EUROPEAN RESEARCH ON CETACEANS - 10

PROCEEDINGS OF THE TENTH ANNUAL CONFERENCE OF THE EUROPEAN CETACEAN SOCIETY, LISBON, PORTUGAL

11-13 MARCH 1996

EDITOR: P.G.H. EVANS

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INTRODUCTION

The Tenth Annual Conference of the European Cetacean Society was held in Lisbon, Portugal between 11th and 13th March, 1996. It was attended by 301 persons from 27 countries - the biggest number yet and greatest range of countries represented. The Society is very grateful to Marina Sequeira and her team of assistants, particularly Monica Silva, for organising such a successful and enjoyable conference, and to the following generous sponsors: EXPO-98, Oceanario de Lisboa, Instituto da Conservaçao da Natureza, Fundaçao Calouste Gulbenkian, and Câmara Municipal de Lisboa.

The Proceedings that follow are abstracts of the talks and posters presented at the conference. As always, the contributions have been edited only to improve clarity and to maintain a uniformity of presentation. The main purpose of the Proceedings is to report upon research conducted by European marine mammalogists, as presented at the Society's Annual Conference. Their value is seen as the rapid communication of results of studies currently underway, or recently completed. However, no external refereeing has taken place, and much of the material presented here it is hoped will eventually be formally published in greater detail in scientific journals.

I have tried to arrange the abstracts broadly by subject, and for this reason, the invited key note lectures are slotted into appropriate spots through the volume. I would like to take this opportunity to give warm thanks to the invited speakers who often travel great distances to address the society: Scott Kraus from the United States, Michel Milinkovitch from Belgium, and Lex Hiby and Tony Martin from England. The theme that invited speakers were asked to address was "Population Biology in relation to Conservation".

Two special workshops were held during the Annual Conference: one was on "cetacean monitoring programmes - theoretical and practical considerations", organised by Peter Evans, and the other was on "cetacean lung morphology", organised by Manuel Hartmann. It is planned to publish the papers associated with both workshops as special newsletters.

Finally, I should like to thank Kirsten Young and Ed Parsons for their most valuable assistance with the typing and editing of these proceedings.

Peter G.H. Evans

NORTH ATLANTIC RIGHT WHALES: CAN WE STOP EXTINCTION?

S. D. Kraus

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About 300 North Atlantic right whales exist today, with most occurring in habitats along the eastern shore of North America. At least one third of all mortality in this species is due to collisions with ships and entanglements in fishing gear. Efforts to reduce human causes of mortality include restrictions on certain types of fishing gear and research to determine the acoustic and hydrodynamic features of large ships. In addition, to reduce the probability of ship/whale collisions, we conduct daily aerial surveys over the calving ground off the southeastern U.S. from December through March to provide an "early warning system" for all shipping activity in the region. All sightings of right whales are relayed through radio, fax and telex to all ships, dredges and military vessels operating in the area. Dredges within 10 miles of a right whale sighting slow all subsequent nighttime operations to five knots to give whales a chance to get out of the way. Despite these efforts, mortalities from both shipping and fishing activities still occur.

In addition, this population is displaying signs of reproductive failure. In the 1980's, North Atlantic right whales produced an average of 1 1 calves per year. From 1989 to 1992, the average was 14, but from 1993 through 1995, only seven calves were born per year. We are aggressively pursuing three possible hypotheses for this: inbreeding depression, food limitation, and pollutants (possibly including hormone mimics). Any one of these may be responsible for the observed low reproductive rate, but deter mining causes and effects will probably prove extremely difficult. It remains an open question whether right whales will survive, but it is clear that management of this species requires both reducing human causes of mortality, and attempting to maximise the ability of right whales to breed.

USING SATELLITE TELEMETRY TO AID THE CONSERVATION AND WISE MANAGEMENT OF BELUGA (*DELPHINAPTERUS LEUCAS*) POPULATIONS SUBJECT TO HUNTING

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The beluga (*Delphinapterus leucas*) has a near-continuous circumpolar distribution, but this range is occupied by a number of distinct populations, most of which have been subjected to hunting. The virtual absence of belugas in areas where thousands were once killed demonstrates that the species can easily be over-exploited. However, the lack of even basic information on abundance, migrations and sustainable yields means that we are not in a position to prevent these mistakes being repeated on other stocks.

Over the past eight years, collaborative satellite telemetry studies between the UK Sea Mammal Research Unit and partner institutes throughout much of the beluga's range have resulted in greatly enhanced knowledge of the species' ecology, behaviour and movements. Over 60 transmitters have been deployed on whales of four different populations, yielding data on movements, physiology, foraging and diving behaviour, surfacing patterns and habitat usage. In turn, this information has been used to provide calibrations of aerial survey results and likely harvesting pressures based on an assessment of which hunting communities are on migration routes.

Results are presented for two contrasting beluga populations, each of which summer in Canadian waters but cross at least one international frontier on their seasonal migrations. Both are currently harvested by Inuit, but one is large enough to sustain the pressure and the other is not.

Satellite telemetry has proved to be a powerful and cost-effective tool in the formulation of management and conservation programmes for belugas. The technique has its limitations and is not cheap, but for cetaceans in remote or extreme habitats, it provides exciting pure and applied data that could not be gathered in any other way.

CAN WE CONSERVE RIVER DOLPHINS? STUDIES OF A BOTO (*INIA GEOFFRENSIS*) POPULATION IN A BRAZILIAN FLOODED RAINFOREST RESERVE

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River dolphins of the superfamily *Platanistoidea* are suffering greatly as humans fragment and pollute their habitat, deplete their food resources, and kill them in fishing gear. Two of the five species could become extinct in our lifetimes. Although the boto is also adversely affected by human activity on a local and increasing scale, it has a wide distribution and is numerically secure at present. As such, it presents our species with an opportunity to learn from past mistakes and take action now to prevent the boto following in the path of the baiji and bhulan.

We present the initial results of a study of the boto in seasonally-flooded rainforest of the middle Amazon. A major objective is to assess the effectiveness and practicality of setting up refuges for this and other threatened Amazonian fauna. Radio telemetry and boat-based observational work of uniquely-marked individuals was used to investigate the spatial distribution and varying abundance of dolphins in the 1.1 million hectare Mamirauá Reserve.

Most of the sixty known animals remained within, or close to, the Reserve year-round, but some were seen up to 100 km away and one travelled some 1,500 km upstream to Peru. Daily movements of up to 20 km in are common, but animals may remain for weeks within a three kilometre stretch of water. Boto density averages about two per km, and group size is typically 2-10, but up to 20 animals may gather at any of the five most favoured localities within the core area of the Reserve. Here, the 44 km of waterway vary in width between 50 m and 400 m and hold between 26 and 106 botos, depending on the water level. The only stable association is the mother/calf bond, which appears to last for a little less than two years.

A PRELIMINARY EXAMINATION OF THE CONSERVATION STATUS OF HONG KONG'S CETACEANS

E. C. M. Parsons[1] and C. C. Hoffmann[2]

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Hong Kong is situated on the south coast of China (22°20'N 14°10'E). The territory covers an area of 1,150 km^2, encompassing 253 islands, and is one of the most densely populated urban areas in the world. Hong Kong has records of 15 species of cetaceans, mostly from stranding. Only two species are thought to be resident year-round: the finless porpoise (*Neophocaena phocaenoides*) and the Indo-Pacific humpbacked dolphin (*Sousa chinensis*) (Parsons *et al.*, 1995).

The status of the Indo-Pacific humpbacked dolphin (*Sousa chinensis*) population(s) in the South China Sea is not known. In Hong Kong, this species primarily occurs in the waters around Lantau Island. This area also coincides with intensive shipping activities, a large fishing fleet, Chek Lap Kok airport, which is the largest civil construction project in the world to date (Greeman, 1995), a new container receiving terminal, contaminated mud pits and over 11,000 sewage outfalls (Hoffmann, 1995; Fig. 1). One current population estimate of Hong Kong's humpbacked dolphins, based on a photoidentification study, is approximately 85 individuals (L. J. Porter, unpubl. data) However, line transect studies based on boat surveys give an estimate of approximately 200 animals (T. A. Parsons, unpubl. data). In 1994/1995 a total of nineteen *S.chinensis* mortalities were reported (Parsons 1996). Preliminary population models based on the above population estimates hypothesise that with the current mortality rate thought to be around 10-20%, extirpation could occur within the next 10-20 years.

Roughly 30 high-speed ferries pass through the area of greatest dolphin abundance daily. In addition to these up to 200 vessels may be present in the area at a given time (Hoffmann, 1995). The noise from these type of vessels has been demonstrated to be harmful to small cetaceans (LGL, 1991). The Hong Kong fishing fleet numbers more than 4,800 vessels consisting of pair trawlers, stern and shrimp trawlers, long liners, gill-netters and purse-seiners (Hoffmann, 1995). There are currently no fisheries regulations in Hong Kong except a ban on the use of explosives, electricity and poison. As a result of unchecked exploitation, over-fishing occurs (Richards, 1985).

Two-thirds of the natural North Lantau coastline, a potential dolphin habitat with fish nurseries, have been destroyed through construction in the last three years. Massive explosions occurred on the airport platform during the construction process. Construction related activities have led to a dramatic increase in boat traffic and decrease in water quality in North Lantau waters.

Three main sewage outfalls discharge 139,000t/d of raw sewage from Lantau Island, and this is forecast to triple in the next five years to 384,000t/d. Additionally, 11,000 other outfalls also drain into north Lantau waters. In total, Hong Kong presently discharges over two million t/d of raw sewage into its waters (EPD, 1995). By comparison, the whole of the UK currently discharges 1.14 million t/d of raw sewage.

Concerns over the dolphins' welfare have led to proposals for the establishment of a marine park with the express purpose of acting as a dolphin sanctuary (Parson & Porter, 1994). Government plans for a 12km^2 marine park in north Lantau waters (Fig. 1) are considered to be woefully inadequate since the area is comprised by shipping, fishing, dredging, contaminated mud pits, large quantities of raw sewage, and development projects associated with the airport (Hoffmann, 1995; Fig. 1), At present the only proposed restrictions for the area are bans on trawling and a 10-knot speed limit. Leisure activities such as wind-surfing, jet-skiing, and water-skiing will also be banned, but none of these are currently carried out in the area anyway.

In order for the proposed marine park to make a significant biological and conservation contribution for the benefit of the dolphins, the changes to the current proposal are necessary. A marine reserve, which is larger and more restricted, is called for. Shipping and fishing activities must be significantly curtailed, and further construction prevented, if the marine park is to be more than a dolphin sanctuary in name only (Hoffmann, 1996a).

Little is known about the other local cetacean species thought to be a resident - the finless porpoise (*Neophocaena phocaenoides*). Preliminary observations suggest that calving appears to take place during the winter months (Parson and Wong, 1995). Their boat -shy behaviour and inconspicuous appearance has made population estimates unsuccessful. An acoustic population survey has been proposed to overcome the inherent limitations of visual techniques when applied to finless porpoises (Hoffmann, 1996b).

In January 1996, six finless porpoise stranding were reported. This is more than the five strandings reported for the whole of 1994, and only one short of the seven reported in 1995. Two of these fatalities had wounds suggestive of boat impacts, and at least one recent and several previous fatalities (Parsons, in press) were apparently the result of fisheries bycatch. One-third of finless porpoise strandings reported in Hong Kong are young calves (Parsons, 1996). Until population estimates can be made, the status of the population is unresolved.

The waters south-west of Lantau Island, and around the Soko Islands, have recently been put forward as the possible site of an additional marine park and reserve (Hoffmann, 1995). The presence of Indo-Pacific humpbacked dolphins as well as finless porpoises, and the less compromised marine environment, were the main considerations for this suggestion.

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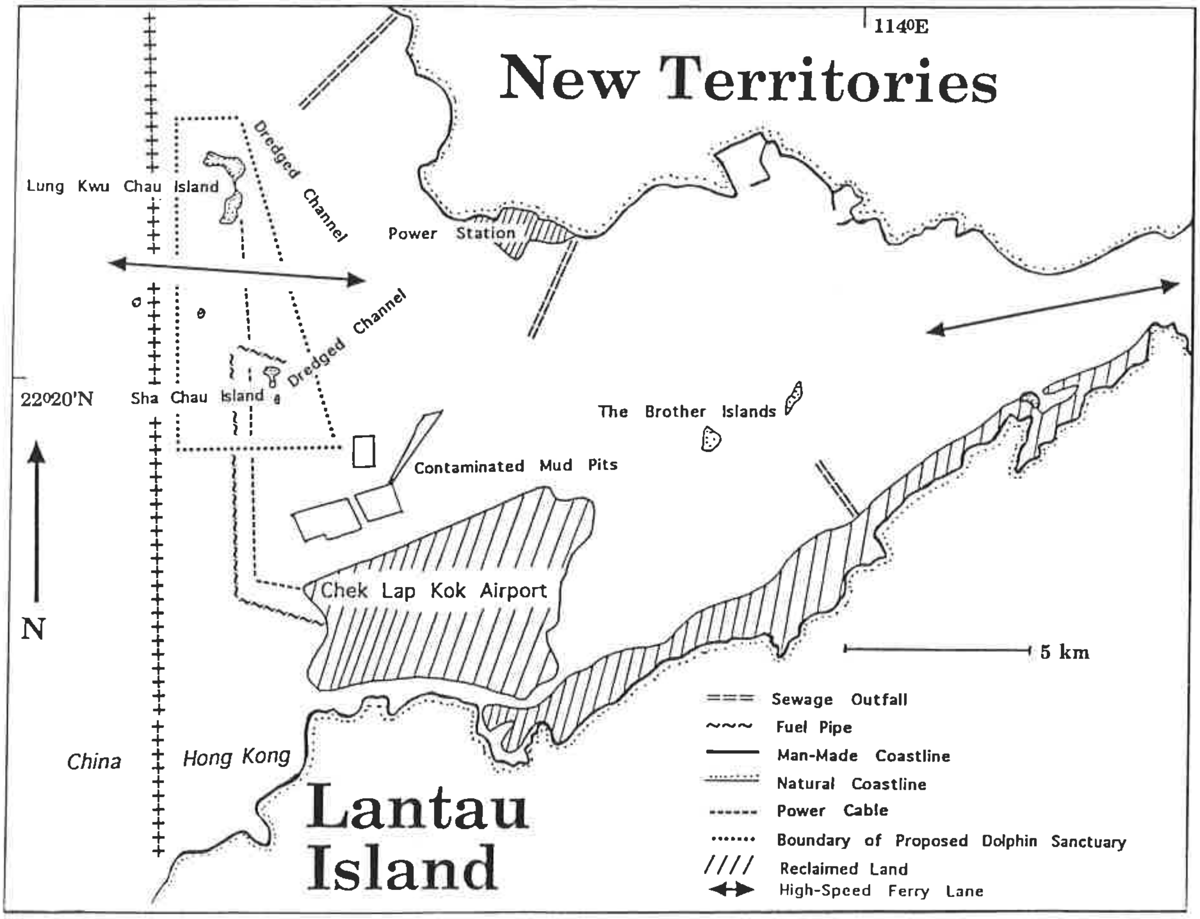

Fig 1. Some factors affection the North Lantau Marine Environment (after Hoffmann, 1995)

DOLPHIN HOME RANGE AND RESERVE ZONATION: Do we need field studies to define management policy?

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INTRODUCTION In Brittany, a Marine National Park, mainly dealing with the marine areas surrounding the western islands, is proposed. These sites have already been given conservation status at various levels including a biological reserve, a regional natural park and a "Man And Biosphere" (MAB) reserve. The zoning and management rules of the future Marine National Park have to be defined. For the last three years, we have been working on marine mammals in this area, mostly on bottlenose dolphins, to study their home range, habitat use, and activity budgets in relationship with various environmental parameters. These studies on marine mammal home range have been undertaken in order to help the administration define the protected areas.

DEFINING DOLPHIN HOME RANGE: THE SCIENTIFIC APPROACH

In Brittany, two groups of bottlenose dolphins are resident year round. Sixteen dolphins dwell in the vicinity of Sein island, whereas the group at the Molene archipelago is estimated at about thirty. Moreover, about fifty grey seals are observed around the Molene archipelago, amounting to about half the French population of this species. In these two sites, the main work was to map habitat utilisation by the two coastal groups of bottlenose dolphins.

At Sein island, we have started the study of habitat use since spring 1993, and field sessions have been performed once every two months. For Molene archipelago, the first field work took place during summer 1992. Additionally, we have had the opportunity to resume this habitat use study on a monthly basis since June 1995. Data have been collected by tracking the animals from a rubber boat, recording the dolphins' location, group size, and activity every five minutes. During each summer session, about 500 sets of data were recorded, whereas during other seasons, sample sizes were only half of this due to difficult sea conditions. Their home ranges have been mapped either on a 200 m or 500 m cell-sized grid, according to the study site. The intensity of space utilisation is shown as peaks on this three-dimensional map, indicating the number of sightings obtained in the corresponding cells of the grid. For each field session, the presence of dolphins per observation effort is given.

Sein island (Fig. 1) The annual, diurnal home range of bottlenose dolphins surrounding the inhabited island is about 4 km long and less than 5 km^2. During summer, the entrance of the harbour, in the northeastern part of the area, is mainly used from June to September. The dolphins' presence corresponds to 88% of the observation effort. By contrast, the group is restricted to the western part during other seasons (from October to May), and the ratio is 93%. Dolphins of Sein Island seasonally change their habitat use but no interannual variation of their home range has been observed during the three years of study.

Molene archipelago During summer 1992, the dolphins' diurnal home range is about 20 km long and 70 km^2 in surface area, which is fourteen times as important as around Sein Island. They concentrate their activities in the western part of this area, and the ratio is only 30% due to the large extent of their home range making more difficult to find them at sea (Fig. 2). During the same period, the presence of grey seals on haul-out sites was recorded. From this summer study undertaken for the MAB reserve, a zonation was proposed for areas of interest to marine mammals. This zone includes the entire summer home range of the bottlenose dolphin, as mapped in 1992, and the majority of the grey seal haul-out sites. In 1995, dolphins changed their range, using mainly the S.E. zone of the archipelago near the mainland, indicating that habitat use can change from year to year (Fig. 3). Consequently, the zoning proposal obtained from the summer 1992 study does not correspond well to the dolphins' home range observed in 1995. In fact, our proposition of protected areas was too close to the observed zone to be able to cope with interannual variability. However, scientific studies of habitat use by marine mammals can produce very detailed mapping of home range and activity.

DEFINING RESERVE ZONATION: THE ADMINISTRATIVE APPROACH The administration has recently proposed a zoning scheme for the Marine National Park which differs from the one based upon our marine mammal studies. Their proposition for the Molene archipelago is about three times larger and, consequently, may appear to be more robust and adapted to cope with temporal variations in space utilisaton by marine mammals . But their zoning proposal is due to the inheritance of a long series of different conservation proposals dating back to the early 1960's.

The historical background (Fig. 4) In 1960, about twenty islets and rocks of the Molene archipelago and Ouessant Island became a biological reserve, and this was extended to three additional islands of ornithological interest in 1972. The management is assumed by a Regional Trust for Nature Conservation in Brittany. The solely terrrestrial regulation deals with almost inaccessible and small sites. In 1969, several districts decide to join to form a regional natural park. They used the 20 m depth contour as their marine limit, which generally encompasses the submarine shelf surrounding the islands, although no marine regulation occurs. Mayors can only decide for terrestrial management, and the main objective of their policy is to take advantage of a preserved environment to develop sustainable tourism. This mostly applies to the inhabited zones, and not at all to marine areas. In 1988, the MAB reserve was created by UNESCO. The marine limits defined are the ones of the regional natural park. The reserve is divided into three zones : the central one corresponding to the biological reserve, where terrestrial regulation already exists, and the buffer and transition zones including inhabited, tidal and marine areas. The MAB reserve status does not allow terrestrial and marine regulations and does not add any new management rules. It simply makes easier and more homogeneous, scientific surveys of the environment, with a growing emphasis on marine ecosystems. Studies are aimed at estimating the biological value and the biodiversity of this area, including marine mammals, in order to propose zonation schemes and regulations for the future Marine National Park. Administrative processes for setting protected areas are well established because of their traditional importance. However, only terrestrial regulation of uninhabited zones currently exists, avoiding conflicts with human activities on the islands. The whole marine habitat remains unprotected owing to the lack of appropriate legislation at sea.

DEFINING MANAGEMENT RULES: BOTH APPROACHES In the framework of the Marine National Park project, zonation and management rules have to be defined, especially for the marine environment according to the needs of each site. The limits proposed by the administration could be the largest zone mostly devoted to sustainable development aims, whereas the zones recommended from scientific studies would describe the core area where human activities can be more closely controlled to reach conservation objectives (Fig. 4). In this context, regulations must be based on a detailed knowledge of the marine ecosystem. However, traditional human activities, like fishing or kelp harvesting, must also be taken into account, and a study of their environmental consequences is necessary to establish marine rules. Another potential threat is tourism which though very low today and concentrating on the terrestrial parts of the inhabited islands, may increase dramatically and extend to marine habitats with the creation of the Marine National Park, and also with the needs of the insular villages to find new income for their maintenance. Although apparently in conflict, human activities and biological conservation will have to co-exist within the framework of the Marine National Park. Only a detailed knowledge of the marine environment can provide management regulations acceptable to both parties.

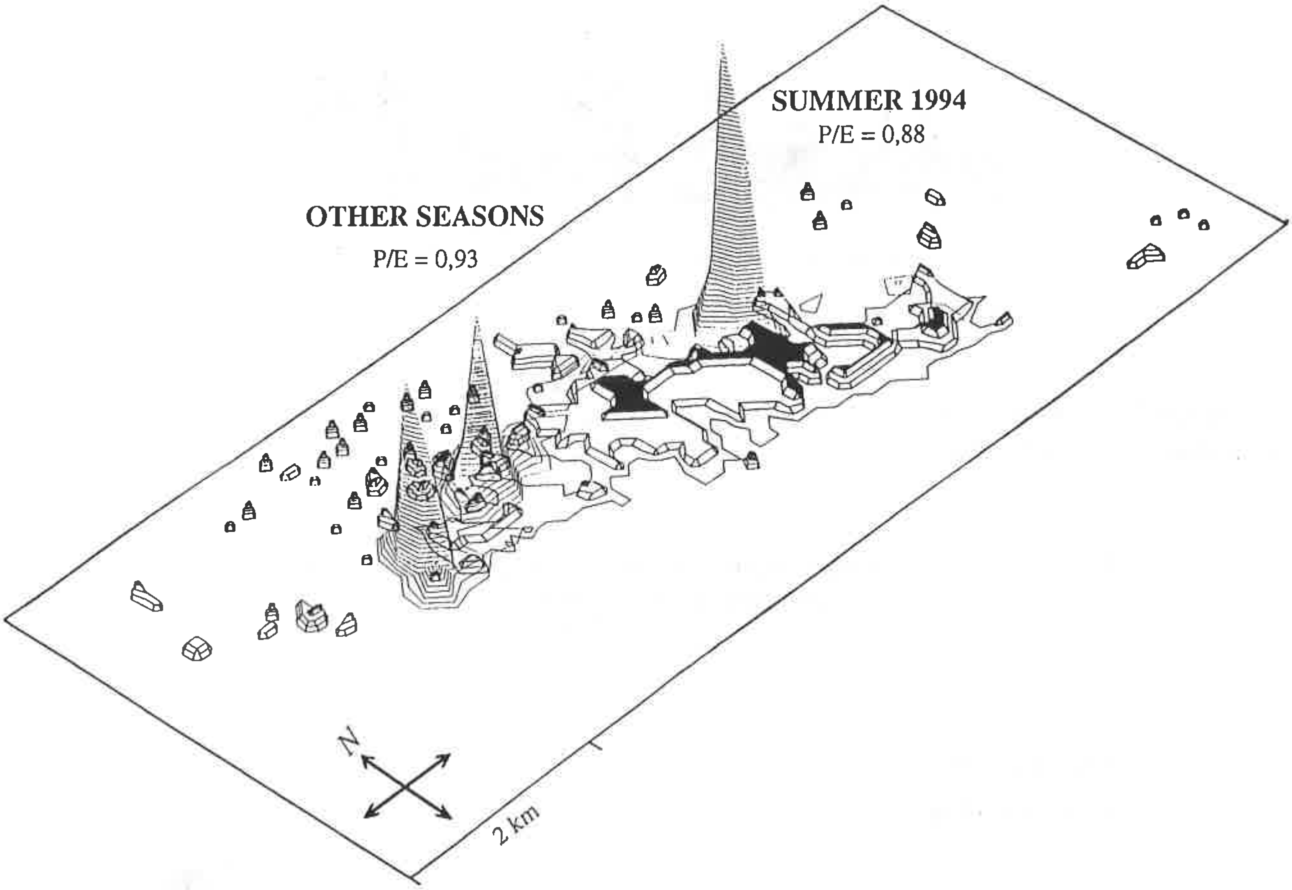

Fig. 1 Seasonal variation in dolphins' habitat use at Sein Island

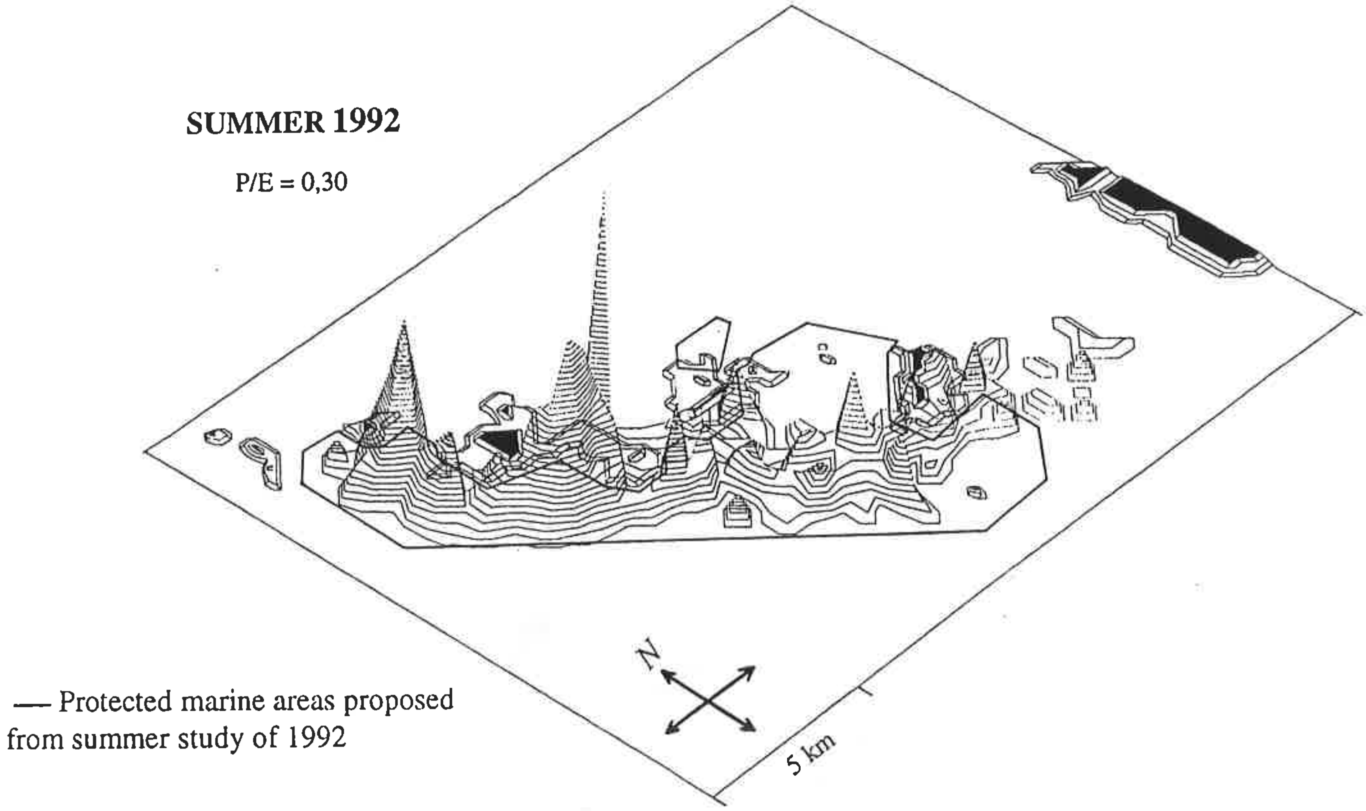

Fig. 2 Dolphins' habitat use at Molene archipelago, and zoning proposal during summer 1993

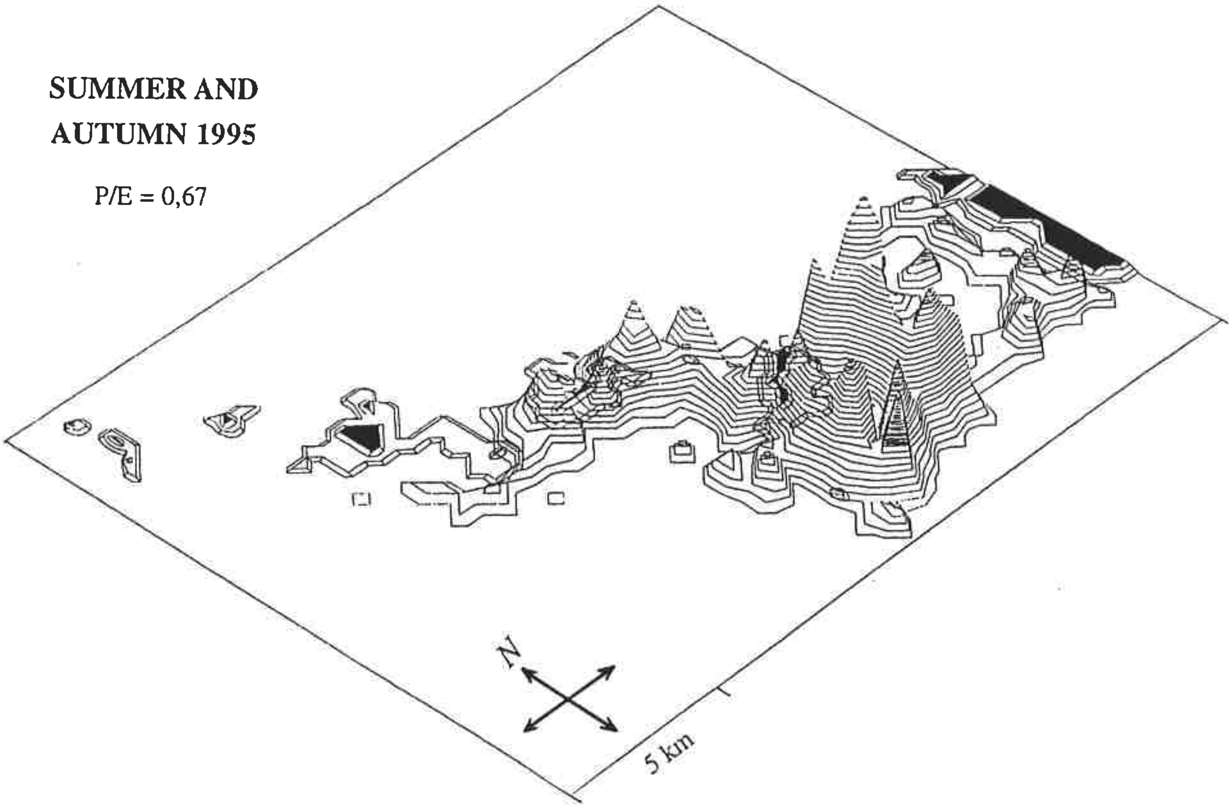

Fig. 3 Dolphins' habitat use at Molene archipelago during summer and autumn 1995

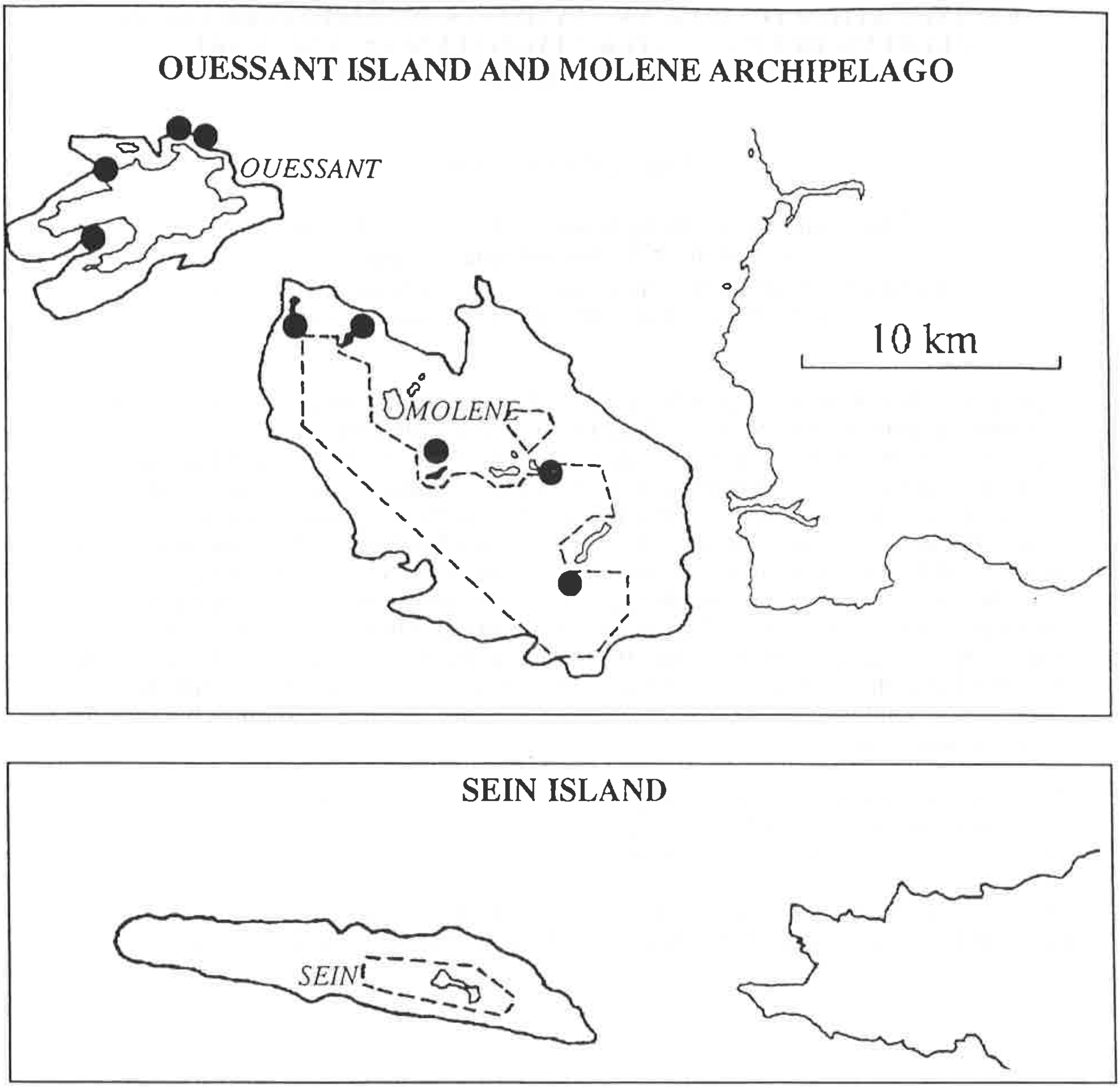

Fig. 4 Different conservation status of the western islands of Brittany and zoning proposals for the Marine National Park project

1960 and 1972 - Biological Reserve ●
1969 - Regional Natural Park —
1988 - Man And Biosphere Reserve
Limits : similar to the Regional Natural Park (20m depth)
Central zone : similar to the Biological Reserve
Buffer and transition zones : inhabited, tidal and marine areas
In project - Marine National Park
Zoning proposed by administration : similar to the Regional Natural Park
Zoning proposed from marine mammals' field studies ---

EXPLOITATION OF MARINE MAMMALS BY MEDITERRANEAN PEOPLES DURING LATER MAGDALENIAN AND EARLY EPIPALAEOLITHIC PERIODS (12,-10,000 BC)

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During an archaeological study in Nerja Cave (Malaga, Spain) a number of bone remains of marine mammals from the Later Magdalenian and Early Epipalaeolithic levels were examined. Samples were identified as belonging to specimens of the Mediterranean monk seal and dolphins, probably common dophins. Most remains of the monk seals appeared in the Early Epipalaeolithic level, whereas those of common dolphins were found only in the Magdalenian one. According to the abundance of these remains, monk seals could be one of the most common prey of humans of this area during the Early Epipalaeolithic, which in turn might suggest that this pinniped species could have been abundant during this period. The marks, fractures and bums detected on the bones indicate that people exploited not only the meat, but also the skin and fat of the seals. On the other hand, the findings of fishing gear and remains of pelagic fishes within the cave suggest that dolphins may have been obtained not only through strandings but also by means of active capture.

The analysis of the zoomorphic wall paintings of this period found in Nerja Cave led to the identification of several monk seal drawings. This finding constitutes one of the oldest records of a marine mammal representation made by humans.

Overall, this evidence points to the great importance played by marine mammals, particularly the monk seal, in the life of these early Mediterranean human settlings.

CETACEAN BYCATCH IN SET GILLNETS IN THE CELTIC SEA

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INTRODUCTION In the winter of 1991-92, over 100 common dolphins stranded on the shores of South-west England. Pressure through television and radio extracted reluctant agreements from local fishermen to take observers onboard fishing vessels. European Commission funding was obtained by the Sea Mammal Research Unit and enabled Simon Berrow to set up a similar observer programme in South-west Ireland where he had already established a good relationship with the fishing industry.

METHODS All the observers were volunteers. The boats were offshore gillnetters, which are mainly around 18m long and set gillnets on the seabed to catch hake. Each boat sets about 10 km of net, steams around the area to keep trawlers away, and then hauls the net in with the catch after about 20 hours of immersion.

RESULTS The extent of the study was 85 trips, 330 days at sea, 2,900 km of net set, and 56,000 km.hrs of net immersion. Mammal bycatches consisted of 43 harbour porpoises (*Phocoena phocoena*) and four common dolphins (*Delphinis delphis*).

Common dolphins are commoner than porpoises in the Celtic Sea but only 1/10th as many are caught, so, taking just three conclusions from our study concerning common dolphins :

- They are seen much more often in winter and were only caught then;
- They seem to get caught during shooting and hauling of the net and one out of four was alive;
- They seem to be most strongly attracted to the boats by the actual shooting of the net. It may be that they like the sound of the headline floats clattering against the hull as the net is shot!

Fishing effort is measured as km.hrs of immersion for the map, since this appears to be the most relevant measure of effort for porpoise bycatch. One area has many bycatches, but it also had the highest concentration of fishing effort. Only one out of 43 porpoises was alive, but in a very bad state. Our findings support the established view that porpoises get caught near the bottom while the net is set.

We had not expected that about half the porpoises were so lightly entangled that they dropped out of the net spontaneously, or with a bit of shaking by the fishermen. Fortunately, we noticed 'dropouts' early on and were able to tell our observers to look at the rising net all the time. Sometimes this is not possible in these small and dangerous boats.

Our observers also saw some dead porpoises floating near the boat during or just after hauling. These 'floaters' are either 'dropouts' that have been overlooked, or have dropped out below the surface and floated up. They were only spotted in calm seas, which makes it very uncertain how many we might be missing.

We have looked for determinants of bycatch. Bycatches occurred at depths ranging from 50 m to 225 m with no hint of a trend in rates in relation to depth. Tidal speed did show a significant correlation, however. More porpoises get caught at neap tides when current speeds are lower, but we do not know how to interpret this because we have thought of five quite plausible factors which might produce this relationship, and only one working the other way. Nets are only set during neap tides because the fast currents of spring tides flatten and tangle the nets.

Two types of hake net were in use: one had two footropes, with the upper rope being about so far off the sea bed. This should make the net more acoustically detectable to a porpoise, but we found no difference in bycatch rates.

A few tangle nets which have no headline floats were set and caught one porpoise, giving them the highest but most uncertain bycatch rate. Tangle nets are set for a few days at a time, and the porpoise which was caught in such a net showed tissue loss around the eye due to scavengers.

UK observers put plastic tags offering a reward on dead porpoises which were discarded at widely dispersed sites, but none have been recovered.

We were able to calculate bycatch rates, and this is the easiest form in which to remember them. One kilometre of net fishing continuously would catch seven porpoises in 365 days, only one less than the number of letters in porpoise, or marsouin.

The SCANS survey tells us that there are about 0.18 porpoises per sq. km in the Celtic Sea so, if bycatch follows a simple relationship, a factor 'k' can be calculated to represents the lethality of the gear, or the 'kill factor'. In words, 'k' is 'the number of porpoises caught per 10,000 km.hrs of net use per porpoise per sq.km living in the area of the fishery'. 'k' can then be compared between different studies and will give us insights into the variety, or the uniformity, of the porpoise entanglement process in different situations and fisheries. The only one we have been able to extract from the literature so far is for the cod fishery in the Skaggerak, studied by Per Berggren and Julia Carlstrom, and that gives an almost identical value for 'k'.

To estimate the bycatch in the whole hake fishery in the Celtic Sea, we have applied bycatch rates per trip for Irish boats, and per day at sea for UK boats to official statistics. The estimate and 95% CI for the Irish fleet is then 1,500 (550-2,500), and for the UK fleet, 740 (400 - 1,100) The result is a figure of 2,200 porpoises per year with a 95% confidence range of 1,000-3,500.

The central figure represents a 6.2% take from the 36,000 porpoises estimated to be in the Celtic Sea in summer in the SCANS survey. This is very high; several models of porpoise population dynamics have given estimates of potential growth of around 4 to 5%, with only the highest estimates coming out at around 10%. Not only is the figure high, but it excludes all French fishing, and all boats using exclusively tangle nets, all UK boats under 15 m and all boats under 10 m. The UK list includes 13 Spanish freezer-netters setting 100-300 km of tangle net, usually on the edge of the shelf to the north, but occasionally in the Celtic Sea.

DISCUSSION The context of this problem is not encouraging. To the south is Brittany where older people remember many porpoises but few are now seen, and the netting industry is huge and growing. To the east is the Channel where commercial porpoise fisheries once existed, but now there are very few, and the same zone of severe depletion extends into the southern North Sea. To the north is the west coast of Ireland, with only a narrow continental shelf, and the Irish Sea. In these areas, porpoises still exist in relatively large numbers.

And what of the fishermen? They are not happy either. They took us to sea because of common dolphin deaths and now they hear us talk about porpoises, an animal which some of them still believe belongs to the group of animals, the fishes, that belongs to them.

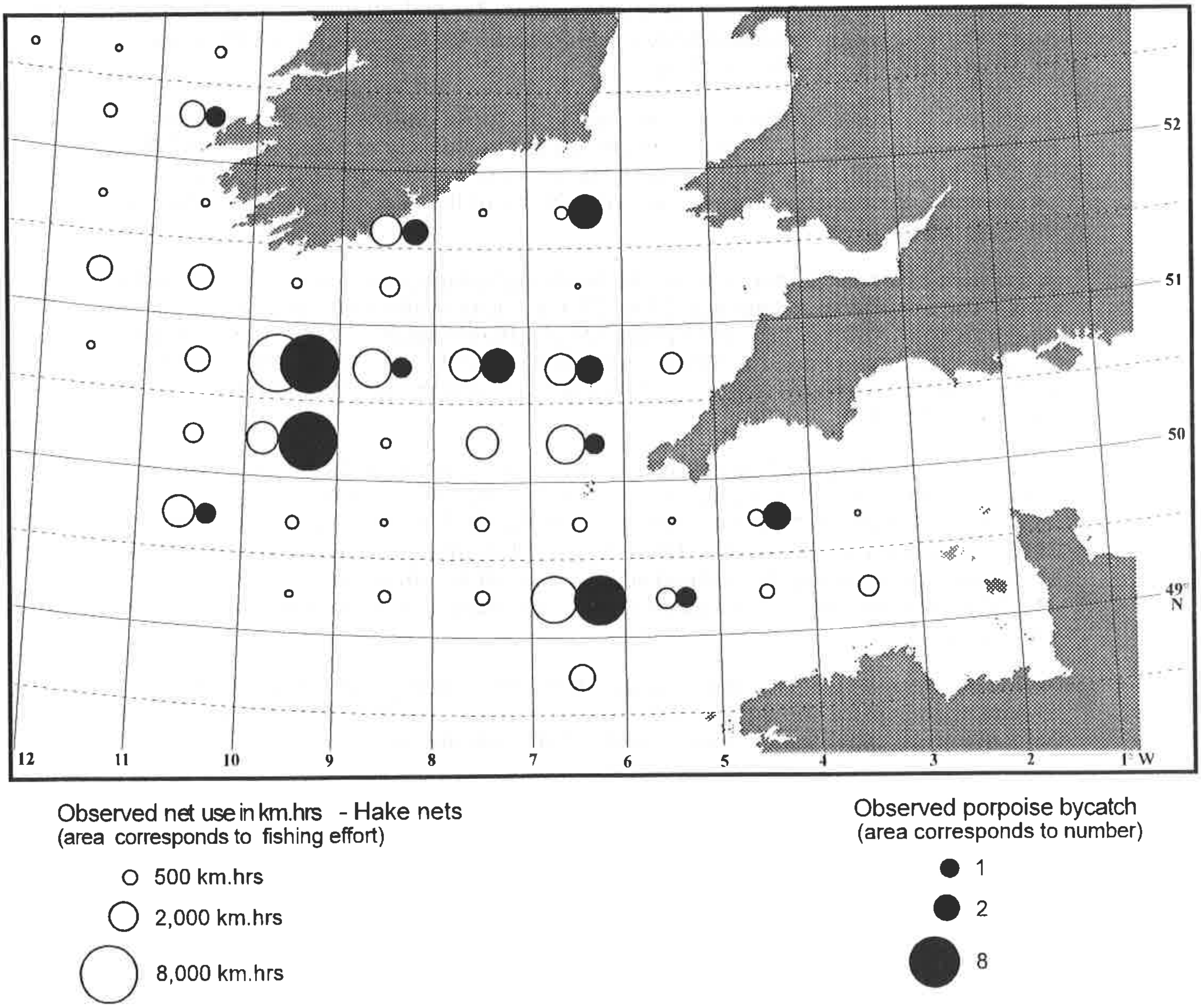

Fig. 1. Observed fishing effort and porpoise bycatch by UK and Irish boats

BYCATCH RATES OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN SWEDISH BOTTOM SET GILLNET FISHERIES OBTAINED FROM INDEPENDENT OBSERVERS

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The harbour porpoise is listed as a vulnerable species in Swedish waters. The major threat has been identified as bycatches in the bottom set gillnet fisheries. This paper presents the results obtained from an observer programme monitoring bycatches of harbour porpoises in the bottom set gillnet fishery for cod (mono- and polyfilament nets). The programme operated between March and May, 1995 in a $2{,}500^2$ km area (ICES area 4456) in the Skagerrak Sea.

The area, the time of the year, and the gear types chosen for the programme corresponded to 24% of 270 year-round bycatches voluntarily reported between 1989-91. Of the 25 active fishermen in the area, 24 were positive and participated in the programme. Four to five observers covered 20.7% of the total yearly fishing effort in the study area.

A total of 11 harbour porpoises were observed caught during 146 km nets hauled on 81 trips. The average soak time was 23 h. 23 min. This results in a bycatch rate of 75 porpoises per 1,000 km net, or 32 porpoises per 10,000 km.h. fished. These bycatch rates are higher than those reported from the Danish North Sea (except during the third quarter), the Celtic Shelf, and the Gulf of Maine observer programmes monitoring the same type of gear.

To evaluate the biological significance of the bycatch in the study area, the ratio was calculated between the estimated total annual bycatch (53 animals) and the summer abundance of harbour porpoises derived from the SCANS 1994 abundance survey. SCANS recorded a density of 0.725 (CV = 0.34) harbour porpoises per km^2 in the Skagerrak Sea, resulting in an abundance estimate in the study area of 1,813 animals. The calculated ratio gave a 2.9% removal rate in the study area, in the bottom set gillnets for cod only.

Following the recommendations from the 1995 IWC meeting that a bycatch of 1% of estimated abundance should be cause for concern, the current levels of bycatches of harbour porpoises in Swedish waters are not likely to be sustainable.

AGE RELATED MORTALITY OF COMMON DOLPHIN (*DELPHINUS DELPHIS*) IN PORTUGUESE GILLNET FISHERIES

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Gillnets are widely used along the Portuguese coast, accounting for higher mortality rates of marine mammals than other gears. The two species that suffer most with this fishery are the harbour porpoise (*Phocoena phocoena*) and the common dolphin (*Delphinus delphis*), with the number killed being particularly high in the central area of the Portuguese coast.

In this study, 33 specimens of common dolphin (15 females and 18 males), from museum collections, were aged using dental growth layer groups (GLG's). An unusual mortality was found in dolphins aged two years. When the data were plotted by cause of death, it was found that the gillnet fishery was responsible for the greatest mortality among two- year olds (52%).

If weaning takes place at approximately 19 months , as reported by some authors for the North Atlantic, this mortality could be due to inexperience in hunting, which could make the animals interact more often with the fishing gear, in order to obtain an easy meal. However, the sample is very small and there is a need for further work to test this hypothesis.

INTRODUCTION Little is known in Portugal about the deaths of marine mammals resulting from interaction with fishing activities, since most cases go unreported because fishermen are afraid of legal sanctions from the authorities. Nevertheless, the existing data suggest that entanglement in gillnets is an important cause of incidental mortality of cetaceans, especially for the common dolphin (Sequeira and Ferreira, 1994). Gillnets are widely used along the Portuguese coast, with the largest number of boats licensed to use this gear in the northern and central zones (Fig. 1). The main target species of the gillnet and trammel net fisheries are Allis shad (*Alosa alosa*), flatfishes (Pleuronectidae and Soleidae), hake (*Merluccius merluccius*), pouting (*Trisopterus luscus*), monkfish (*Lophius* spp.), bass (*Dicentrarchus labrax*), seabreams (Sparidae) and cuttlefish (*Sepia officinalis*) (Sequeira, op. cit.).

While we do know that cetaceans, particularly the common dolphin, fall victim to gillnets in Portugal, their interaction with this gear is poorly understood, as is the impact of such mortality on cetacean populations in Portuguese waters.

Analysis of the age distribution of specimens of common dolphins from museums showed that there was a high mortality rate among two-year old animals, which was mostly due to entanglement in gillnets. These results raised the question about the possibility of a relationship between age and gillnet mortality and led to this work.

MATERIALS AND METHODS The ages of 33 specimens (15 females and 18 males) of common dolphins from museum collections were determined by counting of dentinal Growth Layer Groups (GLGs) in decalcified and stained 25µ tooth sections, based on the assumption that one GLG is laid per year in this species (Scheffer and Myrick, 1980; IWC, 1980; Lockyer, *pers. comm.*).

RESULTS The results showed an unusually high mortality rate in dolphins aged two years old, which made up approximately 30% of the sample (Fig. 2). The causes of death of 25 of the 33 specimens are known, with the gillnet fishery responsible for 64% (16) of the deaths (Fig. 3). The two-year old dolphins made up 50% (eight animals) of all dolphins killed in gillnets in this sample (Fig. 4).

DISCUSSION In the North Atlantic, the weaning of common dolphin calves is thought to take place at approximately 19 months of age (Collet, 1981; Evans, 1987). Although it is known that the calves hunt fish before weaning, they can count on their mother's milk to supplement their diets. Nevertheless, when weaning takes place, the dolphin has to chase its own food, and if its fishing skills are not well developed, success rates may initially be low. This could explain why the frequency of dolphins killed in gillnet fisheries was highest for dolphins that were two years old.

After weaning takes place, the inexperienced animals could have problems in capturing sufficient food, and may therefore interact more often with the fishing gear in order to obtain an easy meal, resulting in higher mortality rates. The animals may have to learn how to handle the fish caught in the nets, and the less experienced dolphins may get entangled more often when trying to steal the fish.

However, one should be cautious when analysing these results, since the sample size is relatively small. There is an urgent need for further work to test this hypothesis properly, because if the assumptions made in this work are correct, one age class of this common dolphin population may be heavily affected, and this may have serious longterm consequences.

ACKNOWLEDGEMENTS I wish to thank Christina Lockyer for the time she spent with me in SMRU, BAS, teaching me to age marine mammals and sharing her vast knowledge in the field. Marina L. Sequeira and Karim Erzini are my mentors, and the people I look up to, and I more than thank their constant support and encouragement. Everything I am, I owe to Ana and Manuel Penha and to J. Prieto da Silva, so my thanks to them also. And thank you Lídia for giving me a kiss whenever all my patience is gone.

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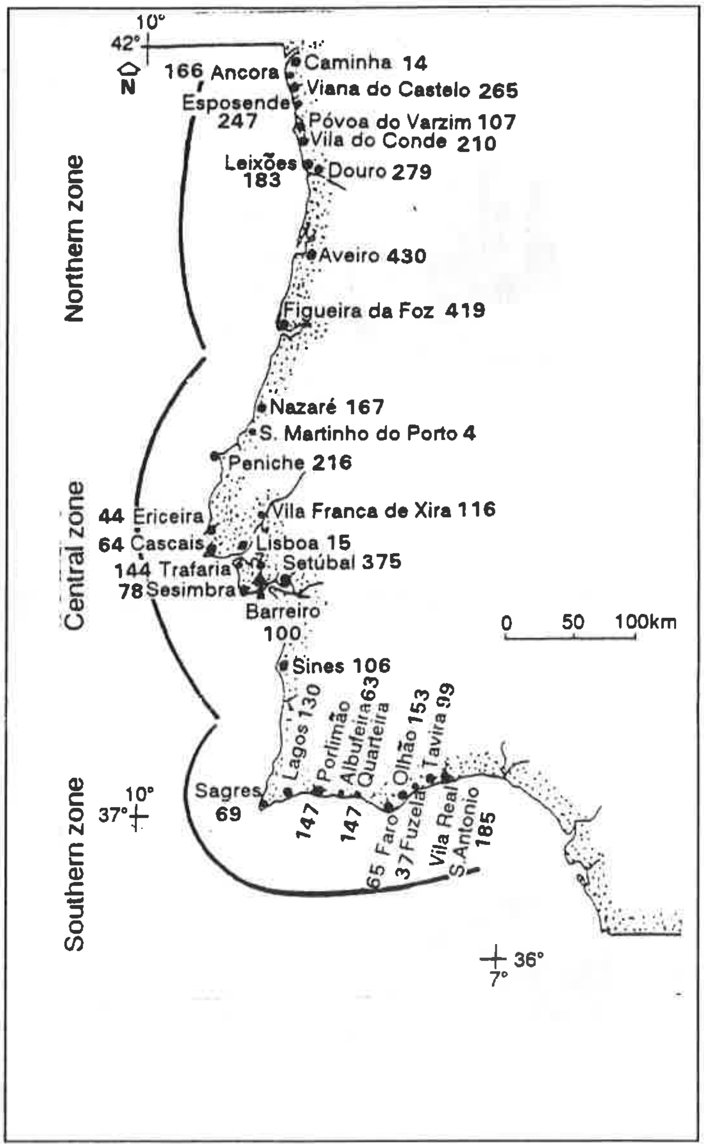

Fig 1 Number of gillnet licences in Portugal in 1991 (from Sequeira and Ferreira, 1994)

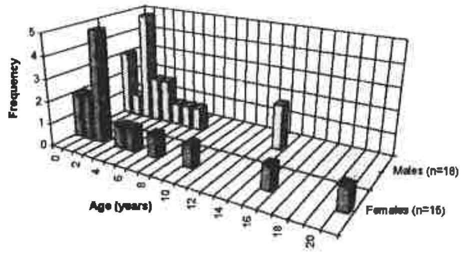

Fig.2 Age distribution for a common dolphin (*Delphinus delphis*) analysed

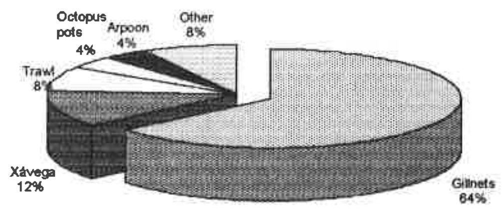

Fig. 3 Common dolphin (*Delphinus delphis*) mortality causes for all ages analysed

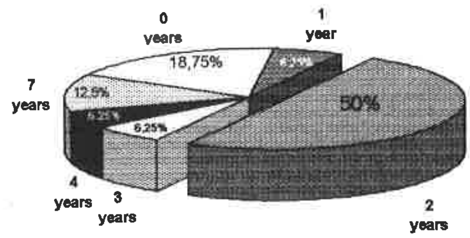

Fig. 4 Common dolphin (*Delphinus delphis*) mortality in gillnet fisheries, by age (years)

PHOTO-ID AUTOMATION AND ANALYSIS

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For large photo-ID catalogues, automating the search for matching photographs has many advantages, in addition to the reduction in routine work. For example, it allows regular and objective measurement of the proportion of missed matches. That measure can be incorporated in mark-recapture analyses, or the system modified to reduce the number of misses.

A simple way to reduce the effect of errors in registration (the location and sampling of the pattern area used by the system for individual identification) is to increase the average number of photographs per individual retained in the system. A similar increase will be less effective in a system based on pattern classification, where allocation of a pattern feature will not be independent for different photographs of the same individual.

The large number of matches potentially available from an automated catalogue presents a challenge to the analyst: to maximise the amount of useful inference available, and minimise the number of assumptions required.

In the case of a small catalogue from a remnant population, the challenge is the same but the approach is different. Automation is probably not worthwhile; instead, we may maximise the information available by recording the decisions reached by visual comparison of photographs more carefully. These ideas are illustrated by reference to photo-ID catalogues of grey seals and Javan rhino.

HOW MANY BOTTLENOSE DOLPHINS ARE THERE IN THE MORAY FIRTH: AN APPLICATION OF MARK-RECAPTURE METHODS TO PHOTO-IDENTIFICATION DATA

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INTRODUCTION Mark-recapture methods (M-R) are well established for estimating the size of animal populations. Traditionally, they have required animals to be captured and marked (by tag or mutilation) such that they would be recognised if recaptured. Using the natural markings of individual animals recorded on film (photo-ID) as the "mark", circumvents the need for physical capture and greatly facilitates the application of M-R methods to populations of small cetaceans. However, these methods are based on a number of assumptions that must be addressed before estimates of population size can be considered to be unbiased (Hammond, 1986). Whether or not these assumptions are violated depends on the methods used to gather the data and on the behaviour of the animals. These assumptions are shown below.

1. The population to be estimated must be definable.
2. Animals do not lose their marks during the sampling period.
3. All marks are recognised on recapture.
4. Marking does not affect the probability of recapture.
5. All individuals in the population must have the same probability of capture on any sampling occasion. Violations could be produced by:
i) geographic heterogeneity,
ii) behavioural heterogeneity,
iii) variations in distinctiveness.

In this study, four years of photo-ID survey data were used to estimate the size of the bottlenose dolphin population in the Moray Firth (Scotland). The assumptions of the M-R models were specifically addressed with the goal of producing an unbiased estimate of population size. The impacts of the assumptions on data and model selection are described in this paper.

METHODS

Assumption 1 by showing that the population is spatially isolated from others (nearest other known group over 445 km away) and discrete with no evidence of immigration occurring (Wilson, 1995). It is also naturally well marked and readily photographable making it ideally suited for a mark-recapture study.

Data were available from 118 photo-ID surveys that had been carried out twice monthly between June 1990 and February 1993. A sub-sample of data were chosen for application to a mark-recapture model. The selection criteria for this sub-sample are shown below.

1. As births and deaths could occur at any time in this population, demographic closure could not be guaranteed. To reduce its impact, the data set was sub-sampled and the duration of this sub-sample made as short as possible. Five months was chosen as it minimised likely population change whilst maintaining enough data to analyse.

2. Only animals with mark types that lasted longer than the five month sampling period, were used to calculate the estimate [addressing *Assumption 2*]. The ratio of these animals to the rest was later used to scale up the final estimates, using a method described by Williams *et al.* 1993.

3. Only high quality pictures in which the whole of the dolphin's dorsal fin was present were selected for the identification of individuals. Then within these photographs, only highly visible marks were used to identify individuals[addressing *Assumption 3*].

4. The sub-sampling period was chosen as the time that all the main areas used by dolphins in the Moray Firth were sampled [addressing *Assumption 5i*].

Using these criteria, data were selected from a five month period in the summer of 1992. In all, 520 photo-captures from 17 day-long photo-identification surveys were used to calculate the estimate. By selective choice of data *Assumptions 1, 2, 3* and *5i* could be addressed. Because bottlenose dolphins are unlikely to alter their behaviour as a result of being photographed, *Assumption 4* could simply be ruled out. *Assumptions 5ii* and *5iii* (heterogeneity) however continued to be problematic. These problems had to be dealt with by selection of an model that could take account of differences in capture probabilities. As heterogeneity cannot (at present) be incorporated into *open* population models, a *closed* population model was required. CAPTURE, a program written to calculate mark-recapture estimates of population size using closed models was selected and from it Model $\mathbf{M_{th}}$ chosen. This model allowed for both temporal and individual differences in capture probabilities (White *et al.* 1982).

RESULTS Using capture histories of permanently marked individuals, the model produced an estimate 80 dolphins (95% confidence interval of 66-113 individuals). These results were then scaled up to include the proportion of animals in the samples that did not have permanent markings (39%) and thus the whole population was calculated to consist of 130 individuals with a 95% confidence interval of 92-169 individuals (CV = 0.15).

CONCLUSION This finding confirms previous concerns over the small size of this population and its subsequent vulnerability to natural or anthropogenic changes in reproductive rates or survivorship.

ACKNOWLEDGEMENTS Thanks go to the many people that took part in the survey work and to the Greenpeace Environmental Trust who provided the financial support for this study.

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ENCOUNTER - SOFTWARE FOR LOGGING GPS DATA AND OBSERVATIONS ONTO PCs

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The software program Encounter makes it possible (1) to record GPS position fixes at any chosen time interval; and (2) to enter and edit observations on a pocket-sized computer (IBM-XT architecture; 5 MHz; 512 kbyte RAM). This computer (Hewlett-Packard 95LX) is small, reasonably rugged, and being diskless is more likely to survive the harsh environment on small boats. It is housed in a splashproof case with a transparent rubber membrane allowing use of the keyboard. Encounter runs under MS-DOS 3.22 (on the HP) or higher, and should run on most DOS-compatible computers.

Positions and observations are stored in ASCII text files. Transferring files to a PC or Macintosh, the track of the vessel and sightings of whales and dolphins can be printed on a chart of the study area using standard software.

OBSERVERS BEGGING FOR TECHNICAL HELP!

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Gone are the days when being a whale observer was synonymous with enjoying life and following the underwater ballet of the mysterious creatures, and making enthusiastic comments on a blank sheet of paper! "Get exact time for initial sighting! Start recording! Assign sighting numbers! Start tracking! Give precise distance and angle! Woe betide you if you round! Record cues! Communicate data! Count, and not too much! Stop looking for that damned blue, go for the next! Record everything! Drink only when the data are entered!" (recorded on and between the lines of the SCANS 94 and the NASS 95 observers' bedside book). Help! The new analytical methodologies require greater and greater accuracy in data recording, (e.g., c.f. *a posteriori* assessment of duplicates), while improvements in recording equipment and procedure occur.

New technologies developed in the world of sailing, both in information processing and electronics, might be applied at non-prohibitive cost to shipboard sighting surveys. They would allow some automation in the individual data recording (e.g., angle, time), the communication between observers and recorder, and the computer data entry, while correcting for example for the short term variations in vessel course. Thus observers could concentrate more on the sighting itself, while getting more accurate data. This contribution presents potential medicines/propositions which germinated in the head of masochistic observers who like it and want to do better.

VIBRATING SIGHTING PLATFORMS? NOT INEVITABLE!

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The vessel vibration at cruising speed has always been considered disturbing during shipboard sightings surveys of cetaceans, especially if binoculars are to be used. It makes searching through binoculars very uncomfortable and at times impossible, especially when binoculars are mounted and distance estimate are to be made using binocular reticles, as for example during the 1994 SCANS survey.

However, very little attention is actually paid to this well-recognised problem, except for holy vows in the cruise report at the end of each survey "........ should be given high priority in future surveys."

During the 1995 NASS survey, the Faroese vessel was to use a procedure similar to that of the SCANS survey, i.e. with a team of trackers searching constantly through mounted binoculars and tracking schools via multiple sightings. Following recommendations of previous surveys, particularly MICA 93 and SCANS 94, it was then decided to give high priority to the problem of vessel vibration and to design a special sighting platform.

The special anti-vibration design, presented here, proved to be successful in greatly minimising the effect of the vessel vibration. Searching through binoculars and reading reticles was still possible and not uncomfortable up to wind speeds of Beaufort 4.

DETECTING CHANGES IN POPULATION SIZE USING MARK-RECAPTURE TECHNIQUES APPLIED TO PHOTO-IDENTIFICATION DATA: CAN SCIENCE PRODUCE THE ANSWERS FAST ENOUGH?

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INTRODUCTION Anecdotal studies would suggest that bottlenose dolphins were once more common in the North Sea, than they are today. At present only one resident population is known to reside within it. These animals occupy an area off the northeastern coast of Scotland, known as the Moray Firth. In 1989, fears of a decline in this population prompted the beginning of a long-term photo-ID study. Two of the aims of this work were to estimate how big the population was and then establish whether it was changing in size (i.e. to determine the population's status).

Mark-recapture methods were applied to photo-ID data collected in 1992 and an estimate of 130 individuals was derived (95% confidence interval = 92-169, CV = 0.15). For more information on how this estimate was calculated see Wilson *et al.* (this volume). Now that the population size is known a number of years will need to elapse before changes can be determined. This desk-top study aimed to calculate, using power analyses, how many annual population estimates would need to be invested in order to detect any trends in the size of the Moray Firth dolphin population.

METHODS Gerrodette (1987) described a series of power analysis models for predicting rates of trend detection using regular estimates of population size. Since the way in which the Moray Firth dolphin population may be changing (linearly, exponentially or some other) is unknown, Gerrodette's most general model was applied (see Fig. 1, Model 1). In this model r is the rate of change of the population, n is the number of estimates (annual in this study), CV is the coefficient of variation and the number in front of the CV value is derived from a chosen probability of making either a type 1 or type 2 statistical error (in this case $P \leq 0.05$).

Values from the CV from the mark-recapture estimate were then applied to this model under a range of potential rates of population change and thus the number of annual estimates needed to detect these trends calculated. In addition the model was re-run using a model permitting a lower threshold of statistical certainty ($P \leq 0.10$, Fig. 1b, Model 2).

RESULTS The values derived by application of model 1 are shown in Fig. 2. This shows how for high rates of population change trends can be detected relatively quickly. For example, a change of 15 % yr^{-1} would take only 5 years to detect. For lower rates of change, however, trend detection will take considerably longer. For example, 1% yr^{-1} would take over 33 years of annual surveys to detect.

The results of application of model 2, with the relaxed statistical confidence threshold is also shown in Fig. 2. Relaxing the statistical threshold does little to increase trend detection rates.

DISCUSSION The results of these analyses clearly show that if the dolphin population in the Moray Firth was changing rapidly it would be far easier and require smaller resources to detect the trend then if the change was slow. In terms of conservation, however, if the population was declining at a high rate it would be very serious. In fact, an exponential decline of 15% yr^{-1} would mean a reduction in the dolphin population from 130 individuals to just 57 in the five years until that trend was detected. For a 1% yr^{-1} decline it may take 33 years to detect the change, but 93 individuals would remain. For the research then, the results of these analyses leave a fairly gloomy picture. Either the population is going to have to be changing rapidly (a scenario more likely to occur in a declining population than in an increasing one) or change will be slow and require considerable investment of research resources. Relaxing statistical confidence makes little difference to the situation, whilst other measures such as increasing the precision of annual estimates (i.e. reducing CV) or carrying out more than one estimate per year would require a considerably greater investment of resources and reliance on suitable weather conditions.

Annual population estimates are currently being carried out and, in the meantime, other ways to establish population status using the photo-ID data are being explored with the Wildlife Population Assessment Research Group at the University of St. Andrews.

CONCLUSIONS

1. Establishing the status of a small, well marked, intensively studied population of bottlenose dolphins using photo-ID techniques may take many years and requires considerable investment of resources.

2. Factors such as the precision and number of estimates are important and every effort should be made to improve them.

3. Available methods of population monitoring should be carefully evaluated before such enormous resources as 33 years of survey work are commenced.

4. If governments and managers require statistical proof of a decline before taking action, any measures may well come too late. In the case of the bottlenose dolphin population in the Moray Firth, current methods cannot produce the answers fast enough for managers. Precautionary measures must, therefore, be implemented for this potentially vulnerable population.

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Model 1. where the probability of making a type 1 or 2 statistical error is set at $P \leq 0.05$.

$$r^2 n^3 \geq 156CV^2$$

Model 2: where the probability of making a type 1 or 2 statistical error is set at $P \leq 0.10$.

$$r^2 n^3 \geq 103CV^2$$

Fig. 1. Simplified versions of Gerrodette's equation 17. Definitions of terms are given in the text

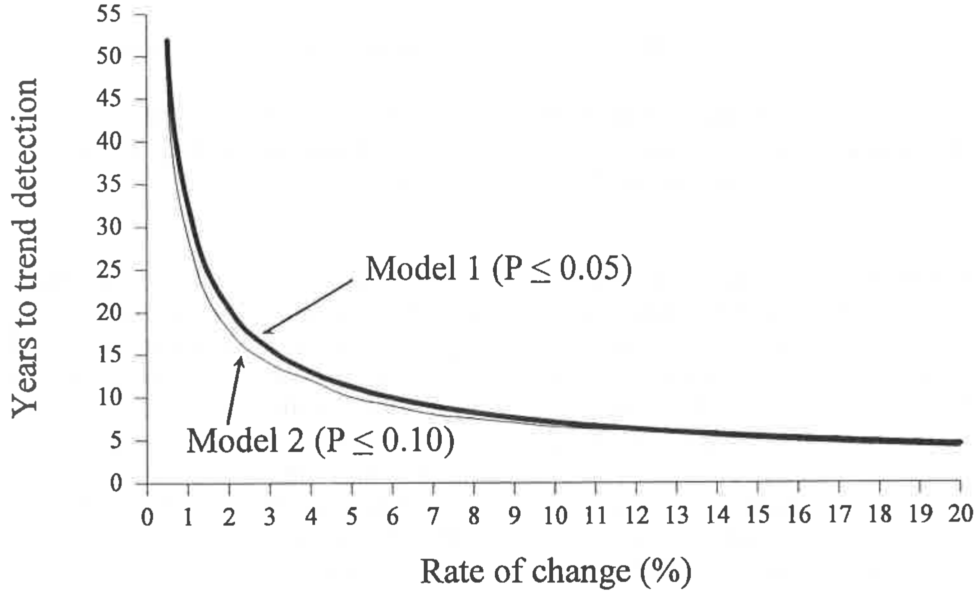

Fig. 2. Relationships between rates of population change and time required to trend detection

REACTIONS OF FIN WHALES TO APPROACHING VESSELS ASSESSED BY MEANS OF A LASER RANGE FINDER

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INTRODUCTION It is foreseeable that, in the near future, commercial whale-watching will develop in the Ligurian Sea fin whale (*Balaenoptera physalus*) feeding grounds, and that knowledge of the whales' susceptibility to vessel disturbance will become necessary for the preparation of appropriate regulations (Notarbartolo di Sciara, in press). The aim of this study was to develop a tool for the description of the movement patterns of fin whales in offshore waters, that would be useful to the understanding of the whales' reactions to approaching boats. Harmless Class 1 laser range-finding binoculars were used to passively plot the movements of whales from a sailing vessel. Successive whale positions were combined with dive and ventilation data to compare behavioural patterns on different levels of disturbance.

MATERIALS AND METHODS Research cruises were conducted aboard a 20 m long ketch motorsailer with auxiliary engine, the Tethys research vessel *Gemini Lab*, between 24 June and 1 October, 1995. Whales were encountered in an area between 44°00' - 42°20' N and 07°40' - 09°20' E. Comparisons were made between an initial phase, in which disturbance was minimal (main vessel moving at minimum speed, at distances in excess of 100 m), and a second phase with higher levels of disturbance (whales approached by the tender, to collect biopsies and close-up identification photographs). The whales' range and magnetic bearing data were obtained using a pair of Leica Vector 1500 DAES laser range-finding binoculars, and downloaded through the serial port onto a portable computer, which simultaneously recorded the vessel's position through GPS data. Instrumental accuracy was preliminarily assessed by tracking by laser the movements of a small vessel, equipped with GPS for independent position determination, from a fixed point ashore. Over a convoluted course 4.2 km long, at a mean speed of 2.8 ms^{-1}, GPS and laser measurements of travelled distance and speed differed by a mere 4.0 and 3.7% respectively.

Ventilation intervals were recorded to the nearest second using a digital stopwatch. Only complete cycles were considered for the analysis. Ventilation and diving parameters considered were: **dive** (interval between two breaths lasting longer than 36 sec.; this cut-off time was determined by plotting the data on a log survivorship diagram (Fagen and Young, 1978)); **surfacing time** (sum of intervals not exceeding 36 s between consecutive blows, constituting a **surfacing sequence**); **cycle** (a dive followed by a surfacing sequence); and **blow rate** (number of blows h^{-1}, calculated by dividing the number of blows in a given cycle from a given whale by the duration of that cycle).

