de la Méditerranée occidentale. *Bulletin de la Societé Zoologique de France*, 114 (3): 84-94

Lázaro, F. and Martín, V. 1999. Sperm whales and drifting nets in the Meditterranean Sea: the example of the Balearic Islands. Pp: 118. In: *European Research on Cetaceans – 13.* Proc. 13th Ann. Conf. ECS, Valencia, Spain 5-8 April (Eds. P. G. H. Evans, J. Cruz and J. A. Raga).). European Cetacean Society, Cambridge, England. 484 pp.

Notarbartolo di Sciara, G. and Gordon, J. 1996. Bioacoustics: a tool for the conservation of cetaceans in the Mediterranean Sea. *Mar. Fresh. Behav. Physiol.*, 30: 125-146.

Notarbartolo di Sciara, G., Venturino, M. C., Zanardelli, M., Bearzi, G., Borsani, F. J. and Cavalloni, B. 1993. Cetaceans in the central Mediterranean Sea: distribution and sighting frequencies. *Boll. Zool.*, 60: 131-138.

Raga, J. A., Raduán, M. A. and Blanco, C. 1985. Contribución al estudio de la distribución de cetáceos en el Mediterráneo y Atlántico Ibérico. *Misc. Zool.*, 9: 361-366.

Roussel, E. 1999. *Les Cétacés dans la partie orientale du Détroit de Gibraltar au printemps: indications d'ecologie.* Masters thesis. University of Paris IV.

Universidad de Barcelona 1998. Primer Inventario Nacional de Cetáceos. Informe Técnico presentado a la Dirección General de Conservación de la Naturaleza. Ministerio de Medio Ambiente.

Viale, D. 1980. Les mofifications du peuplement de cétacés de Méditerranée occidentale. Journés Étud. Systém. et Biogéogr. Médit. Cagliari, C.I.E.S.M.

Table 1. Number of catches at the whaling stations of the Strait of Gibraltar

Getares (Spain)		Benzou (Morocco)	
Period	Num. of catches	Period	Num. of catches
1921-1926	356	1921-1948	?
1950-1953	128	1949-1954	283
1953-1963	?		
TOTAL	+484		+283

SIGHTING RECORD OF HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*) IN THE CANARY ISLANDS

F. Díaz, N. Aguilar, and I. Delgado

Dept. of Animal Biology (Marine Sciences). Faculty of Biology. La Laguna University, Avda. Astrofisico Fco., Sánchez, La Laguna, Tenerife, Spain

Humpback whales (*Megaptera novaeangliae*) have been the most recent member of the family, Balaenopteridae, to be sighted in the waters of the Canary Islands. From May 1999, there have been three confirmed records of the species, bringing to 26 the total number of cetacean species recorded in Canary waters. These sightings are now added to the historical but unpublished references of its presence in the archipelago. On the other hand, Cabo Verde archipelago, with the same oceanic volcanic characteristics, and south of the Canary Islands, has been recognised as a calving area for this species. The humpback whale is a cosmopolitan cetacean, whose abundance is estimated to be about 15,000 individuals, from which only some hundreds are found in the North-east Atlantic, the exact population being unknown. From these facts, a hypothesis is outlined on the existence of a population in the North-east Atlantic independent of that of the North-west Atlantic, which might constitute also a panmictic population, due to the existence of other migratory routes and calving areas. Photo-ID and genetic studies are needed and may reveal that genetic exchange does not exist between the two Atlantic populations.

A PRELIMINARY ANALYSIS OF THE MICROSATELLITE-DNA OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) POPULATIONS IN ICELAND

S. Duke[1], E. Rogan[2] and G. Vikingsson[3]

[1]*Dept of Zoology, University College Dublin, Ireland*
[2]*Dept of Zoology and Animal Ecology, University College Cork, Ireland*
[3] *Marine Research Institute, Skulagata 4, 101-Reykjavic, Iceland*

Populations of harbour porpoise, *Phocoena phocoena*, from around the coast of Iceland were analysed to identify possible sub-populations using PCR-amplified DNA-microsatellites. Samples from harbour porpoises stranded on the Irish coastline will be used as an outgroup. Four polymorphic loci (EV94, EV104, GATA053 and TAA031) have been screened for all the samples. These primers were all isolated from closely related cetacean species (Valsecchi *et al.*, 1996; Palsbøll *et al.*, 1997). Also, they have all been previously used with success to screen porpoise samples (Anderson, *In Press*). Interpretation of the genetic profiles of the populations will be presented and related to previously published studies for other populations.

A NOTE ON THE PERSISTENCE OF DORSAL FIN SCARS ON RISSO'S DOLPHINS PHOTO-IDENTIFIED IN THE LIGURIAN SEA

V. Fadda and S. Airoldi

Tethys Research Institute, viale G. B. Gadio 2, 20121 Milano, Italy

The recognition of individual animals is a powerful tool that may provide insight into the social ecology of cetacean populations. Permanent natural markings enable individual (re)identification by means of photo-identification techniques. Risso's dolphins (*Grampus griseus*) are often heavily scarred and seem to accumulate whitish scratches as they grow older. From 1990 to 1999, over 130 Risso's dolphins have been photo-identified during research cruises conducted in the Ligurian Sea, and consistent photo-identification data were used to test if dorsal fin scars tended to vanish over time. This study examined the persistence pattern of dorsal fin scars of 19 individuals re-sighted across 6-9 years. Fins were classified, based on the degree of change in pattern scars, in 3 categories: 1 - little or no fin pattern change; 2 - moderate change; 3 - major change. Results suggested that (1) scarrings last for a long time, and (2) the rate of overlapping of new scars on a dorsal fin is slow enough as to allow individual re-identification over periods of at least nine years.

CETACEAN POPULATIONS IN THE STRAITS OF GIBRALTAR: A FIRST APPROACH

M. Fernández-Casado[1], R. De Stephanis[1] and N. Pérez Gimeno[2]

[1]*firmm® España (foundation for the information and research on marine mammals),*
C/ Pedro Cortés, 3, 11380 Tarifa, Cádiz, Spain (E-mail: marsop@hotmail.com)
[2]*Facultad de Ciencias del Mar de la Universidad de Cádiz, Polígono Río San Pedro S/N,*
Puerto Real, Cádiz 11510, Spain (E-mail: neus_perez@yahoo.com)

INTRODUCTION *firmm®* España (*foundation for the information and research on marine mammals*) is dedicated to whale-watching activities in the Straits of Gibraltar (South of Spain), which is the only possible passage between Atlantic Ocean and Mediterranean Sea. This whole area has very special oceanographic conditions due to the mixture of these quite different masses of water. In these conditions live some populations of several species of cetaceans, which are still poorly known. A study of these populations was started in 1999, taking as much information as possible in every contact.

MATERIALS AND METHODS The Straits of Gibraltar is nearly 60 km wide. (for study area, see Fig. 1). Its western entrance is situated between the Capes of Trafalgar (Spain) and Espartel (Morocco), where there is a width of c. 44 km, from where it becomes progressively narrower to the east, with a minimum width of 14 km between Tarifa (Spain) and Punta Almina (North Africa). Its eastern entrance is placed between Gibraltar and Punta Cires (Morocco), about 23 km wide (Parrilla *et al.*, 1986). The average depth in the Straits of Gibraltar is about 350 m (Rodriguez, 1982).

This first survey season started on April 15th and it finished on October 31st of 1999. During this time, 271 trips were made using two similar motor-boats of 9 and 11 m length, respectively, with 1 or 2 observers on each with a height of eye of 282 and 293 cm, respectively. All whale-watching trips were carried out between 35° 59' 50'' and 35° 55' 50'' latitude North, 005° 31' 00'' and 005° 40' 00'' longitude West, in a radius of five nautical miles from the port of Tarifa (Cádiz) (covering the most of the Straits, but not the Moroccan waters).

The average duration of every trip was 2 hours and 6 minutes (SD 32 minutes). In total, 568 hours and 48 minutes were spent at the sea. No trip was made when wind force was stronger than 15-16 knots (force 4 in Beaufort scale). During the trip, different data concerning weather conditions, species, positions, accompanying species, social structure and behaviour were collected. Only data at the moment of contact with the animals were considered in this study.In a further analysis, the distribution of every species in relation to area and depth was calculated for all the sightings.

RESULTS 498 sightings recordings were obtained. The most frequent species of cetacean observed during the season (Fig.2) were: long-finned pilot whale (*Globicephala melas*), (with 167 sightings, 33.53% of the total number), bottlenose dolphin (*Tursiops truncatus*), (104 sightings, 20.88%), striped dolphin (*Stenella coeruleoalba*), (95 sightings, 19.08%) and short-beaked common dolphin (*Delphinus delphis*), (90 sightings, 18.07%).

Beside these species, other less frequent recordings were of sperm whales (*Physeter macrocephalus*), (29 sightings, 5.82%), killer whales (*Orcinus orca*), (6 sightings, 1.20%), and fin whales (*Balaenoptera physalus*), (5 sightings,1.00%). All the sightings of killer whales were made around more than 45 tuna fishing boats.

Group sizes: Table 1 provides data on group size for every sighting for the seven different species of cetacean found in the Straits of Gibraltar.

Spatial distribution: Figs. 3, 4 and 5 show the distribution in the study area of common and striped dolphins, and in relation to depth ranges where the groups were found. Figs. 6, 7 and 8 show the distribution of bottlenose dolphins and pilot whales also in relation to depth ranges..

CONCLUSIONS In the research area, seven species of cetaceans, including four delphinids, were observed from April 15th to October 31st, 1999. The species most frequently found, in terms of groups encountered, was the long-finned pilot whale, while the species with the highest number of individuals was the striped dolphin.

The distribution per area, at least in spring and summer, shows that striped and short-beaked common dolphins are the two main species to share the Spanish coastal waters, however, bottlenose dolphins and long-finned pilot whales prefer the offshore waters of the middle area of the Straits. No data were collected in Moroccan waters, or in the autumn and winter seasons in Spanish waters.

There is much interaction between fisheries and killer whales in the area (see De Stephanis, *et al.*, this volume). More effort will be put in the future to analyse this problem.

There is an important presence of sperm whales in the Straits of Gibraltar (see Cañadas, *et al.*, this volume). The results of this survey in the Straits of Gibraltar highlight the area as an important region for several species of cetaceans. The research will continue over the coming seasons in order to define more accurately these habitats, and the threats to these cetacean populations.

ACKNOWLEDGEMENTS The authors would like to acknowledge all staff and volunteers of *firmm*® *España*: Katharina Heyer (President), Keiti, Walter, Phillip, Ricardo, Patricia, Ronny, Fran, Michael, Michelle, Luis, Eva, and Menna. We are also very grateful to the skippers: Antonio, Miguel, Juan, Andrés, from Scórpora Diving Club, to Ana and Ricardo for their continuous support, and finally to Juanmi, from the University of Cadiz.

REFERENCES

Armi, L. and Farmer, D. 1985. The international hydraulics of the Straits of Gibraltar and associated sills and narrows. *Oceanol. Acta.*, 8: 37-46.

Gascard, J. C. and Richez, C. 1985. Water Masses and Circulation in the Western Alborán Sea and in the Straits of Gibraltar. *Prog. Oceanogr.*, 15: 157-216.

Parrilla, G., Kinder, T. H., and Bray, N. A. 1988. Hidrología del agua mediterránea en el Estrecho de Gibraltar durante el Experimento Gibraltar (octubre 1985-octubre 1986). In: *Seminario sobre la Oceanografía Física del Estrecho de Gibraltar (Madrid, 24-28 de octobre 1988):* 95-121.

Rodríguez, J. 1982. *Oceanografía del Mar Mediterráneo.* Ed. Pirámide, Madrid. 174pp.

Sanz, J. L., Acosta J., Herranz P, Palomo C., and San Gil, C. Mapa Batimétrico del Estrecho de Gibraltar. In: *Publicaciones especiales del I.E.O.* No. 7. Instituto Español de Oceanografía, Madrid, Spain.

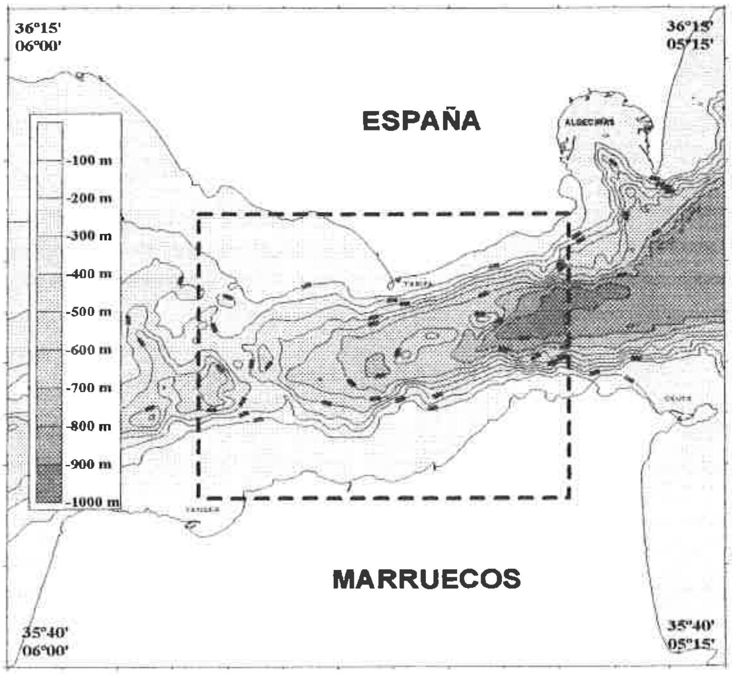


Fig. 1. Map of the study area, the Straits of Gibraltar, showing the different depth ranges of the region.

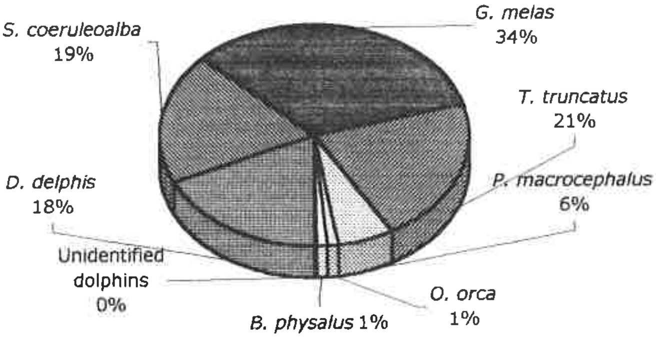


Fig. 2. Percentage of cetacean sightings by species.

Species	Number of sightings	%	Number of individuals	Group size	SD	Max	Min	Mode
Delphinus delphis	90	18.07	2972	33.02	41.31	200	2	30
Stenella coeruleoalba	95	19.08	6115	64.37	79.18	500	1	20
Globicephala melas	167	33.53	3518	21.07	22.14	200	1	20
Tursiops truncatus	104	20.88	1498	14.40	23.17	200	1	5
Physeter macrocephalus	29	5.82	34	1.17	0.54	3	1	1
Orcinus orca	6	1.20	53	8.83	0.41	9	8	9
Balaenoptera physalus	5	1.00	7	1.40	0.55	2	1	1
Unidentiffied dolphin	2	0.40	?	?	?	?	?	?
Totals	498	100.00						

Table 1. Group size of the cetacean sightings by species

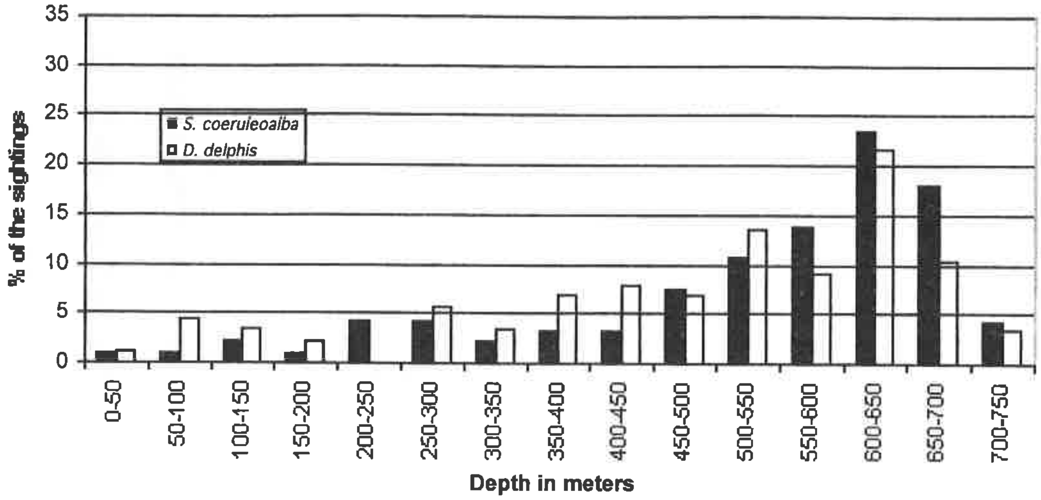


Fig. 3. Histogram with the depth ranges in which the groups of common and striped dolphins were found

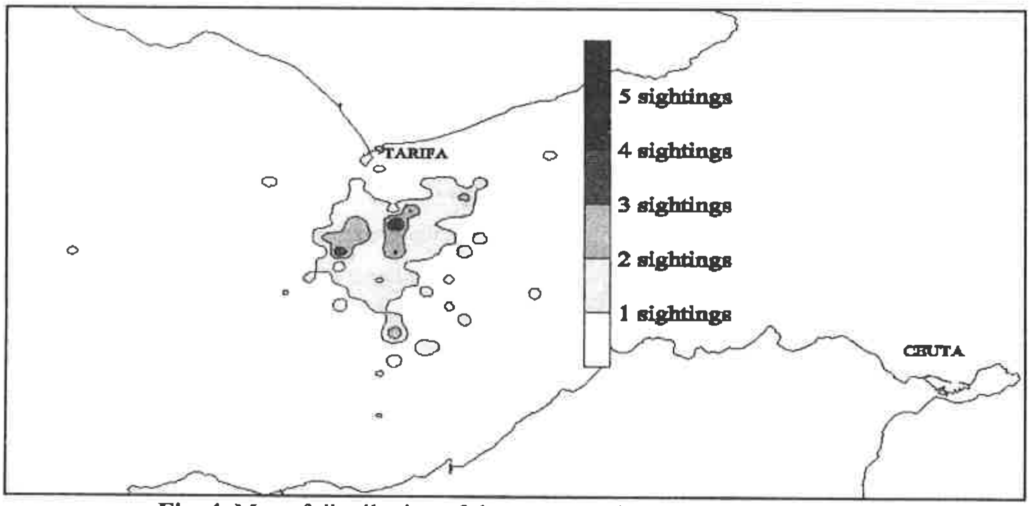


Fig. 4. Map of distribution of the common dolphin in the study area

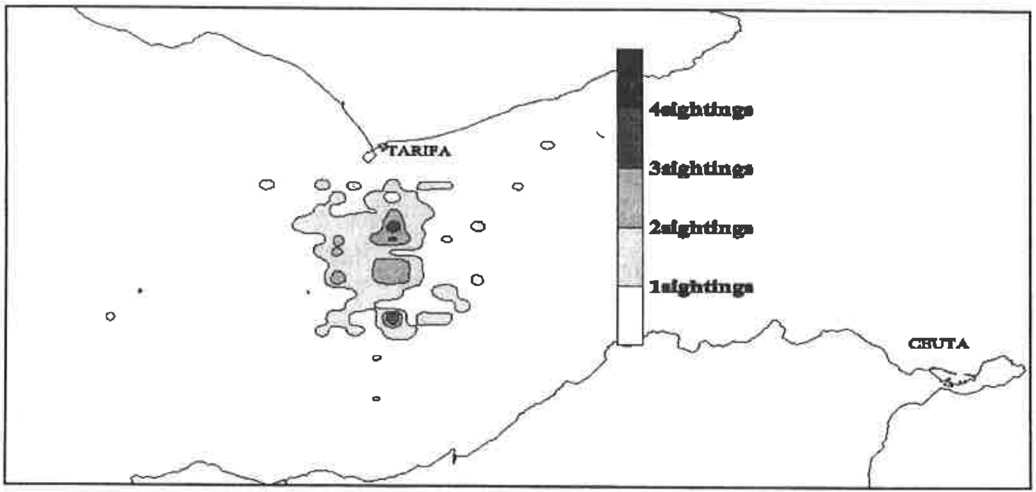


Fig. 5. Map of distribution of the striped dolphin in the study area

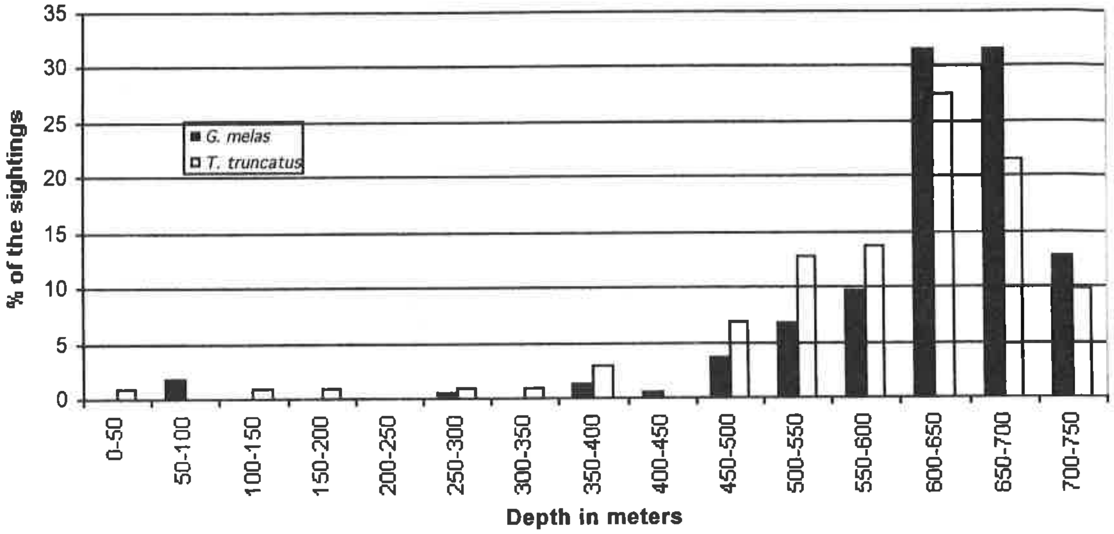


Fig. 6. Histogram with the depth ranges in which the groups of bottlenose dolphins and pilot whales were found

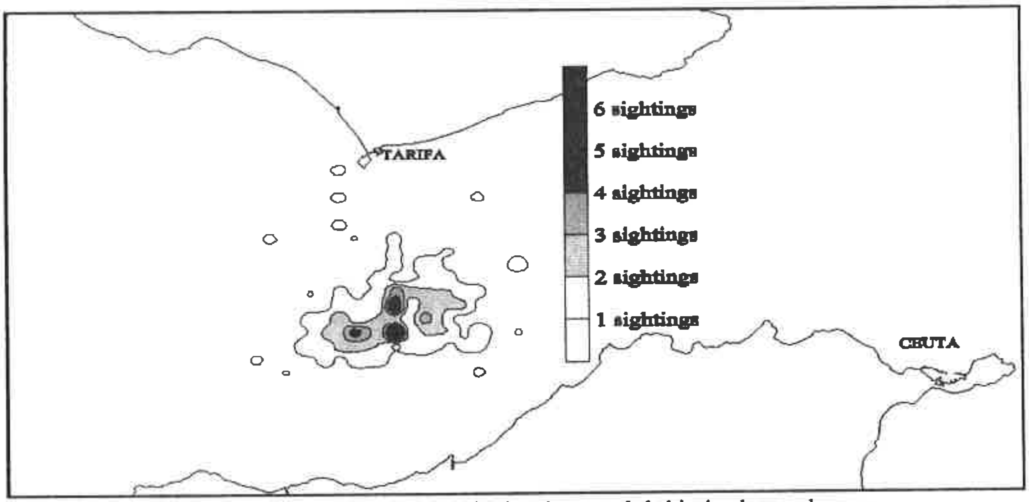


Fig. 7. Map of distribution of the bottlenose dolphin in the study area

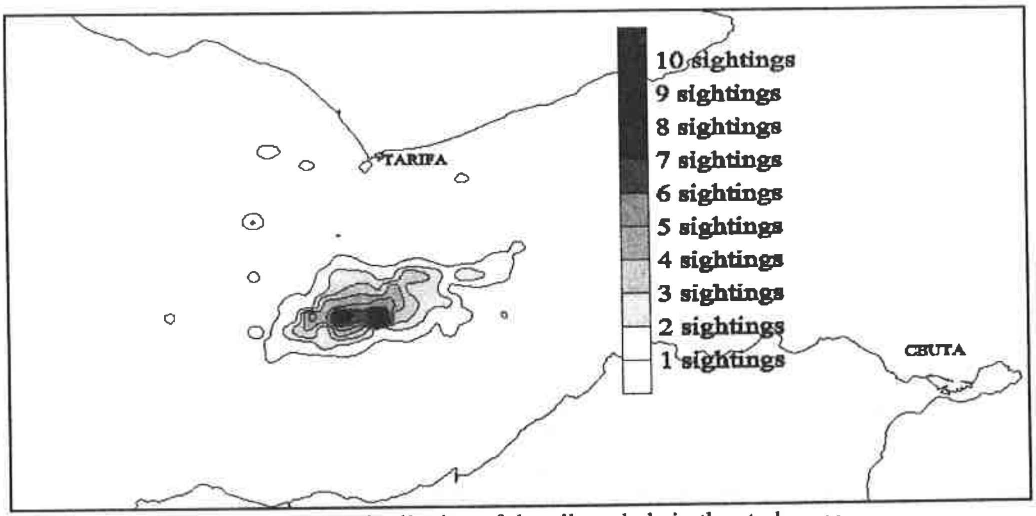


Fig. 8. Map of distribution of the pilot whale in the study area

RECAPTURE ESTIMATES OF ABUNDANCE OF HUMPBACK WHALES

N. Friday[1], T. D. Smith[1] and P. S. Hammond[2]

[1]*NEFSC/NMFS, 166 Water St. Woods Hole, 02543 MA, USA*
[2]*Sea Mammal Research Unit, Gatty Marine Lab, School of Biological and Medical Science,*
University of St. Andrews, St. Andrews, Fife, Scotland, KY16 8LB

The effects of violations of the assumptions of a closed population and of equal probabilities of capture were evaluated for the six Petersen abundance estimators used on the YoNAH data. These abundance estimators compared winter breeding and summer feeding seasons for 1992 and 1993.