RESULTS Distances to the whales could be measured between 25 and 663 m. A total of 22 whale groups and singles were approached and tracked. Of these, eleven yielded workable data because whales were either alone or in groups containing readily recognisable individuals. Mean track duration was 3 h. 14 min. (SD = 48 min.). Differences in diving behaviour, blow rate, and horizontal swimming speed between the "undisturbed" and the "disturbed" phase are summarised in Table 1 and represented in Fig. 1-4. "Disturbed" whales increased their speed by 35% (Wilcoxon signed-rank test, $p<0.05$; Fig. 1), and decreased their blow rate by 17% (Wilcoxon signed-rank test, $p<0.05$; Fig. 3). An increase of dive time (Fig. 2) and decrease of surface time (Fig. 4) were also observed. However, differences were insignificant. Finally, the plotting of the whales' tracks allowed the clear distinction between two different swimming patterns

(Fig. 5): (a) a convoluted pattern, in which the whale was meandering over the same general area (sample # 22); and (b) a sub-linear pattern, in which the whale seemed to be travelling through the area (sample # 30).

DISCUSSION The combined GPS and range-finder technique, to describe cetacean movement patterns and speed in the open sea, proved a valuable tool in the non-invasive, quantitative characterisation of pelagic cetacean behaviour. In particular, reactions to different disturbance conditions, as well as different swimming patterns, could be described. These included an increase in swimming speed and a decrease in blow rate, both in agreement with similar observations of other cetaceans, such as bowhead whales, *Balaena mysticetus* (Richardson *et al.,* 1985), and humpback whales, *Megaptera novaeangliae* (Baker and Herman, 1982; Weinrich *et al.*, 1992). In future studies, the "undisturbed" phase (control) should be assessed through telemetry at large distances from any human influence, to provide an objective term of comparison between absence of interference and different levels of disturbance.

ACKNOWLEDGEMENTS This research was primarily funded by the J&B Programme "Care for the Rare". We thank Leica AG, Intelligent Observation Systems, for their support and technical advice. S. Panigada, M. Zanardelli, L. Cianfanelli, B. Nani, M. Magnanini and C. Vallini helped in the collection of the data. E. Politi, A. Azzellino and J.F. Borsani assisted with the analysis. The cruises were in part made possible by Europe Conservation through the participation of a number of contributing volunteers. Finally, we gratefully acknowledge the generous hospitality that Portosole, San Remo, granted to our vessel.

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Table 1 Comparison of swimming speed, blow rate and dive time between "undisturbed" and "disturbed" whales (n = 11).

parameter	**"undisturbed"**	**"disturbed"**	**comparison**	
	mean *(sd)*	mean *(sd)*	Diff. *(%)*	Wilcoxon test
swimming speed (ms^{-1})	1.1 *(0.35)*	1.5 *(0.47)*	+ 0.39 *(+35.1)*	p = 0.0329*
blow rate (blows h^{-1})	79.9 *(18.1)*	66.1 *(19.5)*	- 13.9 *(-17.3)*	p = 0.02*
dive time (s)	240 *(113)*	258 *(133)*	+ 18.1 *(+7.5)*	n.s. (p = 0.286)

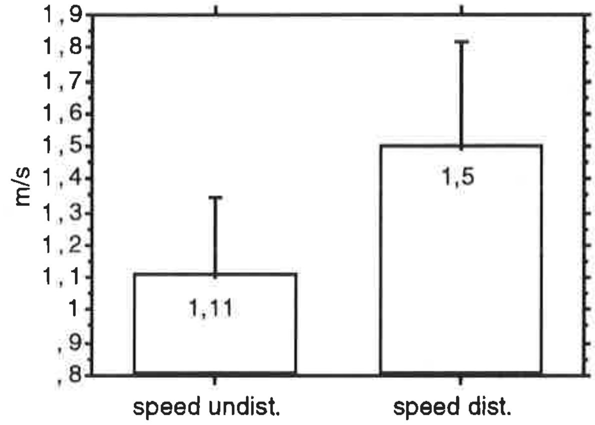


Fig. 1

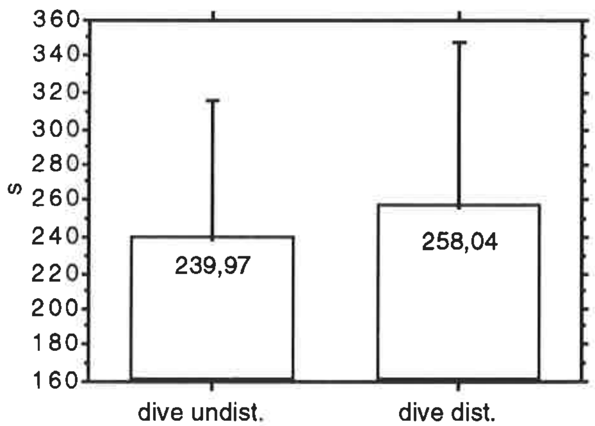
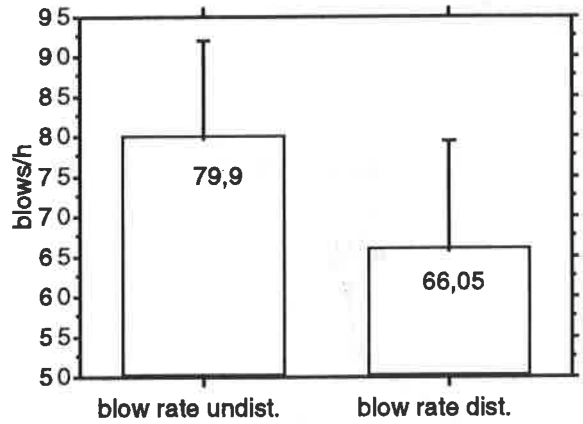


Fig. 2


95
90
85
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75
70
65
60
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50
blows/h
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blow rate undist.
blow rate dist.

Fig. 3

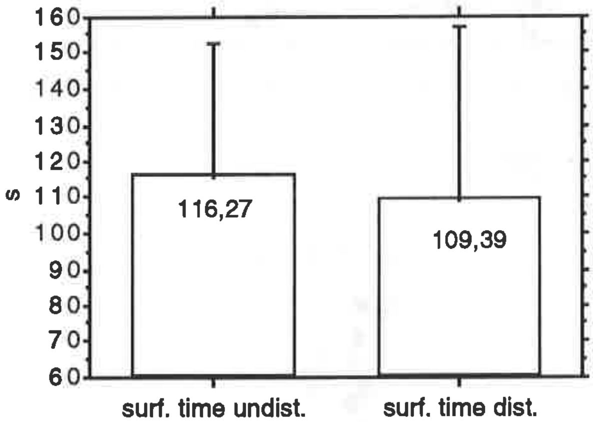
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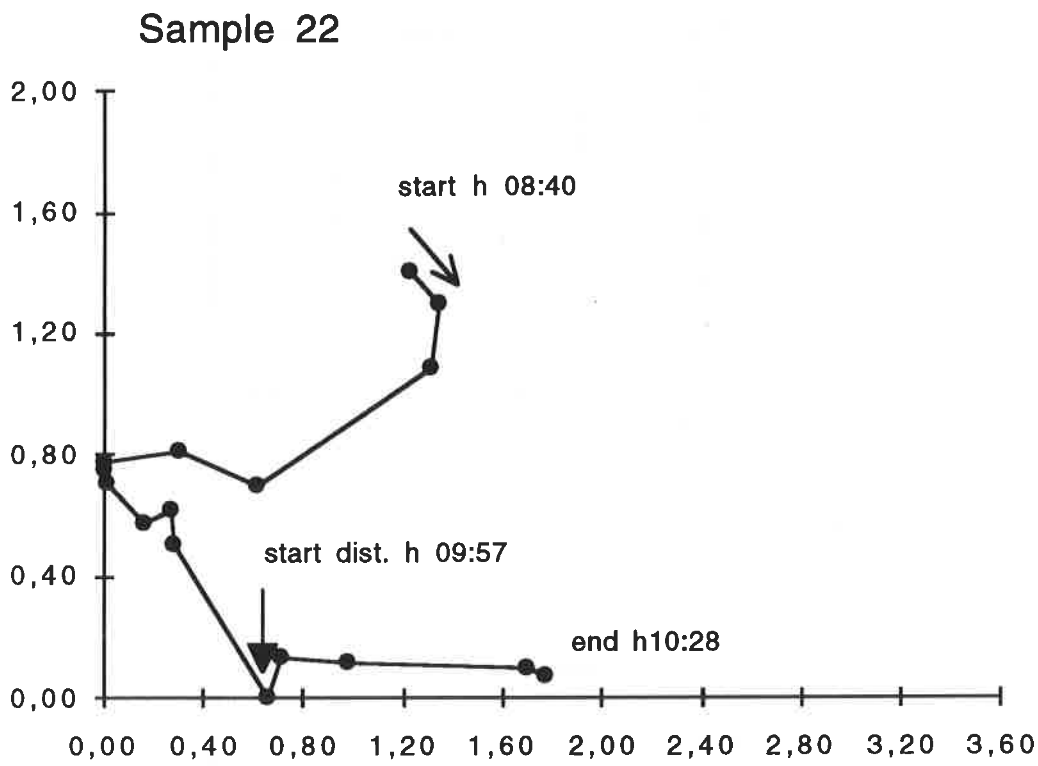
Fig. 4



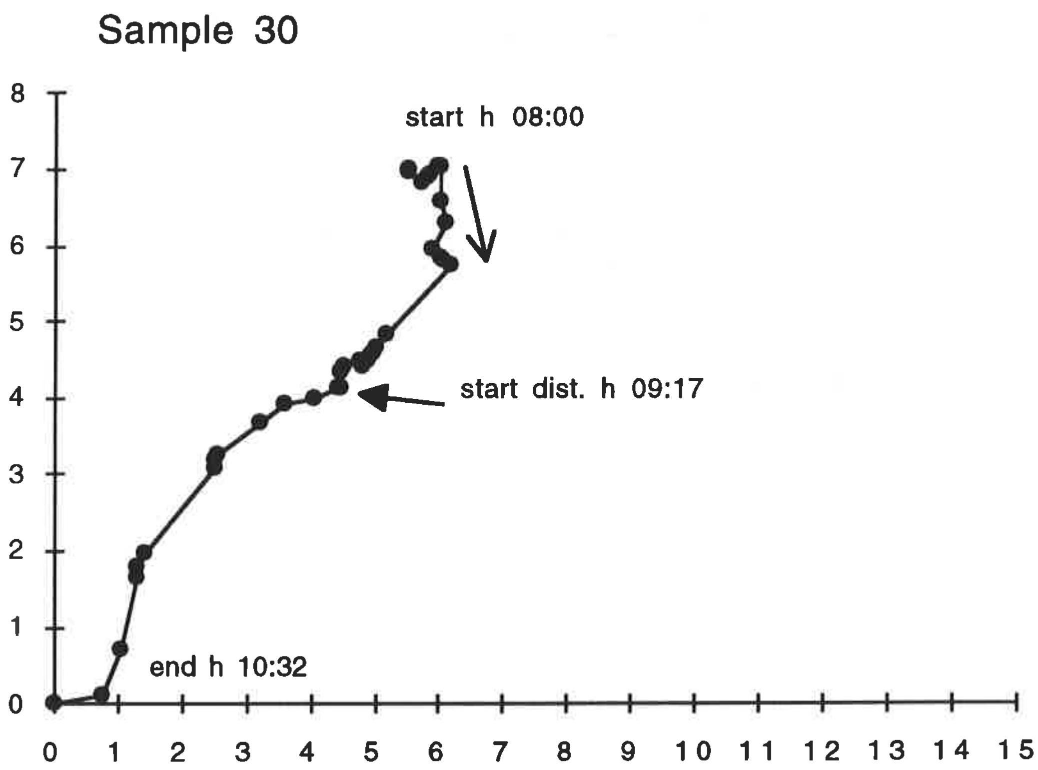


Fig. 5 Two examples of whale tracks: a convoluted swimming pattern (sample 22) and a sub-linear pattern (sample 30). Numbers on the vertical and horizontal axis represent the travelled distance (km)

BEHAVIOURAL REACTIONS TO BIOPSY-DARTING ON MEDITERRANEAN FIN WHALES

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INTRODUCTION Tissue sampling from free-ranging whales represents an important investigative tool for both toxicological and genetic analysis. By means of this latter technique, it was recently possible to obtain indications that the Mediterranean fin whale (*Balaenoptera physalus*) constitutes a population separated from the North Atlantic (Bérubé *et al.*, 1995). This has important management and conservation implications for fin whales in the Mediterranean (Notarbartolo di Sciara *et al.*, in press).

Previous research (Weinrich *et al.*,1991, Clapham and Mattila,1993, Brown *et al.*,1994) suggested that biopsy procedures represent a minimal intrusion into the whale's life and elicit at most a short-term reaction, but even so the degree of disturbance caused to this particularly vulnerable population needs to be assessed.

This study refers to a biopsy collecting programme performed in the Corsican-Ligurian-Provençal Basin (Mediterranean Sea), during a long-term study on fin whale ecology and behaviour.

MATERIALS AND METHODS Research cruises were conducted aboard auxiliary sailing vessels, 15 to 20 m long, equipped with inflatable crafts. Cruise dates were from 6 June to 5 October 1990, from 2 June to 2 October 1991, from 6 July to 23 September 1992, from 13 June to 30 September 1993, from 18 June to 29 September 1994, and from 1 June to 1 October 1995.

The study area included the offshore waters of the Western Ligurian Sea between San Remo, the French Riviera, and Corsica.

Samples of skin and blubber were collected from free-ranging fin whales, by means of a Barnett Wildcat II crossbow with a 150 pound test bow. The biopsy dart consisted of a regular aluminum bolt with a modified collecting tip made of stainless steel (Lambertsen, 1987) with internal barbs, a central hook and a flange to avoid deep penetration and to help it bouncing off the whale. Each dart was fitted with a collar of closed cell foam for flotation (Mathews, 1986) and was retrieved from the water by hand. The length of the tip (and thus, maximum penetration) was 20 mm from edge to stop collar; the diameter was 10 mm. From 1994, a carbon arrow mounting a stainless steel tip without hook and flange was used; a moulded floater prevented the penetration for more than 40 mm, and helped the dart to bounce from the whale. These tips, measuring 0.8 mm in diameter, were provided by the Greenland Fisheries Research Institute. Tissue samples weighed, in anycase, less than 1g.

Animals were approached within a maximum range of 25 m. Biopsies were taken from a dorsal area in the proximity of the dorsal fin and from the upper portion of the caudal peduncle, within an area approx. 2 m in front of and 3 m behind the dorsal fin.

From 1990-94, the whale's reactions to biopsy sampling were recorded *ad libitum*, while in 1995, a one-zero sampling method was adopted (Altmann, 1974). The whale's responses were categorised as follows:

- none (no observable response)
- any reaction, which included:
- sudden speed increase

- sudden change in direction
- tail slap
- breaching
- rolling
- startle

The shot itself, as it is referred to, includes both hits and misses. If a whale was shot more than once, only the first attempt (whether hit or missed) was taken into account for the analysis, in order to guarantee independence of data. Second shots were too few to be analysed separately.

Gender was genetically determined for samples from 1990-94 (Bérubé and Baker, *pers. comm.*).

Group size was arbitrarily defined, for the specific purposes of this study, as the number of whales seen within a radius of approx. 500 m from the boat.

No significant difference was found in the data collected by means of the two different sampling methods (Chi-Square Goodness of Fit test, $p>0.05$); therefore all data were pooled.

RESULTS Fig. 1 shows the overall incidence of reaction to darting. Responses represent 12.36% of the total.

Reactions of females vs reactions of males (Fig. 2) were tested by means of a Contingency Table Analysis and no significant difference was found ($p>0.05$).

Group size was tested vs reaction (Fig. 3), and whales in groups (ranging from 2 to 7) showed significantly fewer responses to darting than singles (Contingency Table Analysis, $p<0.05$).

Hits were compared to misses (Fig. 4), and no significant difference was found (Contingency Table Analysis, $p>0.05$).

DISCUSSION All observed reactions appear to be immediate, short-term responses. There is no evidence of systematic reactions in the time span immediately following the biopsy sampling, nor of a long-term reaction such as a continued avoidance of the boat or an obvious modification of previous activities.

The percentage of non observable reactions is very high (88%), also by comparison with previous similar results on humpback whales, where non-reaction rates range from 7% to 62.9% (Weinrich *et al.*, 1991, Weinrich *et al.*,1992, Clapham and Mattila,1993, Brown *et al.* ,1994).

The lack of significant measurable differences between hits and misses may indicate that fin whales react in the same way to a tactile painful stimulus (deriving from a successful shot) as to the probable acoustic stimulus of the splashing dart in the event of a miss. Contrary to other studies (Brown *et al.*, 1994), there was no difference between the responses of males and females.

Smaller reactions from whales in groups than from single individuals may show that individuals in herds are more confident, or that they are less susceptible to being startled by either tactile or acoustic stimuli.

In conclusion, there is no evidence that skin tissue sampling by means of a fired dart significantly affects the short-term behaviour of Mediterranean fin whales sampled on their summer feeding grounds in the Ligurian Sea.

ACKNOWLEDGEMENTS Research in the Ligurian Sea was funded during the many years of this study by (in alphabetical order): Agnesi, Flli. Carli, Cartasì, Citröen, Comune di San Remo, Corsica Ferries, Europe Assistance, Farinato, Fiamm, J&B, Cinzano, Care for the Rare, Leica, Pekkuod, Prenatal, Provincia di Imperia, Scrigno Sistemi Scorrevoli, Yacht Club San Remo. We wish to thank Portosole San Remo for support and hospitality. Mario Acquarone, Giovanna Benazzo, Marco Magnanini, Claudia Mazzanti, Barbara Nani, Ada Natoli, Cristina Venturino and the many volunteers provided by Europe Conservation helped in the collection of data. Thanks to Claudio Lafortuna for helpful comments.

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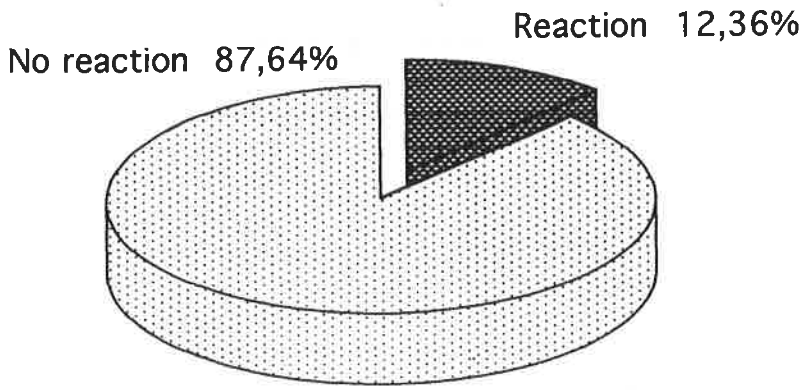

Fig. 1 Overall reactions

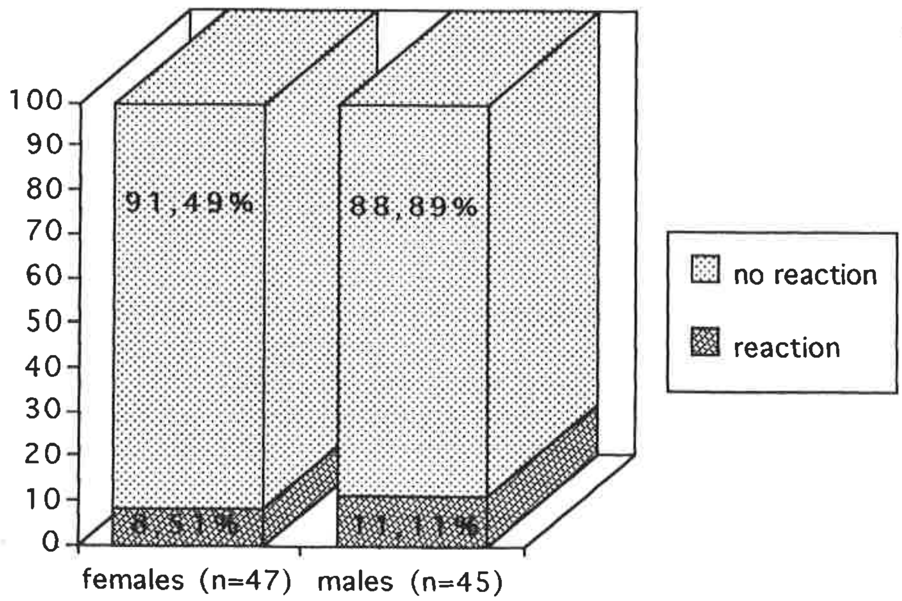

Fig. 2 Reaction vs gender

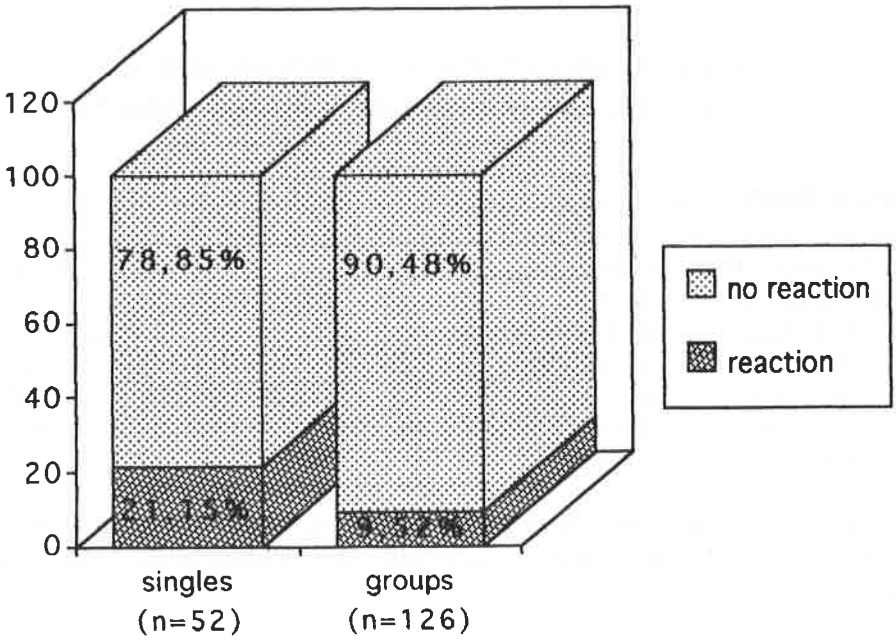

Fig. 3 Reaction vs group size

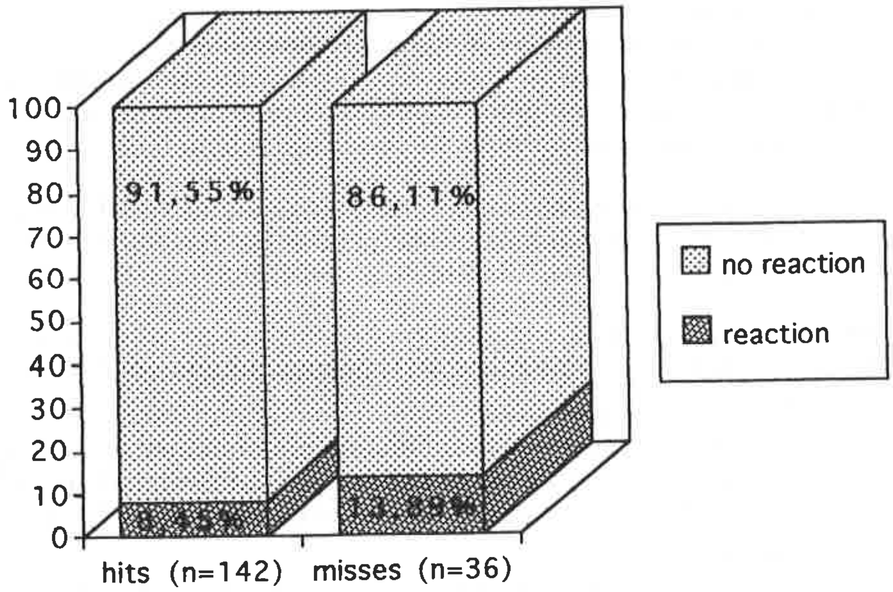

Fig. 4 Reaction vs hits or misses

WHALE-WATCH RESEARCH LA GOMERA: AN INTERDISCIPLINARY APPROACH

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INTRODUCTION On La Gomera, the Club de Mar, Valle Gran Rey is the only organisation offering whale-watching and swimming on a small scale. In collaboration with the Dolphin Project ARION (an NGO based in Germany), new ways of approaching cetaceans in the wild are offered to tourists and other interested people. Two small boats leave the harbour of Vueltas once or twice daily in search of dolphins or whales. A precautionary approach is adopted by respectful behaviour towards the animals, i.e. the cetaceans determine the intensity of the encounters. The golden rule is: "We are guests at sea" and during a sighting, the cetaceans' momentary behaviour is the decisive factor for what can happen.

In Vueltas an information centre was set up where everyone can learn about cetaceans and their environment through offered materials, talks, lectures, films, slide- and multi-media-shows.

During four months of study (Sept-Dec 1995) our aim was to get systematic data about cetacean abundance and their (short-term) reactions to the boats and to swimmers entering the water. The psycholgical part of the study investigates if there are changes of individual attitudes occuring during an encounter of humans with wild cetaceans.

MATERIALS AND METHODS For the collection of behavioural data, the whale watching boats were used as observation platforms. These are former fishing boats licensed to take out to sea six and eight people respectively.

The behaviour sampling method (Altman, 1974; Martin and Bateson, 1993) was modified for our objectives: during three-minute samples of behavioural states, special emphasis was given to the observation of interactive behaviour (e.g. approaches by and to the boat, bow-riding, adaptation of speed, etc.). The spatial relationship of the group to the boat was documented continuously by estimating the animals' distance and recording their relative positions.

When people entered the water ("water encounters"), the duration and characteristics of their stay were made. The distance, movements and number of animals taking part in the interaction were noted from the boat. Additionally, underwater observations were made.

RESULTS We had 46 sightings on 37 (43%) of 86 whale watch trips (see Fig. 1). 301.5 h. of sighting effort totalled 41h. 36min. (13.8%) of observation.

Abundance and Distribution of Cetaceans
At least ten different species where sighted. On three occasions, we found congregations of different species. The extent of the study area and the distribution of the sightings can be seen in Fig. 2 (see Table 1 for a more detailed description of the sightings).

Interaction with Boats
The animals' reactions to an approaching boat varied distinctly. The whole spectrum of responses from obvious avoidance, apparent indifference, evident curiosity and intense interaction could be observed. The sightings as a whole were categorised. Criteria included the typical distance between the boat and the group, the duration of the sighting, the occurrence of interactive behaviour, and the occurrence and quality of water encounters. Four degrees of response were found:

(1) Avoidance: obvious negative reaction, e.g. increase of distance or simply disappearance;
(2) Distance Encounters: observation from a certain distance possible; very little or no interaction;
(3) Close Encounters: small distances to the boat possible or likely; boat interaction possible or common; curiosity by the animals towards the boat but avoidance of swimmers;
(4) Intense Encounters: [as for (3)] with small distances to swimmers, and curiosity/interactive behaviour possible.

It is interesting to note that most of the sightings developed into intense encounters. Note also that "avoidance" was likely to have been under-estimated because of possible negative reactions of cetaceans before they could be sighted (see Fig. 3 for the frequency of each graduation).

Water Encounters
During 24 (52%) of the 46 sightings, people entered the water. The mean number of swimmers at a time was two, and the mean duration of their encounters was 3.86 min.

As before, the reaction of the animals differed markedly even within the same species. A general rule could not be found. Nevertheless some species turned out to be especially "profitable" subjects (from a whale-watcher's point of view): e.g. pilot whales and rough-toothed dolphins were more accessible than others (see Fig. 4 for the frequency of each sighting category per species).

Interaction in Relation to Behavioural States
For three species, the sample size was large enough to reasonably describe categories of behaviour based on existing ethograms (Herzing, 1995; Notarbartolo di Sciara *et al.*, 1994; see Table 2). Preliminary categories were established wherever it seemed appropriate. This made it possible to examine the reactions of the named species in a more elaborate way. We correlated the momentary behaviour of a group with the probability of interactive behaviour (see Table 2 for results).

The Psychology of Whale-watching: Do Dolphins change your Mind?

Method A qualitative method of interviewing people was chosen, known as the Role-construct-repertory Grid (REP-grid). This technique used by the Psychology of Personal Constructs gives insight into an individual's world of ideas, conceptions, and mentalities in relation to a certain subject. During a dialogue, the viewpoints of the persons are recorded, restructured, and finally condensed into an easily understandable graphical model. The dialogues themselves maintain the process of exposition with the subject more than any other interviewing procedure. The result is a vivid representation of the individual's constructs of reality.

To identify changes in these concepts, two interviews were made: one before the whale-watch trip, and a second one after it.

Preliminary Findings The data from approximately fifty interviews is yet to be analysed, but some statements can already be made. Changes of individual attitudes could be observed. These changes concern for example the evaluation of certain subjects like ocean ecology, dolphinaria, industrial fisheries, and the like. Those people who had the chance to swim with cetaceans often were deeply imprcssed emotionally.

The tourists typically appreciated the way in which the whale-watch trips were conducted, i.e. the careful procedures in the vicinity of the animals. Most of them accepted the fact that a sighting cannot be guaranteed.

SUMMARY AND DISCUSSION The waters off La Gomera offer great potential for both whale-watching and scientific research on cetaceans. Our study showed that a great number of species use the same area and often can be found relatively close to the coast.

Using the tourist boats as observation platforms provides very good opportunities for the collection of data on a regular basis. During our investigations, we were able to outline the spectrum of reactions, as well as inter- and intraspecific variances in responsiveness. In doing so, the categorisation of sightings was a valuable means to assess the potential of whale-watching and -swimming in an area where these activities often meet presumably "unprejudiced" animals.

The behavioural observations revealed the difficulty of predicting the animals' reactions to human approach. Many factors play a part in what can happen in a given moment. The results give rise to the hypothesis that a species' responsiveness is a function of its momentary behavioural state. This can be regarded as an interesting basis for further research.

In-depth studies are likely to deliver important facts to identify the relative importance of each factor. Furthermore, considerable biological data, even for "exotic" species like beaked whales and others, will arise from such observations.

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Table 1 Details of Sightings

SPECIES	Group Size Range (min.: max.)	Minimum Distance to the Coast	Depth at min. Distance (m)	Mean Duration of Sightings
Bottlenose dolphin	2; 40-50	<10 m	<10	53 min
Rough-toothed dolphin	11; 40-50	1.2 sm	110	1h 30 min
Striped dolphin	40-50	4.5 sm	1250	48 min
Atlantic spotted dolphin	20; 40-50	2.5 sm	600	1 h 18 min
Pilot whale	7; 10-20	2.8 sm	600	1 h 19 min
Blainville beaked whale	2; 9	0.8 sm	100	30 min
Sperm whale (n=1)	5-10	2.8 sm	900	1 h 56 min
Sei whale	1; 2	1.0 sm	90	53 min

Table 2 Preliminary Behavioural States and the accompanying Probability of interactive Behaviour

SPECIES	Behavioural State	Boat Interaction	Swimmer Interaction
Bottlenose dolphin (*Tursiops truncatus*)	TRAVEL SLOW TRAVEL DIVE TRAVEL	None or little.	None.
	DIVE	None.	None or little.
	FAST TRAVEL FAST DIVE TRAVEL SOCIAL TRAVEL	Possible.	None.
	MILLING	Common.	Possible.
Pilot whale (*Gl. macrorhynchus*)	MILLING REST	Little.	Little.
	SLOW TRAVEL	Little.	None or little.
	DIVE TRAVEL	None or little.	Possible.
	TRAVEL	None.	None or little.
	WIDE FORMATION DIVE	None.	None.
Rough-toothed dolphin (*Steno bredanensis*)	DIVE TRAVEL DIVE SURFACE FEEDING	Possible.	None.
	REST	None.	None.
	TRAVEL	Possible or common.	None or little.
	MIXED	Possible or common.	Possible.
	SOCIAL MILLING	Common.	Little.
	MILLING	Very common.	Possible.

FIGURE 1: Sightings La Gomera 01.09.-31.12.1995

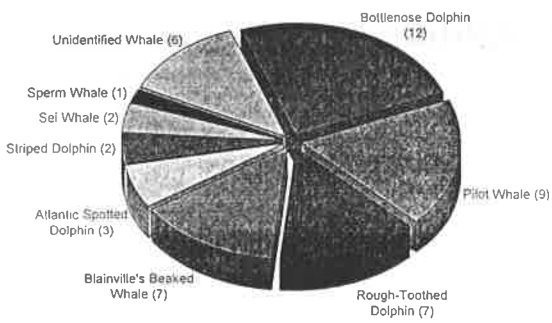


FIGURE 2: Frequency of Sighting Categories

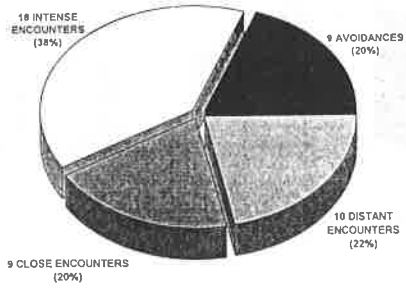


FIGURE 3: Water Encounter (WE) Characteristics

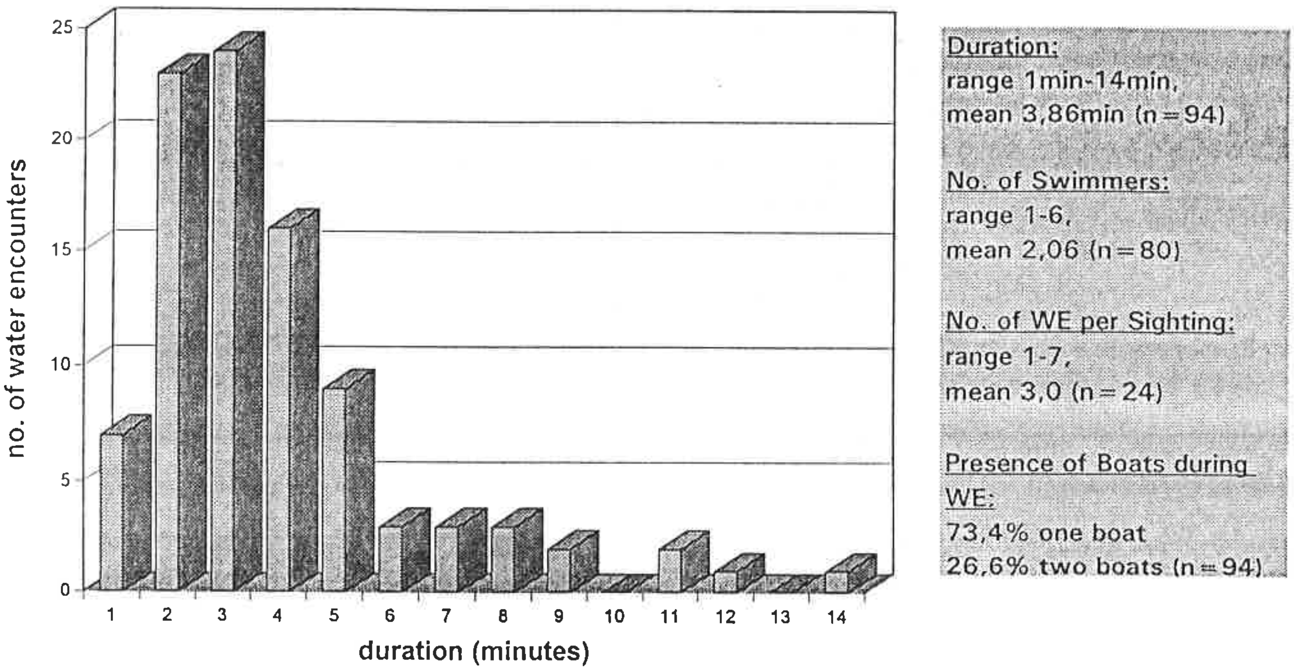
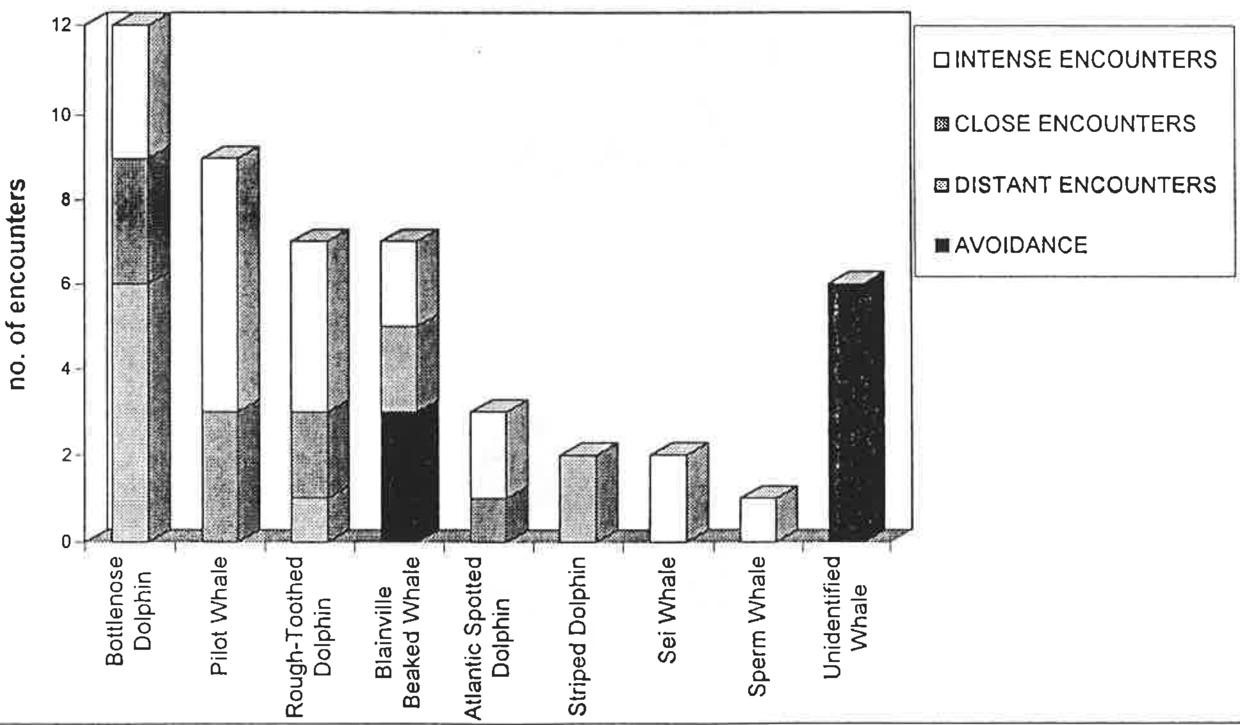


FIGURE 4: Sighting Categories per Species



POTENTIAL AVOIDANCE BEHAVIOUR OF BOTTLENOSE DOLPHINS TO VESSELS IN THE KESSOCK CHANNEL, MORAY FIRTH, SCOTLAND

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INTRODUCTION The Moray Firth is inhabited by one of only two known resident populations of bottlenose dolphins in the UK. This population is considered to be threatened by a range of factors including pollution, prey depletion, and disturbance by different human activities. A recent report for the Scottish Natural Heritage concentrated on vessel traffic in the Kessock Channel, and included a chapter about "dolphin-vessel interactions". The main findings of this chapter are presented here.

METHODS Land-based observations were conducted for 217 hours between 1 July and 9 Sept., 1994. A theodolite was used to record dolphin and vessel positions. Dolphins displayed a tidal movement pattern (Lütkebohle, 1995a,b) which included fairly constant travelling behaviour while leaving or entering the study area. Observations during this study suggested that vessels passing the track of the dolphins were likely to cause interruptions of this constant movement, which mainly occurred in the form of stops, a change of swimming direction, or prolonged dives.

To quantify this impression, 46 situations were randomly chosen from those days when bottlenose dolphins were recorded travelling in to or out of the Kessock Channel. I then compared the number of stops, changes of swimming direction, and number of prolonged dives in those situations with vessels and those without vessel traffic (because the data format sometimes allowed me to analyse only one or two of these behaviours, the sample size had to be reduced in some cases). The following definitions were made:

Travelling movement into or out of study area, with a speed of at least one knot;
Stop circling or milling behaviour within a sequence of travelling in one direction;
Change of Direction a change of more than 20 degrees in direction of travel when a third location was compared with the direction defined by the previous two locations (data presented here only include changes of direction away from the vessel's track);
Prolonged dive a dive, which was at least twice as long as any other dive within event;
Presence of vessel vessels were recorded as present, if they were within 200 m of the dolphins at any time during the event.

RESULTS The comparison showed a considerable increase of stops, changes of direction and prolonged dives when vessels were present as opposed to when no vessels were present.

In the absence of vessels, dolphins stopped in only one of 22 events, and changed their direction of travelling only twice, and never for more than 30 degrees within 20 events. No prolonged dive was observed during eight events without vessels. Dolphins travelling while vessels were present, stopped in seven of 23 events, and changed their direction in six of 23 events, of which three changes exceeded 45 degrees. In seven out of ten cases, dolphins displayed prolonged dives.

A chi-squared test (with Yates' Correction for Continuity) was used to confirm statistically the differences seen between situations with and without vessels. The differences were shown as very highly significant in all three types of behaviour (stops: $c^2_c = 29.64$, $p < 0.001$; change of direction: $c^2_c = 5.61$, $p < 0.025$; dives: $c^2_c = 15.48$, $p < 0.001$).

DISCUSSION The literature describes a range of behavioural changes of cetaceans as potential reactions to vessel traffic. These include changes in diving behaviour (Baker & Herman, 1983; Acevedo, 1991; Henningsen, 1991; Gordon *et al.*, 1992; Janik & Thompson, submitted), blow rates (Gordon *et al.*, 1992), feeding behaviour (Richardson *et al.*, 1990), swimming speed (Blane & Jackson, 1994) and swimming direction (Au and Perryman, 1982; Polacheck and Thorpe, 1990; Henningsen, 1991). These examples stem from eight different species in eight different locations. Although this indicates that vessel traffic might affect a wide range of species among whales and dolphins, it is not appropriate to draw general conclusions by transferring results from one study to another. For every new study conducted, it is important to consider individual characteristics of the population and the habitat. The parameters used to measure changes in behaviour in this study were therefore chosen exclusively on the basis of my own observations in the study area as described under "methods".

First of all it should be stressed that the small sample size can support only very preliminary suggestions, and therefore should be handled with care. Nevertheless, as stated in the results, all three parameters examined showed significant differences between situations with and without vessels, suggesting that vessels caused behavioural changes at least while dolphins left or entered the Kessock Channel.

A change of direction away from the vessel's path, and prolonged dives, may both be determined as avoidance behaviour. A stop while travelling towards a vessel may indicate a state of hesitation. Indeed, five of seven stops were followed either by a prolonged dive or a change of swimming direction away from the vessel's track. Thus most of the changes measured appeared to be some type of "negative" response to the approaching vessel.

Other authors found similar behaviour: Janik and Thompson (submitted) observed decreasing surfacing rates of bottlenose dolphins in the Beauly Firth after a boat approached. This was only significant in those cases which involved a certain dolphin watching boat. In fact a range of different factors are reported to influence potential reactions of cetaceans to vessel traffic. In Janik & Thompson's study, it seemed to be the vessel type, whereas other assessments mention vessel speed, number, behaviour, and proximity.

In the present study, most of these factors were recorded, and some trends were apparent. For example, stops, changes of direction, and prolonged dives seemed to occur at different distances to the approaching vessel. But further analysis is required to select and analyse sufficient situations to provide correct information on whether this or one of the other factors mentioned had an effect on the dolphins. In addition, the observation site and the methods used in this study only allowed identification of a single animal, thus it was not possible to assess whether the level of tolerance to vessel traffic varied with individuals. Finally, the behaviour of the dolphins prior to a vessel approaching might influence their response. Anecdotal observations suggest that dolphins which are concentrated on certain fishing behaviour showed less avoidance than those engaged in other activities.

CONCLUSIONS My own observations as well as the literature and the results of Janik and Thompson (submitted) suggest that a wide range of factors affect the potential responses of cetaceans to vessel traffic, so that future analyses should try to determine whether the behavioural changes found in this study are linked to one or more of these factors, and how far dolphins involved in other behaviours show similar changes to those observed, while travelling in or out of the study area.

It is important to mention that the behavioural changes seen in this study are short-term and small-scale, and at its present state, cetacean research does not provide proven links between these changes and long-term or large-scale effects (IFAW, Tethys, and Europe Conservation, 1995). Therefore, although the present analysis has shown that a significant link between potential avoidance behaviour and the presence of vessels exists, we still do not know whether this will significantly affect the dolphins in the long run. However, the present study and the results of Janik and Thompson (submitted) showed potential avoidance behaviour, and I suggest that the dolphins in the study area are currently subject to disturbance by vessel traffic.

ACKNOWLEDGEMENTS This study was supported by the Scottish Natural Heritage (Inverness) and the Lighthouse Field Station, University of Aberdeen, Department of Zoology).

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THE EFFECT OF A SURVEY VESSEL ON THE MOVEMENT OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

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To protect and manage cetaceans, it has become increasingly important to estimate their abundance as accurately as possible. One of the most common methods applied is the line transect method. An assumption of this method is that all animals surveyed have the same probability of presence in the vicinity of the platform. The movement of animals in reaction to a survey vessel will bias the estimated abundance if the movement occurs before detection of the animals.

In the summer of 1995, a line-transect survey for harbour porpoises was conducted in the Bay of Fundy and the Gulf of Maine. The swimming direction of 481 sighted animals was observed. Eighty-nine sightings of harbour porpoises were tracked with the help of binoculars. Their behaviour at the time of each sighting was also noted. The results indicate a change in behaviour and swimming directions in some animals. The distribution of swimming directions was not uniform.

CHARACTERISING UNDERWATER AMBIENT NOISE

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Underwater ambient noise includes noise of natural, biological and anthropogenic origins. Previous work at the Marine Research Area off the Dorset coast in central southern England (Harland *et al.*, 1996b) has shown that the local population of bottlenose dolphins (*Tursiops truncatus*) tends to move away from the area during the summer months when the ambient noise is at its highest level due to a major increase in small boat traffic during the UK holiday season. It is not clear whether this increase in ambient noise is the dominant cause of this offshore movement or merely a contributory factor. This work aims to characterise the ambient noise levels throughout the year and to determine the principal causes of this noise.

The equipment used consists of a hydrophone on a metal tripod 1.2m above the seabed in 13 metres of water (Harland *et al.*, 1996a). It is located in Durlston Bay approximately 400 metres offshore (Harland *et al.*, 1996b) and near the main route used by small boats heading out of Swanage to the south and west. It is also an area frequented by a small group of bottlenose dolphins during the spring and autumn months.

AMNESEA The Ambient Noise in the SEA (AMNESEA) project consists of a series of concentrated work periods during which ambient noise sources are monitored in detail as possible. AMNESEA was held over the Spring bank holiday 1996 when boat traffic should be at its highest. Unfortunately this period was dogged by bad weather, illness, and organisational difficulties. A short study period was organised in July to improve our data collection techniques. This was dubbed MICRONESEA and yielded our first reliable data on underwater noise sources and levels.

AMNESEA II was held over a weekend in early August 1996 during the peak of the UK holiday season. This yielded a lot of useful data on noise statistics and many of the noise spectra presented in this paper. Fig 1 shows the percentage of time that the ambient noise was dominated by man-made sources. The total number of boats passing in the 16 hour period was 272. The loudest sound recorded was 120 dB re 1uPa from the work boat at a distance of 100 metres from the hydrophone.

Ambient noise The ambient background noise spectrum (Fig 3) is composed of noise from a number of sources. At the low frequency end of the spectrum below 1 kHz the noise is mainly distant shipping moving through the English Channel. The peak around a few hundred hertz is caused by a large distant ship. The sharp roll-off of noise below 1 kHz is because of spectrum shaping within the hydrophone pre-amplifier.

From 1-15 kHz, the dominant noise source is biological. The main source is believed to be the black mussel but there are other possible sources of biological noise and we have yet to prove the cause of a continuous crackling noise with a spectrum peak around 5-6 kHz. The noise in this part of the spectrum can be swamped by wave noise under strong wind conditions or by rain noise when the rain rate becomes significant.

Above 7 kHz, the noise falls off at approximately 6 dB per octave. This agrees well with the Knudsen spectra for ambient noise (Urick, 1975).

In the higher part of the spectrum above 50 kHz, the main noise source is thermal noise. However, rain noise can extend up to this part of the spectra and under certain tide and wind conditions sediment transport noise can dominate to frequencies beyond 100 kHz.

Effect on cetaceans Audiograms of the bottlenose dolphin and harbour porpoise suggests that the animals will be most sensitive to sounds in the 5-50 kHz part of the spectrum. Looking at the spectra of noises presented in this paper suggest that boats such as the RIB's and workboats have the potential to cause a great deal of noise disturbance to these animals.

A cliff-top visual watch has been kept from the research site for a number of years and the results presented in Fig 3. The summer dip in sightings corresponds with a major increase in inshore boat traffic during the summer holiday season. The relationship between this dip in sightings and theœlarge increase in boat traffic is not yet clear. The measurements of ambient noise are part of the work to attempt to establish this relationship but there are other potential causes, for example change in underwater visibility, water temperature, harassment, etc. There may also be effects which affect the efficiency of the visual survey.

Typical noise spectra The rigid inflatable boat (RIB) is very common in the study area and much favoured by divers, water skiers, general pleasure use, and by dolphin researchers. They consist of two inflated rubber tubes mounted on a shallow rigid hull and are usually powered by a large, or even very large, outboard engine with a propellor that has not always been well looked after. They are usually driven at the maximum speed the engine allows so can be very noisy, particularly at the higher frequencies. Their small size means there is little low frequency noise but the mid range and high frequency level can be very high. Figure 4 shows a typical spectra from such a craft.

The high-power work boat is becoming very common around the UK coasts where a semi-displacement mono hull has a very large engine fitted to give high speeds. This allow commercial operators to get out of port and to the sites that earn them money in the minimum time. The propellors are usually cavitating badly and the hull is slamming almost continually. A lot of water is thrown up and generates high frequency noise on impact with the sea surface. Boats of this type are so noisy they invariable overload the hydrophone amplifiers so the spectrum shown was taken at the greater range of around 300 metres to minimise this effect. Figure 5 shows a typical spectrum from such a craft.

Swanage Lifeboat is an 11.6 metre MERSEY class boat typical of the medium-sized rescue craft used around the UK coast. It has a top speed of 16 knots and is propelled by twin four-bladed propellors positioned in ducts to avoid damage from grounding when operating in very shallow water. These ducts have the effect of reducing the medium frequency radiated noise. Figure 6 shows the spectrum taken with the boat at full speed approximately 150 metres from the hydrophone.

The spectrum from a hovering helicopter is shown in Figure 7. A Westland Sea King helicopter hovered approximately 20 metres above the sea surface directly above the hydrophone. The line at 13 kHz is believed to be caused by the turbine blade rate. Lower frequency lines are caused by the rotor blade rates. There is also high frequency noise caused by the water agitation resulting from the down-draught.

The study area is part of the largest onshore oilfield in western Europe. Over the years, we have been visited on a number of occasions by seismic exploration teams. The latest group were operating on behalf of Amoco and with their permission we set up a second hydrophone directly on the line of their source boat which was using an array of 15 air guns. Figure 8 shows the measured waveform at the closed point of approach. Figure 9 is the resulting spectrum.

Future Work This will concentrate on automating the data collection process so that ambient levels and spectra are monitored continuously. Recently installed TV camera will allow the noise levels to be co-ordinated with the track of the boat causing the noise and more accurate estimates made of the absolute levels generated. The visual watch will continue but will be expanded to include statistics on passing boat traffic.

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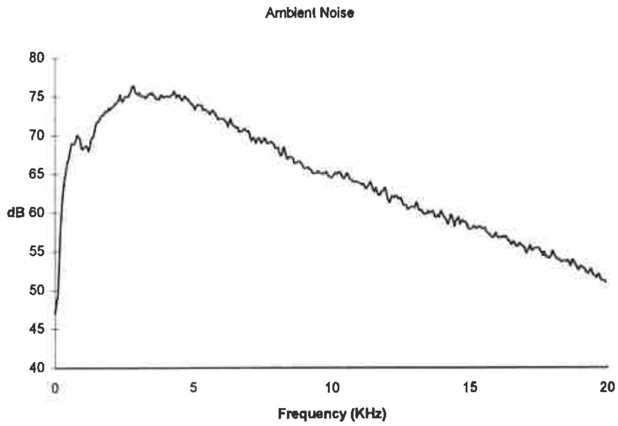

Fig 1. Ambient noise spectrum

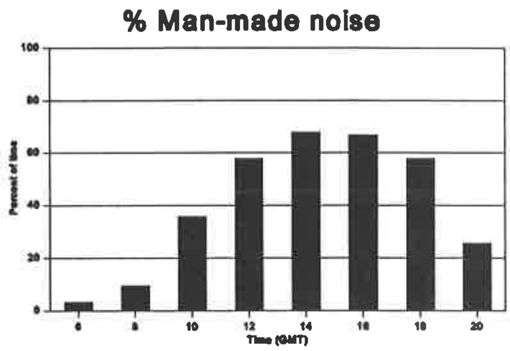

Fig 2. AMNESEA Results - boat noise.

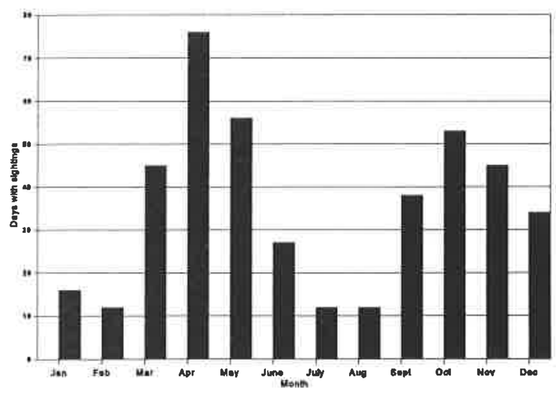

Fig 3. Visual Sightings 1988-1995

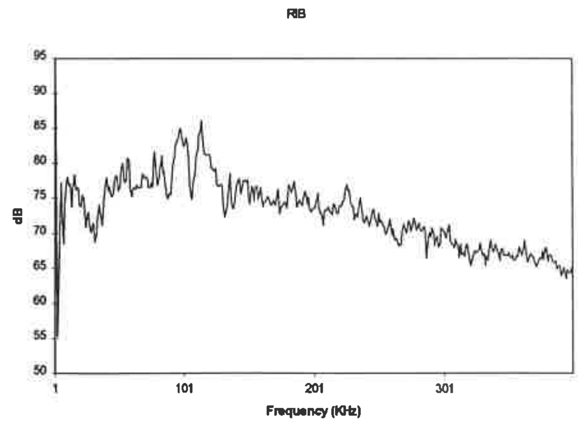

Fig 4. Spectrum of RIB

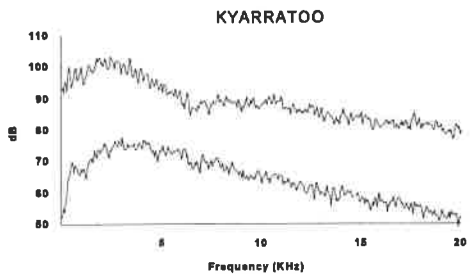

Fig 5. Spectrum from high-power workboat.

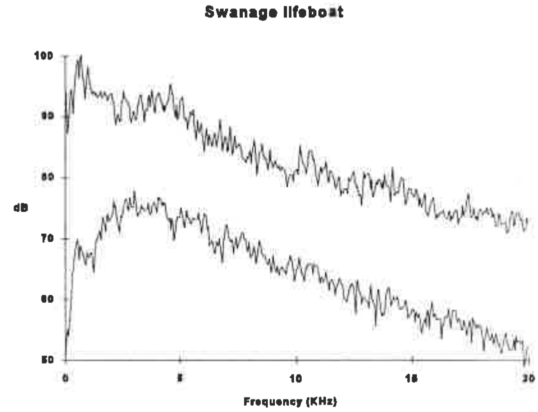

Fig 6. Spectrum of Swanage lifeboat

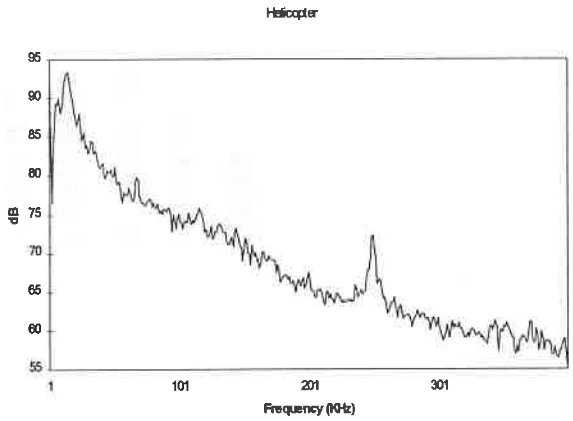

Fig 7. Hovering helicopter

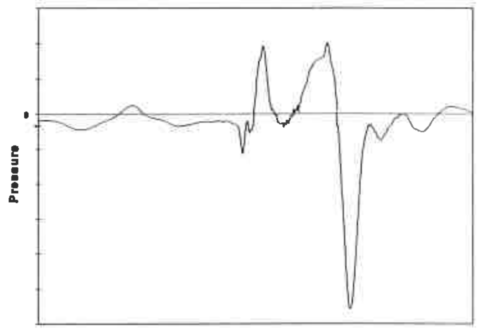

Fig 8. Waveform from air gun array.

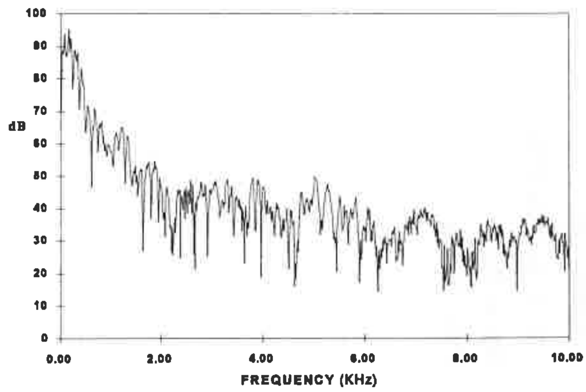

Fig 9. Spectrum of air gun array.

AN INVESTIGATION OF THE INTERACTION BETWEEN ACTIVE SONAR OPERATIONS AND MARINE MAMMALS

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INTRODUCTION During the last decade, the Italian Navy (Marina Militare Italiana) has been concerned about how some military activities in the Mediterranean Sea might affect the marine life, especially marine mammals.

Coinciding with the European Year for the Conservation of Nature (ENCY 95), the Marina Militare Italiana (MMI) has initiated a study of the distribution of large marine mammals in the Mediterranean Sea with the main emphasis on the species fin whale*Balaenoptera physalus* and sperm whale*Physeter macrocephalus*, in order to minimise the extent of interference between these animals and military operations.

Even though the Italian Navy research covered the greatest part of the Mediterranean Sea, this current study was limited to the northwestern Mediterranean Sanctuary (the simulations are referred to the point "P", plotted in Fig. 1).

The main military acoustic activities which might do damage to, or might be significantly disturbing for, marine mammals are anti-submarine sonar (ASW) exercises, which use high-powered sonar.

In order to have some measure as to what extent these activities could affect marine life, we looked at three sonar systems under different, but typical, environmental conditions.

SONAR TRANSMISSION The acoustic pulses emitted by a military sonar are usually of a very high intensity and propagate in the water mass, following paths that depend upon environmental characteristics.

First of all, let us look at the environmental conditions which control the way in which the sonar acoustic pulses are propagated and attenuated.

Propagation is controlled by the sound speed profile, as well as the bottom depth and composition. In the Mediterranean, there are two main seasons: winter with almost isothermal water column conditions, and summer with a warm surface layer, a thermocline followed by isothermal conditions down to the bottom as in the winter.

Since the sound speed, which governs the acoustic propagation conditions, increases with temperature and depth (pressure), the two typical summer and winter profiles for a geographical position "P" (43°30' N, 09° E) in the Ligurian Sea, are shown in Fig. 2.

In general, the MMI operates different types of sonar: hull and bow mounted (Fig. 3 shows the cylindrical antenna of a bow sonar) and one variable depth sonar (VDS). They also operate with different source levels and frequencies. General characteristics of the three systems are shown in Table 1.

Thus, based on the two typical sound speed profiles and the characteristics of the three types of sonar, we have produced six different case studies.

Figures 4-6 display the path of the sound and the resulting transmission loss (TL) based on the acoustic intensity averaged over depth (based upon depth contours) and distance. Losses were calculated using a model which can be considered to be valid for the two frequencies studied. These TL values were computed by a normal mode model, which included volume attenuation obtained from the Thorpe formula. These values are representative for the Mediterranean Sea.

Using the so-called sonar equation, the pressure level (P) at a given point in the water can then be calculated as:

$$P = SL - TL$$

where "SL" is the source level and "TL" is the transmission loss, both in dB.

Based on a vast amount of research on underwater sound prediction in deep water, one can state that transmission loss, in general, can be predicted with a high degree of confidence.

DAMAGE AND INTERFERENCE LEVELS The authors of this paper have tried to find information and rules for the capability of underwater pressure levels to cause damage or disturbance to different species of cetaceans.

Very little data exist on the effects of impulsive sounds on marine mammals. The largest body of research refers to cetaceans that are not typically found in the Mediterranean, to completely different environmental conditions, or to different sound sources (e.g. seismic).

Watkins (1981) studied the reactions of fin whales to different acoustic stimuli and underlined that these animals reacted to sounds between 15 Hz and 28 kHz, and displayed avoidance reactions when the sound intensities were 12 dB higher than the ambient noise level.

Tyack (1993), when studying the reactions of gray whales (*Eschrichtius robustus*) to airgun pulses of 226 dB, noted that this species seemed to display avoidance reactions when the received intensity of the sound pulses was higher than 170 dB.

On the other hand, bow-riding striped dolphins (*Stenella coeruleoalba*) have been sighted in front of a frigate which was operating its hull sonar in an active mode. These animals did not seem to be particularly affected by the high-power sonar pulses emitted at close range (although the bow geometry and the bow wave could have acted as a screen to the acoustic pulses).

In a letter addressed to the authors of this paper, W. Watkins (*pers. comm.*, 1996) underlined the importance of habituation. Quoting directly from his letter: "those animals that have accommodated particular noises appear not to be especially affected, but the same species in areas that are not subjected to those sounds may react very strongly, with severe disruption of their activities".

A recent study by Ketten (1995), based upon the effects of large underwater explosions on marine mammals, suggested a criterion for the evaluation of blast wave effects upon these animals. This criterion assumes different levels of injury based upon the severity of the symptoms caused by the pressure peak.

The conclusion of the above mentioned study indicated that broadband pressure levels with a peak pressure in the range of 30-70 kPa can be lethal for marine mammals, but pressure levels below the 0.4-0.5 kPa range could be considered a reasonable estimate for a safe outer limit for these animals. In terms of decibels/μPa, the values are equivalent to a danger level of 210-217 dB and above, and a safe level limit of 172-174 dB.

Considering the different frequency spectra and the durations of underwater blasts and sonar emitted pulses, taking into account many unknown factors and being extremely conservative in favour of the animals, as a "rule of thumb" we would propose 210 dB to be a danger level and 170 dB as a safe level for a typical narrow-band sonar signal.

As to the levels at which no, or little, interference to marine mammals occurs, there are several confounding factors. Assuming interference to be defined as an impulsive noise which causes the disruption of normal marine mammal activity, it is clear that the problem must be related to the various different species in question. For example, a fin whale, whose communication system operates in the very low frequency range, would probably not be disturbed in the same way as a sperm whale which produces clicks in the same frequency range as sonar pulses. Being conservative in favour of marine life, and with limited knowledge, we would define the non-interference level for sperm whales to be ten times lower than the safe level, which would be equivalent to 150 dB.

Taking 210 dB as the danger level, 170 dB as a safe level, and 150 dB as a non-interference level, let us return to the sound levels produced by military sonar. For a sonar with source levels of 230 dB, this requires a transmission loss corresponding to 20-30 dB to achieve the minimum danger threshold. The safe level of 170 dB would then require a distance which results in a transmission loss of 60 dB and for a non-disturbance distance, a transmission loss of 80 dB would need to have occurred.

In Figs 4-6, the safe and the no-disturbance contours are superimposed upon the transmission loss curves. From this, we can conclude that at a distance greater than 800 to 1000 m, there is no risk of injury to marine mammals. For our arbitrary non-interference limit, the range shown is clearly dependent on depth and season.

SUMMARY AND CONCLUSIONS The possible detrimental effects to marine mammals, caused by ASW sonar transmissions, has been investigated for different environmental conditions. It can be concluded that the danger area around a sonar antenna is limited to some tens of metres for a medium frequency sonar and to about 100 metres for a low frequency bow sonar. Assuming a conservative safety factor, in favour of marine mammals, a range of 800-1,500 m. should be assumed to be a safe distance for various environmental conditions. The non-disturbance range was clearly dependant on the water depth and season, and was dependant upon the cetacean species and the degree of their habituation to the noise. The worst possible case was for a Low Frequency Bow Sonar being used in the winter, with which a potential range for disturbance for some sensitive cetaceans could reach a distance of 20 km or more. For the Medium Frequency Hull Sonar and the V.D.S., the potential range for disturbance should be below 10-12 km.

In the summer, due to acoustic ray propagation, cetaceans that mainly stay close to the surface (e.g., fin whales) are well protected by the thermocline.

A new experimental research programme should be considered to address “in the field”, observations of avoidance reactions to sonar emitted sounds for different cetacean species.

ACKNOWLEDGEMENTS We wish to thank the personnel of the Saclant Undersea Research Centre who instrumental in the creation of this report. M. Ferla performed the acoustic simulations. A. Green, N. Watkins (Saclantcentre), and Dr. A. Zoncheddu (University of Genova) supported the bibliographic research. W. Watkins (Woods Hole Institute) gave fundamental advice for the assumptions of some of the hypotheses upon which this work is based. Admiral D. Nascetti provided data regarding the sonar used by the Italian Navy. A special thanks is given to Claudia Maurelli (Mariperman) and Sandra Chynoweth for their assistance with editing this work.

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Table 1 A comparison of the three main types of sonar utilised by the MMI (source levels are in dB re 1μPa)

Type	Depth (m)	Frequency (KHz)	Vertical Aperture (°)	Source Level
Bow L.F.	5	3.5	15	230
Hull M.F.	5	7.5	15	220
VDS	0150	7.5	15	220

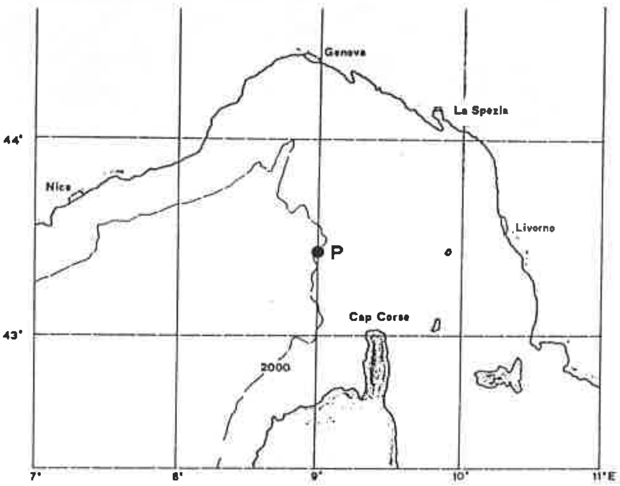


Fig. 1 The Ligurian Sea - The site "P" was selected as being representative of the Northwestern Mediterranean Sanctuary

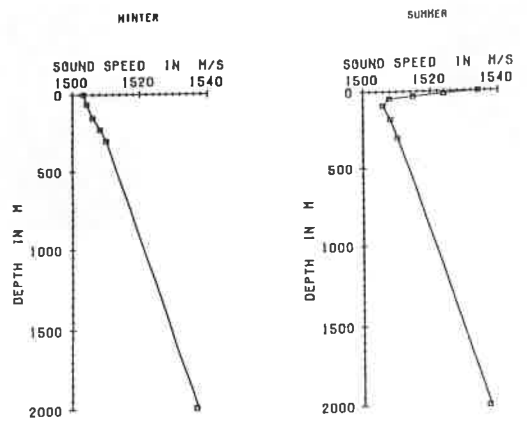


Fig. 2 Typical summer and winter profiles for the geographical position "P" in the Ligurian basin

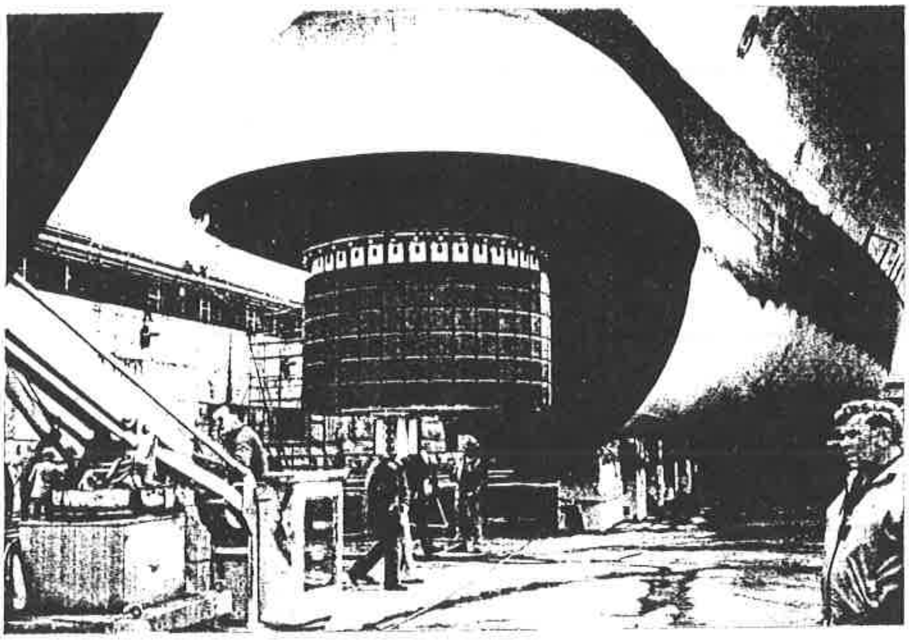
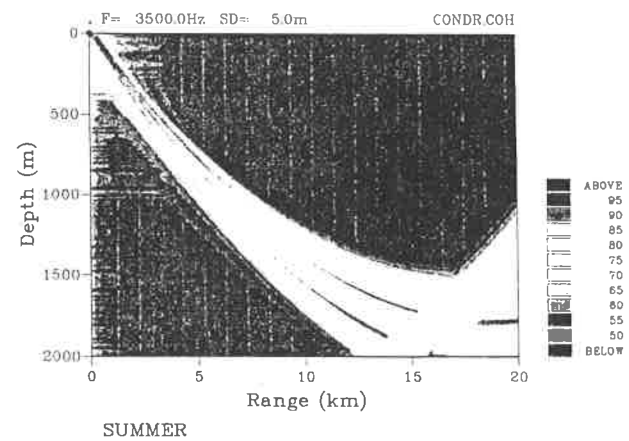


Fig. 3 The cylindrical antenna of the Bow Sonar assembled on board an Italian Navy Cruiser



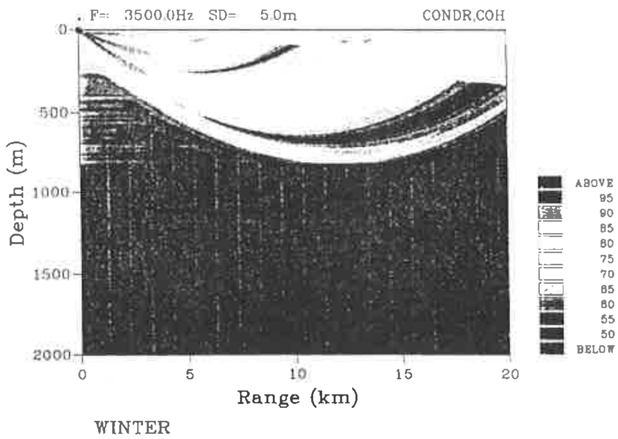


Fig. 4 Transmission Loss for Bow Sonar: (a) summer, (b) winter

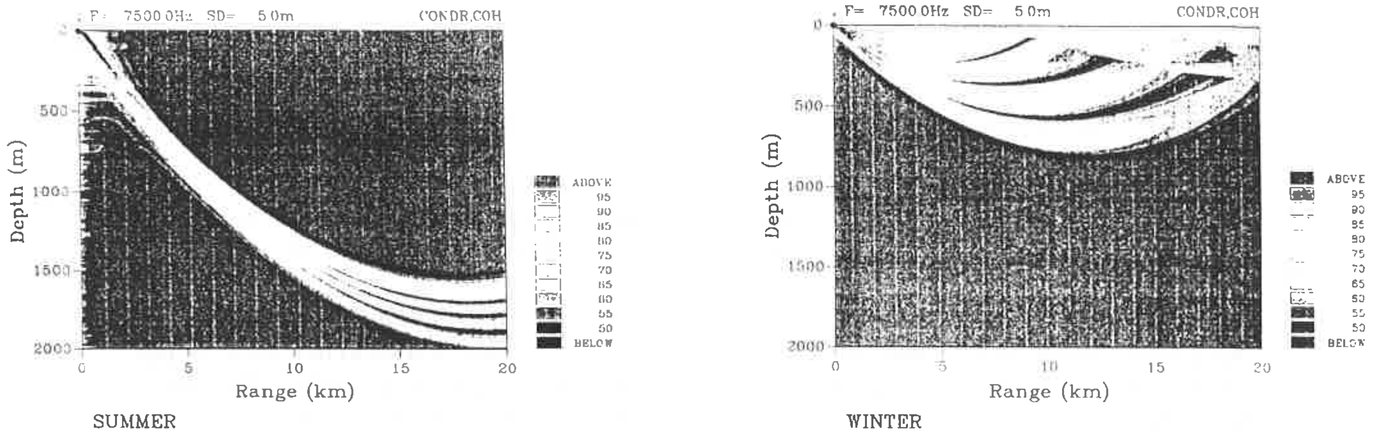


Fig. 5 Transmission Loss for Hull Sonar: (a) summer, (b) winter

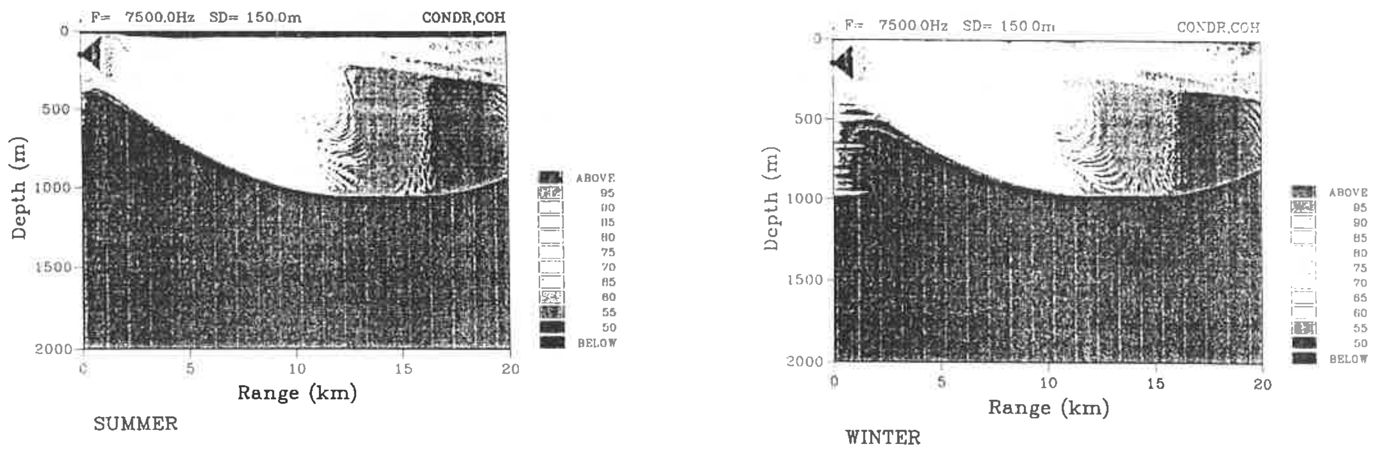


Fig. 6 Transmission Loss for V.D.S. operating in a water depth of 150 m: (a) summer, (b) winter.

VOCAL BEHAVIOURS OF DOLPHINS IN THE CONTEXT OF PASSING PHYSICAL BARRIERS

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Currently, there is a vivid public discussion about the pros and cons of keeping dolphins in captivity, and a growing number of people demand rehabilitation of these creatures. However, such an enterprise is difficult to achieve if one wants to do it in a biologically adequate manner.

A few months ago, we started to tackle this matter by studying a group of bottlenose dolphins (for details, see Todt & Hultsch, 1996, *Europ. Res. Cetaceans - 9*).

The bottlenose dolphin group (*Tursiops truncatus*) is living in semi-free confinement adjacent to the Red Sea (site: Dolphin Reef/Eilat; size of site: >10,000 m^2, max. depth: 18 m ; size of group: five adults (2/3), three juveniles (2/1), one calf). The site is separated from the open sea only by a wide-meshed net, and since recently, a gate to the sea is open for two hours per day. For a long time, however, contrary to expectation, only one individual has made use of the opportunity to swim out for an excursion, whereas the other ones repeatedly inspected the gate without passing it completely.

In order to further investigate why the dolphins seemed to have problems with such physical barriers, we built a new enclosure and invited the animals to explore and also to use it by voluntarily passing a second experimental gate. Then we recorded how the dolphins coped with this setting (recording equipment linked to video cameras and hydrophones). Behavioural data were evaluated in terms of correlations between vocalisations and events causing stress, such as problems preceding or following any trial to pass the gate (for details of parametric analysis, see: Janik *et al.*, 1994. Behav. Ecol. Sociobiol., 23: 15-21, or Hammerschmidt and Todt, 1995, Behaviour, 132: 381 -399).

Our study allowed us to identify a variety of vocal interactions, such as matching of signature whistles, which were correlated with the quality of the particular test episodes. In addition, our results confirmed that bottlenose dolphins indeed may have problems in passing physical barriers. But they showed also how these animals finally can solve such problems.

VOCAL RESPONSES OF LONG-FINNED PILOT WHALES (*GLOBICEPHALA MELAS*) TO MILITARY SONAR PULSES

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INTRODUCTION Sound and the acoustic sense are very important in the life of cetaceans, and they are extremely acoustically sensitive animals. As a consequence, they are vulnerable to being harmed or disturbed by loud underwater noises, and there is increasing concern about the deleterious effects that anthropogenic noise (so-called acoustic pollution) might have on these animals.

One poorly classified source of extremely loud underwater noise is military sonar. During the summer of 1994, loud shrieks from a military sound source were often heard in the Ligurian Sea, an area of high cetacean abundance in the Mediterranean that has been declared a whale and dolphin sanctuary by the governments of France, Italy, and Monaco.

Watkins (1985) reported that sperm whales ceased vocalising when military sonar was heard in the Caribbean. In addition, sonar-type equipment was used by pelagic whalers specifically to scare their quarries (Mitchell *et al.*, 1981), and is one of the methods used to herd pilot whales during drives in the Faroes (Bloch *et al.*, 1990).

Taruski (1979), and Weilgart and Whitehead (1990) have described how vocal behaviour, and, specifically, call type changes with behavioural state. Here, we report on the short term effects of these noises on the vocal behaviour of long-finned pilot whales (*Globicephala melas*).

METHODS Observations were made from the 14 m ketch, "*Song of the Whale*", the research vessel of the International Fund for Animal Welfare, during the course of passive acoustic monitoring project in the Ligurian Sea Sanctuary.

A towed hydrophone (Benthos AQ4 elements, Magrec pre-amplifiers, flat 200 Hz-15 kHz) was monitored every 15 min. while the vessel was at sea, and recordings were made on a Sony TCD10 Pro DAT recorder. Extended recordings were made using the same equipment during the course of the encounter analysed here.

A loud shrieking sound, later confirmed as coming from a military vessel, was often heard during monitoring sessions between 24 July and 8 September, 1994. On some occasions, even when the source vessel could not be seen, this was so loud that it could be heard through the boat's hull and stopped the crew from sleeping. These sounds consisted of three blips (main energy around 4 kHz) and a long "stepped" shriek (main energy around 4 kHz, with additional components around 6 and 8 kHz) emitted in a regular pattern and repeated every 41 seconds (Fig. 1).

The locations of 302 monitoring stations at which this sonar source was heard during work in 1994, are shown in Fig. 2. The position at which the vessel deploying this source (an Italian Frigate, "Francesco Mimbelli") was encountered on 5 September, is indicated, as is the position of the encounter during which recordings for this study were made.

On 2 August 1994, at 19:15 h., a tight pod of between forty and fifty pilot whales were sighted during a period when sonar signals could be clearly heard. The research vessel closed with the whales to confirm identification, and they were found to be remarkably tolerant of the vessel which stayed with them (generally drifting with the engine in neutral or off) for the next three hours, while a more or less continuous recording was made. As it became dark, the whales remained rafted up close alongside the vessel.

Recordings were later digitised at 24 kHz and spectrograms made, using a real time analyser running on a Sun workstation (Entropic Research Lab Recording Spectrogram v1.4). Calls were classified into one of seven categories based on their shape, following the scheme of Taruski (1979) and Weilgart and Whitehead (1990). Spectrograms of typical whistles are shown in Fig. 3.

RESULTS The 444 calls were classified and their relative start time with a sonar cycle noted. The distribution of call production throughout 77 sonar cycles is shown in Fig. 4. The rate of call production within one-sec. cells during, and for two seconds after pulses, was compared with rates during the rest of the cycle using Mann-Whitney U tests. Tests were repeated for all calls combined and for different call categories separately.

The overall rate of calling was higher during and just after sonar pulses ($p = 0.0004$). "Level", "up-down" and "down-up" types were all heard at significantly higher rates during and just after sonar pulses ($p = 0.0038, 0.005, 0.0325$ respectively), while "rising", "waver" and "multihump" calls did not show any significant temporal correlation with sonar pulses. "Falling" type calls did show peaks after pulses but did not show a significant difference to the 95% level ($p = 0.051$).

DISCUSSION The results clearly indicate a short-term response to sonar pulses. Pilot whales appear to call in response to these sonar pulses.

"*Song of the Whale*" had been hearing sonar pulses for some five hours before encountering these whales, and continued to hear them for a further eight hours. The source vessel was not in sight at any point during the encounter with the pilot whales (indicating a range of >15 miles). We can thus assume that this noise could be heard at levels high enough to drastically alter the vocal behaviour of pilot whales over ranges of many tens of miles, and also that pilot whales had not habituated to the sound, even though they had been exposed to it for tens of hours, if not days.

Assessing the significance of these vocal responses is difficult, especially as we know so little about the significance of pilot whale vocalisations. It is difficult to suggest reasons why only certain whistle types showed temporal correlation with the sonar, while others, particularly "multihump", showed none. This does imply, however, that different call types have distinctly different functions.

A recent survey of cetaceans in the Mediterranean by Di Sciara *et al.* (1993) puts pilot whales as the least common of the seven species sighted - seen "occasionally" in the Ligurian and Tyrrhenian Seas. Little is known about this population, and whether numbers are stable or not. However, mating and calving have been observed to peak in September (Pilleri and Pilleri, 1982), so this time of the year is clearly important for the animals. In addition, this study raises questions about the effects of military sonar on other cetaceans in the area, which include populations of striped dolphin, sperm, and fin whales.

The very great range at which these sounds seem to affect cetaceans, the apparent lack of habituation, and the secrecy which surrounds military operations, are causes of considerable concern. Certainly these particular military manoeuvres would seem to be singularly inappropriate activities in a cetacean sanctuary.

ACKNOWLEDGEMENTS This work was funded by the International Fund for Animal Welfare. We thank Dr. Frank Gooding of the University of Wales, Bangor for access to acoustic analysis equipment and advice. We thank the crew and interns on "*Song of the Whale*" for the dedication and hard work which made this project possible.

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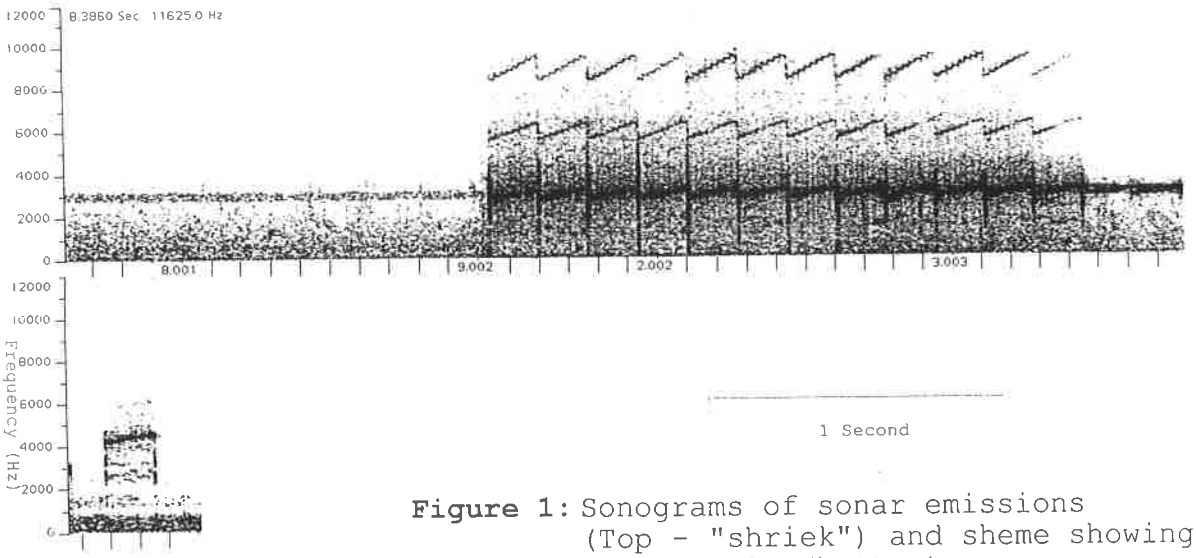
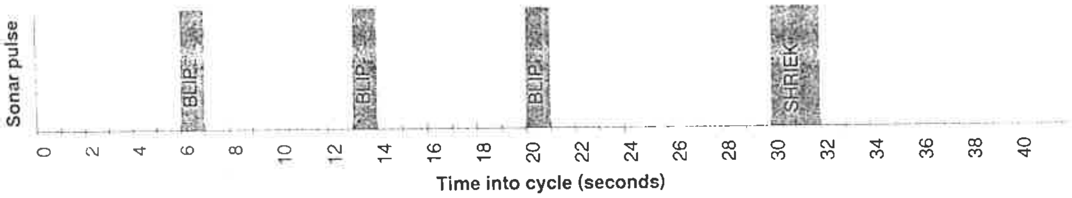


Figure 1: Sonograms of sonar emissions (Top - "shriek") and sheme showing sonar cycle (bottom)



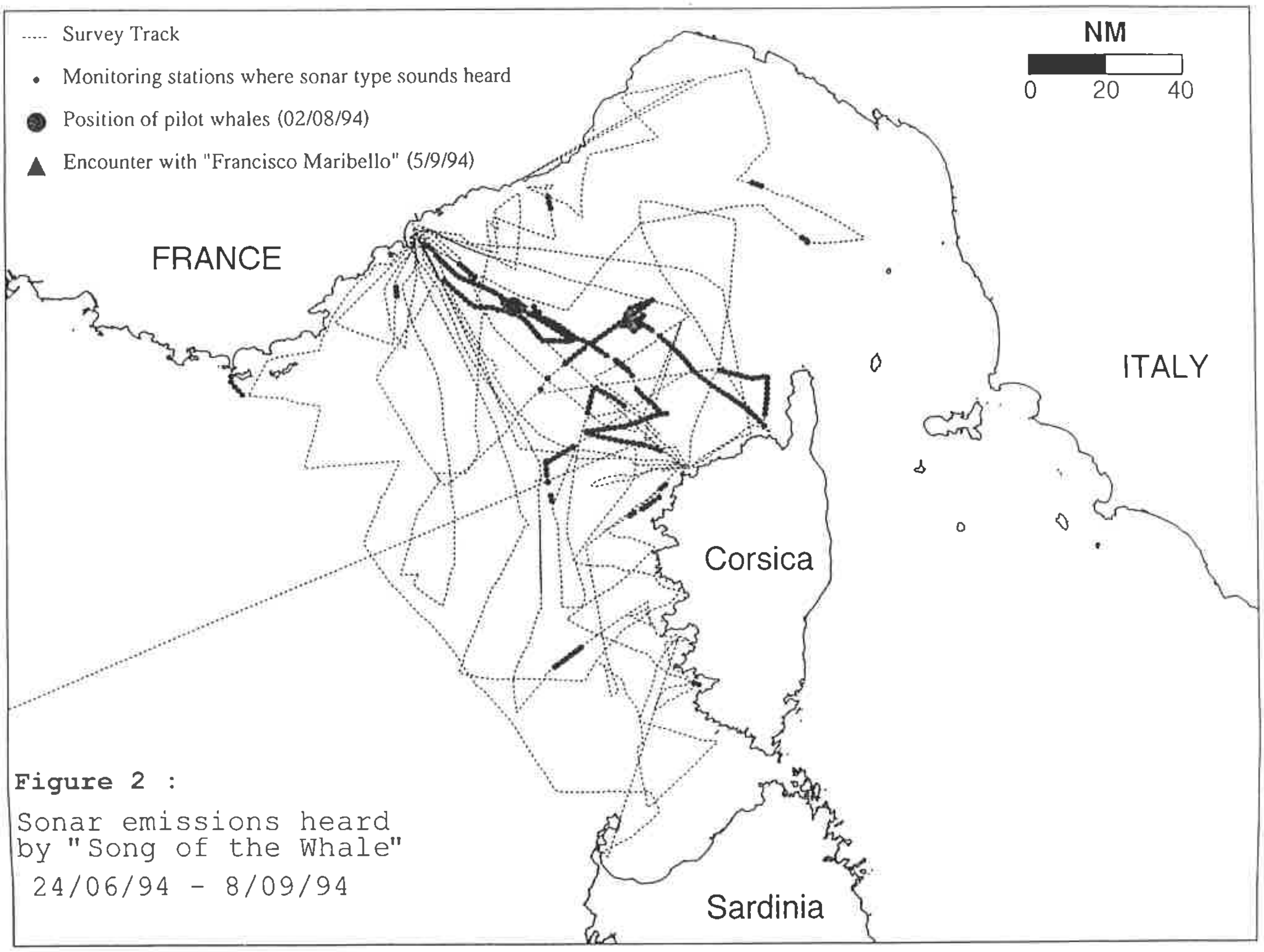


Figure 2 :
Sonar emissions heard by "Song of the Whale"
24/06/94 - 8/09/94

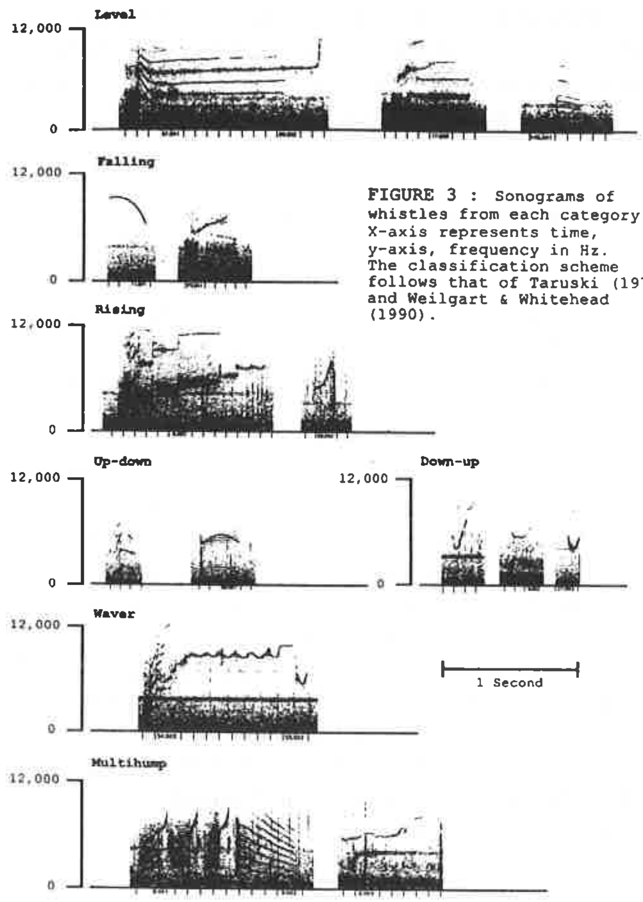
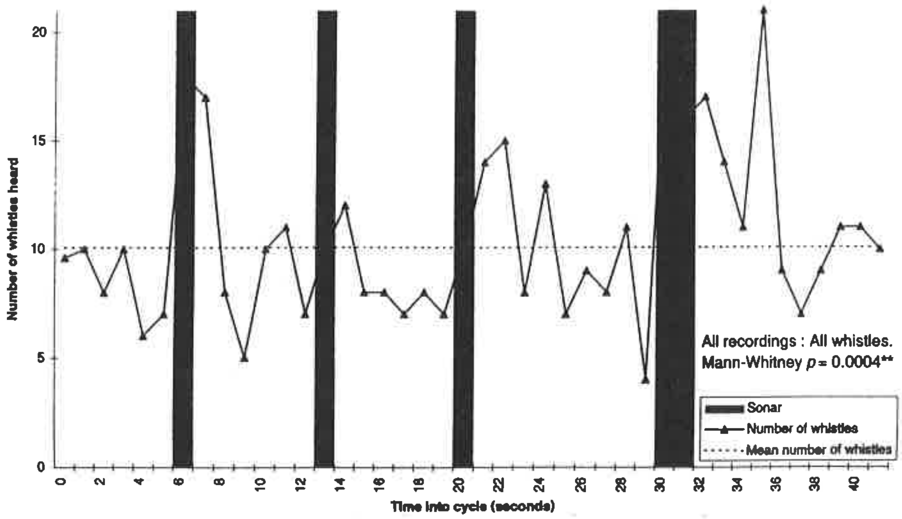


FIGURE 3 : Sonograms of whistles from each category. X-axis represents time, y-axis, frequency in Hz. The classification scheme follows that of Taruski (1979) and Weilgart & Whitehead (1990).

Figure 4 : Plot of numbers of whistles heard during each second of the sonar cycle.



ACOUSTIC BEHAVIOUR OF THE SHORT-FINNED PILOT WHALE (*GLOBICEPHALA MACRORHYNCHUS*) OFF THE SOUTH-WEST COAST OF TENERIFE, CANARY ISLANDS: PRELIMINARY FINDINGS

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Pilot whales have a rich vocal repertoire, and general associations between social-behavioural context and vocalisation types have been demonstrated for the North Atlantic long-finned pilot whale (*Globicephala melas*) (Weilgart, 1990). The vocalisations and behaviour of the short-finned pilot whale off the south-west coast of Tenerife, Canary Islands, are being studied in an on-going project begun in 1993. The aim of this research is to correlate the vocalisations of the animals with their behaviour and social context. When a pilot whale pod was located, underwater recordings were collected in 10-minute sessions and their general activity pattern and behaviour was recorded during 30 minutes. The acoustic equipment used consisted of an omnidirectional hydrophone connected to a stereo-cassette recorder (Sony TC D5 PROII) with a frequency range from 40 Hz to 16 kHz. Sounds were categorised aurally as whistles, pulse sounds (e.g. squawks, buzzes, barks) and echolocation activity.

Whistles were classified on the basis of their energy, duration, and changes in frequency, using the categories developed by Taruski (1976). The present paper shows the preliminary findings of this research. There is a significant relationship between the vocalisations of the short-finned pilot whales and their activities. Simple whistles predominated when several pods were travelling spread out over the área. This type of whistle probably plays an important role in maintaining the contact and co-ordinating movements inside the pod as well as among different pods in the area. More complex whistles were heard, frequently accompanied by a variety of pulse sounds, when pilot whales were in a state of excitement such as socialising or during the encounter between two pods. On the other hand, during rest, the whales were silent most of the time.

AVERSIVE SOUND PRESSURE LEVELS AND A HARBOUR PORPOISE

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As part of an EC funded research programme designed to develop efficient acoustic warning devices for attachment to fishing nets, a variety of low level signal wave forms and frequencies were presented to a harbour porpoise, confined within a 20 x 30 m floating net cage. The reaction of this animal to each type of sound, and the avoidance and habituation behaviour that ensued, were carefully recorded. The preliminary results of this first study suggest that, even at very low source level's (below 120 dB re 1μ Pa at 1 m), some signal types remained effective in inducing a sustained avoidance reaction and that while these were being presented, the animal moved to select areas of the pool where the sound pressure level was believed to be at a minimum.

Subsequent computer modelling has permitted the complex pressure level variations around this pool to be mapped in fine detail. The observed porpoise surfacing behaviour clearly correlated with localised reductions in the sound pressure pattern, which was created by transmitting digitally synthesised signals through four transducers configured as a sparse array along one side of the pool. The data also suggest that this animal was able to discriminate and exploit quite small sound pressure level variations.

Three signal types were presented: Clicks (in bursts of ten); Tones lasting 270 ms. (with a randomised mark/space interval); and Chirps (3-octave frequency sweeps) at several different intensities, and in a range of frequencies between 10 kHz and 140 kHz. From these signal types, the maximum effect was found to be induced by the Chirp wave form although Tones, when presented at high frequencies, were also quite effective. This contribution examines the physical parameters which affect these observations, and illustrates the complex nature of sound propagation in shallow water.

FEASIBILITY STUDY USING SONOBUOYS TO STUDY CETACEAN ACOUSTIC BEHAVIOUR IN THE COASTAL WATERS OF THE INNER HEBRIDES, SCOTLAND

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As part of the Hebridean Whale and Dolphin Trust's (HWDT) ongoing acoustic research, successful sea trials of fixed and drifting sonobuoys were carried out in late September 1995. The aim of these trials was to assess the feasibility of using sonobuoys as benign tools for studying cetacean acoustic behaviour, in particular that of the minke whale, *Balaenoptera acutorostrata.* A modified Ultra Electronics sonobuoy was deployed at night in the Sound of Eigg, and transmissions monitored using a modified Yaesu communications receiver and Sony Pro DAT-corder. A second buoy was anchored in 39 m of water off Calliach Point, Mull.

Preliminary analysis of results indicates that equipment functioned well, and recordings of low frequency vocalisations have been made. The vocalisations occur in the range c.50-500 Hz, and are undergoing further analysis at this time. Results and future modifications to the sonobuoys are discussed in this contribution.

The International Fund for Animal Welfare (IFAW) provided the funding and equipment for this study.

A RIVER OF SONG: ACOUSTIC TRACKING OF MIGRATING HUMPBACK WHALES

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Six North-east Pacific humpback whales (*Megaptera novaeangliae*) were equipped with ARGOS satellite telemetry tags in late March and early April 1995 near the Hawaiian island of Kauai. Three of the six whales were tracked north of the Hawaiian islands following tagging. Two of the three tagged whales were tracked for more than 14 days, and travelled more than 1,500 km during that time. Using the locations of the tagged whales to guide an initial search, a U.S. Navy array of acoustic receivers (IUSS) was then able to track a progressive shift north in recorded song through May 1995. In September 1995, the IUSS hydrophones began recording a latitudinal shift in the location of song south from the Aleutian Islands area.

We hypothesise that this seasonal trend in acoustic activity indicates the migratory route of humpback whales between Alaska summer feeding grounds and Hawaii wintering/breeding grounds. To our knowledge, it is the first evidence that song is a common behaviour during migration. These data obtained from IUSS, along with similar data obtained for other species and locations by Clark, Watkins, and others, indicate that IUSS is an unrivalled tool for tracking the large-scale movements of vocally active marine mammals.

REGIONAL VOCALISATIONS OF THE SPERM WHALE: MEDITERRANEAN CODAS

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INTRODUCTION Sperm whales, (*Physeter macrocephalus* (=*catodon*) Linnaeus 1758) are well known for producing particular vocalisations called codas (Watkins *et al.*, 1977). Throughout the world's oceans, several different temporal patterns of codas have been recorded, and, although their function remains unclear, it has been suggested that there are geographical variations in repertoire (Watkins *et al.*, 1985; Gordon, 1987; Weilgart, 1990; Moore. *et al.*, 1993; Weilgart *et al.*, 1993; Borsani *et al.*, 1994). During eleven encounters in the Tyrrhenian Sea from 1988 to 1994, we recorded 48 codas. Forty-four of these could be analysed: all showed the same temporal pattern and varied slightly in total duration. The codas were produced by at least seven different individuals, identified using photographs of their flukes. Out of eleven encounters, four were of single animals, while during the other encounters, more than one individual could be sighted in the same area, and at least three individuals could be heard vocalising at the same time. Although cruises were held in different seasons, codas were heard only in summer.

MATERIALS AND METHODS Using auxiliary sailing vessels up to 26 m long, we cruised across the central Mediterranean Sea from 1988 to 1994, gathering data on the distribution and the acoustic behaviour of sperm whales and other cetacean species. In July 1988 and August 1989, we recorded vocalisations of sperm whales each time that animals were sighted visually; on such occasions, one hour of recordings was collected in 1988 and three hours in 1989. Recordings were made with an unfiltered ITC 8073 preamplified hydrophone and an analog tape recorder at a speed of 19 cm/s, the system giving acceptable acoustic quality from approximatively 100 Hz to 20 kHz. During dedicated cruises in 1991, 1992, 1993, and 1994 (Pavan *et al.*, 1996a), five-minute listening sessions were held every 30 min. while towing hydrophones at speeds of 7-10 km/h; 43 hours of recordings were collected using several different towed dipole-arrays and Dat recorders, and stored in the Cetacean Sound Library of the Centro Interdisciplinare di Bioacustica (Pavan *et al.*, 1996b). Identification photographs of the flukes were taken whenever possible and, on seven occasions, animals could be identified. Distinctive codas were heard 29 times during four encounters in 1991, 1992, and 1994. While whales were recorded during the entire period from 1988 to 1994, codas were recorded only in 1991, 1992, and 1994. In 1994, IFAW's R/V "Song of the whale" encountered several whales, and heard 19 codas. Forty-four out of a total of 48 codas could be analysed with regard to their total duration and interclick intervals, while four were masked by noise and could not be reliably measured. The relative duration of the interclick intervals vs. the total duration of the codas was calculated. Measurements were taken by means of the Digital Signal Processing Workstation (DSPW) from the Centro di Bioacustica (Pavan *et al.*, 1996c). The data were plotted as scattergrams, their regression functions calculated, and correlation coefficients determined. The data were also plotted as frequency histograms and compared to the Gaussian distribution. The degree of similarity of the coda pattern was assessed (Sokal *et al.*, 1981; Zar, 1984; Siegel *et al.*, 1988).

RESULTS All codas recorded match a 3+1 (/// /) pattern (Fig. 1). The analysis shows total durations of codas ranging from 960 to 1,124 ms (n=44, average=1,050.727 ms., SD=42.61, SE=6.4). Interclick intervals (ICI) from the first click (T1) to the second (T2) are positively correlated with the total duration of the codas, measured from the onset of the first click to the onset of the fourth (T4); the correlation coefficient is $R^2 = 0.3555$; the equation of the linear regression is $y = 0.2639x - 19.936$.

ICI's of T2 to the third click (T3) are positively correlated with the total duration (T1 to T4), with $R^2 = 0.633$ and the regression equation $y = 0.5213x - 16.96$.

The individual difference between vocalising whales was confirmed for seven animals by comparing fluke ID's and visual length estimates. The animals encountered ranged in length from approximatively six to 16 m. Sexes could not be assessed unequivocally for all animals heard, thus no evidence of a clear distribution of sexes between the vocalising animals could be provided. However, fully grown males, subadult males, adult females and calves were sighted and are also reported from sightings (Notarbartolo-di-Sciara *et al.*, 1993), strandings, and bycatches occurring in the area (Centro Studi Cetacei, 1987, 1988, 1990, 1991, 1992, 1994, 1995).

DISCUSSION Some variation in the total duration of codas could be assessed, where the coefficient of variation of the total duration was CV=4.06%. The distribution of the relative duration of ICI's suggests that the 3+1 pattern is stable (Fig. 3). Codas were shared by several individuals, which argues against the hypothesis that codas identify single individuals. Rather, results seem to suggest that the function of codas could be of identifying a number of different whales that happen to share, at least temporarily, one and the same area (Moore *et al.*, 1993).

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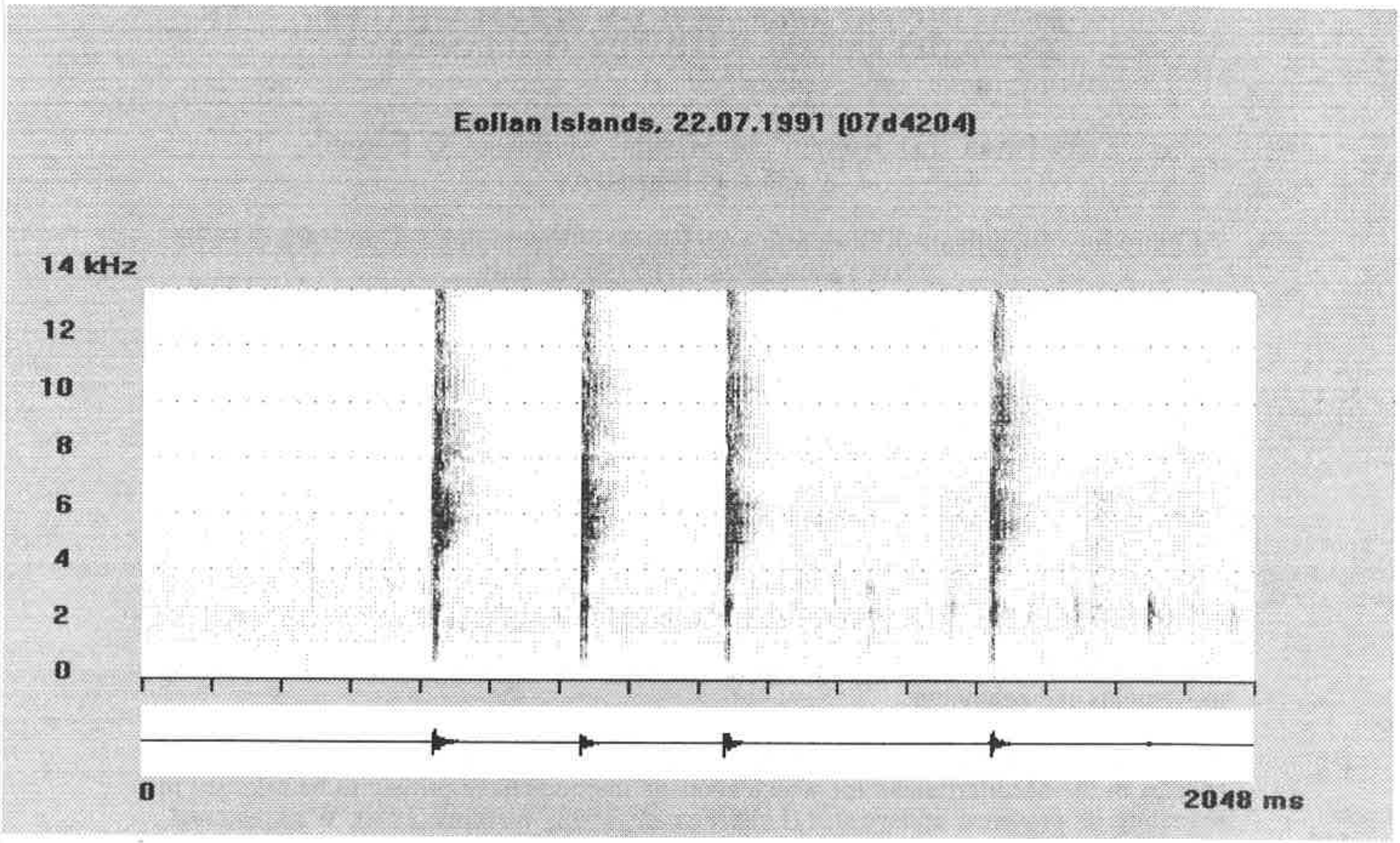

Fig. 1 A typical 3+1 coda pattern for sperm whale

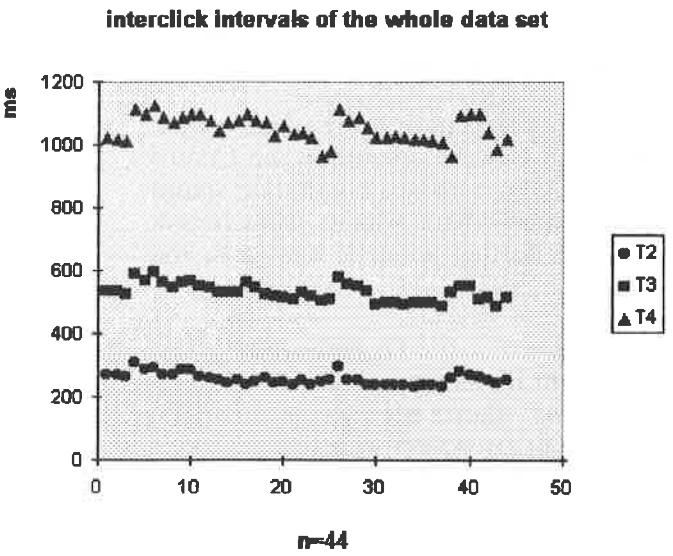

Fig. 2 Interclick intervals of entire data set

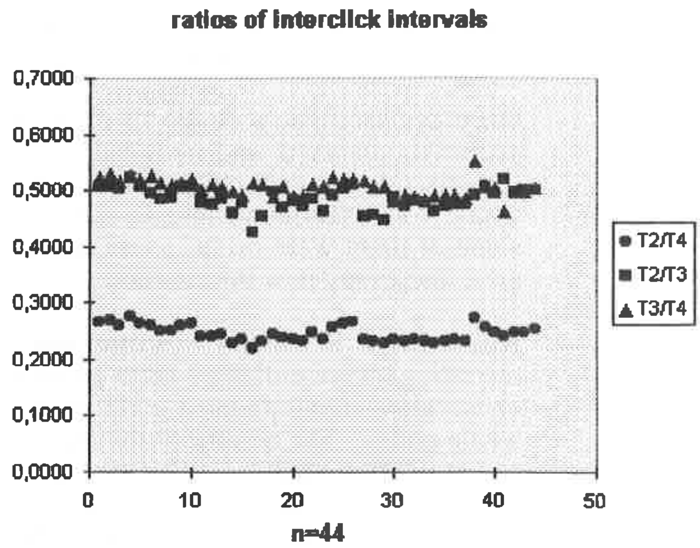

Fig. 3 Ratios of interclick intervals within codas

BIOACOUSTIC RESEARCH ON SPERM WHALES IN CO-OPERATION WITH THE ITALIAN NAVY

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INTRODUCTION Within the European Nature Conservation Year 1995, the Italian Navy set up a co-operative research program with universities and other institutions to give logistic support, and to apply its technologies to the study and protection of the marine environment.

The project includes a research programme on cetacean acoustics, mainly dealing with the two larger species in the Mediterranean Sea, the fin whale *Balaenoptera physalus* and the sperm whale *Physeter macrocephalus*, in order to unveil and monitor their seasonal movements and behaviour.

Target species for the first year of the project was the sperm whale; a relatively rare species in the Mediterranean for which acoustic methods have proven to be relevant in revealing its presence underwater (Leaper *et al.*, 1992; Watkins, 1980; Watkins *et al.*, 1977).

The main goals for this first year included collecting Navy recordings made by different platforms, such as surface vessels, submarines and sonobuoys. Particular emphasis was put into tuning protocols for data interchange and into co-ordinating efforts for the development of shared methodologies and instrumentation. Training activities were also made to instruct the operators to pay attention to biological sources and to co-ordinate their efforts in recording them while performing their institutional patrolling activities.

Once declassified, acoustic recordings of biological sources made by the Navy were acquired, analysed, and included in the Cetacean Sound Library created at the Centro Interdisciplinare di Bioacustica (Pavan *et al.*, in press). All recordings containing sperm whale vocalisations (Table 1) were used to map locations where whales were heard; some of them were of sufficient quality to be useful for further acoustic analyses, and gave interesting new information.

Recordings made by submarines and sonobuoys To date, only a few recordings were collected from submarines; one of them included a sequence of eight consecutive signal patterns, emitted in 40 sec., resembling "short" Mediterranean sperm whale codas. The quality of the recording was low due to the source-receiver distance, and at the first analysis, those signals were classified as "not identified". Some months later, new recordings made with sonobuoys in the same area, confirmed that they possibly were "short codas", where the pattern (//// /) was similar to those recorded in previous years (Borsani *et al.*, this vol.), but the duration was shorter (mean duration = 486 ms., SD = 15.6, n = 8).

The most interesting recordings were made with sonobuoys deployed by ASW aircrafts. Two types of sonobuoys were used in the first stage of the project: MISAR sonobuoys, omnidirectional with a 10 kHz frequency range, and DIFAR sonobuoys, directional with a 2.5 kHz frequency range.

The first recording from a MISAR sonobuoys was made in the Gulf of Taranto (May 1995). The recording included regular clicking and two codas (whose duration was 1,118 ms. and 1,140 ms. respectively) (Fig. 1), matching the Mediterranean codas (mean duration = 1,051 ms, SD=42.6, n=44) described by Borsani *et al.* (this vol.).

Further recordings were collected during a flight south-east of Sardinia (October 1995); eight omnidirectional broad-band MISAR sonobuoys were deployed over a range of 70 km, with sonobuoys about 10 km apart. From one of them, sperm whale clicks were heard, and consequently DIFAR sonobuoys were deployed to locate the whales.

More than two hours of recording from a DIFAR sonobuoy (transducer 30 metres deep) revealed the presence of at least three sperm whales, located where the depth of the sea bottom exceeded 1,500 metres.

Clicking by three sperm whales, and several "short codas" by one of them, were recorded (Fig. 2). The analyses made at our lab showed a sequence of ten consecutive "short codas" emitted in 50-sec. bursts. This recording confirmed the existence of a variation to the codas, previously recorded and described in the Mediterranean. After these analyses, the previous recording of short codas made by a submarine was reconsidered.

Short codas recorded in 1995 appear to be quite different from the previous codas when total duration and absolute values of interclick intervals are considered. Also, the recording shows a variation in coda duration within the same sequence emitted by the same whale. The ten codas recorded in October have increasing duration, the first coda being 572 ms. long and the last one 724 ms. long (mean duration = 627 ms, SD=73.0, n=10) (Fig. 3). On the other hand, the number of the clicks and the analysis of their temporal pattern, made on the basis of the interclick intervals ratios, demonstrate the homogeneity of this new coda with the structure of previously described ones. The analysis of interclick interval ratios for the entire data set (all codas recorded in years 1991-95) shows that, on average, the second click is located at 24.3% and the third one at 49.1% of the entire duration.

Recordings made with towed arrays Along with data collection by military platforms, research cruises with traditional instruments such as stationary hydrophones and towed arrays of hydrophones have been supported by the Navy. A 12-day research cruise has been organised in the Ligurian and North Thyrrenian Sea, to detect and record cetacean sounds with the towed array of the Centro Interdisciplinare di Bioacustica (Pavan *et al.*, in press). The hydrophone was towed for 111 hours (out of 12 cruising days) at speeds up to 14 km/h; listening stations were held on a 24 h. schedule for at least 10 min every half an hour. The detection and tracking of the vocalising animals was supported by a portable real-time DSP-Workstation (Pavan, 1992, 1994, in press).

Only one sperm whale was detected and located. It was heard at night (02:00 AM), and acoustically tracked for the subsequent eight hours. Within this period, the whale was sighted five times at the surface during which eight complete dives were continuously recorded. No other sperm whales were detected, and no codas were heard, thus supporting the hypothesis that solitary sperm whales do not produce codas. Advanced analyses of all the recordings showed peculiar underwater acoustic behaviours (work in progress).

CONCLUSIONS The results gained so far show that military technologies (Carlson, 1994; Clark, 1994) can be used to solve scientific problems, and to widen our awareness about the seasonal distribution of sperm whales in the Mediterranean Sea. The project demonstrated that the acquisition of biological sounds and information can be carried out side by side with the institutional patrolling activities of the Navy.

We strongly hope that co-operation with the Navy will continue in terms of training operators and in consolidating protocols for data interchange to widen these activities and to provide new information to biologists. If this occurs, in the near future, ASW (Anti Submarine Warfare) underwater acoustic systems should be used to extensively study sperm whales and other cetaceans in the Mediterranean Sea.

ACKNOWLEDGEMENTS The activities of the Navy were organised within the ENCY 95 (European Nature Conservation Year). Financial support for the research and the development of the instrumentation was provided by the Italian "Ministero dell'Ambiente - Ispettorato Centrale Difesa Mare". Recordings in 1995 were made possible thanks to the enthusiasm of the crews of the ASW flights involved in the project, and of the skipper Helga Arp.

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Table 1 Summary of results of the first year of the Navy's project

Platform/Source	Date	Effort	Position	Recording	Nsw	Notes
Towed array	25-06-95	12 d (m) 111 h (t) 88 h (l)	43:46N 009:20E	7:20 h	1	8 dives contin.
Submarine	04-04-95	n.d.	38:20N 009:00E	8 m	>2	clicks, 8 short codas
Sonobuoy	03-05-95	n.d.	39:44N 017:29E	20 m (1 sw surfacing)	2	clicks, 2 codas
Sonobuoy	24-10-95	5 h (m) 3 h (l)	38:33N 010:13E	2 h	3	clicks, 10 short codas bursts

Effort: numbers indicate the effective listening period (l) out of the total duration of the mission (m); (t) indicates the effective time spent towing the array.
n.d. means that the recordings were occasional and not related to a specific effort; Nsw = number of sperm whales

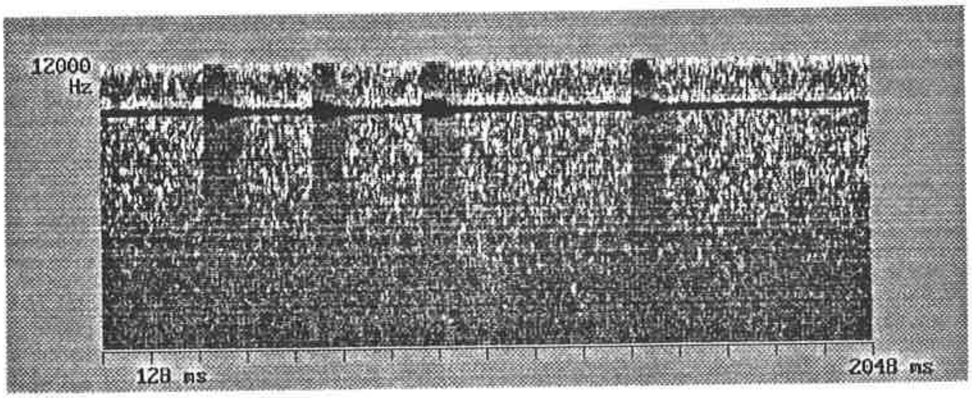

Fig. 1. Gulf of Taranto, May 95. Spectrogram of a sperm whale coda (duration 1,140 ms); the signal propagated through a highly reverberant environment. The black trace represents the envelope of the signal.

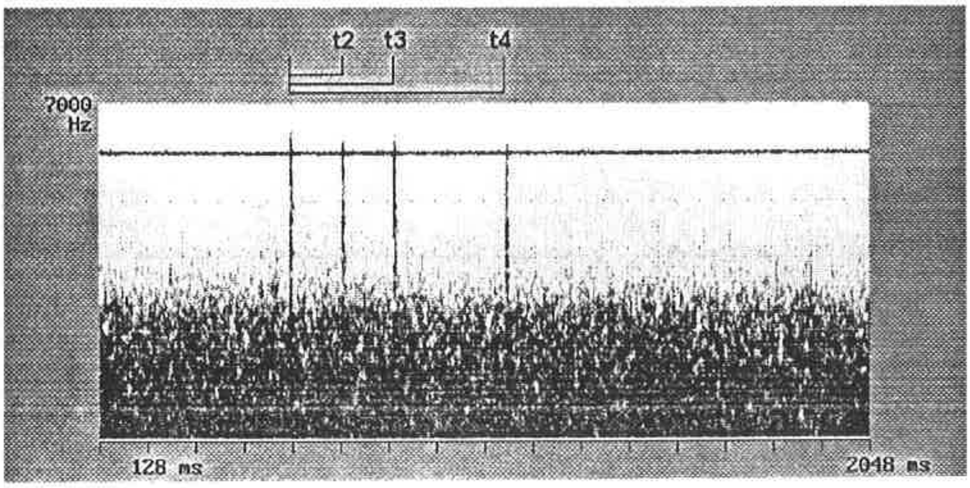

Fig. 2. Spectrogram of a "short coda" and the measure points (t2, t3, t4) taken. South of Sardinia, October 1995.

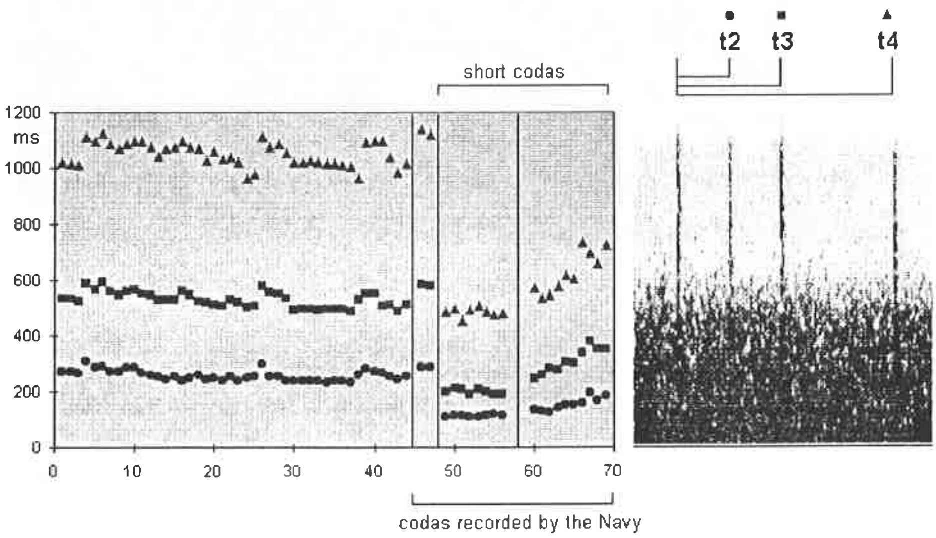

Fig. 3. Plot of interclick intervals for the whole data set. From left to right: 44 codas recorded in years 1991-94, two codas recorded in May 1995, eight codas recorded in April 1995, ten codas recorded in Oct 1995. The sequence recorded in Oct 1995 shows codas with increasing duration.

DETECTION OF SPERM WHALE (*PHYSETER MACROCEPHALUS*) CLICKS, AND DISCRIMINATION OF INDIVIDUAL VOCALISATIONS

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INTRODUCTION Acoustic methods are particularly appropriate to locate and study sperm whales because of their loud, regular click type vocalisations and long dive cycle. Sperm whales start sequences of regular clicks shortly after fluking up to dive. Vocalisations also include distinctive stereotyped patterns of clicks (e.g. codas), and short bursts of rapid clicking (e.g. creaks). Sperm whale clicks are impulsive broadband signals with frequency peaks anywhere between 500 Hz and 4 kHz and energy over a frequency range up to at least 12 kHz; these can be detected at ranges up to 8 km using relatively simple equipment (Leaper *et. al.*, 1992). In many areas, sperm whales are found in large groups, and behavioural studies are limited by not being able to follow the vocalisations of an individual.

Software has been developed to detect sperm whale clicks from digitised stereo recordings, and to separate the vocalisations of individuals within a group. Recordings are analysed with a digital trigger algorithm to extract click-like blocks of data. Candidate clicks are assigned to individuals according to their relative bearing, amplitude, and correlation coefficient with the power spectrum of previously categorised clicks. The program provides an interactive analysis environment, with graphical display and playback facilities. The system has applications for surveys, behavioural studies monitoring click rates, and analysis of codas. The program has been written to run using Windows on a PC.

Recordings were made using a simple towed hydrophone containing two elements mounted 3 m apart. The 3 m spacing is designed to give adequate bearing resolution (approx. 1° for whales at and angle of 45° the hydrophone axis). At the same time, the maximum time difference between waveform on each channel is 2 ms which keeps to a minimum the possibilty of clicks from different whales becoming interleaved.

CLICK DETECTION (DIGITAL TRIGGERING ALGORITHMS) A two stage algorithm is used to extract click like blocks of data from digitised recordings. The first stage employs pulse detection algorithms and is primarily designed to run fast and to reduce the amount of data to analyse with the second stage which employs a more complicated frequency analysis. As each block of data is extracted, the bearing to that sound is calculated, using the difference in arrival time, and stored with that data in a separate file. The original data may then be discarded to free disk space.

In the first stage, the waveform for each channel is rectified and then passed through two low pass filters. The first, which has a high cut-off frequency, is designed to remove noise spikes; the second has a very low cut off frequency and gives a measure of background noise. Decisions are based on the difference between the two filter outputs. In the second stage, the power spectrum of each block of data selected by the first stage is analysed, and the data are only accepted if the sum of the energy in certain regions of the spectrum is above some pre-determined threshold. A graphical display of the original waveform, the filter output, and extracted clicks is shown to facilitate the setting of thresholds. All thresholds and filter frequencies are adjustable by the user.

CLICK DISPLAY AND INDIVIDUAL WHALE IDENTIFICATION Each candidate click is represented by an ellipse on a plot of bearing against time (Fig. 1.). The width of each ellipse is proportional to the duration of the click, and the height proportional to the click amplitude. Typically, one minute of data is displayed at a time. It is possible to scroll forwards and backwards through longer recordings using control buttons at the top of the display. The mouse may also be used to zoom in on regions where more detail is required.

Clicks from an individual whale appear as rows of ellipses on a consistent bearing. As clicks are assigned to individual whales, they are displayed in different colours (hence the program name - "*Rainbow Click*"). The waveform and power spectrum for a click can be displayed, and the click played back through the computer's sound card. It is also possible to play back sequences of clicks, using an accurate time base to fill the gaps between blocks of data with zeros. All clicks on the display can be played back, or a selection of clicks within a given bearing/time range, or only those clicks assigned to an individual whale.

AUTOMATIC INDIVIDUAL IDENTIFICATION The program automatically compares sequences of clicks and assigns them to individual whales. A seed click is first selected with the mouse. This forms an initial reference with which subsequent clicks are compared. The relative bearing, amplitude, and correlation coefficient with the power spectrum of subsequent clicks are compared with the reference to provide an overall coefficient of similarity. If this coefficient is above some threshold, the click is labelled as coming from that whale, and the reference updated. The weight attached to each component of the coefficient of similarity may be varied. For instance, if many whales are on the same bearing, more weight will need to be attached to the spectral information and amplitude. However, if there are few whales on clearly different bearings, then the bearing information will be the most useful tool in making decisions.

Although there is generally a high level of consistency between the waveform and spectrum of successive clicks from an individual whale, the click properties tend to vary slowly over time. This could reflect changes in the orientation of the whale relative to the hydrophone, or changes in the acoustic path. To allow for this effect, the reference power spectrum is continually updated by calculating a weighted mean of the existing reference and the spectrum of the latest click. The weighting parameter may be varied to change the speed at which the reference is updated. The reference amplitude is updated in a similar fashion, but the reference bearing is simply the bearing of the last click to be selected. Clicks may be labelled 'by hand' if the user wishes to override the automatic decision making process.

Figure 2 shows the same data as Figure 1, but only the clicks which have been assigned to two individuals are shown. Surface echoes sound and appear very similar to clicks. Echoes are identified and assigned to clicks based on the similarity of their spectrum and the relative time delay between clicks and echo candidates. On the display, echoes are shown as hollow ellipses.

PROGRAM OUTPUT AND OTHER DISPLAYS Once clicks are labelled as coming from an individual whale, the times, amplitudes, and inter-click intervals of sequences of clicks may be output to a disk file for further analysis. The bearing/time display may also be changed into a click-interval/time display, where the intervals between successive clicks from an individual are plotted against time (Fig. 3).

To measure inter-pulse intervals from individual clicks, the cross correlation function of two data segments are displayed alongside the two pulses. Moving the mouse across the cross correlation display causes the two pulses to slide across each other so that the optimal correlation can easily be selected.

SUMMARY The software package provides a versatile, easy to use method of analysing recordings of vocalisations from individuals or groups of sperm whales, to extract data such as individual click rates, or examine patterns of clicks such as codas. This has applications for both behavioural studies and acoustic surveys. It has been used to monitor vocalisations from individuals within groups for several dive cycles around the Azores, and is being used to analyse data from a recent acoustic survey in the Southern Ocean (Gillespie, 1996).

The software is under continual development. Planned upgrades include real time raw data analysis, which will include digital transfer of data from DAT and more sophisticated click detection algorithms. The authors are interested in collaboration, and welcome suggestions of useful features which could be added to the program.

ACKNOWLEDGEMENTS We would like to acknowledge Dr. Jonathan Gordon and Per Gjerlov for providing many useful ideas and suggestions, and the International Fund for Animal Welfare for providing the research vessel and office space. This work was carried out as part of a study of the effects of low frequency ATOC type noises on sperm whales.

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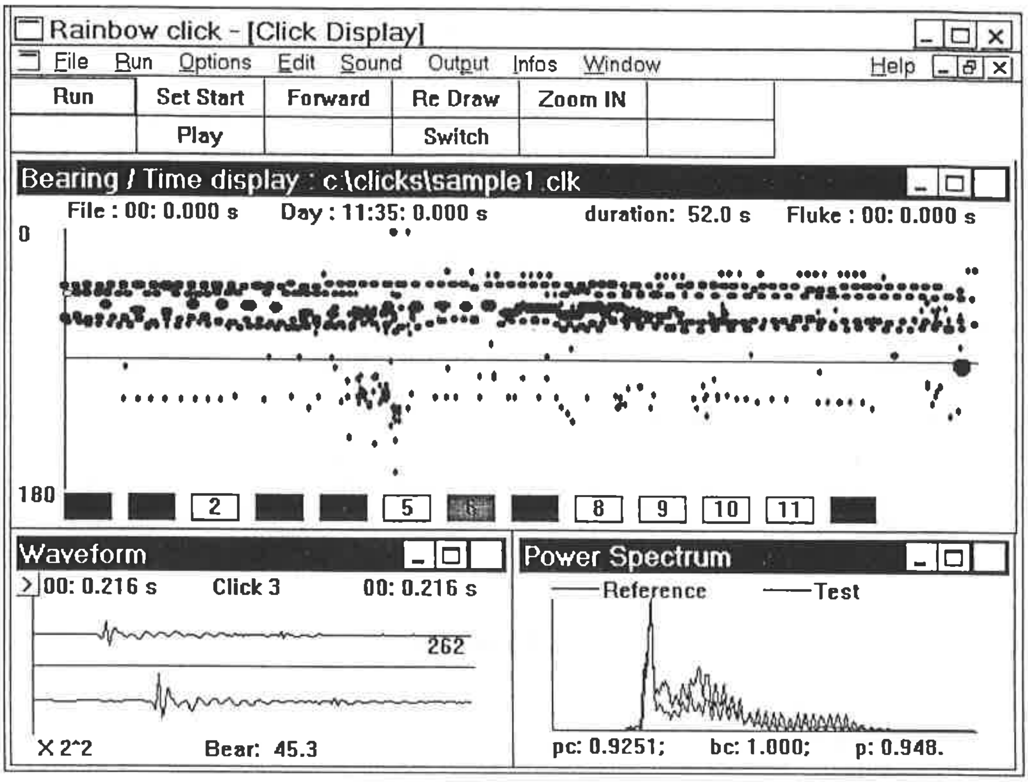

Fig. 1 The interactive display showing the plot of bearing against time, the waveform and power spectrum of the selected click

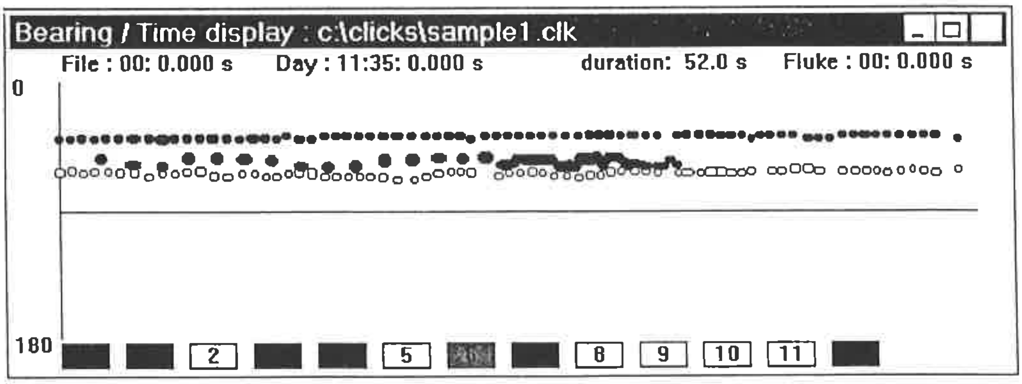

Fig. 2 Clicks from two identified individuals are now shown

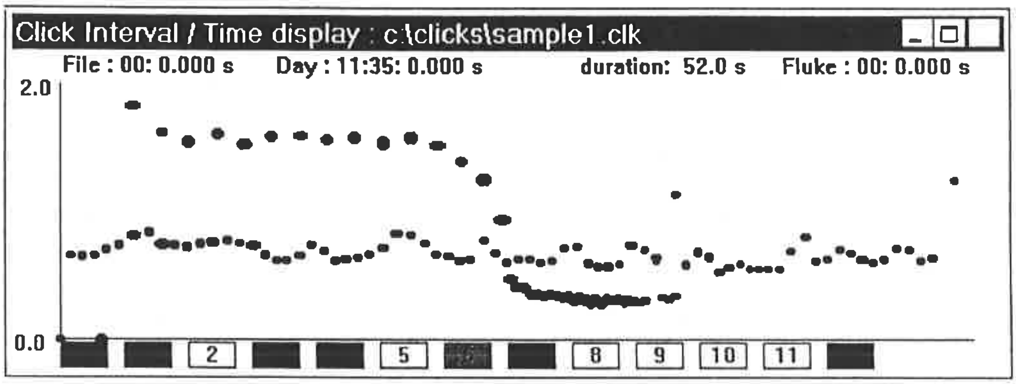

Fig. 3 Clicks plotted against time

SPERM WHALE (*PHYSETER MACROCEPHALUS*) BEHAVIOURAL RESPONSE AFTER THE PLAYBACK OF ARTIFICIAL SOUNDS

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Cetaceans have been lately of special interest for the ferry companies carrying passengers in the Canary Islands. At least two documented accidental collisions with whales have been reported in the last five years.

Among the many species sharing daily the area, sperm whales have appeared to be the most convictive regarding possible future collisions.

A series of experiments with an underwater transducer was conducted to estimate the behavioural response of the whales to the playback of artificial sounds, as a method to keep them away from the ships cruising routes.

We present here the results of 215 experime nts ran in presence of sperin whales. Six sound types were played back, including killer whales' vocalizatiotis, water surface hits, five click codas, engine sounds, 1 -30 kHz sweep sound and 10 kHz pulse sounds.

The reaction of the whales was evaluated and classified whether they were fast swimming (short or long distance), resting or in a feeding process.

None or little reaction was observed after the playback of the first five sounds. The 10 kHz pulse sound induced a strong reaction when the whales were feeding and none when they were fast swimming. While resting, the whales first strongly reacted to the sound but then ignored it completely.

Those results suggest that the sper in whales are more sensitive to their environmental noise when they are in a feeding process (long dives), and seem to ignore (get used to?) a sound emission, though very aggressive, when they remain at the surface resting or fast swimming.

ACOUSTIC CENSUSING OF SPERM WHALES AT KAIKOURA, NEW ZEALAND - AN INEXPENSIVE METHOD FOR COUNTING CLICKS AND WHALES AUTOMATICALLY

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Special DSP-software was developed to automatically count sperm whale clicks recorded along acoustic transects, and to facilitate the calibration of these counts through automated and interactive analyses of dive cycle and range experiments. Minimum pulse width and maximum inter-pulse interval are used as criteria for automated click detection. In addition to these criteria, the inter-click interval (ICI), the amplitude of the first click pulse, and the number of pulses per click can be used for tracking of clicks during interactive analyses.

Interactive analysis of a dive of a single whale recorded under ideal conditions gave the following results: the mean of all inter-clicks intervals measured within bouts of regular clicks was 0.801 secs (n = 2,203 intervals, CV = 27.5%), the reciprocal of which corresponds to *ca.* 1.25 clicks per second. Including ten seconds between fluke-up and the first click recorded, silences between bouts of regular clicks detected and two surface clicks found 3:37 minutes later, the average click rate over a dive time of 42:23 mins is 0.88 per sec. (n = 2,244 clicks).

In several dive cycles analysed, inter-clicks intervals were found to oscillate periodically during bouts of regular clicks. These oscillations correlated with click amplitude.

ACOUSTIC BEHAVIOUR OF A BOTTLENOSE DOLPHIN MOTHER-CALF PAIR IN CAPTIVITY

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INTRODUCTION On 5 September, 1994, Bonnie; a 20-year old bottlenose dolphin, delivered a healthy female calf, which was named Cleo. Bonnie and Cleo are housed at Genova Aquarium and they both belong to Aquatic World Cattolica, run by Delphinarium Riccione. The main objective of this part of our research was to study the development and use of distinctive whistles for individual recognition in a mother-calf pair in captivity.

MATERIALS AND METHODS The behaviour of Bonnie and Cleo was monitored for one year after the delivery occurred, through both video and acoustic recordings. Acoustic recordings were carried out by connecting a hydrophone with a DAT recorder, while images were taken by a video camera placed outside the tank, right in front of the 24-metre long acrylic wall, which characterises our pool. Video and acoustic signals were also integrated in a S-VHS video-recorder. Recordings were made in the frequency range from 100 Hz to 22 kHz.

In order to be able to better correlate vocal and gestural behaviour, which was our main intention, the acoustic signals were analysed with the Digital Signal Processing Workstation developed by Pavan (Pavan, 1992, 1994), which gives a real-time spectrographic analysis of the signal. Such spectrographic images were superimposed on all the recorded video sequences through a video-mixer.

DISCUSSION From the day of the birth, the mother started showing a spectacular vocal activity, which continued for a few days (Fig. 2). Such unusual activity was extremely stereotyped, since most of the time only one single whistle was produced.

Such whistles had already been recorded before delivery and identified as the mother's signature whistle (Caldwell and Caldwell, 1965). However, in no other situation were we able to record such an obsessive production of this same whistle. A second whistle, which we called "whistle 2", was often recorded in association with the signature. Such whistles look very much like the initial part of the first one and actually we believe it is just the same whistle or, more accurately, we believe that whistle 1, the signature, is the complete and distinctive form of whistle 2 (Fig. 1). Whistle 1 and whistle 2 not only seem very similar, but they always occur in the same context with a very similar frequency distribution (Fig. 3).

Focusing on the first day, in order to better understand why Bonnie was whistling so much, we observed that Bonnie's vocal activity increased very suddenly exactly when Cleo was delivered. The frequency that the signature whistle was uttered increased during the first hour following the birth and became really obsessive in the late afternoon (Fig. 3) This second and really spectacular increase in whistling from Bonnie appears somehow to be related to the suckling behaviour (Fig. 4).

CONCLUSIONS We believe that the first increase of whistle production, right after the birth, enables the calf to learn for the first time the individual signal associated with the mother, through a typical learning process based upon imprinting. The same signal is then utilised by the mother to stimulate the calf during the first suckling attempts, and, at the same time, the milk intake probably works as a reward for the calf, reinforcing its imprinting on the mother's distinctive whistle. The calf learns to associate the whistle with the mother and with suckling behaviour. Such associations can be utilised to co-ordinate nursing, and we often observed the mother whistling just before the calf starts suckling.

The imprinting process that we described probably has also longterm effects; it was already suggested that the mother's signature whistle may contribute to the calf's own signature whistle development. In our situation, such similarity was actually observed; nevertheless the lack of acoustic input from other dolphins in the calf's environment should also be noted.

Our final suggestion is that recognition between mother and calf is the first and most important factor leading to distinctive signal development. Nevertheless, such signals may be reutilised in other contexts and with other conspecifics.

ACKNOWLEDGEMENTS Thanks to Alenia-Elsag Sistemi Navali for technical support, to FONDAZIONE CETACEA for references, and to Dr. Diana Reiss from Columbia University for her nice and helpful collaboration.

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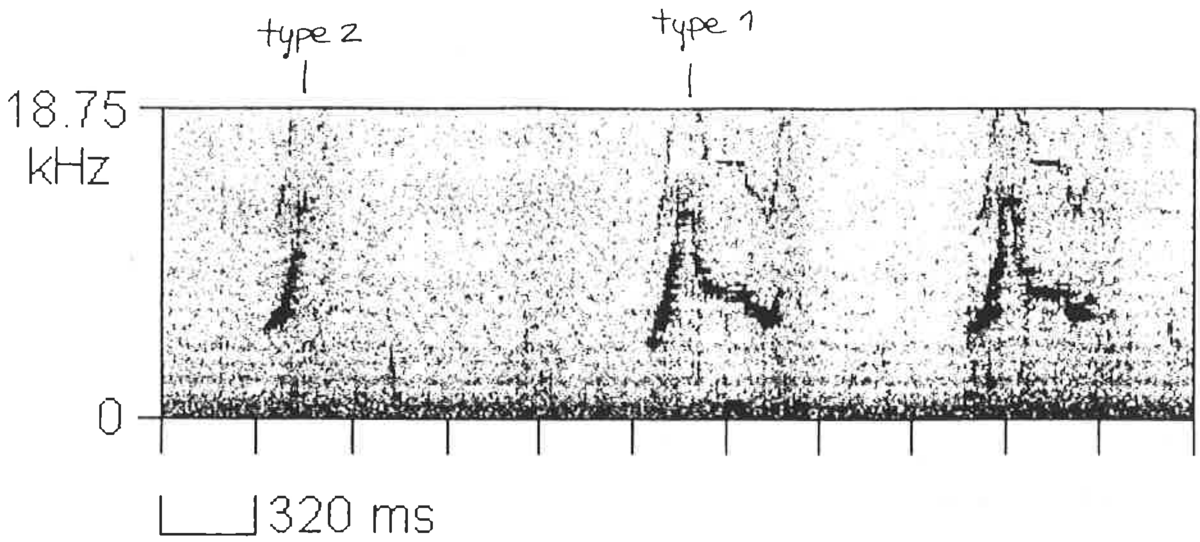


Fig. 1 Spectrographic analysis of whistle 1, Bonnie's signature whistle, and whistle 2

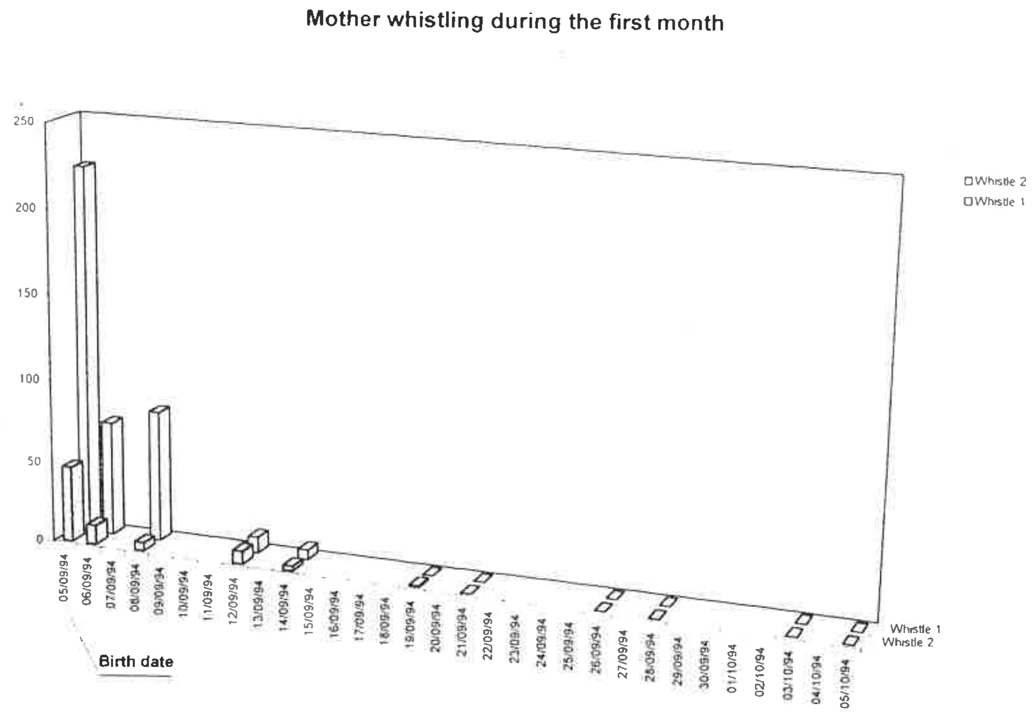


Fig. 2 Whistling behaviour from Bonnie during the first month since the delivery occurred, in relation to whistle 1 and whistle 2. Every single bar represents the average of whistles uttered every hour in the observation periods.