Within-year breeding to feeding estimators were robust to violations of the closed population assumption. The between-year estimates were susceptible to violations in the assumption of a closed population because they spanned a time period that included recruitment and mortality. For violations in the assumption of equal probabilities of capture to affect an estimator, the unequal probabilities must have occurred in both sampling periods.

All estimators were sensitive to variability in individual sampling probabilities. To measure the bias of these estimates of abundance, estimates are needed of the variability in individual sampling probabilities, of the proportion by age and sex of individuals who did not migrate to the breeding area, and of the relative length of time which females remained in the breeding area.

FIRST REPORTS ON A SPECIMEN OF BLAINVILLE'S BEAKED WHALE (*MESOPLODON DENSIROSTRIS*) AND ON A SPECIMEN OF GERVAIS' BEAKED WHALE (*MESOPLODON EUROPAEUS*) STRANDED ON THE ATLANTIC COAST OF FRANCE

Alexandre Gannier[1], Olivier Van Canneyt[2] and Laurent Soulier[3]

[1]*Groupe d'Etude de la Faune Marine Atlantique, Capitainerie du Port, BP75, 40130 Capbreton, France*
[2]*Centre de Recherche sur les Mammifères Marins, Port des Minimes, 17000 La Rochelle, France*
(E-mail: vcanneyt@univ-lr.fr)
[3]*Musée de la Mer de Biarritz, BP 89, 64202 Biarritz Cedex, France*

On 9 January 1998, members of the French stranding network discovered a Blainville's beaked whale, *Mesoplodon densirostris* (Blainville, 1817), stranded dead on the beach of Tarnos village, located on the southern French Atlantic coast (43°30' N x 01°30'W). This specimen was a 435 cm long adult male. On 19 January 1999, a second *Mesoplodon* species, identified as a Gervais' beaked whale, *Mesoplodon europaeus* (Gervais, 1855), was found stranded dead 120 km northwards, on the beach of Biscarrosse village (44°20' N x 01°20' W). This specimen was a 409 cm long adult male. For each specimen, external and cranial measurements (Tables 1 and 2) were noted, and genetic samples and the skull preserved. Both strandings are the first records on the French coasts.

Mesoplodon specimens are rarely observed in the north-east Atlantic with most of the species more frequently found in warmer waters. Blainville's beaked whale shows a world-wide distribution, being found in the Pacific, Indian and Atlantic Oceans. It frequents the Atlantic Ocean from tropical waters (Mead, 1989). Apparently, it is more widespread in the North-west Atlantic with 22 observations recorded along the north American coast (Mead, 1989), and only four along the European coast. Of these four, one specimen was stranded in Madeira in 1924 (Harmer, 1924), one in Portugal in 1979 (Reiner, 1979) and the other two were found in Spain; one on the Mediterranean coast in 1980 (Casinos and Filella, 1981) and the other in the south of Spain in 1988 (Valverde, 1996). The jaw fragment which permitted the naturalist H.M. Ducrotay de Blainville to describe this new species is supposed to come from the French coasts.

Gervais' beaked whale frequents the warm waters of the Atlantic Ocean, possibly showing a preference for the North-west Atlantic where 54 specimens have been recorded since 1985. Indeed, this species may be the most common species of *Mesoplodon* along the North American coast. In the North-east Atlantic, 18 specimens have been recorded since the holotype was discovered dead in the English Channel around 1840 (Gervais, 1855). Of these, 11 specimens were found in the Canary Islands between 1985 and 1997, a skull was discovered along the Guinea-Bissau coast in 1979 (Reiner, 1980), and other whole specimens were found in Portugal in 1986 (Inacio, 1987), the Azores (Galhardo, 1990), Ireland in 1989 (Burton and Cotton, 1989), the Mauritanian coast in 1992 (Robineau, 1993), and the south of Spain in 1993 (Valverde, 1996).

Given the infrequency of these occurrences, the discovery of the two specimens recorded here appears, at first, unusual. However, their presence in the Bay of Biscay, south-west France, may be more common than supposed, being influenced by the bathymetric features of this area. For example, a deep canyon in the continental shelf, called "Gouf de Capbreton", attracts the natural prey of the beaked whale. Changes in the currents of the Gulf Stream may also play a role since these animals would follow the easterly moving currents of the North-west Atlantic via Europe. Furthermore, the southern area of the Bay of Biscay appears to be unusual, given the right angle created by France and Spain and the easterly moving currents into the area, and as such it attracts several species of marine fauna including the loggerhead turtle, the sreepdassie bream, the Canary bleak, and members of the Ziphiidae family. Three beaked whale species occur in this area: the bottlenose whale, Cuvier's beaked whale and Sowerby's beaked whale, and recent observations of Sowerby's beaked whale and True's beaked whale have been reported by the Biscay Dolphin Research Program team (Williams *et al.*, 1999).

The cetacean diversity in this zone is certainly the most important along the French littoral coast (17 registered species / 25 French species. Favourable environmental conditions and, above all, food availability could extend the distribution of *Mesoplodon* species to the Bay of Biscay. Thus, one may speculate that the occurrence of these two specimens reported in this paper may not be a simple case of erratic movement. Given that both strandings occurred in winter, the storm period in the Bay of Biscay, it may be a case of weakened animals being forced too far inshore. To date, the autopsies have not clarified the causes of death.

ACKNOWLEDGEMENTS We gratefully acknowledge Damian C. Lidgard for improving the English of the manuscript.

REFERENCES

Bruton, T. D., Cotton, D. and Enright, M. 1989. Gulf Stream beaked whale *Mesoplodon europaeus* (Gervais). *Irish Naturalists' Journal*, 23(4): 156.

Casinos, A. and Filella, S. 1981. Notes on cetaceans of the Iberian coasts: IV. A specimen of *Mesoplodon densirostris* (Cetacea, Hyperoodontidae) stranded on the Spanish Mediterranean littoral. *Saügethierkund Mitteil*, 29: 61-67.

Castells, A. and Mayo, M. 1992. Relacion de citas de cetaceos. (Mammalia, Ceatacea). Espana y Portugal. *Centro de Estudios de Mamiferos Marinos* (Madrid), 1(2): 80.

Carrillo, M. and Martin, V. 1999. First sighting of Gervais' beaked whale (*Mesoplodon europaeus* Gervais, 1855) (Cetacea; Ziphiidae) from the Northoriental Atlantic coast. Pp. 180. In: *European Research on Cetaceans – 13*. Proc. 13 th Ann. Conf. ECS, Valencia, 5-8 April, 1999 (Eds. P. G. H. Evans, J. Cruz and J. A. Raga). European Cetacean Society, Cambridge, England. 484pp.

Galhardo, M. L. 1990. *Cetáceos que ocorrem nos Açores (Biologica, Ecologia e Taxonomia) e estudos sobre a história da Baleação nos Açores*. Relatorióde Estágio da Licenciaturia em Biologia e Geologia do Departemento de Biologia Universidade dos Açores. 330 pp.

Gervais, F. L. P. 1855. *Histoire naturelle des mammifères*, Vol. II. L. Curmer. Paris.

Harmer, S. F. 1924. On *Mesoplodon* and other beaked whales. *Proc. Zool. Soc.* (Lond.): 541-587.

Inacio, A. M. 1987. Cetaceos e Pinipedes observados nas costas portuguesas no periodo 1979-1986, registados no Aquario Vasco da Gama. *Relatorios de Actividades do Aquario da Gama*, 16: 1-25pp.

Mead, J. G. 1989. Beaked whales of the Genus *Mesoplodon*. Pp. 349-430. In: *Handbook of marine mammals*, vol. 4 (Eds. S. H. Ridgway and R. Harrison. Academic Press, London. 442pp.

Reiner, F. 1979. Nota sobre um raro ziphioid, *Mesoplodon densirostris*, Blainville 1817, nas costas de Portugal. Memorias do Museu do Mar, Cascais, *Portugal Série Zoologica*, 1: 1-12.

Reiner, F. 1980. First record of an Antillean beaked whale, *Mesoplodon europaeus*, Gervais, 1855 from the Republica Popular de Guiné-Bissau. Memorias do Museu do Mar, Cascais, *Portugal Série Zoologica*, 1(8): 1-8.

Robineau, D. 1993. Stranding of a specimen of Gervais' beaked whales (*Mesoplodon europaeus*) on the coast of West Africa (Mauritania). *Marine Mammal Science*, 9(4): 438-440.

Valverde, J. A. and Galan, J. M., 1996. Notes on a specimen of Gervais' beaked whale *Mesoplodon europaeus* (Gervais), Ziphioidae, stranded in Andalucia, Southern Spain. Pp. 177-183. In: *European Research on Cetaceans – 10*. Proc. 10 th Ann. Conf. ECS, Lisbon, 11-13 March, 1996 (Eds. P. G. H. Evans). European Cetacean Society, Cambridge, England. 334pp.

Valverde, J. A. 1996. Notes on a specimen of Blainville's beaked whale *Mesoplodon densirostris* (de Blainville, 1817), Ziphioidae, stranded on the coast of Donana, Huelva, Southern Spain. Pp. 184-189. In: *European Research on Cetaceans – 10*. Proc. 10th Ann. Conf. ECS, Lisbon, 11-13 March, 1996 (Eds. P. G. H. Evans). European Cetacean Society, Cambridge, England. 334pp.

Williams, A. D. , Brereton, T. and Williams, R. 1999. Seasonal variation in the occurrence of beaked whales in the Southern Bay of Biscay. Pp. 275-277. In *European Research on Cetaceans – 13*. Proc. 13th Ann. Conf. ECS, Valencia, 5-8 April, 1999 (Eds. P. G. H. Evans, J. Cruz and J. A. Raga). European Cetacean Society, Cambridge, England. 484pp.

Table 1. External measurements (cm) of two *Mesoplodon* specimens

Measurements	***M. densirostris***	***M.europaeus***
Total length	435	409
Length from the corner lips to the tip of the snout	31.5	30
Length from the tooth to the tip of the snout	27	10
Length from the eye to the tip of the snout	54.5	44
Length from the blowhole to the tip of the snout	53	34
Length from the anterior flipper to the tip of the snout	100	78
Length from the dorsal fin to the tip of the snout	280	264
Length from the genital slit to the tip of the snout	295	219
Length from the anus to the tip of the snout	335	238
Length of the flipper	45	42
Width of the flipper	17	18
Width of the fluke	102	121
Height of the dorsal fin	21	20.5
Length of the dorsal fin	33,5	35

Table 2. Cranial measurements (mm) of two *Mesoplodon* specimens

Measurements	***M. densirostris***	***M. europaeus***
Condylobasal length	735	707
Rostrum length	390	416
Rostrum width at base	105	183
Rostrum width 60 mm anterior to the base	65	112
Rostrum width at middle	62	66
Rostrum width at 3/4 of the length	43	41
Maximum premaxillae width	108	151
Skull width at level preorbital angle	331	296
Skull width at level postorbital angle	334	335
Skull width at level zygomatic apophysis	316	322
Skull width at level parietals	252	213
Length of temporal fossa	115	103
Height of temporal fossa	72	52
Tip rostrum to anterior border of nares	515	482
Tip rostrum to posterior end of the wing of pterygoid	574	532
Tip of rostrum to anterior extension of pterygoid	335	359
Tip of rostrum to posterior margin of pterygoid	585	546
Maximum span of the occipital condyles	121	102
Maximum width of right occipital condyle	44	44
Maximum length of right occipital condyle	74	66
Maximum width of foramen magnum	46	47
Mandible length	633	602
Coronoid height	127	107
Length of mandible symphysis	174	121
Maximum height of the mandible	161	112
Length between tip of mandible and anterior border of alveolus	-	81
Length of alveolus	70	34
Height right tooth	125	70
Width right tooth	66	36

THE USE OF TELEMETRY TO STUDY BOTTLENOSE DOLPHIN STOCK STRUCTURE ALONG THE U.S. ATLANTIC COAST

A. A. Hohn[1], L. J. Hansen[2], F. Townsend[3], and M. D. Scott[4]

[1]*NOAA, National Marine Fisheries Service, SEFSC, Beaufort, NC, USA*

[2]*NOAA, National Marine Fisheries, SEFSC, Charleston, SC, USA*

[3]*Bayside Hospital for Animals, Fort Walton Beach, FL, USA*

[4]*Inter-American Tropical Tuna Commission, La Jolla, CA, USA*

Bottlenose dolphins, *Tursiops truncatus*, are currently under study along the Atlantic coast of the U.S. to elucidate stock structure, estimate abundance, and document the level of incidental mortality in commercial fisheries. Determining the number of stocks is particularly important because fishery mortality is suspected to be quite high in one part of the range, thereby potentially being disproportionately detrimental to one stock. The patterns of residency, however, are complex and varied. In the northern part of the range, *Tursiops* are present only in warmer months and are migratory, while in other areas both resident and transient or migratory groups occur.

A multi-faceted investigation of *Tursiops* stock structure began in 1996, incorporating studies of photo-identification, genetics, stable isotope ratios, morphometrics, life history, contaminant burdens, and telemetry. One goal of the telemetry component has been to tag dolphins throughout their range and monitor their movement patterns. In September 1998, a PTT (satellite-linked radio transmitter) and VHF transmitter were deployed on one female in Virginia, where *Tursiops* are migratory. Two weeks later, the female and a large group of dolphins migrated to North Carolina for the winter, using both coastal and estuarine waters, before returning to Virginia in the summer. Two additional PTTs and nine VHF transmitters were deployed near Charleston, South Carolina, in October, 1999. To date, the tagged animals have remained relatively close to where they were tagged, and all of the PTTs and all but one of the VHF tags are still functioning. In November, 1999, 4 PTTs and 7 VHF tags were deployed near Beaufort, North Carolina, and all are functioning. This large sample of simultaneously tagged dolphins has the potential to significantly help elucidate stock structure and migration patterns, and define habitat use, particularly in conjunction with the other techniques being employed.

SITE FIDELITY, MOVEMENTS PATTERNS AND GROUP MIXING OF NORMANDY BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

V. Lahaye and G. Mauger

Groupe d'Etude des Cétacés du Cotentin, C.I.T., rue Louis Aragon, 50130 Octeville, France

INTRODUCTION According to local fishermen, the presence of bottlenose dolphins in the adjacent coastal waters of "Manche" is nothing new and, in their opinion, they could be found all year round. Nevertheless, up to now, little information has been available to determine the status of this population. The present study analyses the first results of photo-identification in Normandy from 1997 to 1999.

MATERIALS AND METHODS The Normandy coast and around the Channel Islands contain four study sites (Fig. 1), which consist of approximately 3500 km^2 of water, averaging 10 m in depth : SW (Mont-Saint-Michel Bay), NW (Carteret to Jersey Island), N (Cherbourg) and E (Saint-Vaast-La-Hougue to Utah Beach). Our photo-identification surveys were conducted from a motorised dinghy, mainly in summer, due to adverse weather conditions (only in Beaufort sea state of 4 or less). First, our effort was limited to the NW (1997); then, we extended our study area to N and E (1998) and SW (1999).

RESULTS From 1997 to 1999, 42 daily surveys were carried out, totalling 3392 photos. This enabled the identification of 66 dolphins (Table.1). Following Maze and Würsig (1999), seasons were defined as autumn (Sept-Nov), winter (Dec-Feb), spring (March-May), and summer (June-Aug). Boat surveys took place mainly in summer, but our sighting network indicates the presence of *Tursiops* throughout the year, even if we do not know their identity.

The reliable re-sighting of 48 individuals (72.7%) once at least during these three years suggests that bottlenose dolphins exhibit a more or less high fidelity to the area. Furthermore, the fact that twelve of 66 dolphins (18.2%) have been observed three years in succession, implies that there is a long-term site fidelity for some individuals (Fig. 2).

Two main movement patterns have been determined in the total area. Indeed, in summer 1998, survey boats in the E made it possible to identify or re-sight 14 dolphins. Among them, nine were sighted in August and September 1998, travelling between the NW and E zones in different groups (in size and composition), totalling about 70 km. We noticed an influx of four individuals initially sighted in the E in Cherbourg harbour in November (three of these dolphins were also in the NW in late summer). Moreover, nine other dolphins observed only in the NW in August-September were in the N in November too. Otherwise, during our last surveys in the SW, we photographed seven individuals, previously identified in the NW in 1997, in groups of newly-identified dolphins. It reveals a 30 km coastal movement for these seven dolphins.

DISCUSSION The site fidelity between years has been confirmed for most of the identified dolphins: some were observed during each year of the study; some were sighted during two consecutive years; and others were seen every other year. Besides, some were sighted in summer and also during the periods of spring or autumn. Nevertheless, we cannot assert an annual site fidelity due to the lack of information in winter; for this reason, the sedentary life of some dolphins has to be confirmed in the future with greater sampling effort.

During our surveys in the E, the same group of 14 identified dolphins accompanied by calves was observed from 2-11 Aug 1998. In fact, bottlenose dolphins often frequent a particular area for a period of several days or weeks, and then abruptly change their pattern and move to another location (Würsig, 1978). Indeed, four of these dolphins from the E were sighted in the NW on 29 Aug 1998. In the SW in 1999, we re-sighted five dolphins that were not observed since 1997, but whether this represents a long- or short-term movement is not known because surveys could not be thorough in the NW in 1998 (because of our presence in the E). Anyway, coastal movements of 30 and 70 km are not surprising for this species: Maze & Würsig (1999) reported movements between San Luis Pass and Galveston Bay (45 km) for three identified dolphins.

In Normandy, we generally observe groups of 15-20 dolphins, and sometimes more. For example, on 19 Aug 1998, we observed a group of 50-60 dolphins, where some individuals, sighted in the E from 2-11 Aug 1998, were travelling with individuals observed in the NW on 18-19 and 29 Aug 1998. Close associations between dolphins of the two sectors were noticed. The fact that dolphins are found in different sectors in different groups shows how groups are mixing through the different zones. In the same way, research in Galveston Bay and adjacent waters of the Gulf of Mexico shows that group composition was fluid (Maze and Würsig, 1999).

CONCLUSIONS The degree of mixing between populations or groups can only be determined after individual units have been identified by movement patterns and associations, which are the main behavioural factors of primary importance in identifying populations (Shane *et al,* 1986). As a result, the study effort must be continuous throughout the year, in order to complete the photo-identification catalogue, estimate the use of space, the movements, and mixing habits of the groups, especially in winter.

ACKNOWLEDGEMENTS The help of fishermen and semaphores in our sighting network is gratefully acknowledged. The authors thank C. Liret and S. Pineau for their helpful reviews of this paper; and C. Tissier, A..Lalis, and B. Lapeyre for their valuable work on the photo-identification catalogue.

REFERENCES

Maze, K. S. and Würsig, B. 1999. Bottlenose dolphins of San Luis Pass, Texas : Occurrence patterns, site-fidelity, and habitat use. *Aquatic Mammals*, 25(2): 91-103.

Shane, S. H., Wells, R. S., and Würsig, B. 1986. Ecology, behaviour and social organization of the bottlenose dolphin : a review. *Marine Mammal Science*, 2(1):34-63.

Würsig, B. 1978. Occurrence and group organization of Atlantic bottlenose porpoises (*Tursiops truncatus*) in an Argentine bay. *Biological Bulletin,* 154: 348-359.

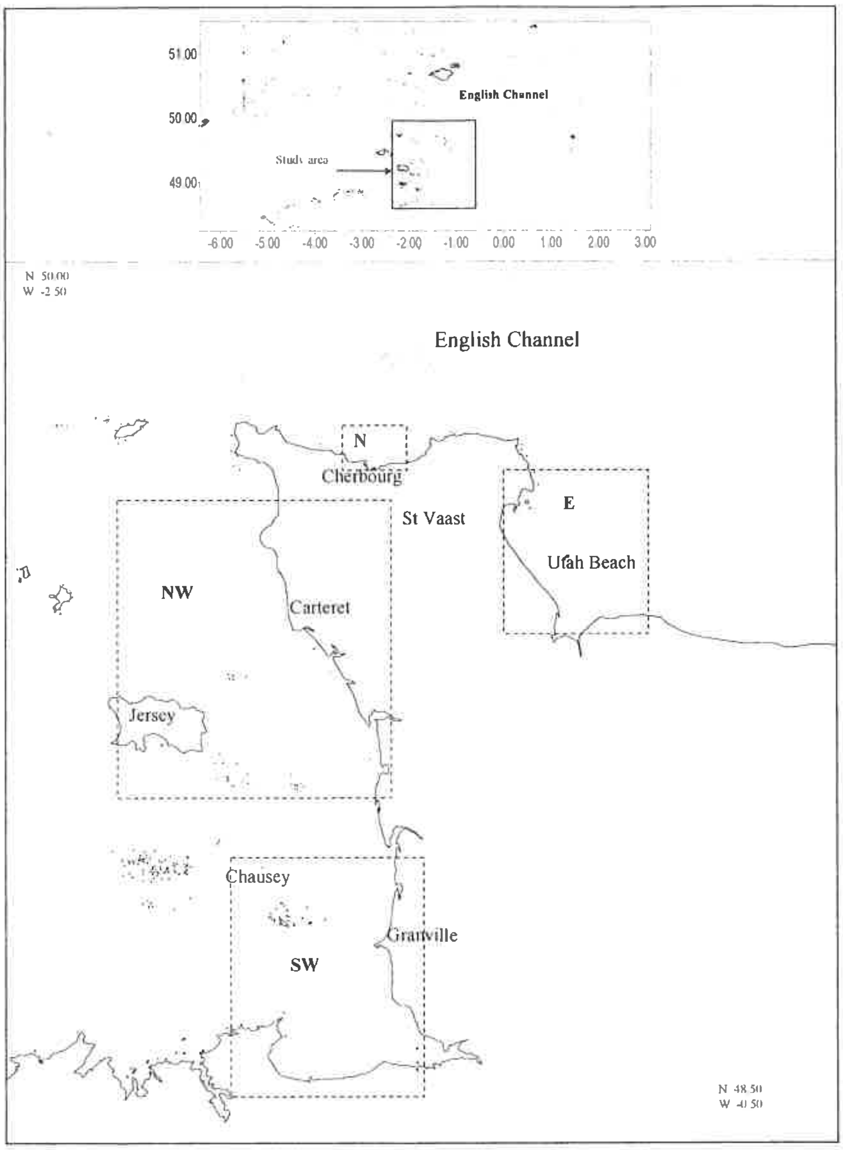


Fig.1. Presentation of the study area

Year	1997		1998			1999	
Season	summer	autumn	spring	summer	autumn	spring	summer
Total surveys	9	3	1	10	3	3	13
Newly-ID	46	4	0	9	1	0	6
Total ID	46	11	2	39	15	10	21

Table.1. Review of boat surveys

	1997	1998			1999	
I,D,#	NW	NW	N	E	SW	NW
G001	■	■				
G002	■	■				■
G003					■	
G004	■	■				■
G006	■	■		■		
G007	■					
G008	■	■				
G010	■	■	■	■		■
G011	■					■
G012	■	■	■			
G013	■			■		
G014	■	■		■		■
G015	■	■	■			■
G016	■		■	■		
G017	■					■
G018	■	■				■
G019	■					
G020	■		■			
G021	■	■	■			■
G022	■				■	
G023					■	
G024	■	■	■			
G029	■	■	■			
G030					■	
G031	■				■	
G033	■	■	■	■		
G035	■					■
G038	■	■	■			
G040	■					
G041	■				■	
G042	■	■		■		■
G044					■	
G045	■					
G048	■	■	■	■		
G049	■			■		
G050	■			■		
G051	■					
G052	■	■				■
G053		■				
G054	■	■				
G055	■				■	
G056	■	■				
G058	■	■				
G060					■	
G061	■	■				
G063	■					■
G064					■	
G065	■	■				
G066		■	■			
G067		■	■			■
G068					■	
G069	■				■	
G070		■				
G071			■			■
G072		■	■			
G073	■	■			■	
G074	■	■			■	
G075	■	■		■		■
G076		■		■		
G077	■	■				
G078		■				
G079	■	■				
G080				■		
G081		■				
G082		■		■		
G083	■	■				

Fig. 2 : A year-by-year summary of the presence of identified dolphins (I.D) during the period study ; shaded blocks represent the presence of each dolphins at least once per year for each sector.

APPLICATION OF A NEW METHOD OF INVESTIGATING POPULATION STRUCTURE OF HARBOUR PORPOISE, *PHOCOENA PHOCOENA*, USING TOOTH ULTRA-STRUCTURE

C. H. Lockyer

Danish Institute for Fisheries Research, Charlottenlund Slot, DK 2920 Charlottenlund, Denmark

Tooth ultrastructure in harbour porpoise has been examined as a tool for differentiating between animals from different geographical regions throughout the North Hemisphere. Nine different characteristics in both dentine and cementum have been identified and recorded in the decalcified, sectioned and stained teeth which were examined microscopically. Although three of these characteristics were consistently found not to be useful in this study, several could be used to detect significant differences between porpoise tooth samples from Canadian east coast and West Greenland, between Iceland and Celtic Shelf and North Sea, as well as sub-divisions within the North Sea, and between North Sea, Skagerrak, Kattegat, Inner Danish waters and the Baltic Sea.

Teeth from Californian porpoises in the North Pacific were found to be distinguishable from North Atlantic samples examined. The method therefore appears promising as a tool for differentiating between groups of harbour porpoises, if used on groups of known geographic origin. However, it is not certain that any one tooth could be assigned to a particular geographic group, when selected randomly. In conclusion, results on distinction between putative populations using tooth ultrastructure were supported by findings from other types of investigation using genetics, and morphological and ecological factors.