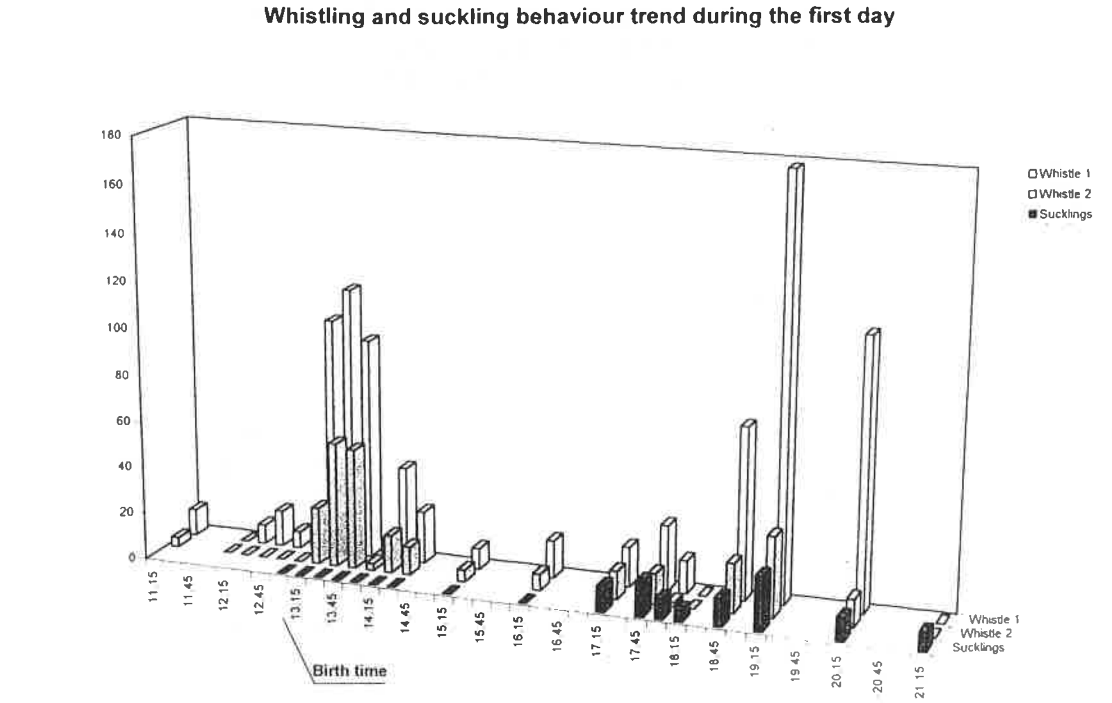
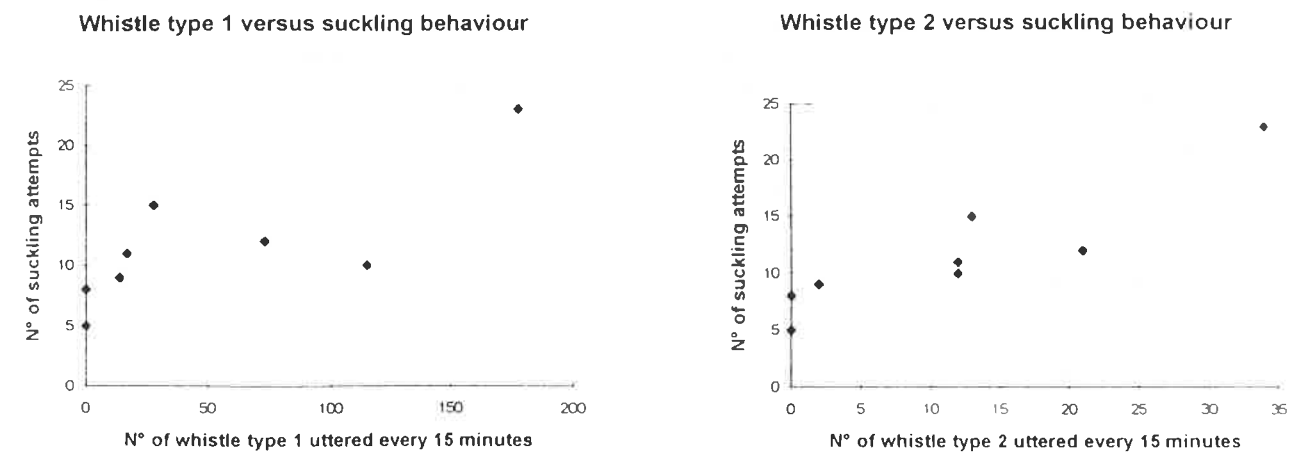


Fig. 3 Whistling behaviour from Bonnie during the first day. Every single bar represents the numbers of whistles produced by Bonnie every 15 mins (above) and the numbers of suckling attempts from Cleo in the same time (below). When the calf starts to attempt suckling the mother drives it by whistling continuously. The milk intake probably works as a reward for the calf, reinforcing its imprinting on the mother's distinctive whistle.



Spearman ranks correlation test

	Whistle 1	*Whistle 2*	*Suckling*
Whistle 1	1		
Whistle 2	0.721551	1	
Suckling	0.811503	0.802829	1

n	*P*=0.05	*P*=0.01	(1 tail)
8	0,643	0.833	

Fig. 4 Whistle 1 and 2 are both meaningfully related to the suckling behaviour

ECHOLOCATION AND SURFACE ACTIVITIES OF *INIA GEOFFRENSIS* AND *SOTALIA FLUVIATILIS* IN THE UPPER AMAZON IN PERU

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INTRODUCTION The echolocation of dolphins has been studied since 1952, when Kellogg and Kohler first proposed that these animals might orient through sound. However, little is known about the use of echolocation in their natural environment (Goodson, 1992; Norris *et al.*, 1972), and therefore the importance of this sense and its susceptibility to human disturbance, e.g. boat noise, remains unclear.

The objectives of our study were to reveal correlations among specific behavioural activities and distinctive echolocation patterns. Furthermore, we were interested whether the observed patterns could be found in more than one species.

METHODS From June to September 1995, we observed the freshwater dolphins *Inia geoffrensis* and *Sotalia fluviatilis* in different tributaries of the Amazon river in Peru. Blackwater rivers with very poor transparency (Secchi-disc: 70 cm) restricted observations to the water surface. On the other hand, they suggest that dolphins may entirely depend on their sonar system in these environments.

Recordings were made from the side of a wooden boat, tied or anchored at the river bank to minimise disturbance of the animals. The acoustic equipment consisted of a hydrophone with a flat response up to 100 kHz, a transient recorder with an analog-digital converter (sampling rate: 312.5 kHz) which allowed storage of sequences of up to 6.7 secs and the possibility to transmit them to a Sony Professional Walkman (WMD6C) at 15- to 64-fold reduced playback rate. Signal analysis was performed with two different computer systems (Modular Signal Processing System, MOSIP, Medav GmbH and Sona PC, University of Tübingen).

RESULTS According to our visual observations, we categorised different surface activities. From those, three were chosen for closer analysis in correlation with the echolocation patterns. For both species, we defined:

1. **foraging:** a dolphin was chasing a fish close to the water surface or a small group was obviously engaged in hunting;

2. **travelling:** a dolphin was moving up- or downstream, without an observable change of direction or a stop; and

3. **socialising:** two or more dolphins had body contact at the water surface.

Data analysis concentrated on the repetition rate of the sequences in order to find differences in click intervals due to different behavioural objectives.

Acoustically, four different categories could be distinguished for both species. During foraging (Fig. 1), phases of high and variable click intervals change to phases of short, less variable click intervals ranging between 2-5 ms. with minimum intervals of 2.4 ms. for *Inia* , and 1.9 ms. for *Sotalia.*

During travelling, both species emitted sequences with large click intervals (mean value: 65 and 48 ms. for *Inia* and *Sotalia* respectively) with a high variability (SD = 28 and 14 ms. respectively) but without the characteristic decline to phases with short intervals (Figs 2 and 3).

The final pattern presented for both species consisted of surprisingly short intervals (mean value: 0.7 and 0.9 ms.; *Inia* and *Sotalia* respectively) with a very low variability (SD = 0.1 and 0.2 ms. respectively) (Fig. 4), and was recorded during socialising and resting for *Inia*, and during foraging and uncategorised behaviour for *Sotalia* (socialising *Sotalia* were never observed at the water surface). These sequences were often emitted as a series of rather uniform 'buzzes' (fast click trains of 10 to 300 ms. duration).

DISCUSSION To understand the function of different click intervals, it is necessary to look at the physics of underwater sound. We assume that a dolphin emits a new click only after the echo of the precious click has returned from the target of interest. Therefore the 'two way transit time' may indicate the distance to the target. With a click interval of 100 ms. between two clicks (for example during the first phase of foraging sequences), the dolphin can check a distance of 75 m. (v = 1,500 m/s). The echolocation patterns recorded during foraging could therefore be divided into at least three different phases due to the functional purposes: the first phase (large variable click intervals) could be regarded as a search phase during which the dolphin is scanning variable distances in the range of 15 to about 300 m for potential prey. After the presumable detection of a fish, the click intervals shorten while the dolphin approaches its target, until they reach a minimum when a dolphin is close to his object. The corresponding click intervals of 2-3 ms. represent a maximum target distance of 1.5-2 m. During travelling, these patterns were absent, and clicks were emitted with >20 ms. intervals, and changes alternated between longer and shorter intervals with different standard deviations. Possibly those differences in the variation of click intervals indicate two different travel-types: travel-feeding (click intervals like those of the search phase, Figs. 1 and 2) and 'real' travelling, where a dolphin is only orienting at a rather constant distance ahead (Fig. 3). Since these dolphins live in an environment with many obstacles such as trees to be avoided, it seems likely that river dolphins have to use their sonar more or less constantly for orientation during travelling in these turbid waters. Also, they take advantage of an occasional detection and subsequent hunting of prey. Due to the limited storage capacity of the computer, sequences are not always complete, and travelling dolphins could not be tracked over larger distances to further test these interpretations.

We consider the last pattern of very short (0.8 ms.) and constant click intervals as social vocalisations due to the following considerations: (1) 'buzzes' were always isolated and rapid without previous clicks that would indicate a function for echolocation; and (2) click intervals of less than 1 ms. would indicate a maximum target distance of less than 75 cm, which is almost the tip of the snout of an *Inia* (measured from the melon) and therefore does not seem to make sense as an echolocation tool. These 'buzzes' were very similar for both species.

In conclusion, we can say that there is a correlation between the presented behavioural categories and the corresponding echolocation patterns, and they are very similar for both species.

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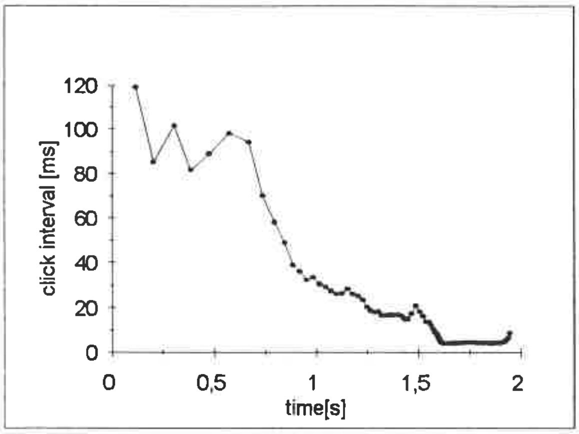
fig.1 **INIA foraging**



SOTALIA foraging

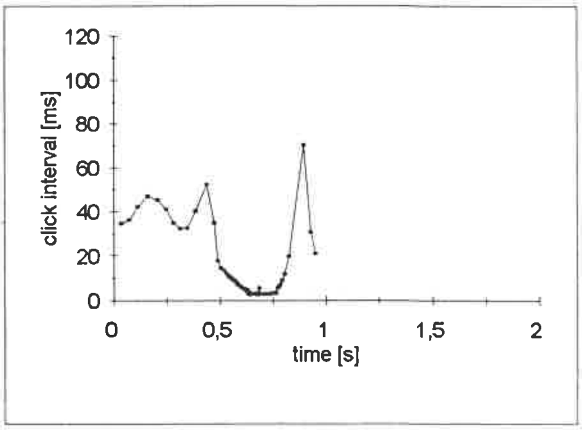
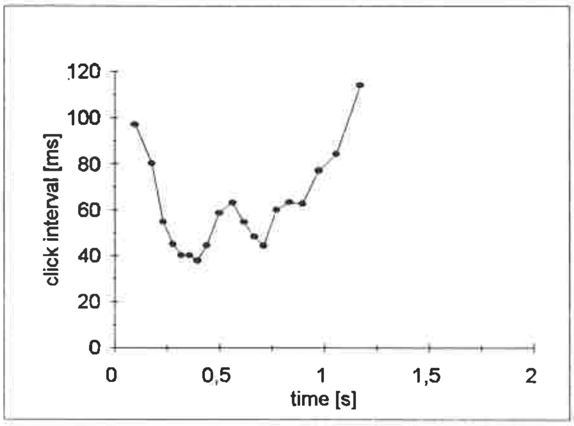


fig.2 **INIA travelling**



SOTALIA travelling

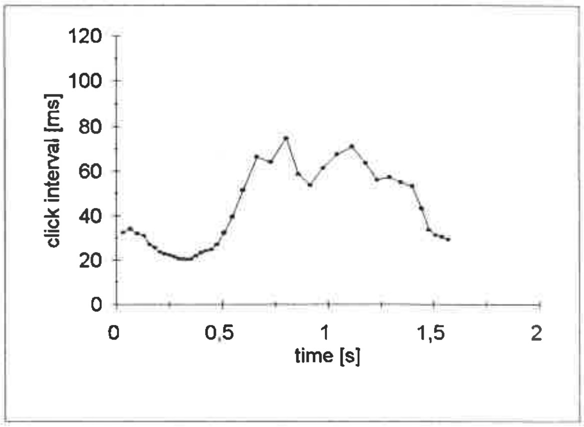
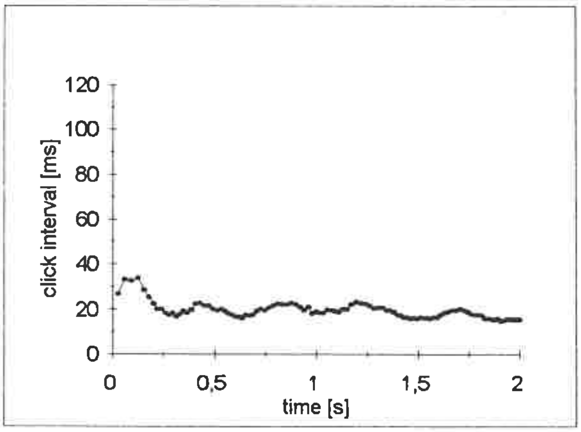


fig.3 **INIA travelling**



SOTALIA travelling

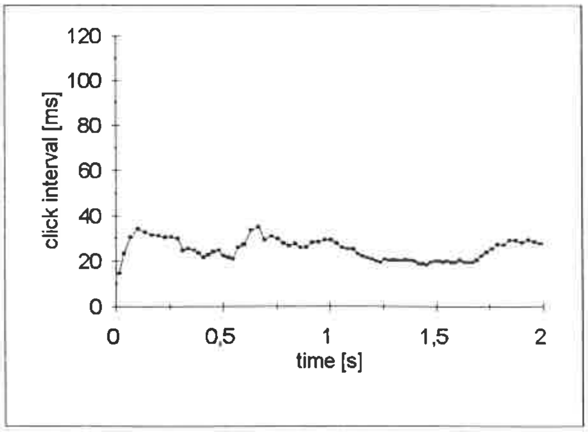
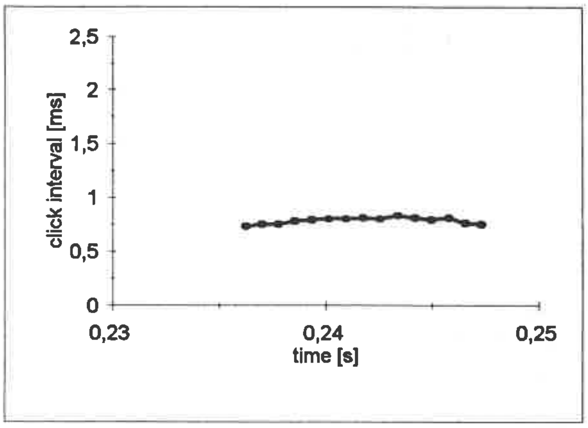


Fig. 1 - 3 Typical sequences of *Inia* and *Sotalia* during different surfacing activities. Dots represent clicks.

INIA socializing



SOTALIA behaviour unclear

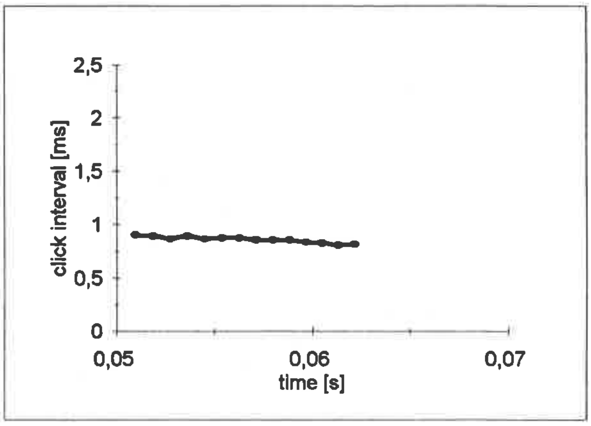


Fig. 4 Typical 'buzz' from *Inia* and *Sotalia.* Preceding and following click trains not shown.

HUNTING AND ECHOLOCATION BEHAVIOUR OF A CAPTIVE AMAZON RIVER DOLPHIN (*INIA GEOFFRENSIS*)

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The behaviour of a captive Amazon river dolphin (*Inia geoffrensis*) chasing and capturing live trout was investigated. Synchronised video and echolocation recordings, taken in a darkened pool, enabled the correlation of the pursuit with the echolocation behaviour.

Two successive stages could be distinguished within echolocation behaviour: the 'Far Stage' and the 'Near Stage', the latter beginning when the dolphin gets closer than about 1 m. to the fish. In the 'Far Stage', the echolocation clicks are characterised by high amplitudes and spectra with high peak frequencies. The click interval is rather variable with a mean at 26 ms. The peak frequency of 'straight on' signals (recorded directly ahead of the dolphin's rostrum) is about 103 (+/-1) kHz and the -3 dB bandwidth is 'about 24 (+/-10) kHz. The instantaneous frequency (inverse of a cycle period) of the first two cycles of a click waveform is about 93 (+/-3) kHz. In the =9INear Stage=92, the dolphin decreases the signal amplitude while approaching its prey. Within this stage, the click interval diminishes to a minimum of about 10 ms. until the dolphin reaches the fish. With decreasing amplitude, the 'straight on' signal structure changes in a transition phase from clicks with high frequency and low bandwidth to clicks with low frequency and low bandwidth.

The change in the peak frequency is due to a gradual reduction of the high frequency part of the signal spectrum. During the transition, the instantaneous frequency of the first two cycles of the waveform decreases with signal amplitude. After the transition, the peak frequency of 'straight on' signals is about 50 (+/-2) kHz and the -3 dB bandwidth is about 24 (+/-21) kHz. The instantaneous frequency of the first two cycles is about 65 (+/-6) kHz. The reduction of the click interval and thus the increase of information flow could result in a better control of the final approach to the prey. The decrease of signal amplitude is interpreted as a gain control mechanism to compensate the increase of echo sound pressure level during an approach.

CHARACTERISING DOLPHIN ECHOLOCATION BEHAVIOUR

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Studying the vocalisations of dolphins provides an insight into their underwater behaviour, whereas visual methods are normally restricted to surfacing behaviour. Apart from whistles, which seem to be produced in a social context, the sonar emissions of dolphins consist of pulsed signals used for different echolocation purposes. Single hydrophone recordings of 'click' sequences can provide information on pulse periodicity, frequency spectrum and intensity. By analysing the temporal and spectral components, and relating these to video recorded surfacing behaviour, it should be possible to extract characteristic patterns which indicate different kinds of dolphin behaviour.

Examples from a solitary dolphin provide unambiguous conditions where the environmental constraints can be observed and understood. Almost all the pulsed emissions recorded during a series of 24-h. long intensive studies suggest behaviour related to foraging. Goodson and Datta partitioned these pulse sequences into distinct phases: 'foraging search'; target detection'; 'target interception' and the 'capture phase'. These sub-classifications have been further examined using an extended data set from the same source and are more closely defined here.

Graphical and statistical analysis of the data in relation to sonar parameters allows a better definition of the presence of these foraging partitions. Possibilities also exist for the application of this analysis approach to behaviour types other than foraging.

COMPUTER CHARACTERISATION OF DOLPHIN WHISTLES

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A computer program has been developed which detects and characterises the whisles produced by bottlenose dolphins. Digital filtering techniques were used to overcome problems in detection due to impulsive noises from echolocation clicks and environmental noises, and the time-frequency contours of the whistles extracted from the raw signals. These algorithms have also enabled the whistles from simultaneously whistling animals to be separated and analysed. 101 whistle contours have been characterised, including eight from two simultaneously whistling animals where the contours crossed each other in frequency. An additional fifteen whistles could not be characterised with the routines, but these contours also could not be isolated visually from the spectrogram.

The data contained in the contours has been reduced by representing the whistles as a series of syntactic segments, indicated as "rising", "falling", or "flat" in frequency movements, or "blank" indicating a break in the contour. Within each of these segments, the data points have been approximated to a quadratic curve with a least squares error fit. The use of a segmentation technique, and representation of the segment data with a fitted curve, facilitates a syntactic pattern recognition approach for further analysis of these data, whilst also drastically reducing the data requirements for each contour. It is believed that this method still holds the key features used by dolphins to identify each other's individualised whistles whilst reducing the complexity of the signal.

OBSERVATIONS OF CETACEANS FROM SHORE IN THE AZORES (1993 - 1994)

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Twenty-one species of cetaceans have been recorded in the Azores, and several are commonly sighted from shore. An old whaling watchtower in the island of Pico, now converted to assists whale-watching operations, has been used in summer months since 1993 as a base for tracking cetaceans.

It is feasible to cover from the watchtower up to 18 miles from shore, where depths of 1,600 m are reached. Identification of species is often confirmed with the records of whale-watching boat crews.

Sperm whales, beaked whales, bottlenose dolphins, bottlenose whales, pilot whales, common dolphins, spotted dolphins, striped dolphins, Risso's dolphins, killer whales, false killer whales, and fin whales were the species or genera detected in descending order of number of sightings. Many mixed groups were observed, with the following combinations: bottlenose dolphins/pilot whales, bottlenose dolphins/sperm whales, spotted dolphins/pilot whales, spotted/striped dolphins, spotted/common dolphins, and striped/common dolphins.

FIRST DATA ON THE DISTRIBUTION OF CETACEAN ALONG THE MOROCCAN COASTS

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A first inventory of the Moroccan Marine Mammals has been set up by the "Groupe d 'Etude des Cétacés et Pinnipèdes du Maroc " (Bayed and Beaubrun, 1987). The present work has been undertaken in order to improve our knowledge of cetaceans off the Moroccan coasts. Observations at sea are taken into account and occasionally stranding cases. The species considered are those for which available data allow us to draw up preliminary distribution maps.

It appears that the common dolphin, *Delphinus delphis*, shows a distribution pattern which encompasses the Alboran Sea and the Straits of Gibraltar, and extends southwards to the latitude of Casablanca. Killer whales, *Orcinus orca*, have been mainly identified in three coastal areas: Cap Spartel, the Bay of Agadir, and the Bay of Dakhla. Bottlenose dolphins,*Tursiops truncatus*, are always observed near the coast in several coastal areas. Long-finned pilot whales, *Globicephala melas*, are known in the Mediterranean, but in the Atlantic, there are only two records, both from the Bay of Agadir. Although there are frequent observations of cetaceans from the Atlantic, they never refer to striped dolphin, *Stenella coeruleoalba*, which instead has been observed only along Mediterranean coasts. The interesting species, Atlantic humpbacked dolphin, *Sousa teuszii*, is recorded only from the Bay of Dakhla.

This review of cetacean distribution brings up to date our information on the status of a number of cetacean species in Moroccan waters. These species occupy a privileged position covering the Mediterranean and the Atlantic, and between the European and West African coasts.

CETACEANS FOUND IN THE WATERS SURROUNDING LANZAROTE, CANARY ISLANDS

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INTRODUCTION A series of dedicated surveys were conducted in winter 1994-95, to study cetacean abundance and distribution in the waters surrounding the island of Lanzarote, Canary Islands. Previous studies conducted in these highly productive waters, were based mostly on stranded cetaceans (Vonk and Martel Martin, 1988; Vonk and Martel Martin, 1989; Martin *et al.*, 1992; Montero and Martin, 1992). Regular observation programmes were targeted on specific species, such as short-finned pilot whale*Globicephala macrorhynchus* near Tenerife, (Heimlich-Boran and Heimlich-Boran, 1992), bottlenose dolphin*Tursiops truncatus* near Gomera and Tenerife (Escorza *et al.*, 1992), and sperm whale*Physeter macrocephalus* off Gran Canaria (André *et al.*, 1994). For the waters surrounding Lanzarote, except for opportunistic data (Hervé-Gruyer, 1989), very little information exists.

MATERIALS AND METHODS A series of surveys were conducted from December 1994 to April 1995 in the waters surrounding Lanzarote, Canary Islands, aboard a 20 m-long motorsailer. *Ad libitum* transects were followed in order to cover as regularly as possible the study area, which was stratified into 24 squares of 10 x 10 nm. (Fig.1). Search sessions were conducted by at least two trained observers, from both sides of the boat.

To compute sighting frequencies, only navigation in good weather and sea state conditions was considered (Beaufort <3, visibility >1 km, two observers constantly on watch). Cetacean sighting frequencies were calculated as number of sightings every 10 km. Data recorded included: cetacean species, position, group size, distance from the nearest coast, and water depth at the position of sighting.

RESULTS Sixty-five days were spent at sea, yielding a total of 2,321.1 km, surveyed in good sighting conditions (Table 1). A total of 77 sightings were made (Table 2), of which 60 occurred in good sea conditions.

RELATIVE ABUNDANCE AND DISTRIBUTION The study area was stratified into 24 squares, labelled from A to X (Fig. 1), of which 22 were surveyed at least once. In squares D, E, F, I, K and L (Fig. 2), the effort was considerably higher than in the rest. Overall mean cetacean sighting frequency in the study area was 0.25 groups/10 km (n = 232, SE = 0.004).

Comparing the sub-areas D, E, F, I, K and L, a remarkably high sighting frequency was found for squares F and I, and these differed significantly from squares E, D, and L (Fig. 3; F= 3.87, df = 5, p<0.05, Fisher's PLSD test, significance p<0.05).

Sighting frequencies did not show any significant seasonal difference. Due to the small number of sightings, only common dolphin *Delphinus delphis* and spotted dolphin*Stenella frontalis* could be compared. Sighting frequencies for these species showed a clear trend (Fig. 4).

HABITAT AND GROUP SIZE Mean water depths for bottlenose dolphin and Risso's dophin were significantly different from other species (Table 4; F = 4.256, df = 11, p <0.001, Fisher's PLSD test, significance p<0.05). By contrast, no differences were found among species in relation to the distance from the nearest coast (Table 5).

DISCUSSION The high number of species sighted confirmed the remarkable cetacean diversity of the Canarian waters. Five of the Ziphiid sightings were identified as *Mesoplodon* species. Cetaceans were not distributed homogeneously throughout the study area, being concentrated mostly to the north-east of Lanzarote. Sighting frequencies did not show seasonal changes, with the exception of spotted dolphin and common dolphin. This may indicate competitive exclusion by the two delphinid species, which seem to occupy the same habitat.

Risso's dolphin and bottlenose dolphin, as expected, were found in shallower waters than other more pelagic species. It was very surprising that bottlenose dolphins, typical of a neritic environment, were found on average in deeper waters than Risso's dolphin, a species with a well-known preference for slope waters. The lack of a difference in the distances from the coast among species is likely to be due to the topographic characteristics of the area, where the sea bottom increases abruptly at a short distance from the land.

ACKNOWLEDGEMENTS We would like to thank Dr. luis Felipe Lopez Jurado of the University of Las Palmas for the logistical support. A special thanks goes to Carla Almirante, who helped in organising the database and gave useful suggestions for the analysis. The data collection has been carried out with the help of Giorgio Barbaccia, Alex Bocconcelli, Arianna Azzellino, Nicoletta Biassoni, Ada Natoli, Elena Monzini, Liselotte Medlund, and Georges Paximadis. The research has been possible thanks to the financial support of the participant volunteers and Wolftrail.

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Table 1. Research effort in winter 1994-95

Month	Days	Km surveyed
December	14	636.1
January	14	570.5
February	8	246.8
March	17	500.2
April	12	367.5
TOTAL	**65**	**2321.1**

Table 2. Summary of sightings

SPECIES	NUMBER OF SIGHTINGS	PERCENT FREQUENCY
Delphinus delphis	14	18.18
Stenella frontalis	13	16.88
Grampus griseus	9	11.69
S. coeruleoalba	6	7.79
Tursiops truncatus	4	5.19
Small delphinids	4	5.19
Stenella sp.	3	3.90
Ziphiidae	8	10.39
Globicephala macrorhynchus	5	6.49
Physeter catodon	3	3.90
Pseudorca crassidens	1	1.30
Kogia sp.	1	1.30
Balaenoptera physaus	3	3.90
Balaenoptera borealis	1	1.30
Balaenoptera sp.	1	1.30
large non-identified cetacean	1	1.30
TOTAL	**77**	**100.00**

Table 3 Overall mean cetacean sighting frequencies subdivided by squares (squares in which no sightings were made are not reported in the table)

SQUARES	Mean sighting frequencies	SD	SE	n
A	0.02	0.045	0.020	5
B	0.04	0.054	0.020	7
E	0.01	0.040	0.006	42
F	0.05	0.068	0.011	39
H	0.05	0.058	0.029	4
I	0.05	0.070	0.012	35
J	0.08	0.096	0.048	4
K	0.03	0.065	0.012	28
O	0.02	0.045	0.020	5
P	0.03	0.050	0.025	4
R	0.03	0.058	0.033	3

Table 4 Descriptive statistics of water depth at sighting location for each species

Species	Mean water depth (m)	sd	se	n
Physeter catodon	1250	88.9	51.3	3
Balaenoptera borealis	1220	-	-	1
Kogia sp.	1200	-	-	1
Delphinus delphis	1178	145.3	38.8	14
Pseudorca crassidens	1160	-	-	1
Ziphiidae	1078	268.4	94.9	8
Balaenoptera physalus	1073	161.7	93.3	3
Globicephala macrorhynchus	1072	215.3	96.3	5
Stenella coeruleoalba	1059	203.5	83.1	6
Stenella frontalis	1040	286.4	79.4	13
Tursiops truncatus	628	666.1	333.1	4
Grampus griseus	488	350.4	116.8	9

Table 5 Descriptive statistics of distance from the nearest coast at sighting location for each species

Species	Mean dist. coast (km)	sd	se	n
Delphinus delphis	12.3	5.30	1.42	14
Balaenoptera physalus	10.6	12.47	7.20	3
Globicephala macrorhynchus	9.7	4.50	2.01	5
Physeter catodon	9.6	6.08	3.51	3
Stenella frontalis	9.3	4.33	1.20	13
Kogia sp.	8.5	-	-	1
Ziphiidae	8.1	3.05	1.08	8
Pseudorca crassidens	7.7	-	-	1
Tursiops truncatus	7.1	6.60	3.30	4
Stenella coeruleoalba	7.0	4.83	1.98	6
Grampus griseus	5.7	5.34	1.78	9
Balaenoptera borealis	5.5	-	-	1

Table 6 Descriptive statistics of group size for each species

Species	Mean group size	sd	se	n
Stenella frontalis	43.0	52.31	14.51	13
Stenella coeruleoalba	38.5	30.13	12.30	6
Delphinus delphis	25.5	17.15	4.58	14
Globicephala macrorhynchus	15.0	3.08	1.38	5
Pseudorca crassidens	10.0	-	-	1
Grampus griseus	9.6	5.85	1.95	9
Tursiops truncatus	6.0	4.08	2.0	4
Physeter catodon	3.7	2.31	1.33	3
Kogia sp.	3.0	-	-	1
Ziphiidae	1.6	0.92	0.32	8
Balaenoptera physalus	1.3	0.58	0.33	3
Balaenoptera borealis	1.0	-	-	1

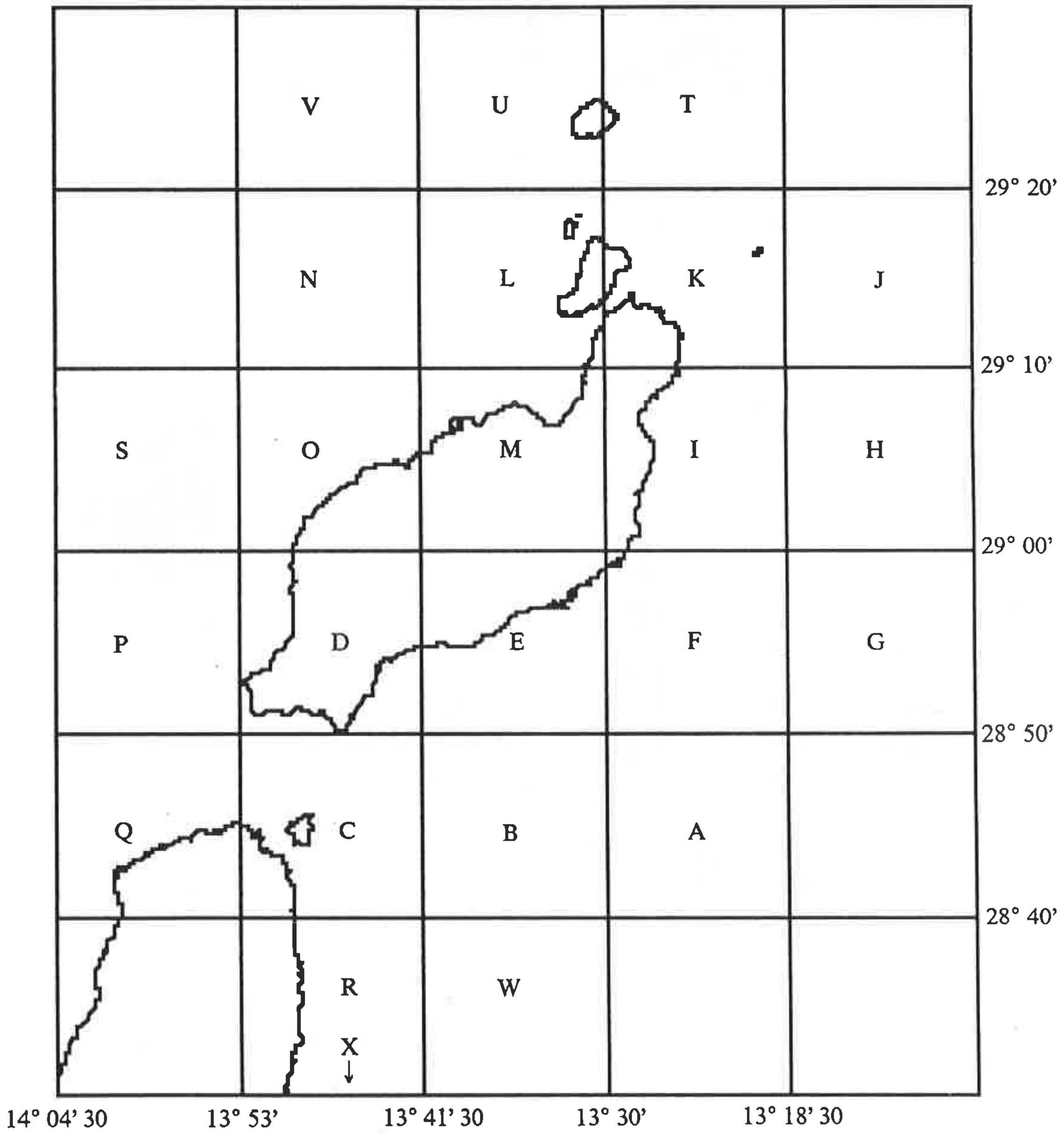

Fig. 1. The study area, stratified in 10 x 10 miles squares.

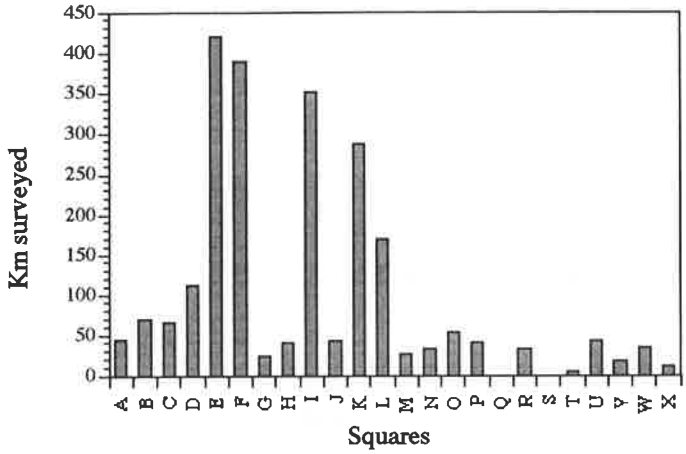

Fig.2. Km surveyed in good sea conditions for each area and the ratio to compare research effort for areas of different size.

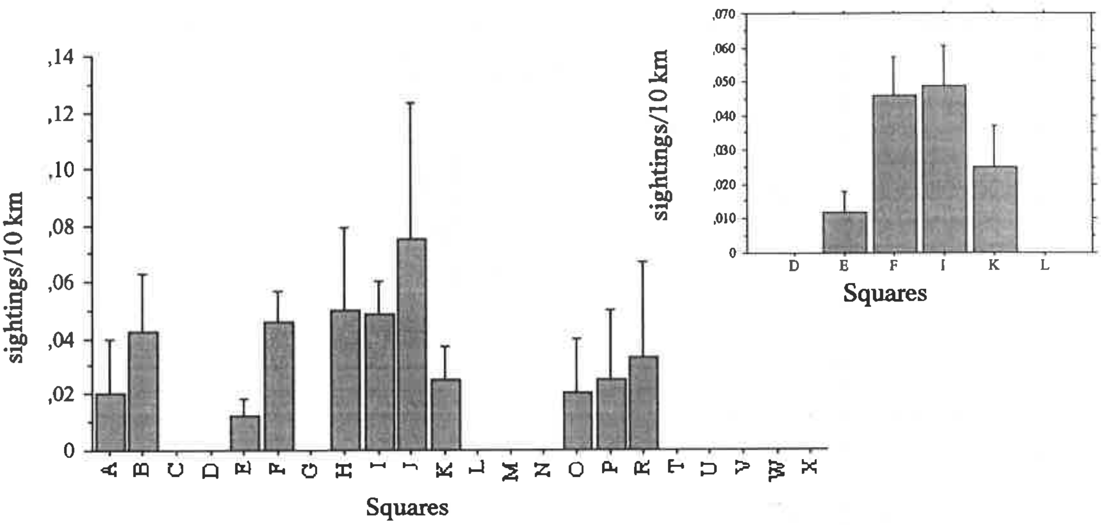

Fig. 3. Mean cetacean sighting frequencies subdivided by squares. The smaller graph shows sighting frequencies for the squares in which search effort was higher.

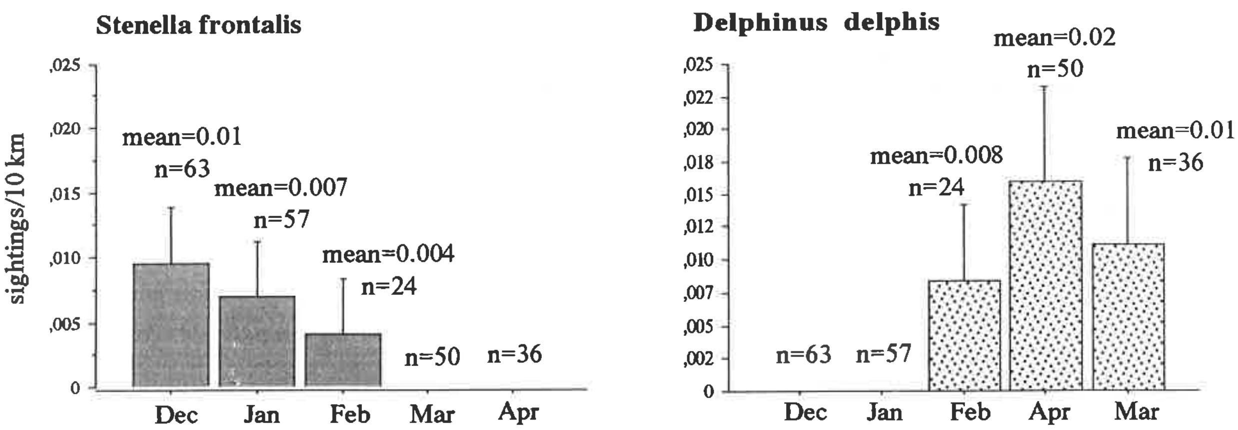

Fig. 4. Seasonal changes of mean sighting frequencies of *S. frontalis* and *D. delphis.* Error bars represent 1 standard error.

CURRENT STUDIES ON CETACEANS IN TURKEY

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Turkey is facing three seas of different characteristics, that is, the Black Sea, Mediterranean, and Aegean Sea. Thus it has a long coastline. However, little is known about the cetaceans in Turkish coastal waters. On the other hand, there is an increasing concern over these animals due to pollution, food shortage, and accidental catches, although the present situation is currently not well documented. We have started studies on cetaceans in Turkish waters since 1993, firstly to elucidate the current situation concerning these animals and, secondly, to understand their biology and ecology to make appropriate protection measures for these animals.

Our studies consist of: (1) collecting information and samples (teeth for age determination, reproductive organs, stomach contents, tissue samples for genetic and toxic contamination studies, skeletons for morphological study) from stranded and by-caught animals; (2) interviewing fishermen and sailors concerning the occurrence of cetaceans; (3) direct observation at sea; and (4) collecting historical information and searching for cetacean specimens existing elsewhere in Turkey. Particular emphasis has been placed on the Bosphorus (Istanbul) Strait since it is considered to be an important migratory route for cetaceans and fish prey that they follow between the Black Sea and the Marmara Sea.

CETACEANS AND CETOLOGY IN THE HELLENIC SEAS

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2,350 YEARS AGO... "The dolphin is provided with a blowhole and lungs... and has been seen asleep with his beak above the water, and when asleep he snores. None has ever been seen to be supplied with eggs, but directly with an embryo, just as in the case of mankind and viviparous tetrapods. Its period of gestation is ten months, and it brings forth its young in the summer. The dolphin is provided with milk and suckles its young... which accompany it for a considerable period. In fact, the creature is remarkable for the strength of its parental affection. The young grow rapidly, being full grown at ten years of age. It lives for many years; some are known to have lived for more than twenty-five, and some for thirty years; the fact is that fishermen sometimes nick their tails and set them adrift again, and by this expedient, their ages are ascertained." (Historia Animalium, 350 B.C.). Although astonishing, this first cetological reference was published 2,350 years ago! After accurate field observations and interviews with fishermen of the Aegean Sea, Aristotle described the dolphin's natural history with so many details that there is little we can add to it even now.

DURING THE LAST 2,350 YEARS... Unfortunately, during the last 23.5 centuries that followed Aristotle's works, Greek scientists did not add anything new to the knowledge concerning the Hellenic cetacean fauna. Marchessaux's review (1980) for cetaceans present in the entire Eastern Mediterranean, and two references concerning "unusual" strandings (Kinzelbach, 1986a,b) were the only ones to provide new information. Cetological data concerning the Hellenic seas remain scarce. However, since 1991, two independent events marked a new period for cetology in Greece: (a) the dramatic outbreak of the Mediterranean striped dolphin epizootic (Aguilar and Raga, 1993); and (b) the interest of Italian cetologists to expand their activities in the unexplored Ionian and Aegean waters, in collaboration with Greek marine biologists.

The massive striped dolphin die-off in 1991-92 resulted in increased public awareness, and drew the attention of NGO's and Port Police Authorities to cetaceans. The strandings and sightings recorded during that period give a rough preliminary idea of the presence and distribution of cetaceans in Hellenic Seas (Cebrian and Papaconstantinou, 1992; Androukaki and Tounta, 1994). However, the reports of amateurs are affected by serious biases (see also Zanardelli *et al.*, 1992). As a result, lack of experience partially has affected the scientific literature produced, by providing incorrrect data.

EXISTING KNOWLEDGE ABOUT THE CETACEAN FAUNA OF THE HELLENIC SEAS Almost everything that we know about the presence and distribution of cetaceans in Hellenic seas comes from:

(a) Personal observations and *in situ* examinations of stranded cetaceans;
(b) Critical re-evaluation of stranding data, collected mainly since the striped dolphin epizootic;
(c) Dedicated summer surveys in the Ionian (Tethys Research Institute 1991-94, University of Athens, 1995) and Aegean Sea (Marine Mammal Group, Universita "La Sapienza", 1993-94).

The above efforts revealed the regular presence of seven common Mediterranean cetacean species (bottlenose dolphin*Tursiops truncatus*, striped dolphin*Stenella coeruleoalba*, common dolphin *Delphinus delphis*, Risso's dolphin *Grampus griseus*, Cuvier's beaked whale *Ziphius cavirostris*, sperm whale *Physeter macrocephalus*, and fin whale *Balaenoptera physalus*), and the occasional presence of false killer whale *Pseudorca* *crassidens*. Despite some incorrect references existing in the current literature, long-finned pilot whale *Globicephala melas* and killer whale *Orcinus orca* have not been observed yet in Hellenic Seas. In fact, except for a floating carcass of an unidentified *Mesoplodon* species, no other definitely identified species has ever been recorded in Hellenic Seas.

Strandings data not recorded personally by the author have been retained only after careful study of available documents allowing unbiased identifications. With such documents, we considered good photographs of recently stranded individuals or, exceptionally, measurements accompanied by precise descriptions (for Cuvier's beaked whale *Z. cavirostris*). All other kinds of stranding data were discarded. Existing data from the epizootic period 1991-92 (numerous strandings reported spontaneously by amateurs and Port Police authorities) were meticulously checked again. Very few undocumentated cases were retained.

In general, the striped dolphin is observed in deep offshore waters. Sightings and strandings from Rodos Island and almost all other Aegean and Ionian coasts (unpubl. data) during and after the morbillivirus epizootic (Aguilar and Raga, 1993) indicate that this species could be common in all the pelagic waters of Hellenic Seas. It is worthwhile to note that striped dolphins are common even in closed sea areas such as Korinthiakos Gulf (pers. observs.). Three strandings (two of them alive) were recorded recently at coasts surrounded by the shallow waters of South Evvoikos and Petalion Gulfs (depth 60 m). Although this fact does not prove that striped dolphins regularly inhabit the above sea area, it would be interesting to check out this hypothesis.

The distribution and number of sightings of bottlenose dolphin (Politi *et al.*, 1994; Carpentieri *et al.*, in prep.) indicate that this species is common all around Hellenic Seas. It seems to be the most frequent species in the Cyclades Archipelago, taking advantage of the shallow waters around the islands. As expected, bottlenose dolphins prefer regions of neritic waters. Together with the striped dolphin, it is the most common species among stranded cetaceans.

A small community of common dolphins (now rare in many parts of the Mediterranean Sea) is predictably present in a shallow and relatively closed sea area between some Greek Ionian islands and the mainland (Politi, *et al.*, 1994). The absence of common dolphin among strandings could be the first indication of its scarcity in the Aegean Sea. At least during summer, common dolphin is present in Northern Sporades (pers. observs.). It has also been observed in the neighbouring Magnisiakos Gulf (Marchessaux, 1980), in the Cyclades (Cebrian, *pers. comm.*) and near Samos Island (Carpentieri *et al.*, 1994). Further investigations are urgently required in order to assess the actual status of the species, and to allow formulation of conservation measures.

Strandings and direct observations of Risso's dolphin (Carpentieri *et al.*, in prep.) indicate that this species is not so rare as previously thought in some deep parts of the Aegean Sea. Two strandings in Lakonikos Gulf (Kinzelbach, 1986a, and the present study) and one sighting recorded in the neighbouring sea area around Kythira Island indicate the frequent presence of this species in pelagic waters between south-east Peloponissos and north-west Kriti Islands. Risso's dolphins are also present in the Ionian Sea, where one specimen stranded recently, at Zakynthos island.

Cuvier's beaked whale is considered extremely difficult to observe at sea because of its unobtrusive and shy behaviour (Heyning, 1989). The situation seems to be quite different in the Greek part of the Ionian Sea, where an important number of direct observations have recently been made, with relatively small search effort (Pulcini and Angradi, 1994; Politi *et al.*, 1994). Direct observations were also made in the Aegean Sea. During the last five years, ten strandings were reported in the Ionian Sea (Frantzis, unpubl. data) and thirteen in the Aegean Sea (Carpentieri *et al.*, in prep.). All these data indicate that Cuvier's beaked whale could be a frequent species in the Hellenic Seas.

Since 1984, sperm whales have stranded at least twice in the Aegean Sea. Six older documentated stranding records exist in the same sea. This species has been directly observed in the south-east, central west, and north-west Aegean Sea (Carpentieri *et al.*, in prep.). Many amateurs report schools of "big whales" in the northern Aegean Sea (sea area between North Sporades and Chalkidiki Peninsula) and the south-east Peloponnisos (Kythira Island sea area). Although we are not able to say if this phenomenon is frequent or not, sperm whales do enter the inner part of the Aegean Sea. In contrast, this species has not been observed yet in the Ionian Sea.

At least in summer, fin whales are present in the Ionian Sea where the continental slope is situated very close to the Hellenic coasts (Politi, *et al.*, 1994). All existing sightings in the Aegean Sea (Marchessaux, 1980; Carpentieri *et al.*, in prep.) were recorded on the Aegean arc of Rodos-Karpathos-Kriti-south-east Peloponnisos, where depth increases very steeply. Fin whales have never stranded or been observed in the inner shallow waters of the Aegean plateau. Marchessaux's (1980) hypothesis that the occurrence of fin whale in the eastern Mediterranean is sporadic and related to animals wandering from the western basin, does not seem to be correct anymore, since this species is present all around the Greek continental slope.

False killer whale is only an occasional Mediterranean species, observed in the Hellenic Seas. One stranding in Peloponnisos (in 1993), one rare photographed sighting of an entire pod (group size = >7) between Chios Island and the Turkish coast (in 1992), and one stranding close to Izmir Bay (in 1995), together provide evidence for at least the occasional presence of the species in the Aegean Sea.

IONIAN DOLPHIN PROJECT AND NATURA 2000 The Ionian Dolphin Project (IDP) represents the first longterm cetological project in Greece. Its objectives are the study and protection of those cetaceans which inhabit the coastal waters of the Central Hellenic Ionian Sea. The IDP is co-ordinated by the Tethys Research Institute and the University of Athens. Through longterm monitoring of the local communities of common dolphins and bottlenose dolphins, this project aims to provide a concrete picture of their population dynamics, behavioural ecology, and social structure. Photo-identification techniques have been applied to both dolphin communities since 1992. Approximately 130 resident and perhaps some "isolated" common dolphins inhabit the study area according to the project's results. They could represent the last remnants of a formerly large Ionian-Adriatic "population", since the common dolphin is very rare or absent from the Adriatic and North Ionian Sea.

Common dolphins, which were rather frequent in the Mediterranean until a few decades ago, have recently almost disappeared for unknown reasons. Similarly, bottlenose dolphins, although among the most frequently observed dolphin species in the basin, have decreased drastically in many parts of it. Therefore, the situation found in the Central Hellenic Ionian Sea, with bottlenose and common dolphins sharing the same coastal habitat, is a rare (if not unique) opportunity for shedding light upon the causes of the decline of the common dolphin in the region. Since there is evidence that the study area is a valuable refuge for both dolphin species, the IDP's scientific team proposed and has succeeded in including the greater part of it within the NATURA 2000 European network (Habitat Directive 92/43/EEC), as a "Site of Community Importance". In addition, within the limits of the project, a training programme of Greek biology students of Athens University, has provided theoretical and practical expertise for future Greek cetologists.

FUTURE PROJECTS EXPECTATIONS Considering all existing information concerning Hellenic cetaceans, the following research fields present a special interest for future studies:

(1) The presence of a striped dolphin community in the closed Korinthiakos Gulf provides unusually favourable conditions for longterm studies on this pelagic species;

(2) The simultaneous summer presence of fin whale in both the Ligurian and Ionian Seas provides an opportunity for a comparative study;
(3) Investigation of the presence of harbour porpoise in the North Aegean Sea is of great interest, since this species inhabits the neighbouring Black Sea;
(4) The closed Amvrakikos Gulf faces problems of organic pollution. The presence of a bottlenose dolphin community offers a good chance to study interactions throughout the trophic chain;
(5) The unusual easy approach of Cuvier's beaked whale in the Ionian Sea provides the opportunity for studies of this normally shy species.

With the aim of developing cetology in Greece, the author intends to involve the Universities of Athens, Patra, and Kriti, as well as the Institute of Marine Biology of Crete and the Ministry of the Environment, in combined actions for the study and protection of the Hellenic cetacean fauna. The most crucial steps towards this direction will be the creation of the Hellenic Cetacean Society, and the establishment of projects with other countries.

AKNOWLEDGEMENTS I wish to thank Marina Sequeira personally and the Conference Organisers, who made a big effort in order to support the Greek participation in the 10th Annual Conference of the ECS. I also wish to thank Guiseppe Notarbartolo di Sciara and Elena Politi of the Tethys Research Institute, Nikos Charalampidis of Greenpeace-Greece, Maria Corsini of the Hydrobiological Station of Rhodes, Vrasidas Zavras and Jenny Androukaki of the Mom-Hellenic Society for the Protection of the Monk Seal, Dimitris Karavelas of WWF-Greece, Luca Marini of the University "La Sapienza", and G. Verriopoulos of the University of Athens, for providing data, photographs, information, or means and help in the field.

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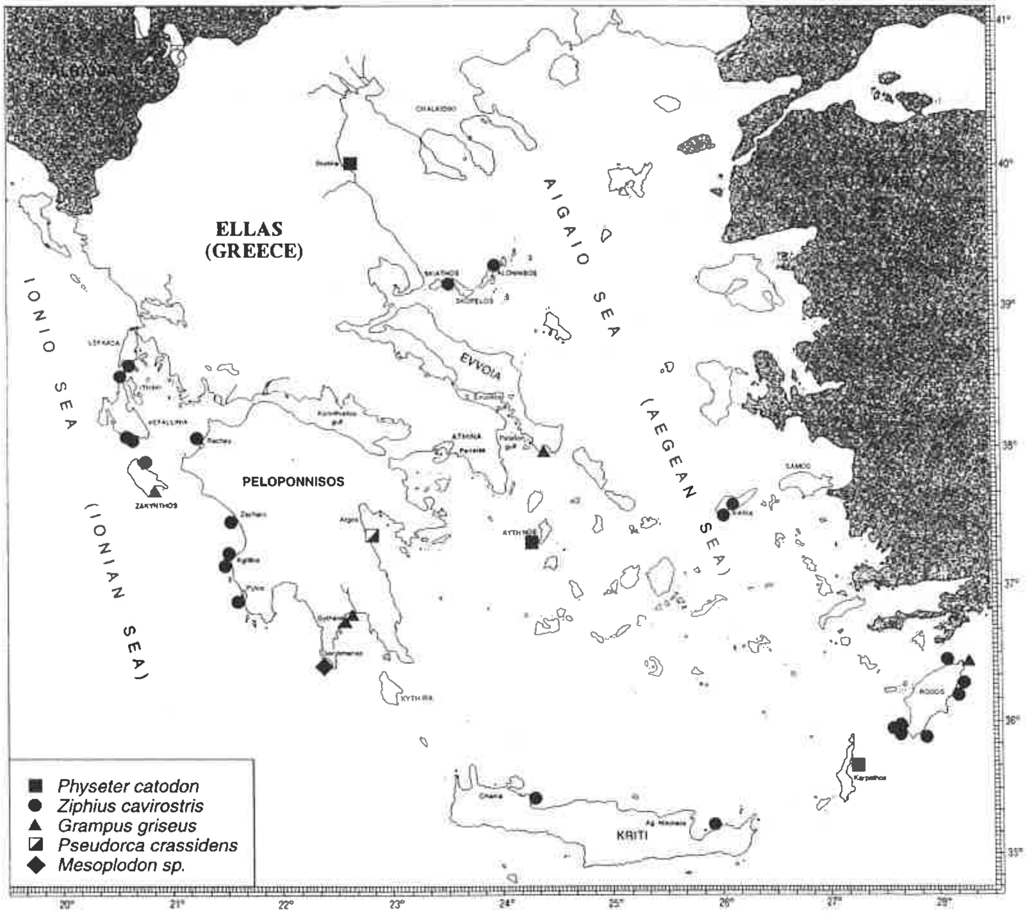

Fig 1. "Unusual" cetacean strandings recorded along the Hellenic coasts, the last five years. The map also includes four strandings belonging to the species, *Physeter macrocephalus* (Karpathos 1965, Skotina 1984), *Grampus griseus* (Gytheio 1986) and *Mesoplodon* sp. (Gerolimenas 1989). We consider all species except *Tursiops truncatus* and *Stenella coeruleoalba.* as "unusual" strandings. No definite *Delphinus delphis* were observed except those strandings recorded. Strandings were only recorded systematically at Rodos Island.

CETACEANS AROUND THE MALTESE ISLANDS

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INTRODUCTION The Maltese Islands are a small archipelago, consisting of six islands and islets situated in the middle of the Mediterranean about 90 km south of Sicily and 334 km north of the Libyan coast. The total area of the Maltese Islands is 246 km^2. The coast around Malta measures up to 136 km, whilst that of Gozo, the second largest island, reaches a maximum length of 43 km. The Maltese population is about 400,000 persons.

Marine Life Care Group is a non-profit making organisation and it has been set up since March, 1993. This is the only organisation that specialises in the marine area. We presently deal with strandings of cetaceans (mainly dead), saving turtles from death (due to fishermen as a result of hooking), marine pollution in general (effects of fish farms, raw sewage, etc), and also treat injured seabirds and shorebirds, amongst which are gull species, terns, sandpipers, and curlews. We also try to manage the education side of the subject with lay people, especially young people at schools.

RESULTS Cetacean Fauna As regards cetaceans, there is not much to report since no local research has ever been done. In the distant past, dolphins were very popular around the Maltese Islands, and in fact, pictures of them could be found on local coins. Sightings of them in the Gozo Channel were relatively common until around 15 years ago. However, their presence has now diminished substantially due to many factors, with sea traffic one of the most important of them all.

Unfortunately, Malta's coastline does not lend itself to receiving cetacean strandings, and generally if dolphins live strand, it is very unlikely for them to end up on one of our beaches. Of course there are exceptions such as the incident that occurred back in January 1990, when a 17 foot cetacean (species unknown) was rescued by the armed forces as it tried to beach itself at Armier (north of Malta). In fact this is the only live stranding ever known to have occurred here. This particular cetacean, however, did not survive, since it beached itself again the next day. Despite the co-operation and the efforts to try to save this animal, perhaps lack of experience may have been the result of this unhappy incident. A week later, however, another stranding occurred at Mgiebah Bay near Selmun, in the north-east of Malta. On this occasion, the dolphin was washed up ashore already dead.

Another curious incident occurred towards the end of June in 1984, when two bottlenose dolphins entered Dwejra, an inlet sea, in Gozo. It took the people who were handling the matter, quite a few days until they managed to lead the dolphins out to the open sea with the help of divers. During this incident, the police had to intervene to ensure that the fishermen did not harm the dolphins.

Another incident, in which dolphins and locals encountered eachother, was in April, 1989. However, this experience turned out to be a rather unhappy and unfortunate one with three bottlenose dolphins (*Tursiops truncatus*) dared to enter a bay in the south of Malta where no protective legislation existed. The result was that they were all shot at, and harpooned, despite the efforts of some people to save them.

Fortunately, the legal status of marine mammals, as well as marine turtles, has improved since 1992. An Environment Protection Act was passed in 1991, in which various environmental regulations were made. The Marine Mammals (Protection) Regulations came into force in 1992. These listed the following 14 marine mammal species:

Minke whale (*Balaenoptera acutorostrata*)
Fin whale (*Balaenoptera physalus*)
Common dolphin (*Delphinus delphis*)
Long-finned pilot whale (*Globicephala melas*)
Risso's dolphin (*Grampus griseus*)
Killer whale (*Orcinus orca*)
Sperm whale (*Physeter macrocephalus*)
False killer whale (*Pseudorca crassidens*)
Striped dolphin (*Stenella coeruleoalba*)
Rough-toothed dolphin (*Steno bredanensis*)
Bottlenose dolphin (*Tursiops truncatus*)
Cuvier's beaked whale (*Ziphius cavirostris*)
Harbour porpoise (*Phocoena phocoena*)

Mediterranean monk seal (*Monachus monachus*)

The regulations state that no person shall pursue, take, kill, possess, sell, buy, exchange, import or export any of the species mentioned in the schedule. If any fisherman during the course of his work accidentally catches a marine mammal, and it is landed at the fish market, this must be given to the Director of Fisheries who shall then dispose of it for scientific purposes only. Contravention of the regulations are liable to fines ranging from 25-100 Maltese liri.

In the last two years, sightings of cetaceans have increased considerably. Notwithstanding the negative impact which sea-based fish farms are having on the Maltese Islands, they could be contributing to the increase in sightings of dolphins. The aquaculture industry in Malta started in 1989 when the Ministry for Food, Agriculture and Fisheries set up the National Aquaculture Centre which was intended to sefve as the pilot project to promote aquaculture as a new industry in Malta. There are now four farms which are currently operating on a relatively large scale around the Maltese Islands, producing a total of 1,200 tonnes in 1995. The fish being bred at the farms are mainly the Awrata or sea bream/gilt-head (*Sparus aurata*) and the bass (*Dicentrarchus labrax*), spnotta or sea bass.

Returning to the strandings issue, at the beginning of November 1995, the lower part of a skeleton of a whale was washed ashore on the north coast of Malta. A month later, a Cuvier's beaked whale was stranded as a result of the very bad weather, again in a bay in the north-east of the island. Finally, in January 1996, we had two incidents occurring in different circumstances. One of them was a bottlenose dolphin which stranded due to rough weather in the southern part of the island. The second was the finding of a striped dolphin in a bay in the south of Malta. This was definitely killed, and its meat was taken away to be used as bait for octopus. Unfortunately, it was a female dolphin which was also pregnant, since a foetus was left behind by butchers, together with its mother's internal organs. Despite our efforts, no post-mortem examinations have been undertaken on any of the carcasses, and no clear conclusions could be reached.

Fishing Methods in the Maltese Islands Some of the most popular fishing methods are the parit, consisting of three walls of netting suspended from a single head rope. The seine net (Tartarun) is used to encircle a shoal of fish. It has always been subject to much controversy regarding the harm that is caused by catching immature fish. Besides others, the most important type of seine net is the purse seine. In Malta it is used in conjunction with lights, and the fishing method is called lampara fishing. There are also gillnets, of which mesh size and depth depend upon the size of the fish and the depth at which it is found. Dredges are another type of fishing gear used locally. These are bag nets which are drawn along the sea-bed. Bottom trawling is surely the most important form of dredging used locally.

One of the worst forms of fishing is explosives which although illegal are still in use. Although a small number of fishermen make use of this method, it does a considerable amount of damage to the marine life around the Maltese Islands.

According to research carried out, the main type of explosive used is GELATINA, a jelly type of explosive which is waterproof. The gelatina is normally placed in a plastic container, after which a waterproof card is attached to it, and lit on the boat. It is then thrown far out into the sea. All the fish in the area are blown away with the explosion of the bomb, and eventually they begin to surface.

The technique used in this method has been very well studied. The first thing that fishermen do is to choose the area of operation. This is done by visiting a number of places and observing the quality of life in that area. Then they visit the locality about twice a day, and feed the fish until they get accustomed to feeding. Firstly, a small bomb is blasted to get rid of the small fish at the sea surface. When the larger fish are sighted, a more powerful bomb is exploded further down to kill them. The bomb is exploded further down to kill them. The bomb is exploded at various water depths, depending on the season and the type of species they are fishing. The water level is regulated by the length of the cord. When fish are caught in this manner, it can easily be recognised and, therefore, instead of taking it to the official fish market, it is sold at a fishing stall.

CONCLUSIONS As mentioned earlier, no scientific research is currently being undertaken on cetaceans in Malta, and this includes studies of interactions with fishermen, an obvious and potentially important threat to these animals.

In this respect, however, we have recently started a survey of dolphin sightings, amongst other animals, around our waters, and throughout the Mediterranean. The information that we collect will be gathered into a database which will be made available to other research institutions. One of our main goals is to start conducting research on dolphin populations of dolphins inhabiting our waters.

MONITORING OF CETACEANS IN THE LIGURIAN SEA: SUMMER 1995

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OBJECTIVES WWF-Liguria is particularly interested in educational aspects of whale-watching. For this reason, during summer 1994 and 1995, WWF-Liguria has organized research cruises, which have involved one hundred of its members.

WWF-Liguria is also concerned with scientific aspects, in the form of teamwork co-operation with the Department of Anatomia Comparata of Genoa University. This collaboration allows WWF to monitor the coastal waters of the Ligurian basin in order to describe the distribution, sighting frequencies, and group sizes of cetacean species present in this area, and to provide the information necessary to prepare appropriate conservation measures. This work presents data collected in summer 1995, and compares them with those collected in summer 1994 (Barberis *et al.*, 1994).

METHODS The monitored area has been the Ligurian basin from Bordighera (IM) to Lerici (SP), in the Western Mediterranean Sea. For the research, two 14 m. sailing ships were used.

Sampling has taken place from 8 July to 11 August 1995, by sailing along coastal waters, with a day-long cruise from 1 h. 30 min. to 9 h. 30 min. in daylight hours. Observation shifts were organised to cover the entire sailing time, cetaceans were detected by naked eye, and identified with binoculars.

No survey grid was pre-designed: the regions of interest were visited in turn, depending on weather conditions.

At each sighting, a form, in which position (calculated with GPS system), and time of sightings, group size, presence of juveniles, and observations about behaviour was completed.

RESULTS The "Summer '95" surveys are summarised in Table 1. In five weeks, 14 sightings were made and 1,061 miles covered, resulting in an encounter rate of 0.013 group of cetaceans per mile of sampling.

Three species have been identified: striped dolphin (*Stenella coeruleoalba*), bottlenose dolphin (*Tursiops truncatus*), and fin whale (*Balaenoptera physalus*); one *Balaenoptera* species has been sighted, and in one case it has not been possible to recognise the species.

Most sightings (71.4%) have been of striped dolphin; bottlenose dolphin, fin whale, *Balaenoptera* sp., and an unidentified cetacean accounting for the remaining 28.75% (7.1% each one) (see Table 2). School sizes for each sighting could only be calculated for striped dolphin (see Fig. 1).

DISCUSSION AND CONCLUSIONS The differences between summer '94 and summer '95 surveys are summarised in Fig. 2. In summer 1995, the total sightings decreased, as well as the number of sightings of bottlenose dolphin; Risso's dolphins (*Grampus griseus*) were not sighted, while sightings of striped dolphins increased.

These data confirm that the Ligurian Provençal basin is an area of major importance for the striped dolphin in the Mediterranean Sea (Gannier and Gannier, 1993), and it underlines the importance of establishing a connection between the presence of craft and distribution, sighting frequencies, and behaviour of cetacean species.

ACKNOWLEDGEMENTS We wish to thank Prof. Maurizio Wurtz, Istituto di Anatomia Comparata, Università di Genova for his valuable help.

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Table 1 Summary of summer 1995 surveys

DAYS & MONTH	DISTANCE SAMPLED IN MILES	NO. OF SIGHTINGS
8 July - 14 July	290.8	2
15 July - 21 July	186.5	3
22 July - 28 July	216.8	3
29 July - 4 Aug	178.0	3
5 Aug - 11 Aug	197.5	3

Table 2 Cetacean sightings by species

SPECIES	SIGHTINGS		INDIVS.	
	No.	%	No.	%
Stenella coeruleoalba	10	71.43	9	4.3
Tursiops truncatus	1	7.14	10	4.0
Balaenoptera physalus	1	7.14	1	0.4
Balaenoptera sp.	1	7.14	2	0.8
Not identified	1	7.14	1	0.4

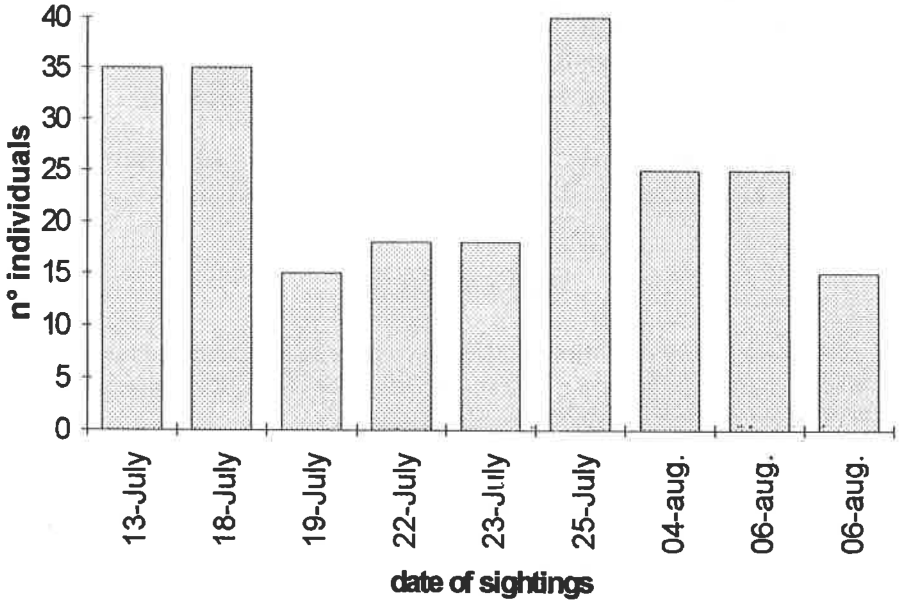
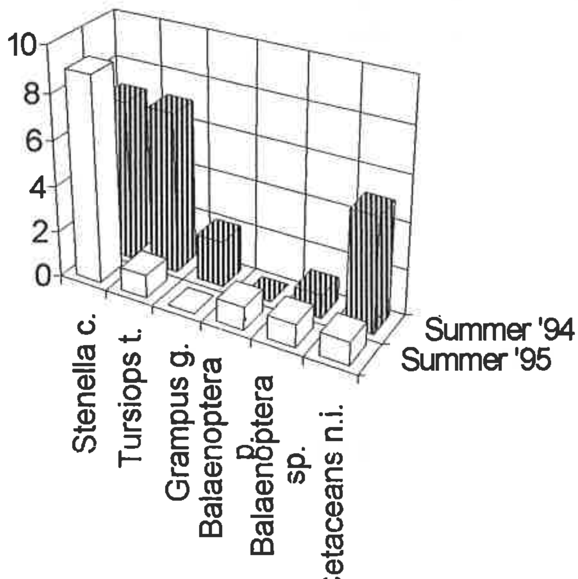


Fig. 1 Group sizes of striped dolphin



	MILES	SIGHT.	ENCOUNTER RATE
SUMMER '94	1052	24	0.019
SUMMER '95	1061	14	0.013

Fig. 2 Comparison between Summer '94 and Summer '95 surveys

A LONG-TERM SURVEY ON DISTRIBUTION AND DYNAMICS OF CETACEANS ALONG THE SOUTH-EASTERN COAST OF SPAIN: FOURTH YEAR OF RESEARCH, 1992-95

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INTRODUCTION Since 1992, the Alnitak Marine and Environment Research Centre has carried out a longterm survey of the distribution and dynamics of cetaceans along the south-eastern coast of Spain. One of the most important aims of this study was to establish the possible relationships between the distribution and dynamics of the different species with oceanographic and meteorological factors, given that the distribution of the cetaceans is probably determined primarily by that of their prey, which in turn is related to oceanographic factors (Evans, 1987). The in-flowing Atlantic surface waters under the influence of winds, atmospheric pressure, and topography are deflected inside the Alboran basin, creating one, and sometimes two, anti-cyclonic gyres and small meanders which ultimately end up forming the North African current. The clashing of this colder, and less saline, water with Mediterranean water masses results in the formation of fronts, such as the Almería-Oran front and other important areas of upwelling (Cheney *et al.*, 1979; Wannamaker, 1979; Parrilla *et al.*, 1987; Tintore *et al.*, 1988). Even though these hydrographic studies have highlighted the biological importance of the Alboran Sea, very little research has been carried out in order to monitor these productive regions. Two regions of high productivity are located inside research areas III and IV of this study (see below). These are upwellings on the southern slope of a bank named "Seco de los Olivos" and a frontal line extending from Cabo de Gata to the North African Coast: the Almería-Orán Front (Rubín *et al.*, 1992). Previous surveys had clearly highlighted this region as one of special interest for cetaceans, even though comparatively less survey effort had been expended in this area than in the other survey regions further to the north. This lack of effort was mainly due to adverse climatic conditions created by the magnification of winds around the Cape and the funnelling effect of the Alboran basin. In order to homogenise survey effort in all areas, line transects were specially designed to comprehensively cover the southern regions III and IV. The results of the survey carried out during 1995 are presented in this paper, particularly those relevant to the southern region (IV).

MATERIALS AND METHODS Sighting cruises were carried out onboard the 60' gaff-rigged ketch "Toftevaag" during the months of April, June, July, August, September and November, from 1992 to 1995. Navigation, oceanographic and meteorological data are recorded during surveys. During sightings of cetaceans, data were recorded on the species, number of individuals, social structure, and behaviour. These data were complemented with photo-identification. For the analyses of distribution, the entire research region (area from Cabo de Palos - 37°38'N, 00°33'W - to Almerimar - 36°20'N, 2°55'W) was divided into four major areas (I=north, II=centre, III=south, and IV=south-west) which, in turn, were subdivided into 5x5 nm. quadrats. In addition, six depth ranges were considered: 0-200, 200-500, 500-1,000, 1,000-1,500, 1,500-2,000 and >2,000 metres in depth. Sea-state was also taken into account for the analyses, five categories were used (Douglas sea-state scale): 1, 1S, 2, 2S, and 3 (S indicates swell). Sighting effort ceased if the sea-state exceeded three. In 1995, the collection of data collected was aided by the use of "Logger", a data entry computer program conceived by the International Fund for Animal Welfare. This program, which directly records navigational data from the GPS in addition to environmental and sighting data entered during the survey, has greatly simplified the work onboard.

RESULTS A total of 1,955 hours of survey effort were expended onboard the sixty foot research vessel "Toftevaag", and 8,727 nm. of transect lines were covered. In four years of research, 333 hours were spent observing cetaceans, during which 530 sightings of nine species were made (in decreasing order of number of sightings) - striped dolphin*Stenella coeruleoalba*, common dolphin *Delphinus delphis*, long-finned pilot whale*Globicephala melas*, bottlenose dolphin *Tursiops truncatus*, Risso's dolphin *Grampus griseus*, sperm whale *Physeter macrocephalus* (*catodon*), fin whale *Balaenoptera physalus*, Cuvier's beaked whale*Ziphius cavirostris*, and false killer whale *Pseudorca crassidens* (see Table 1).

Sightings in 1995 In 1995, a total of 177 sightings were made, a greater number of sightings than in previous years. Once again, striped dolphin was the most frequently sighted species, with 75 sightings (42.3%), followed by common dolphin, with 50 sightings (28.2%). Risso's dolphin was the third most frequently sighted species, with 14 sightings (7.9%). Long-finned pilot whale was observed less frequently in 1995 than in previous years, with only nine sightings (5%). Bottlenose dolphin was sighted ten times in 1995 (5.6%). Four more species were sighted, albeit only once, in 1995: fin whale, sperm whale, Cuvier's beaked whale, and false killer whale.

Area IV This survey area (see map) was the most south-westerly sector of the research region, and is located in the Alboran Sea, south of Almería. The area was surveyed in 1992 and 1995, but not in 1993 and 1994, mainly due to the adverse observation conditions noted above. The encounter rates per area for the five commonest species in the research region are shown in Table 2. An important feature of this area is the presence of the submarine mountain called "Seco de los Olivos", known for its very high phytoplankton and icthyoplankton productivity - the highest submarine mountain of the northern Alboran basin (no data on productivity are available for the southern part) (Rubín *et al.*, 1992). Many species of cetacean were abundant in this area. During the beginning of September, 1995, high productivity was detected around the "Seco de los Olivos", and in Almería Bay. This was visible to the naked eye as a change from warm clear blue waters to cooler turbid dark green water. During this period, many fish banks were observed (*Belone belone*, *Clupea aurita* , and *Clupea pilchardius*) being fed upon by schools of dolphins - especially common dolphins - most of the time, gannets were also present. In future surveys, more survey effort will be expended this area, as well as a more intensive research into the phenomena of upwellings and productivity in the region, in order to study the possible relationships between these parameters and the presence and behaviour of cetaceans.

Striped dolphin (*Stenella coeruleoalba*) In 1995, as in previous years, the maximum number of sightings was obtained in September (Fig. 7). Groups observed during the summer possibly migrate from the area, and are replaced by large groups of stenellids which display different pigmentation patterns and also demonstrate an evasive attitude towards ships. These individuals which generally, seem to be larger than individuals of the summer groups, have a whitish patch on their melon, and usually have a sharply contrasting pigmentation pattern upon their bodies (see photographs) (Cañadas and Sagarminaga, 1996, this vol.).

A sighting of a false killer whale On 3 September, 1995, a group of eight false killer whales was sighted at 36°59.20' N - 1°50.00' W, less than one mile off the coast of Carboneras, in water 120 metres deep. They were dispersed, swimming slowly (three knots), in a NNE direction. The encounter lasted for approximately 60 mins., during the beginning of which three of the individuals approached the boat for several minutes. Unfortunately, due to a sudden increase in wind force and sea-state, it was not possible to follow the group which seemed to be approaching the coast. Some photographs, however, were taken. During the sighting, four spectacular jumps out of the water were observed. All animals seemed to be healthy, and no strandings have been reported in the region. There are few records of this species from the Mediterranean Sea.

ACKNOWLEDGEMENTS The authors would like to thank more than 350 volunteers who have contributed with the look-out watches on board the "Toftevaag", and contributed to the financial support of the research. Special thanks are also due to

A.N.S.E. Cartagena, Julio Más (Oceanographic Institute of Mar Menor), the local office of the Government of Murcia, the Environment Agency (Delegación Provincial del Medio Ambiente) of Almería, and the customs and guardia civil of the region, for their support and collaboration. Our grateful thanks also go to IFAW for contributing their "Logger" program, and to Jauma Forcada for his advice.

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Table 1 The number of cetaceans sighted during each year of surveying

SIGHTINGS	YEAR				
OF SPECIES	**92**	**93**	**94**	**95**	**TOTAL**
Stenella coeruleoalba	23	36	61	75	**195**
Delphinus delphis	25	34	26	50	**135**
Globicephala melas	10	13	14	9	**46**
Tursiops truncatus	10	15	3	10	**38**
Grampus griseus	8	4	5	14	**31**
Physeter catodon	0	1	4	1	**6**
Balaenoptera physalus	0	0	2	1	**3**
Ziphius cavirostris	0	0	0	1	**1**
Pseudorca crassidens	0	0	0	1	**1**
Small cetaceans	13	28	18	15	**71**
TOTAL	**89**	**131**	**133**	**177**	**530**

Table 2 Encounter rate per area for the five most commonly seen species in the research region

SPECIES	AREA I	AREA II	AREA III	AREA IV	TOTAL
Stenella coeruleoalba	1.23	3.84	2.29	2.24	**2.23**
Delphinus delphis	0.96	1.44	2.47	2.49	**1.56**
Globicephala melas	0.19	0.96	0.82	0.50	**0.53**
Tursiops truncatus	0.51	0.22	0.18	0.75	**0.44**
Grampus griseus	0.24	0.35	0.73	0.37	**0.36**

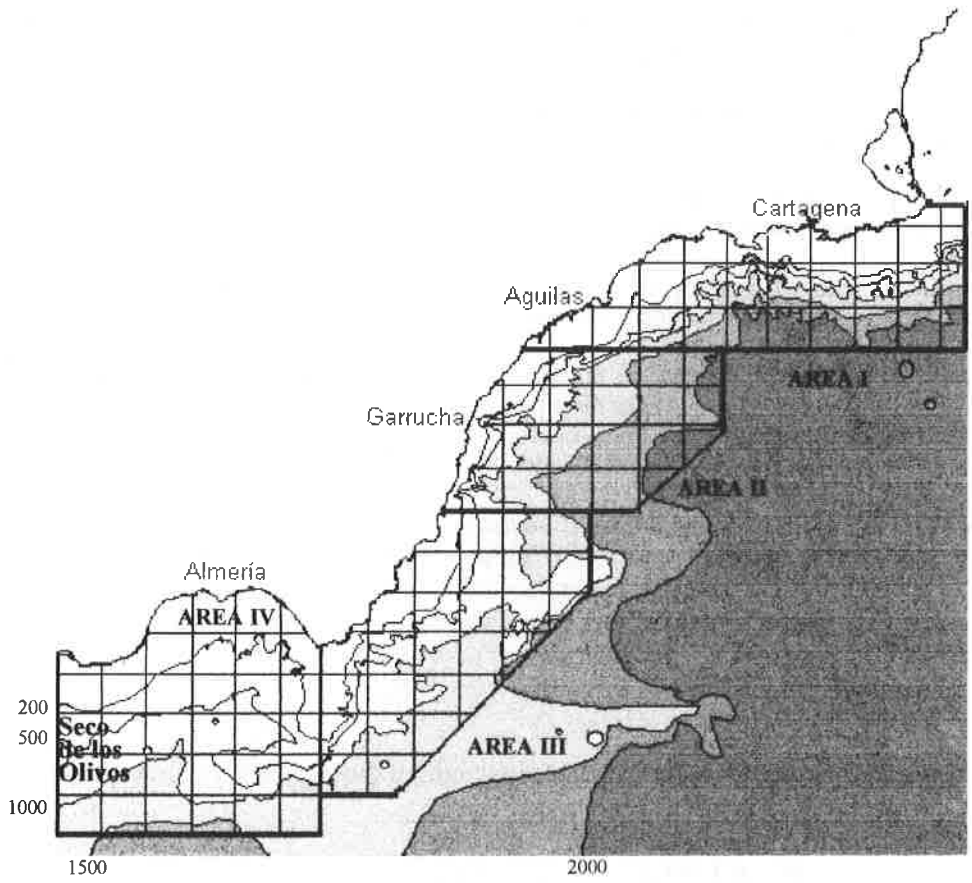

Fig. 1 The research region and its subdivision into study areas and quadrats

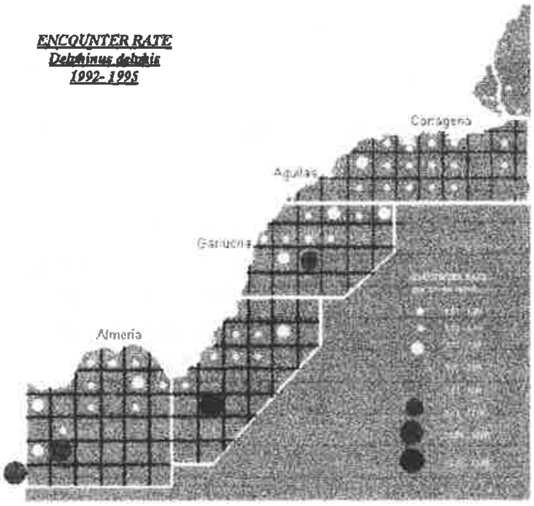

Figure 2. Encounter rate per cuadrats for *Delphinus delphis* (1992-1995)

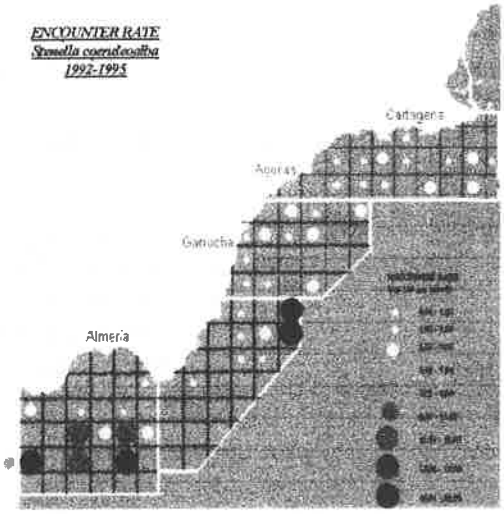

Figure 3. Encounter rate per cuadrats for *Stenella coeruleoalba* (1992-1995)

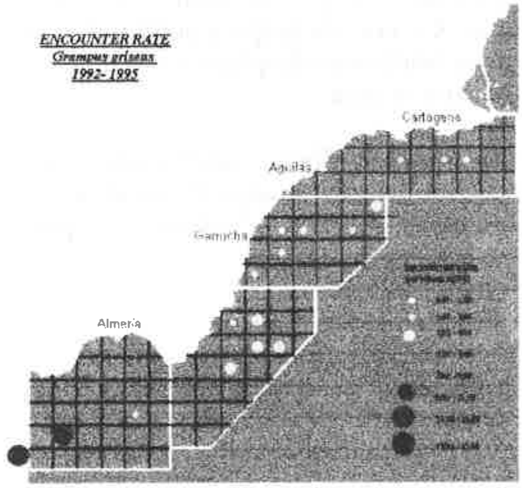

Figure 4. Encounter rate per cuadrats for *Grampus griseus* (1992-1995)

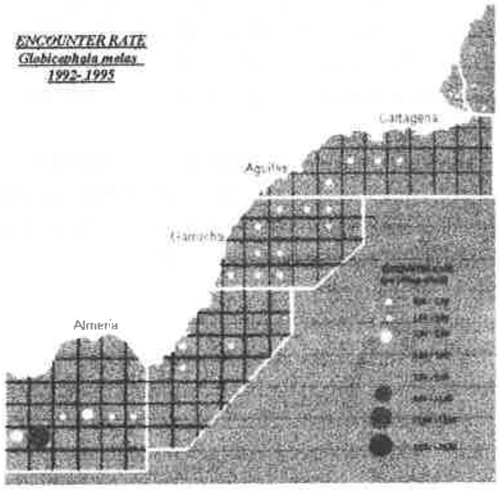

Figure 5. Encounter rate per cuadrats for *Globicephala melas* (1992-1995)

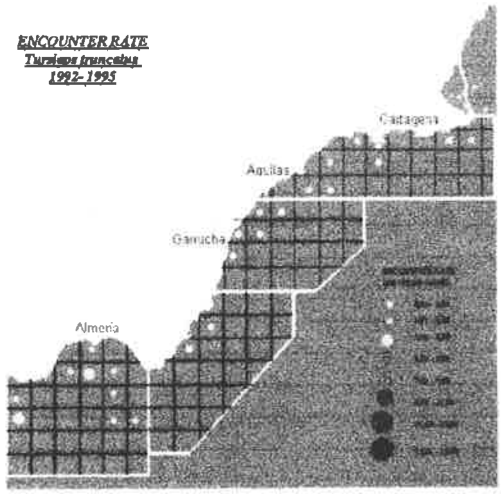

Figure 6. Encounter rate per cuadrats for *Tursiops truncatus* (1992-1995)

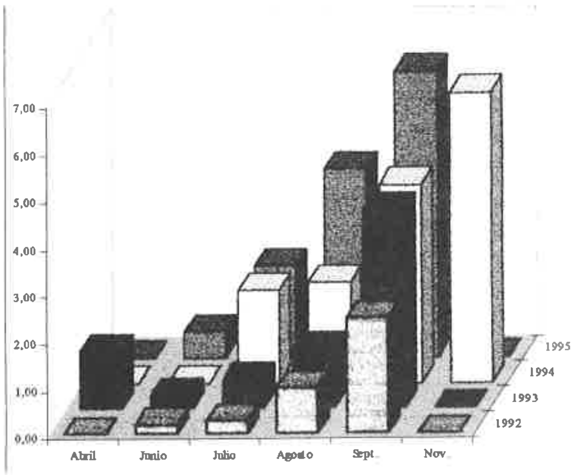

Figure 7. Encounter rate per month for the striped dolphin (*Stenella coeruleoalba).*

CETACEA SURVEY AROUND GIBRALTAR

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Two studies were conducted as part of an ecotourism operation on the dolphin populations off Gibraltar between July and September, 1994 (420 hours of data and 107 sightings). Data collection and analysis were standardised and the following survey techniques were assessed: photo-identification of individuals of all species and use of the LOGGER Program (IFAW) - relating effort to dolphin distribution with positional data from a GPS.

The spatial distribution and the group structure of common dolphin *Delphinus delphis,* striped dolphin *Stenella coeruleoalba* and bottlenose dolphin *Tursiops truncatus* varied seasonally and between species. The greatest specialisation in habitat selection occurred between 30m and 700 m contours. Common dolphins favoured feeding grounds over underwater escarpments, and evidence from photo-identified individuals suggested that groups might stay for up to ten days around Gibraltar Bay. Striped dolphin concentrated in the oceanic habitat outside the main concentration of common dolphin sightings in the Bay. No individuals were identified. Four individual bottlenose dolphins were regularly identified in a group of thirteen which inhabited the survey area.

There has been a decline in common dolphins in the western Mediterranean, and striped dolphins are now considered the dominant species. In contrast it appeared that around Gibraltar there was a habitat which was used by both species, with the common dolphins more suitably adapted to it.

SOME UNUSUAL CETACEAN STRANDINGS AND SIGHTINGS ON THE GALICIAN COAST, NORTH-WEST SPAIN

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INTRODUCTION The Galician coast, located at the north-west of the Iberian Peninsula (Fig. 1), with 1.720 km of extension, is an important area for cetaceans, confirmed by the one hundred strandings recorded each year on average, involving 14 different species - three mysticetes and 11 odontocete species; and by the permanent presence of several populations of small cetaceans, easily observed from the coast, such as the bottlenose dolphin *Tursiops truncatus*.

METHODS The reporting and recording of cetacean strandings in Galicia is carried out by various institutions, notifications by the public, and also by coastal surveys made by the members of CEMMA. In almost all cases, specialised persons visit the location to identify the animal, and to collect data such as sex, biometrics, photographs, and biological samples, when possible. The records have been registered on a database since 1990, and also appear on the annual list of the Northern Peninsula records.

The sightings records are mainly registered by opportunistic observations, and also by periodical special surveys undertaken to detect and follow the movements of bottlenose dolphin groups.

RESULTS Unusual strandings: Between 1990 and 1995, 602 cetacean strandings were recorded, involving 624 specimens. The composition of strandings is given by Figure 2. The most frequent species is the common dolphin *Delphinus delphis*, with 45% of strandings. Unusual strandings include one species of mysticete (humpback whale *Megaptera novaeangliae*), and three odontocetes (pygmy sperm whale *Kogia breviceps*, killer whale*Orcinus orca*, and Atlantic white-sided dolphin *Lagenorhynchus acutus*), which comprise 1% of the total strandings.

The different kinds of strandings can be classified in the following categories:

- Strandings of dead animals, forming 95% of the total: mostly individual strandings, but occasionally multiple strandings when some specimens of particular species at varying stages of decomposition appear in the same location or beach. This tends to occur during storms.

- Live animal strandings: 5% of total strandings involve 52 animals (30 cases, or 8% of the total number of animals); these include one species of mysticete and eight species of odontocete. In 54% of cases, these were apparently successfully rescued.

- Individual and solitary strandings: 22 cases: 7 common dolphin, four striped dolphin*Stenella coeruleoalba,* four bottlenose dolphin, one long-finned pilot whale *Globicephala melas*, one Risso's dolphin *Grampus griseus*, one fin whale *Balaenoptera physalus*, three unidentified dolphins, and one unidentified ziphiid.

- Individual strandings accompanied by one or more specimens that did not strand: four cases, one sperm whale *Physeter macrocephalus*, two long-finned pilot whales, and one common dolphin.

- Collective strandings: four pairs (three of common dolphin, one of pygmy sperm whale, and a mass stranding of twenty common dolphins out of a group of one thousand.

Unusual stranding descriptions

1.- humpback whale, 28 March 1993: 490 cm male specimen, Baldaio Beach, Carballo, A Coruña (42°42´55" N, 9°05´54" W). Recently dead. Observers: A. López and M. Dacosta (CEMMA).

2. - pygmy sperm whale, 20 October 1995: 285 cm female specimen, San Xurxo Beach, Ferrol, A Coruña (43°31'30" N, 8°18'30" W). Observer: J. I. Díaz (SGHN).
23 October 1995: two specimens on the San Xurxo Beach, Ferrol, A Coruña (43°32'20" N, 8°17'50" W). A female of 258 cm and a 140 cm live female, apparently successfully released. Observers: J. I. Díaz (SGHN) and A. López (CEMMA).

3.- killer whale, 14 December 1990: 430 cm male specimen, Campelo Beach, Narón, A Coruña (43°35'00" N, 8°12'50" W). Observer: J. I. Díaz (SGHN).

4. - Atlantic white-sided dolphin, 12 April 1994: 240 cm male specimen, Frouxeira Beach, Valdoviño, A Coruña (43°37'00" N, 8°55'50" W). Observer: J. I. Díaz, (SGHN).

5. - Atlantic white-sided dolphin, 1 May 1995: incomplete male specimen, without tail (a total length of 170 cm estimated), Torradas Beach, Malpica, A Coruña (43°17'40" N, 8°44'10" W). Observer: CEMMA.

6.- Common dolphin, 11 August 1996: one thousand individuals came into Langosteira Cove, Fisterra, A Coruña (43°55' N, 9°15'W) during the afternoon, causing twenty individuals to strand, the youngest specimens were all rescued, and finally departed. The bathers and Civil Protection members thus avoided a greater disaster. Observers: R. Vázquez, A. Barreiro, and M. Pérez (CEMMA).

Unusual sightings Most of the 880 coastal sightings (92%) are bottlenose dolphin; other common species in these waters include common dolphin, striped dolphin, long-finned pilot whale, harbour porpoise *Phocoena phocoena*, Risso's dolphin, and fin whale all rarely observed near the coast, and because of their behaviour and the fact that they often strand, these probably had some health problems. On one occasion, a rare northern right whale *Eubalaena glacialis* was sighted from the coast.

Unusual sighting description

7.-Northern right whale, 5 December 1993: specimen swimming 200 metres from the coast in Estaca de Vares, Mañón, A Coruña (43°47'30" N, 7°41'30" W), and showing breaching behaviour. The duration of the observation was ten minutes. Observers: F. Arcos and I. Mosquera (ERVA).

DISCUSSION The stranding records of Atlantic white-sided dolphins in Galicia, and also the repeated strandings at the Cantabrian coast and in France, would indicate that the southern limit of the distribution of this species is about the 40°N parallel, as occurs along the American coast (Gaskin, 1991).

The presence of species like pygmy sperm whale and killer whale, given their normally oceanic distribution in Atlantic waters, is surprising, and it may be that they stranded as a result of some unusual factor such as a maritime accident or a predator attack, combined with strong south-west winds.

The records of species such as humpback whale and northern right whale with very reduced or extinct populations in this part of the Atlantic (Blanco & González, 1992), could indicate the existence of small relict populations, since these individuals were probably not travelling alone. The right whale sighting stands out as the first record of a coastal sighting for centuries.

The common dolphin group for some unknown reason was looking for the protection of a cove thus causing the mass stranding of those individuals like females and calves that were closest to land. With the help they received, and bearing in mind that they were probably already out of danger, they returned to the open sea.

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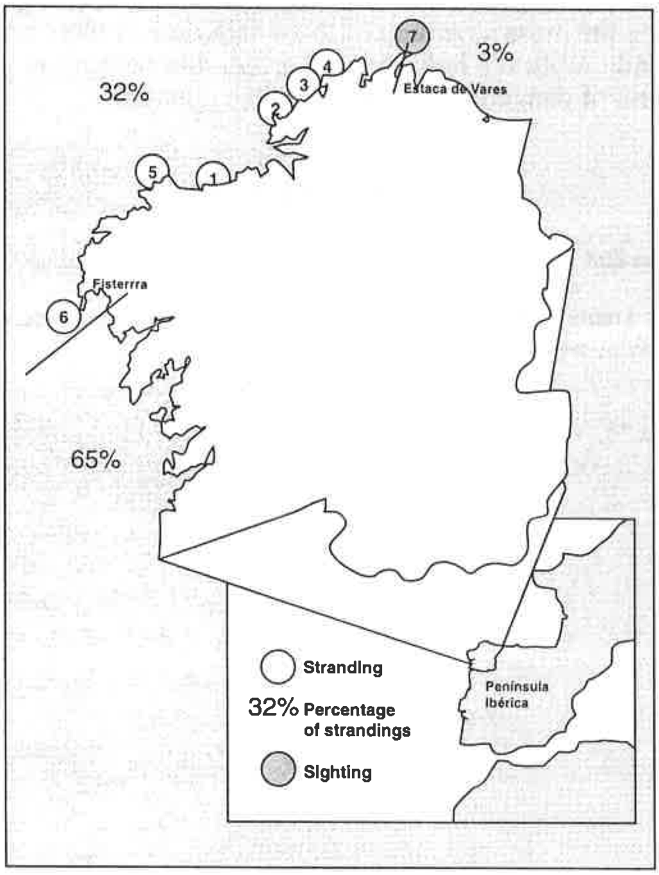

Fig. 1 Location of records

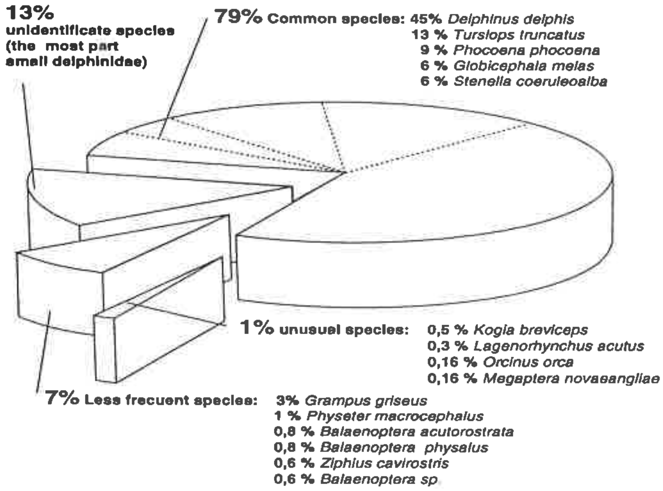

Fig. 2 Composition of strandings

CRAMC'S REPORT ON CETACEAN STRANDINGS ALONG THE COAST OF CATALONIA BETWEEN 1994 AND 1996

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The CRAMC (Marine Animal Rehabilitation Centre of Catalonia) is a non-profit marine animal rehabilitation organisation, created in 1994 to control activities related to stranded marine animals along the Catalan coast of Spain.

A rapid-response network has been organised to attend emergency calls received by local government coastal services. When an alert is received, a group is sent to the stranding site. Living animals are transported to the centre for treatment, while dead ones are necropsied. A maximum amount of data is collected from them. All records are entered on a database for future reference.

This work was conducted between January 1994 and January 1996. During 1994, the network responded to emergency calls on ten strandings. Six of these animals were alive, of which five were successfully returned to the sea. The remaining five were necropsied. In 1995, the number of alerts rose to 26. Three dolphins, which were still alive when found but which subsequently died, were necropsied in the same way as the rest of the animals that had stranded during this period. A table of all the cases is presented showing the wide range of species encountered, with the striped dolphin (*Stenella coeuroleoalba*) being the most common. The clear increase in emergency calls received during the second year strongly suggests that a well-organised network must be established to obtain a complete and reliable record of cetacean strandings.

CETACEAN STRANDINGS IN PORTUGAL: 1993-95

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INTRODUCTION Valuable information on several aspects of the biology and ecology of cetacean populations can be obtained from data collected through a national network set up for stranding surveys. Although dealing only with dead animals and making it difficult to assess changes in numbers of strandings in relation to population changes in food abundance, a series of questions on topics such as patterns of distribution, mortality factors, feeding habits, and reproductive biology can be addressed using stranding data.

Collecting information from strandings has some advantages over a sighting survey scheme:

1) identification of individuals can be more accurate;
2) up to a certain point, strandings can sample cetaceans that usually do not inhabit coastal areas or that are frequent in areas of little human presence;
3) geographical area and weather conditions have little influence on the collection of data.

Nevertheless, it should be noted that any programme aimed at monitoring cetacean populations in a given region, must combine information obtained from both strandings and sightings schemes.

METHODOLOGY Since 1976, records have been collected from a large network of observers, including the Maritime Delegations, the Custom authorities, and a comparatively large group of volunteers and conservation groups all reporting cetaceans found stranded on the shore. At first, only a small number of the records gave sufficient details for reliable identification, and many gaps existed along the coastline. From 1988 onwards, more people became involved in this network, and, today, the entire coastline is surveyed throughout the year. In addition to the information collected by the regular observers, a Beached Bird Survey has been organised in the last five years from October to March, covering several kilometres of coast. Participants in these surveys were instructed to identify and report any cetacean found dead on the beach.

RESULTS AND DISCUSSION Between 1993 and 1995 (note that data for 1995 are not yet complete), a total of 291 cetacean strandings were recorded along the Portuguese coast. From a total of eleven species identified (nine odontocetes and two mysticetes) (Fig. 1), the common dolphin *Delphinus delphis* was the most abundant cetacean, accounting for 35.4% (n=103) of all strandings recorded. However, this figure can be increased up to 60% if we consider that 35% (n=102) of the overall mortality was included in the *Delphinidae* category. Also important was the stranding of one false killer whale, *Pseudorca crassidens*, and one beaked whale, *Mesoplodon* sp. In recent years, a few beaked whales have been recorded on the Portuguese coast (Sequeira, 1990; Sequeira *et al.*, 1992; Sequeira *et al.*, in press), but the presence of false killer whale has not been detected since 1935 (Nobre, 1935, 1937; Fraser, 1950). Other odontocete species regularly reported along the coast between 1993 and 1995 include the striped dolphin *Stenella coeruleoalba* (n=22), harbour porpoise *Phocoena phocoena* (n=22), and bottlenose dolphin *Tursiops truncatus* (n=18). Mysticetes were less common, and only two species were identified: minke whale *Balaenoptera acutorostrata* and fin whale *Balaenoptera physalus*, with only five cases reported for each species.

The geographical distribution of strandings revealed that 87.6% (n=255) of all observations were recorded in the northern and central zones of the Portuguese coast, with particular reference to the areas between Aveiro and Figueira da Foz harbours (northern zone), and between Cabo da Roca and Sines (central zone). The coastal areas of North-west Portugal are well known for their biological richness. In fact, the wider continental shelf, extending from Viana do Castelo to Nazaré, as well as the occurrence of regular strong upwellings (Fiúza, 1983), allows for a rich marine fauna. Consequently, high fishing effort occurs here, and there is a great number of catches by the local fisheries (Franca and Costa, 1984; Costa and Franca, 1985; INE, 1990-93). Furthermore, high levels of primary productivity have been recorded for the area between Cabo da Roca and Sines, related to the high concentrations of nutrients from the Tejo and Sado river systems. The greater prey availability in these areas is exploited both by the fishermen and cetaceans, and conflicts with fisheries are therefore common, with many cetaceans being caught accidentally in fishing gear.

Most of the strandings occurred between October and March when adverse weather conditions can be fatal to weak or diseased animals (Fig. 2). Although this period coincides with the Beached Bird Surveys, a similar pattern had already been detected before, and apparently does not reflect a bias in the monitoring surveys since, during summer when the entire coast is intensively used by potential observers, the number of strandings reported is much lower.

CONCLUSIONS Most valuable information on patterns of distribution and occurrence of cetaceans along the Portuguese coast has been collected by the national network for strandings. In the last few years, the number of observers has increased, and many new areas are now being surveyed, increasing the amount of data added annually to the stranding database. Nevertheless, a considerable number of records do not give sufficient details for reliable identification (102 cetaceans were included in the *Delphinidae* category, for example), a situation we hope to be able to correct with the publication of a guide to identification, to be distributed soon.

The distribution of cetaceans (particularly of small odontocetes) along the Portuguese coast is highly related to areas of high prey availability. As a consequence, high mortality rates are recorded in the northern and central zones, involving a considerable number of common dolphins and harbour porpoises. This situation calls for urgent monitoring in order to assess the real impact of fisheries upon the cetacean populations.

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Table 1 Cetacean species detected on the Portuguese coast between 1993 and 1995*
(* note for this table and all those following, that data for 1995 is not yet complete)

	1993	**1994**	**1995***	**TOTAL**
D. delphis	44	32	27	**103**
S. coeruleoalba	9	10	3	**22**
T. truncatus	5	6	7	**18**
P. phocoena	7	9	6	**22**
G. griseus	1	2	1	**4**
G. melas	2	0	1	**3**
P. macrocephalus	0	0	1	**1**
P. crassidens	0	1	0	**1**
Mesoplodon sp.	0	0	1	**1**
Delphinidae	40	23	39	**102**
B. acutorostrata	2	2	1	**5**
B. physalus	0	3	2	**5**
Balaenoptera sp.	2	0	0	**2**
Unidentified cetacean	0	0	2	**2**
TOTAL	**112**	**88**	**91**	**291**

Table 2 Monthly distribution of cetacean strandings (1993-95*)

	1993	1994	1995*	TOTAL
JAN	2	13	19	34
FEB	1	22	7	30
MAR	21	14	8	43
APR	6	3	10	19
MAY	2	4	10	16
JUN	2	11	6	19
JUL	9	0	6	15
AUG	9	3	1	13
SEP	4	1	1	6
OCT	15	7	6	28
NOV	14	5	10	29
DEC	27	5	7	39
TOTAL	**112**	**88**	**91**	**291**

Table 3 Geographical distribution of strandings (1993-95*)

ZONES	1993	1994	1995*	TOTAL
NORTHERN	52	44	29	**125**
CENTRAL	48	36	46	**130**
SOUTHERN	12	8	16	**36**
TOTAL	**112**	**88**	**91**	**291**

FIG. 1 - CETACEAN SPECIES STRANDED IN PORTUGAL
(1993 - 1995)

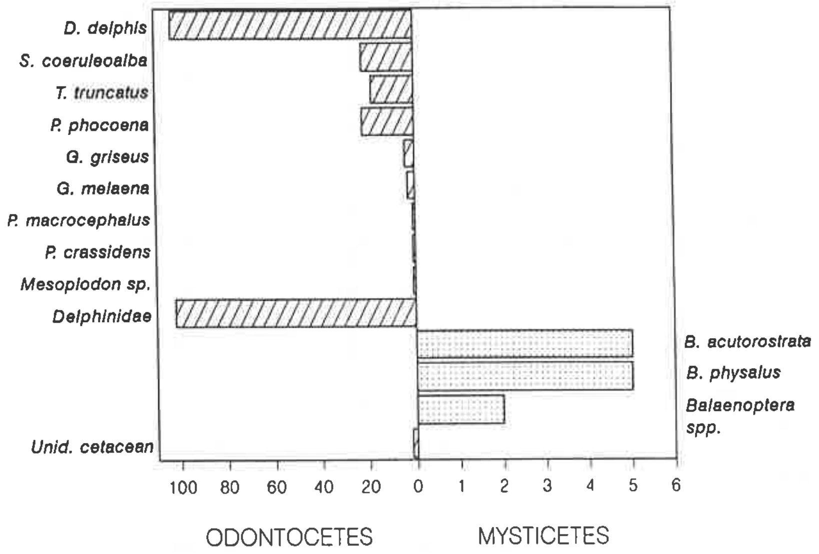


FIG. 2 - GEOGRAPHICAL DISTRIBUTION OF STRANDINGS (1993-1995)

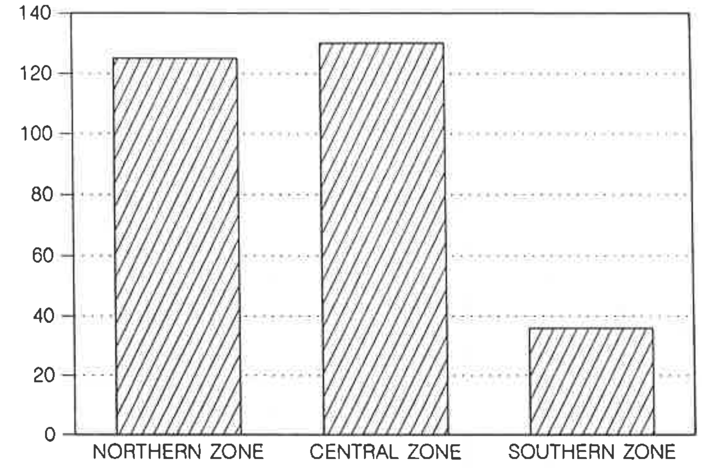
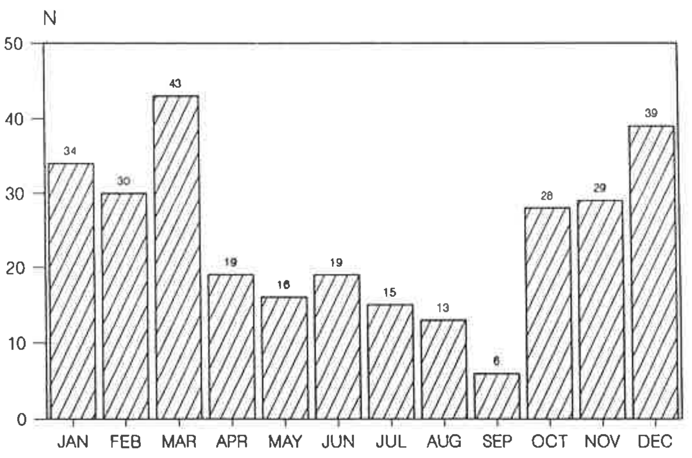


FIG. 3 - MONTHLY DISTRIBUTION OF CETACEAN STRANDINGS IN PORTUGAL
(1993-1995)



CETACEANS RECORDED BY THE WEST WALES GREY SEAL CENSUS

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During the operation of the West Wales Grey Seal Census from 1992 to 1994, cetacean observations made during seaborne fieldwork were recorded. The study area comprised the inshore sea area between Aberystwyth and Milford Haven and an offshore area surrounding the Pembrokeshire islands and the Smalls reef. Land-based watches of Ramsey Sound and Strumble Head were also carried out, using a systematic method of observation and recording.

Effort during seaborne fieldwork was quantified by dividing the study area into cells measuring 4 min. East by 5 min. North, and scoring one unit of effort for each transit of a cell. In 158 days at sea, 1,383 cell transits were made, and a total of 965 cetaceans of five species were recorded in 209 sightings.

The relative abundance of harbour porpoise *Phocoena phocoena*, bottlenose dolphin*Tursiops truncatus*, and common dolphin *Delphinus delphis* in the study area suggests that the different habitat preferences displayed by these species may be related to substrate type, tidal streams, depth or prey distribution. Land-based watches demonstrated a strong tidal influence on behaviour and local abundance of harbour porpoise. The relative abundance of harbour porpoise and bottlenose dolphin peaked in August and September in each of the three years, 1992-94.

CETACEAN RESEARCH IN THE COASTAL WATERS OF THE ISLE OF MULL, SCOTLAND, UK

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The Hebridean Whale and Dolphin Trust (HWDT), set up in 1994, aims to conduct longterm studies into the distribution, behaviour, and ecology of cetaceans in the coastal waters of the Isle of Mull. The main focus of this research is the minke whale *Balaenoptera acutorostrata*, which is regularly sighted within the survey area. HWDT works from a whale-watching vessel operated by Sea Life Surveys, who formerly conducted the research until the trust was set up.

This contribution reviews the following aspects of HWDT's research

- Sightings information on species observed within the survey area;
- Photo-identification study of the minke whale;
- Dive times of the minke whale;
- The collection of effort and environmental data;
- Monitoring of a juvenile humpback whale in the Clyde Estuary, near Glasgow.

The International Fund for Animal Welfare (IFAW) is thanked for helping to fund HWDT 's research.

SIGHTINGS FREQUENCY AND DISTRIBUTION OF CETACEANS IN SHETLAND WATERS

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INTRODUCTION The waters surrounding the Shetland Islands are one of the richest in the whole of Europe for whales and dolphins, with 21 species recorded in the region, sixteen in the last few years (Evans, 1994). Between 1991 and 1994, a project funded jointly by the WWF-UK, the Shetland Amenity Trust, and Scottish Natural Heritage was conducted on the harbour porpoise, to study its ecological distribution in Shetland, and interactions with potential food fishes to assess the role of changes in various fish stocks in porpoise population declines (see Evans & Borges, 1996; Evans, 1996). In the course of those studies, it became clear that some localities were favoured by various cetacean species. Identifying these areas and determining the ecological factors that determine their importance to cetaceans would be valuable not only for coastal management and conservation purposes, but also for the potential development of a cetacean watching industry.

METHODS Over the 13-week field season (from mid-June to mid-Sept 1995), the coastline of Shetland (including islands of Unst, Yell, Fetlar, Whalsay and Bressay) were visited to identify key locations where the public could readily observe cetaceans. Altogether, 400 h of standardised (sea state of two or less) timed, land-based watches were carried out at a total of nineteen sites. This was supplemented by 80 h of offshore vessel-based surveys incorporating pre-determined tracks. Fourteen boat transects were conducted from Lerwick, to sample the following five areas: Whalsay and Out Skerries; South-east coast to Sumburgh Head via Mousa Sound; c. 30 miles east of Noss (a fishing bank where whales and dolphins have commonly been reported by fishermen); east coast to north end of Yell Sound; and north-east coast to Colgrave and Bluemull Sounds. Visits were also made by ferry to Fair Isle, Papa Stour, and Out Skerries.

Coastal localities identified as of likely importance for cetaceans were monitored over the entire field season from mid-June to mid-September. Survey methodology followed that developed during the Shetland porpoise study, with use of both visual and acoustic techniques to detect cetaceans. From the land-based watches and offshore boat surveys, encounter rates (per 100 min. of observation) through the summer were calculated for different locations (see Table 1). Watches only commenced when sea conditions were two or less, and ranged from 100 min. to six hours duration, though the great majority lasted either three or six hours (i.e. half a tidal cycle).

A total of 400 h of standardised timed, land-based watches were carried out at 17 sites around the mainland and smaller isles of Shetland, and including Sumburgh Head, North Voe (Boddam), Quendale Bay, St. Ninians, Mousa Sound, Hamnavoe, Fedaland, Lunna Ness, Melby, Hillswick, Skaw (Whalsay), Marrister (Whalsay), Isbister (Whalsay), Ness of Sound (Yell), Head of Brough (Yell), Tresta (Fetlar), and Funzie Bay (Fetlar) (Fig. 1). Although some sites were visited once or twice, ten sites were visited 5-12 times between June and Sept. Effort per site ranged from 3-38 h watching.

RESULTS Over the study period, a total of nine cetacean species were observed (in descending order of sightings frequency): harbour porpoise, minke whale, white-beaked dolphin, killer whale, Atlantic white-sided dolphin, Risso's dolphin, common dolphin, long-finned pilot whale, and humpback whale. Harbour porpoise was recorded in greatest numbers, followed by white-beaked dolphin, Atlantic white-sided dolphin, minke whale, killer whale, Risso's dolphin, common dolphin, long-finned pilot whale and humpback whale.

Harbour porpoises were the most widely distributed species. They have formed the subject of a special study since 1990, the results of which have been summarised elsewhere (Evans, 1996; Evans & Borges, 1996). Harbour porpoise numbers generally increased during the summer, reaching a peak in August or September, and supporting previous findings from watches at 50 sites distributed around Shetland (Evans, 1995, 1996). For harbour porpoises, the highest encounter rates occurred at Skaw (Whalsay), in Noss Sound, in Mousa Sound, around St Ninian's Isle and in Quendale Bay (Table 1).

For other cetacean species, sightings reported in 1993-95 indicate that although cetaceans can be seen in many parts of Shetland, species distributions tend to be aggregated into three principal areas: inshore waters around Sumburgh Head; the waters surrounding Mousa; and the area of sea between Whalsay and Out Skerries. Furthermore, the island ferries between Shetland mainland and Fair Isle, and between Shetland mainland and Whalsay/Out Skerries are also regularly productive, with sightings of several species of cetaceans. Status reviews for those species (except harbour porpoise) recorded during the project, and including records from 1993 and 1994, are given below:

Minke whale *Balaenoptera acutorostrata* This species was recorded mainly close to the east and south coasts of Shetland. Fifty-one out of 82 sightings (i.e. 62%) were made either off Sumburgh Head or in the vicinity of Whalsay and Out Skerries. Other popular haunts were in the vicinity of Noss and Mousa, with a combined total of 16 sightings. At least 49 sightings were additionally made from the MV "Good Shepherd" between Shetland and Fair Isle, particularly within 10 nm of Sumburgh Head. Eighty-four of 131 sightings (64%) comprised single animals, maximum group size being 6-12 indivs off Sumburgh Head on 26 and 27 June 1995. Sightings occurred in all months except Jan and Nov, but the great majority (94%) were between June and Sept (27 in June, 48 in July, 29 in August, and 19 in Sept).

Humpback whale *Megaptera novaeangliae* One to two (possibly up to three) individuals have been seen on 21 occasions between 26 June 1992 and 13 July 1995, all but five being from Sumburgh Head. The earliest sighting was on the 11 May and the latest on 16 Sept, with most sightings in the months of June and July. At least one animal has been individually recognised in four consecutive years by the white mark along the dorsal surface of the fin and white along the back just behind the fin. Besides the records from the vicinity of Sumburgh Head, the species has also been seen east of Fair Isle, in Mousa Sound, and east of Fetlar. It has been seen repeatedly breaching clear of the water, and also observed close inshore rubbing against rocks at Sumburgh Head.

Killer whale *Orcinus orca* There have been 94 sightings of killer whales in Shetland coastal waters between 1993-95. Group size has varied from single individuals to pods of 8-12 whales (including up to three adult males). Sightings around Shetland have occurred between April and Dec, but with the great majority of records (71 out of 94, or 76%) between May and July (6 sightings in May, 33 in June, 32 in July). Although killer whales have been seen all round Shetland, particular areas appear to be favoured in different years: In 1993, there were eight separate sightings between Mousa and Sumburgh Head from 30 June to 17 Sept. In 1994, nine sightings occurred in Yell Sound between 22 May and 28 July, 14 sightings in Bluemull and Colgrave Sounds between 19 April and 13 Sept (but mainly up to 29 July), but only two sightings between Mousa and Sumburgh Head. In 1995, killer whales reappeared along the south coast with five sightings between Levenwick and Sumburgh Head from 16 June to 10 Sept.

Long-finned pilot whale *Globicephala melas* The long-finned pilot whale is normally a pelagic species, a herd of about 100 individuals being seen 30 miles north-west of Foula on 20 Feb 1994, single individuals in Bluemull Sound on 27 May and 9 Oct 1994, and about ten at Burra Haaf on 29 Aug 1994. In 1995, one to two animals swam right up Olna Firth on 3 Aug and remained there until at least 15 Aug.

Atlantic white-sided dolphin *Lagenorhynchus acutus* Another pelagic species, the white-sided dolphin occasionally occurs close to the Shetland coast. Since 1993, there have been 12 sightings around Shetland or south to Fair Isle. Six of these have occurred off South Shetland, mainly off Sumburgh Head or in the Fair Isle Channel. All sightings have been between June and Sept, but with the majority (8/12, or 67%) during August. Group sizes have varied from 2-500+ indivs, the latter being seen on 27 June 1995 off Sumburgh Head. In 1993, two groups of 50 were seen near Haroldswick, Unst on 18 July, and in Mid Yell Voe on 23 July.

White-beaked dolphin *Lagenorhynchus albirostris* Although formerly one of the most frequently recorded species of cetaceans in Shetland waters, the number of sightings since 1993 has been relatively low, with 38 records around Shetland between March and Sept, and an additional 33 from the MV "Good Shepherd" between Shetland and Fair Isle between Jan and Oct. Most records (57/71, or 80%)) occur in July (8), Aug (35) or Sept (14). Group sizes vary from single animals to groups of 50-100 indivs. At least 80 were seen 7 nm south-west of Sumburgh on 29 July 1995, 50-100 east of Whalsay on 18 Aug 1995, and 60-100 off Sumburgh Head on 16 June 1994.

Common dolphin *Delphinus delphis* A rare species in Shetland waters, occurring in greatest numbers off SW Britain and Ireland. In 1993, three entered Mavis Grind on 20 September and one remained there until at least 27 December.

Risso's dolphin *Grampus griseus* A comparatively scarce dolphin, this species has been sighted on 14 occasions around Shetland, or south to Fair Isle, with group sizes varying from 1-15 indivs. Most sightings have been on the east coast, with half the records between Whalsay and Hermaness. All sightings have occurred between July and Oct, with the majority (8/14, or 57%) in August.

CONCLUSIONS Cetaceans occur regularly enough during the summer months to support a small-scale whale- and dolphin-watching industry in Shetland coastal waters. Shetland offers one of the best locations in the United Kingdom for seeing harbour porpoises, with several cliff sites affording excellent land-based vantage points. Between the months of June and September, the keen watcher may see between six and ten different species of cetacean, and most of these can be seen either from land or the inter-island ferries. Sumburgh Head is currently probably the best watching point although other excellent sites exist - the waters between Whalsay and Out Skerries, Noss and Bressay and Mousa and Shetland mainland amongst others. With increased observation effort in some of the more remote Shetland locations (such as Hermaness on Unst, and Out Skerries), it is likely that the list of good watching sites will be enlarged.

Boat trips around Whalsay and Out Skerries were consistently rewarding, with concentrations of harbour porpoises and small aggregations of minke whales in these waters, and occasional sightings of killer whales, white-beaked, Atlantic white-sided and Risso's dolphins. White-beaked dolphins and minke whales were also encountered regularly along the ferry route between Sumburgh Head and Fair Isle, and there were occasional sightings of groups of Atlantic white-sided dolphins, killer whales and Risso's dolphins. From land, Sumburgh Head is the best vantage point for visitors wishing to see a variety of cetaceans. During the dedicated watches in summer 1995, harbour porpoises, minke, killer and humpback whales were all sighted from this location. Incidental sightings of Atlantic white-sided dolphins, white-beaked dolphins, and Risso's dolphins also were made.

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Table 1 Encounter Rates (nos/100 mins observ.) for cetacean species at 17 land-based sites around Shetland

Land-based Site	No. hrs watched	Harbour Porpoise	White-bkd Dolphin	Minke Whale	Killer Whale	Humpback Whale	Total no. spp.
Tresta (Fetlar)	6.0	6.67	0.00	0.00	0.00	0.00	1
Funzie Bay	6.0	3.61	0.00	0.00	0.00	0.00	1
Brough (Yell)	6.0	6.94	0.56	0.00	0.00	0.00	2
Ness of Sound	6.0	0.00	0.00	0.00	0.00	0.00	0
Lunna Ness	18.0	1.28	0.00	0.00	0.00	0.00	1
Skaw (Whalsay)	26.0	28.2	0.00	0.00	0.00	0.00	1
Marrister	25.7	2.57	0.00	0.00	0.00	0.00	1
Noss Sound	27.0	12.9	0.00	0.12	0.00	0.00	2
Mousa Sound	35.7	30.3	0.24	0.14	0.00	0.00	3
North Voe	30.0	4.97	0.00	0.05	0.00	0.00	2
Sumb. Head	38.3	1.47	0.00	1.07	0.04	0.12	4
Quendale Bay	30.0	11.3	0.00	0.00	0.00	0.00	1
St Ninian's	37.7	15.3	0.00	0.00	0.00	0.00	1
Hamnavoe	32.0	2.80	0.26	0.00	0.00	0.00	2
Papa Stour	6.0	0.47	0.00	0.00	0.00	0.00	1
Hillswick	18.0	0.82	0.00	0.00	0.00	0.00	1
Fedaland	15.0	8.33	0.00	0.00	0.00	0.00	1

Note: The cetacean species list recorded at a particular site is not exhaustive; it refers to those noted during timed watches.

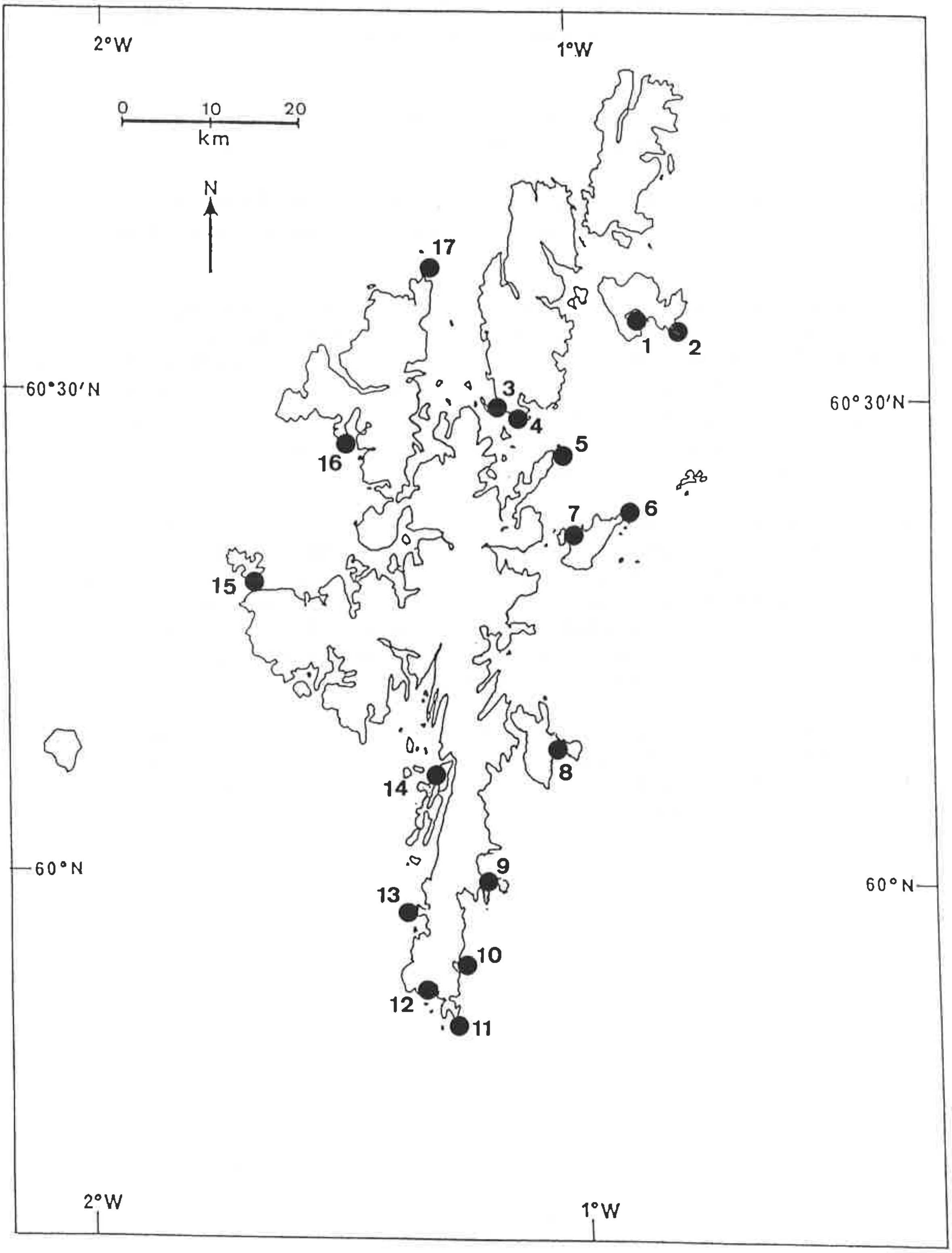

Fig. 1 Map showing seventeen land-based coastal sites systematically watched and offshore transects undertaken during summer 1995

1	Tresta (Fetlar)	7	Marrister	13	St Ninian's
2	Funzie Bay (Fetlar)	8	Noss Sound	14	Hamnavoe
3	Brough (Yell)	9	Mousa Sound	15	Papa Stour
4	Ness of Sound	10	North Voe	16	Hillswick
5	Lunna Ness	11	Sumburgh Head	17	Fedaland
6	Skaw (Whalsay)	12	Quendale Bay		

NASS-95 SURVEY: PRELIMINARY REPORT OF THE FAROESE CRUISE

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An account of the Faroese shipboard survey conducted during July-August 1995, as a contribution to the joint 1995 NASS survey, is presented. The Faroese survey was designed to estimate the abundance of pilot whales in the waters south and west of the Faroe Islands (5° W -18° W longitude, 65° N - 52° N latitude, and 18° W - 28° W longitude, 57°30' N - 52° N latitude), but sightings of all cetacean species were recorded. The whale survey was combined with a bird survey (Joint Nature Conservation Committee, Aberdeen).

The aim of the Faroese survey was to estimate the proportion of pilot whale schools detected on the transect, and the extent and direction of responsive movement. Special experiments were also conducted to accurately assess the size of the schools and the presence of "super schools" in the area of sightings. The procedure used was similar to that of the SCANS survey: trackers searching constantly through mounted binoculars plus independent primary observers searching with naked eyes, using passing mode,and delayed closure to confirm species and size of schools.

The species encountered most included Atlantic white-sided and common dolphins, northern bottlenose and long-finned pilot whales. The special procedure used for pilot whale sightings was successful in revealing the presence of other pilot whale schools in the vicinity of the initial sighting.

OBSERVATIONS OF CETACEANS IN THE RUSSIAN ARCTIC

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This work is based on data collected over several years involving air-ice reconnaissance, research expeditions, and inquest data. Most of the observations were conducted in the Chukchi and Barents Seas. As a rule, whales occur nearshore (within 100 km) in water that was free of ice, rarely among broken rarefied ice, and exceptionally in the solid ice zone within so-called "ice traps". Observations of single animals or small groups predominate over observations of groups of 6-100 whales.

Bowhead and gray whales migrating in April from the Bering Sea to the Chukchi Sea remain in ice-free water. In the beginning of the 1980's, small groups of bowhead whales from the Svalbard population were observed for the first time in the area of Franz-Josef Land. In those instances, bowheads were recorded in the Kara Sea near the western and northern shores of the Sevrnaya Zemlya archipelago. There are data showing that part of the population winters in the area of Severnaya Zemlya. Narwhals were seldom observed in the areas of Franz-Josef Land, Severnaya Zemlya, or the Novosibirsk Islands.

A FIN WHALE AND SPERM WHALE SIGHTING PROGRAMME UNDERTAKEN BY THE ITALIAN NAVY IN THE CENTRAL MEDITERRANEAN SEA

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INTRODUCTION Among the initiatives undertaken by the Italian Navy in favour of the conservation of the marine environment, launched within the framework of the European Nature Conservation Year (ENCY), an opportunistic cetacean sighting and listening programme was initiated in 1995 from a number of different available military platforms.

The programme was focused on the reporting of sightings of fin whales, *Balaenoptera physalus*, and sperm whales, *Physeter macrocephalus*, two cetacean species presently considered in need of special conservation attention in the Mediterranean (Notarbartolo di Sciara *et al.*, 1996; Notarbartolo di Sciara and Gordon, in press).

The preliminary results presented here demonstrate the importance and potential of such a programme, and provide the impetus for its longterm continuation and improvement.

MATERIALS AND METHODS Appropriate sighting sheets containing diagnostic information for the two target species, were prepared and distributed to 75 surface ships, eight submarines, helicopters, maritime patrol aircraft, and sailing vessels operating in the seas surrounding Italy (Central Mediterranean Sea), between Latitude 37° and 44° N, and Longitude 6° and 19° E. Sightings were performed between April and December, 1995.

The programme was initiated with a number of seminars organised in the principal Italian naval bases early in 1995, to enhance involvement in the programme of the Navy personnel, and to provide basic background on its objectives and methods.

Observations were conducted visually, and, when possible, by acoustic listening through sonobuoys, on-board passive listening systems, towed arrays (in co-operation with the *Centro Interdisciplinare di Bioacustica*, University of Pavia), and portable hydrophones.

RESULTS Six cetacean species were observed, for a total of 88 sightings (Table 1). As expected, because of the pre-defined aims of the programme, most observations (77.3%) were of fin and sperm whales.

Among the target species, 46 were fin whales (67.6%) and 20 (32.4%) sperm whales. Most sightings were visual.

One group of three fin whales was spotted on sonar by a helicopter before being seen, and two sperm whale groups were heard before being sighted. The distribution of sightings is shown in Fig. 1 (fin whales) and Fig. 2 (sperm whales). Overall, cetacean sightings were more frequent in the seas west of Italy than to the east. Fin whales were found scattered throughout the southern Tyrrhenian Sea in the early months of the programme (until 31 May), while during summer they tended to concentrate in the northwestern region (Fig. 1). This is in good agreement with the known movement pattern of this species in the Mediterranean, which congregates to feed during summer in the Corsican-Ligurian Basin (Notarbartolo di Sciara, 1994). By contrast, sperm whales seemed to be more evenly distributed throughout the area (Fig. 2). In the Strait of Messina, sperm whales where seen four times, and fin whales once, whereas no cetacean was sighted in the Sicily Channel and in the Malta Channel. Mean group size for fin whales was 2.1 (SD=1.39), and 1.9 (SD=1.88) for sperm whales; in both species, the largest group was of eight individuals. The eight sperm whales, of which four appeared to be calves and juveniles, were sighted from the air while engaging in a "daisy" formation, typical of the species but never documented in the Mediterranean Sea.

CONCLUSIONS The steady presence at sea of military craft throughout the year provides an excellent occasion for opportunistic cetacean sightings, which could greatly enhance centralised databases such as the one currently aintained for the Mediterranean Sea by the Marine Mammal Working Group of the *Commission Internationale pour l'Exploration Scientifique de la Méditerranée* (CIESM). A further necessary improvement which is being planned for future field phases, involves the estimation of sighting effort, to allow weighting of the observation data, and making them comparable across time and between different areas.

ACKNOWLEDGEMENTS We wish to thank all the personnel of the Italian Navy ships and aircraft who participated in the programme, and who contributed to these preliminary results with their dedication and interest. The co-operation of the *Centro Interdisciplinare di Bio-Acustica* of the University of Pavia is also acknowledged.

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Table 1. Summary of sightings

Species	no. sightings	no. indivs.	mean grp size	range
Balaenoptera physalus	46	96	2.1	1-8
Physeter macrocephalus	22	42	1.9	1-8
Stenella coeruleoalba	9	58	6.4	1-25
Grampus griseus	6	47	7.8	1-17
Delphinus delphis	1	10		
Orcinus orca	1	2		
undetermined	3	9		
Total	**88**	**264**		

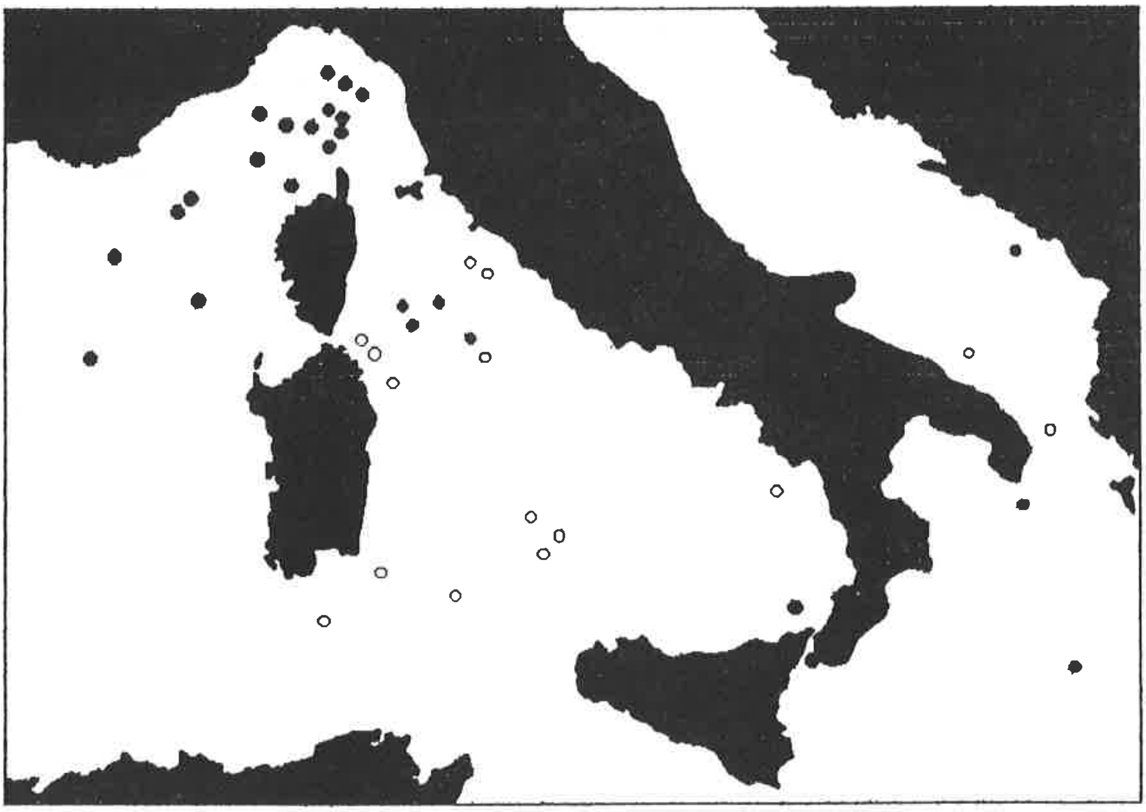

Fig. 1 Fin whale sightings. O = before or on 31 May. l = after 31 May

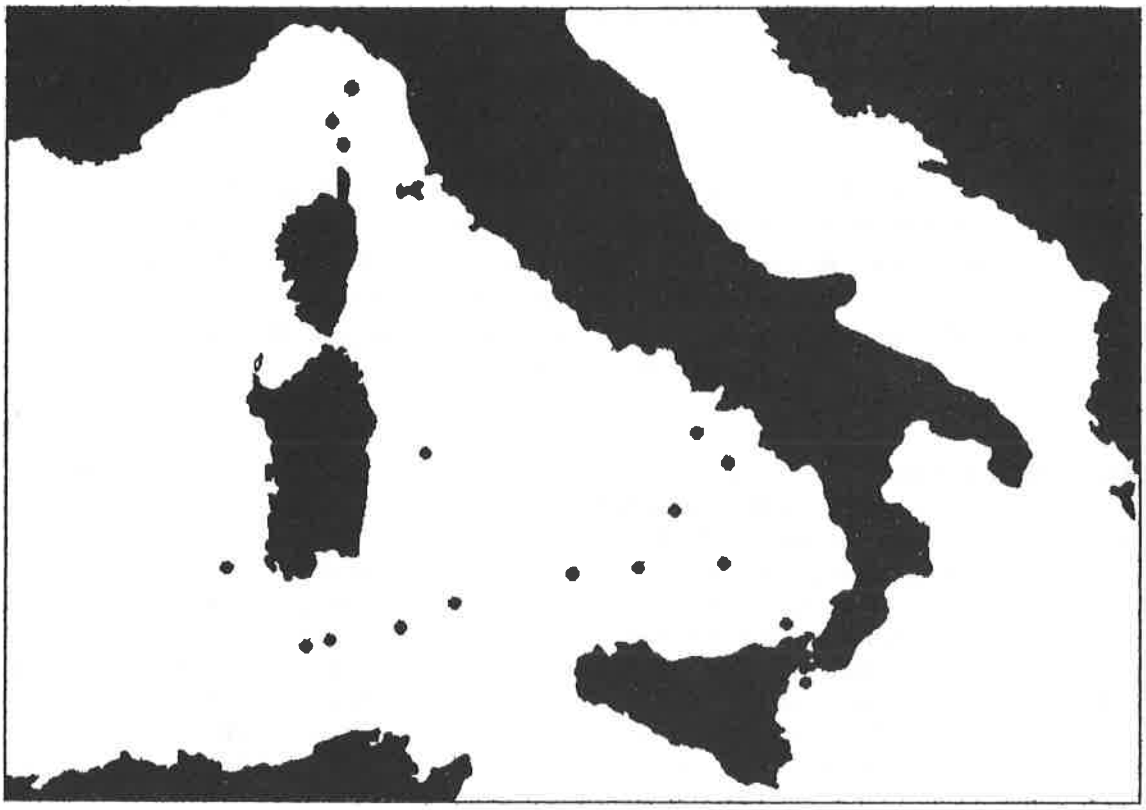

Fig. 2 Sperm whale sightings

ASSESSMENT OF RELATIVE ABUNDANCE AND DISTRIBUTION OF THE MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*) USING DATA COLLECTED FROM A WHALE WATCHING OPERATION

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INTRODUCTION A real time computerised database system (Logger, developed by Conservation Research Ltd) has been used to collect data during whale-watching trips from the island of Mull on the west coast of Scotland since 1992. All observations were made from the 12 m motor vessel *Alpha Beta*. The data collected included records of the number of observers on watch and their positions on the vessel, environmental conditions, and detailed records concerning each sighting. These data were used to investigate seasonal geographical trends in relative abundance of minke whales (*Balaenoptera acutorostrata*). The analytical methods were chosen such that similar methods could be applied to other whale-watching operations where such data are available. A secondary aim of the analysis was to investigate the effects of environmental conditions on the sighting probability of minke whales.

METHODS OF ANALYSIS The measure of effort was the distance travelled until the first sighting of a minke whale was made on any trip. Trips were defined as separate if the vessel returned to the base at Dervaig on Mull in between. This did not necessarily mean a change of crew, and sometimes more than one trip was made in a day. For trips where no minke whales were sighted, the total vessel effort was accumulated until a sighting was made on a subsequent trip. This method provided data in the form of total kilometres searched for each initial sighting on a trip, resulting in a total searching effort of 22,520 km. The numbers and locations of observers 'on-watch' were sufficiently consistent that inter-observer variation was more significant than numbers of observers.

The relative effects of environmental conditions on overall sighting rates were investigated by dividing the total number of sightings made in each environmental category condition by the total searching effort under each condition. A correction was applied to these effort measures to compensate for the low whale density close to the base.

Of the environmental variables examined (sea-state, swell height, cloud cover and visibility) only sea-state (Fig. 1) and swell height (Fig. 2) had a significant effect on sightings rates. Sea-state had a similar effect on sighting rates to that observed from other studies (see, for example, Northridge *et al.*, 1995). A model for sighting rates for combined sea-state and swell height conditions which used the relative rates multiplied by eachother gave a good fit to the data. This model was used to adjust vessel effort in kilometres travelled, to allow for the relative probability of a sighting under the given sea state and swell height conditions (referred to as effort index).

The study area was divided into areas by range times and sectors. The study period was also divided into years (1993-95) and time of season (April-May, June-July, August-September). Sighting rates for each sector in each time period were calculated from the number of initial sightings divided by the effort index. Analyses were performed on sectors with greater than 2% of the total effort index (Expected number of sightings >5).

RESULTS Whale distributions changed significantly between time of season, and these trends were generally consistent between years with no obvious trends over the three-year period. Whales were frequently found early in the season around the entrance to the Sound of Mull, but numbers decreased and densities were very low by August-September. In June-July, whales were more evenly dispersed over a larger region with similar densities to those found at the entrance to the Sound of Mull in April-May. This suggests that more whales entered the region. The highest densities were in August-September in the area north of Ardnamurchan, densities between Coll and Mull were much lower at this time, but the area around the Treshnish Isles to the south also showed an increase.

Whales were usually found singly, and the occurrence of groups was sufficiently rare to have a minor effect on estimates of relative abundance when just the first sighting was considered. There were no significant trends in the numbers of whales observed in groups.

DISCUSSION The Logger program has demonstrated the value of collecting data directly to a computer. This has enabled large quantities of data to be efficiently collected and analysed. For such results to be of use, it is important to consider the study area in relation to adjacent waters.

Quantifying effort is one of the main problems in using opportunistic data to estimate relative abundance. Several possible measures of effort were considered, such as using time rather than distance travelled, or including all searching effort. The method chosen gave the most consistent relationships between sighting rates and environmental conditions. If whales are evenly distributed within each subdivision of the study area, this method gives an unbiased estimate of density relative to observations made from a vessel following a fixed trackline. For clumped distributions, the method results in negatively biased estimates of relative density. However, if particular locations consistently have higher densities, this may result in a positive bias because prior knowledge allows the whales to be found with less searching effort. One method of investigating the extent of clumping is to examine the distribution of distances between successive sightings. For this analysis, sighting locations within a subdivision were defined as 'clumped' if the upper limit of the 95% confidence interval for the distance between successive sightings was less than would be expected from a random distribution. When divisions of 4-km squares were used, only 3% showed clumping, but the effort index within most of these squares was not sufficient to allow valid comparison of sighting rates over time. Hence, the sector system which allowed reasonable sample sizes was used to calculate relative sighting rates for comparison within seasons and between years, but may be subject to biases due to uneven whale distribution.

There is no evidence from the study to indicate that whale densities within the study area are any higher than those in adjacent areas. In fact, the highest densities occur towards the limits of the study area in June-July and August-September. The Hebrides are one of the most important areas for minke whales in British waters (Hammond *et al.*, 1995), and minke whales are known to be present throughout the Sea of the Hebrides. Similar seasonal trends in abundance have been observed in this larger area with few animals in winter and maximum numbers in late summer (Northridge *et al.*, 1995). It is not known whether numbers of whales in the study area are an indication of overall numbers in Hebridean waters, or whether small overall fluctuations in distribution might cause relatively large changes within the area studied.

The whale watching trips from Mull by Sea Life Surveys are ongoing, and the information will become of increasing value as data from each season give a longer time series for analysis.

ACKNOWLEDGEMENTS Funding for the development of Logger and for this analysis came from the International Fund for Animal Welfare.