PRELIMINARY RESULTS IN THE USE OF SATELLITE IMAGERY TO STUDY THE DISTRIBUTION OF COMMON DOLPHIN (*DELPHINUS DELPHIS*) AND STRIPED DOLPHIN (*STENELLA COREULEOALBA*) WITH RESPECT TO SEA SURFACE IN THE ALBORAN SEA

P. Marcos[1], S. García[1], E. Saldaña[1], M. Benito[1], R. Sagarminaga[2] and A.Cañadas[2]

[1]*ALBORAN, Universidad Autónoma de Madrid, Facultad de Ciencias, 28049 Cantoblanco, Madrid, Spain*
(E-mail: m_marcos@mundivia.es)
[2]*ALNITAK, Nalón 16, 28240 Hoyo de Manzanares, Madrid, Spain*

INTRODUCTION The Alboran Sea is considered a transition chamber between the Atlantic and the Mediterranean Sea, and it has been defined as the "hydrological motor of the Mediterranean" (Tintoré *et al.*, 1991). Due to the clash of Atlantic water, cooler and with lower salinity, and Mediterranean water, warmer and with higher salinity, important thermohaline fronts and upwellings are created, inducing primary production. Previous studies in other parts of the world have shown an important relationship between the distribution of common dolphins (*Delphinus delphis*) and some oceanographic parameters (Reilly *et al.*, 1994), whilst the striped dolphin (*Stenella coeruleoalba*) appears to have a random distribution with respect to the same parameters (Scott *et al.*, 1985). These relationships seem to be justified if we take into consideration the diet of each species (Cañadas *et al.* 1999). Based on bibliographic information that reports the existence of a direct relationship between ichthyoplankton masses and temperature (Rubin, 1992), we addressed the following aims:

- To determine whether the distribution of common dolphins in the Alboran Sea is influenced by sea surface temperature;
- To determine if the distribution of striped dolphins in the Alboran Sea is influenced by sea surface temperature.

MATERIALS AND METHODS Sampling has been carried out onboard Alnitak's research vessel Toftevaag. The research area covered from Cabo de Palos -36°38'N 0°33'W to Almerimar -36°20'N 2°55'W. Eight to ten hours per day were sailed during June, July, August, and September of 1997, 1998 and 1999, covering 30 to 50 nm per day, with an average speed of 5 knots. The transects were established from port to port, following a course as perpendicular as possible to the coastal line. During those transects, a towed array hydrophone was used for the acoustic detection of cetaceans. For the visual detection, we kept continuous watches both from the deck and the crow's nest. Once a group of animals was located, we undertook a careful approximation, recording the position of the cetaceans at the moment of contact.

For the determination of sea surface temperature (SST), we used images supplied by the AV sensor of the NOAA satellite. As reported by Rubín *et al.*, (1992) this is particularly useful for this application due to its spatial coverage (1.1 km), its high radiometric sensitivity, and the special characteristics of its thermal bands. These images were supplied by CREPAD (INTA). We studied daily images (selecting those that did not present a high cloud coverage) of the area corresponding to the days with dolphin sightings (a total of 51 satellite images). We considered presence (position of sightings) and absence (positions taken at every hour of sailing with no sightings at that moment) of cetaceans. We used MapInfo GIS software to geo-position both the data relating to presence (148 samples) and absence (211 samples) of cetaceans.

RESULTS **Common dolphin** We checked a total of 270 samples, corresponding to 59 sightings and 211 absences. We established three ranks of SST; rank 1: <20°C, rank 2: 20.5°C - 22°C, and rank 3: >22.5 (Figure 1). For the analysis, we used the Pearson χ^2 test. The null hypothesis H_0 was that the distribution of common dolphins was independent of the SST. The results showed that there was no significant relationship between the distribution of common dolphins with the SST (χ^2=2.697, df=2, p>0.05). So, there was no statistical evidence to reject H_0.

Striped dolphin For this species, we tested a total of 300 samples, corresponding to 89 sightings and 211 absences. We established the same three ranks of SST as for the common dolphin (Figure 2). The null hypothesis H_0 was that the distribution of striped dolphins was independent of the SST. The results showed that there was no significant relationship between the distribution of striped dolphins and the SST (χ^2 = 5.833, df = 2, p >0.05). So, there was no statistical evidence to reject H_0.

DISCUSSION AND CONCLUSIONS This study has been a preliminary approach to the analysis of the distribution of two species of small dolphins in relation with a first oceanographic parameter: the sea surface temperature in the north-eastern Alboran Sea.

Unlike other studies in other geographical regions that highlight the strong relationship between sea surface temperature, among other parameters, and the distribution of the common dolphin (Reilly *et al.*, 1994), in our case it seems that this species is not so influenced by this oceanographic parameter. We assume that there is possibly a bias in the analysis as only data from the summer season was considered, thus providing a very narrow range of temperatures. On the other hand, the results for the striped dolphin do agree with other reports (Reilly *et al.*, 1994). This species shows a distribution independent of the SST. However, this analysis was probably biased in the same way as for the common dolphins.

To solve the problem of the bias mentioned above, we will extend our sampling period to the four seasons of the year. We will also extend the research region to the whole Alboran Sea, including the Strait of Gibraltar and the contiguous Atlantic area. In this way, we expect to have a wider range of temperatures, increasing at the same time the sample size. In order to optimise the efficiency of the study of the satellite images, we will also include other oceanographic variables both from satellite imagery and from direct sampling at sea, such as salinity, concentration of chlorophyll, etc. Thus, more research will be conducted in order to obtain a deeper insight on the possible influence of certain oceanographic parameters on the distribution of cetacean species in the Alboran Sea.

ACKNOWLEDGEMENTS This work would have not been possible without the strong effort of the entire ALNITAK team, including the volunteers. We are very grateful also to Drs. Begoña Peco, Angel Baltanás and Antonio Pou from the Universidad Autónoma de Madrid for their help with the statistical and satellite imagery analysis. We would also specially like to thank the CREPAD (Centro de Recepción, Proceso, Archivo y Distribución de datos de la Tierra) of the INTA (Instituto Nacional de Técnicas Aeroespaciales) for providing the satellite images.

REFERENCES

Cañadas, A., Sagarminaga, R., Garcia, S. and Marcos, P. 1999. Cetacean distribution with respect to the physiography of the Alboran sea. Pp. 175-179. In: *European Research on Cetacean -13.* Proc. 13th Ann. Conf. ECS, Valencia, 5-8 April, 1999 (Eds. P. G. H. Evans, J. A. Raga and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Reilly, S. B. and Fiedler, P.C. 1994. Interannual variability of dolphin habitats in the eastern tropical Pacific. Research vessel surveys, 1986-1990. *Fishery Bulletin*, 92: 434-450.

Rubin, J.P., Gil, J., Ruiz, J., Cortés, M.D., Jiménez -Gómez, F., Parada, M. and Rodriguez, J. 1992. La distribución ictioplantónica y su relación con parámtros físicos, químicos y biológicos en el sector norte del mar de Alborán, en julio de 1991 (Resultados de la campaña "Ictio. Alborán 0791"). *Inf. Téc. Inst. Esp. Oceanogr*, 139: 1-49.

Scott, G. P., Kenney, R. D., Owen, R. E., Hyman, M. A. M., and Winn, H. E. 1985. Biological and physical oceanographic correlatives to cetaceans density distribution in the Great South Channel. *Oceanogr. Mar. Biol. Ann. Rev*, 6: 1-36.

Tintore, J., Gomis, P. and Alonso, S. 1991. Mesoscale dynamics and vertical motion in the Alboran sea. *Journal of Physical Oceanography*, Vol 21 (6)

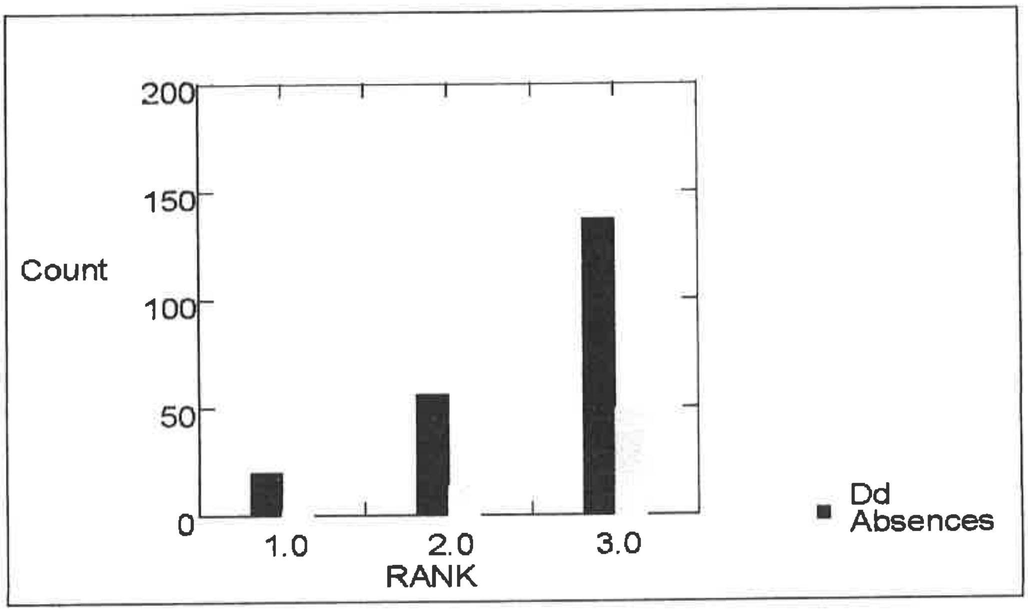


Fig. 1, Frequency of sightings of common dolphins and absences by rank

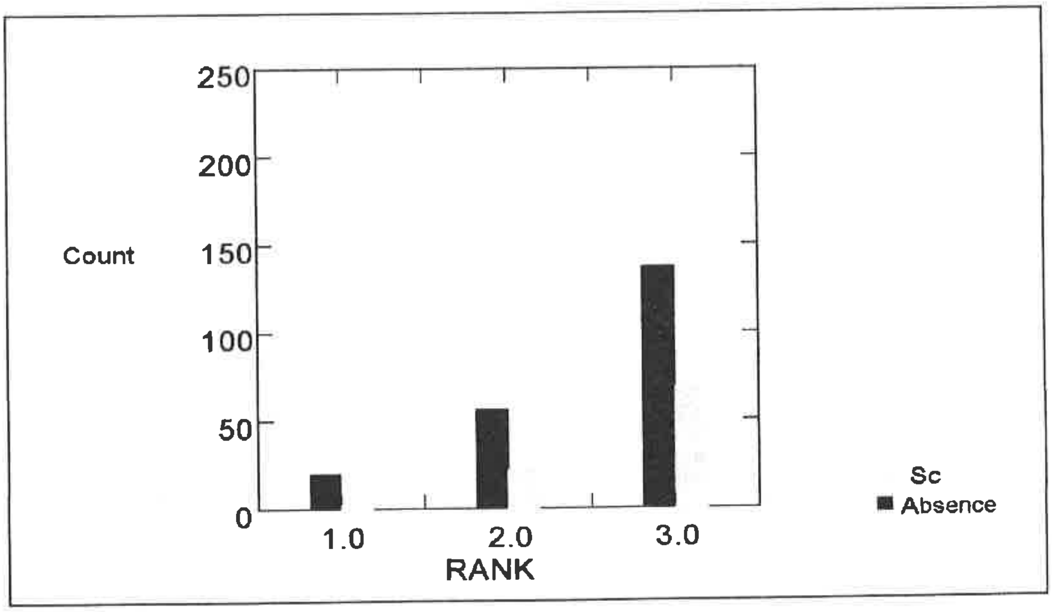


Fig. 2, Frequency of sightings of striped dolphins and absences by rank

GENETIC DIVERSITY IN A MEDITERRANEAN POPULATION OF THE BOTTLENOSE DOLPHIN IN THE CONTEXT OF WORLD-WIDE PHYLOGEOGRAPHY

A. Natoli and A. R. Hoelzel

Dept. of Biological Sciences, University of Durham, South Road, Durham DH1 3LE, UK

The assessment of phylogeography and the identification of different stocks at the intraspecific level are fundamental to the development of effective conservation and management programmes. This helps ensure the maintenance of natural levels and patterns of diversity. Bottlenose dolphins (*Tursiops* ssp.) are widely distributed around the world. However, the phylogenetic relationships among different populations are unclear, and taxonomic work is still needed to clarify nominal species. Behavioural, morphological and genetic studies have identified two distinct ecotypes: an inshore and an offshore form. However, since characteristics of the two types do not appear to be consistent across all populations, problems of stock identification are complex.

Our study focused on the phylogeographic structure of the Mediterranean bottlenose dolphin population in comparison with other Atlantic populations. Analyses of five microsatellite loci and sequences from the mtDNA control region were carried out on 46 samples coming from different Mediterranean areas and compared with data from the eastern North Atlantic, western North Atlantic offshore and inshore populations, and South African populations. Patterns of differentiation revealed in phylogenetic reconstructions and measures of population structure (such as Rst) indicate shared lineages between Mediterranean and 'offshore' populations from the western North Atlantic. These data suggest gene flow between the Mediterranean and North Atlantic populations, and indicate a high level of polymorphism among bottlenose dolphins within the Mediterranean.

DEFINING THE POPULATION STRUCTURE AND DISPERSAL PATTERNS OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN BRITISH AND IRISH WATERS

K. M. Parsons[1], L. R. Noble[1] and P. M. Thompson[2]

[1]*Zoology Department, University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK*

[2]*University of Aberdeen, Lighthouse Field Station, Cromarty, Ross-shire, IV11 8YJ, UK*

Recent proposals to identify Special Areas of Conservation (SAC) for bottlenose dolphins in European waters have highlighted a lack of fundamental knowledge of the population structure of this species around the British Isles and Ireland. Although comprehensive data exist from photo-identification studies, sightings schemes and strandings programmes, these techniques present contrasting pictures of the likely dispersal patterns for this species in British and Irish waters. This project uses molecular genetic analyses to determine patterns of population structure of bottlenose dolphins in these waters. We compared mtDNA sequences from skin samples collected from stranded individuals in four areas; the Moray Firth, NE Scotland; the west coast of Scotland; Cardigan Bay, West Wales; and SW Ireland. Eight mtDNA haplotypes were identified from a total of 29 individuals. These data demonstrate the utility of conserved mitochondrial DNA markers in addressing conservation issues through the analysis of archived tissues from stranded dolphins, and are used to propose the most likely population structure and dispersal patterns of bottlenose dolphins in British and Irish waters. Our results also highlight extremely low levels of genetic variability amongst animals from the relatively isolated Moray Firth, raising additional concerns for the future of this vulnerable population.

FIRST RESULTS OF NORMANDY BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) HOME RANGE: USE OF SIGHTING NETWORK

S. Pineau[1], K. Pyman[2], V. Mison-Jooste[1] and G. Mauger[1]

[1]*Groupe d'Etude des Cétacés du Cotentin (GECC), Centre d'Innovation Technologique,*
rue Louis Aragon, 50130 Octeville, France
[2] *Société Jersiaise, 7 Pier Road, Saint Helier, Jersey, JE2 4XW*

The bottlenose dolphin (*Tursiops truncatus*) community living in Normandy and Channel Islands waters is estimated to be over 100 individuals, divided into numerous groups. The study area covers about 3,500 km^2. Photo-ID, commonly used to study cetaceans, is an efficient technique but takes time and covers a limited area. Due to the vastness of the area and the mobility of the groups, we are unable to survey all year round. To compensate for this lack of data on population distribution, we have set up a sightings network. This method, based on communication with coastal stations and fishermen, gives us an indication of the changes in home range of the species during the year. In the field, this network helps finding the animals more quickly . At the same time, interest in the protection and study of this species is promoted among the marine community.

We obtained over 600 sightings covering >50% of the study area. The groups have generally been observed on the Cotentin Peninsular eastern coast and Mont-Saint-Michel Bay in summer, and all year round on the Cotentin western coast (Carteret to Jobourg). Most sightings have been noted around Chausey and Minquiers reefs, south and east of Jersey, and west of Cotentin. In this way, we can estimate the home-range potentially occupied by the groups, and hypothesise that at least part of the population is sedentary. However, the results depend on weather and tidal conditions, and on nautical activity, and information such as numbers of individuals, identification, and behaviour can be unreliable. Ideally, we should increase the photo-ID effort and start a local programme of observation by using transects. This would allow us to sample regularly part of the home-range, and to validate the sightings network results. To track movements, the use of satellite transmitters would be most informative.

MESO SCALE VARIABILITY IN THE DISTRIBUTION OF THE HARBOUR PORPOISE *PHOCOENA PHOCOENA* – COMPARISONS BETWEEN ESTUARINE AND OCEANIC ENVIRONMENTS

H. Skov[1], D. Bloch[2] and J. Durinck[1]

[1]*Ornis Consult Ltd, Vesterbrogade 140, DK-1620 København V, Denmark*
[2]*Museum of Natural History, FO-100 Tórshavn, Faroe Islands*

We report on a study on the spatial variability of the harbour porpoise *Phocoena phocoena* in relation to oceanographic gradients in two high density areas of the North Atlantic (The Faroese Shelf) and the eastern North Sea (German Bight). The physical environment of both areas is anisotropically structured, with strong cross-shelf gradients in bathymetry and hydrography. Cross-shelf density profiles of harbour porpoises were obtained during dedicated ship-based cruises: in late summer in the North Atlantic and during the non-breeding season in the North Sea. Comparisons between the density profiles obtained around the Faroes during 1987-89 and in 1997 indicate a preference for the whole area within the 200 m contour, which is influenced by the residual current, and an avoidance of the deeper shelf and oceanic waters surrounding the Faroese shelf. Although the drop in densities can be observed in all directions from the islands, most animals are found east, south, and west of the islands, where the shelf slopes gently towards the deeper waters. Over the shallow shelf of the German Bight, the density profiles of porpoises observed during the surveys in 1987-88, 1992-94 as well as in 1999 show a preference for the estuarine frontal system, which is controlled by the outflows of fresh water from the Elbe and other large rivers. The results indicate that meso-scale stability in the habitat preferences of harbour porpoises can be expected in a wide range of environments, and they suggest that fine-scale time series may provide data necessary for the definition of the integrity of the primary habitats of the species.

OPTIMISED SURVEY DESIGN: THE ZIGZAG SAMPLER IN LINE TRANSECT SURVEYS

S. Strindberg and S. T. Buckland

RUWPA, University of St Andrews, Maths Institute, North Haugh, St Andrews, Fife KY16 9SS, UK

Line or strip transect surveys are used to estimate abundance, monitor trends, and quantify changes in the spatial distribution of marine and other biological populations. These populations exist within geographical regions and a survey design determines the placement of the line or strip samplers within the survey region. Systematic continuous samplers are often used in marine or other surveys, and their systematic nature offers a number of advantages over non-systematic discrete samplers. A systematic sampler provides better spatial spread over the survey region. This improves the possibility of selecting a representative population sample. We show how less variability in spatial spread improves estimator precision. A continuous sampler also wastes no effort in between sampler segment movement and this improves efficiency. We focus on zigzag samplers. In the past, zigzag samplers with a constant angle or that pass through equally spaced points on opposite sides of the survey region boundary have been used. Such samplers only provide even coverage probability within a rectangular region and give variable coverage probability within most survey regions. The shape of the survey region determines the amount of variability, which is greater for the constant angle zigzag sampler. If the coverage probability is assumed to be even when it is not, standard estimation methods are biased. We present a zigzag design that under specified conditions provides approximately even coverage probability within convex survey regions. The problem of non-convex survey regions can be dealt with either by convex partitioning of the non-convex survey region, or by the application of a convex hull to almost convex partitions. This may lead to some discontinuity in the sampler. The survey designs are implemented by means of GIS software and are illustrated with examples from marine mammal surveys.

THE MID-ATLANTIC BOTTLENOSE DOLPHIN PHOTO-ID CATALOGUE: A COOPERATIVE APPROACH TO EXAMINE STOCK STRUCTURE

K. Urian[1], A. Hohn[1], L. Hansen[2], S. Baker[3], S. Barco[4], N. Bowles[5], M. Caldwell[6], C. Gubbins[7], F. Lapolla[8], R. Mallon-Day[9], K. Mazzarella[9], T. Murphy[10], R. Petricig[11], A. Read[12], K. Rittmaster[5], G. Rountree[13], W. Ryan[14], L. Sayigh[15], D. Scholfield[13], J. Tapia[15], V. Thayer[1], R. Young[17], and E. Zolman[18]

[1]*NMFS-SEFSC, Beaufort, NC*
[2]*NMFS-SEFSC, Charleston, , SC*
[3]*Chesapeake Bay Dolphin Project, North Potomac, MD*
[4]*Virginia Marine Science Museum, Virginia Beach, VA*
[5]*North Carolina Maritime Museum, Beaufort, NC*
[6]*Univ. Miami, Miami, FL*
[7]*Hilton Head Dolphin Study/Univ. Nevada, Reno*
[8] *The Dolphin Project, Savannah, GA*
[9]*Nags Head Dolphin Watch/Cape May Dolphin Survey, Berwyn, PA*
[10]*South Carolina Dept Natural Resources, Green Pond, SC*
[11]*313 North Locust St, Hagerstown, MD*
[12]*Duke Univ. Marine Lab, Beaufort, NC*
[13] *Christopher Newport University, Newport News, VA*
[14]*Marine Science Consortium Project, Wallops Island, VA*
[15]*Univ. North Carolina, Wilmington, NC*
[16]*Florida Inst. of Technology, Melbourne, FL*
[17]*Coastal Carolina Univ.y, Conway, SC*
[18]*NOS-CCEHBR, Charleston, SC USA*

In 1997, the US National Marine Fisheries Service established the Mid-Atlantic Bottlenose Dolphin Photo-ID Catalog (MABDC) as part of a programme to elucidate stock structure of bottlenose dolphins along the US Atlantic coast. The current stock assessment assumes that coastal bottlenose dolphins from New Jersey to Florida form a single stock, but recent work suggests that several stocks may exist. The objective of the MABDC is to provide information on stock structure by identifying movements and residency patterns of individual dolphins and to facilitate interpretation of genetic analyses of biopsy samples of known animals. The MABDC is a co-operative programme, comprising images and data contributed by researchers conducting photo-ID studies at 19 field sites from New Jersey to Florida. Images of 6,233 individual dolphins have been evaluated; 2,731 were selected, based on image quality and distinctiveness of dorsal fins. These images were digitised in the MABDC with associated field data. Systematic matching efforts are currently in progress; to date no matches have been made between the northern (New Jersey) and southern (Florida) field sites, indicating a lack of movement between these areas. As of November 1999, dolphins have been identified at more than one site; dolphins have been identified at four sites. Biopsy samples are available from 60 identifiable dolphins from Virginia, South Carolina, and Florida. The number of dolphins in the MABDC is greater than the minimum population estimate of 2,482 used in the current stock assessment, suggesting that the latter estimate is negatively biased. Patterns emerging from this analysis suggest a complex stock structure that will require innovative approaches to management and conservation.

PRELIMINARY RESULTS OF THE FIRST SURVEY OF CETACEANS IN THE NORTH-CENTRAL ALBORAN SEA

N. Villalba[1], A. Segura[2] and A. Cañadas[3]

[1,2]*ESPARTE, C/. Campillos 570. 29130 Alhaurín de la Torre, Málaga, Spain (E-mail:villalba@ari.es)*
[3]*ALNITA, Universidad Autónoma de Madrid, Nalón 16, E-28240 Hoyo de Manzanares, Madrid, Spain (E-mail: alnitak@cetaceos.com)*

Atlantic surface water flowing into the Mediterranean through the Strait of Gibraltar under the effect of atmospheric pressure and local winds enters the Alboran Sea describing a circular pattern known as the Western Alboran Gyre (Parrilla and Kinder, 1987; Gascard and Richez, 1985). This Gyre is a well studied phenomenon known to give rise to an important upwelling along its northern limit bordering the southern coast of Málaga, where primary and secondary production reach the highest levels of the Alboran Sea (Rubín *et al.*, 1982).

In September 1999, ESPARTE initiated the first survey on the populations of cetaceans in the north-central section of this basin. The aim was to study the importance of this productive region for cetaceans, and especially for the common and bottlenose dolphins, which are considered to be declining in the Mediterranean Sea. These species have recently been listed as "vulnerable" in the Mediterranean area in the National Endangered Species Act.

METHODOLOGY Surveys were conducted during September 1999 onboard the motor vessel *Mome*, at a constant speed of 6 knots. The journeys started every day at sunrise, sailing from the ports of Caleta de Vélez or Fuengirola (Málaga) and returning to port in the evening. Data were recorded on meteorological conditions, depth, time and position of sightings, social structure and behaviour of the sightings.

Some of the data were compared with that obtained by Alnitak in the north-eastern section of the Alboran Sea from 1995 to 1999. In this way, we had two independent surveys carried out in the same season of the year in two adjacent areas of the Alboran Sea: ESPARTE for the north-central section, and ALNITAK for the north-eastern section. In order to homogenise the data as much as possible for comparison, only data from the months of September, for depths of up to 1000 m, and from the area of Alboran were considered from the Alnitak database (which includes also the area of the Gulf of Vera, north from the Alboran Sea). (Fig. 3 and Fig. 4).

RESULTS AND DISCUSSION During 17 days of survey, 515 nautical miles (956 km) were sailed on effort, covering depths from the coast to 1000 m. Effort stopped with sea state 3 Douglas or more. Sixty-seven groups of cetaceans of five species were encountered. The most sighted species were the common dolphin (*Delphinus delphis*) with 55% of the sightings, and the striped dolphin (*Stenella coeruleoalba*) with 30%. Bottlenose dolphins (*Tursiops truncatus*), long-finned pilot whales (*Globicephala melas*) and fin whales (*Balaenoptera physalus*) were also encountered (Table 1).

A summary of depth at encounters and group sizes are shown in Tables 2 and 3 for the species sighted more than once. The fin whales were observed at a depth of 600 m, and two individuals comprised the sighting.

Common dolphins Although there were no statistically significant differences in the encounter rates of groups of common dolphins per depth range, there was a highly significant greater encounter rate in terms of the number of individuals (χ^2=2147.5, $p<0.000$) on the continental shelf (0-200 m depth). For the chi-square analysis, the data were corrected for the effort made in each depth range (Table 4). Similarly, the common dolphin showed a higher average group size in shallower waters than in areas off the continental shelf (x=199 in the range of 0-200 m, 48 in the range of 200-500 m and 34 in the range of 500-1000 m). At the same time, the average depth at which the dolphins were found feeding was 262.5 m, and the average group size was 185; whereas when the dolphins were observed in any other behavioural state (other than feeding), the average depth was 416.6 and the group size was 61 (Table 5). These results suggest that common dolphins gather in big groups in shallow waters, where they are seen more often feeding. In deeper waters, the dolphins split into smaller groups, maybe feeding on much smaller and dispersed prey schools or engaged in other kind of activities such as travelling or socialising.

In Figures 1 and 2 we have represented the sighting frequencies of common dolphins per depth obtained in the area surveyed by Alnitak (north-eastern section of the Alboran Sea) and that obtained by ESPARTE in the north-central area. These figures indicate that in both independent studies an apparent bi-modal distribution, with the maximum frequencies in shallower waters, and a secondary peak around 800-1000 m depth. This apparent bi-modal distribution has also been suggested by other authors for this species in other regions (Forcada *et al.*, 1990; López, *pers. comm.*). Future efforts will focus on this aspect to verify if this bi-modal distribution does exist, and whether it is due to a sex/age segregation of the population, to differing use of the habitat, or to the existence of two different populations: an inshore and an offshore population.

CONCLUSIONS

1. In the north-central Alboran Sea, common, striped, and bottlenose dolphins are very often encountered. The long-finned pilot whales are also observed, although less frequently.
2. The continental shelf of Malaga appears as an important feeding ground for the common dolphin in the month of September.
3. The common dolphin, both in central and eastern Alboran, appears to have a bi-modal distribution with respect to ocean depth. We found a main peak over the continental shelf, and a second peak around the depth of 800 metres.

REFERENCES

Forcada, J., Aguilar, A., Evans, P. G. H., and Perrin, W. 1990. *Distribution of common and striped dolphins in the temperate waters of the Eastern North Atlantic.* Pages 64-66. In: *European Research on Cetaceans - 4.* Proceedings of the Fourth annual conference of the European Cetacean Society. (Eds. P. G. H. Evans, A. Aguilar and C. Smeenk). Palma de Mallorca, Spain, 2-4 March 1990. European Cetacean Society, Cambridge, England. 140pp.

Gascard, J. C. and Richez, C. 1985. Water masses and circulation in the Western Alboran Sea and in the Strait of Gibraltar. *Programa Oceanog.* 15: 157-216.

Rubín, J. P., Gil, J., Ruiz, J., Cortés, M. D., Jiménez-Gómez, F., Parada, M. and Rodríguez, J., 1992. *La distribución ictioplanctónica y su relación con los parámetros físicos, químicos y biológicos en el sector norte del Mar de Alborán, en Julio de 1991 (Resultados de la campaña "Ictio.Alborán 0791"). Instituto Español de Oceanografía.* Informe técnico No. 139, Madrid. 49pp.

Parrilla, G. And Kinder, T.H., 1987. *Oceanografía física del Mar de Alborán. Boletín del Instituto Español de Oceanografía*, 4(1): 133-165.

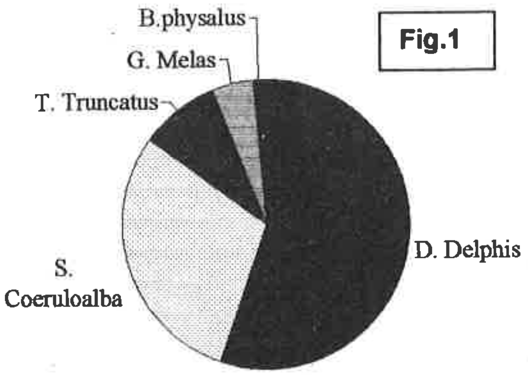


Fig.1

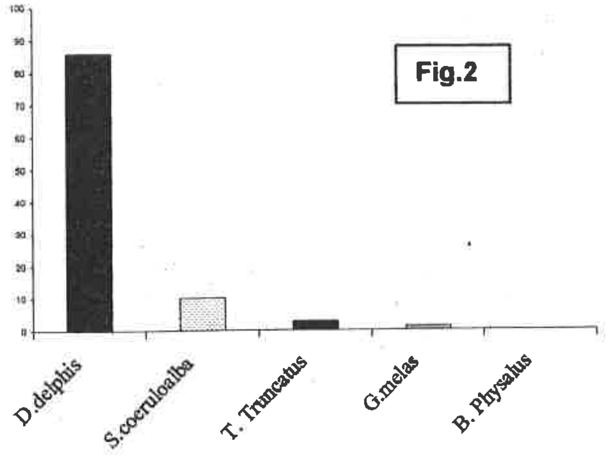


Fig.2

Table 1. Species sighted, by number of sightings and number of individuals

Species	Nº of sightings	% of sightings (Fig.1)	Nº of individuals	% of individuals (Fig.2)
Delphinus delphis	37	55.2	4016	85.9
Stenella coeruleoalba	20	29.9	476	10.2
Tursiops truncatus	6	9.0	133	2.8
Globicephala melas	3	4.5	50	1.1
Balaenoptera physalus	1	1.5	2	0.04
TOTAL	**67**	**100**	**4677**	**100**

Table 2. Average, standard deviation, minimum and maximum depth at encounters per species

	Depth at encounters			
	Delphinus delphis	***Stenella coeruleoalba***	***Tursiops truncatus***	***Globicephala melas***
average	369,7	495,5	281,7	610,0
sd	286,74	263,54	147,7	130,77
min	55	86	70	460
max	895	895	470	700
n	37	20	6	3

Table 3. Average, standard deviation, minimum and maximum group size at encounters per species

	Group size			
	Delphinus delphis	***Stenella coeruleoalba***	***Tursiops truncatus***	***Globicephala melas***
average	108,5	23,8	22,2	16,7
sd	233,58	32,85	15,43	7,64
min	1	3	8	10
max	1000	150	50	25
n	37	20	6	3

Table 4. Chi-square statistics for encounter rates. **a)** analysis for the number of individuals sighted on each depth range; **b)** analysis for the number of groups encountered on each depth range. L = nautical miles sailed on effort on each class; n = number of individuals or groups observed respectively; E = expected frequencies (calculated as N x (l/L), where N is the total number of groups or individuals observed, l is the effort made on each depth range, and L is the total effort); Enc. Rate = encounter rate (calculated as n/L in a) and (n/L)x100 in b)).

a) **N° of individuals sighted**

	Depth range	L	n	E	χ^2	Enc. rate
1	0-200	223,5	3188	1742,5	1199,1	14,26
2	200-500	178,9	382	1394,8	735,4	2,14
3	500-1000	112,7	446	878,7	213,1	3,96
	TOTAL	**515,1**	**4016**	**4016,0**	**2147,5**	**7,80**
	df=	2				
	P	<0.001				

b) **N° of groups encountered**

	Depth range	L	n	E	χ^2	Enc. rate
1	0-200	223,5	14	13,5	0,0	6,26
2	200-500	178,9	6	10,8	2,1	3,35
3	500-1000	112,7	11	6,8	2,6	9,76
	TOTAL	**515,1**	**31**	**31,0**	**4,8**	**6,02**
	df=	2				
	P	>0.05				

Table 5. Average, mode, standard deviation, minimum and maximum depth and group size at encounters per behavioural state for the common dolphin in the north-central Alboran Sea

	Feeding		**1.1 Other than feeding**	
	Depth	**Group size**	**Depth**	**Group size**
average	262.5	185	416.6	60.8
mode	80	100	150	30
sd	240.51	333.77	299.7	115.09
min	55	3	85	1
max	880	1000	895	500

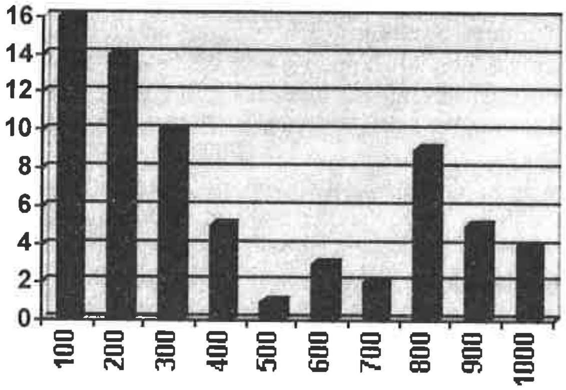


Figure 3. Frequency histogram of groups sighted per depth in the north-eastern section of the Alboran Sea (ALNITAK 1992-1999)

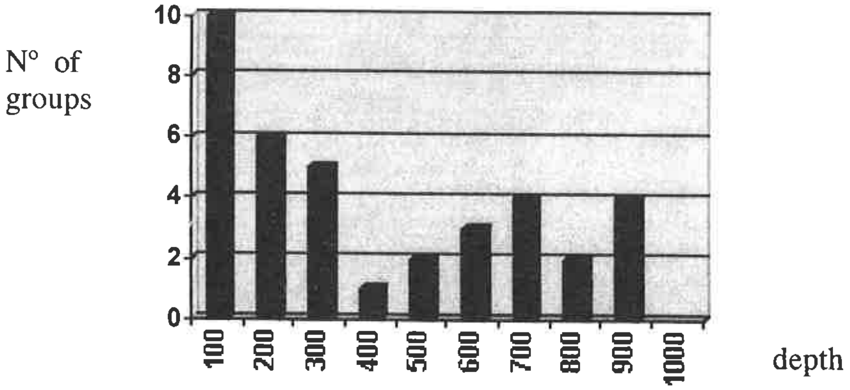


Figure 4. Frequency histogram of groups sighted per depth in the north-central section of the Alboran Sea (ESPARTE 1999)

OCCURRENCE OF PYGMY KILLER WHALE (*FERESA ATTENUATA*) IN THE BAY OF BISCAY

R, Williams[1], A. D. Williams[1], and T. Brereton[2]

[1]*Biscay Dolphin Research Programme, 6 Manor Way, Lee-on-Solent, Hampshire, PO13 9JH, UK*
[2]*Biscay Dolphin Research Programme, c/o 20 Mill Street, Puddletown, Dorchester, Dorset. DT2 8SH, UK*

A survey programme was established in 1995 by the Biscay Dolphin Research Programme to determine the distribution and relative abundance of cetaceans in the Bay of Biscay. The programme comprises monthly, year-round surveys along a fixed route (southern England to northern Spain) through the Bay of Biscay, using the P&O cruise-ferry, MV *Pride of Bilbao*. On each trip, effort-based cetacean surveillance work is carried out by a team of three experienced volunteer observers, using standard survey methods developed for platforms of opportunity by the Cetacean Group of the Mammal Society (now Sea Watch Foundation).

Between August 1995 and December 1998, there have been three confirmed and one probable sighting of pygmy killer whales in the Bay of Biscay. On three occasions, each group of animals was seen in very close association with other cetaceans, representing three species. Most notable was the behaviour of a pod of adult striped dolphins (*Stenella coeruleoalba*) seen to form a ring with all the juveniles at the core, and a small group of pygmy killer whales seen in very close proximity with a mother and calf fin whale (*Balaenoptera physalus*).

This species is normally considered to be tropical, associated with low latitudes. Three sightings occurred during the summer months, with one probable sighting in November 1999 involving hunting common dolphin (*Delphinus delphis*) and large tuna. While photographs have not yet been possible, the three confirmed sightings involved pygmy killer whales that approached to within a few tens of metres of the research vessel.

SURVEYS & ABUNDANCE

CETACEAN SIGHTING DISTRIBUTION IN WEST SCOTLAND IN 1999

S. Barry[1], E. C. M. Parsons[1], J. Mcnee[1], R. McClellan[1], P. G. H. Evans[2], and L. McClellan[3]

[1]*Hebridean Whale & Dolphin Trust, 28 Main Street, Tobermory, Isle of Mull, Argyll PA75 6NU, UK*
[2]*Sea Watch Foundation, 11 Jersey Road, Oxford OX4 4RT, UK*
[3]*Islay Natural History Trust, The Field Centre, Port Charlotte, Isle of Islay PA48 7TX, UK*

Although the west of Scotland is an important habitat for cetaceans, there have been no year-round surveys to assess patterns of cetacean distribution throughout the year. To improve our knowledge of cetacean distribution in West Scotland, a major sightings reporting initiative has solicited year-round sightings of cetaceans from marine-users, local naturalists, and marine biologists in West Scotland.

In 1999, eleven species of cetacean were sighted in West Scotland. In order of abundance these were: harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), killer whale (*Orcinus orca*), Risso's dolphin (*Grampus griseus*), white-beaked dolphin (*Lagenorhyncus albirostris*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), northern bottlenose whale (*Hyperoodon ampullatus*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), and a sperm whale (*Physeter macrocephalus*).

The data collected in 1999 presented some new information on cetacean distribution in West Scotland: (1) Regular sightings of bottlenose dolphins were reported around the coasts of Islay and Mull, suggesting possible resident groups of this species in addition to the known resident group off the Isle of Barra; (2) Minke whales are believed to migrate out of inshore waters in the autumn. Sightings of smaller, possibly juvenile, animals were frequently sighted until the end of October suggesting that young minkes may stay in West Scotland for at least part of the winter; (3) White-beaked dolphins are normally one of the most common species in Northwest Scotland; however, in 1999, sightings of this species have substantially declined; and (4) Common dolphins are normally observed during June-July in southwestern Scottish waters. However, in 1999, sightings were received as far north as the Isle of Lewis and as late as October.

AN OVERVIEW OF CETACEAN SIGHTING DATA FROM THE NORTHERN ADRIATIC SEA: 1987-1999

G. Bearzi[1], E. Politi[1], C. M. Fortuna[1], L. Mel[1] and G. Notarbartolo di Sciara[1,2]

[1]*Tethys Research Institute, Viale G.B. Gadio 2, 20121 Milano, Italy (E-mail: bearzi@tin.it)*
[2]*ICRAM, Via di Casalotti 300, 00166 Roma, Italy*

INTRODUCTION During the last decades, the northern Adriatic Sea has suffered from persistent eutrophication phenomena, anoxic die-offs, deterioration of water quality, dramatic shifts of biotic communities, and contamination of the food chain by noxious man-made compounds (Chiaudani and Premazzi, 1995; Corsolini *et al.*, 1995; Cingolani *et al.*, 1996; Conti, 1996; UNEP, 1996). Trends in commercial fish stocks in the last decades are indicative of the shifts in prey type and density that have affected the northern Adriatic Sea, largely resulting from a combination of large-scale environmental changes that were both natural and man-induced (Bombace, 1990; Marasovic *et al.*, 1995; Regner, 1996; Solic *et al.*, 1997). Although a long-term perspective on environmental changes is largely prevented by the lack of historical data, high contaminant levels were found in stranded dolphins (*e.g.*, Corsolini *et al.*, 1995; Marsili 1995), collapses of potential dolphin key prey species were recorded (*e.g.*, in 1987: Cingolani *et al.*, 1996; Piccinetti and Piccinetti Manfrin, 1994), and overfishing has been probably been an issue (Jardas *et al.*, 1985; Farrugio and Papaconstantinou, 1998).

While habitat degradation and human pressure increase, good data on cetaceans remain scarce, and nothing is known about population numbers and dynamics. This overview of cetacean sightings from the "Gulf of Venice" (Fig. 1*a*) and from the "Kvarneric" (Fig. 1*b*) is aimed at encouraging more intensive and focused research in this area.

MATERIALS AND METHODS Cetacean sighting data were opportunistically collected by the Tethys Research Institute between 1987-99. Sightings were reported from platforms ranging from large speedboats to inflatable craft and sailing boats. The survey effort was particularly intense in the Kvarneric (Fig. 1*a*), where a long-term study on the local bottlenose dolphin community has been consistently conducted since 1990 (Bearzi *et al.*, 1997, 1999).

A "sighting" was defined as an uninterrupted observation of a cetacean group. Only the initial position was considered, disregarding sighting duration or group-size changes occurring during the sighting, resulting in plots of one-spot-per-sighting as in Fig. 1.

The dataset included 613 "confirmed" sightings (*i.e.*, reports from trained observers and documented sightings by untrained observers), and 58 "undocumented" sightings (*i.e.*, reports from untrained observers without photographic or video documentation). "Confirmed" and "undocumented" sightings were distributed as shown in Table 1.

RESULTS The distribution of the sightings (Fig. 1) largely reflects the opportunistic survey effort. In particular, the predominance of sightings in the Kvarneric, as compared to other areas, likely reflects the much greater observation effort which occurred there.

Of 613 "confirmed" sightings, 607 (99%) were of bottlenose dolphins (*Tursiops truncatus*), the rest comprising one short-beaked common dolphin (*Delphinus delphis*), a lone striped dolphin (*Stenella coeruleoalba*), two fin whales (*Balaenoptera physalus*), and two mixed bottlenose dolphin / short-beaked common dolphin groups (Bearzi, 1996). Two rather unusual – yet well documented - fin whale sightings were reported from the Velebit Channel (15 August 1997; 44°21'10 N 15°16'30 E; one individual) and from the Novigrad Sea (13 August 1998; 44°12'60 N 15°32'20 E; two individuals).

Most (99%) of the sightings made in the Kvarneric study area were "confirmed", while 58% of the sighting reports in the Gulf of Venice were "undocumented". Of these 53 "undocumented" sightings made in the Gulf of Venice, 52 related to dolphins (reports included 42 "bottlenose dolphins", 4 "striped dolphins", and 6 unidentified Delphinidae), and one to a large cetacean (reported as a "12m-long fin whale").

CONCLUSIONS The bottlenose dolphin is the only species that was consistently sighted in the area across a 13-year period. Other cetacean species seemed to be represented largely by stray individuals, or species with a sparse distribution. A bottlenose dolphin "hot spot" was found in the Kvarneric, where, however, average dolphin density was very low compared to other sites within the species' range (Bearzi *et al.* 1997; Fortuna *et al.*, this volume).

As the bottlenose dolphin is the most common cetacean species over the Mediterranean Sea continental shelf (Notarbartolo di Sciara and Demma, 1994), it is no surprise to record it as the prevalent species in the shallow offshore waters of the Gulf of Venice, where water depth does not exceed 40 m.

However, both short-beaked common dolphins and bottlenose dolphins were reportedly common in the area until a few decades ago (Bearzi and Notarbartolo di Sciara, 1995). Yet, unknown reasons prompted a dramatic decline of the short-beaked common dolphin, and its almost complete disappearance from the northern Adriatic Sea, where the bottlenose dolphin remains the commonest cetacean species (Notarbartolo di Sciara and Bearzi, 1992; Stanzani *et al.*, 1997; Gomercic *et al.*, 1998; Francese *et al.*, 1999).

Anecdotal evidence collected throughout the course of this study suggests that in the northern Adriatic Sea bottlenose dolphins were more frequent in the 1960s than today, as in most parts of the Mediterranean Sea, where wide gaps in the species' distribution are clearly developing (UNEP/IUCN, 1994; Notarbartolo di Sciara and Gordon, 1997; Aguilar *et al.*, 1999). While an overall reduction of food resources in the last decades and dramatic fluctuations of key prey may be at issue, contamination by xenobiotics such as PCBs (*e.g.*, Corsolini *et al.*, 1995; Marsili, 1995) may represent a good candidate to explain the cetacean population drops that have seemingly affected the degraded northern Adriatic Sea.

Competition with striped dolphins – listed among the possible causes of the decline of the short-beaked common dolphin in the Mediterranean Sea (Viale, 1985; Perrin, 1988; Cagnolaro and Notarbartolo di Sciara, 1992; Notarbartolo di Sciara and Demma, 1994; Gannier, 1995; Sagarminaga and Cañadas, 1995) - is an unlikely cause of common dolphin decline in the northern Adriatic Sea, since today striped dolphin numbers appear to be low in this area (Stanzani *et al.*, 1997; Francese *et al.*, 1999), as they probably were in historical times (Notarbartolo di Sciara and Bearzi, 1992). A recent slight increase in striped dolphin sighting and stranding reports in the northern Adriatic Sea may either be a function of an increased interest in cetacean studies, or an indication of a progressive northward extension of the species' range (Bearzi *et al.*, 1998); either way, this is unlikely to account for the earlier disappearance of the short-beaked common dolphin.

ACKNOWLEDGEMENTS We are grateful to the Venice Customs (*Guardia di Finanza*) and to its officers for their collaboration and logistic support, to Thetis SpA for "welcoming" a Tethys base in Venice, and to the many friends who have contributed to data collection.

REFERENCES

Aguilar, A., Forcada, J., Arderiu, A., Gazo, M. and Silvani, L. 1999. Status and conservation threats of small cetaceans in Spanish waters. P. 75. In: *European Research on Cetaceans* – 13. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999 (Eds. P. G. H. Evans, J. A. Raga and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Bearzi, G. 1996. A "remnant" common dolphin observed in association with bottlenose dolphins in the Kvarneric (northern Adriatic Sea). P. 204. In: *European Research on Cetaceans – 10.* Proc. 10th Ann. Conf. ECS, Lisbon, Portugal, 11-13 Mar, 1996 (Ed. P. G. H. Evans). European Cetacean Society, Kiel, Germany. 334pp.

Bearzi, G., Fortuna, C. M., and Notarbartolo di Sciara, G. 1998. Unusual sighting of a striped dolphin (*Stenella coeruleoalba*) in the Kvarneric, northern Adriatic Sea. *Natura Croatica*, 7(3): 169-278.

Bearzi, G. and Notarbartolo di Sciara, G. 1995. A comparison of the present occurrence of bottlenose dolphins, *Tursiops truncatus*, and common dolphins, *Delphinus delphis*, in the Kvarneric (Northern Adriatic Sea). *Annales (Annals for Istrian and Mediterranean Studies)*, 7: 61-68.

Bearzi, G., Notarbartolo di Sciara, G., and Politi, E. 1997. Social ecology of bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Marine Mammal Science*, 13(4): 650-668.

Bearzi, G., Politi, E., and Notarbartolo di Sciara, G. 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Marine Mammal Science*, 15(4): 1065-1097.

Bombace, G. 1990. Fisheries of the Adriatic Sea. Pp. 57-67. In: *Marine eutrophication and population dynamics*. (Eds: G. Colombo, I. Ferrari, V. U. Ceccherelli and R. Rossi). Olsen & Olsen, Fredensborg, Denmark.

Cagnolaro, L. and Notarbartolo di Sciara, G. 1992. Attività di ricerca sui cetacei e loro status di conservazione in Italia. *Boll. Mus. Ist. biol. Univ. Genova*, 56-57: 53-85.

Chiaudani G. and Premazzi, G. 1995. Recent technical and scientific initiatives for the management of the Adriatic Sea problems. *Water Science and Technology*, 32: 357-363.

Cingolani, N., Giannetti, G. and Arneri, E. 1996. Anchovy fisheries in the Adriatic Sea. *Scientia Marina*, 60: 269-277.

Conti, M. E. 1996. The pollution of the Adriatic Sea: Scientific knowledge and policy actions. *International Journal of Environment and Pollution*, 6: 113-130.

Corsolini, S., Focardi, S., Kannan, K., Tanabe, S., Borrell, A., and Tatsukawa, R. 1995. Congener profile and toxicity assessment of polychlorinated biphenyls in dolphins, sharks and tuna collected from Italian coastal waters. *Marine Environmental Research*, 40(1): 33-53.

Farrugio, H. and Papaconstantinou, C. 1998. The status of fisheries resources in the Mediterranean. Pp. 13-24. In: *Gaps in Mediterranean fishery science*. CIESM Workshop Series 5. Dubrovnik, Croatia. 3 June 1998.

Francese, M., Zucca, P., Picciulin, M., Zuppa, F., and Spoto, M. 1999. Cetaceans living in the North Adriatic Sea (Gulf of Trieste - Grado lagoon): Intervention protocol for healthy and distressed animals. Pp. 410-415. In: *European Research on Cetaceans – 13*. Proc. 13th Ann. Conf. ECS, Valencia, Spain, 5-8 Apr, 1999 (Eds. P. G. H. Evans, J. A. Raga and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Gannier, A. 1995. *Les Cétacés de Mediterranée nord-occidentale: estimation de leur abondance et mise en relation de la variation saisonnière de leur distribution avec l'écologie du milieu.* These de Doctorat, Ecole Pratique des Hautes, Sciences de la Vie et de la Terre, Montpellier, France. 438pp.

Gomercic, H., Huber, D., Gomercic, A., and Gomercic, T. 1998. Geographical and historical distribution of cetaceans in Croatian part of the Adriatic Sea. *Rapp. Comm. Int. Mer Médit.*, 35: 440-441.

Jardas, I. 1985. Trammel bottom set catches along the eastern Adriatic coast (1971-1984). *FAO Fisheries Report*, 345: 189-199.

Marasovic, I., Grbec, B., and Morovic, M. 1995. Long-term production changes in the Adriatic. *Netherlands Journal of Sea Research*, 34: 267-273.

Marsili, L. 1995. *Indagini ecotossicologiche e morfometriche su alcune specie di Cetacei del Mediterraneo*. Ph. D. dissertation in Environmental Sciences. University of Siena. 237pp.

Notarbartolo di Sciara, G. and Bearzi, G. 1992. Cetaceans in the Northern Adriatic Sea: Past, present, and future. *Rapp. Comm. Int. Mer Médit.*, 33: 303.

Notarbartolo di Sciara, G. and Demma, M. 1994. *Guida ai mammiferi marini del Mediterraneo*. Franco Muzzio Editore, Padova. 262 pp.

Notarbartolo di Sciara G. and Gordon, J. 1997. Bioacoustics: A tool for the conservation of cetaceans in the Mediterranean Sea. *Marine Freshwater Behaviour and Physiology*, 30: 125-146.