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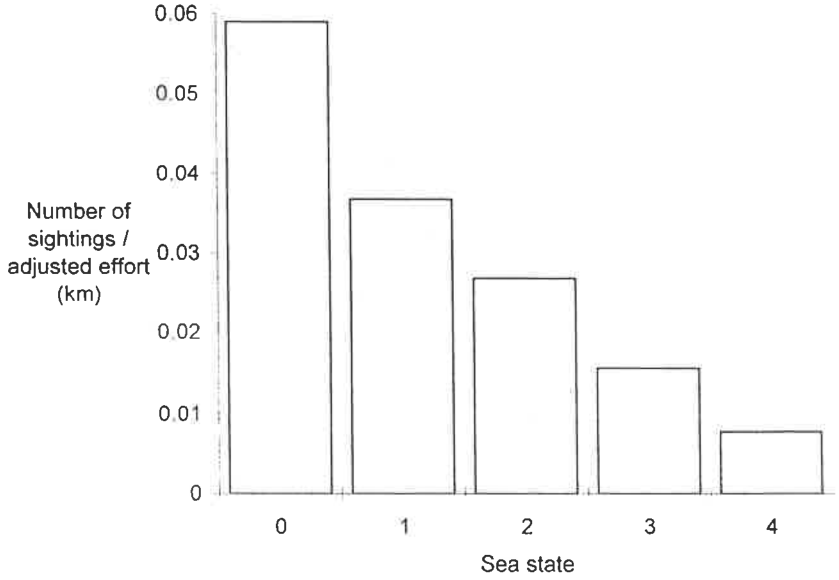

Fig. 1 Relative sighting rates for sea-state categories

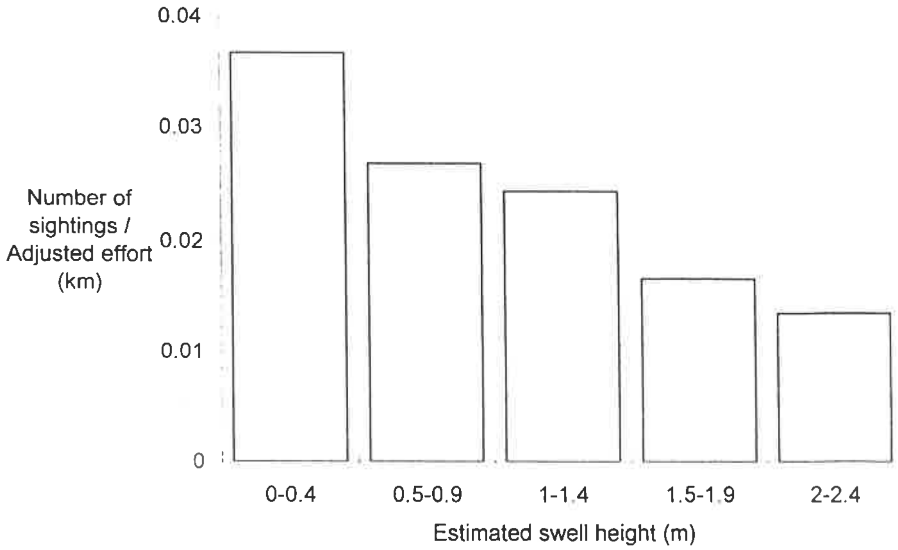

Fig. 2 Relative sightings rates for swell height categories

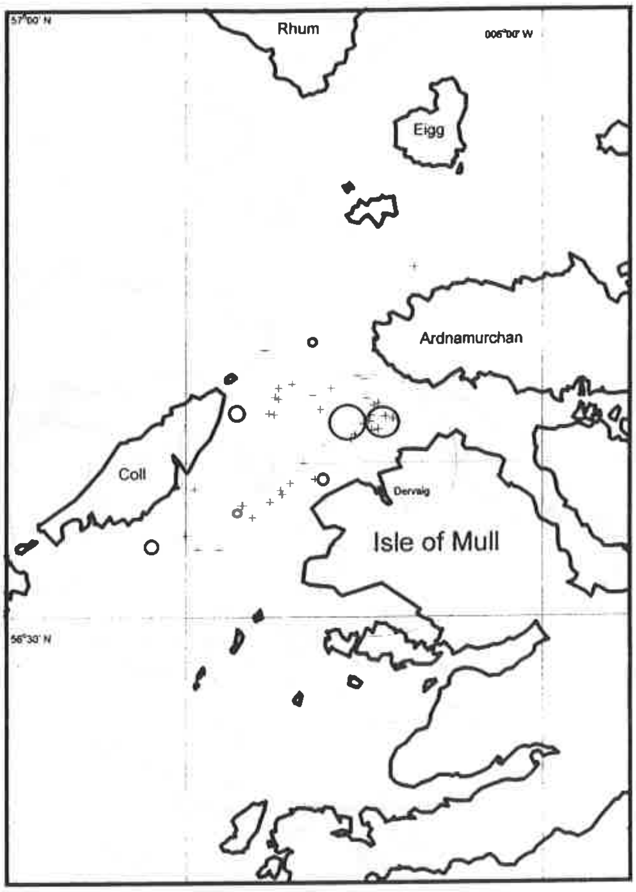

Fig. 3a Sightings and relative densities of minke whales: April - May

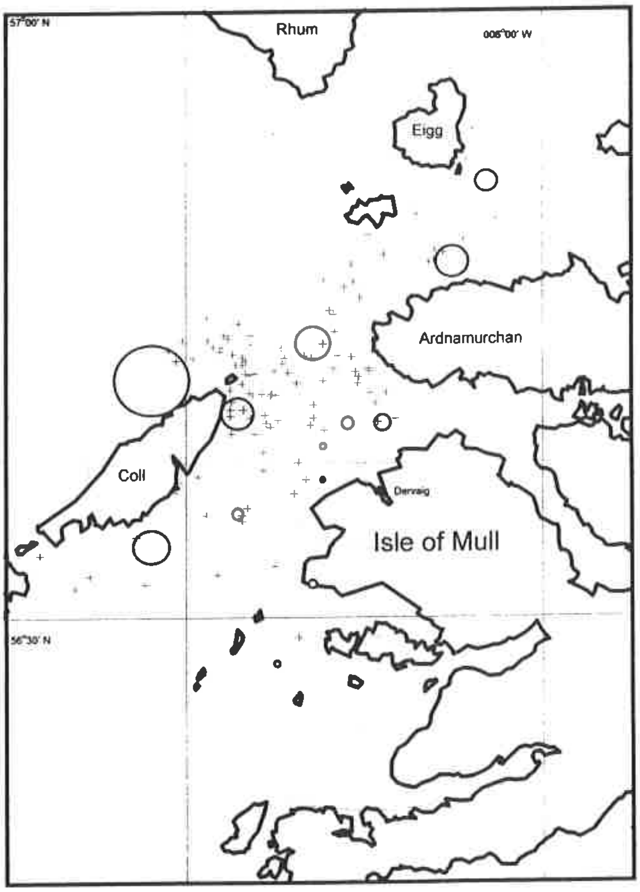

Fig. 3b Sightings and relative densities of minke whales: June - July

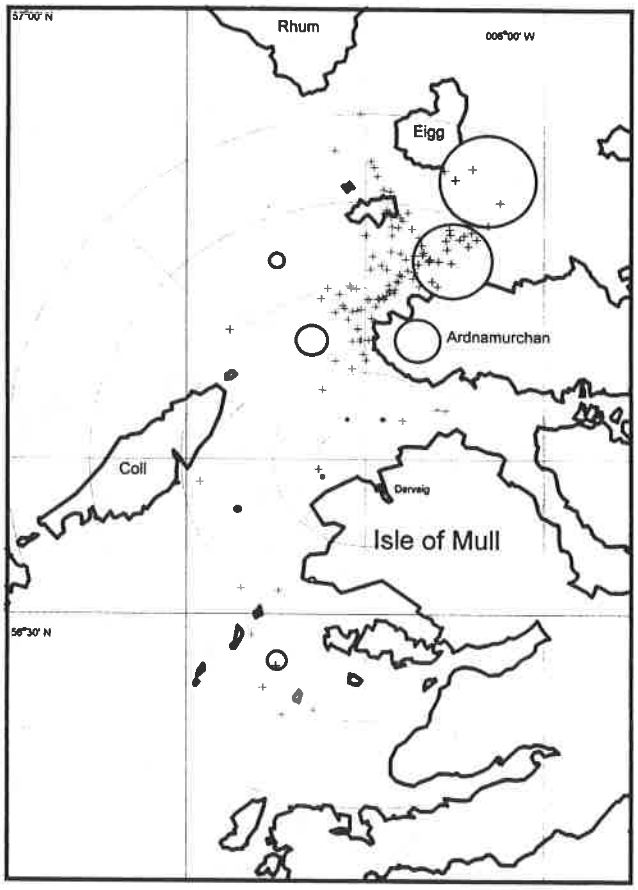

Fig. 3c Sightings and relative densities of minke whales: August - September

SITE FIDELITY, MOVEMENT PATTERN AND SEASONAL MIGRATION OF DOLPHINS IN THE PERUVIAN AMAZON

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Site fidelity, seasonal migration, activity and daily movement patterns of the boto *Inia geoffrensis* and tucuxi *Sotalia fluviatilis* were studied between October 1994 and September 1995 in the black water river systems of Río Samiria and Río Tapiche in Peru. The Río Samiria is part of the second largest nature reserve in the Amazon: the Pacaya-Samiria National Reserve, where the Río Tapiche just outside of the reserve is under strong human influence due to the 25,000 people, who are living on and from the river in the town of Requena and in a further 13 villages.

METHODS The 18 metre wooden river houseboat "Miron Lento", powered by a 24 horsepower inboard diesel engine, and the 6.5 m aluminum boat "Miron de Bufeo", powered by a 65 horsepower outboard engine, were our observation platforms.

We used focal animal observations - up to 14 hours, to study activity and daily movement patterns. Due to the light conditions, the observations were limited to the time between 05:30 h. in the morning and 19:30 h. in the evening.

We followed a single dolphin or a dolphin which was easy to recognise by size, natural marks, or pigmentation pattern within a small group (maximum group size of three animals). The chosen dolphin was observed as long as possible from a distance where no influence of our boat towards the behaviour of the dolphin was recognisable: a distance of at least 100 metres. Every ten minutes (due to the long dive times), the behaviour, travel type, and travel distance measured with GPS was noted. The ten-minute behaviour units were interrupted by a 30-sec. break.

We classified four different travel types:

- "floating": dolphin: travelling downriver at more or less the speed of the current, showing very low surfacing pattern, and with very little movement of the fluke;
- "normal speed": travelling orientated either up- or downriver, and the surfacing pattern occurring at regular time intervals with almost constant movement of the fluke;
- "running": high surfacing with splashes and rapid movement of the fluke;
- "travel-feeding": dolphin moving in one direction, and interrupted often by bouts of foraging and hunting.

Site fidelity and seasonal migration were studied by photo-identification. Natural marks including nicks, scars, and pigmentation pattern were used for identification (Leatherwood *et al.*, 1991; Trujillo, 1994).

RESULTS Boto and tucuxi have different movement patterns (see Fig. 1). The boto floats down river for more than 40% of its travel time, and very rarely moves at a greater speed (only 1.8% of the travel time). Tucuxi, on the other hand, almost never floats, instead swimming for more than 50% of its travel time at a "normal" speed, and rarely (5.6 %) very fast. It is common for both species whilst travelling to also look for food and take the opportunity to hunt for fish. This we have called "travel-feeding". The boto engages in this activity does for 20.7% of its travel time, and tucuxi for 41.5% of its travel time.

We observed diurnal movements of up to 60 kilometres in both species, along which a river section of up to 44 kilometres was used regularly (Fig. 2).

We found that the range of those animals which we re-sighted most often, was about 100 km. One boto has been re-sighted more than ten times since 1992, and always in the same 100 km section of the Samiria river.

Migration of the dolphins is strongly correlated with the water cycle ,and to migration of fish. Boto migrate during the rainy season upriver into side streams, lakes, and the flooded forest, and then retrace their route during the dry season (Best and da Silva, 1989). Tucuxi does the same, but does not go so far upriver, and normaly does not enter smaller tributaries or the flooded forest.

DISCUSSION Fast swimming ("running") rarely seems to be necessary for either the boto or tucuxi. A reason for this could be that these animals have no natural predators, and that at least in our study site, the prey is so abundant and/or easy to catch.

The movement pattern also indicates that the two dolphin species have different foraging strategies. Tucuxi is the more active swimmer, and seems to take almost every opportunity to hunt. The boto is more passive, and quite often simply floats with the current downriver.

Some botos were seen every year in our study site. This was also found by Martin and da Silva (this volume) in their study site in the Mamirauá Reserve in Brazil. The dolphins always used the same sections of the rivers. Thus it is possible that at least some dolphins have stable home ranges.

On the other hand, no "new" dolphins entered or left the study site during the entire time of the study. This occurrence, together with a sighting of one boto which was radio-tracked and marked by Vera da Silva and Tony Martin near Tefé, nearly 2,000 km downriver in Brazil, showed that long-distance migration of dolphins also exists in the Amazon.

Our findings also suggest that we have the same distribution pattern in the Amazon as is known for some other marine dolphins, for example orcas (Balcomb *et al.*, 1982) and bottlenose dolphins (Wells *et al.*, 1987; Henningsen, 1991): a resident population with a more or less well-defined range, and a larger number of transients.

ACKNOWLEDGEMENTS We acknowledge the help, advice and patience of Prof. Bernd Würsig, Prof. Gotthilf Hempel, and Steve Leatherwood, and the financial support of Artists For Nature, Munich, Germany and the Deutsche Forschungsgemeinschaft (German National Foundation of Science).

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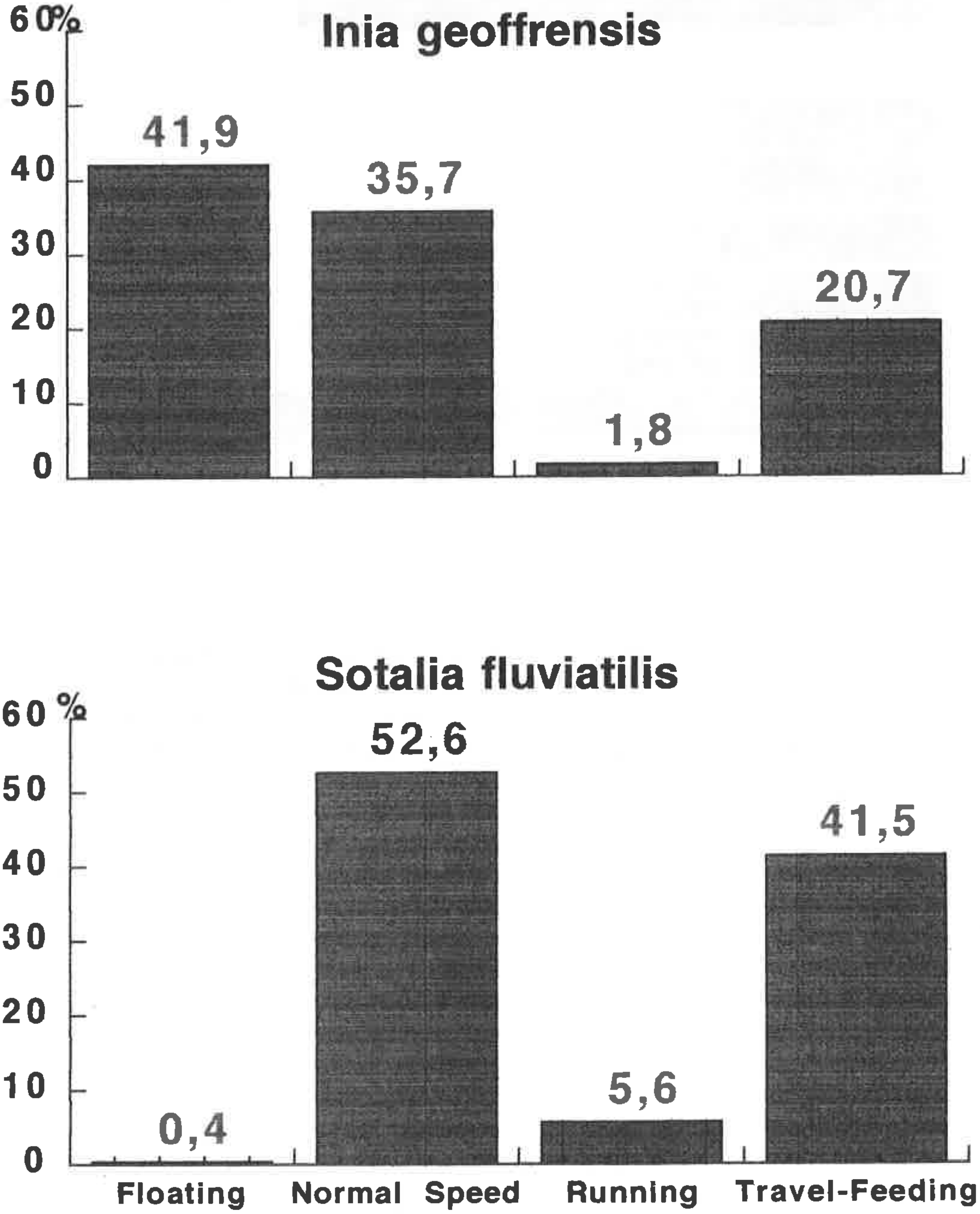

Fig.1 Travel types of *Inia geoffrensis* and *Sotalia fluviatilis* in 1994/95 in the Blackwater river systems of Río Samiria and Río Tapiche in the Peruvian Amazon

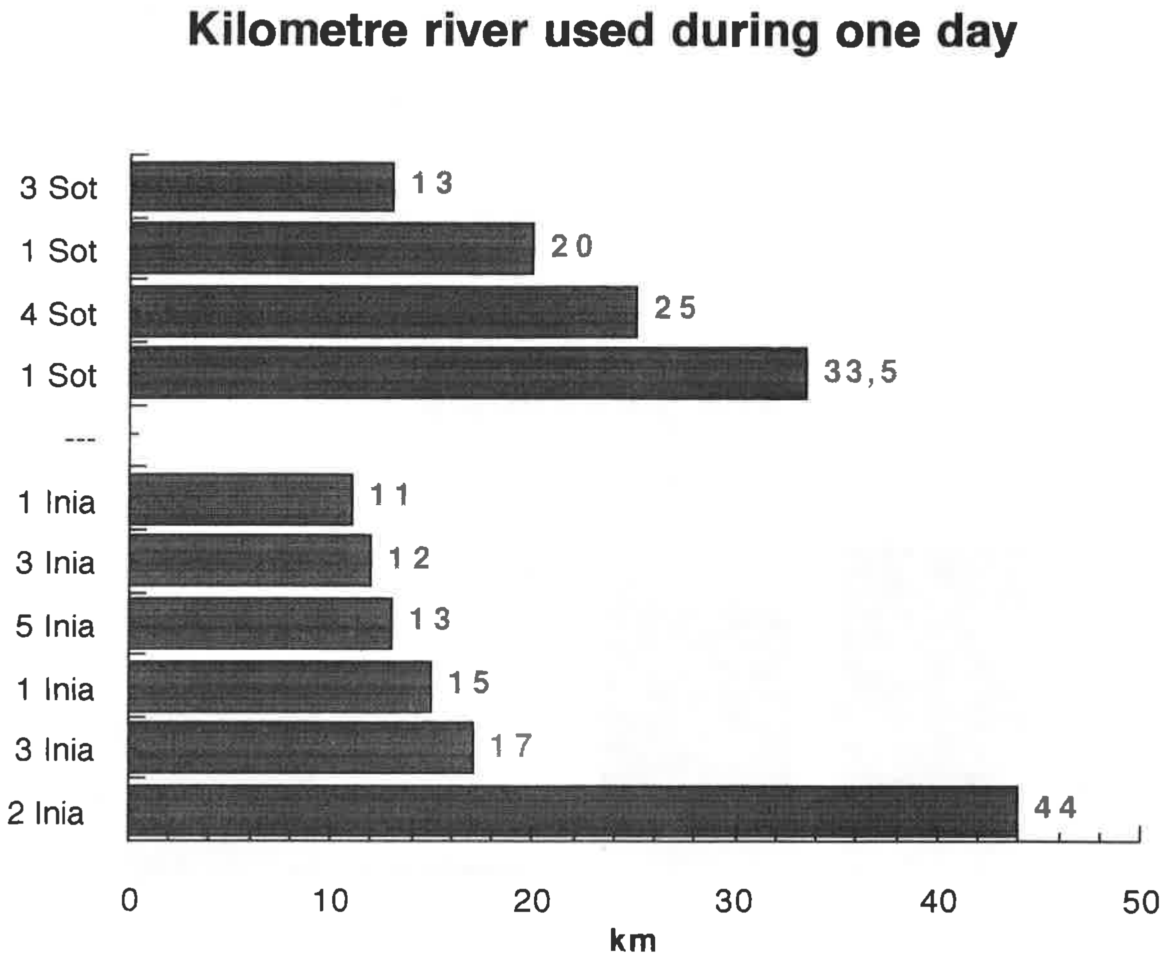

Fig. 2 Amount of river (in kilometre) used in 10 hours during daylight by different travelling groups of *Sotalia fluviatilis* and *Inia geoffrensis* in 1994/95 in the Blackwater river systems of Río Samiria and Río Tapiche in the Peruvian Amazon. (The Y-axis indicates species and group size)

COHERENCE BETWEEN SMALL-SCALE MOVEMENTS AND FEEDING SUCCESS OF SPERM WHALES IN THE SOUTH PACIFIC

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INTRODUCTION Sperm whales (*Physeter macrocephalus*) spend about 80% of their time at depths exceeding 400 metres, foraging mainly on meso- and bathypelagic cephalopods. Because of the ability of these deep-living squid to escape trawls and nets (Clarke, 1985), and because of the difficulty of observing them using acoustic methods (Starr and Thorne, in press), very little is known about the ecology, distribution, and patch sizes of the main prey species of sperm whales. The understanding of habitat utilisation by an animal is central to the study of its ecology. However, when direct observations of an animal feeding are not possible, habitat utilisation may be inferred from its feeding success. Whitehead *et al.* (1989), Smith and Whitehead (1993), and Whitehead (in press) have shown that the defaecation rate of a group of sperm whales (a measure which can easily be recorded in the field) gives valid indication of their feeding success. If the small-scale movement patterns of groups of whales are correlated with feeding success, it is then likely that the extent of a group's movements gives an indication of the size of a patch of prey, and on the distances between the patches.

The goals of this study are to examine the small-scale movements of groups of sperm whales, and to relate them to feeding success, to determine the probable size of prey patches and the distances between them, and finally to investigate foraging behaviour.

METHODS Data were collected from a 12.5m, ocean-going cutter during a survey around the South Pacific in 1992-1993. Groups of sperm whales were followed closely over periods of eight hours to 2.5 days. For each group which was followed for more than eight consecutive hours, the means of all the variables listed in Table 1 were calculated during the period that the group was followed. To investigate the relationship between the feeding success and the small-scale movement of a group, a Spearman coefficient of correlation was calculated between *zigzag* and *feedsucc* . The spatial and temporal scales of sperm whale movements were investigated by calculating for each group, the mean straight-line distance travelled in any three hours, then the mean straight-line distance travelled in any six hours, and so on until the total length of time a group was followed had been covered (maximum = 66 h.). For each group, the mean straight-line distance travelled over time intervals from three to 66 hours was then plotted against the time interval in hours. If a group is moving back and forth over a certain area, the mean straight-line distance covered by the group in any time interval cannot be larger than the largest diameter of the area. On the other hand, if a group is moving in a straight-line, the straight-line distance covered by the group will keep increasing with increasing time intervals. These small-scale movements were then related to feeding success.

Differences in foraging behaviour between groups of sperm whales having a high feeding success and groups having a low feeding success, were investigated by correlation analyses. Spearman coefficients of correlation were calculated between *meanspeed* and *feedsucc*, between *meanspeed* and *zigzag*, between *timefeed* and *feedsucc*, and between *timefeed* and *zigzag*.

RESULTS AND DISCUSSION Eighteen groups of female and immature sperm whales were followed for more than eight hours, the maximum was 67 hours and the mean was 32 hours. The summary statistics of the measurements of all the variables recorded while following groups are presented in Table 2. Feeding success was significantly correlated with *zigzag* index (r_S=0.729, p<0.05), suggesting that sperm whales are feeding more when they are going back and forth over an area than when they are moving in a straight line.

For each group, the mean straight-line distance travelled during periods of 3 to 66 h. is plotted on Fig.1. Fig 1a shows that, when the feeding success was low (<0.06 defecations/fluke-up), sperm whales tended to travel in a rather straight line without zigzagging, as indicated by the straight-line relationship between distance moved and time interval. The slope of these relationships is very similar among all these groups, suggesting a very similar mode of travel. None of the curves reaches an asymptote, indicating that none of the groups started backtracking while being followed. Therefore, since these groups travelled between 100 and 240 km, this suggests that the distance between "good quality" prey patches is in the order of at least 100 km. Fig. 1c show the relationship between distance travelled and time intervals for the groups having a high feeding success (>0.11 defaecations/fluke-up). For three of the groups (#11, #72, #73), the curves levelled after 28 to 45 km, suggesting that the groups are moving back and forth over an area with a maximum span of 45 km. Since these groups have a high feeding success, it is likely that these areas correspond to patches of prey. The curve describing the movement of group #11, which was followed for a longer period of time than #72 and #73, further indicated that the entire prey patch may have been moving at a mean speed of 1.5 km/h. Group #59 showed the same behaviour as the groups with low feeding success, suggesting exceptions to the general rule of zigzagging with high feeding success, and straight-line movement with low feeding success. The curves representing the groups with moderate feeding success (between 0.06 and 0.08 defaecations/fluke-up) are found in between the ones representing groups with low feeding success and the ones representing groups with high feeding success (Fig. 1b), suggesting a continuity in foraging behaviour.

There were no significant differences in foraging behaviour between groups that were travelling in a straight-line and the groups that were zigzagging over an area roughly 30-50 km across. The mean speed through the water was very consistent among groups, and the coefficient of correlation between *meanspeed* and both *feedsucc* and *zigzag* were particularly low (r_S=0.1 and r_S=0.0 respectively). The coefficients of correlation between *timefeed* and both *feedsucc* and *zigzag* were not significant either (r_S=0.505; r_S=0.482). These results suggested that sperm whales continue foraging (maybe on solitary or well-dispersed squid) even while travelling between patches.

These results are very consistent with previous analyses on sperm whale spatial organisation (Jaquet and Whitehead, 1994). This previous work has shown that groups of sperm whales formed aggregations in which groups are about 18 to 37 km apart, and that these aggregations are usually separated by 150-300 km (Fig. 2). It seems, therefore, that the spatial scale of these aggregations corresponds to the size of patches of squid.

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Table 1 Description of the variables calculated for each group of whales

Variables	Description	Units
Meanspeed	Total distance travelled by a group while followed over the number of hours it was tracked	km/h
Straidis/12	Mean distance travelled in a straight-line during 12 hours	km
Realdis/12	Mean total distance travelled during 12 hours	km
Zigzag	Total distance travelled by a group between the position when first encountered and the position when left divided by the straight-line distance between these two positions	-
Timefeed	Proportion of daylight time during which most of the group is showing "foraging behaviour"	percentage
Feedsucc	Number of fluke ups with defecation divided by total number of fluke ups checked	-

Table 2 Summary of statistics for all variables recorded while following a group of sperm whales

Variable	N. of cases	Min.	Max.	Mean	S.D.	Units
Meanspeed	18	2.5	5.4	4.2	0.7	km/h
Straidis/12	16	13.6	48.9	54.7	12.9	km
Reeldis/12	16	29.6	64.8	50.3	9.0	km
Zigzag	18	1.05	3.7	1.68	0.80	-
Timefeed	13	11	90	58.65	26.77	%
Feedsuc	11	0	0.325	0.084	0.09	-

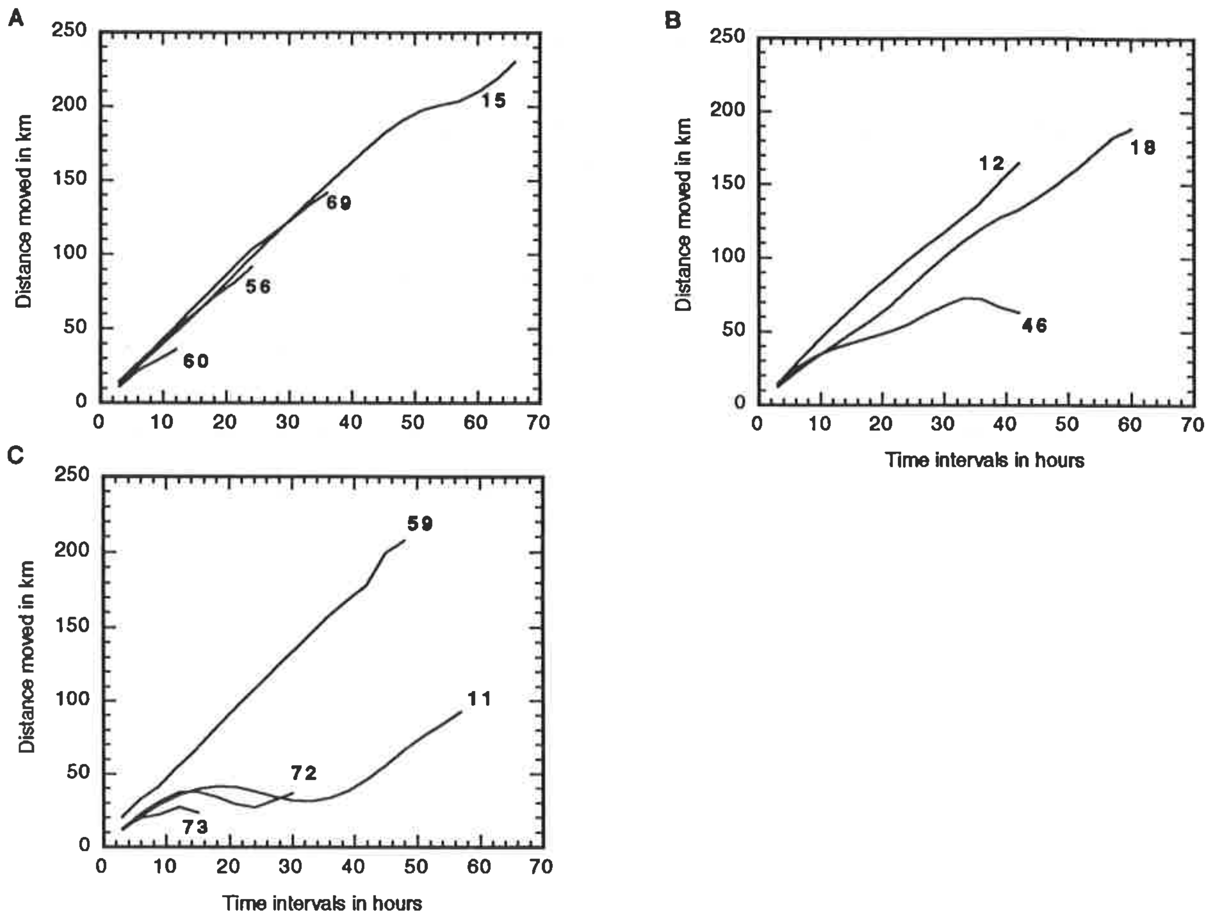

Fig. 1. Mean straight-line distance travelled by each sperm whale group versus time interval. (A) groups with low feeding success (0% - 5.4%); (B) groups with moderate feeding success (6.15 -8%); (C) groups with high feeding success (11.4% - 32.5%). The numbers at the end of each curve represent the identity number of the groups

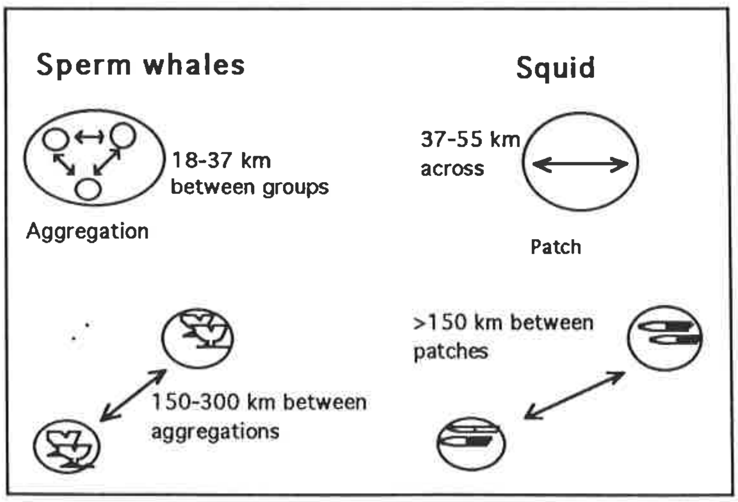

Fig. 2. Sperm whale spatial organisation versus probable squid patch sizes and distances between patches

SPERM WHALE STRANDINGS AROUND THE NORTH SEA: HISTORY AND PATTERNS

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Sperm whale strandings in the countries bordering the North Sea have been well documented since the end of the sixteenth century. All known strandings in this area have been summarised. There is no clear temporal pattern in the occurrence of sperm whales in the North Sea except that there are very few strandings between the late eighteenth and early twentieth century. All sperm whales of which details are known have been males, ranging between about 14 and 18 m in size. Most strandings occur during the period November to February. It seems likely that the majority of sperm whales enter the North Sea during their southward migration. If the animals do not find their way out in time, they become weakened and many will die at sea or become stranded. Multiple strandings occur in the southern part of the North Sea, in areas with vast expanses of sandbanks, mudflats or estuaries. The large gap in the occurrence of sperm whales in the North Sea from the late eighteenth until the early twentieth century is perhaps connected with whaling activities in the North Atlantic over the last centuries, which have greatly reduced sperm whale numbers in this area. Sperm whales in the North Sea have been increasing again in the 1980's.

ON DWARF SPERM WHALE *KOGIA SIMUS* (OWEN, 1866), PHYSETEROIDEA, IN SPAIN: A CORRECTION

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INTRODUCTION The study of osteological material from a male *Kogia* from the Gulf of Cadiz reported in a previous paper (Caminas and Rey, 1988) as pygmy sperm whale *K. breviceps* has revealed that it was really dwarf sperm whale*K. simus*. Unfortunately, since then the record has passed into general papers (e.g. Niethammer and Krapp, 1995) under this erroneous name, and a correction is long overdue to prevent any further spreading of this mistake.

METHODS AND RESULTS The specimen was deposited in the collection of the Estacion Biológica de Doñana under the catalogue number E.B.D 22.522, and includes a complete skeleton, with the minor exceptions of the tympano-periotic bones and the residual pelvic girdle. In addition, a dermoplastic model, albeit a rather poor one, was also made and is currently on exhibit.

Detailed external measures, wherever possible, were noted in Duguy (1995), although the species was classified incorrectly (see Duguy, 1995: page 599, Table 53). This paper retains the following data:

Locality: Puerto de Santa Maria, Gulf of Cadiz, Spain; date of capture - 1987; sex male; total length 212 cm.; weight 137 kg.

A more detailed description of the animal will be published elsewhere. Only selected cranial measurements are included in this paper (see Fig. 1):

Condylo-basal length	273
Rostrum length	127
Rostrum breadth at base	135
Post-orbital breadth	230
Zygomatic breadth	225
Mandibular length	231
Mandibular height	63
Number of mandibular teeth	11/11

According to the very clear comparative data given for *Kogia* by Handley (1966), Caldwell and Caldwell (1989), and Duguy (1995), our specimen could only be of the species, dwarf sperm whale *K. simus*. The pterygoid-basi-occipital wings are so short that the foramen magnum is well below the midpoint of skull height, a characteristic that has been discussed previously (see Ross, in Caldwell and Caldwell, 1989), but which is clearly shown in posterior views of the skull, such as in Figure 1 of Handley (1966).

We compared our specimen with the specimen of *K. breviceps* held at the Acuario Vasco de Gama, Lisbon. The dorsal cranial fossae are clearly cupped posteriorly, with the posterior wall of the dorsal rim sloping steeply into the fossae. This is, really, an extraordinary structure (Fig. 1d). In order to get a more precise idea of the shape of the cranial fossa, we made a transverse cut of the maxilla and premaxilla at the level of the proximal foramen of the maxillaria and across the sagittal septum built up by both bones (Fig. 2), using a "Mimic instant shape tracer" (Temco Tools Ltd.), and completing some details by hand. The asymmetry of the skull was quite remarkable: the right fossa was deeper than the left fossa, and the central plateau formed by the left premaxilla had the crest of the sagittal septum deeply bent and overlapping the right fossa.

Teeth and mandibles No vestigial teeth were apparent in the upper jaw. In the lower jaw, the documented number of teeth was 24. However, after preparation, only 22 were found. The length of the longest tooth was 17.5 mm, and its width was 3.5 mm. Dentine analysis on one of the teeth did not show any age annulae, and since annulae were clearly apparent in the teeth of*Stenella* prepared simultaneously, this leads us to conclude that the animal must have been very young, probably in its first year. The total length of the symphysis was 32 mm and showed, as would be expected, a clearly flat ventral union.

Postcranial skeleton Radiography of flippers (Fig. 3) showed a phalangeal formula of 1, 2/2; 2, 9/8; 3, 8/8; 4, 7/7 and 5, 3+x/5. The last phalanx of three and four fingers were very small modulla, slightly over 1 mm in diameter.

Additional notes According to Caldwell and Caldwell (1989), fully grown *Kogia simus* males can reach between 233 and 234 cm. The specimen discussed in this paper was only 185 cm in length, and would, thus, be a sub-adult or juvenile.

This is the first record for this species in Spain, and the fifth from European coasts. Dark, reddish-brown, intestinal contents, which resulted in red faecal staining of the water, is mentioned for the dwarf sperm whale by Caldwell and Caldwell (1989). We have observed a similar faecal color in *Caretta caretta* which fed exclusively on squid.

ACKNOWLEDGEMENTS We thank A. Andreu for her help with the radiography, and S. C. Zapata for help with the aging techniques.

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Fig. 1 Skull of a sub-adult male *K. simus* (EBD 22.522). The figure in the lower right is intended to show the deeply cupped shape of the maxillary and premaxillary bones

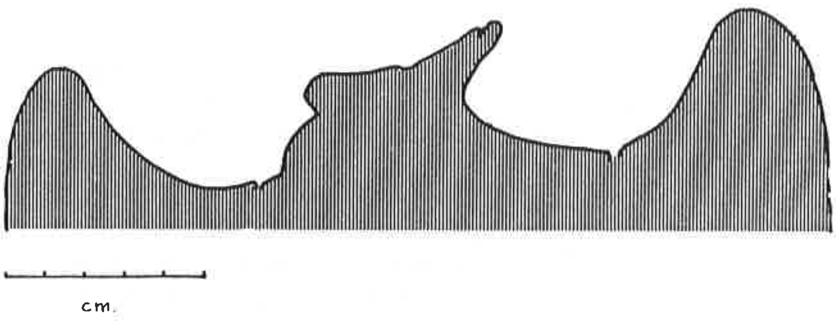

Fig. 2. Frontal view, made with the help of shape tracer, of a cut across the cranial fossae at the level of the main maxillary foramina. The central tabula is formed mainly by the right premaxilla

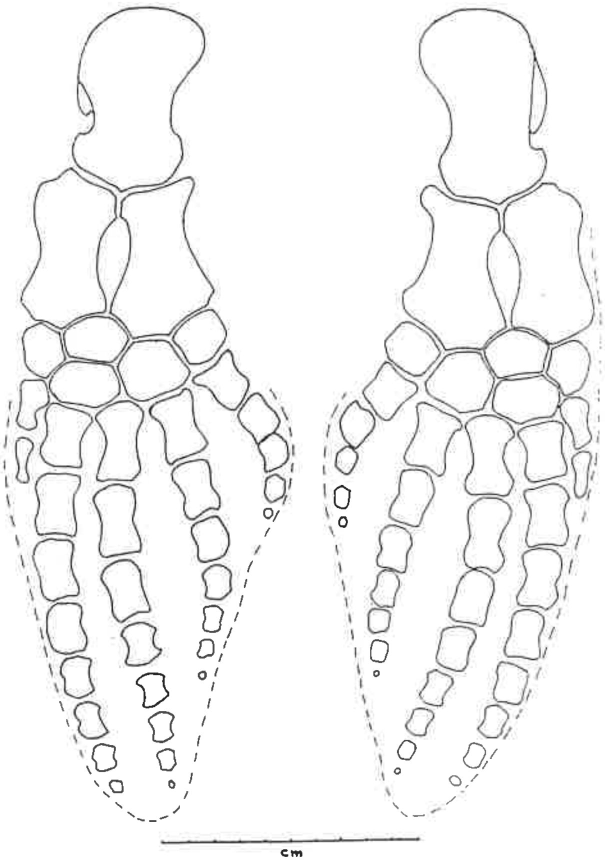

Fig. 3. Phalangeal formulae, as shown by radiography. The olecranom of one of the flippers is broken

POPULATION OF NORTHERN BOTTLENOSE WHALES (*HYPEROODON AMPULLATUS*) IN THE GULLY, NOVA SCOTIA, CANADA

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Approximately 213 northern bottlenose whales (*Hyperoodon ampullatus*) inhabit the Gully, a prominent submarine canyon on the Scotian Shelf, Nova Scotia, Canada. At the entrance of the Gully is a small core area (12 x 8 km) where the highest densities of whales are sighted.

Mark-recapture models indicate that these animals leave the core area (0.45/month) and then re-immigrate (0.55/month). Evidence suggests that this population is largely separate from other populations in the North Atlantic, although the degree of mixing is not well known.

This small population is threatened since they appear dependant on a single small core area located close to the southern limit of the range of bottlenose whales. The most serious threat that this small population faces is the proposed exploitation of several natural gas fields close to the Gully (the closest field is approximately 50 km away). Natural gas exploitation could expose these whales to noise pollution, chemical contamination, as well as increased shipping (with risk of collision) and marine debris. Additionally, the habitat of the bottlenose whales in the Gully is routinely exposed to commercial shipping and fishing.

A STRANDING RECORD OF THE CUVIER'S BEAKED WHALE IN ALGERIAN WATERS

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INTRODUCTON Although the Cuvier's beaked whale (*Ziphius cavirostris*) exists in all temperate and tropical seas and oceans, it is rarely observed because it frequently dives for long periods (Boutiba, 1992).

Little information is known about this odontocete species in the Occidental basin of the Mediterranean Sea. It is nore frequently observed in the north of the Mediterranean (Marini *et al.*, 1992 and Bayed *et al.*, 1995).

During the last two decades (1974-94), there were two observations and six strandings of Cuvier's beaked whale, proving the existence of this species along the Algerian seaboard. We were lucky in finding the most recently stranded specimen, and in very good condition.

INFORMATION ON THE STRANDED SPECIMEN We found this animal on 21 November 1994, stranded on the shore of Beni Saf, 100 km west of Oran, Algeria. It was an adult female of length 550 cm and weight 3,000kg. Its caudal fin was heavily parasitised (Boutiba and Abdelghani, this volume). A necropsy performed on the beach showed a general infection of most organs with parasites. Such heavy parasitism might have caused the death of this animal. Body measurements and colour photographs were taken. The skull and skeleton were conserved.

Table 2 includes body measurements of this specimen and comparisons with the following: measurements of another specimen which committed suicide on the rocky shore of Corales, 20 km west of Oran, Algeria (Boutiba, 1992); body measurements of one stranded close to Genova, Italy in April 1964 (Cagnolaro, 1965); body measurements of an individual stranded on beach near Barcelona, Spain on 20 May 1970 (Fillella, 1971); body measurements of the specimen found on 15 November 1975 at Var, France (Duguy, 1975); and body measurements of five adult animals stranded along the coasts of France (Viale, 1977).

Table 1 summarises information on Cuvier's beaked whale. However, such data are not sufficient to identify the morphology of this species. The average length of the twelve non juvenile animals (440 cm) is slightly lower than those reported in the literature where the length ranged between 550 and 650 cm.

The specimens "*Z. cavirostris* 4/64" and "*Z. cavirostris* 9/87" have a relatively short total length (218 and 250 cm respectively). We think that such total length probably relates to young animals (newborn?).

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Table 1. Stranded *Z. cavirostris* along Algerian coasts from 1977 to 1994.
M = Male; F = Female; ? = undetermined sex; W = Wilaya

Site and date of stranding	*Sex*	*Length (cm)*	*Weight (kg)*	*Reference*
1. Z.c. 10.4.1977 Tamenfoust (W. Boumerdes)	?	600	-	Lloze (1980)
2. Z.c. 22.5.1978 Cap Blanc (W. A. Temouchent)	M	630	-	Lloze (1980)
3. Z.c. 10.11.1979 Cap Blanc (W. A. Temouchent)	M	430	-	Lloze (1980)
4. Z.c. 10.11.1979 Salamandre (W. Mostaganem)	M	550	-	Lloze (1980)
5. Z.c. -.7.1982 Honaine plage (W. Tlemcen)	?	350	550	Boutiba (1992)
6. Z.c. 23.9.1987 Coralès (Oran)	M	250	300	Boutiba (1992)
7. Z.c. 28.11.1994 Béni Saf (W. Tlemcen)	F	550	3000	Present work

Table 2. Body measurements of *Ziphius cavirostris* stranded on occidental coasts of the Mediterranean Sea. M = Male; F = Female; ? = undetermined sex

Reference of specimens	Algeria				France				Spain				Italy			
	Z.c. 9/87 (BOUTIBA, 1992)		Z.c. 11/94 F		Val. Lim. n=5 (*in* VIALE, 1977) F (3); M (1); ? (1)		Z.c. 11/75 (*in* DUGUY, 1975) F		Z.c. 3/70 (*in* FILELLA, 1971) F		Z.c. 1893 (*in* FILELLA, 1971) M		Z.c. 4/64 (*in* CAGNOLARO, 1966) F		Z.c. IV (*in* CAGNOLARO, 1966) F	
	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%	cm	%
Total length	250	100	550	100	510-543	100	542	100	519	100	445	100	218	100	471	100
snout to apex of melon	-	-	15	2.7	0-18	2.6	-	-	16	3	-	-	-	-	10	2.1
snout to posterior angle of month	12	8	40	7.3	29-39	6.4	40	7.3	39	7.5	-	-	14	6.42	32.5	6.9
snout to center of blowhole	-	-	36	11.5	57-69	12	67	12.3	66	12.7	-	-	-	-	55	11.8
snout to center of eye	-	-	70	12.7	62-75	12.8	74	13.6	74	14.2	-	-	-	-	61	12.9
snout to tip of dorsal fin	142	56.8	370	67.3	286-380	62.9	390	71.9	320	61.6	285	64	134	61.5	288	61.4
maximum width of flipper	10	4	16	2.9	16-28	4.1	17	3.1	17.5	3.3	-	-	8	3.6	-	-
height of dorsal fin	14	5.6	40	7.3	19-22	3.9	21	3.8	28	5.3	-	-	12	5.5	19	4
length of dorsal fin base	20	8	25	4.5	30-40	7.1	40	7.3	48	9.2	30	6.7	18	8.2	30	6.3
width of flukes	59	23.6	148	26.9	104-115	21	130	23.9	142	27.3	130	29.2	51	23.3	96	20.3

NOTE ABOUT THE PRESENCE OF CUVIER'S BEAKED WHALE *ZIPHIUS CAVIROSTRIS* IN THE IONIAN ISLANDS OF GREECE

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Cuvier's beaked whales (*Ziphius cavirostris*), occurring in the deep waters adjacent to the islands of Lefkas and Cephalonia (Ionian islands of Greece), were observed during the summers of 1993, 1994 and 1995.

Repeated sightings - nine sightings involving a total of 28 individuals, of Cuvier's beaked whale may indicate a degree of site fidelity, as shown from a comparison with the results of photo-identification studies. In fact, some photo-identified individuals were repeatedly observed during the three years of survey.

The sightings were made in areas between 650 and 1,000 m deep, according to the feeding behaviour observed within nine miles of the Greek coast, near a geomorphological change in the continental shelf.

NOTES ON A SPECIMEN OF GERVAIS' BEAKED WHALE *MESOPLODON EUROPAEUS* (GERVAIS), ZIPHIOIDEA, STRANDED IN ANDALUCIA, SOUTHERN SPAIN

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INTRODUCTION On 8 November 1993, a fresh specimen of *Mesoplodon* was found stranded upon the coast of Almonte, Huelva, Spain. Some measurements were recorded, and notes upon the sex and coloration of the specimen were taken by H. Garrido and M. Mañez. This specimen was probably the same animal discovered by the authors of this paper, later in the month, on a beach several kilometres away. This latter specimen was an almost complete, preserved skeleton.

METHODS AND RESULTS In order to identify the species, we followed the characters defined by Moore (1966) and Mead (1989) for the skull, and Robineau (1995) for the mandibles and teeth.

Skull Details of the skull are displayed in Figs. 1 and 2. Selected cranial measurements are summarised in Table 1. From a frontal view, the premaxillary foramina were lower than the horizontal plane that transected the centres of the maxillary foramina. Dorsally, the jugal bone was visible at the side of the antorbital notch. The right nostril on the vertex of the skull was 52 mm in length, which was longer than had been anticipated. The vomer did not fill the mesorostral canal, but it seemed to rise proximally above the premaxillary rims, which had slightly deteriorated. We could not measure the length of the vomer visible on the palate. From a lateral view, the dorsal aspect of the rostrum was clearly convex with the tip pointing downwards, and the lower profile was concave near the tip. The transverse section of the rostrum at its mid-length was very different to that of Blainville's beaked whale *M. densirostris.* In *M. europaeus*, the rostrum was dorsally flattened, instead of laterally flattened as in *M. densirostris.*

Mandibles The greatest length of the symphysis was 145 mm, but their structure was not clear. In fact, the proximal part of the symphysis was filled by porous and pale bone, or the remains of connective tissue. We have included this in the measurements.

Teeth Figure 3 shows the interpretation of a radiograph. The left tooth - thick line - is seen laterally, and the right - thin line - in section. The estimated symphysal area is dotted. It appears that the teeth are situated just at the level of the porous and pale bone, or connective tissue, that fills the proximal part of the symphysis. From a ventral aspect, the jaw was thicker in the area where teeth were embedded. The left tooth was 69 mm in length and apparently only 35 mm in width. The length is similar to a 67-68 mm tooth retrieved from a male specimen from Cuba; the width is, however, considerably smaller than the Cuban specimen. The tooth which we collected was shaped more like a tooth from *M. hectori* (Mead, 1989: Fig. 14), and suggests that our specimen could have been female. Although the tips of the teeth protruded 9 mm from the outer border of the bony mandible, they were not noticed by the initial field observers, who mention in their notes that the specimen was "without teeth".

Bulla The right bulla was 45 mm in length - much smaller than the bulla of a Spanish specimen of *M. densirostris* which was 53 mm in length (Valverde, this volume).

Hyoid The corpus and an anterior cornua were preserved.

Postcranial skeleton The sternum was formed by four sternebrae (Fig.4) which were rather different to those described by Raven (1937). The sternebrae on our specimen did not have any fenestra between the third and fourth sternebrae, but the general outline was similar, with both the manubrium and the xiphiod deeply forked (Raven, 1937). It should be noted that although Raven (1937) detailed four sternebrae in *M. europaeus*, only three were drawn in his paper. This is also reproduced in Niethammer and Krapp (1995).

The vertebral formulae was C 7 (3 + 4), Th 9, L 11, Cd 17(?), total 44, but some small caudal vertebrae may have been missing as Raven (1937) and Robineau (in Niethammer and Krapp, 1995) both report the total number of vertebrae to be 47. The last cervical vertebra shows an articulating surface (Fig. 5) that probably corresponds to the capitulum of the first rib, which would be united to the first dorsal by the tuberculum, but could also be a lost cervical rib. There were nine ribs, six of which were double-headed and three were united by the capitulum. In the right side, one-sixth of the distal section of ribs nos. 6 and 7 were broken and fused into the correct position. It was difficult to determine the precise number of the lumbar vertebrae since one of the haemal arches seemed to be missing, and it was subjective as to whether the articulating surface of the first caudal vertebra was, indeed, articulating. Nine chevrons were conserved.

Description Field notes and photographs - both black and white and colour slides were taken when the animal was freshly stranded. They showed a very dark animal with a typically elongated rostrum and straight commisural border to the mouth. The specimen was thought to be female. The photographs also showed that the tail fluke was slightly, but not regularly, concave with a central area roughly straight. The head was really small compared to the head of *Ziphius*. There was a well-marked depression on the neck; the upper mandible was narrow and rather shorter than the lower mandible.

Coloration When the specimen was "very fresh" but already stranded upon the land, it was described as "entirely black. There was no colour difference between the dorsal and ventral surfaces. The only other coloration was "a rosy patch under the flipper" (Garrido, unpubl. data). Mañes (unpubl. data) describes the colour of the specimen as "very dark, uniform indigo colour" except for the axillary area. This agrees with the coloration typically ascribed to the species, although no references could be found citing a ruddy axillary patch.

Distribution A recent paper (Robineau, in Niethammer and Krapp, 1995) mentions only three specimens of *M. europaeus* in European waters: the type specimen, found in the English Channel in 1840; another on the north-east coast of Ireland in 1980, and a final specimen from Deiras, Portugal, in 1992. This is, therefore, the fifth European specimen, and the second from the Iberian Peninsula. Up to eight specimens have been recorded from the Canary Islands (Castells and Mayor, 1992).

ACKNOWLEDGEMENTS We wish to thank A. Andreu for the radiographic work, and both G. Garrido and M. Mañez for their field notes and photographic records.

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Table 1 Summary of the cranial measurements (in mm) of the *M. europaeus* specimen

Condylobasal length	762
Rostrum length	466
Rostrum width at base	195
Rostrum width 60 mm anterior to the base	120
Rostrum width at middle (233)	65
Rostrum width at 3/4 of the length (349.5)	33
Maximum premaxillae width	145
Preorbital width	318
Postorbital width	347
Zygomatic width	346
Width of braincase across occipital	334
Least distance between maxillary foramina	89
Least distance between premaxillary foramina	31
Length of temporal fossa	130
Height of temporal fossa	59
Tip rostrum to the nares	547
Tip rostrum to posterior end of the wing of pterygoid	618
Tip of rostrum to anterior extension of pterygoid	399
Tip of rostrum to posterior margin of pterygoid	655
Greatest span of the occipital condyles	110
Greatest width of right occipital condyle	41
Greatest length of right occipital condyle	74
Greatest width of foramen magnum	40
Height of skull between vertex and most ventral point of pterygoids	298
Lower jaw length	652
Coronoid height	108
Length of lower jaw symphysis	145
Length of condyle to tooth alveolus	515
Maximum height of the lower jaw	111
Length of alveolus	19

Table 2 External measurements (in cm) of the *M. europaeus* specimen stranded upon 8 November 1993 (H. Garrido unpublished data). The total length is within the normal range for females of this species (420-482 cm)

Total length	453
Tip of rostrum to rostral border of dorsal fin	274
Tip of rostrum to tip of dorsal fin	299
Tip of rostrum to blowhole	63
Tip of rostrum to eye	61.5
Maximum length of flipper	42
Width of flipper	13
Height of dorsal fin	10
Length of dorsal fin	21
Width of fluke	110
Length of fluke	32.5
Maximum girth	212

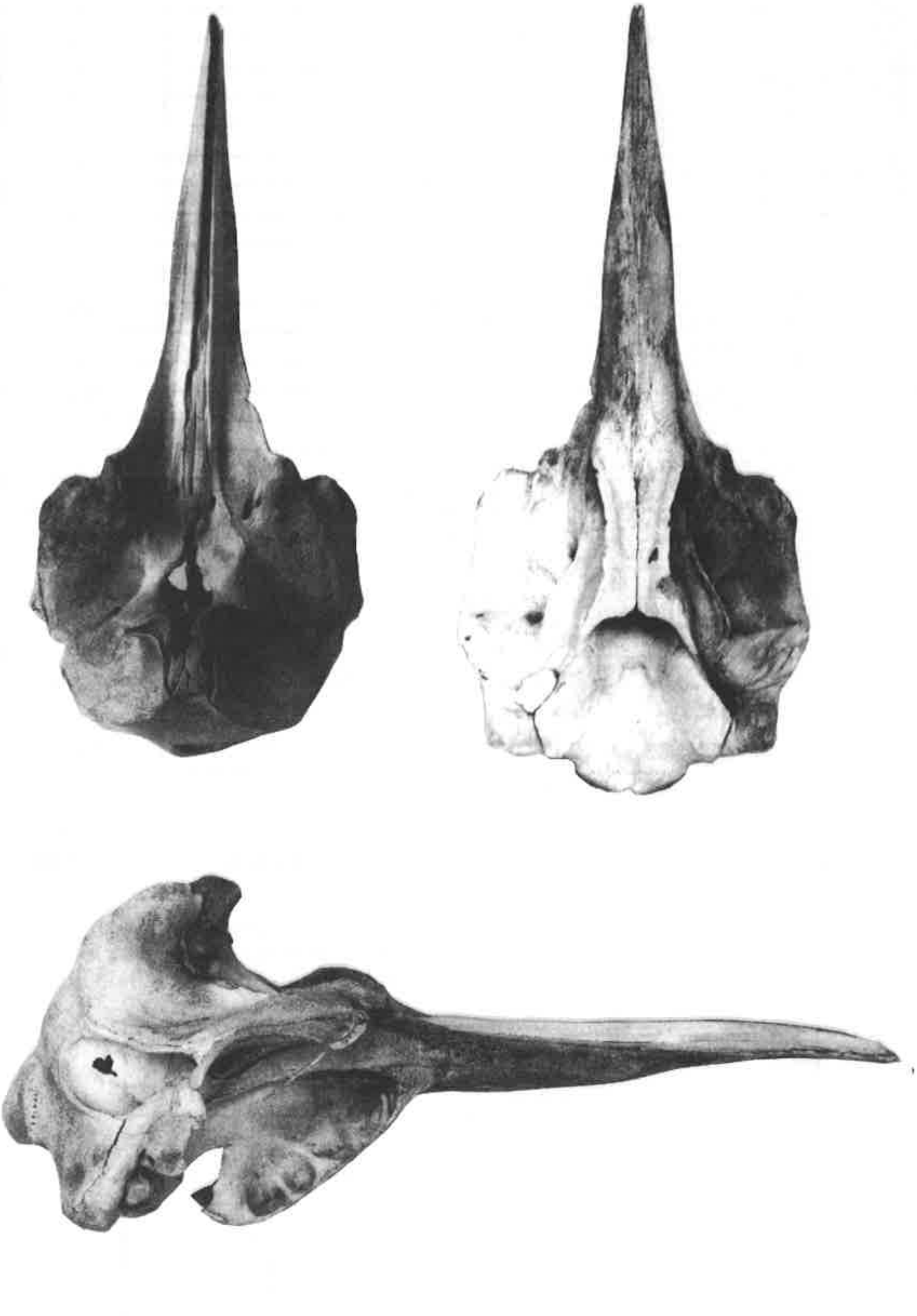

Fig. 1. *Mesoplodon europaeus*, EBD 22.522.
Upper, lower and lateral view of skull

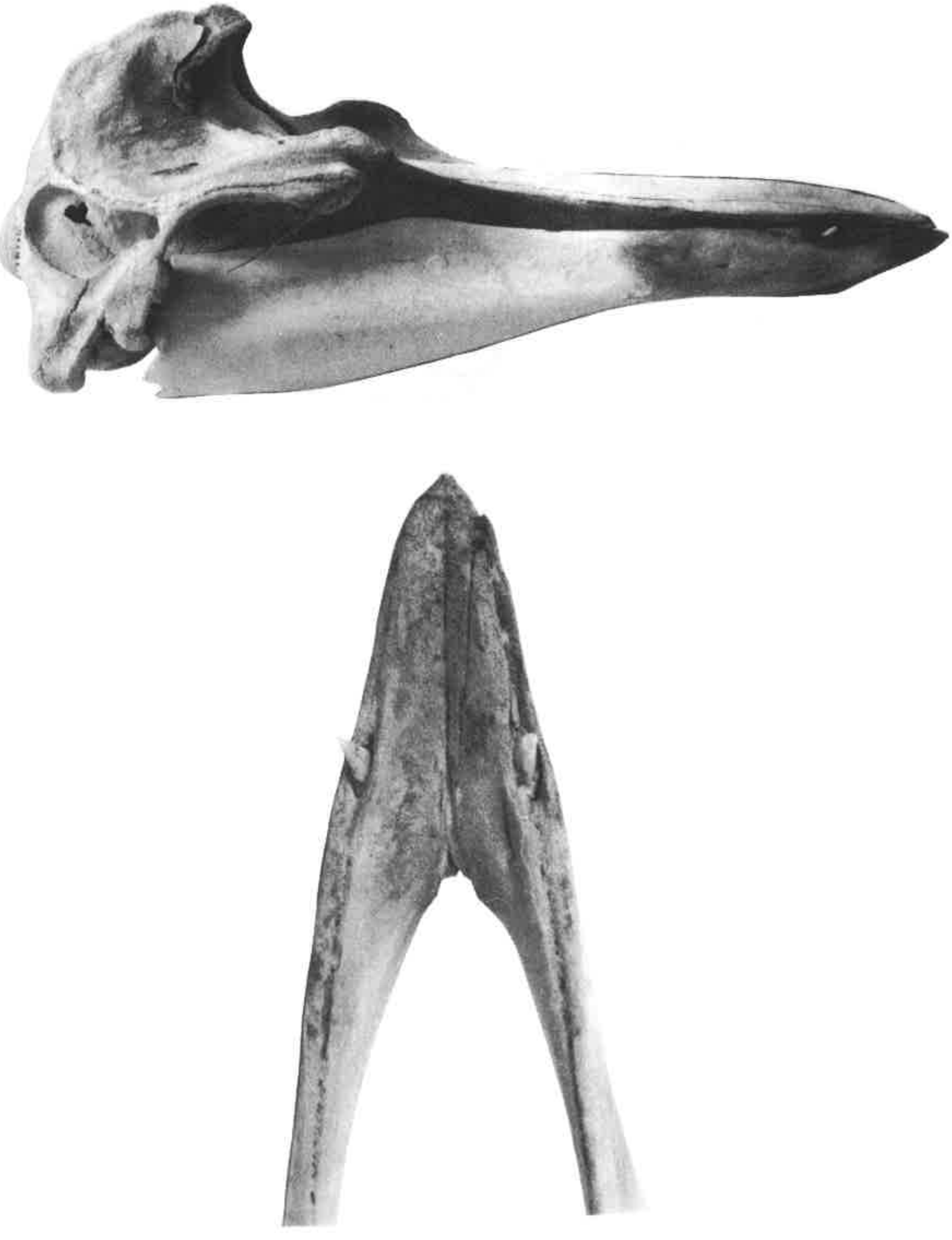

Fig. 2. Lateral and upper sight of the mandible. The teeth protude clearly but were not visible in the dead animal.

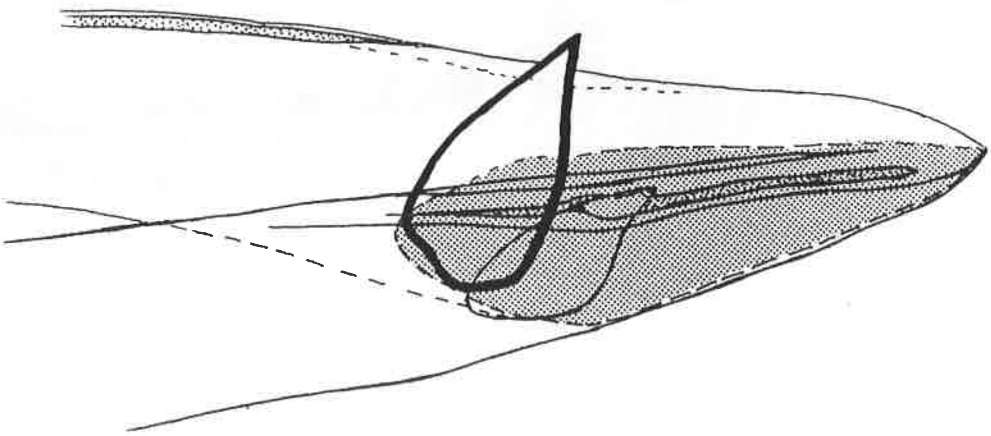

Fig. 3. Drawing on a radiography of the mandible showing the shape and size of teeth. The left tooth, in thick line, is seen vertically to their main plane

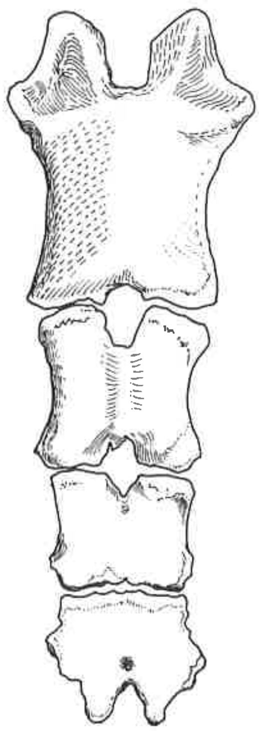

Fig. 4. Sternum from EBD 22.522. Note the lack of fenestra between the third and fourth sternebrae

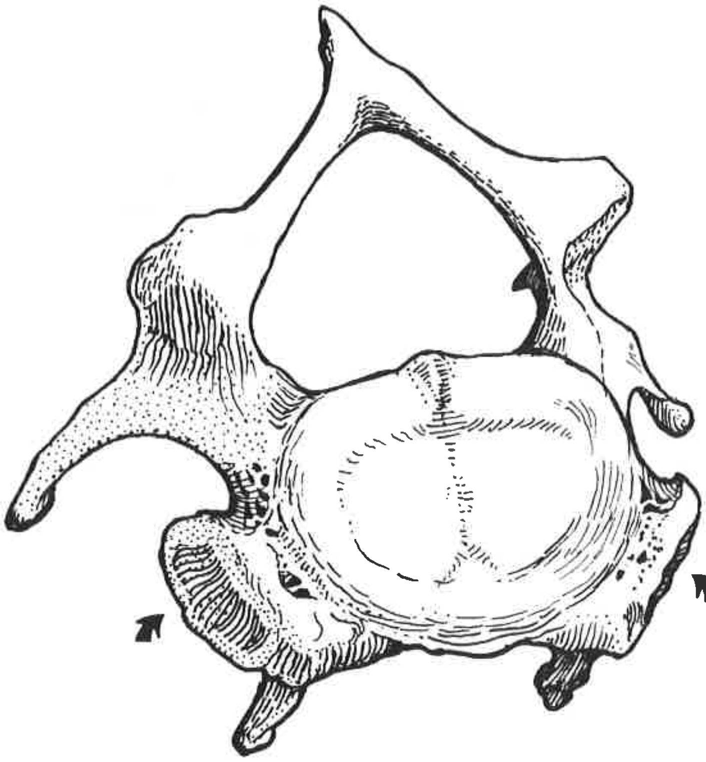

Fig. 5. Last cervical with the articular surfaces indicated in the text

NOTES ON A SPECIMEN OF BLAINVILLE'S BEAKED WHALE *MESOPLODON DENSIROSTRIS* (DE BLAINVILLE, 1817) STRANDED ON THE COAST OF DOÑANA, HUELVA, SOUTHERN SPAIN

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INTRODUCTION A skull of a female Blainville's beaked whale *Mesoplodon densirostris*, with no records except for locality, was located in the osteological collection of the Doñana Biological Station under the catalogue number EBD 19.309. It was found stranded upon the coast of Doñana National Park, Huelva, Spain, and a note from one of the collectors stated that it had been collected in 1990, pre-cleaned, from a site where cetacean specimens were deposited. The osteological material included the skull and the left ramus of the mandible, both of which were eroded. This erosion was probably caused by the action of other animals.

DESCRIPTION

Skull (Fig. 1) About 17 mm of the tip of the rostrum is missing. This amount was calculated by a comparison with photographs of two adult females (Moore, 1966; Besharse, 1971), In each measurement on our list, where this has been taken into account, the measurement is shown within brackets. Osteological specimens are frequently found with the ends of the rostrum broken off, for example in both of the Iberian animals noted by Reiner (1979) and Filella (1981).

Only the right broken ramus of the mandible was available. The symphysal region is very much eroded distally, but an idea of their original shape may be obtained by comparing it with photographs of other female mandibles (Besharse, 1971; Reiner, 1979).

Other remarks The skull was examined for the characteristics pointed out by Moore (1966), and was found to conform with the following points:

a) horizontal position of spiracular plate in lateral view;
b) proximal portion of the premaxilla smoothly curved behind and above the nares;
c) maxillary foramina opening directly forward.

The vertex of the skull was eroded, but what remained suggested that the upper butt of premaxilla was, as expected, rounded and tilted forward. The right maxillary foramina was double, divided into two openings by a vertical wall in the last 10 mm.

Our specimen clearly showed a third non-functional condyle situated midway between the other condyles, which were 12 mm apart, and 5 mm in height. This is visible in Figure 1. This "condylus tertius" was mentioned by Casinos and Filella, and also appears in a photograph of their Cascais specimen. The tertiary condyle has been reported to be a normal occurrence in *M. densirostris*, but it has been also described for three other species of *Mesoplodon* (Mead, 1989).

Bulla and periotic The skull conserved the right tympanic bulla and periotic bone. Kasuya (1973) also describes these bones for *M. densirostris*. Our specimen agrees, in general, with Kasuya's drawings and photographs. In a lateral aspect, the bulla is flat for *Mesoplodon*. The bulla of *M. densirostris* keeps the same general appearance, but the anterior spine shows the lateral indentation of the internal side in a lower position, and the interprominential notch of the posterior end of the bulla is deeper. In ventral aspect, the upper border of the sigmoid process is more up-turned, similar to *M. europaeus*, and the lateral furrow seems to be deeply marked. The periotic bone is similar to Kasuya's (1973) photographs although it is difficult to ascertain the significance of differences, since we ignore the intra-specific variations.

Teeth Radiography of the skull shows a very large tooth deeply inserted in the jaw which has a characteristic bottle aspect (Fig. 2). The teeth of two females from Midway (Pacific Ocean), SIU 0-638 and SIU 0-636, depicted in Besharse (1971), which are considered to belong to a sub-adult and an adult, as well as another young female from Nova Scotia (Raven, 1942), are also available for comparison. It should be noted, however, that figures in Besharse (1971) probably refer to the wrong indivuduals and should possibly be swapped.

Our specimen was similar to the Nova Scotia specimen in shape (Raven, 1942). In size, it is intermediate between the Midway specimens (Besharse, 1971). It displayed a bulbous upper end that suddenly came into a sharp point, directed backwards, whose last 7 mm possibly protruded through the skin to judge by the different texture of the enamel, but did not protude above the bony edge of the ramus. The pulp cavity was clearly visible when using radiography and measured 55 mm by 3 mm, and did not reach the base of the tooth, that seemed to be fairly compact, suggesting an old animal. The tooth appeared to be reminiscent of the teeth of *M. ginkodens*, a species with which, sometimes, *M. densirostris* is united within the genus *Dioplodon*. Both our tooth and those of the two immature females have a characteristic bottle shape (Raven, 1942; Besharse, 1971), which does not appear in either the adult Midway female (Besharse, 1971) or the prominent, large teeth of male mandibles.

Age According to the age criteria for females, described by Besharse (1971), our specimen must have been an adult. The vomer and mesethmoid filled and thickened the mesorostral groove proximally. The bony overlays of the maxillary, palatine and pterygoid in the orbital and auditory regions seemed rather extensive. In the braincase, the posterior profile was not so rounded as in a sub-adult female.

The shape of the rostrum at mid-length seemed to be a good age criterion (see Besharse, 1971) being broader in the lower region in sub-adults. In Figure 3, we represent the shape of our specimen, drawn with the help of a "Mimic instant shape tracer". Details of the mesorostral groove have been made by hand.

It was interesting to attempt to correlate the filling of the pulp cavity of the tooth, as shown in the radiograph, with the filling of mesorostral groove. This was fortunately possible as the rostrum was broken some 20 cm proximally to its mid-length, and the growing layers of porous bone which filled the mesorostral groove were clearly seen in the broken section. The position and main direction of these layers has been transposed onto the Figure 3.

Colour A stranded specimen of *Mesoplodon densirostris* was photographed in April 1988 at the same beach where our specimen was collected, and is probably the same individual. Five colour slides show the animal to be blue-grey dorsally while it was floating, and dark grey dorsally and white ventrally, when it eventually stranded many hours later. The lower jaw was white. An ill-defined, white, central patch ran ventrally downwards until a distance 1/3 of the way between the genital area and the root of the tail. This band extended laterally in three areas: around the genitals; between the pectoral fins; and in the commisural and inter-ramial region, already mentioned. As a result of the latter, a dark band appeared to extend from the pectoral fins, at the head end towards, although not quite reaching, the two throat grooves.

Additional notes When Besharse wrote his paper in 1971, only four female specimens of *M. densirostris* were known, as opposed to eleven male specimens. It seems surprising that all animals reported from the waters of the Iberian Peninsula should turn out to be female, especially since males are easier to identify due to their large, diagnositic teeth. As the number of males appears to be higher in northern areas, it could be that females are restricted to lower latitudes.

ACKNOWLEDGEMENTS I wish .to thank A. Andreu for help with the radiography and J. M. Pérez de Ayala for the slides.