Perrin, W. F. 1988. *Dolphins, porpoises, and whales - An action plan for the conservation of biological diversity: 1988-1992*. International Union for the Conservation of Natural Resources, Gland, Switzerland. 30pp.

Piccinetti, C. and Piccinetti Manfrin, G. 1994. Considerazioni sullo stato di sfruttamento delle risorse demersali (Alto e Medio Adriatico). *Biol. Mar. Medit.*, 1(2): 77-87.

Regner, S. 1996. Effects of environmental changes on early stages and reproduction of anchovy in the Adriatic Sea. *Scientia Marina*, 60: 167-177.

Sagarminaga, R. and Cañadas, A. 1995. Studying a possible competition for ecological niche between the common dolphin, *Delphinus delphis*, and striped dolphin, *Stenella coeruleoalba*, along the southeastern coast of Spain. Pp.

114-117. In: *European Research on Cetaceans – 9*. Proc. 9th Ann. Conf. ECS, Lugano, Switzerland, 9-11 Feb, 1995 (Eds. P. G. H. Evans and H. Nice). European Cetacean Society, Kiel, Germany. 302pp.

Solic, M., Krstulovic, N., Marasovic, I., Baranovic, A., Pucher Petkovic, T., and Vucetic, T. 1997. Analysis of time series of planktonic communities in the Adriatic Sea: Distinguishing between natural and man-induced changes. *Oceanologica Acta*, 20: 131-143.

Stanzani, L. A., Bonomi, L., and Bortolotto, A. 1997. "Onde del mare": An update on the Italian network for cetacean and turtle sightings. Pp. 87-89. In: *European Research on Cetaceans – 11*. Proc. 11th Ann. Conf. ECS, Stralsund, Germany, 10-12 Mar, 1997 (Eds. P. G. H. Evans, E. C. M. Parsons and S. L. Clark). European Cetacean Society, Kiel, Germany. 314pp.

UNEP. 1996. *State of the marine and coastal environment in the Mediterranean region*. Mediterranean Action Plan. Technical Reports Series No. 100, UNEP, Athens, Greece. 142pp.

UNEP/IUCN. 1994. *Technical report on the state of cetaceans in the Mediterranean*. Mediterranean Action Plan Technical Reports Series No. 82, UNEP, Regional Activity Centre for Specially Protected Areas, Tunis. 37pp.

Viale, D. 1985. Cetaceans in the northwestern Mediterranean: their place in the ecosystem. *Oceanogr. Mar. Biol. Ann. Rev.*, 23: 491-571.

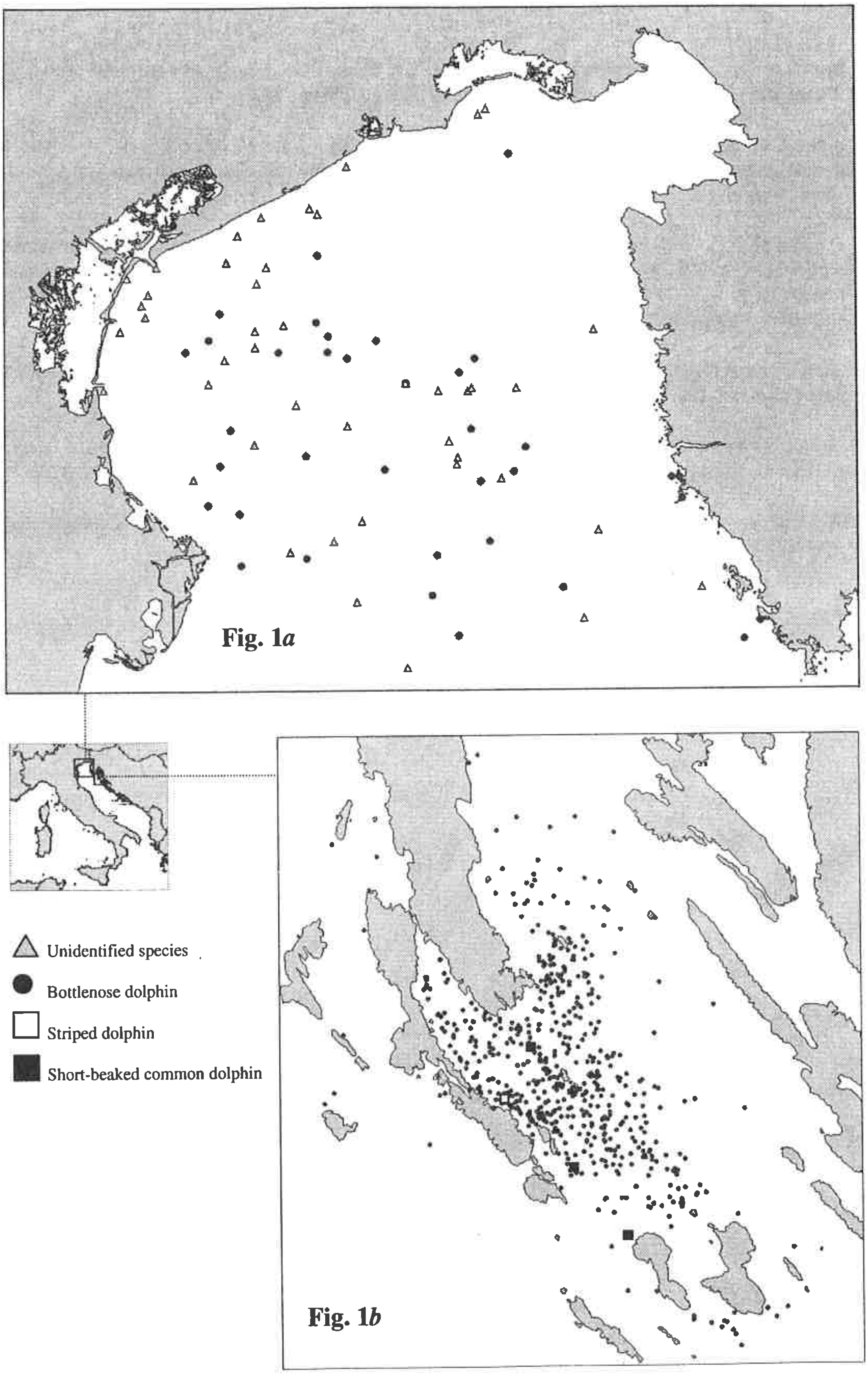


Fig. 1. Cetacean sightings in the northern Adriatic Sea: 1*a*) Gulf of Venice; 1*b*) Kvarneric.

Table 1. Number of "confirmed" and "undocumented" sightings across the study period

year	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**TOT**
confirmed	2	24	--	39	46	92	76	80	62	39	68	50	35	613
undocumented	--	1	--	--	--	5	10	15	5	3	3	13	3	58
	2	25	0	39	46	97	86	95	67	42	71	63	38	**671**

A SURVEY ON CETACEAN IN THE NORTH LIGURIAN SEA – SUMMER '99

B. Bonsignori[1] and R. Trucchi[2]

WWF – Sezione Liguria Vico Casana 9/3 16123 Genova Italy
(E-mails: bbfc@libero.it (BB); r.trucchi@mclink.it (RT))

INTRODUCTION The WWF Italia - Sezione Liguria - together with "Cooperativa Battellieri del Porto di Genova", during summer 1999 organised a cetacean watching campaign. This campaign is part of a research project that involves different activities focused on conservation and protection of the "Ligurian Sea Cetacean Sanctuary", recently created (25 November, 1999) after an international agreement between Italy, France and the Monaco Principality. The first aim of the campaign is to let people know about the presence of Cetaceans in the Mediterranean Sea, drawing attention to the concern for their protection, and the importance of the "ten golden rules" not to disturb them. The second aim is to control presence and distribution of different species along the coast. Finally Cetacean interactions and reactions to human activities are studied to guarantee a correct regulation in the Sanctuary area.

MATERIALS AND METHODS Weekly trips started on 21 June and ended on 13 September. Those one-day long trips took place only under proper sighting conditions (*below 4 Beaufort*), heading westward from Genoa harbour. The motorboat used (" La Superba" – length 29m. – medium speed: 10 knots.) was equipped with two researchers, and four sailors trained in cetacean watching, and carried about 1600 tourists in total. At the start of each journey, we gave practical information (Es. clock system, advice on recognising animals in the field), and a code of behaviour during sightings. Using a visual aid we provide general information about cetacean evolution, ecology and biology, and how to locate and recognise the species who live in the Mediterranean Sea. During the encounters, we identify the species and invite people to be silent and listen to the blow of cetaceans, and help people in establishing an emotional contact. On the return trip, we discuss points raised during the journey, and suggest arguments to ponder about conservation.

Watching took place mainly on naked eye or with binoculars (Tasco 7x50). When seen, the cetaceans have been approached, with close contacts taking place only with engine stopped. During each contact, a form in completed with date, time, position, weather condition, sea state, species, number of individuals, behaviour, other animals' presence, and any necessary notes.

RESULTS Results of this campaign bring to light unusual behaviours and an unexpected distribution of coastal species. A total of 15 trips, with the survey effort amounting to about 90 hrs, resulted in 23 sightings with four different species identified (Figure 1).

Striped dolphins (*Stenella coeruleoalba*): 13 encounters. Groups of striped dolphins were distributed over the entire study area, from the coast to 24 miles. During four sightings, calves were present. As expected, they resulted in the most approachable species. Bow riding, leaping or breaching were exhibited.

Risso's dolphins (*Grampus griseus*): Risso's dolphins were encountered five times, always close to the coast corresponding to submarine canyons where the sea reaches 700 metres depth. Most of the time, groups were composed mainly of young individuals with a homogeneous greyish colour and only few scars (easily approachable). An unusual "head-standing" behaviour was observed three times and this occurred with a large number of animals. During this behaviour, the animal stands upside down with its tail out of the water for a few seconds.

Bottlenose dolphins (*Tursiops truncatus*): surprisingly rare, being encountered only once near the coast. During this encounter, we noticed some calves and that the dolphins were very confident.

Curvier's beaked whale (*Ziphius cavirostris*): Three encounters. In contrast to the literature, but in agreement with recent reports, the species was relatively often seen, and curious; in fact, they came very frequently near our boat, also after long dives.

CONCLUSIONS Whale-watching is a worldwide activity accepted as a "sustainable use" of cetacean populations, compatible with *Agenda 21* of the 1992 Rio de Janeiro UN Conference on Environment and

Development. (Hoyt, 1997). Whale-watching provides the opportunity for people across all ages and cultures to become familiar with environmental issues, and to get involved in conservation efforts. At least it gives the opportunity to study this animal and to collect useful data. The results of this campaign showed unusual behaviours, unusual distributions, and other interesting facts of these species' lives.

ACKNOWLEDGEMENTS We wish to thank Simone and "La Superba" crew for their enthusiasm, and Carla for her valuable advice.

REFERENCES

Hoyt, E. 1997. *Educational values of whale watching* IFAW. 25pp.

Heyning, J. E. 1989 Cuvier's beaked whale Ziphius cavirostris G. Cuvier, 1823. In: *Handbook of marine mammals. Vol 4 River dolphins and the larger toothed whales* (Eds. S. Ridgway and R.J. Harrison). Academic Press, London and New York.

Leatherwood, S., Reeves, R. R. and Foster, L.. 1983 *The Sierra Club handbook of whales and dolphins,* Sierra Club Books, San Francisco. 302pp.

Notarbartolo di Sciara, G. 1997. *Guida ai Mammiferi marini del Mediterraneo* Franco Muzzio. 264pp.

Kruse, S. L. 1989. *Aspects of the biology, ecology, and behavior of Risso's dolphins (Grampus griseus) off the California coast*. MSc thesis. California University, Santa Cruz. 120pp

Trucchi, R., Ottonello, C., and Tribocco F. 1999. The first experience of a daily whale-watching activity to collect data and to inform people about cetacean biology and ecology carried out by WWF-Liguria In *European Research on Cetaceans – 13*. Proc. 13th Ann. Conf. ECS, Valencia , Spain 5-8 Apr, 1999. (Eds. P. G. H. Evans, J. A. Raga, and J. Cruz). European Cetacean Society, Valencia, Spain. 484pp.

Viale, D. 1985. Cetaceans in the northwestern Mediterranean; their place in the ecosystem. *Oceanogr. Mar. Biol. Ann. Rev.* 23: 491-571

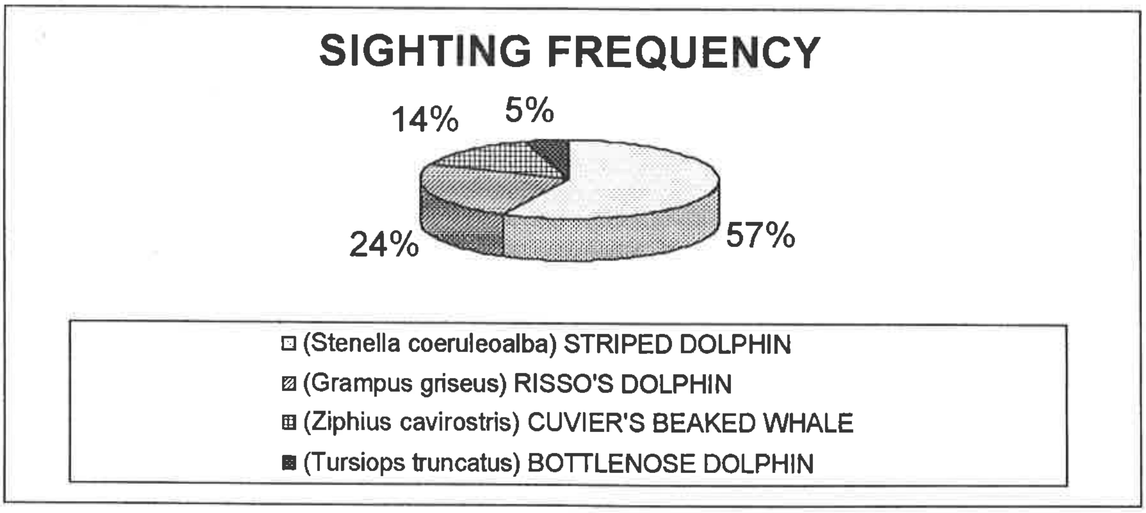


Fig. 1. Proportion of Cetacean Species seen during Surveys

CETACEAN VISUAL SIGHTINGS IN SIRENA 99 - A SOUND, OCEANOGRAPHY AND LIVING MARINE RESOURCES PROJECT RESEARCH CRUISE

A. D'Amico [1], M. Podestà [2], N. Portunato [1] and V. Teloni [1,3]

[1]*SACLANT Undersea Research Centre, via S. Bartolomeo 400, 19100 La Spezia, Italy*
[2]*Museo di Storia Naturale di Milano, corso Venezia 55, 20121 Milano, Italy*
[3]*CIBRA Centro Interdisciplinare di Bioacustica e Ricerche Ambientali, Università di Pavia, viale Taramelli 24, 27100 Pavia, Italy*

INTRODUCTION SACLANTCEN has over 40 years of experience in underwater acoustic and oceanographic research and modelling. The Centre is in a unique position to monitor the marine environment through the use of Dual Use Technology, i.e., technology developed originally for the military but increasingly being pressed into civilian service since the end of the cold war. The SACLANTCEN program entitled Sound, Oceanography and Living Marine Resources (SOLMAR) is undertaking research and development of reliable methods for detection, localisation and tracking of underwater biological sounds to support the formulation of an Acoustic Risk Mitigation Policy. Sirena 99 was the first sea trial of a multi-year at-sea effort to use existing technologies to monitor a region of high cetacean density, collect the associated environmental information and determine the correlation of these parameters (Forcada *et al.*, 1995; Gannier, 1998). This trial, Sirena 99, was successfully conducted in the Ligurian Corsican basin, which has recently become the first International Marine Sanctuary in the Mediterranean Sea (Orsini *et al.*, 1992). An integrated approach to the understanding of cetacean ecology has been presented by Croll *et al.* (1998), in which the authors examined the temporal and spatial relationship of marine birds and mammals to the structure and variability of their environments in a region offshore of California. Sirena 99 expanded on this approach by using dual-use acoustic technologies developed by the Centre, and satellite remote sensing data.

MATERIALS AND METHODS During the period 1-13 August, the NATO research vessel R/V Alliance and the Italian Navy hydrographic vessel N/I Amm.o Magnaghi navigated the tracks shown in Figures 1 and 2. A total of 1,337 nautical miles were covered by the R/V Alliance; 2,057 nautical miles were covered by the N/I Amm.o Magnaghi. The cetacean visual survey on board of the R/V Alliance was conducted by trained observers that were stationed on the upper bridge, which was 14.8 metres height of eye above the sea surface and allowed for unobstructed vision through 180 degrees forward. Two observers worked two hours on watch on the flying bridge; observer pairings were also arranged on a rotational basis throughout the period. The survey area was scanned continuously by the observers using a combination of naked eye and binoculars. A third person (the recorder) was situated on the bridge, to collect environmental and vessel log data, and to fill in the sighting log with the data transmitted from the observers on the upper bridge. Environmental and vessel data were collected every half hour (and in the case of a sighting) and included date, time, latitude, longitude, sea state, swell height, wind speed and direction, visibility, precipitation and the possible sighting reference. The sighting log included date and time, name of the primary observer, latitude and longitude, species and degree of certainty, number of individuals (max, min, best estimate), number of adults, juveniles and calves, description of observed behaviour (slow swim, stationary/milling, tail slap, fast swim, leap/breach, bow ride, blow only, lobtailing, other), bearing to animal, direction of travel when first sighted, animal movement relative to ship.

The daylight survey started at 06:00 hrs and ceased at 21:00 hrs, with a total of 141 hours of observations during the cruise. The night survey was conducted using ITT Mariner 260 NVD, resulting in 11 hours worked on observation. Observers worked for one hour with a one-hour stand-down. The Navy's Magnaghi's primary objective was to conduct oceanographic and lower trophic level measurements, and to acquire some limited acoustic measurements. This restricted the space available for dedicated cetacean observers so the visual survey on board of the N/I Amm.o Magnaghi was conducted by crew members on a rotational basis; these had been trained before the cruise and had species identification information available on the bridge. Data collection consisted of a sighting log with basic information on the sighted cetacean and the environmental data at the time of the sighting. The daylight survey resulted in 168 hours of observations, with no night-time operations at 37 stations spaced approximately 12 nm apart along this track. The cruise planning included a two-hour transect (as shown on the map) towing a body for plankton estimation followed by a shorter period on a station during which CTD, fluorometer, TAPs (Tracor Acoustic Profiler) and net casts were carried out to determine temperature, salinity, phytoplankton (chlorophyll), small zooplankton, large zooplankton, small nekton plankton, and small nekton distribution. All the on-board activities (buoy launching, cetacean sighting, tape recording, weather conditions, etc) were noted in a paper log. Remotely sensed data was also used to help understand the mesoscale physical and biological oceanographic patterns that exist in the Ligurian Sea during the summer.

RESULTS Figure 3 shows a 3-layer plot from a geographic information system. The lower layer shows the bathymetry in the Sirena '99 trial area with the deepest portion of the basin at water depths below 2000 m. This central portion of the basin is the region in which the upwelling occurs. This can be seen in the middle figure, where the light colour indicates the depth of the top of the deep isothermal, nutrient rich layer which shallows to about 30 m as compared to 90 m at the basin's edges. The dots on this figure indicate the geographic position of the sightings made by both vessels during the cruise. The upper figure shows peak chlorophyll levels measured at each station. The highest levels of chlorophyll were found at the centre of the basin. The depth of the chlorophyll maximum was found at the depth of the top of the deep isothermal layer shown in the central figure. The area of high cetacean density observed in Sirena '99 is consistent with the areas of high chlorophyll productivity (Data provided by D. McGehee, Marconi, Inc., San Diego, CA and D. A. Demer, Southwest Fisheries Science Center, San Diego, CA). It has been demonstrated that regions of enhanced primary phytoplankton productivity support increased density of zooplankton and small fish (Boucher *et al.*, 1987; Zakardjian *et al.*, 1998; D. McGhee, *pers. comm.*).

A total of 146 sightings were made from the R/V Alliance, including the undetermined cetaceans. Five different species were recognised, with a total of 869 individuals. The two most abundant species with the widest distributions were fin whale (*Balaenoptera physalus*) and striped dolphin (*Stenella coeruleoalba*). The same was true for the N/I Magnaghi, but with a total of only 35 sightings, with four species recognised and a total of 211 individuals sighted. The biggest group of fin whales sighted from the R/V Alliance was composed of five individuals; for striped dolphins, the largest group was composed of 70 individuals. The Cuvier's beaked whales (*Ziphius cavirostris*) were sighted during the same day (8 August). Two sightings involved a single individual, the other was of 3 individuals together. No sightings were made during the night observations (Fig. 4).

DISCUSSION The area of high cetacean density observed in Sirena 99 is consistent with the areas of high chlorophyll productivity. The great number of sightings of fin whales and striped dolphins confirms once more the high density of these species and the importance for the protection of the area. The sightings were more numerous during the first and the last hours of daylight. Cuvier's beaked whales were the rarest cetaceans sighted during the cruise. They were in deep waters between the Ligurian and northern Corsican coasts. The negative result of the night survey could suggest the poor performance of this method, even if only a few hours were spent using it. The comments of the observers were quite negative. We cannot give a qualitative description because there were no sightings of cetacean during the night vision experiment.

A complete set of oceanographic and lower trophic level measurements coupled with the distribution of marine mammals is used to determine if there is a correlation between the location of the marine mammals and the organisms forming the food web upon which the whales feed. If we can understand this, then we may be able to use circulation and ecosystem models and satellite remote sensing data to predict areas of high productivity and to monitor how these areas change seasonally.

The Mediterranean Sea is a fascinating marginal sea from both the oceanographic and marine resource utilisation points of view. The Ligurian Sea, the site of the International Cetacean Sanctuary provides a mini-basin ideal for intense but manageable studies of physical and biological processes. However, for these efforts to succeed, it is also essential to establish a comprehensive GIS-based database of marine life existing in these seas and the relevant physical/biological parameters. Sirena 99 has demonstrated a basin- wide multidisciplinary approach to develop an understanding of the factors determining cetacean distribution in the region. Even with extensive monitoring and observational efforts, there are significant temporal and spatial gaps. To fill these gaps, the Centre is currently developing regional ecosystem models, which can be used as a management tool to provide information, as a valuable supplement to observations related to the marine habitat.

ACKNOWLEDGEMENTS SACLANT Under Research Center. Italian Navy and Istituto Idrografico della Marina. U.S. Office of Naval Research (ONR). UK Defence Research Agency. R/V Alliance Visual Observers: Andy Williams, co-ordinator (Biscay Dolphin Research Programme), Chris Gobey (SACLANTCEN), Tony Di Natale and Guido Gnone (Acquario di Genova), Simone Panigada (Tethys Research Institute), Marco Priano and Gianni Pavan (CIBRA), Maria Elena Quero (Aquastudio). Biological Data Collection: J. F. Borsani (ICRAM), and A. Bocconcelli (UNC). Amm.o Magnaghi Visual Observers: Claudio Fossati and Michele Manghi (SACLANTCEN, CIBRA). Biological Data Collection: Duncan McGhee BAE systems (formerly Marconi, Inc.), and Dave Demer (Southwest Fisheries Science Center).

REFERENCES

Boucher, J., Ibanez, F., and Prieur, L., 1987. Daily and seasonal variations in the spatial distribution of zooplankton populations in relation to the physical structure in the Ligurian Sea Front. *Journal of Marine Research*, 45: 133-173.

Croll, D. A., Tershy, B. R., Hewitt, R. P., Demer, D. A., Fiedler, P. C., Smith, S. E., Armstrong, W., Popp, J. M., Kickhefer, T., Lopez, V. R., Urban, J., and Gendron, D. 1998. An integrated approach to the foraging ecology of marine birds and mammals. *Deep Sea Research II*, 45(7): 1352-1371.

Forcada, J., Notarbartolo di Sciara, G., and Fabbri, F., 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. *Mammalia*, 59(1): 127-140.

Gannier, A., 1998. Les Cétacés de Méditerranée nord-occidentale: nouveaux résultats sur leur distribution, la structure de leur peuplement et l'abondance relative des différentes espéces. *Mésogée*, 56: 3-19.

Orsi Relini, L., Relini, G., Cima, C., Fiorentino, F., Palandri, G., Relini, M. and Torchia, G., 1992. Una zona di tutela biologica ed un parco pelagico per i cetacei del Mar Ligure. *Boll. Mus. Ist. biol. Univ. Genova*, 56-57: 247-281.

Zakardjian, B. and Prieur, L., 1998. Biological and chemical signs of upward motions in permanent geostrophic fronts of the Western Mediterranean. *Journal of Geophysical Research*, 103: 849- 866.

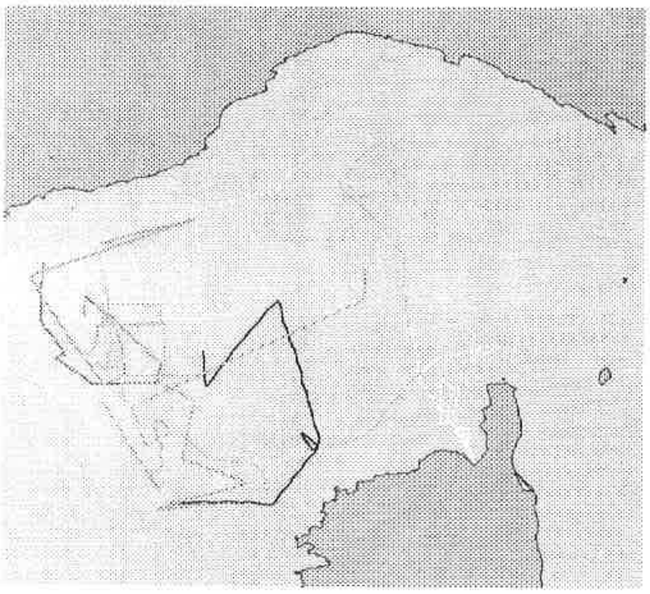


Fig. 1. Alliance Track (different line shading indicates tracks on individual days)

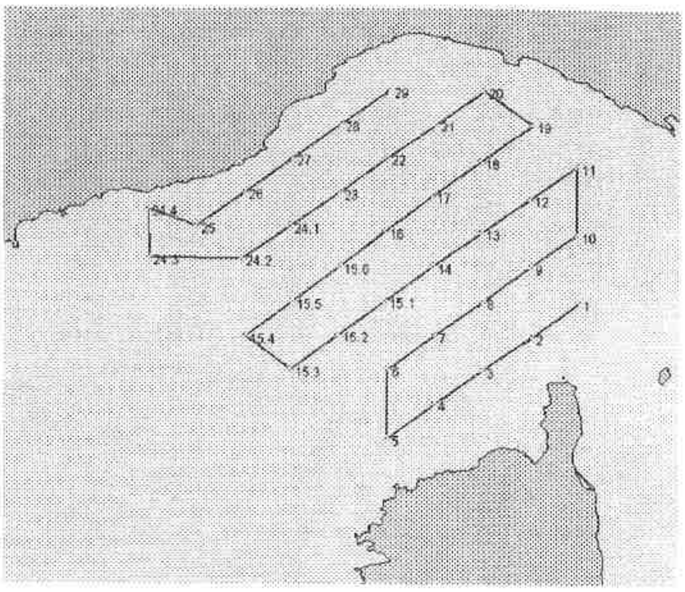


Fig. 2. Magnaghi Track

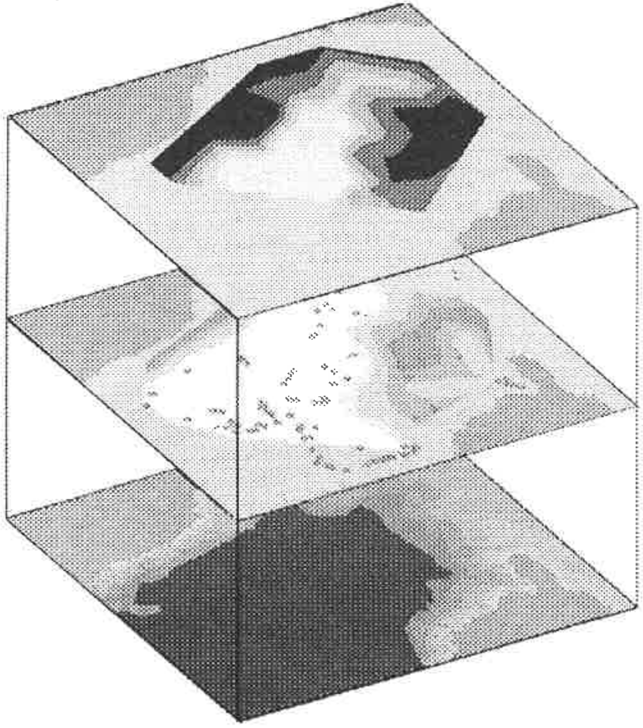


Fig. 3. Sirena sub surface image

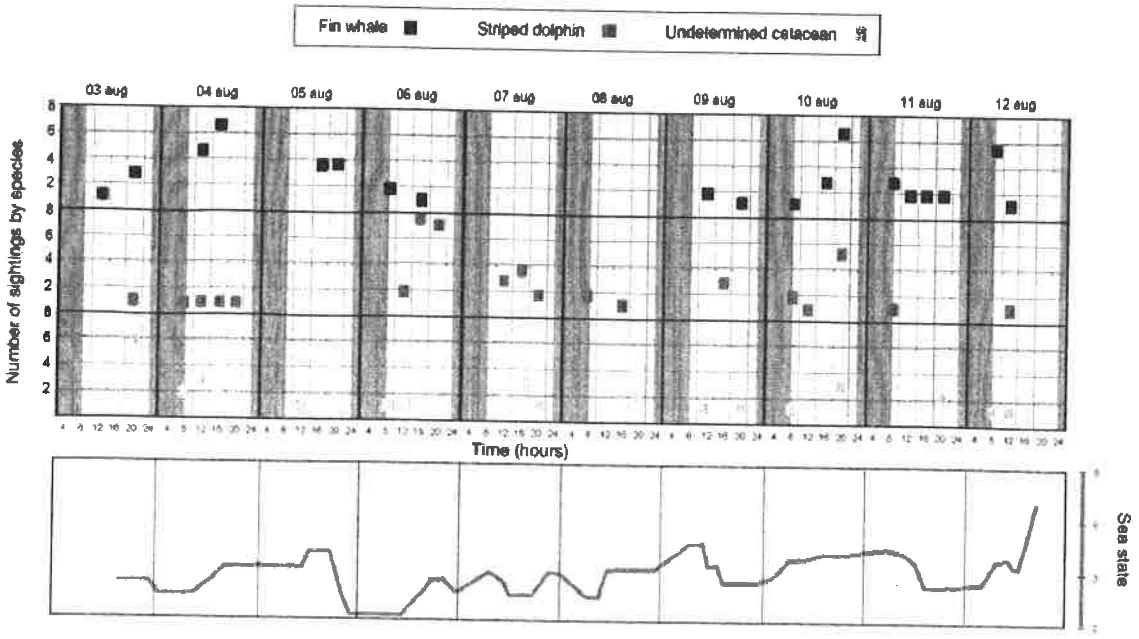


Fig. 4. Alliance sightings by species by day (lower figure shows daily sea state).

BAYESIAN TREND ANALYSIS FOR MARINE MAMMAL POPULATIONS

J. W. Durban[1] and P. M. Thompson[2]

[1]*Department of Zoology, University of Aberdeen, Aberdeen AB24 2TZ, UK*
[2]*University of Aberdeen, Lighthouse Field Station, Cromarty, Ross-Shire IV11 8YJ, UK*

Scientific advice on the status of marine mammal populations is increasingly being sought to assist in conservation and management decisions. However, status information on population size and dynamics is generally not directly observable for these populations, but instead must be estimated from sample data using statistical models. Furthermore, due to the difficulties of studying marine mammals, sample data are often sparse and abundance estimates imprecise, greatly limiting power for detecting significant trends using conventional analyses.

Through example case studies, we demonstrate the utility of a Bayesian approach to the analysis of sparse and imprecise trend data, and demonstrate how such an analysis can be easily implemented and understood through the use of graphical models. By presenting trend estimates with a probability-based treatment of uncertainty, we illustrate how a Bayesian approach can contribute to the informed management and conservation of marine mammals.

HOW MANY DOLPHINS ARE WE STUDYING AND IS OUR STUDY AREA BIG ENOUGH?

C. M. Fortuna[1], B. Wilson[2], A. Wiemann[1], L. Riva[1], S. Gaspari[1,3], M. Matesic[1],
S. Oehen[1] and S. Pribanic[1]

[1]*Tethys Research Institute, viale G.B. Gadio 2, I-20121 Milano, Italy*
[2]*Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, UK*
[3]*University of Durham, Dept. Of Biological Science, Durham, UK*

INTRODUCTION Little is known about the distribution and abundance of marine life in the Northern and Central Adriatic Sea. Bottlenose dolphins are the only cetacean species regularly sighted in Croatian waters (Notarbartolo and Bearzi, 1992; Bearzi and Notarbartolo, 1995).

In a core area of about 700 km^2, east of Cres and Losinj islands, a longterm study on socio-ecology of bottlenose dolphins was started in 1987 by Tethys Research Institute (Bearzi *et al.*, 1997; Bearzi *et al.*, 1999).

Population size is of fundamental importance in any work to establish if a population may be vulnerable to extinction. Therefore, estimates of population size and status are required for rational conservation and management.

Our aim here is to determine how many dolphins use our core study area and to test whether this number is representative of the whole NE Adriatic.

MATERIALS AND METHODS Photo-identification (photo-ID) techniques were applied to bottlenose dolphins in an area of over 1000 km^2 (Fig. 1). Photographs were taken with a Minolta 8000i autofocus camera fitted with a 80-200 mm lens. Transparency (slide) film Ektachrome Pro 64 ISO was used for this study.

The study are was divided into two zones: area A (the core) and area B (adjacent zones).

Individuals were recognised using natural marks on their dorsal fins, and placed into two categories based on their marks: highly marked (HM) and poorly marked (PM) (Fig. 2).

Capture histories of individuals with highly distinctive marks were applied to a closed mark-recapture model (Chao *et al.*, 1992), which permitted individual and temporal heterogeneities of capture probabilities. The resulting estimates of highly marked individuals were then weighted to include the proportion of poorly marked individuals seen on surveys (proportion of highly marked animals divided by the total).

Two population estimates were performed; one for effort in the core study area (area A) only, and the other considering the core and the adjacent area together (area A+B).

RESULTS From May to October 1997, photo-identification data were collected during 51 encounters in the core study area, and 12 encounters from adjacent areas (the wider study area being over 1000 km^2).

Discovery curves of new HM individuals (red dots and line) and all individuals (PM+HM, yellow dots and line) over time is given in Fig. 3.

Analyses of data were performed by means of the software CAPTURE. The data set was analysed in time blocks of 10-days. Two total population size estimates were calculated (Table 1).

DISCUSSION AND CONCLUSIONS Our results suggested that: the population inhabiting the Kvarneric is small, and this implies that it should receive special attention for conservation purposes, being exposed to a strong seasonal anthropogenic pressure (especially tourism); by expanding the survey area of about 40%, we did not obtain a radical increase in the estimated population size; all dolphins encountered during 1997 were already present in our historical catalogues (1995, 1996); four specimens not listed within the most frequent category by Bearzi *et al.* (1997) were actually encountered in the secondary area (B);

If our core study area (A) would have represented the exact home range of the population under study, the estimate should not have changed. On the other hand, that slight increase might suggest that the wider area (A+B=1000 km^2) could be closer to the real home range, but it is still not big enough to define it. Therefore, more widespread survey efforts are necessary to assess the geographical limits of this population, as well as its total size.

ACKNOWLEDGEMENTS We owe a debt of gratitude to Dr. Nikola Tvrtkovic and Mr. Drasko Holcer for including our project in the Ministerial scientific work permission of Croatian Natural History Museum. We also want to thank the Whale and Dolphin Conservation Society and all our paying volunteers of 1997 for funding our project. And, last but not least, a special acknowledgement goes to Giovanni Bearzi and Dr. Giuseppe Notarbartolo di Sciara for initiating the Adriatic Dolphin Project.

REFERENCES

Bearzi, G. and Notarbartolo di Sciara, G. 1995. A comparison of the presnt occurrence of bottlenose dolphins, Tursiops truncatus, and the common dolphins, *Delphinus delphis*, in the Kvarneric (Northern Adriatic Sea). *Annales (Annales for Istrian and Mediterranean Studies)*, 7: 61-68.

Bearzi, G., Notarbartolo di Sciara, G., and Politi, E. 1997. Social ecology of bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Mar. Mamm. Sci.*, 13(4): 650-668.

Bearzi, G., Politi, E., and Notarbartolo di Sciara, G., 1999. Diurnal behavior of free-ranging bottlenose dolphins in the Kvarneric (northern Adriatic Sea). *Mar. Mamm. Sci.* 15(4): 1065-1097.

Chao, A. S., Lee, S. M. and Jeng, S. L. 1992. Estimating population size for capture-recapture data when capture probabilities vary by time and individual animal. *Biometrics*, 48: 201-216.

Notarbartolo di Sciara, G. and Bearzi, G. 1992. Cetaceans in the Northern Adriatic Sea: past, present and future. *Rapp. Comm. Int. Mer. Mèdit.*, 33: 302-303.

Wilson, B., Hammond, P. S., and Thompson, P. M. 1999. Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications*, 9(1): 288-300.

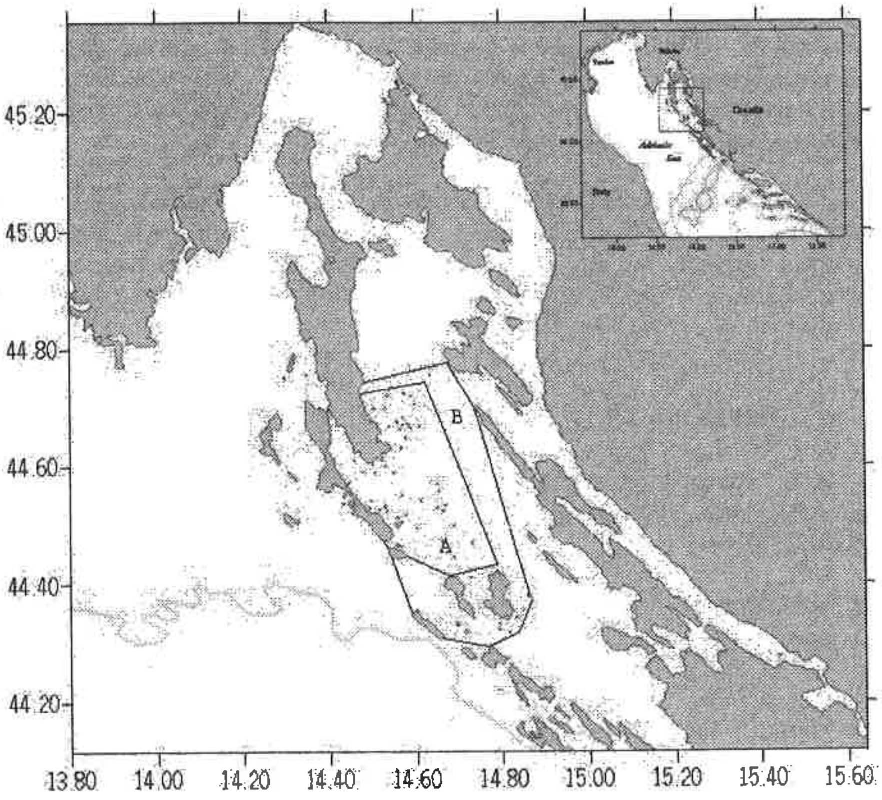


Fig. 1. Study area: core (A) and adjacent zones (B)

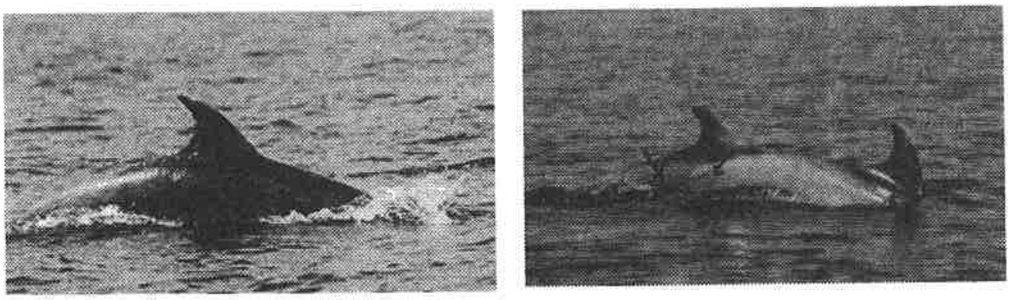


Fig. 2. Highly marked (HM) and poorly marked (PM) bottlenose dolphins

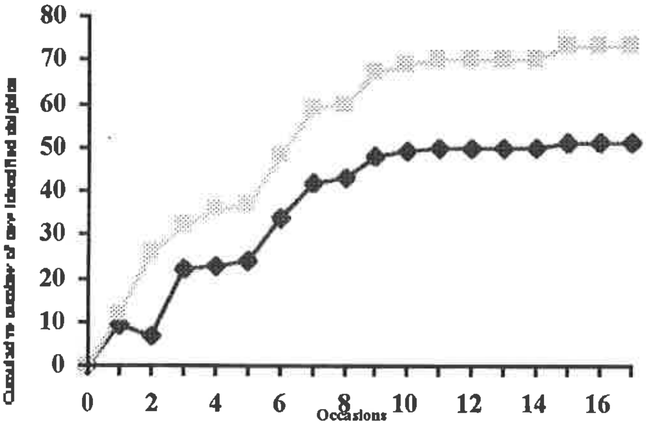


Fig. 3. Discovery curves of new HM individuals (red dots and line) and all individuals (PM+HM, yellow dots and line) over time

Table 1. Population size estimates
Area A (about 700 km^2) • Weighted estimate: 98 dolphins (95% CI = 94-105), SE=5.7524 - proportion of HM: 0.55 - 22 PM and 22 calves
Area A+B (about 1000 km^2) • Weighted estimate: 113 dolphins (95% CI = 107-121), SE=6.967 - proportion of HM: 0.53 - 27 PM and 24 calves

IMAGE RETRIEVAL FROM SPERM WHALE PHOTO CATALOGUE

R. Huele[1], H. A. Udo De Haes[1], and J. Gordon [2]

[1]*Centre of Environmental Science, Leiden University, PO Box 9518, 2300 RA Leiden, Netherlands*
[2] *IFAW, 1a Howard Street, Oxford, OX4 3AY, UK*

In 1999, European sperm whale researchers co-operated to make available a large part of the European photographic material on sperm whales in the form of the North Atlantic and Mediterranean Sperm Whale Catalogue (NAMSC). The NAMSC was published on CD by IFAW and CML of Leiden University. For each photograph, the year and the place of observation are given, plus the name of the contributor. The copyright of the photographs remains with the contributors. The catalogue offers a unique opportunity to test computerised contour matching procedures as an aid to photo-identification of individual sperm whales. Image processing methods based on wavelet transforms were developed to extract the contour of the trailing edge of the fluke from the photographs. Wavelet transformations were also applied to represent the contour as a normalised set of numbers. Cross correlation was used as a measure of similarity between two wavelet transforms of contours.

Due to the highly varying quality and resolution of the photographic material, several methods were needed to extract the contour from the photograph. Most contours could be extracted automatically from the photograph, but in some photographs the area of interest had to be indicated by the user. Likewise, it was found that representations of the contour as wavelet transforms were needed on several scales in order to identify similar contours from different photographs, as the identifying features could be in the higher or lower frequencies of the contour. In total, the catalogue contains 2,081 photos. Of these, 77 were found not suitable for individual identification by the contour of the fluke. The remaining 2,004 photographs were found to represent 1,768 individuals. In total, 339 matching couples of photographs were found. Many matches were found within collections spanning several years, though only one match was found between photographs of two different contributors.

HIGH SIGHTING FREQUENCY OF THE PELAGIC SPECIES STRIPED DOLPHIN *STENELLA COERULEOALBA* IN A CLOSED SEA AREA

I. Mardikis, V. Podiadis and G. Verriopoulos

Zoology - Marine Biology, Department of Biology, University of Athens,
Panepistimioupolis, Athens GR 157 84

INTRODUCTION In August 1996, July and August 1997, the Cetacean Research Group of the University of Athens conducted a sighting survey in Korinthiakos Gulf (Fig. 1), in order to determine the distribution and relative abundance of small cetaceans. The main subject was striped dolphin *Stenella coeruleoalba,* a pelagic species whose presence, according to previous observations, was intense.

MATERIALS AND METHODS The survey took place with the use of two sailing boats (Kamari and Argo) and two inflatable crafts (Oceanos I and Archran) which operated at different time periods and areas. The presence of animals was assessed visually and strip transect sampling technique was applied. In addition, a preliminary photo-identification study was carried out. The fieldwork was assisted by ten researchers including the authors. We used: GPS units for vessel tracking, motor drive auto focus cameras equipped with 80-200 mm lenses, and SeaPro 2000 navigation software to process the results.

RESULTS Table 1 includes detailed data of distances travelled every day in the field. During a total of 189 hours of effort time, which covered 983 nautical miles, 33 sightings of striped dolphins were made (Fig. 2). The school size varied from few individuals to large aggregations of 50 or more dolphins (Table 1). We also witnessed the phenomenon of interspecies association (*Stenella coeruleoalba* with *Delphinus delphis* and *Grampus griseus*). The analysis of the photo-identification data enabled the recognition of 45 individuals.

DISCUSSION Striped dolphins are abundant mainly in offshore waters, at depths greater than 800 metres, and at least 15 nautical miles away from the nearest coast (Beaubrun 1995; Forcada *et al.*, 1990; Franco *et al.* 1995; Notabartolo di Sciara and Bearzi 1992; Notarbartolo di Sciara and Demma 1994; Politi *et al.*, 1992; Watson 1981).

The diet of this species consists of fish (*Diaphus, Erythocles, Micromesistius, Trisopterus, Gadinculus, Merluccius, Merlangius, Trachurus, Atherina, Chauliodus, Engraulis*) and squid (Ommastrephidae, Chiroteuthidae, Loliginidae, Histioteuthidae), and decapods (Evans 1987; Notabartolo di Sciara and Demma 1994)

The data obtained lead to the conclusion that we are witnessing an unusually high density of this pelagic species in the closed sea of Korinthiakos Gulf, and in some cases closer than half a mile to the coast.

The most probable causes of this phenomenon are:

- The geomorphology of the study area which is characterised by great depths very close to the shore (Fig. 2), (Jefferson *et al.*, 1993).
- The abundance of certain fish (*Micromesistius, Merluccius, Trisopterus, Gadinculus, Trachurus, Engraulis*) (Papakonstandinou 1986) which represent a main element of this dolphin's diet.

ACKNOWLEDGEMENTS We would like to express our gratitude to Dr. A. Frantzis for his invaluable help. We also thank Dr. D. Zafiropoulos, V. Karpoulis, M. Trivourea, A. Verriopoulou, T. Hassidis, and G. Praximadis for their support, and last but not least to the Kostopoulos Foundation and A. Efstathiou for providing the necessary equipment.

REFERENCES

Beaubrun, P. C. 1995. *Atlas preliminaire de distribution des cetaces de Mediterranee.* CIESM, Musee Oceanographique Monaco. 87pp.

Forcada, J., Aguilar, A., Evans, P. G. H., and Perrin, W. F. 1990. Distribution of common and striped dolphins in the temperate waters of the Eastern North Atlantic. Pp. 64-66. In: *European Research on Cetaceans - 4* (Eds. P. G. H. Evans, A. Aguilar and C. Smeenk. Proc. 4th Ann. Conf. ECS, Palma de Mallorca, Spain, 2-4 March 1990. European Cetacean Society, Cambridge. 140pp.

Franco, I., Mas, J., and Rodriguez C. 1995. Cetacean sightings in the Alboran Sea. July 1993. *Rapp. Comm. int. Medit.,* 34.

Evans, P. G. H. 1987. *The natural history of whales and dolphins.* Academic Press, London. 343pp.

Jefferson, T., Leatherwood, S., and Webber, M. 1993. *Marine mammals of the world.* UNEP/FAO. 320pp.

Notarbartolo di Sciara, G. and Bearzi, G. 1992. Cetaceans in the Northern Adriatic Sea: past, present and future. *Rapp. Comm. Int. Mer Medit.*, 33: 303

Nortabartolo di Sciara, G. and Demma, M. 1994. *Guida dei mammiferi marini del Mediterraneo.* Editore Franco Muzzio. Scienze Naturali. 262pp.

Papaconstantinou, C. 1986. The Ichthyofauna of Korinthiakos and Patraikos Gulfs and the Ionian Sea. *Biologia Gallo-hellenica* , 12: 229-236.

Politi, E., Bearzi, M., Notabartolo di Sciara, G., Cussino, E., and Gnone, G. 1992. Distribution and frequency of cetaceans in the waters adjacent to the Greek Ionian Islands. Pp. 75-78. In: *European Research on Cetaceans - 6.* Proc. 6th Ann. Conf. ECS, San Remo, Italy, 20-22 Feb, 1992 (Ed. P. G. H. Evans). European Cetacean Society, Cambridge, England. 254pp.

Watson, L. 1981. *Sea guide to whales of the world.* Hutchinson. 302pp.