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Table 1 Measurement (in cm) of *Mesoplodon densirostris* specimen No. EBD 19309 from Doñana, Southern Spain

Condylobasal length	(751)
Rostrum length	(455)
Rostrum width at basis	100
Rostrum width 60 mm anterior to the base	65
Rostrum width at middle	(43)
Rostrum width at 3/4 of the length	(32)
Maximum premaxillae width	129
Preorbital width	279
Postorbital width	327
Zygomatic width	321
Width of braincase across occipital	277
Least distance between maxillary foramina	51
Least distance between premaxillary foramina	29
Length of temporal fossa	102
Height of temporal fossa	62
Tip rostrum to the nares	(558)
Tip rostrum to posterior end of the wing of pterygoid	(610)
Tip rostrum to anterior extension of pterygoid	(388)
Tip rostrum to posterior margin of pterygoid	(582)
Greatest span of the occipital condyles	104
Greatest width of right occipital condyle	42
Greatest length of right occipital condyle	79
Greatest width of foramen magnum	32
Height of skull between vertex and most ventral point of pterygoids	289
Coronoid height	c. 122
Length of condyle to tooth point	357
Maximum height of the lower jaw	130
Length of alveolus (upper sight)	c. 26
Width of alveolus	11.5

Table 2 Tooth measurements in millimetres of the teeth of female specimens of *Mesoplodon densirostris*

	EBD 19.309	SIU. 0-638	SIU. 0-636
Greatest length of tooth	61	59	57
Antero-posterior width of tooth	34	31	49

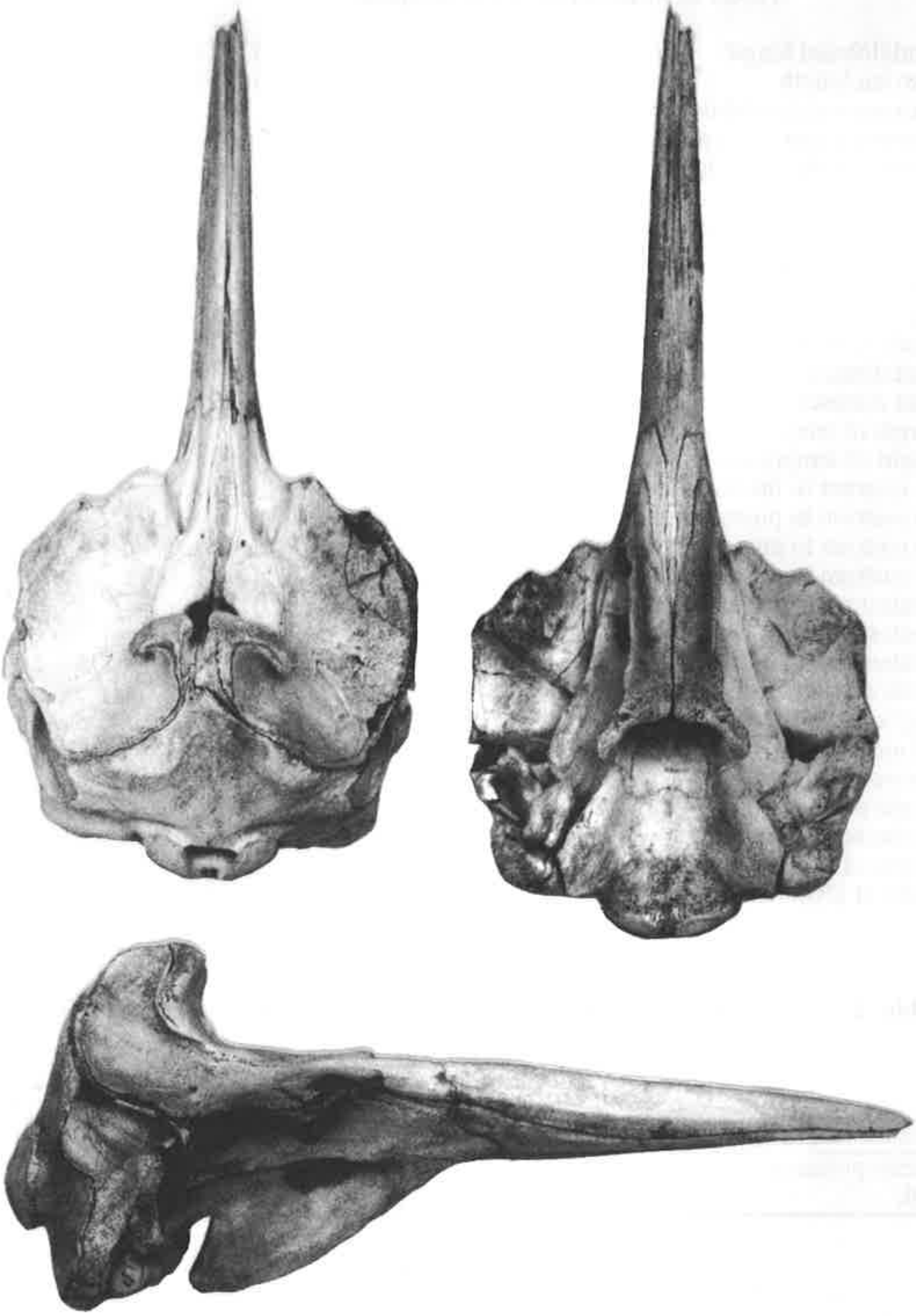

Fig. 1 *Mesoplodon densirostris*, female (EBD 19.309).
The tip of the rostrum is missing

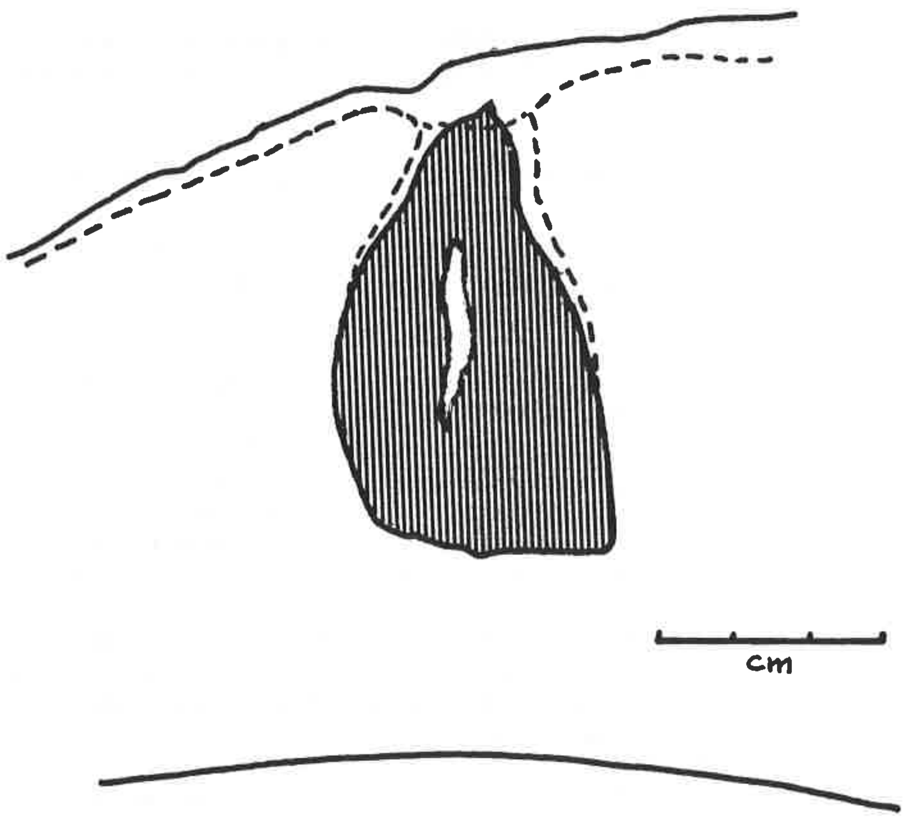

Fig. 2 A radiographic drawing of the left ramus showing the tooth and the borders of the alveolus. The broken line also shows the border of the gum channel, where the tip of the tooth possibly appeared through the skin

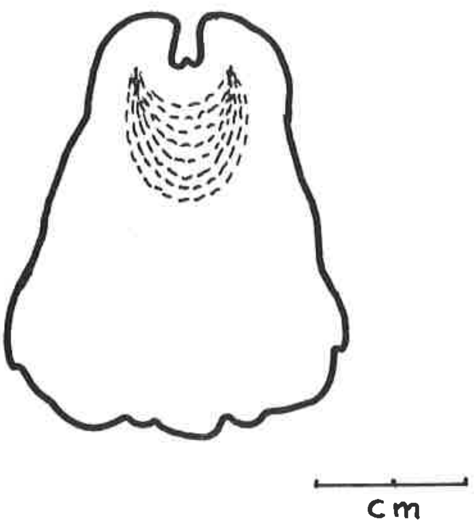

Fig. 3 Profile of a transversal cut of the rostrum at mid-length. The broken lines show the direction of the bone layers filling the mesorostral channel in a cut 20 cm caudal to the profile

BELUGAS IN THE RUSSIAN ARCTIC: SEASONAL PATTERNS OF DISTRIBUTION, DEPENDING ON ICE CONDITIONS

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A database of observations of marine mammals in the Russian Arctic has been used to study peculiarities of seasonal distribution and relative density of beluga whales *Delphinapterus leucas*. The database includes about 800 records on observations of belugas. Each observation of an animal or a group of animals is accompanied by notes on ice conditions in the site of the observation. The majority (more than 90%) of the observations were provided by air-ice reconnaissance. The others were accomplished by crews of drift polar stations, special research expeditions, ice-breakers, and so on.

Analysis of the data supports a preliminary proposition about the existence of a natural obstacle consisting of multi-year ice in the central portion of the East-Siberian Sea. The obstacle restricts migration of marine mammals including belugas from the Chukchi Sea to the Laptev Sea. Also, available data confirm the occurrence of this species in the Arctic basin during the summer period in years when ice cover recedes far north. In summer, the majority of the beluga population occurs along the mainland coast, from Yamal Peninsula to the east of Taimyr Peninsula, and along the northern coast of Chukotka Peninsula.

In winter, whales of the Barents Sea population are distributed evenly in the entire sea. Belugas of the Bering Sea population, with the exception of a few animals, migrate from the East Siberian and Chukchi Seas to the Bering Sea.

ANALYSES OF AGE AND SEX OF CATCHES OF BELUGAS IN WEST GREENLAND AND WESTERN RUSSIA

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Age and sex were determined for the harvest of approximately 1,000 belugas, *Delphinapterus leucas*, in West Greenland between 1985-86 and 1989-94. For comparison, a sample of 570 belugas from the White and Kara Seas were included in the analyses. Age estimation was confounded by the early onset of tooth wear (averaging 7.7 yr in females and 6 yr in males) in West Greenland belugas which meant that the precise age could not be determined for 35% of the older sample. Tooth wear occurred later in the Russian sample, where 15% of the older tooth sample could not be aged accurately.

During 1985-93, a clear segregation of whales was evident in the autumn drive fishery in Avanersuaq and Upemavik, West Greenland. Primarily immature whales of both sexes and mature females were taken. No trends in mean or median ages could be detected during the period 1985-93. In 1994, however, many more adults of both sexes were taken, and the mean age more than doubled and the median age trebled.

The sudden appearance of old whales in the drive fishery must be explained by a change in availability of whales. On the wintering grounds from Disko Bay and southwards, both immature and mature whales are taken. The oldest ages observed were 34 yr for females, and 29 yr for males.

Estimation of survival rates for West Greenland belugas were 0.85 for females, and 0.81 for males, using all ages >1yr including those from worn teeth. Survival rates calculated for the White and Kara Sea belugas were 0.85 for females >7yr of age, and 0.83 for males aged >9yr. The age ranges for both West Greenland and Russia were similar, although age distributions differed: immature whales predominate in West Greenland, whereas the mean and modal ages in the Russian sample represented mature belugas.

BEHAVIOUR AND HABITAT USE OF KILLER WHALES IN NORTHERN NORWAY

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The behaviour and habitat use of killer whales has been studied in northern Norway in 1990-93. The aims of the study have been to investigate the behavioural budget, possible seasonal differences in behaviour, whether the behaviour of killer whales is affected by the time of the day or tides, and how the whales use their habitat. 29,763 mins. of behavioural observations has been gathered between October and November, and 13,691 mins. in June - August.

The behaviour has been divided into four different categories: travelling, feeding, resting, and socialising/playing. Travelling behaviour was the most common behaviour observed during both seasons, and it is possible that this category included some feeding behaviour which was not observed from the surface, or that a substantial proportion of feeding took place during night-time.

The behavioural budget differed between autumn and sununer: during autumn, whales spent 40% of their time travelling, 24% feeding, 18% resting, and 17% socialising/playing. During summer, travelling was observed 60% of the time, feeding 14%, resting 16%, and socialising/playing 8%.

Herring seem to be the main type of prey during both seasons, and the behaviour and distribution patterns of herring seems to be the key to understanding the behavioural patterns of killer whales in Norway. During autumn, the whales were found in coastal waters in a fjord system, and they favoured the shallowest parts of the fjord with varied bottom topography for feeding. The feeding was concentrated to a period between 10.00-14.00 h., which could be related to the diurnal pattern of migration of herring, or that good light conditions were beneficial for feeding (during autumn, daylight is limited). In addition, rising and high tide seemed to be favourable for feeding.

During summer months, killer whales are mainly present in offshore waters, and they were only occasionally found in the coastal waters studied. The whales occurred often in areas where schools of herring were found. No tidal rhythm in the behaviour could be demonstrated in the summer months. During summer, the midnight sun allowed whales to be followed throughout the day, and the longest continuous observation of a group was 36 hours.

DISTRIBUTION PATTERNS, RELATIONSHIPS BETWEEN DEPTH, SEA SURFACE TEMPERATURE, AND HABITAT USE OF SHORT-FINNED PILOT WHALES SOUTH-WEST OF TENERIFE

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INTRODUCTION The geographical distribution of delphinids has been related to a great variety of environmental and biological factors. Prey distribution (Nishiwaki & Handa, 1958; Mercer, 1975; Condy *et al.*, 1978; Würsig & Würsig, 1980; Irvine *et al.*, 1981; López & López, 1985; Heimlich-Boran, 1986), tidal variation (Felleman *et al.*, 1991), submarine topography (Evans, 1971; Hui, 1979; Heimlich-Boran, 1988; Würsig *et al.*, 1991), water depth (Saayman & Tayler, 1979; Wells, 1986; Ballance, 1990) and surface temperature (Uda, 1954; Mercer, 1967; Gaskin, 1968; Nishiwaki, 1975; Perrin, 1984; Kasuya *et al.*, 1988; Mate, 1989) are the most obvious. The short-finned pilot whales *Globicephala macrorhynchus* resident in waters off the south-west shore of Tenerife, one of the Canary Islands, seem to be concentrated in a limited area. The aim of this study is to delimit the population´s distribution area and analyse some of the above variables.

METHODS The study area is part of the 27 km wide channel between Tenerife and La Gomera, with limits between latitude 28°08´00" N and longitude 16° 40´00" and 16°57´00" W.

The submarine topography of the zone lacks an island shelf around both islands. The deep narrow canyon between them has an average depth of some 1,500 m. at its centre. Extending north and south, the two basins reach depths near 2,400 m. Sea surface temparature is subject to strong seasonal variations from 17°C in December and January to 25°C in September and October. These are lower than expected for a subtropical zone as a consequence of upwelling on the African coast, and the cold Canary Current.

The study area was divided into squares according to a regular grid of 1 min. x 1 min. areas. By means of linear transects through the central axis of each, its density of whale groups was estimated, and categorised into areas of high, medium, and low use. The observations were made from a 7 m. boat with 40 hp motor, from October to December. The limits and central point of each grid square, and whale group positions were taken using a GPS Magellan Nav 5000. Some environmental variables like weather and sea conditions, were noted during transect development. Others, like depth, submarine topography, and surface sea temperature (SST), were determined from the nautical charts and satellite photographs.

In each grid square, maximum, minimum, and average depth were determined, along with the depth variation coefficient (DVC) (Hui, 1979), given by the expression:

$$\text{CVP} = \frac{P - p}{P} \times 100$$

The SST was obtained from the apparent temperatures from channels 4 and 5 of the polar orbit satellite NOAA-14 by means of the following regional algorithm optimised for the Canaries area (Arbelo *et al.*, 1995):

$$\boxed{\textbf{TSM} = T4 + 1.6468\ (T4 - T5) + 0.3931\ (T4 - T5)\ (\sec(z) - 1) + 0.0887}$$

z = satellite observation angle
T4, T5 = Temperatures form channels 4 and 5 (AVHRR-NOAA)

Each SST datum corresponds to an area of approx 1 km^2 and has a standard error of estimation of 0.18°C.

For the determination of environmental variables influencing whale distribution, a Multiple Logistic Regression Analysis was carried out, allowing categorical variable (whale presence-absence) to be related to other variables, whether categorical (sea conditions) or not (SST, depth, DVC, distance from coast).

In order to determine homogeneous environmental areas, a Factorial Analysis was used upon the variables entered in the logistic regression model. The first step was to make a correlation matrix among all the variables from the original data matrix. Once studied and checked for adequacy on factorial analysis, the components were extracted by Principal Components Analysis (PCA). The first factor extracted is the one that most explains the total variance, the second best summarises the remaining information, and so on. To determine the number of factors to conserve, we follow the criteria of Kaiser (1960), i.e. by choosing eigenvalues greater than one. By means of the regression models, the factor score of each grid square is obtained, and, afterwards, from a frequency histogram, the squares are divided into classes according to their factor score. Grouping the squares of each class, the homogeneous environmental units are obtained (A. Valido *pers. comm.*).

RESULTS Short-finned pilot whales were sighted on each day of sampling. For the 117 areas analysed (340 km^2), whales were detected in 54 of them (46.15% of the study zone). Their total distribution area was 156 km^2, between 27°59´and 28°08' N, and 16°42' and 16°54' W.

The Multiple Logistic Regression Analysis gave values significant for SST, offshore distance and DVC, while depth and sea conditions did not enter the equation. Analysis of standardised residuals shows that they follow a normal distribution, with a mean of -0.01 and standard deviation of 0.8234 (Kolmogorov-Smirnov Test = 1.8131, $p<0.05$) (See Table 1).

The factorial analysis (Tables 2 and 3) gives a single factor whose own value is superior to one, including in it all the variables according to the common values of Table 2. The grid squares were divided into four classes according to their factor scores (high, medium, low and very low), thus obtaining four homogeneous units (Fig.1).

__Area I__ Characterised by very low factor 1 values. They are shallow areas near the coast, with a high DVC and lower SST than elsewhere in the area;
__Area II__ Low factor 1 values. Contignous with Area I with depths between 200 and 700 m, high DVC and SST slightly higher than area I;
__Area III__ Medium factor 1 values. Of extensive area and depth, gently varying from 700 to 2,000 m, with slightly higher temperature than the previous two, increasing with distance from coast;
__Area IV__ High factor 1 values, further from coast, reaching depths of 1,600 to 2,300 m, and SSM maximum for the whole zone.

The zones of use by whales are shown in fig. 2. A chi-square test shows significant differences in whale distribution in the homogeneous environmental units ($\chi^2 = 49.4$, $p< 0.01$). The area of greatest use is well inside area III, surrounded by areas of low use coinciding with it at its westernmost end, and with areas II at its shore-facing end.

CONCLUSIONS The maritime zone to the south-west of Tenerife is a peculiar area from both a climatic and oceanographic point of view. To the mass effect generated by the island (conferring protection from prevailing north-easterly winds), must be added the existence of cyclonic eddies in the currents, bordering an area of calm water (Molina, 1979).

Within this zone, the pilot whale population is restricted to a reduced area. Most delphinids have adapted to diverse habitats, being thus species of great ecological flexibility and high behavioural diversity. On the other hand, other members, among them the pilot whale, are more demanding in ecological preferences, restricting their habits of behaviour, social organisation, feeding, etc.

Despite the existence of an apparently resident population, the short-finned pilot whale is a common species throughout all the Canary Islands. Their great mobility, combined with the detection of 300 transient individuals catalogued by photo-ID studies, suggest that other similar concentrations may exist elsewhere in the islands.

The environmental variables most affecting their spatial distribution are: (1) surface sea temperature; (2) depth variation coefficient; and (3) distance from coast. The surface temperature is a particularly important environmental factor since, despite it varying only slightly, cetaceans are particularly sensitive to such variations. Furthermore, the depth variation coefficient appears to be a better predictor than depth itself, pointing to changes in submarine topography independent of average depth. The whale frequented areas present intermediate DVC values associated with the underwater slope which is normally attributed to a greater richness. Sea conditions are omitted from the model, implying that as a structural variable they do not influence whale distribution. Perhaps the state of the sea has greater influence on the detectability of the whales.

The high correlation between those environmental factors analysed and distribution patterns, does not necessarily imply a cause-effect relationship, since the predicting variables might also be considered indirect indicators of resource distribution in the zone. In this sense, cephalopod fishing grounds (the main item in their diet) are frequent here, showing an abundance of these species, concentrated in certain areas in winter and dispersing at other times of the year (A. Brito, *pers. comm.*). These areas coincide with those most heavily used by the whales.

The pilot whale is a species that is usually distributed throughout deep waters of the open sea. In South-west Tenerife, and generally in the Canary Islands as a whole, the insular shelf is practically non-existent, so oceanographic characteristics with great depths are present in coastal waters. It is this factor which permits the resident pilot whale population to exist despite our confirming their environmental preferences as being otherwise similar to those of oceanic waters.

The proximity of the whales to the coast is positive in providing a natural resource for scientific research, environmental education and tourism. This raises a conservation problem, since the area is accessible to all types of boats. Also, the fragility of the population is increased by such a restricted distribution.

ACKNOWLEDGEMENTS This study was carried out thanks to the support of the Consejería de Turismo y Transportes and the enthusiasm of the staff of the state enterprise SATURNO. Our gratitude also goes to A. Valido and A. Brito, who contributed diverse information.

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Table 1. Variables in the Equation of Multiple Logistic Regression

Variable	B	S.E.	Wald	Sig	R	Exp(B)
DVC	-0.0770	0.0200	14.8386	0.0001	-0.2835	0.9259
Distance	-0.5056	0.2263	4.9897	0.0255	-0.1368	0.6032
Sea conditions			7.8338	0.0496	0.1072	
Sea conditions (1)	2.3932	1.1256	4.5202	0.0335	0.1256	10.9484
Sea conditions (2)	0.3433	0.5629	0.3720	0.5419	0.0000	1.4096
Sea conditions (3)	-1.1437	0.6384	3.2101	0.0732	-0.087	0.3186
SST	-5.3191	1.8514	8.2543	0.0041	-0.197	0.0049
Constant	129.2817	42.5515	9.2309	0.0024		

Mean Deviation: -0.04, SD: 0.7927

Table 2. Factorial Analysis

Factor	Eigenvalue	% of Var.	Cumul. % Var.
1	3.55785	71.2	71.2
2	0.69330	13.9	85.0
3	0.48381	9.7	94.7
4	0.17910	3.6	98.3
5	0.08594	1.7	100

Table 3. Factorial Analysis

Variable	Communality	Factor 1
Distance	0.88683	0.94171
Depth	0.85628	0.92535
DVC	0.70469	-0.83946
Sea condition	0.60412	0.77725
SST	0.50594	0.71129

Determinant of Correlation Matrix = 0.018
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.777
Bartlett Test of Sphericity = 453.669, P <0.00001

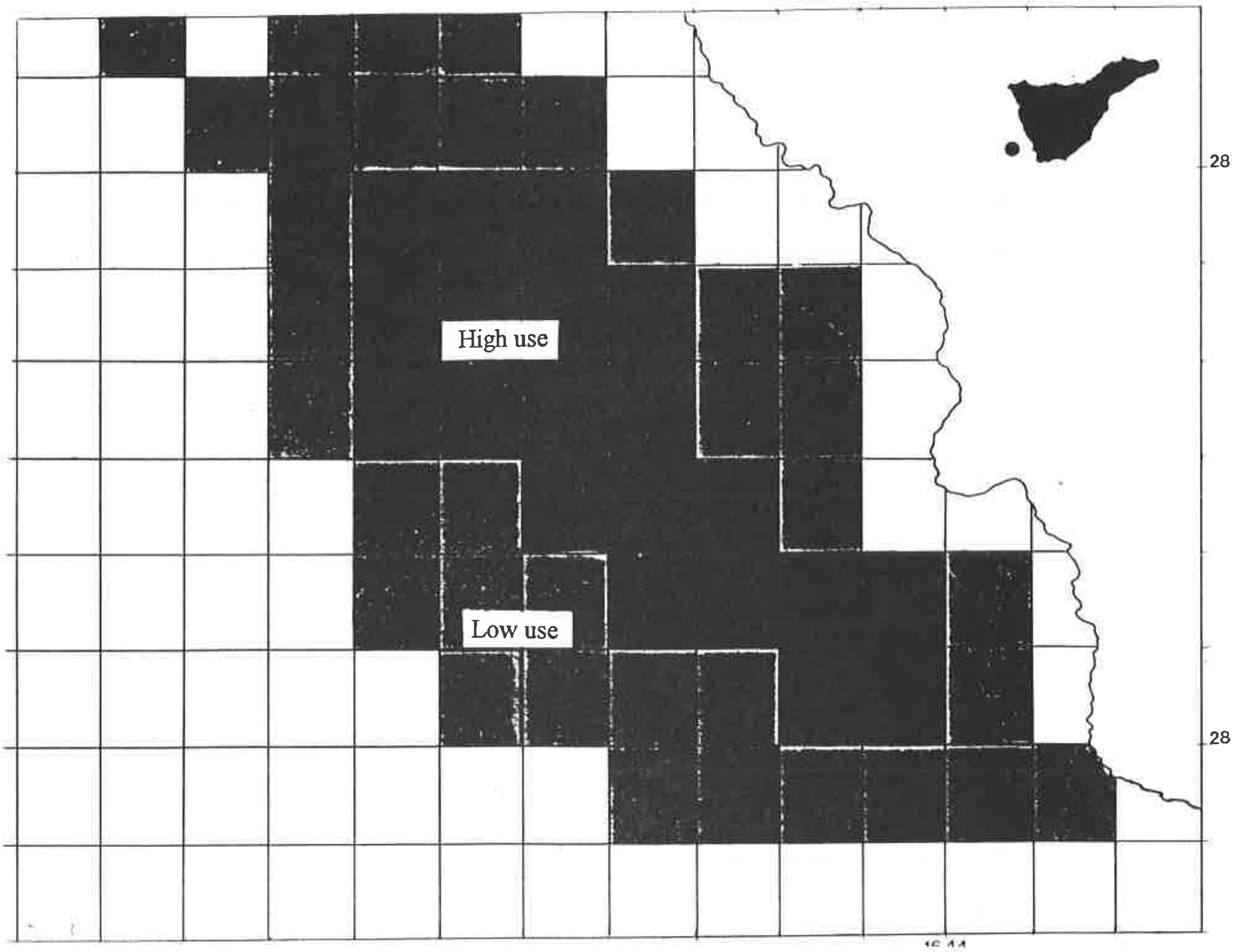

Fig. 1 Distribution Pattern for Short-finned Pilot Whales in Tenerife

DIURNAL ACTIVITY PATTERNS AND BEHAVIOUR IN THE SHORT-FINNED PILOT WHALE (*GLOBICEPHALA MACRORHYNCHUS*) OFF SW TENERIFE, CANARY ISLANDS

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The presence of a resident population of short-finned pilot whales (*Globicephala macrorhynchus*) off the South-west coast of Tenerife has been amply documented. The social ecology of this species is being studied in an ongoing project begun in December 1992. From January to August 1993, I conducted research with the primary purpose of getting to know the activity patterns of the species. This contribution summarises some results from this research.

The study area is situated south-west of Tenerife between 27°58' N and 28°08' N latitude, and 16°40' W and 16°51' W longitude. The submarine topography is characterised by the absence of a nearshore shelf, resulting in a narrow canyon between the islands with an average depth of 1,500 m. This drops into deeper water to the north and the south.

Pilot whales were observed primarily from a 5 m inflatable boat, and they were identified on the basis of characteristics of the dorsal fins. Black and white photographs and colour slides were taken with a 35 mm Nikon 801 camera equipped with a 75 -300 mm zoom lens and data-back for imprinting date and time on each frame. Records included group composition and size, speed and direction of movement, group configuration and activity.

To obtain representative information of the behavioural budget of the short-finned pilot whale, I used instantaneous sampling of focal-group activity every three minutes according to Shane (1991). Each recording session lasted over 30 minutes (N = 10 instantaneous records).

Based on preliminary observations, the activities were divided into four categories: (a) travel, (b) rest, (c) travel/rest - a rest category, and (d) omni-directional activity. Simultaneously, I also recorded surface behaviours in *ad libitum* mode. I completed 47 sessions (470 I.R.), and found that the most frequent activity in the area was travel (N =177; 37.7%), followed by rest N=158 (33.6%) travel/rest N=104 (22,1%) and omni-directional N=31 (6.6 %).

NEW DATA ON THE EXISTENCE OF BOTTLENOSE DOLPHINS IN THE SEA OF AZOV

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INTRODUCTION The Sea of Azov - the largest (approx. 38,000 sq. km) gulf of the Black Sea, is situated in the north-eastern corner of this basin (Fig. 1a). The Kerch Strait, 41 km long and 4-15 km wide, located between the Crimean peninsula and Caucasian coast, is a single waterway connecting both seas; it plays an important role for migratory marine species and, at the same time, for ship traffic. The Sea of Azov is very shallow (max. depth is about 14 m) and not as saline (9-10 g/l) as the Black Sea (17-18 g/l); it is fed by numerous small and two large rivers, Don and Kuban, polluted by run-offs from the main industrial and agricultural territories of south Ukraine and Russian Federation. Thirty to forty years ago, the Sea of Azov was known as one of the most biologically productive seas of the world. Since the mid-1960's, pollution, eutrophication, overfishing, and other human-associated devastating processes have affected the Sea of Azov's ecosystem, and led to the depletion of fish abundance. Nevertheless, the Sea of Azov and contiguous waters of the Black Sea currently remain under pressure from the continued fisheries for turbot, sturgeon and dogfish, using bottom-set gill nets that are so dangerous for dolphins and porpoises (Artov *et al.*, 1994).

There are no recent scientific data on cetacean distribution, abundance, and migrations in the Sea of Azov and Kerch Strait (Beaubrun, 1995). Meanwhile, since the 1930's - 60's (the period of extensive Soviet studies of marine mammal stocks for commercial killing needs), the Sea of Azov is recognised as the most important breeding, calving, and feeding area for Black Sea harbour porpoise *Phocoena phocoena relicta* Abel, 1905 (Kleinenberg, 1956; Geptner *et al.*, 1976; Arseniev, 1980). The above-mentioned authors and others also noted that individuals of all three Black Sea species including bottlenose dolphin *Tursiops truncatus ponticus* Barabasch, 1940, and common dolphin *Delphinus delphis ponticus* Barabasch, 1935, congegated in the Kerch Strait during annual mass migrations of Azov's anchovy throughout the channel. However, no-one recorded common dolphins strictly in the Sea of Azov, and a single record of bottlenose dolphin in this sea was published in 1940 by V. I. Tsalkin. Unfortunately, he did not present indisputable evidence and has written briefly: "Belobochka [common dolphin] does not occur in the Sea of Azov... Harbour porpoise and afalin [bottlenose dolphin] exist not only in the Black Sea, but also in the Sea of Azov, where harbour porpoise is sufficiently numerous, and afalin occurs sporadically."

Currently there is strong opinion circulating among cetologists that bottlenose and common dolphins do not inhabit or even visit Azov's waters. We know one exception (Jefferson *et al.*, 1993), showing, without any references and comments, the presence of*Tursiops truncatus* and *Delphinus delphis* (!?) in the Sea of Azov on their global maps of species' distribution.

METHODS Active searches and records of stranded animals were provided annually during June 1990-95 by two groups of trained volunteers who travelled on foot along Kazantip Bay seashore (Fig. 1b). In April 1994 and May 1995, special stranding/bycatch research expeditions to Arabat Spit were undertaken by BREMA Lab's staff. Interviews of fishermen and local inhabitants were carried out on Arabat Spit and Biryuchy Island.

RESULTS Local inhabitants (not fishermen) do not distinguish between Azov's cetaceans. They use names such as "dolphin", "porpoise" and "azovka" for each and all marine mammals seen in the water or found on the sand. Fishermen know two kinds of cetaceans: small (harbour porpoise = azovka) and big ("non-azovka"). They meet azovkas very often year after year, but "non-azovkas" are not so usual. Fishermen describe "non-azovka" as an animal with a tall falcate dorsal fin and prominent beak, but even experienced persons cannot choose requisite pictures among images of common and bottlenose dolphins.

S. I. Aleko, the head huntsman of Azov-Sivash National Park, told us that in May 1980 he has found alive a young dolphin "non-azovka" in shallow water at the beach of Genichesk. The animal, about 1.5 m long, was slowly drifting on the surface and did not show any resistance to man. There was a deep round (approx. 5 cm in diameter) wound on its back just under the dorsal fin, a possible mark from a fishing harpoon. Another *Tursiops/Delphinus*-like dolphin was found stranded in Kazantip Bay on 28 June 1990. The carcass (1.65 m long) was significantly decomposed. The volunteers (schoolchildren) did not take any bones, samples of teeth, or photos for species identification; it was the only "non-azovka" among 195 cetacean strandings recorded in their field diaries during six years.

The first BREMA Lab's expedition to Arabat Spit examined twenty stranded harbour porpoises, but no signs of other cetaceans were found. The following year, we recorded four stranded harbour porpoises and two bottlenose dolphins, both on sandy shores to the north of Solyanoye settlement (Fig. 1b). The carcass of a young male (No.161-A, 17.5.1995, 1.75 m long) had obvious marks of bycatch: cut-off tail fluke and two deep cuneiform knife-notches on tail trunk (the result of disentanglement from a fishing net). The second carcass of an adult female (No. 164-A, 19.5.1995, 2.73 m) was seriously injured by seabirds; the anterior teeth were almost completely worn, testifying to its senility. Obvious post-mortem lesions of skin and internal organs indicated the probable time of death for both dolphins - late October to early November 1994 (the end of the fishing season, and period before pack-ice develops in that area).

There are two possible interpretations to account for the appearance of bottlenose dolphin carcasses on the west coast of the Sea of Azov: (1) animals were by-caught in the Black Sea or in the Kerch Strait and then translocated by fishermen (artificially) or taken by sea currents and wind (naturally) to the place of stranding; and (2) the dolphins perished directly in Azov's waters. The first hypothesis is less likely than the second one, but only continued studies can "dot all i's and cross all t's" in this matter.

CONCLUSIONS The bottlenose dolphin occurrence is only one small incident in a long list of obscure questions concerning cetaceans of the Sea of Azov. Of course, ignorance of the true situation is does not suit the aims of marine mammal conservation here. It is impossible to obtain necessary reliable information on Azov's dolphins and porpoises without special research programmes including co-operative efforts between Ukraine and Russia.

ACKNOWLEDGEMENTS We are thankful to Pavel Agapov, Sergey Aleko, Victor Bobyor, Marina Narovlyanskaya, Vasily Plebansky, and Alexander Shvatsky for their assistance. Our special thanks to volunteer observers from the Young Naturalists' Station (Simferopol) and Bamby's Club (Kiev).

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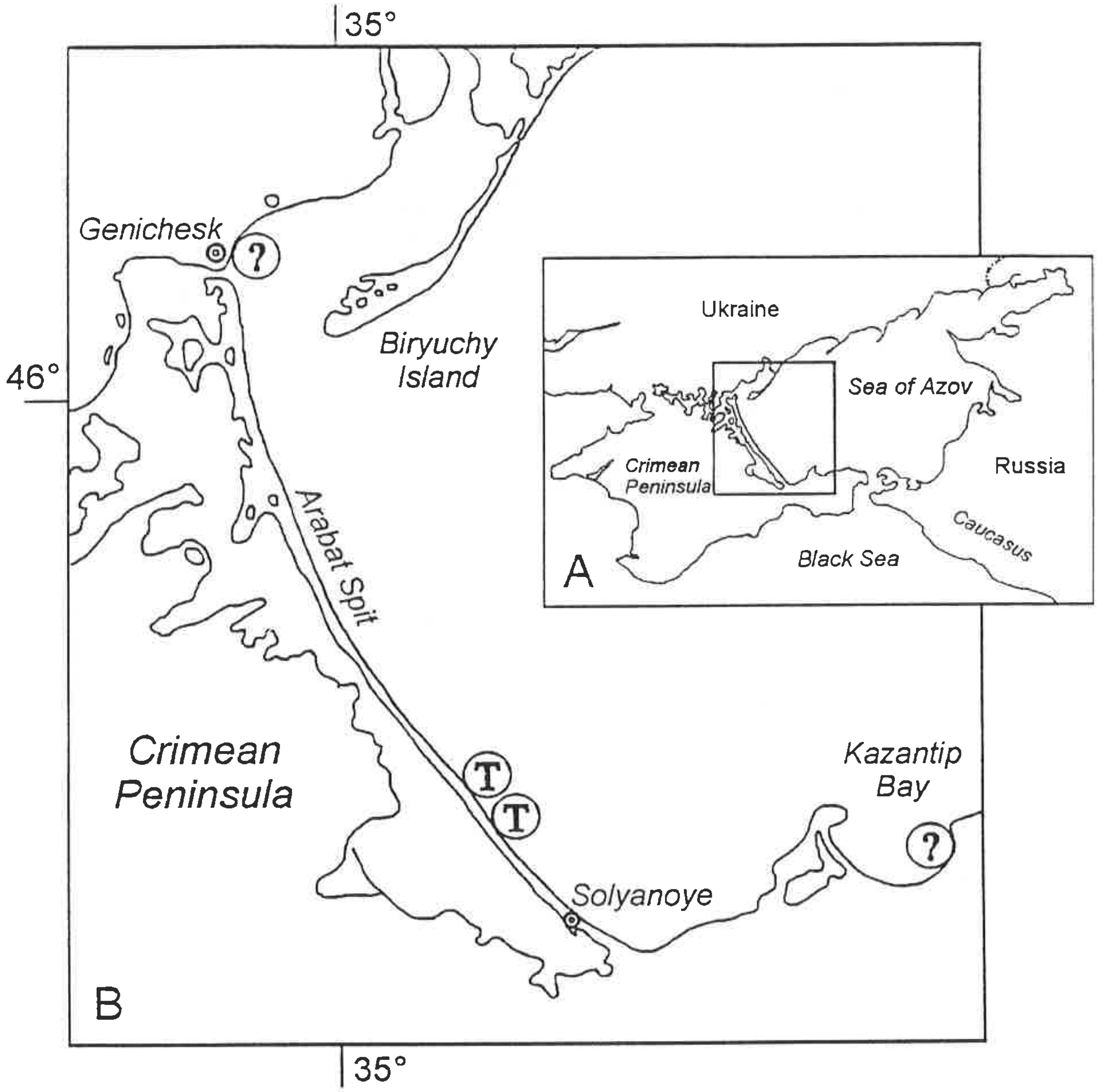

Fig.1 Findings of bottlenose dolphins on the coast of the Azov Sea

(T) - exact cases

(?) - possible cases ("non-azovkas")

A "REMNANT" COMMON DOLPHIN OBSERVED IN ASSOCIATION WITH BOTTLENOSE DOLPHINS IN THE KVARNERIC (NORTHERN ADRIATIC SEA)

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In the course of a longterm study focusing on bottlenose dolphin social ecology and behaviour, conducted since 1987 in the Kvameric (Northern Adriatic Sea), common dolphins - the only other cetacean species observed in the region, were encountered only three times. The same individual common dolphin was photo-identified on all three occasions: the first time (August 1991) with three other conspecifics, and the other two times (August 1994 and July 1995) together with bottlenose dolphins.

In August 1994, the common dolphin was observed in close association with a bottlenose dolphin calf, apparently taking care of it while its mother, nicknamed Badfin, was engaged in feeding activities with the rest of the group. The 1995 observation also included Badfin and her grown-up calf, in close association, while the common dolphin accompanied an adult bottlenose dolphin.

The behaviour of the four common dolphins observed in 1991 consisted of surface-feeding activities rarely seen in bottlenose dolphins in the area. On the other hand, when accompanied by bottlenose dolphins, the identifiable common dolphin behaved exactly like them.

The occurrence of common dolphins in the Northern Adriatic Sea has dramatically declined during the recent decades. The "remnant" common dolphin may have been taking advantage of the benefits of a school by associating with bottlenose dolphins. The care-giving behaviour and the observed patterns of association indicate that the bottlenose dolphins may have considered the common dolphin to be a community member.

AGE DETERMINATION OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*, MONTAGUE, 1821) FROM THE NORTH ADRIATIC SEA

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INTRODUCTION Recent scientific records show that the only species that is regularly seen in the Northern Adriatic Sea is the bottlenose dolphin *Tursiops truncatus* (Kovacic 1986; Brusina, 1989; Bearzi and Notobartolo di Sciara, 1993). In this area, Tethys Research Institute (Milan) has been conducting general research since 1987, including a population study. Therefore, we have found that the information we have collected will contribute towards our knowledge of this species, which has been protected in Croatia since 1995.

There are various methods of age determination of odontocetes (Perrin and Myrick, 1980), and the most common is the examination of layered dentine by microradiography, light microscopy, tetracycline marking, and scanning electron microscopy (SEM). We decided to use SEM because by getting a three-dimensional image of the surface, the tooth growth layers (GLG's) are more easily determined and counted.

Bottlenose dolphins possess cone-shaped teeth which are slightly curved, consisting internally of layered dentine covered coronally by a thin mantle of prismatic enamel, and laterally by layered cementum. Dental deposition may occlude the pulp cavity, and cease before the animal dies. In that case, only the minimum age of the animal can be estimated (Perrin and Myrick, 1980).

Incremental growth layers are layers which occur parallel to the formative surface of the dentine and comprise GLG's. Sometimes an incremental layer appears particularly prominent within the GLG, and is referred to as an accessory layer, defined as an irregularly occurring, non rhythmic layer that disrupts the expected mineralisation pattern and complicates the problem of counting GLG's (Hohn 1978). The effect of confusing the incremental and accessory layers in counting GLG's is diminished by etching.

Etched sections show GLG's as pairs of ridges and grooves that result from a greater collapse of dentinal tissue in those layers which were initially hypercalcified. GLG's in bottlenose dolphin teeth are considered to be annual (Sergeant, 1959), one valley/ridge group indicating one GLG and a neonatal line appearing as a ridge in SEM.

The aim of this study is to determine the age of stranded bottlenose dolphins found between 1990 and 1995 in the North Adriatic Sea.

MATERIALS AND METHODS During the period from 1990 until 1995, eight stranded animals were found in the North Adriatic Sea by Kvarneric and Istra (see Fig. 1); five of these were females and three were males. The animals were measured and some tissue samples taken, together with teeth.

We tried different methods for age determination, including light microscopy of decalcified sections and pencil rubbing, but analyses carried out using SEM were shown to be most reliable.

Two teeth were taken from seven animals and only one tooth from the youngest dolphin (because of the difficulty of making a transverse section of the tooth). Large, straight (and not overworn) teeth were chosen. All the teeth were measured before they were cut, boiled in a trisodium phosphate solution (15g/l), air dried, and stored in 70% ethanol, as suggested in the report of the workshop of the International Conference on determining age in odontocete cetaceans and sirenians (Perrin and Myrick, 1980). Teeth were sectioned with a circular diamond saw. Mid-longitudinal and transverse sections were made.

Both sections were soaked in 5% formic acid at room temperature (25°C) for six hours, rinsed in water, then dipped in acetone (not exceeding three minutes), left overnight in running water to remove remaining acid, and allowed to dry in air.

Sections were mounted on an SEM stub, plated with gold, and viewed with a Philips 515 SEM. We used Polaroid 552 professional film. Micrographs of both longitudinal and transverse cuts were taken at different angles, magnifications, and kV. These parameters were determined during the process of scanning. These photographs included at least one half a tooth from the centre of the periphery.

When counting the GLG's, we used SEM photographs, and gold plated sections which we viewed under the 16x magnification of a stereo-microscope.

Four persons counted GLG's independently, the result were compared, and the age of each animal was estimated.

RESULTS Our sample included eight animals, mostly sexually mature (Peddemors, 1989) and only one was a juvenile (Table 1). Three were very old, and their minimum age was 17 years.

DISCUSSION Decalcification and etching gives very good results for delphinid teeth (Perrin and Myrick, 1980). We found that after the SEM analysis, gold plated sections can be further examined under the stereo-microscope, and results can be confirmed by re-counts.

A possible mistake in counting resulting from a few GLG's in the centre being lost should be taken into consideration , because during the preparation of the longitudinal sections it was almost impossible to cut exactly through the centre of the pulp. We tried to overcome this problem by using transverse sections and, in most cases, they showed few layers more than the longitudinal sections.

In older animals, the main problem was occlusion of the pulp cavity. In that case, we could only estimate the minimum age of the animal. The problem was also "contraction" of GLG's that made them more difficult to read.

Stranded animals were mostly adults, which could be a result of lower mortality of sexually immature animals (Peddemors, 1989), but further studies should be carried out considering these aspects, since this area of bottlenose dolphin biology has not been researched in the Adriatic.

Although small, our sample shows a growth rate (body length against no. of GLG's) similar to other cetaceans in having high initial rate of growth with no difference in growth between females and males (Hohn 1980a; see Fig 2)

Data collected in this study could be used in population studies to examine age distribution, biological parameters such as survival rates, and sexual maturation rates (Calzada and Aguilar, 1995). In general, up to now no research has been done in this field in the Croatian part of the Adriatic Sea, and the collection of a larger sample would help us to provide more information about these cetaceans

ACKNOWLEDGEMENTS We are especially indebted to G. Bearzi and the Tethys Research Institute for providing us with material and lots of useful information. We also thank Prof. H Gomercic of the Veterinary Faculty, Zagreb for giving us samples that he had collected. For the use of the SEM and preparation of the micrographs, we are grateful to R. Holub and R. Slavkovic from INA Naftaplin-Zagreb. Thanks go to D. Holcer who encouraged us during this research, and also to all the other people for their help.

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Table 1. Data about stranded dolphins, their body length, and estimated age

code	date of stranding	sex	length(cm)	estimated age
002	30.07.1992.	male	288	17*
003	25.08.1992.	female	290	17*
004	22.09.1993.	male	241.5	5
005	28.01.1994.	female	263	8
007	21.06.1995.	female	272	17*
G1	16.10.1990.	female	265	7
G2	01.11.1990.	female	164	less than 1
G3	18.06.1992.	male	263	7

* probably more, occluded pulp cavity
002-007 leg. G. Bearzi
G1, G2, G3 leg. H. Gomerčić

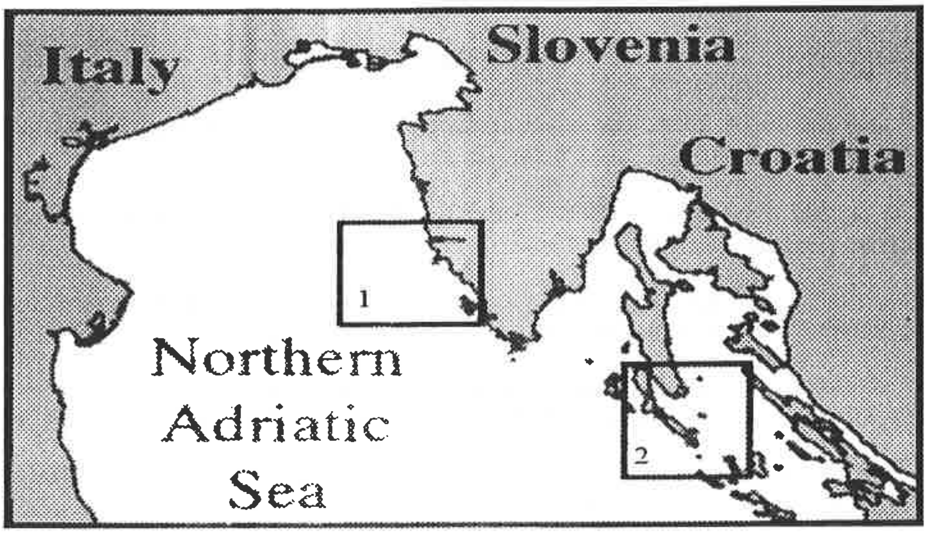

Fig. 1. Map of the research area: 1 - Istra; 2 - Kvarneric

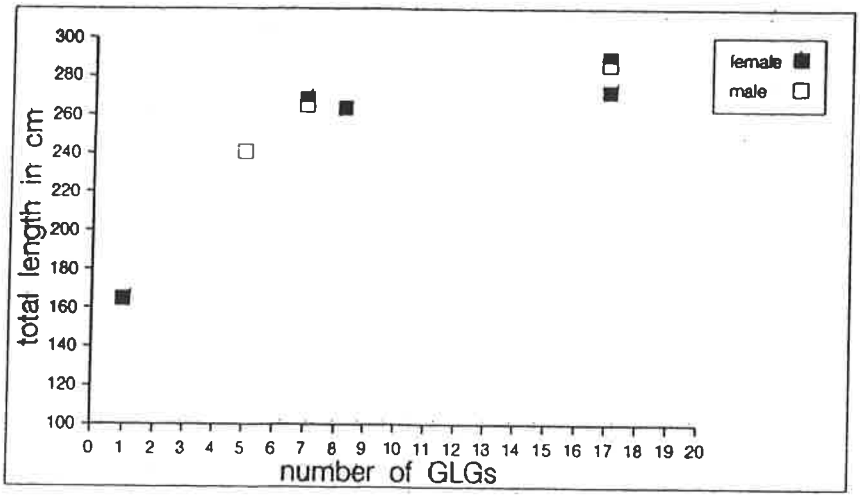

Fig. 2 Total length vs number of GLG's for bottlenose dolphins from the North Adriatic Sea

EFFECTS OF MARINE ENVIRONMENT ON HOME RANGE AND BEHAVIOUR OF A SOLITARY BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

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Correlations between features of the marine environment and the behaviour and home range in wild dolphins have been investigated by monitoring sociable and solitary bottlenose dolphins (*Tursiops truncatus*). A solitary female dolphin, resident off the Catalan coast (North-west Mediterranean) since 1988, is the focal animal of this study. Data from 18 months of monitoring of the dolphin's diurnal and seasonal migrations were acquired using radio-tracking equipment and a well established information network covering the home range. Environmental quality of the home range was assessed by integrating the geographical and ecological characteristics of the different habitats. In particular, data on the climate were used to evaluate ecological influences on the dolphin's behaviour. The relationship between fish migrations in the dolphin's foraging grounds, and the dolphin's seasonal movements indicate the importance of variability in food availability throughout the year. Human activities also have an influence on the dolphin's use of home range.

Biological monitoring of wild, solitary dolphins can provide important information on the direct effect of marine quality and human impact on marine mammals and their behaviour. Results of the present research, however, indicate that the use of the home range by solitary dolphins should be viewed as a "Black Box" System. Characteristics of the bottlenose dolphin have to be taken into account as essential "input". Within highly evolved forms such as primates and dolphins, exploration, curiosity, playfulness, and individuality all influence the behaviour of the animals, including temporal patterns of home range occupation.

A STUDY OF HABITAT USE BY BOTTLENOSE DOLPHINS IN THE SADO ESTUARY, PORTUGAL

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Groups of resident bottlenose dolphins were observed for forty days from April to June 1995 in a study focusing on their distribution and activities in the Sado estuary and adjacent coastal waters, as part of a broader longterm research project on this population.

This habitat includes very shallow areas upstream, with salt marshes, deeper estuary channels bordered by sandy beaches or industrial facilities and harbours, and open waters also on sandy sediment.

Dolphin groups were followed in a small boat for periods from 60 min. to 390 min., and every 10 min. their position was determined using landmarks and an electronic compass. In the 136 hours of direct observation, the numbers of animals near the boat and their behaviour were recorded. Between sample points, behavioral descriptions were recorded. Additionally, the reaction of the dolphins to the presence of boats was noted.

The largest proportion of observation time was spent in the south channel of the estuary (less polluted and with greater flux than the north channel). Near the river mouth and in deeper areas, the groups' surface envelopes were tighter, usually with dispersion upstream.

"Traveling/feeding" and "bottom foraging" were the most frequent activities. Mullets, eels, and cuttlefish have been identified as prey.

OCCURRENCE PATTERN OF BOTTLENOSE DOLPHINS IN THE SADO ESTUARY REGION, PORTUGAL

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The Sado Estuary region is part of the home range of a resident bottlenose dolphin population which since the beginning of the 1980's has been studied by several workers. During the last few decades, the estuary has been subjected to habitat degradation. In order to establish a conservation status for the population, Sado Estuary Nature Reserve initiated in 1994 a longterm monitoring programme.

Photo- and visual identification were used during year-round (1994 and 1995) boat surveys in the study area (212.6 km^2). Location of sightings in the study area and the occurrence of individuals in the school accompanied by calves were noted.

Out of 38 animals identified in 1994, seven were not sighted in 1995. During this year, however, a new animal was identified. It should be noted that these were sighted very rarely in the area. Meanwhile, two carcasses were positively identified as members of the population, and two calves were born. Taking this into account, a conservative estimate of the population size was made, and indicates 31-39 individuals.

The previous observed occurrence pattern of known animals within the calves' school was maintained except for a few animals. One animal that temporarily occurs within the calves' school gave birth. It is interesting to note that this observation shows that peripheral animals may also be females, and thus females with calves from this population may have different movement and habitat use patterns within the estuary region.

In one of these cases, an individual (which subsequent events showed to be a female) that occurs temporarily within the school, joined the calves' school during its latest months of pregnancy and first weeks after birth.

THE SOCIAL STRUCTURE OF THE BOTTLENOSE DOLPHIN, *TURSIOPS TRUNCATUS*, IN THE SADO ESTUARY, PORTUGAL

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For the first time, details of the social structure of the Sado dolphins are presented. The animals were systematically observed throughout 1986/87 and 1992/93, from both boat and shore. Individual dolphins were identified through natural markings on the dorsal fin. Affiliations among individuals were measured using both the Simple-Ratio and the Half-Weight-Indices, and the application of a Cluster analysis.

Based on 13,500 positive identifications, a total of 49 individuals were identified. Only 25 animals were encountered in both study periods. High re-sighting frequencies over the years indicate that these animals are longterm residents in the 150 km^2 study area. This may represent only part of a possibly larger home range. Group sizes ranged from one to over 30, with a mean of nine animals.

The mean association coefficient for the 25 animals in both periods was 0.50 (±0.18). A female-juvenile pair had the highest coefficient (0.94), followed by a pair of two presumed females (0.91). Four pods could be distinguished, characterised by a high degree of site fidelity, and relatively high percentages of females, juveniles, and/or calves. This, and the relatively low total number of individuals identified, suggest that these pods may represent breeding units of a larger community or population.

THE BOTTLENOSE DOLPHIN, *TURSIOPS TRUNCATUS*, ALONG THE GALICIAN COAST, WITH SPECIAL REFERENCE TO THE RIA DE VIGO HERD

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INTRODUCTION The scarce references to bottlenose dolphin *Tursiops truncatus* strandings and sightings in the coastal waters adjacent to North Galicia, and in northern Portugal, contrast with its abundance in the Galician coastal waters, particularly in the Rías Baixas, where the presence of herds is traditionally well known as also testified by the celebration of "bottlenose dolphin fights" (remembering the bullfighting) in the Ría de Pontevedra in the second half of the nineteenth century, the records of fishermen (who have talked about their continuous presence throughout this century), and is also reflected in the study of place-names and in local proverbs.

The rising number of observers in the last few years has resulted in an increase of sightings in the most meridional Rías Baixas, suggesting the continuous presence of bottlenose dolphins throughout the year. With this evidence, a more detailed study of this species was developed in the area where the largest number of dolphin sightings were registered.

STUDY AREA The Galician coast is characterised by the presence of a great number of "Rías", fluvial valleys flooded by sea, with a gradation from the open sea to the end, with oceanic characteristics to estuarine ones, respectively.

The Ría de Vigo extends over 176 km^2, and lies between 42° 09' N to 42° 21' N and 8° 37' W to 8° 54' W. Its length is 33 km, varying in width between 10 km at the mouth and 0.6 km in Rande Strait near its end (Fig. 1). The maximum depth is found at the mouth, where it is 27 m deep on the north side and 48 m on the south side, highlighting the presence of a central canyon reaching depths of 43 m. The Atlantic Galician coast has an average tidal range of 3 m.

The mass of water currents into the "ría" are very complex (with tidal currents, a flowing estuary, and Corioli's forces). There is a surface current towards the mouth and another compensating for it at a geater depth moving in an opposite direction, and having an influence on stratification of the waters and the entry of deep waters from the Eastern North Atlantic Central Water (ENACW) system, slightly modified, and related to frequent movements of deep waters rising to the surface. These movements produce high biological productivity.

MATERIALS AND METHODS During 1995, a network of sixty helpers including fishermen, students, mussel raft owners, shell-fishermen, etc, was created in the Ría de Vigo, mainly on its northern shore. Their aim was to report the occasional sightings of bottlenose dolphin by recording on a card the following data: date, hour, number of specimens, presence of calves, behaviour, place of observation, and direction of movement. All those sightings made by different observers within periods of time exceeding 20 minutes were considered as separate records. These observations were carried out both from the coast and from vessels. The helpers were informed four times a year about the results obtained, so as to maintain the feedback of the network. Opportunistic sightings were also carried out from land by using both binoculars (7x35, 8x30) and telescope (20-60x), and, from the sea, by using kayaks and motor boats. The sightings were collected using a dictaphone.

Photographs for individual identification were taken from land and from boats using 500, 80-200 and 35-70 mm lenses, and slide, black and white and colour films of 100-400 ASA. The photographic material was studied with a 20x binocular. The dorsal fins in good position were enlarged, and those easily recognised were drawn.

The zones with different categories of presence of bottlenose dolphin in Galicia were defined from the data collected during 1995 in the Ría de Vigo, and from the Galician registrations of occasional sightings of coastal bottlenose dolphins in the files of the CEMMA (Cetbase) in the 1987-94 period. The reporting and subsequent recording of cetacean strandings are undertaken by institutions, public reports, and also by the coastal surveys made by the CEMMA members. The sighting records are mainly registered by opportunistic observations, and also by periodic surveys carried out to detect and follow group movements of bottlenose dolphins.

RESULTS AND DISCUSSION From 905 sightings between 1987 and 1995, we have set different categories of presence in six areas along the Galician coast (Fig. 2). From these records, we think that there are both coastal and resident groups in those sheltered places, and with a high quantity of available food in the "Rías Baixas". Thus there is a possibility that these groups are interrelated with each other. In Figure 1, we also show the sites and distribution of strandings and incidental catches of bottlenose dolphin in the same areas (n=76), without attempting to relate these strandings to the presence of coastal groups in the "rías", since there are observations of feeding that show the animals stranding come from groups feeding out along the continental shelf.

In the Ría de Vigo, a network of observers registered the presence of bottlenose dolphins on 181 days distributed throughout the whole of 1995, with an average recorded presence of 15.4 days a month (Fig. 3). A decrease in the number of observations is noted in January (coinciding with the beginning of our network of observation), December (caused by bad weather conditions and the difficulty of observation), and August (with the longest period up to 19 consecutive days without sightings, and so far without any apparent explanation) when the few records are concentrated at the mouth of the "ría" (Fig. 4).

Most sightings are located near the coastal zones that do not exceed 20 m depth, and the preferred feeding grounds seem to coincide with inlets and mussel rafts.

The Ría de Vigo is considered the core area of a herd since most of its daily life occurs here (485 records in 1995 distributed throughout the 24 hours of a day), although the individuals of that herd occasionally move towards the open sea, so that a larger home range and possible connection with herds from the contiguous Ría de Pontevedra cannot be rejected.

The size of the herd varies from 1 to 50 individuals with a standard median size of 18.03 (n=169), a minimum of 9.91 (n=17) in July, and maximum of 26.00 (n=23) in November (Fig. 5). Summertime differs from the rest of the year with standard median group sizes of 21.04 individuals from January to March (n=26), 19.12 from April to June (n=61), 11.91 from July to September (n=35) and 19.23 from October to December (n=47).

The Ría de Vigo has an average density of 0.1 individuals/km^2, a comparable value to that found in the Bay of Archaron.

Except in August and December, there are records of calves in the herd throughout the year. The maximum number of calves sighted in a single observation was four.

The photographic identification of 15 individuals was accomplished (Fig. 6). They were all sighted more than once, and the presence of two of them has been proved for five and seven months respectively throughout 1995, with the presence of the latter record also in the previous four years.

From this, we can conclude that a resident herd of bottlenose dolphins is present in the Ría de Vigo.

INTERACTIONS WITH THE MAN Bottlenose dolphins have always been considered a nuisance by fishermen for being their direct competitors and for the damage they usually cause to their nets, so that they have been actively persecuted, and many legal regulations were enacted in the past (R.O. 23.04.1911) to control their increasing numbers. Firecrackers are used nowadays by fishermen to keep them away, and they are falsely said to be responsible for the decrease in the amount of fish in the "ría".

The Vigo city (with 300,000 inhabitants), with car, canning, and ship industries, and with one of the greatest growth rates in Europe this century, is situated on the southern margin. Urban and industrial sewage treatment plants do not exist at the moment. The marine resources generate 7,000 direct jobs in the "ría". 740 fishing vessels and 511 mussel rafts of 500 m^2 each are registered, and shell-fishing both on food and from small boats is practised.

The coastline has suffered dramatic modifications due to landfills that have changed the currents and the sedimentation areas causing degradation on the sea bottom and increasing the amount of mud in the waters. 4,700 pleasure boats are registered in Vigo at the moment (176 boats/km^2), and there is an unspecified number of jet-skis because their registration is not compulsory. A maritime filling station is proposed in order to attract the traffic of the second most visited route in the world, averaging 40,000 vessels per year.

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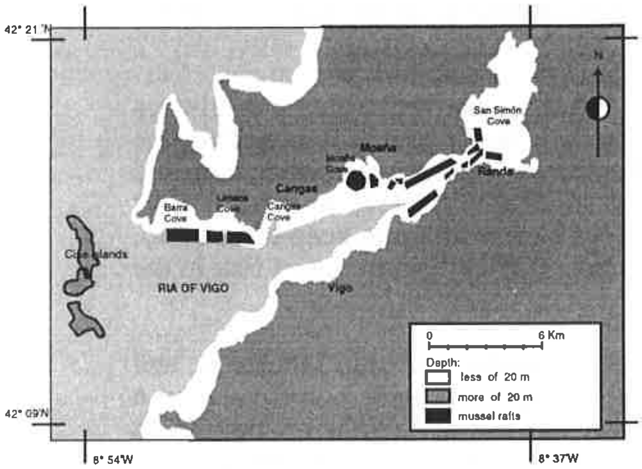

Figure 1

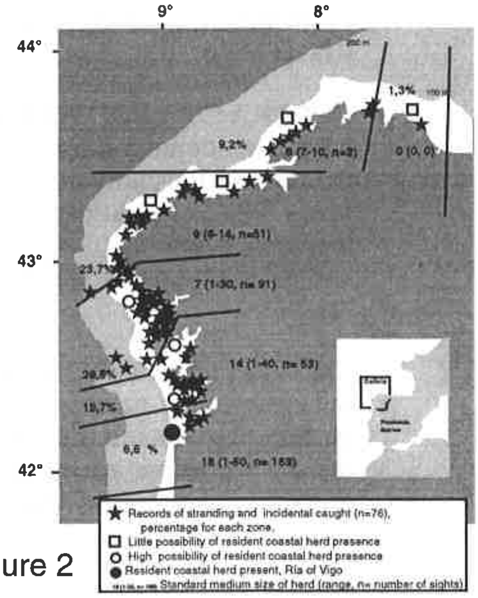

Figure 2

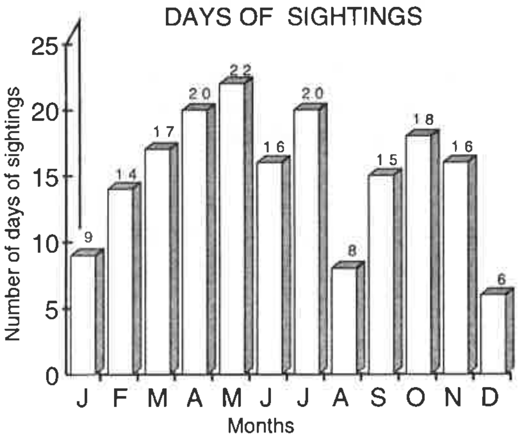

Figure 3

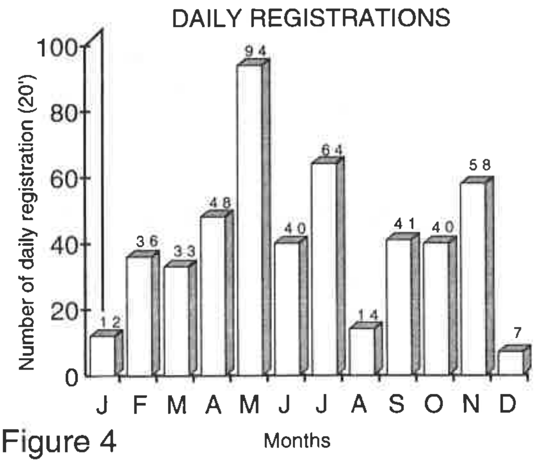

Figure 4

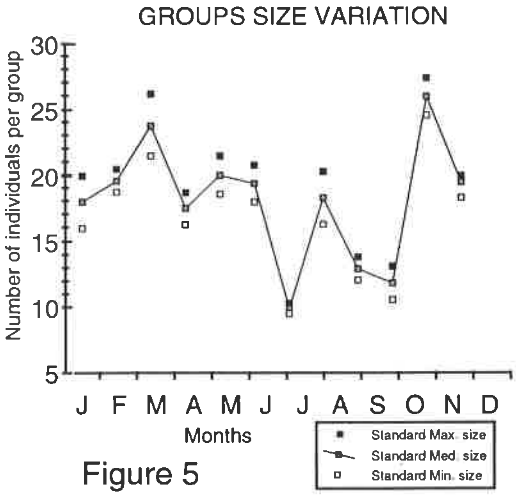

Figure 5

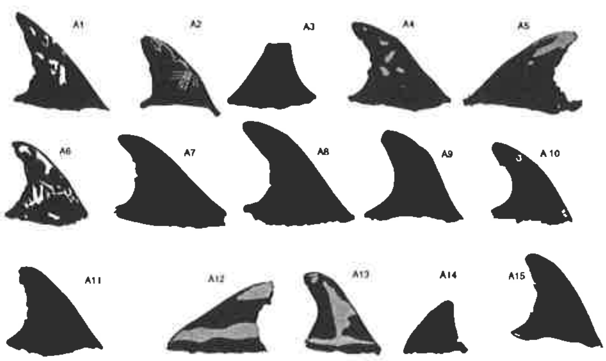

Figure 6

A PRELIMINARY REPORT ON AN INVESTIGATION INTO BOTTLENOSE DOLPHINS (*TURSIOPS TRANCATUS*) OF THE ENGLISH CHANNEL: A COLLABORATIVE APPROACH

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INTRODUCTION A number of French and English researchers have been conducting studies of bottlenose dolphins (*Tursiops truncatus*) along the French and English coasts of the Channel (Evans, 1992; Harland, 1995; Ridoux, 1995, Tregenza, 1994, Williams, A., 1995). Within Britain, there has been little awareness of dolphins living along this coast, with most public attention going to populations in Cardigan Bay (West Wales) and the Moray Firth (North-east Scotland). A need was identified to investigate the use of the Channel by bottlenose dolphins on an broad-based rather than local basis. Individual bottlenose dolphins are known to range over great distances (Thompson and Wilson, 1994). To bring together the work of these researchers, a Channel Coast Dolphin Workshop was organised by the Sea Watch Foundation in 1994.

Two one-day workshops have now been held during the autumns of 1994 and 1995 at the Durlston Country Park Visitor Centre, Swanage, Dorset, UK. Delegates were invited from cetacean projects throughout the Channel.

OBJECTIVES The main aim of the workshops have been to investigate the population biology and behaviour of bottlenose dolphins in the Channel and Western Approaches using a collaborative approach that brings together different research groups and individuals. The four principal objectives are:

- To establish regular contact and promote co-operation between all cetacean research groups along the French and English Channel coasts.
- To hold an annual meeting to review projects, discuss methodology, and compare and exchange data on bottlenose dolphins in the study area.
- To produce a joint catalogue of all photographically identifiable bottlenose dolphins in the study area.
- To facilitate an investigation of bottlenose dolphins to determine:
  a) location and home range of distinct populations; b) demography of these populations; and c) movements of individuals within the Channel region

METHODS Delegates agreed to produce a catalogue of all photo-identified bottlenose dolphins in the Channel. The catalogue will be reproduced and distributed to all people concerned with bottlenose dolphin studies in the Channel. It will serve as an immediate reference against which to compare individual dolphins from which the location, home range, and identity of distinct populations will be determined. The catalogue will be updated regularly.

The comparison of photo-ID data is achieved by initially reviewing the Channel Coast Dolphin Catalogue to which research projects have contributed tracings of identified individuals. Slides and photographs are then selected for closer scrutiny of those individuals where there is a potential match between sites. Slides are projected and superimposed onto a screen, and further tracings made during the analysis. The distinguishing features usually used for photo-identification are then used to determine an animal's identity; i.e. by dorsal fin nicks, pigmentation, and scars.

RESULTS A preliminary dolphin catalogue, comprising three main data sets representing animals from Dorset, Devon/Cornwall, and the Archipel Molene Ouessant and Ile de Sein in Brittany, has been produced. The format of these data varies between the contributing sites. Vincent Ridoux of Océanopolis, Brittany, has produced a colour photocopy layout for text and images, and this will be used as the final format for individual animals to be entered into the catalogue, to be funded by the French Ministry of the Environment (Fig. 1). As a result of the workshop, additional photo-identification projects are being established. These projects will report to the 1996 workshop, expanding the identification catalogue. The first edition of the catalogue will be circulated early in 1997.

During the 1995 workshop, the delegates were invited to plot all their bottlenose dolphin sightings for the previous twelve months up to the date of the workshop in November. Separate distribution maps of the Channel for each each month of the year were produced. The results indicated a general east-west seasonal migration. During winter, most sightings along the south coast of England occurred around Cornwall. During spring, sightings occurred eastwards as far as the east Sussex coast. By summer, the majority of sightings were from Lyme Bay eastwards, whilst during autumn, most sightings occurred off the Dorset coast east to the Isle of Wight (Hampshire) (Fig. 2). Sightings of bottlenose dolphins in the Channel Islands peak in July and August, at the same time as animals are seen in greatest numbers off the north Brittany coast. Further south, two distinct groups associated with the Archipel Molene Ouessant and Ile de Sein. One group comprises only 14 individuals occupying a home range of c. 6 km^2; the second comprises 22 individuals. Both groups are resident year-round in the region.

CONCLUSIONS Sightings observations and Photo-ID studies indicate that members of a group (estimated to number up to about thirty animals) start to move eastwards in spring, along the Cornish coast into Devon, Dorset, and finally, Hampshire, during the summer and early autumn. Bottlenose dolphins are seen in most months around the Channel Islands, although peak numbers and frequency of sightings occur in July and August, extending primarily through to November.

Initial comparisons of photographs taken of bottlenose dolphins taken in 1992 in Cornwall, and in 1995 in Dorset, have also produced positive matches of two individuals. Together, these preliminary findings demonstrate the value of groups of researchers from different geographical regions collaborating with one another in this way, and, by so doing, attempting to establish the extent of movement of individuals or groups of bottlenose dolphins throughout the Channel.

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Thompson, P. and Wilson, B 1994. *Bottlenose dolphins.* Colin Baxter Photography. 72pp.

Identification Sheets — *Fiches d'identification*
Bottlenose dolphins — *Grands dauphins*
Tursiops truncatus — *Tursiops truncatus*

Research group name :
Nom du groupe de recherche

Address :
Adresse

Name and tel. number of contact person:
Nom et num. de téléphone du responsable

Name or code for animal :
Nom ou code de l'animal

Site/*Site* :
Identified by:
Identifié par

Date of first identification :
Date de 1ère identification

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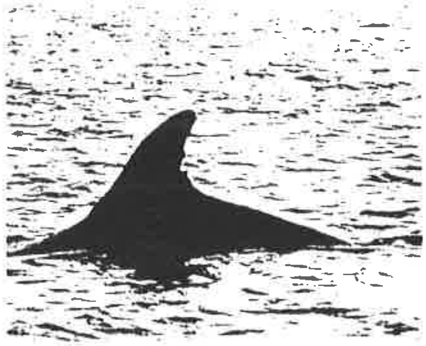

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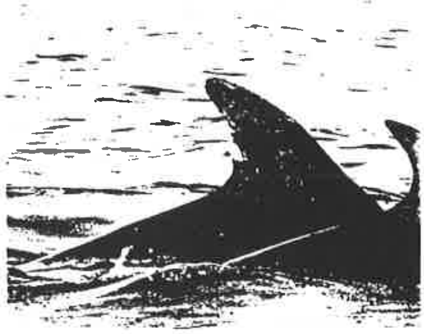

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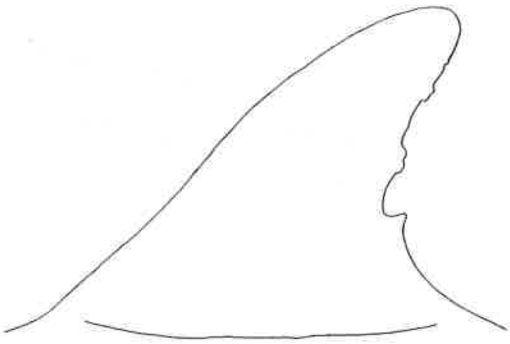
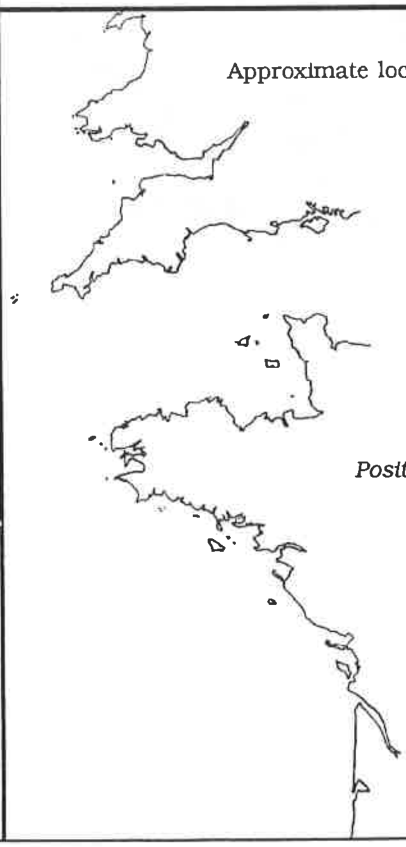
Dorsal fin contour / *Contour de l'aileron dorsal*





Approximate location of sightings

Position approximative des observations

Other identification clues
Autres critères d'identification

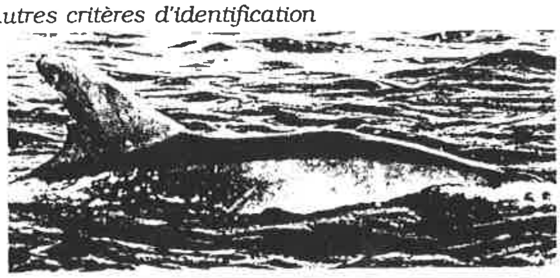
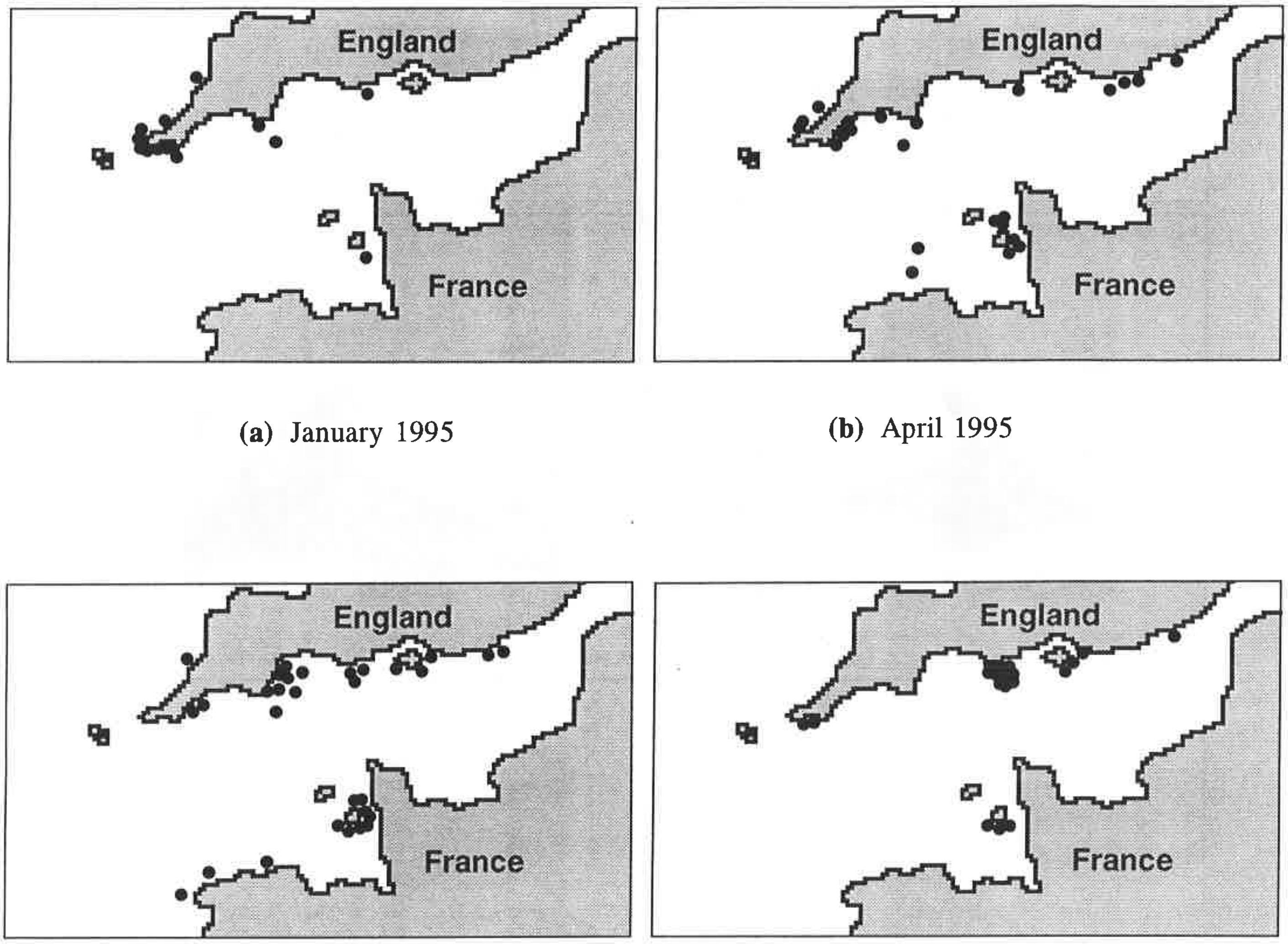


Fig. 1 Reproduction of a page from the Channel Bottlenose dolphin catalogue



(a) January 1995 (b) April 1995

(c) July 1995 (d) September 1995

Fig. 2 Reproduction of maps of bottlenose dolphin sightings from the Channel during (a) January; (b) April; (c) July; and (d) September 1995

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

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INTRODUCTION Since 1992, the Alnitak Project has conducted a research programme on cetaceans along the south-eastern coast of Spain. Five species are commonly seen: bottlenose dolphin *Tursiops truncatus*, common dolphin *Delphinus delphis*, striped dolphin *Stenella coeruleoalba*, long-finned pilot whale *Globicephala melas* and Risso's dolphin *Grampus griseus*. More rarely, sperm whale *Physeter macrocephalus* (*catodon*) and fin whale *Balaenoptera physalus*, are also observed. Two other species have also been seen on one occasion: Cuvier's beaked whale *Ziphius cavirostris* and false killer whale *Pseudorca crassidens*. Photo-ID material has been collected on the bottlenose dolphin, common dolphin, pilot whale and Risso's dolphin. For the moment, the analysis of this material has centred upon Risso's dolphins. Records of this species in the western Mediterranean, and especially in the more south-westerly area (i.e. the Spanish Mediterranean coast and the Algerian and Moroccan coast) are very scarce. The North African coast is said to be very poor in Risso's dolphins (Boutiba, 1993; Duguy, 1990), and also along the Spanish coast, this species is considered scarce (Evans, 1987; Duguy, 1990). The greatest concentrations of this dolphin species seem to occur mainly in the Ligurian Sea (Evans, 1987; Duguy, 1990; Beaubrun *et al.*, 1995), where it is seen all year round (Gannier, 1992; Beaubrun *et al.*, 1995; Bompar, *pers. comm.*). In this paper, we present data collected from four years of research along the south-eastern coast of Spain.