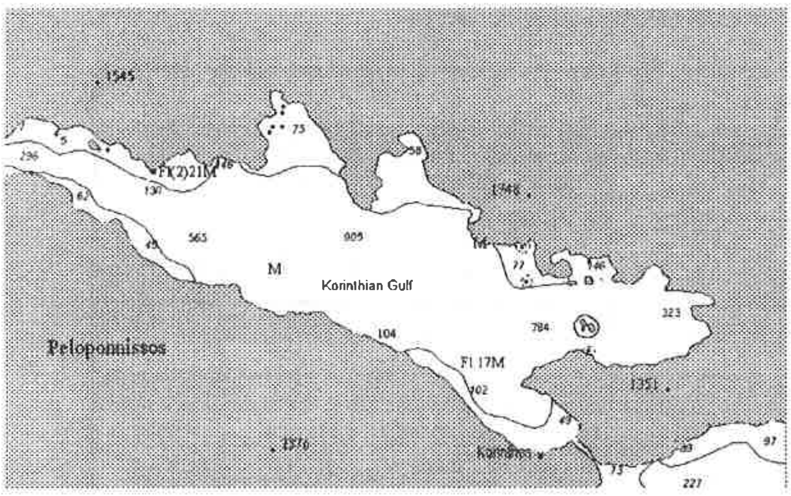


Fig. 1. The geomorphology of the study area
Maximum Length: 65 nm. Maximum Width: 19 nm. Maximum Depth 905 m

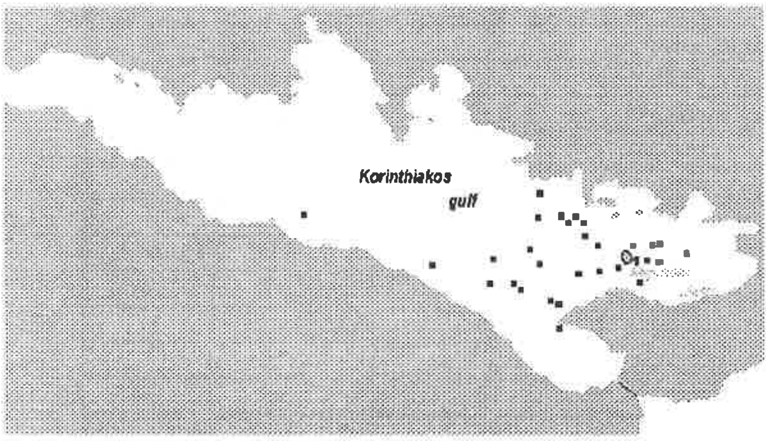


Fig. 2. The 33 sightings in the study area

Table 1. Distances travelled every day in the field

Sightings of Stenella coeruleoalba (S.c.) - Korinthiakos gulf								
Sailing boat "Kamari "								
Date	Miles "+"	Miles with dolphins	Tot.miles	Number of sighting	Number of groups	Number of dolphins	Groups/ / miles"+"	Doplhins/ miles"+"
22/8/1996	18,61	3,25	64,4	sight.#1 Sc	1	25	1/18,61	25/18,61
Tot.results "Kamari "	18,61	3,25	21,86		1	25	1/ 18,61	25/ 18,61
Sailing boat "Argo "								
Date	Miles "+"	Miles with dolphins	Tot.miles	Number of sighting	Number of groups	Number of dolphins	Groups/ / miles"+"	Doplhins/ miles"+"
5/7/1997	22,73	5,01	27,74	sight.#2 Sc	1	22	1/22,73	22/22,73
6/7/1997	17,57	14,3	32,68	sight.#3 Sc& &Dd	1	18	1/17,57	18/17,57
7/7/1997	0	0	4,1		0	0	0	0
8/7/1997	3,92	0	21,7		0	0	0	0
11/7/1997	* Simultaneous research			sight.#4Sc*	1	30	** s#6 is the	
	conducted by the			sight.#5Sc	1	15	same with	
	inflatable boat "OKEANOS I"			sight.#6Sc**	1	15	"Okeanos I"	
	23,81	7,28	34,56		3	60	3/23,81	60/23,81
12/7/1997				sight.#9Sc	1	5		
				sight.#10 (Sc	1	7		
Total	30,83	10,7	41,53	&Gg&Dd)	2	12	2/ 30,83	12/ 30,83
13/7/1997	19,44	1,23	31,62	sight.#13 Sc	1	42	1/19,44	42/19,44
14/7/1997	31,22	6,68	38,03	s#14 Sc&Dd	1	55		
				s#15S&D&G	1	18		
				s#16 Sc	1	17		
					3	90	3/ 31,22	90/ 31,22
15/7/1997	7,23	0	23,19		0	0	0	0
16/7/1997	2,47	0	6,38		0	0	0	0
17/7/1997	49,16	0,72	49,88		0	0	0	0
18/7/1997				sight.#20Sc	1	25		
	* Simultaneous research			sight.#21Sc	1	12		
	conducted by the			sight.#22Sc&	1	26		
	inflatable boat "Archran"			&Dd				
	21,44	3,78	43,31		3	63	3/ 21,44	63/ 21,44
20/7/1997	0	0	21,41		0	0	0	0
21/71997	6,91	1,27	21,1	sight.#24Sc	1	11	1/ 6,91	11/ 6,91
22/7/1997	2,69	0	25,65		0	0	0	0
23/7/1997	38,9	0	41,97		0	0	0	0
24/7/1997				sight.#25Sc	1	21		
				sight.#26Sc	1	23		
Total	43,91	5,64	50,13		2	44	2/43,91	44/ 43,91
25/7/1997	14,24	0	14,86		0	0	0	0
Tot. results "Argo"	336,47	56,61	529,84		17	362	17/336,47	362/ /336,47

Inflatable boat "Okeanos I"								
Date	Miles "+"	Miles with dolphins	Tot.miles	Number of sighting	Number of groups	Number of dolphins	Groups/ / miles"+"	Doplhins/ miles"+"
11/7/1997	* Simultaneous research			sight.#6 Sc*	1	15	** s#6 is the	
	conducted by the			sight.#7 Sc	1	10	same with	
	sailing boat "Argo"			sight.#8 Sc	1	10	"Argo"	
Total	48,99	7,68	62,8		3	36	3/ 48,99	36/48,99
12/7/1997				sight.#11 Sc	1	14		
				sight.#12Sc	1	9		
Total	38,9	18,11	76,34		2	23	2/ 38,9	23/ 38,9
13/7/1997	12,43	0	19,82		0	0	0	0
14/7/1997				sight.#17 Sc	1	1		
				sight.#18Sc&Dd	1	40		
				sight.#19 Sc	1	2		
Total	19,47	12,81	32,28		3	43	3/ 19,47	43/ 19,47
15/7/1997	34,14	0	53,29		0	0	0	0
Tot. results	153,93	38,6	244,53		8	102	8/ 153,93	102/
"Okeanos"								/153,93
Inflatable boat "Archran"								
Date	Miles "+"	Miles with dolphins	Tot.miles	Number of sighting	Number of groups	Number of dolphins	Groups/ / miles"+"	Doplhins/ miles"+"
18/7/1997	6,03	4,87	19,13	sight.#23 Sc	1	25	1/ 6,23	25/ 6,23
			* Simultaneous research conducted by the sailing boat "Argo"					
29/7/1997	26,38	0	26,38		0	0	0	0
4/8/1997	31,46	4,1	56,26	sight.#27Sc	1	8	1/ 31,46	8/ 31,46
6/8/1997	22,72	0	23,99		0	0	0	0
8/8/1997				sight.#28Sc	1	7		
				sight.#29Sc	1	3		
Total	0	3,56	61,58		2	10	2/ 56,17	10/ 56,17
9/8/1997	20,24	0	20,24		0	0	0	0
10/8/1997				sight.#30Sc&				
	11,69	7	18,69	&Dd	1	24	1/ 11,69	24/ 18,69
12/8/1997	24,27	0	24,27		0	0	0	0
13/8/1997				sight.#31Sc	1	20		
				sight.#32Sc	1	6		
Total	37,43	7,13	44,75		2	26	2/ 37,43	26/ 37,43
14/8/1997				sight.#33Sc				
	15,62	13,71	29,33	&Dd	1	40	1/ 15,62	40/ 15,62
Total result	252,01	40,37	324,62		8	133	8/ 252,01	133/
"Archran"								/'252,01
TOTAL RESULTS	Miles"+"	Miles with dolphins	Total miles	sightings 33	Total no. of groups	Total no. of dolphins	Total no. of groups/ /total miles "+"	Total no. of dolpins/ /total miles "+"
	680,58	138,83	1139,12		33	606	36/	607/
							/736,75	/736,75

MEDITERRANEAN MONK SEAL (*MONACHUS MONACHUS*) SIGTHINGS ON OPEN BEACHES IN DESERTAS ISLANDS – MADEIRA ARCHIPELAGO

R. Pires and H. C. Neves

Parque Natural da Madeira, Caminho do Meio, Quinta do Bom Sucesso, 9050 Funchal, Portugal
(E-mail: pnm@mail.telepac.pt)

INTRODUCTION The Mediterranean monk seal *Monachus monachus* is a species that humans have persecuted for centuries. As a direct result, the monk seal now is classified as one of the most endangered mammal species of the world. Its population, estimated to a total of only 300-400 individuals (Aguilar, 1998), is distributed over the Mediterranean, Black Sea, and in the Atlantic Ocean off the Western Sahara and the Madeira Archipelago (Reijnders, 1998). As an indirect result, the seals have had to change some of their habits and behaviour to survive, as has occurred with their choice of habitat. Looking for security, the seals started to use only the beaches inside of caves to rest and to breed, instead of the open beaches (Bareham and Furreddu, 1975; Sergeant *et al.*, 1978; Machado, 1979; Trotignom, 1982; Marchessaux, 1989; Brasseur *et al.*, 1997). Nevertheless, observations were recently made on the Desertas Islands of monk seal on open beaches. We analyse here these observations.

BACKGROUND Originally on the Island of Madeira, the monk seal used open beaches and easily accessible caves to rest and breed (Machado, 1979). However, with the increase of the human presence after its colonisation in 1419, the population began to decline. Nowadays, it is likely that only a small population survive on the Ponta de São Lourenço. So the Desertas Islands became the last area of the Madeira archipelago with suitable conditions for monk seal survival.

Desertas comprises three islands (Ilhéu Chão, Deserta Grande and Bugio) located 11 miles SE of Madeira Island. Most of the 37 km coastline of these islands is composed of steep inaccessible cliffs. However, there are numerous beaches and caves that provide good conditions for the seals. In these uninhabited and isolated islands, the seals have found security and excellent food resources. Old fishermen report the use of the beaches by seals. However, with the increase of the fishing activity in the area during the seventies (Neves, 1998), the seals started to use only the caves to rest and to breed and the seal population started to decline steeply.

Sergeant *et al* (1978) estimated a population of 50 individuals and, by 1988, the numbers had dwindled to only 6-8 individuals. So at that time was started a programme to preserve this species and, by 1990, the Desertas were legally protected.

CONSERVATION PROGRAM The conservation programme follows three main objectives: environmental education, effective protection of the monk seal and its habitat, and study and monitoring of the species.

To ensure effective protection of both the seals and their habitat, the main approach was to patrol the islands by boat. Monk seal study and monitoring is carried out using methodology that was as non-intrusive as possible. To do this, lookout sites were established around the islands. From here, observations are documented and photo-identification studies are conducted. During the last eight years, 3,818 hours have been spent patrolling by boat and 5,085 hours on the lookout sites.

RESULTS Actually, the human disturbance on the Desertas Islands is practically non-existent. There are no effective threats for the population.

Throughout these years, there were 670 sightings of monk seals, which provide a sound basis for monitoring the status of the population. The population, actually estimated as 23 individuals, is increasing, having also shown an increase in the annual productivity, from 1 to 3 births.

In 1997, seals started to use open beaches. For almost 20 days, two females used Tabaqueiro beach, located on the extreme SW of Deserta Grande where exists one maternity cave, to rest and to suckle their pups.

In July 1999, seals were seen on the shore again. But on this occasion, they were on the Areias beach at the Calhau das Areias inlet, where monk seals show most activity associated with breeding behaviour (Pires, 1997). One was a juvenile, recognised as one of the pups that used the Tabaqueiro beach. The other was an unidentified immature. They used the beach to rest.

A few months later, in December, the same reproductive females and the new pups again used Tabaqueiro beach in addition to the cave. They used the beach to rest and suckle for almost two months, and in fact the animals still sporadically use this as a place to rest.

DISCUSSION Seals only started to use open beaches nine years after the start of the protection programme, *i.e.* nine years after the cessation of human persecution on the islands. Although it has taken a long time, the seals are now beginning to use the open beaches during the breeding period when they are most sensitive. Last year, the time spent on the shore by the seals increased considerably. In addition, new individuals are showing a tendency to use the open beaches.

It shows that the seals are gradually re-acquiring a sense of security on the Desertas Islands and, consequently, returning to their natural and original habitats, and behaviour. This and the recovery of the population that we are assisting is a promising sign for the future of this species on the Madeira archipelago.

ACKNOWLEDGEMENTS We would like to thank all those who, in various ways, contributed to the monk seal conservation, namely the Nature Wardens of Parque Natural da Madeira, and the European Community for their financial support

REFERENCES

Aguilar, A. 1998. *Current status of Mediterranean Monk Seal (Monachus monachus) populations*. United Nations Environment Program Doc. UNEP(OCA)WG.146/4, UNEP SPA/RAC, Tunis.

Bareham, J. R. and Furreddu, S. J. 1975. Observations on the use of grottos by Mediterranean Monk Seals (*Monachus monachus*). *J.Zool.* (Lond.), 175: 291-298.

Brasseur, S. M., Reijnders, P. J., and Verriopoulos, G. 1997. Mediterranean Monk Seal, *Monachus monachus*, Pp. 12-26. In: *Status of Pinnipeds relevant to the European Union.* (Eds. P. J. Reijnders, G. Verriopoulos, and S. M. Brasseur). IBN Scientific Contributions 8. DLO Institute for Forestry and Nature Research (IBN-DLO), Wageningen, The Netherlands.

Machado, A. 1979. *Os Lobos marinhos (Género Monachus, Fleming 1822).* Contribuição para o seu conhecimento e protecção. Câmara Municipal de Cascais, Museu do Mar. 237pp.

Marchessaux, D. 1989. *Recherches sur la biologie, lécologie et le statu du phoque moine, Monachus monachus.* GIS Posidonie Publ. ISBN N°2-905540-13-3, Marseille, France. 280pp.

Neves, H., 1998. Preliminary findings on the feeding behaviour and general ecology strategy of the Mediterranean monk seal *Monachus monachus* – (Pinnipedia: Monachinae) on the Desertas Islands. *Bol. Mus. Mun. Funchal*, Sup.n° 5: 263-271.

Pires, R., 1997. - *Estado actual e aspectos da biologia e ecologia da colónia de lobos marinhos, Monachus monachus, das Desertas Islands.* Relatório de estágio para ingresso na carreira técnica. Secretaria da Agricultara Florestas e Pescas, Parque Natural da Madeira, Funchal.

Reijnders, P., 1998. *Vulnerability of small Mediterranean monk seal groups and conservation policy.* United Nations Environment Program Doc. UNEP(OCA)WG.146/4, UNEP SPA/RAC, Tunis.

Seargent, D., Ronald, K, Boulva, J., and Berkes, F. 1978 The recent status of *Monachus monachus*, the Mediterranean monk seal. *Biol. Conserv.*, 14: 259-287.

Trotignom, J. 1982. Les derniers phoques sahariens. *Currier de la Nature*, 77: 14-20.

CETACEAN STUDIES IN THE CELTIC SEA, ENGLISH CHANNEL AND SW NORTH SEA: USING TRAINING SURVEYS FOR DATA COLLECTION

M. J. Rosen[1,2], P. G. H. Evans[1], J. R. Boran[1,2], G. Bell[2,3] and C. Thomas[3]

[1]*Sea Watch Foundation, 11 Jersey Road, Oxford, OX4 4RT, UK*
[2]*WhaleSense, 32 Birch Road, Manchester, M8 5RU, UK*
[3]*EarthKind, Town Quay, Poole, Dorset, BH15 1HJ, UK*

INTRODUCTION Vessel-based whale and dolphin surveys are not only expensive to run but require a large number of experienced cetacean observers, who must be available for a specific period of time. Due to these factors it is often difficult to organise. EarthKind, in collaboration with the Sea Watch Foundation, carried out cetacean surveys as part of their campaigning tour around the UK, using volunteers to conduct dedicated surveys. Each set of volunteers was given intensive training in cetacean identification and survey techniques by scientists from Sea Watch and EarthKind. Approximately 100 volunteers and crew were trained, greatly expanding the numbers of observers available. In addition, during each cruise there was at least one experienced observer onboard who could confirm and validate cetacean sightings. The data collected were entered onto the National Cetacean Sightings Database. Cruises took place on board EarthKind's MV "Ocean Defender" who started her life in 1921, as 'Bjerk', a Norwegian whaling vessel. In 1991, she was converted and began her role with EarthKind in marine wildlife rescue, education, and conservation.

STUDY AREA The Celtic Deep is situated just south of the St. George's Channel between West Wales, Southwest England, and Southern Ireland, on the northeast edge of the Celtic Sea. It is an area of great importance to a variety of cetacean species, with twelve species recorded here in the last twenty years (Evans, 1995). With depths regularly exceeding 100 m, this basin attracts species that are usually found beyond the continental shelf edge. By far the most abundant species is the common dolphin *Delphinus delphis*, but other species recorded here include fin whale *Balaenoptera physalus*, northern bottlenose whale *hyperoodon ampullatus*, Cuvier's beaked whale *Ziphius cavirostris*, and other beaked whales of the genus *Mesoplodon.* Continental shelf species like harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus*, Risso's dolphin *Grsampus griseus*, and minke whale *Balaenoptera novaeangliae*, are also commonly seen. With intense fishing pressure from bottom set gillnets in the Celtic Sea including the Celtic Deep, the region has experienced high bycatches of cetaceans, particularly common dolphin and harbour porpoise (Tregenza *et al.*, 1997a, b). Due to the sparse sampling within this area, it was decided to carry out a dedicated survey to gain better information on the seasonal distribution and abundance of cetacean species in the area. Other surveys were also conducted in the English Channel and south-western North Sea.

METHODS Surveys were run with up to four observers on watch throughout daylight hours, recording position and environmental parameters every 15 minutes. The results presented here are from surveys conducted on 12 days between 18 August and 29 October 1997 and 25 days between 27 March and 18 June 1998, for a total of 345.6 hours, covering over 4,000 km of survey track-line in an area of 58,000 km^2. Effort-corrected analyses were performed using a grid size of 30 minutes latitude x 60 minutes longitude. Correction factors for observations in higher sea states were determined for abundant species.

RESULTS A total of 166 cetacean sightings were made involving 1,408 cetaceans, identified to seven species. Common dolphins and harbour porpoise were the most abundant species with five additional rare species. The numbers of individuals sighted per 100 km of survey were corrected for the reduced detectability caused by higher sea states, by using factors derived from numbers seen in calm conditions. These species are plotted on the effort-related grid cells in Figs. 1-4.

Harbour Porpoise Harbour porpoises were the only species seen in April 1998 in surveys along the east English coast (Fig. 1). Off South-west England and Ireland, they were mainly seen in shallow, nearshore waters and on offshore banks (Fig. 2). A total of 69 individuals from 35 sightings were spotted (Table 1). They were most common in the south-west North Sea, but also had high encounter rates in shallow waters east of the Celtic Deep (Fig. 2).

Common Dolphin Common dolphins were abundant in the Celtic Deep and off the Channel Islands (Fig. 3). There were 105 sightings of 1,286 individuals (Table 1), by far the most frequently observed cetacean in these surveys. Effort-corrected analyses of common dolphins revealed highest distributions (sighting rate of 0.53 sightings/km) in the Celtic Deep.

Other Species In addition to the species listed above, five other species were sighted (Fig. 4). Bottlenose dolphins and minke whales were seen on multiple occasions, whilst there were single sightings of fin whale, Cuvier's beaked whale and killer whale (Table 1).

CONCLUSIONS In establishing a protocol for training inexperienced volunteers in methods of cetacean surveying, EarthKind and Sea Watch have succeeded in demonstrating that surveys can be achieved using enthusiastic volunteer observers with limited experience. The results highlighted the importance of the Celtic Deep for many cetacean species, with all species showing a preference for this area, confirming that this is an important area, not only for commonly observed species but also for Cuvier's beaked whales and fin whales. By comparison, they also demonstrate the paucity of previous cetacean sightings within the Channel. However, the sighting of a minke whale near to Guernsey and the porpoises recorded with young near the Channel Islands, indicate that this is also an important area for cetaceans and that there is need for more dedicated surveys within this area.

ACKNOWLEDGEMENTS Many people were involved in the research and it could not have been done without their help. We thank Captain Francis Noel-Hudson, Derek Fett (First Mate), Charlie Smith, (Chief Engineer), Peter Todd, and all the volunteers onboard the Ocean Defender, and Sharon Clouston and Jane Galloway at EarthKind for collating datasheets and copying information.

REFERENCES

Evans, P. G. H. 1995. Whales, dolphins and porpoises. Chapter 5.15. Pp. 137-140. In *Coasts and Seas of the United Kingdom. Region 12 Wales: Margam to Little Orme.* (Eds. J. H. Barne, C. F. Robson, S. S. Kaznowska and J. P. Doody). Joint Nature Conservation Committee, Peterborough. 239pp.

Tregenza, N. J. C., Berrow, S. D., Hammond, P. S. and Leaper, R. 1997a. Harbour porpoise (*Phocoena phocoena* L.) by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science*, 54: 896-904.

Tregenza, N. J. C., Berrow, S. D., Hammond, P. S. and Leaper, R. 1997b. Common dolphin, *Delphinus delphis* L., by-catch in bottom set gillnets in the Celtic Sea. *Rep. int. Whal. Commn.*, 47: 835-839.

Table 1. Number of sightings and individuals of all species sighted in the study area

SPECIES	SIGHTINGS	INDIVIDUALS
Fin Whale	1	2
Minke Whale	12	14
Cuvier's Beaked Whale	1	2
Killer Whale	1	2
Bottlenose Dolphin	11	34
Common Dolphin	105	1286
Harbour Porpoise	35	69
TOTAL	166	1408

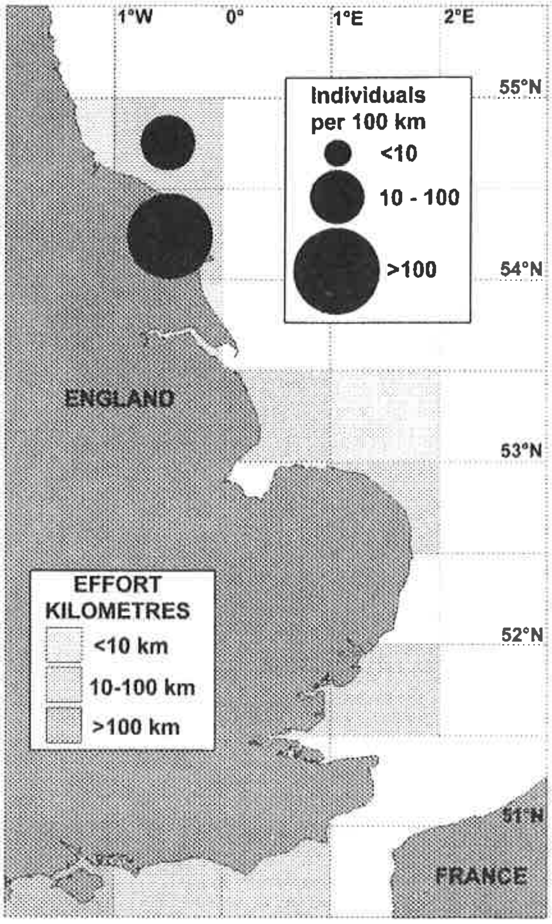


Fig. 1. Map of harbour porpoise sightings: numbers of individuals per 100 km

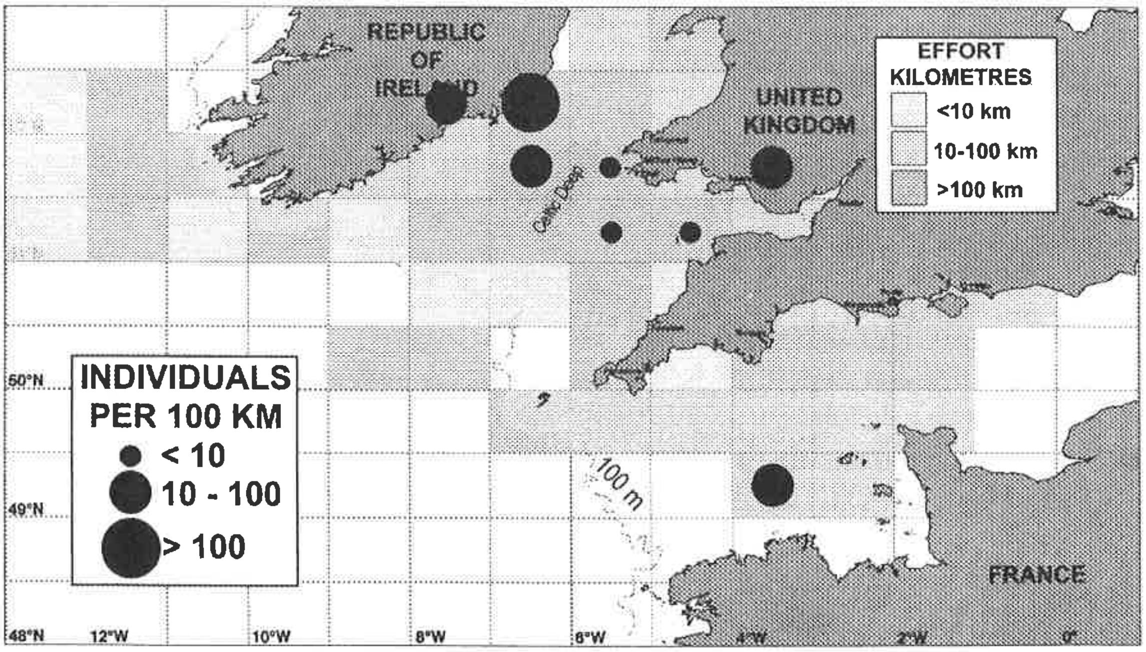


Fig. 2. Map of harbour porpoise sightings: numbers of individuals per 100 km. The 100m depth contour between Ireland and the UK is the Celtic Deep

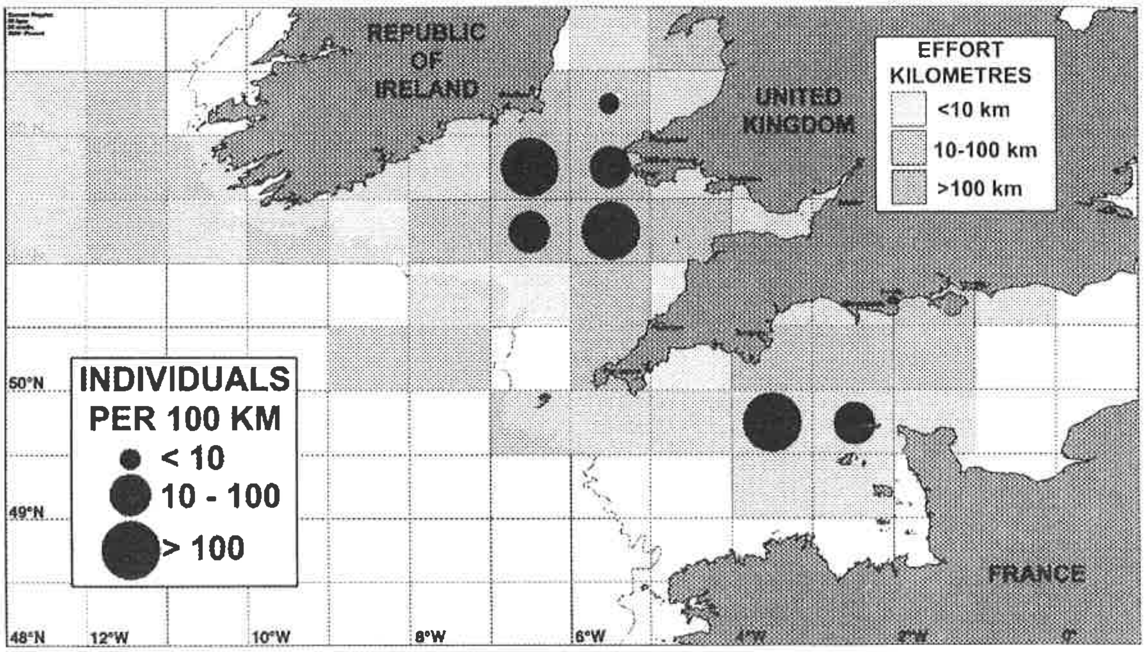


Fig 3. Map of common dolphin sightings: numbers of individuals per 100km

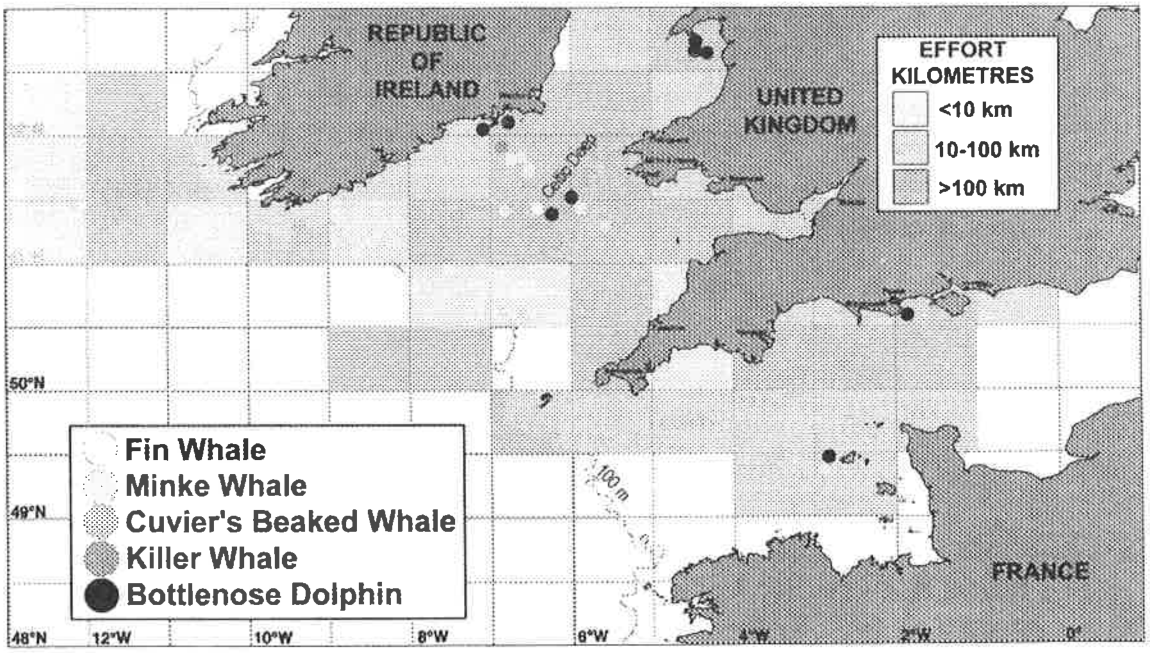


Fig. 4. Map of sightings of miscellaneous species. See Table 1 for numbers of individuals seen

THE OLD HEAD OF KINSALE, COUNTY CORK: THE BEST LAND-BASED WHALE-WATCHING SITE IN EUROPE?

P. Whooley

Irish Whale and Dolphin Group, c/o 21 Donnybrook Cottages, Douglas, Cork, Ireland

Between 16 June and 29 November 1999, 25 quantified effort watches were carried out, during sea-state 2, from the Old Head of Kinsale on the south coast of County Cork.

Cetaceans were seen on 88% of watches, including harbour porpoise (12 watches), common (7), Risso's (1) and bottlenose (1) dolphins and sei (6), minke (5) and fin (1) whales. On 24% of watches, more than one species was observed.

This poster reviews all historic and contemporary cetacean sightings from the Old Head of Kinsale. Sighting rates are compared to similar studies from other land sites both in Ireland and abroad, in order to assess the excellence of this location for whale-watching, and the relative importance of this habitat for cetaceans.

THIRTEENTH ANNUAL REPORT OF
THE EUROPEAN CETACEAN SOCIETY: 1999

Membership

Paid-up members of the European Cetacean Society numbered 391, including 13 institutional members, with members from 24 European and 16 non-European countries.

The highest representation came from Spain 88, with Germany at 51, Italy 47, United Kingdom 42, France 34, Portugal 32, Switzerland 12, The Netherlands 11, and Greece 11.

Countries with 10 or less members include USA, Belgium, Denmark, Ireland, Australia, Norway, Sweden, Croatia, Hungary.

Countries with one member only are Algeria, Austria, Brazil, Canada, Chile, China, Finland, Iceland, India, Israel, Japan, Malaysia, Maldives, Malta, Monaco, Morocco, Poland, Singapore, Slovenia, South Africa, Turkey, and Ukraine.

The Membership list of the Society continues to be run from the German Museum for Marine Research and Fishery in Stralsund, which also takes care of the mailing of material including Proceedings. The Society is very grateful to its director Harald Benke, and to Ines Westphal who is responsible for these tasks.

Conference

The 13th European Cetacean Society Annual Conference was held in the Palacio de Musica, Valencia between 5th and 8th April 1999. The theme was 'Marine Mammal Conservation for the New Millennium' with key lectures by Greg Donovan, Aleta Hohn and Bernd Würsig. It was attended by 325 people from 29 countries. The conference was organised by Toni Raga and team.

A conference scientific committee was chaired by Juan Antonio Balbuena and all abstracts were peer-reviewed and published in European Research on Cetaceans - 13, edited by Peter Evans, Joana Cruz and Juan Antonio Raga.

Workshops were held on 'Protected Areas', ' Research on Small Versus Large Seal Populations in European Waters, Opposite or Complementary Approaches?', and on 'Cetacean Pathology: Dissection Technique and Tissue Sampling in Large Cetaceans'.

Jacques-Yves Georges won the verbal presentation award, with Krishna Das as runner-up. Stephanie Plön won the poster prize.

Council

The ECS Council has met twice during the conference, and once in Cork in October.

Two newsletters were produced during the year, and a third special newsletter reporting the results of the protected areas workshop is due to be published shortly.

Jan Willem Broekema continues to manage the ever-expanding web site, and email mailing lists.

Finally, the European Cetacean Society has continued to provide information or advice to government departments and non-governmental organisations in European countries, with representation at both ASCOBANS and ACCOBAMS.

Nick Tregenza
Secretary

FINANCIAL REPORT FOR THE YEAR UP TO 1 APRIL 2000

	German account DM	**British account GBP**
Balance as of 1 April 1999	57.265,60	678.63
INCOME		
ECS account savings from 1998/99	57.265,60	678.63
Membership fee during the year 1999/2000	20.511,66	45.00
Profit, Conference Valencia / Monaco	3.500,08	868.80
Other payments (Sell of Proceedings, T-Shirts etc)	2.642,01	80.00
Interest on Savings account	1.074,84	9.22
Total Income	**84.994,19**	**1681.65**

EXPENSES	**German account DM**	**British account GBP**
Travel expenses board meeting 1999	-219,70	207.84
ECS-Newsletters (printing)	1.527,51	
ECS-Proceedings Monaco (printing & typing)	10.680,34	405.95
Secretarial Expenses (Address List)	304,00	
Postage (Newsletters, Proceedings, E-mail subscribtion, etc)	11.130,55	150.00
Bank account and credit card expenses	2.547,58	
Computer Support Group	0,00	
Total Expenses	**25.970,28**	**763.79**
Balance as of 1 April 2000	**59.023,91**	**917.86**
Total	**DM**	**61.869,28**
	(EURO	**31.633,26)**

Roland Lick
Treasurer

EUROPEAN CETACEAN SOCIETY – 2000

The **European Cetacean Society** was formed in January 1987 at a meeting of eighty cetologists from ten European countries. A need was felt for a society that brought together people from European countries studying cetaceans in the wild, allowing collaborative projects with international funding.

AIMS (1) to promote and co-ordinate the scientific study and conservation of cetaceans;
(2) to gather and disseminate information to members of the society and the general public.

ACTIVITIES The Society set up seven international working groups concerned with the following subject areas: sightings schemes; strandings schemes; cetacean pathology; bycatches of cetaceans in fishing gear; computer data bases that are compatible between countries; the harbour porpoise (a species in apparent decline in Europe, and at present causing serious concern); and a regional agreement for the protection of small cetaceans in Europe (in co-operation with the United Nations Environment Program/Convention on the Conservation of Migratory Species of Wild Animals, Secretariat in Bonn, Germany). Some of these have been disbanded now, having served their purpose, and other groups (such as one covering the Mediterranean Sea) have been established. The names and addresses of contact persons for all working groups are given at the end.

Contact persons have been set up in each European member country, where appropriate, to facilitate the dissemination of ECS material to members, sometimes carrying out translations into the language of that country. Their names & addresses are given below.

A newsletter is produced three times a year for members, reporting current research in Europe, recent publications & abstracts, reports of working groups, conservation issues, legislation & regional agreements, local news, and cetacean news from around the world.

There is an annual conference with talks and posters, and at which the annual general meeting is held. The results are published as annual proceedings, under the title *European Research on Cetaceans*. Besides the present volume, ten others have been published for conferences held in Hirtshals (Denmark) in 1987, Tróia (Portugal) in 1988, La Rochelle (France) in 1989, Palma de Mallorca (Spain) in 1990, Sandefjord (Norway) in 1991; San Remo (Italy) in 1992, Inverness (Scotland) in 1993, Montpellier (France) in 1994; Lugano (Switzerland) in 1995, Lisbon (Portugal) in 1996, and Stralsund (Germany) in 1997. In January 1998, the ECS joined with the Society of Marine Mammalogy (SMM) to hold the first World Marine Mammal Science Conference, held in Monaco. In April 1999, the annual conference was held in Valencia, Spain, and in April 2000 in Cork, Ireland.

At intervals, workshops are held on particular topics, and the results published as special issues of the newsletter: no. 6 - a workshop on the harbour porpoise, held in Cambridge (England), 1988; no. 10 - a sightings workshop held in Palma de Mallorca (Spain), 1990; no. 17 - a workshop to standardise techniques used in pathology of cetaceans held in Leiden (Netherlands), 1991; no. 23 - a workshop to review methods for the field study of bottlenose dolphins held in Montpellier (France), 1994; and no. 26 - a workshop for the diagnosis of by-catches in cetaceans held in Lugano (Switzerland), 1995.

Membership is open to *anyone* with an interest in cetaceans. The annual subscription is **DM 75** (=39 Euros) for full members; **DM 150** (= 77 Euro) for institutional members and **DM 45** (= 23 Euro) for student members. For members outside of Europe, an additional **DM 30** (= 15 Euro) will be charged for higher postage costs. Payment may be made at the Annual Conference in German Marks or the currency of the host country. During the year, payment must be in German Marks by **Eurocheque** or any other cheque drawn to a German bank, payable to the *European Cetacean Society* (you are advised not to send cash). Send cheques together with membership details to: European Cetacean Society, Mrs Ines Westphal, Deutsches Museum für Meereskunde und Fischerei, Katharinenberg 14-20, D-18439 Stralsund, Germany.

Membership fees can also be paid by **credit card** or **transferred directly** to the following ECS-account: Dr Roland Lick, Treasurer, ECS, Postbank Hamburg (FRG), Account No. 789584-205, Bank Code 200 100 20 (giving your name and calendar year for membership fee.) Payment in excess of the membership fee will be gratefully received as a donation to the Society.

OFFICERS AND MEMBERS OF COUNCIL: 1999-2000

Chairman:	Christina Lockyer
Secretary:	Nick Tregenza
Treasurer:	Roland Lick
Editor:	Peter Evans
Members:	Giovanni Bearzi
	Anne Collet
	Greg Donovan
	Jaume Forcada
	Beatrice Jann
	Emer Rogan
Student Member:	Simon Ingram

Chairman:
Christina Lockyer,
Danish Institute for Fisheries Research, Charlottenlund Slot, DK-2920, Charlottenlund, Denmark
(Tel +45 33 96 3373; fax +45 33 96 3333; e-mail chl@dfu.min.dk)

Secretary:
Nick Tregenza,
Beach Cottage, Long Rock, Penzance, Cornwall TR20 8JE, UK
(Tel +44 (0)1736 711783; e-mail nick@chelonia.demon.co.uk)

Treasurer:
Roland Lick,
Kaiserstrasse 27 B, D-24143 Kiel, Germany (Tel. +49 431 738942; e-mail rlick2059@aol.com)

Editor:
Peter Evans,
Sea Watch Foundation, 11 Jersey Road, Oxford 0X4 4RT, UK
(Tel./fax +44 1865 717276; e-mail peter.evans@zoology.ox.ac.uk)

Other Members of Council:

Giovanni Bearzi,
c/o Venice Natural History Museum, Santa Croce 1730, 30135 Venezia, Italy
(Tel: +39 0412750206; fax: +39 041721000; e-mail: bearzi@inwind.it)

Anne Collet,
Centre de Recherche sur les Mammifères Marins, Port des Minimes, 17000 La Rochelle, France
(Tel +33 546 44 9910; fax +33 546 44 9945; e-mail crmm@univ.lr.fr)

Greg Donovan,
International Whaling Commission, The Red House, Station Road, Histon, Cambridge CB3 0DL, UK
(Tel +44 1223 233971; fax +44 1223 232876; e-mail gdonovan@iwcoffice.org)

Jaume Forcada,
National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, CA 92038, USA
(Tel +1 858 5465681; fax: +1 858 5467003; e-mail Jaume.Forcada@noaa.gov)

Beatrice Jann,
Via Nolgio 3, 6900 Massagno, Switzerland (Tel/fax +41 91 9660953; e-mail jann@dial.eunet.ch)

Emer Rogan,
Department of Zoology, University College Cork, Lee Maltings, Prospect Row, Cork, Ireland
(Tel. +353 21 904053; fax +353 21 277922; e-mail rogan@bureau.ucc.ie)

Simon Ingram (Student Representative)
ADC, University College Cork, Lee Maltings, Prospect Row, Cork, Ireland
(Tel. +353 21 904053; fax +353 21 277922; e-mail singram@bureau.ucc.ie)

Working Group Contact Persons:

Computer & E-mail Support Group:
Jan Willem Broekema
Brikkenwal 20, 2317 GT Leiden, The Netherlands
(Tel. +31 71 5212076; e-mail j.w.broekema@inter.nl.net

Pathology:
Manuel García Hartmann
Duisburg Zoo, Mülheimer Str. 273, 47058 Duisburg, Germany
(Tel +49 203 3055900; fax +49 203 3055922; e-mail ha005ha@unidui.uni-duisburg.de)

Beaked Whales:
Colin D. MacLeod, Flat 2/2, 13 Kennoway Drive, Glasgow G11 7UA, Scotland
(Tel: +44 141 337 2209; e-mail: macleod_c@colloquium.co.uk)

Andy Williams, Biscay Dolphin Research Programme, 6 Manor Way, Lee on the Solent, Hampshire PO13 9JH, UK
(Tel/fax: +44 1705 552631; e-mail: Andy.Williams@Biscay-Dolphin.org.uk)

ECS Electronic Mail Addresses:
ECS-all@jiscmail.ac.uk
(An open list to which cetacean-related discussions, remarks, or requests can be sent.)

ECS-pathology@jiscmail.ac.uk
(A list for members with a special interest in the pathology and anatomy of cetaceans.)

ECS-news@jiscmail.ac.uk
(A list specially for students)

ECS-board@jiscmail.ac.uk (Closed list)
(For all messages to the ECS-board members. You may send, but cannot receive messages unless you are a board-member.)

ECS-sperm-whale@jiscmail.ac.uk (Closed list)
(A list for those with a special interest in sperm whales)

ECS-braer@jiscmail.ac.uk (Closed list)
(A list for the country representatives of the ECS)

ECS-all-request@jiscmail.ac.uk
(To reach ECS Computer Support Group)

TO BECOME A MEMBER OF A LIST, SEND THE FOLLOWING MESSAGE:

To: jiscmail@jiscmail.ac.uk
Subj:
Text: join ecs-all firstname.....lastname stop

The ECS Home Page can be reached at:
http://web.inter.NL.net/users/J.W.Broekema/ecs

The ECS mailing lists can also be reached through World Wide Web:
http://www.jiscmail.ac.uk/lists-a-e/ecs-all (or any other list)

For enquiries about the membership list (address, telephone, fax and email), and copies of ECS publications, please contact:

Dr Harald Benke, Deutsches Meeresmuseum, Katharinenberg 14-20, 18439 Stralsund, Germany
(Tel. +3831 26 50 21; Fax +3831 26 50 60; e-mail 101676.1264@compuserve.com

NATIONAL CONTACT PERSONS

Algeria Zitouni Boutiba, Institut des Sciences de la Nature, Laboratoire de Biologie et Pollution Marines, University of Oran, Es-Senia, 31000 Oran (Tel. +213 6 337048; fax +213 6 410078)

Belgium Claude Joiris, Vrije Universiteit Brussel, Laboratorium voor Ecotoxicologie, Pleinlaan 2, B-1050 Brussel (Tel. +21 2 629 3414; fax +32 2 629 3438; e-mail cjoiris@vnet3.vub.ac.be)

Croatia Danijela Miokovic, Rebar 145, 10000 Zagreb (Fax 385-1-210 361; e-mail: miokovic@Cim.Irb.Hr)

Denmark Jonas Teilmann, Center for Sound Communication, Institute of Biology, University of Odense, Campusvej 55, DK-5230 Odense M (Tel. +45 40 53 36 97; fax +45 65 32 47 04; e-mail danbiu@dk-online.dk

Faroe Islands Dorete Bloch, Museum of Natural History, Fútalág 40, F0-100 Tórshavn (Tel. +298 31 8588; fax +298 31 8589; e-mail doreteb@ngs.fo)

France Vincent Ridoux, Laboratoire de Biologie et Biochimie Marines, Université de La Rochelle, 15, rue de Vaux de Foletier, 17026 La Rochelle Cedex (Tel. +33 546 513922; fax +33 546 513942; e-mail vridoux@univ-lr.fr)

Germany Ursula Siebert, Forschungs- und Technologiezentrum Westküste, Universität Kiel, Werftstr. 6, D-25761 Büsum (Tel. +49 4834 604280; fax +49 4834 6772; e-mail usiebert@ftz-west.uni-kiel.de)

Greece Alexandros Frantzis, Institute of Marine Biological Resources, National Centre for Marine Research, Agios Kosmas, GR-166 04 Hellenikon (Tel: +301 8962730; fax: +301 8960108; e-mail afrantzis@mail.otenet.gr)

Hungary Hajnalka Elekes, 2800 Tataba'nya II, Erdèsz u 9, 1/4 (e-mail helekes@freemail.hu)

Iceland Jóhann Sigurjónsson, Marine Research Institute, Skúlagata 4, P.O. Box 1390, IS-121 Reykjavík (Tel. +354 1 20240; fax +354 1 623790; e-mail johann@hafro.is)

Ireland Emer Rogan, Department of Zoology, University College Cork, Lee Maltings, Prospect Row, Cork (Tel. +353 21 904053; fax +353 21 277922; e-mail rogan@bureau.ucc.ie)

Israel Oz Goffman, Israel Marine Mammal Research & Assistance Center - IMMRAC The Recanati Center for Maritime Studies, University of Haifa, Mount Carmel, Haifa, 31905 (Tel. +972 4 8240600; fax +972 4 8240493; e-mail: goffman@research.haifa.ac.il)

Italy Giovanni Bearzi, Tethys Research Institute, c/o Venice Natural History Museum
Santa Croce 1730, 30135 Venezia, Italy (Tel: +39 0412750206; fax: +39 041721000; e-mail: bearzi@inwind.it)

Malta Adriana Vella, Department of Biology, University of Malta, Msida (Fax: +356 32903049; e-mail avel@cis.um.edu.mt)

The Netherlands Richard Witte, National Institute for Coastal and Marine Management, P.O. Box 8039, 4330 EA Middelburg (Tel: +31 118 672 351; fax: +31 118 651046 e-mail R.H.Witte@rikz.rws.minvenw.nl)

Norway Arne Bjørge, Norsk Institut for Naturforskning - NINA, University of Oslo, PO Box 736, Sentrum, N-0105 Oslo (Tel. +47 22 940371; fax +47 22 940301; e-mail arne.bjorge@ninaosl.ninaiku.no)

Poland Iwona Kuklik, Hel Marine Station, University of Gdansk, 84-150 Hel, PO Box 37
(Tel. +48 58 750836; fax +48 58 750420; e-mail oceik@monika.univ.gda.pl)

Portugal Marina Loewenstein de Sequeira, Instituto de Conservação da Natureza, Rua Filipe Folque 46-3º,
P-1050 Lisboa (Tel. +351 1 3523018; fax +351 1 3574771; e-mail msequeira@mail.telepac.pt)

Slowenia Darja Ribaric, Slovenia Museum of Natural History, Presernova 20, 1000 Ljubljana
(Tel. +386 61 1258 472; fax +386 61 218846; e-mail darja.ribaric@guest.arnes.si)

Spain Juan Antonio Raga, Departamento de Biologia Animal, Universitat de Valencia, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain (Tel. +34 96 3864375; fax: +34 96 3864372; e-mail toni.raga@uv.es)

Sweden Patrik Børjesson, Department of Zoology, Stockholm University, S-10691 Stockholm (Tel. +46 816 4029; fax +46 816 7715, e-mail please@zoologi.su.se)

Switzerland Beatrice Jann, Via Nolgio 3, CH-6900 Massagno (Tel/fax +41 91 9660953; e-mail jann@dial.eunet.ch)

Turkey Bayram Öztürk, Istanbul University, Faculty of Fisheries, Ordu Cad. No. 200, 34480 Laleli Istanbul (Tel. +90 3239050; fax +90 216 3239050; e-mail ozturkb@istanbul.edu.tr)

United Kingdom Nick Tregenza, Beach Cottage, Long Rock, Penzance, Cornwall TR20 8JE (Tel +44 (0)1736 711783; e-mail nick@chelonia.demon.co.uk)

Ukraine Alexei Birkun, BREMA Laboratory, R. Luxembourg Str. 27-2a, Simferopol, Crimea, 333720 (Tel./fax +380 652 253503; e-mail alexei@birkun.crimea.ua)

INSTRUCTIONS FOR CONTRIBUTORS TO ECS PROCEEDINGS

Members of the European Cetacean Society are invited to submit summaries of their talk or poster for publication in the Society's Conference Proceedings. They can be half-page abstracts as submitted before the conference, or fuller papers up to five pages in length. The latter will be peer reviewed. If rejected for full publication, the abstract originally submitted will be used instead. Please use the format given below.

(1) Keep the text, references, and figures/tables to a total of no more than five pages (single-spaced). For those to whom English is not their native language, please ask an English speaker to check the entire text.

(2) Prepare all tables and figures in their final form (in black and white NOT colour), and provide the originals for camera-ready printing. Number every table and figure for cross-reference to the text. Place tables, then figures, in chronological order, and on separate pages to the text. DO NOT INCLUDE THEM WITHIN THE MAIN BODY OF THE TEXT. Re-size so they occupy as little space as possible whilst still being legible. Place Figure captions underneath each figure and Table captions above each Table, with Fig. 1, Table 1, etc. in bold type, lower case, and the caption itself in ordinary type, lower case and centred.

(3) Centre the title of your contribution, in capitals and bold type (latin names in the title should be in capitals and italics); two lines below place a list of authors in lower case ordinary type (with their initials/first names BEFORE the surname, and a space between initials); one line under this, use ascending numbers (Times font size 10, at 5-point position superscript) for the addresses of the respective authors.

(4) Place the main text two lines below the authors' addresses. Do not indent the first line but include one line space between paragraphs. Please use double-spacing for two of the three hard copies of the text.

(5) Use common (vernacular) names of species in preference to Latin names, but on the first occasion only, please use both. All Latin names should be in italics and in parentheses. References in the text should be written as follows: (Capelli *et al.*, 1979; Di Sciara, 1982). Note the commas between name and year.

(6) Sub-headings such as **INTRODUCTION**, **MATERIALS AND METHODS**, **RESULTS**, **CONCLUSIONS**, and **ACKNOWLEDGEMENTS** should be in the body of the text, at the left edge, but **REFERENCES** should be centred. There is no need for an abstract of any five-page contribution.

(7) Check references carefully to ensure they are complete, including full title and page numbers. Place in ordinary type (except for book titles which go in italics), in Times font, size 10 pt, as follows:

Aguilar, A. and Jover, L. 1982. DDT and PCB residues in the fin whale, *Balaenoptera physalus*, of the North Atlantic. *Rep. int. Whal. Commn*, 32: 299-301.

Sequeira, M. L. 1990. On the occurrence of Ziphiidae in Portuguese waters. Pp. 91-93. In *European Research on Cetaceans - 4*. Proc. 4th Ann. Conf. ECS, Mallorca, 2-4 March, 1990 (Eds. P. G. H. Evans, A. Aguilar & C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

Stewart, B. S. and Leatherwood, S. 1985. Minke whale *Balaenoptera acutorostrata* Lacépède, 1804. Pp. 91-136. In *Handbook of marine mammals*, vol. 3. (Eds. S. H. Ridgway and R. J. Harrison). Academic Press, London. 430pp.

(8) Please provide either half-page abstracts or longer five-page contributions both as hard copies and on CD/floppy disc, using Microsoft Word, and Times font, size 10 throughout. **Do not send only by e-mail**. Include three copies of the longer contributions (two of which will go to independent referees).

PLEASE ENSURE THAT YOU FOLLOW THE ABOVE INSTRUCTIONS AND SEND TO THE EDITOR BY 30TH JUNE. IF YOU DO NOT COMPLY WITH INSTRUCTIONS, OR ARE LATE, YOUR PAPER MAY NOT BE INCLUDED.

Dr Peter Evans, Department of Zoology, University of Oxford, South Parks Road, Oxford 0X1 3PS, UK
(Tel/Fax 44-1865-717276; e-mail peter.evans@zoology.ox.ac.uk)

INDEX

INDEX