MATERIALS AND METHODS Sighting cruises were carried out on board the 60' sailing boat "Toftevaag", during the months of April, June, July, August, Sept and Nov 1992 to 1995, covering the area from Cabo de Palos (37°38' N, 0°33' W) to Almerimar (36°20' N, 2°55' W). Navigational, oceanographic and meteorological data were recorded during surveys. During cetacean encounters, data were recorded on the species, number of individuals, social structure and behaviour. Since 1995, most of the data collected during surveys was directly down-loaded from the GPS to a personal computer which was running IFAW's "LOGGER" computer program. Whenever possible, individuals were photographed using two 35 mm cameras with lenses of 75 to 200 mm focal length (one camera with autofocus lens), and Kodachrome or Ektachrome 200 ASA slide films. Distinctive natural marks on the dorsal fin and the body, as well as some pigmentation patterns, were used for individual identification. For the analysis of distribution, the entire research region is divided into four major areas (I=north, II=centre, III=south and IV=south-west) which, in turn, were subdivided into 5 x 5 nm. quadrats. Area IV was only surveyed during the years 1992 and 1995. In addition, six depth ranges were considered: 0-200, 200-500, 500-1,000, 1,000-1,500, 1,500-2,000 and >2,000 metres in depth. Sea-state was also taken into account for the analysis. Sea-state was divided into five categories using Douglas sea state scale: 1, 1S, 2, 2S and 3 (S denotes swell). Survey effort stopped if the sea-state achieved a value greater than three.

RESULTS AND DISCUSSION 8,727 nautical miles of sailing effort was carried out. Thirty-one sightings of Risso's dolphin were made, of which photo-ID material was obtained from twenty-three. Additionally, in 1990, six sightings were made during four days of survey effort, which covered 410 nm. of the Algerian coast. The encounter rate of 0.36 indivs. per 100 nm. sailed in the research region, was calculated for this species. A notable increase in sightings was recorded during 1995, with an encounter rate of 0.68 (as compared to rates of 0.32 for 1992, 0.19 for 1993 and 0.25

for 1994). This was also observed by other ships sailing in the region, such as the "Cornide de Saavedra" of the Spanish Oceanographic Institute I.E.O. (Julio Mas, *pers. comm.*). On the other hand, an encounter rate of 1.46 was calculated for the Algerian coast. This latter result apparently shows an important presence of Risso's dolphins off the Algerian coast, which has some interesting oceanographic features such as a very short continental shelf, the Habibas and Algerian escarpment, and the North African current (Arnone, 1984; Wiesenburg *et al.*, 1986). This rate, however, only represents a four-day survey, and the result should be regarded tentatively until more surveys are carried out in the area.

Most of the sightings were made in areas with a water depth of between 400 and 1,200 m (90.3% of the sightings) with a peak in areas of between 800 and 1,000 m depth (32.3%), as reported in other literature (Gannier, 1989; Fabri *et al.*, 1992; Pulcini *et al.*, 1993). Two sightings (6.5%) were made in a region with a water depth of 1,700 m. Some of the groups were tracked for several miles, and in most cases they seemed to follow depth contours, especially those around 600-800 m depth (see Fig. 1). These results apparently agree with reports that Risso's dolphins are teuthophagous, shown by the stomach contents of stranded animals, with mesopelagic cephalopods forming the bulk of the diet of Risso's dolphin, especially squid from the genus *Histioteuthis* (Bello, 1992; Carlini, 1992; Fabri *et al.*, 1992; Wurtz *et al.*, 1992). These squid are known to live usually in areas between 500 and 1,000 m in depth (Guerra, 1992). For 28 of the 31 sightings, an average group size of 17.2 was recorded (range 2-55, SD=13.88). Of the three other sightings, one was of around one hundred individuals, seen at the same time, spread out in three to four sub-groups. The other two sightings were of lone individuals, both of them injured: one was an old animal with a cut dorsal fin, and the other was a juvenile with a 6 m piece of nylon fishing line (longline) entangled around the base of the tail, which was reduced to flaccid tissue due to the desperate movements of the animal to disentangle itself.

The number of individuals photographically identified was 128 from both sides, 88 from the left side only, and 65 from the right side. This means that a minimum of 216 (assuming that all 65 right sides correspond to one of the 88 left sides) and a maximum of 281 (supposing that all left and right sides are from different individuals) animals occur here. A comparison of the visually estimated number of dolphins per group and the number of individuals photographically identified shows that between 44% and 100% of the specimens could be identified - with 16 sightings where 100% of the individuals could be identified. In total, between 71 and 81 animals (28.8 - 32.9%) were sighted more than once (up to five times), some within a year and some in different years (see Table 1). Of the 23 groups for which photographs were taken, only three had all new individuals without "re-captures". The other twenty groups shared one or more individuals, with one or more different sightings. This could indicate the possibility that the groups sighted were sub-groups of a larger herd or population. The recaptures tend to show a variable composition of sub-groups from one sighting to another, with the exception of some individuals that seem to be more strongly associated, since they were seen together in the same sightings over a period of three years (Table 1).

ACKNOWLEDGMENTS The authors would like to thank the more than 350 volunteers who have contributed to the watches onboard the "Toftevaag", and to the financial support of this research. Special thanks are due also to A.N.S.E. Cartagena, Julio Más (Oceanographic Institute of Mar Menor), the local office of the government of Murcia, the Environment Agency (Delegación Provincial del Medio Ambiente) of Almería, and the customs and guardia civil of the region, for their support and collaboration. We are also especially grateful to IFAW for supplying the Logger program, and to Jauma Forcada for his advice.

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INDIVID.				SIGHTINGS																						
				1992						1993			1994				1995									
				July		Sept.				June		Ag	July		Ag	Sep	July					Ago.			Sept.	
				21	23	3	12	21	28	19	20	14	3	24	17	27	12	15	15	15	27	5	7	26	25	28
Nº		L	R	159	165	196	206	215	216	237	240	280	359	388	414	465	500	505	507	508	529	546	559	597	650	663
3	A	X	X	●										●				●	●							
6	A	X	X	●										●				●	●							
9	A	X	X	●										●				●								
146	A	X	X	●										●				●	●							
20	A	X	X			●	●	●																		
22	J	X	X			●	●	●	●																	
23	A	X	X			●	●	●	●																	
28	A	X	X			●	●	●	●																	
18	A	X	X			●	●																			
21	A	X	X			●	●		●																	
27	A	X	X			●	●		●																	
19	A	X	X			●		●	●																	
24	A	X				●		●	●																	
30	J	X	X				●	●																		
118	J	X	X				●				●					●										
218	A		X				●													●						
41	A	X						●	●																	
45	A	X	X					●	●																	
52	A	X	X					●	●										●							
53	A		X					●	●																	
55	A	X	X					●	●																	
56	A		X					●	●																	
57	A	X	X					●	●		●															
58	A	X	X					●	●																	
61	A	X	X					●	●																	
65	A		X					●	●																	
67	J	X	X					●	●							●				●	●					
68	A	X	X					●	●						●											
69	A	X	X					●	●																	
71	A		X					●	●																	
73	A	X	X					●	●																	
84	J		X					●	●																	
94	A	X						●	●																	
95	A	X	X					●	●																	
96	A	X	X					●	●																	
97	A	X	X					●	●																	
247	A		X					●	●																	
89	A		X							●	●															
103	A	X	X							●	●	●	●													
100	A	X	X							●				●							●	●				
101	A	X	X							●				●							●	●				
102	A	X	X							●												●				
105	A	X	X								●			●				●				●				
107	A	X	X								●			●								●				
112	A	X	X								●								●							
113	A	X	X								●												●			
115	A	X	X								●												●			
117	A	X	X								●			●				●								
121	A	X	X								●			●				●								
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128	A	X										●	●													
130	A	X	X									●	●										●			
131	A	X	X									●	●													
132	A	X	X									●	●													
133	J	X	X									●	●													
135	A	X	X									●	●													
137	A	X	X										●			●										
136	A		X											●		●										
143	A		X											●						●						
175	A	X	X															●	●							
183	A	X	X																●			●	●			
189	J	X	X																●				●			
191	A	X																	●			●				
262	A	X	X																●				●			
204	A	X	X																	●			●			
208	A	X	X																	●	●	●				
211	A	X	X																	●	●	●				
212	A	X	X																	●	●	●				
221	A	X	X																		●	●				
222	A	X	X																		●	●				
228	A	X	X																		●	●				
229	A	X	X																		●	●				
231	A	X	X																		●	●				
232	A	X	X																		●	●				
234	A	X																			●	●				
235	A	X																				●	●			
242	J	X	X																			●	●			
243	A	X	X																			●	●			

Table 1. Recaptured individuals of *Grampus griseus*

ANALYSIS OF HARBOUR PORPOISE *PHOCOENA PHOCOENA* STRANDING RECORDS IN THE NETHERLANDS: 1920 - 1994

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Historical stranding records in the Netherlands date back to the 1920's. Well documented sightings are available for the 1930's. Although these records do not reflect abundance, they do tell something about the population structure during this period. For 1920-94, over 1,700 records are available.

The number of neonate or very young porpoises (size 84 cm) has decreased dramatically, from 28% of all recorded strandings for 1920-34, to 5.6% for 1985-94. Systematic and anecdotal sightings confirm this trend. The once abundant summer population has virtually disappeared.

Pelvic bones can be used as indicators of sexual maturity in male and female harbour porpoises. Using pelvic bones collected in the 1920's and 1930's, we looked for possible differences in the length of attaining sexual maturity between those porpoises and animals stranded between 1990-94. No statistically significant differences were found.

Anecdotal sightings and stranding records suggest that a serious decline occurred between the late 1950's and early 1960's. In 1956/57, there was a significant increase in strandings, possibly indicative of an increased mortality.

The causes of the decline are part of our further study, and are thought to be related to pollution, bycatches, or overfishing. 165 porpoises stranded between 1970-94 have been aged: 26.3% were one-year old, only 3.5% were over 10 years old. These values do not differ greatly from those in other porpoise populations studied, no matter whether the samples were from bycatches or strandings; about 10-20% of recent Dutch strandings are bycatches. However, the age-classes 2-3 and 3-4 yrs appear to be under-represented. It is unclear whether this signifies some kind of spatial separation for these age-classes.

ASPECTS OF DISTRIBUTION AND BIOLOGY OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN THE GERMAN NORTH AND BALTIC SEAS

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The harbour porpoise is the most common cetacean in the German North and Baltic Seas. Since 1990, all strandings on German coasts and bycatches from German fishermen have been recorded and examined. Complete autopsies and zoological examinations were carried out on these specimens. All incidental sightings of harbour porpoises in German waters were recorded centrally at the University of Kiel and at the German Museum for Marine Research and Fishery in Stralsund.

Along the German North Sea and Baltic Sea coasts, approximately 120 dead harbour porpoises were found annually, with 37% of these animals younger than one year. The distribution of dead stranded animals along the German North Sea coast clearly shows a decrease in density from north to south. The analyses of incidental sightings in the German Bight and Kiel Bight gave a similar picture. The waters around the Isle of Sylt constitute both an area of high density as well as a breeding site. The sighting rate of porpoises and the number of strandings in the Baltic Sea were much lower than in the North Sea.

A total of approximately 500 stranded and bycaught cetaceans from the North Sea and Baltic Sea were examined. The maximum length of the animals were 1.64 m for females, and 1.56 m for males. The maximum weight of the animals were 78 kg for females and 45 kg for males. The oldest harbour porpoise was a 22-year old female from the Baltic Sea. The age of the oldest male was 20 years. Mean length of neonates was 0.78 m and mean weight was 9 kg.

Infdormation on age and length in relation to sex and location found were taken to calculate growth curves. The shape of the curves indicates that females older than one year were larger than males of the same age.

Females in the North Sea attain sexual maturity at the age of four year, and males between two and five years. For harbour porpoises in German waters, mating is assumed to take place between June and August.

THE COASTAL WATERS OFF THE ISLAND OF SYLT (GERMANY) AS A BREEDING AREA FOR HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

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INTRODUCTION Harbour porpoises are the most abundant cetaceans in the North Sea. Nevertheless, they are threatened due to a high annual bycatch. In the Danish bottom-set-net fishery for cod and turbot alone, an annual bycatch of 4,449 harbour porpoises has been calculated based on an observer programme in this fishery (Vinther, 1995). Since there are no data available on other fisheries, it can be assumed that the annual bycatch is considerably higher than this figure.

To provide effective protective measures, it is necessary to learn more about their favoured areas and particularly their breeding areas. Therefore, we investigated the coastal waters of Schleswig-Holstein for mother-calf pairs of harbour porpoises.

METHODS As part of a national research project on the abundance, health status, and migration of cetaceans in German waters, thirteen freezers are deployed along the North Sea coast of Schleswig-Holstein in order to store stranded cetaceans. Postmortem examinations were performed at regular intervals to investigate biological parameters and the state of health of the cetaceans.

In addition to collecting stranding data, an aerial survey was conducted along the west coast of Schleswig-Holstein, Germany. A high winged twin engine plane, equipped with bubble windows on both rear seats, was used for the survey. Flights were made along zig-zag tracks designed before starting the survey.

Weather conditions were registered constantly, whereas quality of the conditions was mainly dependant upon sea-state. Sea-states 0 and 1 were considered good, whereas sea-state 2 was considered moderate. Other factors influencing the sighting conditions included turbidity of the water and cloud cover.

In the aerial survey, 5.35 h. were flown in good and moderate conditions: on 25 June and 21 July, 1995, along the North Sea coast of Schleswig-Holstein.

In addition to this survey, sighting data from the SCANS aerial survey (Hammond *et al.*, 1995), and from an aerial survey conducted in 1992 in German waters (Heide-Jørgensen *et al.*, 1993) were analysed for data on mother-calf pairs.

RESULTS Of the 447 harbour porpoises stranded between 1990 and 1995 along the North-Sea coast of Schleswig-Holstein, 169 (37.8%) were calves. Most of them (122, or 72.2%) were found on the island of Sylt, where the calf-adult ratio of strandings was 42.7%. A further 7.1% of the calves stranded on the neighbouring island of Amrum. The remainder were spread along the coast with decreasing numbers southwards (Fig. 1).

In the aerial survey, 33 actual sightings (39 animals) were made, including four sightings of mother-calf pairs (10.3% of the sightings). Three of the mother-calf pairs were seen in the coastal waters of Sylt, and one near the neighbouring island of Amrum (Fig. 2). No mother-calf pairs were seen south of Amrum.

Analysis of the SCANS data showed similar results. Of the SCANS sightings in this area, 14.1% were mother-calf pairs, all north of Amrum with the exception of one, which was a little further to the south.

The 1992 survey was a pilot study in the waters of northern Sylt to investigate the possibilities of aerial surveys in the turbid waters of the North Sea. In this area off Sylt, 17.9% of the 39 animals seen were calves.

DISCUSSION There is no information on what percentage of the harbour porpoise population are calves. In the SCANS aerial survey of 1994, the highest calf density in the North Sea was in block Y, along the German and the Danish North Sea coast including the islands of Sylt and Amrum, with about 14.1% calves. This was the highest calf density observed in the North Sea during the SCANS aerial survey (Table 1). The reason that the density in this case is higher than in the 1995 survey might be due to the possibility that the breeding area extends north into Danish waters. Furthermore, in the 1995 survey, more offshore waters were included in the area investigated, and mother-calf pairs seemed to prefer coastal areas (Hammond *et al.*, 1995).

In the 1992 pilot study off Sylt, the calf density of 17.9% was even higher. This density is the highest calf density of harbour porpoises observed in European waters during an aerial survey. Unfortunately, there is no aerial survey data available from the British North Sea coast.

In addition to the high mother-calf densities around Sylt, we observed high numbers of stranded porpoise calves in this area. Of the 169 dead calves registered along the coast of Schleswig-Holstein, 79.3% stranded on the neighbouring islands of Sylt and Amrum.

Looking at all strandings along the coast of Schleswig-Holstein, the calf-adult ratio was 37.8%, whereas the calf-adult ratio on Sylt was 42.7%. This is the highest calf-adult ratio noted for strandings along the German coast.

The aerial survey data, together with the stranding data, show that the waters off Sylt, and perhaps also off Amrum, are the most important breeding areas for harbour porpoises in German waters. Considering the data of the SCANS Survey (Table 1), it is perhaps the most important for the whole North Sea.

This study shows the importance of this breeding area which is not, as yet, part of the Wadden Sea National Park. There are even plans to increase the sport boat business in this area, such as rentals for jetskis and speedboats, which are considered very disturbing for porpoises (Evans *et al.*, 1994). Therefore, it is necessary to increase the protection status of these waters, in order to protect the porpoises and their offspring from boat traffic and fishing activities.

ACKNOWLEDGEMENTS In addition to the authors, Mats Anderling (University of Stockholm) participated as an observer and Leif Petersen (Danish Air Survey ApS) acted as pilot during the aerial survey. Numerous students helped with the dissection of the porpoises, and Laura Chavez-Lissembert determined the age of the specimens. Financial support was provided by the German Ministry of Education and Research, the German Ministry of Environment, Nature Conservation and Nuclear Safety, and the Ministry for Nature and Environment of Schleswig-Holstein.

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Table 1 Calf-densities observed during aerial surveys in the North Sea

Investigated area:	calves/porpoises	percent calves
Sylt Pilot Study 1992	7/39	17.9%
Westcoast Schleswig-Holstein (German Survey 1995)	4/39	10.3%
Danish and German Wadden Sea (SCANS Block Y)	10/71	14.1%
Danish Northwest coast (SCANS Block L)	8/69	11.6%
Norwegian coast (SCANS Block M)	3/56	5.4%
Shetland and Orkneys (SCANS Block J)	0/40	0.0%
SCANS aerial survey 1994 (all aerial survey blocks)	33/449	7.3%

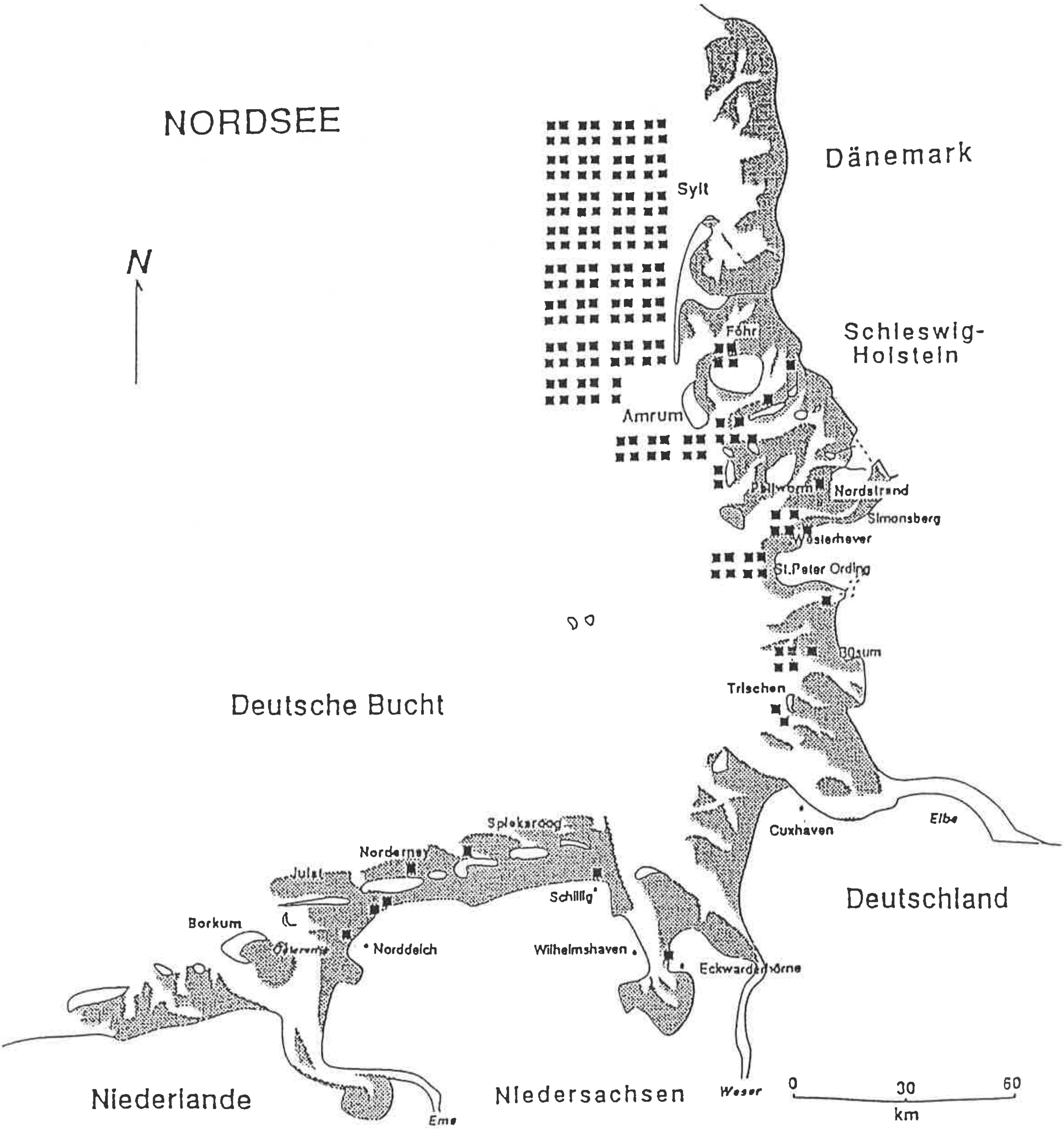

Fig. 1 The coast of Schleswig-Holstein, Germany showing strandings of harbour porpoise calves

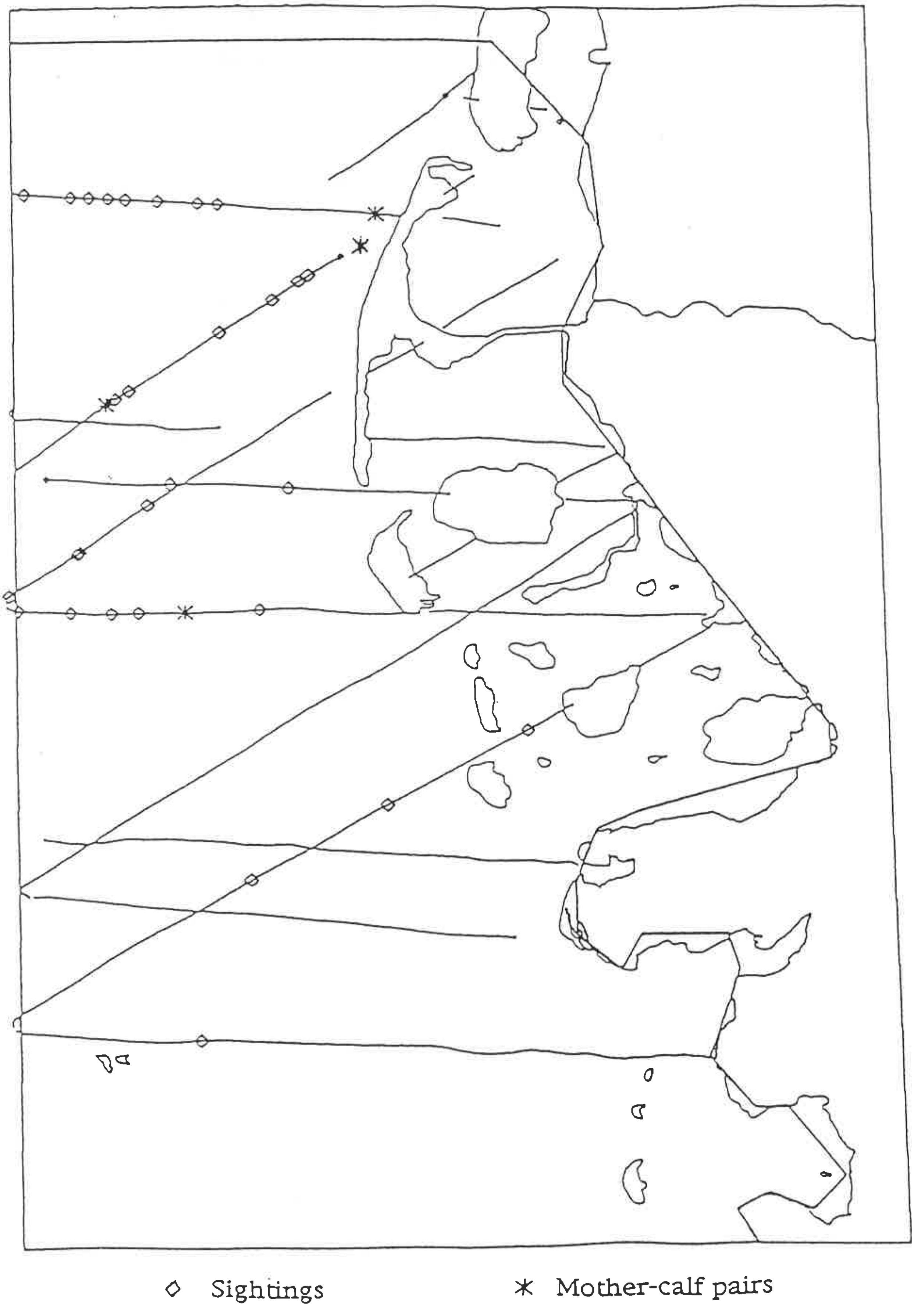

Fig. 2 Map of the survey area showing transect lines of the aerial survey in the North Sea and sightings of mother-calf pairs

OBSERVATION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) BETWEEN THE ISLANDS RØMØ, DENMARK, AND SYLT, GERMANY, SUMMER 1995

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Sylt is the northernmost island in the German part of the Wadden Sea. Adjacent is the Danish island of Rømø. Both islands are connected with the mainland by a dyke. Only.through the "Lister Deep", do ebb and flood tides enter the Wadden Sea between the islands and the mainland.

Between 27 June and 9 September 1995, collaborators from the Seevogelrettungs-und Naturforschungsstation Sylt e. V." observed this area from two ferry ships of the Rømø-Sylt-line, as well as from a tourist vessel of the ADLER-line. They looked out for harbour porpoises and seals (harbour seals as well as grey seals) in this area, and noted the co-ordinates of the sightings. Furthermore, they estimated the distance between the water craft and the animals, and how the animals reacted to those.

447 sightings in 73 days resulted in a total of 606 animals. 254 animals were observed from the MV VIKINGLAND during 185 sightings, whereas there were 187 sightings (254 animals) from MV WESTERLAND. The observations from the tourist ship resulted in 75 sightings with 98 harbour porpoises.

Some animals could be seen surfacing only a few metres in front of, or very close to the ships, and also surfacing behind in the wake. Several harbour porpoise cows and calves swam quietly between ferries that met. This shows that under these circumstances at least, porpoises were not afraid of large ships.

HABITAT USE BY HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) OFF THE ISLE OF SYLT, GERMAN WADDEN SEA, SUMMER 1995

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From the beaches of the Isle of Sylt, harbour porpoises (*Phocoena phocoena*) are easy to observe. In summer 1995 between 20 July and 17 October, one female harbour porpoise could be identified as an individual animal because of a notch in the fin, and could be tracked for several months.

This harbour porpoise, together with its calf, could be watched most of the time in front of the beach of the city of Westerland. The animals could be followed nearly 7 km along the coast, but it was not possible to find out how far into the sea their home range extended.

Together with this mother-calf group, other animals also used the area but could not be identified as individuals. Sometimes two other mother-calf pods as well as single porpoises could be seen together with the above-mentioned individuals.

Often this female harbour porpoise led its calf very close to people swimming and playing in the water. In so doing, they swam into areas of only 80 cm depth, and approached the humans up to half a metre distance.

TEMPORAL AND SPATIAL DISTRIBUTION OF HARBOUR PORPOISES IN SHETLAND WATERS, 1990-95

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INTRODUCTION In recent years, the harbour porpoise *Phocoena phocoena* has experienced widespread declines in Europe, becoming scarce or absent along the coasts of all countries bordering the southern North Sea. Over the last decade, declines have also been recorded from a number of localities in northern Britain bordering upon the northern North Sea. The Shetland Islands have long been a stronghold of the species in Britain, but marked declines have been observed during the 1980's. Whilst those declines have been taking place, there have been major changes in local fisheries, notably sandeels, but also other fish species. The cause of those changes remains unclear.

The main aim of this project was to investigate more fully the possible relationship between observed porpoise declines and oceanographic changes, including changes in the stocks of various potential prey species. Developments in technology have enabled one to learn much about the feeding ecology of small cetaceans without recourse to examination of stomach contents of dead animals. The objectives of this study were to identify the major determinants of harbour porpoise distribution in coastal waters of Shetland by non-intrusive field methods with particular reference to potential fish prey species. The present contribution examines spatial and temporal variation in porpoise abundance and relates this to variations in prey abundance.

METHODS During the month of August, 100-minute land-based systematic watches were carried out annually over a six-year period from 1990-95 at fifty sites distributed around the Shetland mainland (reduced to 25 in 1995). From the data collected, an abundance index was determined for three main regions: southern, north-western and north-eastern Shetland (see Fig. 1 for locations of the 50 sites and regional subdivisions). Watches were carried out in calm weather conditions (sea-state 2 or less) so that data for different areas and different years could be directly compared. Additionally, boat transects were conducted at the same time, between 1977 and 1989, and throughout the 1990-95 study period. The month of August was selected because this was the time when porpoises in Shetland coastal waters appeared to reach peak numbers. Offshore surveys were undertaken using either the 32ft motor fishing boat “Queen of Hearts”, owned by Robbie Leask and skippered by him or Jimmie Birnie, or the 30 ft motor fishing boat, "Spirit of the North", owned and skippered by John Moncrieff from Lerwick.

RESULTS The land-based watches indicated that porpoises have a wide distribution around Shetland, but are concentrated towards south and east coasts of the mainland, particularly Whalsay, Noss Sound, Mousa Sound, and in the vicinity of Sumburgh Head (see Evans, 1995, 1996).

Fig. 2a showed long-term annual variation in the abundance of porpoises in Shetland, with declines occurring particularly between 1982 and 1990. During the six-year study period there has been an increase in porpoise numbers over the latter three years, compared with the 1990-93 data (Fig. 3). Each region showed annual variation in porpoise abundance indices (Fig. 4a). Because a sub-set of 25 sites were surveyed in 1995, the analysis was repeated using only these sites (Fig. 4b). The Southern region contained a greater abundance of individuals throughout the study period, and has shown a substantial increase in numbers since 1991. The North-west and North-east regions show uneven fluctuations over the six-year period, although the North-west population appears to have declined over the last two years.

Other ecological studies of harbour porpoises in Shetland have shown that sandeels are most commonly recorded in close proximity to porpoises (Evans, 1996; Borges & Evans, this volume). The distribution of sandeel fishing grounds around Shetland is shown in Fig. 5. Many areas of porpoise concentration are correlated with sandeel distribution, including the important areas of South Noss Sound and Mousa Sound. Futhermore, a spatio-temporal analysis showed significant association between porpoises and sandeels but not with any other fish group (Evans, 1995, 1996; Evans & Borges, 1996). The changes in porpoise abundance shown in Fig. 2a, may therefore be related to annual variation in sandeel populations (Fig. 2b). It is interesting to note that sandeel spawning stock biomass declined markedly from 1984-92 when coastal summer populations of porpoises also apparently declined. During 1993 and 1994, sandeel spawning stock biomass was relatively high (following high recruitment in 1991) and porpoise abundance was also higher. These findings indicate that in recent years the presence of porpoise numbers in Shetland inshore waters during summer has been determined primarily by the status of local sandeel stocks.

CONCLUSIONS Harbour porpoises are concentrated principally in the southern and eastern regions of Shetland mainland, and can be observed frequently in the following areas: Skaw (Whalsay), Mousa Sound, Noss Sound, St Ninian's Isle, and Quendale Bay, with numbers increasing through the summer to a peak in August or September. Each of these areas can be watched very readily from land. The distribution and abundance of harbour porpoises around the Shetland coast may be partially explained by that of the sandeel, a known prey species. Porpoises and sandeels are significantly associated both in time and space. Harbour porpoises summering in nearshore waters of Shetland declined markedly during the 1980's, at a time when local sandeel stocks also declined. Since 1991, the Southern region of Shetland mainland has shown a continual increase in porpoise numbers, and is now an important stronghold for the species, with aggregations at times numbering in the low hundreds. The resulting overall increase in porpoise numbers since 1991 indicates a recovery from previous population declines, and highlights the current importance of Shetland waters for this species. Although harbour porpoises showed a decline in numbers during the 1980's in Shetland coastal waters, since 1991 this trend has been reversed. This is thought to be at least partly due to the increase in local sandeel populations following a very good recruitment year in 1991. It remains to be seen whether the trend will be sustained during the 1990's.

ACKNOWLEDGEMENTS The Shetland porpoise project has received generous funding from WWF-UK, Shetland Amenity Trust, Shetland Wildlife Fund, and Scottish Natural Heritage. Thanks also go to all volunteers who have worked on the project, particularly Paula Barnett, Lisa Borges, Quentin Carson, Heidi Cluley, Judith Denkinger, James Farrell, Paul Fisher, Lucy Gilbert, Dorien Hoogerheide, Lisa Kendrick, Rachael Limer, Ian Rees, Julie Wainright, and Katy West. Robbie Leask and John Moncrieff have kindly provided the services of their boats, and Martin Heubeck, Pete Ewins, Pete Kinnear, Mike Richardson, and Bobby Tulloch contributed to the offshore boat surveys. Over the years, British Petroleum and Shell UK have given valuable logistic support.

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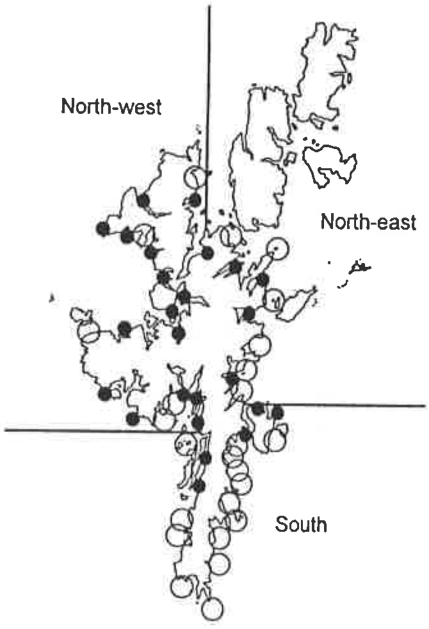

Fig. 1 Distribution of land-based sites watched around Shetland Mainland, Solid circles 1990-94; hollow circles 1990-95

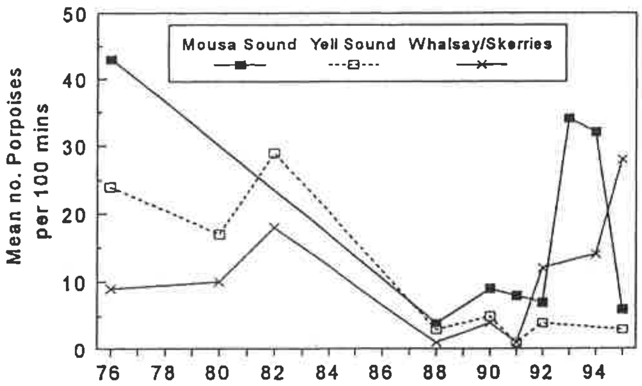

Fig. 2a Population changes of the Harbour Porpoise in Shetland

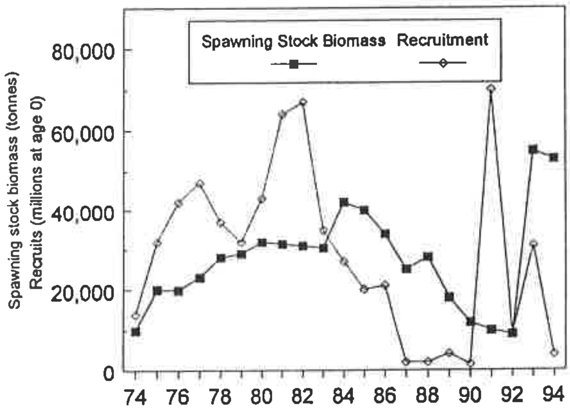

Fig. 2b Annual changes in biomass and recruitment of Sandeel stocks in Shetland waters. From Anon (1995) Report to the Working Group on the Assessment of Norway Pout and Sandeel. ICES, Copenhagen

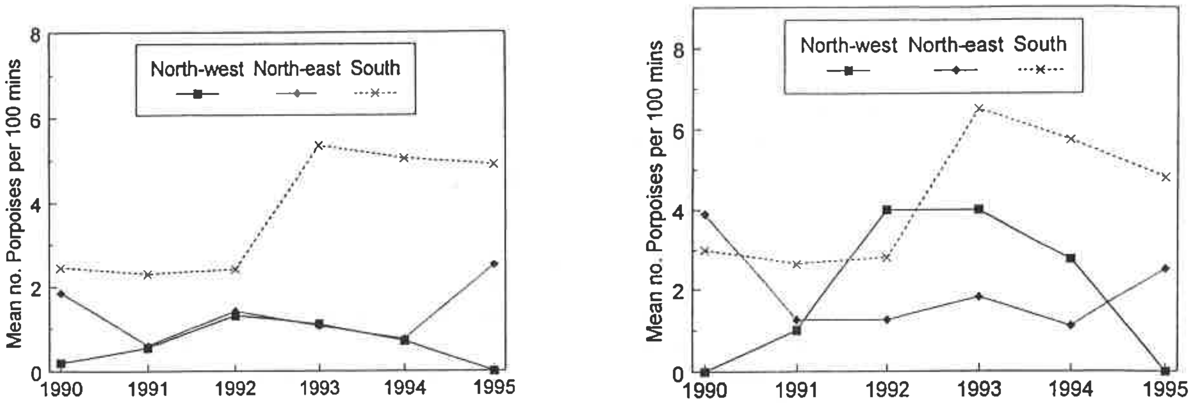

Fig. 3 (a) Annual changes in Porpoise abundance indices for three main regions of the Shetland Mainland (1990-94 = 50 sites, 1990-95 = 25 sites);
(b) Annual changes in Porpoise abundance indices for subset of 25 sites within three main regions of the Shetland Mainland

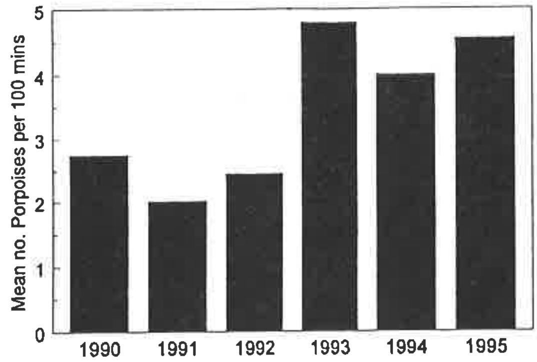

Fig. 4 Annual variation in numbers of Harbour Porpoises in Shetland at 25 mainland sites

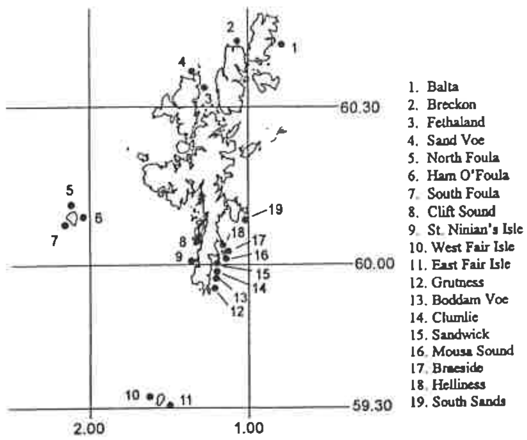

Fig. 5 The Sandeel fishing grounds around Shetland

PRELIMINARY RESULTS ON THE BEHAVIOUR OF *INIA GEOFFRENSIS* IN CAPTIVITY

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The knowledge gathered about social interactions of the boto (*Inia geoffrensis*) is still scarce, partly due to very poor observation conditions and lack of individual identification in the wild. Although aggression amongboto males of has been indicated as one of the difficulties in maintaining this species in captivity (Perrin and Brownell, 1989), two males have been kept for 20 years at Duisburg Zoo, Germany.

In the summer of 1995, a study was conducted to investigate the social interactions and the time-budget of their general activities. For this purpose, three hours of daily observations were carried out, distributed through morning, midday and late afternoon periods, with a daily additional thirty minutes for the observation of the feeding behaviour. The ethogram shows a highly rich variety in elements. During the daytime (07:00-20:00 h.), these individuals spend most of their time interacting, especially engaging in sexual and play behaviour, showing an extremely rich behavioural repertoire.

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BELUGA WHALE (*DELPHINAPTERUS LEUCAS*) ACTIVELY FRUSTRATES TRAINING ATTEMPTS

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INTRODUCTION This presentation is based on a research project involving about 16 months of daily observation, and describes certain difficulties when working with live animals. Our project was based on the training of a male beluga whale (*Delphinapterus leucas*) called Ferdinand, of c. 4.3 m length and c. 1,100 kg weight. He has lived in Duisburg Zoo (Germany) since 1975, and shares his pool with a female beluga whale and a male Commerson's dolphin (*Cephalorhyncus commersonii*). Ferdinand is the dominant member in this group. An important basis for the training was his habit of performing regularly in shows, each day of the year, several times a day. This rhythm was not interrupted during the period of this study.

The experiment consisted of a matching-to-sample task with three pairs of geometric objects of black painted aluminium: two spheres, two cylinders, and two ellipsoids. One sample at a time was shown to the whale visually above water, and, blindfolded, he would choose between the objects of comparison underwater by means of echolocation. His ability in this task finally achieved a success rate of 87.5% (Kamminga *et al.*, 1993). However, there was a period of time that Ferdinand refused to co-operate.

PROBLEMS When the preparatory training was finished, the whale was obviously able to master the requested task, and we started the "routine" runs. After one week, the success rate decreased markedly. For months, he continued to give very unstable results. A statistical analysis of the behaviour confirmed our suspicion: most of the time the whale was pulling our leg!

A list of all factors having a possible influence on the results was made. A scheme of reasons for a wrong choice ("NO" answer) during a matching-to-sample task is presented in Table 1.

ANALYSIS Various possible factors (Table 1) were examined one by one so that they could proven or excluded:

(1) We already had evidence of the whale's ability in the requested task. Case (1) was excluded;

(2) Misunderstanding during the training is mainly the responsibility of the person guiding it. Any signal has to be definite and should never be used within different contexts. Misunderstanding leads to insecurity, shown for example by hesitation during choice-making. This factor was no longer present during the late phase of training.

Distraction often occurred in our experiment, mainly caused by the co-habitants of the pool. The female beluga, probably both out of curiosity and jealousy, has also tried occasionally to solve the task, thus hindering Ferdinand. The small Commerson's dolphin often frisked provocatively around the blindfolded alpha-animal in a manner that he would never dare under normal conditions. It may be that Ferdinand swam listlessly up and down, and simply chose the first object he met. Low concentration and listlessness were associated with general low commitment. The results from case (2) say nothing about the ability to comply with the requested task, and therefore should be excluded from the statistical evaluation.

(3) Case (3) was not only the most frequent, but also the most interesting one. After several run units, the large amount of data gave the basis for statistical study of behavioural patterns in the whale's alternative choices to the requested correct choice. To give objectiveness to our observations, we only used patterns of a high repetition rate, since it was precisely this characteristic of frequent occurrence which led us to recognise strategies in the whale's behaviour, e.g. choice-making modes independent of our reaction in judging the result "right" or "wrong". Every strategy was deliberately created by the whale, and carried out with remarkable perseverance. Very simple strategies were those of an apparent preference or aversion for one object or one position. Since this kind of strategy is independent of the shown sample, it gives no information about the ability to be proven, and should be ruled out of the corresponding statistics. More complicated strategies such as always choosing the object which would have matched in the previous run (at that time not chosen and not reinforced), involves the requested connection between the visual registration of the sample and the echoic identification of the comparison object. Strategies of this kind are interesting for behavioural studies, and statistical evaluation of matching-to-sample tasks and short-term-memory analysis.

When comparing cases (2) and (3), it is remarkable that while the listless whale swam slowly, and made no clear confrontation, etc., the committed whale conducted his strategies with energy, swimming complicated paths after a clear confrontation, in spite of no reward.

CAUSES AND SOLUTIONS Ferdinand's behaviour patterns involved reactions, and there were two kinds of them:

(a) **listlessness**: "reduce the energy spending to a minimum".
Situations of listlessness and low concentration occurred mainly during early morning hours. It had to be accepted that belugas do not repay training attempts before 10:00 h.

To avoid disturbance by Ferdinand's cohabitants, these were distracted during his training.

(b) **commitment**: "bring some fun into the task".

The assumption that playfulness was basis for the complicated strategies (and perhaps defiance as origin of the monotonous ones) was supported by the following observations:

1. He never refused to execute the whole course. He swam his path and made a choice;
2. The strategies showed a high degree of repetition;
3. There could be located half a dozen of these strategies;
4. Strategies were carried out with high commitment;
5. The strategies alternated with quite well performed runs;
6. Fish rewards demonstrated to be no incentive.

While efficient and regular results were obtained in winter, strategies were developed almost entirely during the summer (hot weather, high season). It became possible to recognise and to correct them in time. A very successful measure was to randomise the positions of the comparison objects so quickly that the beluga was forced to change results or his strategy - at least he had to think about it. Furthermore, small breaks of about five minutes were effective: if he started to lose concentration, he could regenerate; if he was using one of his strategies, after the break he was so keen to become the centre of attention again that he started to perform well.

Training is based upon mutual communication. It is no one-way system, but promotes interaction, reciprocal observation, signal emission and signal reception by both participants. Belugas have several clearly observable behaviour patterns because of their non-fused cervical vertebrae, movable melon, loud vocal expressions, and calm and explicit movements. Very distinct are also their expressions directed to humans. Ferdinand often tried to focus the attention on himself and impose his will (sometimes arising the question: who is training who?). An adequate role of the trainer in the group hierarchy is necessary for the training not only of belugas. But one cannot impose oneself by strength: rewards, positive reinforcement, and positive interaction led to outstanding success, and finally gave the scientific results to the questions posed by this research. It should not be forgotten that a whale is not a machine. Actually Ferdinand is a grandfather of a whale, and still his learning ability is amazing!

ACKNOWLEDGEMENTS For their solid help, their creative suggestions, and last but not least, their patience, we wish to express our thanks to: Dr. W. Gewalt, Dr. B. Neurohr, the late R. Reimann, H. Bolz, R. P. Terry, and M. G. Hartmann.

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Table 1 Reasons for a "NO" answer (wrong choice)

I) NOT ABLE because of:		
- physiological inadequacy (sensory limitations)		**"NO" is "NO"**
II) WOULD BE ABLE IF there were not:		
- logical misunderstanding		
- insecurity		
- physical barriers (light, turbidity, turbulence, sounds etc.)		**"NO" is "?"**
- distraction by other animals, sounds etc.		
- low concentration level		
- listlessness / no interest	LOW COMMITMENT	
III) ABLE, BUT in a different way, because of:		
- defiance		**"NO" could be a**
- playfulness	HIGH COMMITMENT	**kind of "YES"**

SELF RECOGNITION IN KILLER WHALES (*ORCINUS ORCA*)

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Recently, self-recognition in mammals has been increasingly investigated. Exposed to a mirror for a long period, chimpanzees use it to examine previously unobservable parts of their body, while monkeys, such as macaques, fail to recognise themselves and socially respond to the reflection. In cetaceans, bottlenose dolphins seem to examine themselves in front of a mirror (exposing the marked side of their body) and also play with objects in front of it. In order to investigate the scope of this cognitive ability, we attempted to replicate the mirror self-recognition paradigm with killer whales.

This work has been conducted on four killer whales (*Orcinus orca*) of the Antibes Marineland (France) in September 1995. After some days of sham marking, marked and unmarked animals were exposed to a mirror three times a day. Their complete behavioural repertoire was then recorded, using a video camera, during control periods and mark tests.

Preliminary results highlight individuality: according to their age, sex, and status in the group, animals displayed different behavioural patterns (item bouts and duration, sequences, etc) in front of the mirror. We can presume that at least one female recognised herself. Confirmation is expected from further analyses of the data.

COEFFICIENTS OF ASSOCIATION OF REPRODUCTIVELY ACTIVE FEMALE ATLANTIC SPOTTED DOLPHINS, *STENELLA FRONTALIS*

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From 1986-95, a resident pod of Atlantic spotted dolphins has been extensively observed, and studied, off Little Bahama Bank, Bahamas. Of 150 identified individuals, 16 females of reproductive age, and 23 of their successful offspring, were chosen for analysis. Coefficient of association (COA) values among these 39 dolphins, and the identified population, was determined using the half-weight index. Values are compared between years and through changes in reproductive status.

Mother/infant pairs showed high COA's from birth through the first three years (range 0.42-1.00). COA values remained high until the year of the birth of a subsequent sibling. At that time, a significant drop in association with the mother occurred (range of drop spanning 0.36-0.86).

Females, who entered sexual maturity during this analysis period, displayed strong association values (ranging between 0.43 and 0.67) with other subadult females. These values dropped significantly upon reaching sexual maturity or change in reproductive status. These first-time mothers then formed associations with older, more experienced, previously unassociated females, who also gave birth the same year (ranging from 0.22 to 0.73).

SURFACING PATTERN OF BOTTLENOSE DOLPHINS FOLLOWING BOTTOM TRAWLER IN THE KVARNERIC (NORTHERN ADRIATIC SEA)

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Bottlenose dolphins observed east of the islands of Losin are often found in the wake of trawling boats operating on a flat, muddy sea bed about 75 m deep, presumably foraging in the proximity of the net. Respiration intervals for well-recognisable focal individuals engaged in such activity, were timed from small inflatable craft between August 1991 and October 1995. A total of 12 h 39 min, including 1,798 dive-time intervals were recorded for 13 different individuals. The average dive time lasted 25.4 sec (SD=59.28, SE=1.40, N=1798, range 2-363, mode=6). The respiration pattern was characterised by sequences of about ten short dives or "ventilation" (mean=8.8, SD=5.15, SE=0.42, N=153, range 1-22) lasting an average of 8.83 sec (SD=4.46, SE=0.11, N=1,645, range 2-30, mode=6), and single long dives averaging 201.75 sec (SD=85.25, SE=6.81, N=153, range 31 -363, mode=248).

The positive correlation between long dive-time and number of surfacings during each sequence of ventilations suggested that physiological recovery is affected by the number of ventilations. No correlation was found between long dive-time and duration of a ventilation sequence, the time spent at the surface being affected by bottom depth.

The regular respiration pattern of bottlenose dolphins engaged in following bottom trawlers, as compared with dolphins engaged in other activities, seemed to be related to a reduced number of environmental variables, possibly including: (1) constant speed of movement; (2) constant depth; (3) predictable prey location; and (4) predictable energetic investment required to catch food during each long dive. This "simplified" respiration pattern may provide insight into the physiological needs of dolphins, and help understand the surfacing patterns observed during other more complex behavioural activities.

ONTOGENY OF BEHAVIOUR IN A CAPTIVE NEWBORN BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

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INTRODUCTION On September 5, 1994, a twenty-year old bottlenose dolphin called Bonnie gave birth to a female calf at Acquario di Genova. The behaviour of the newborn, called Cleo, was monitored from the moment of birth to the first year of age, with the intention of studying its development in relation to the mother's presence and to the new environment.

The main aspects analysed in our research were: changes in the duration of mother-calf pair separations (with special attention to the subject withdrawing and approaching), the period of time spent in resting, the trend in frequency of lactation, the first approaches to different food, play behaviour, and stroking behaviour. The animals belong to Aquatic World Cattolica run by Delphinarium Riccione, Italy.

MATERIALS AND METHODS The calf's activity was monitored using both video and acoustic recordings. The acoustic data have been used to study the vocal behaviour of the newborn in a parallel research project.

Recordings were made by means of a S-VHS movie camera connected with a S-VHS Hi-Fi video recorder. Observations were carried out every Monday, Wednesday and Friday from 09:00 to 18:00 h. Approximately 150 hours of recordings were collected. Two different kinds of data were gathered to be used for quantitative and qualitative analysis respectively.

Quantitative analysis: recordings took place on Monday and Wednesday during four 15-min. periods, starting at 09:00 h, 11:00 h, 14:00 h. and 17:00 h. The main aim was to provide data for statistical analysis regarding early variation in the calf's activity, and to find sequential correlations between different behaviours.

Qualitative analysis: free recordings took place on Monday, Wednesday, and Friday to collect new behaviours and those not frequently recorded in quantitative tapes.

DISCUSSION At first, Cleo remained always near its mother, spending almost all the time resting (Fig. 1). Generally, they rested whilst slowly swimming side by side and were perfectly synchronised in their movements. Moreover, they kept open the eye closest to their fellow and closed the opposite one. This is probably a way to reduce energy costs whilst remaining sufficiently aware of dangers. In fact, two animals with an eye open, could together observe an area of approximately 360°. The same behaviour was also recorded in adults.

In the first nine months, we observed how Cleo withdrew more frequently from Bonnie, while during the last three months of the study period, it was Bonnie who separated more frequently from the calf (Fig. 2). It may be that at first the calf is interested in exploring the environment, while the mother tries to remain beside the newborn to prevent accidents; later, the mother is more interested in encouraging the calf's independence, otherwise her parental investment would be too high. With regard to approaches, we found that during the first six months, Cleo was more active than Bonnie, but afterwards any significant difference between mother and calf was not evident (Fig. 3).

A frequent activity occurring between adult bottlenose dolphins is rubbing and stroking. Nevertheless, the trend in frequency during the year may suggest that such behaviour is typical of a mother-calf relationship. In particular, we observed how the mother frequently stroked Cleo, especially during the first three months, whilst the calf started stroking the mother only after the third month (Fig. 4). This kind of activity is usually considered a way to facilitate social cohesion, as well as to eliminate parasites from the skin. In our case it resulted as part of typical parental behaviour.

Another interesting behaviour that we recorded is a sort of false "inverted" suckling: the calf behaved as a mother would while nursing a newborn. Cleo bumped with her genital area upon her mother's melon, then Bonnie put her rostrum onto her calf's mammary slit. At an age of ten months, this behaviour could not be functional, but its structure was already perfectly developed. This presumably means that Cleo will be able to nurse her first calf at the right moment. Analysing our data, we found that what is generally described as "mother genital push", could be considered as a prior step in the development of the complete behaviour of "false suckling". In fact, the "mother genital push" occurs quite frequently during mother-calf interactions (Fig. 5), with the calf presenting its genital slits to the mother who starts pushing the newborn with her rostrum upon the mammary area.

As soon as Cleo was able to perfectly control her movements, she started to investigate her environment and to play with objects in the pool. Moreover, she was able to create bubbles with particular shapes, such as rings or strings. We have described such activity as "creative playful behaviour".

CONCLUSIONS Most of the behaviours involving the mother and the calf were also described in relation to adult individuals. Nevertheless, the frequency with which they were displayed during the year may suggest that such behaviours are typical of the mother-calf relationship. Adult individuals probably often re-utilise infantile behaviours when socialising. On the other hand, at least one behaviour involving calves - "false suckling", is a typical adult behaviour, and appears in very young individuals, often associated with playful activities. We believe that this behaviour, involving the mother and the calf, may be part of a learning process which will increase the breeding success of the calf once it reaches adulthood. It would be interesting to observe if male calves also show the "false suckling" behaviour, as well as the female.

The "creative playful behaviour" may be part of a playful, exploratory activity, but it is interesting to note how the "air shaping" is rewarding by itself, for the calf. Even if the air may be somehow utilised in a functional way in the future, when associated with playing it can truly be considered simply as pure creative activity.

It proved to be very useful to start research at the moment of birth, so that nothing interesting was missed. Video recordings are very useful in research on animal behaviour because they can be watched by different observers and more than once. For this reason, our data are useful for future collaborations or exchanges with other researchers, especially with the aim of developing a complete ethogram of the bottlenose dolphin.

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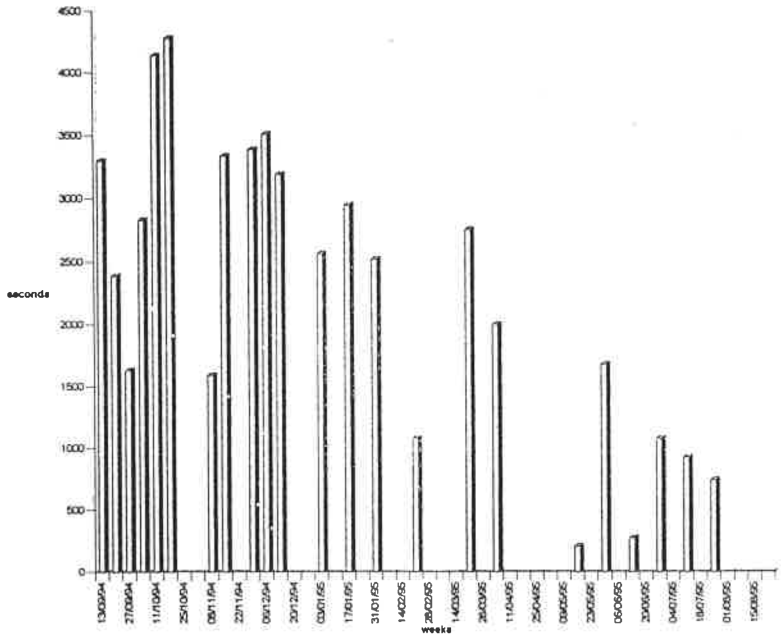

Fig. 1 Weekly resting behaviour trend during the first year

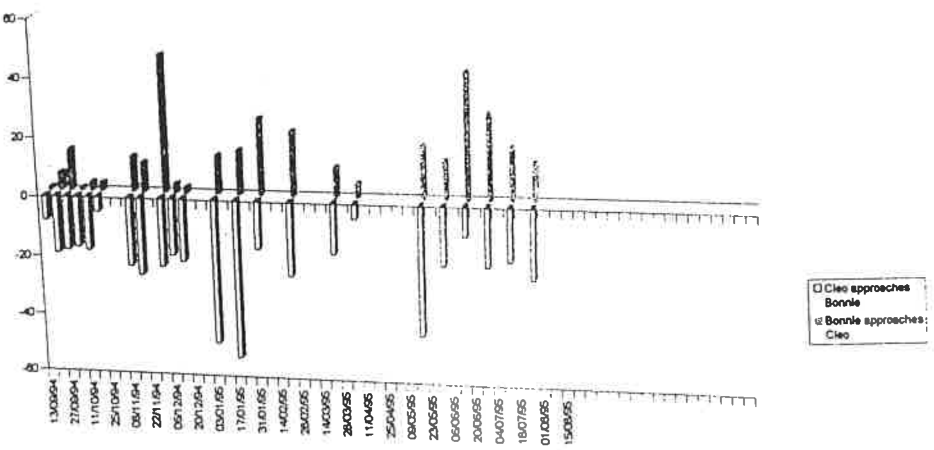

Fig. 2 Approaching subject trend

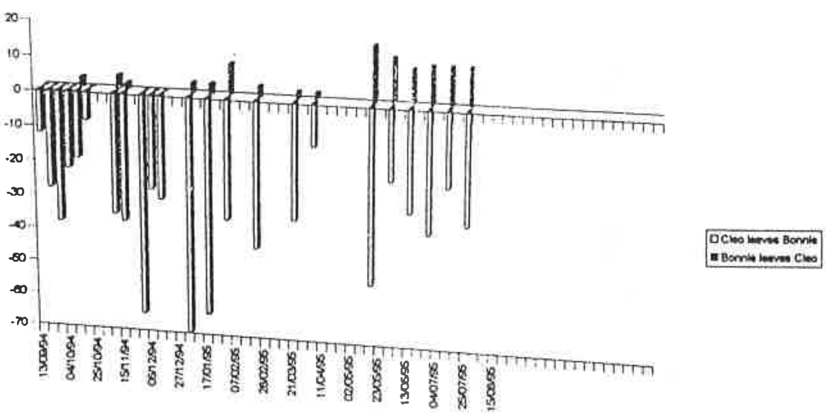

Fig. 3 Separating subject trend

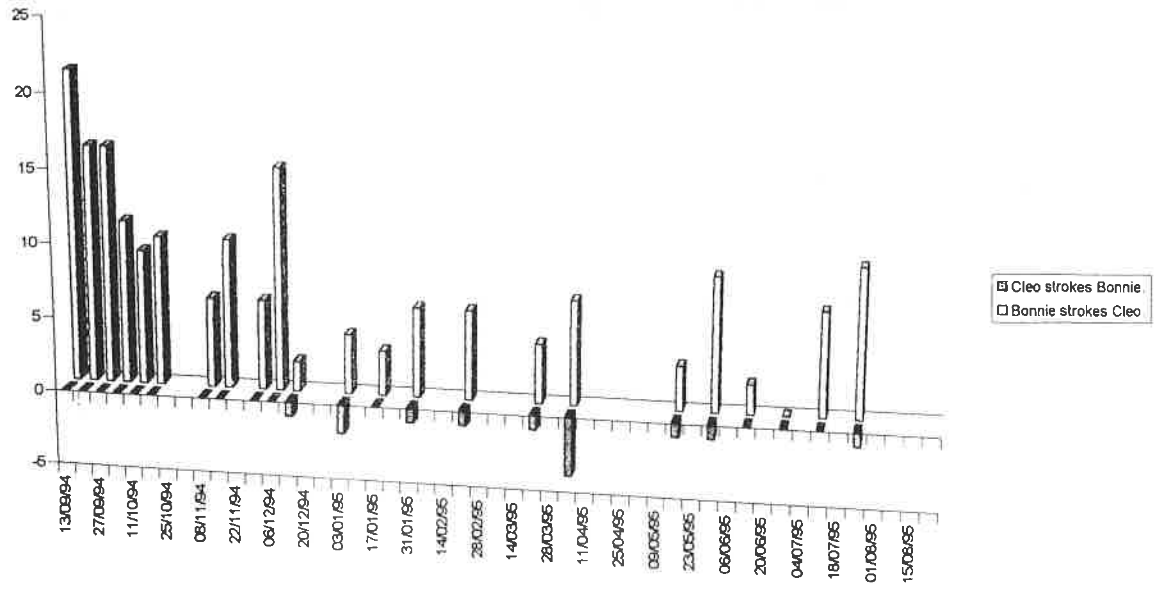

Fig. 4 Weekly stroking behaviour

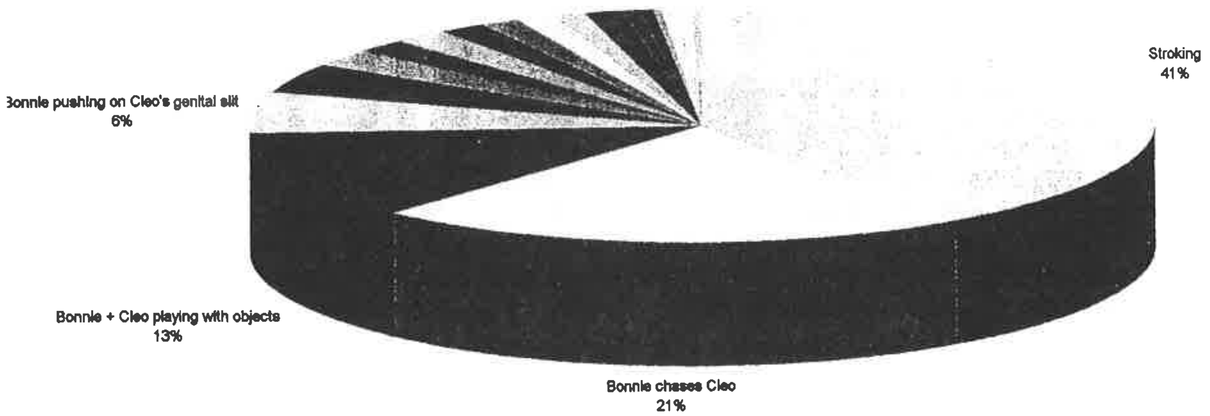

Fig. 5 Interactions with the mother

SIGNAL LEARNING AND THE SOCIAL MODELLING THEORY TESTED IN BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

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Various forms of dolphins' cognitive competence have been examined with respect to their accomplishments in imitating sounds or other behaviour patterns. However, it has remained unclear whether dolphin learning occurs according to the so-called Social Modelling Theory (review in Pepperberg, 1993). We have tested this question in a group of bottlenose dolphins living in semi-free confinement (site: Dolphin Reef/Eilat, Red Sea; size of site: >10,000 m^2; size of group: five adults (2/3). three juveniles (2/1), one calf). Here, dolphins can feed on self-caught fish but nevertheless have access to additional food originally offered during several training sessions. Since summer 1995, this feeding has been separated from the training sesions which, in order to prepare our novel experiments, include only social reinforcement. The new training comprises three procedures:

First step: We selected a particular dolphin (e.g. individual A or B) as a model subject, and trained him or her to interact with a human trainer by producing a newly and individually learned signal pattern (e.g. Signal *Sa* or *Sb*). Beforehand, we checked that neither *Sa* nor *Sb* was in the signal repertoire of the other group members.

Second step: We allowed other dolphins (preferably individual-wise) to observe when dolphin A (or B) was interacting with the trainer, and, at the same time, producing *Sa* (or *Sb*, respectively).

Final step: We inquired whether and when one of the other dolphins (C, D, E, or F) began to produce either *Sa* or *Sb*, and whether such a signal was related to specific interactions, namely with the trainer. Dolphin behaviours and contextual data were recorded by audio-visual equipment, including hydrophones. Analyses of data followed methods published elsewhere (Todt *et al.*, 1992), and allowed us to identify a number of successful signal imitations which the animals acquired by simply watching dolphin/trainer interactions and without normal conditioning. Our results show that bottlenose dolphins are indeed able to learn according to the predictions of the Social Modelling Theory.

POPOISES IN CAPTIVITY: A RESEARCH OPPORTUNITY - INFORMATION

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Combining a marine research laboratory (Odense University) with an active exhibition centre, The Fiord & Belt Centre will open during the summer of 1996 in Kerteminde, Denmark. The Kerterainde Fiord and the Danish belts will be the common basis for all the activities. As such, the harbour porpoise, which exhibits the highest density known in Europe in the Great Belt, will be the main topic of research and one of the main attractions.

Permission has been given by the Danish Ministry of the Environment and Energy to hold three porpoises in captivity for research purposes. The centre benefits from an outdoor pool of 390 m^2 area and 1,300 m^3 volume, bordered on one side by an underwater tunnel. The volume of water will be suitable for different behaviour studies and reaction patterns to different fishing gear, while the tunnel will allow scientists to observe the porpoises in their daily underwater activities, and for a closer monitoring of their reactions to various kinds of underwater devices.

To date, the central research programme on harbour porpoise has four main components:

- investigation of the bio-sonar navigation and prey localisation system;
- experiments exploring reactions to fixed and mobile fishing gear, and other devices;
- feeding ecology, including food requirements and prey choice;
- monitoring individuals in terms of growth, metabolism, and reproductive physiology.

OPPORTUNISTIC FEEDING BEHAVIOUR BY MINKE WHALES (*BALAENOPTERA ACUTOROSTRATA*) IN ASSOCIATION WITH SARDINE PURSE-SEINE FISHERY OPERATIONS IN GARNET'S BAY, NORTH-WESTERN SAHARA

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The minke whale (*Balaenoptera acutorostrata*) is the smallest member of the genus *Balaenoptera*, and is widely distributed in all waters of the world. Nevertheless, there is an absence of knowledge about its distribution in the meridional waters of the Central East Atlantic. Several feeding interactions between cetaceans and fishery operations have been reported in the last few years, most of these involving odontocetes. Garnet's Bay, in the north-western Sahara, is an area of high primary and secondary productivity, and is a well-known fishing ground of the sardine (*Sardina pilchardus*). On 12 November 1994, I was aboard the vessel *Albacora*, a sardine purse-seine fishery vessel, when an individual minke whale approached the stationary boat and began diving and moving quickly within a short distance (<10 m) around the vessel, showing evidence of sub-surface feeding.

At the end of the fishery operations, the whale was seen eating dead sardines which had been discarded previously, displaying a distinct repertoire of feeding behaviours reported by other investigators (e.g. plunges, bubble clouds, lateral, vertical, oblique and ventral lunges). Several photographs were taken of the event.

Similar approaches, without surface-feeding, were observed during the following three days. I have received verbal reports from fishermen who observed the species in the same area, feeding with sardine fishery boats, at least ten years ago. These simple observations raise two questions: (a) do minke whales have an unknown feeding ground in the relatively low latitude waters of Garnet's Bay? and (b) does the opportunistic feeding behaviour in association with fishery operations occur more often in this species? I do not know any records in the literature of such behaviour in the minke whale.

PRELIMINARY RESULTS ON THE DIET OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) OFF THE PORTUGUESE COAST

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INTRODUCTION Despite being the most abundant cetacean in Portuguese waters, as demonstrated by the large number of strandings and sightings (Teixeira, 1979; Santos *et al.*, 1988; Sequeira & Teixeira, 1988; Sequeira *et al.*, 1992), there is no published work on the feeding habits of the common dolphin in this area of the North Atlantic.

Previous studies on the diet of common dolphins have reported them as opportunistic feeders, preying on the most abundant species, and sometimes even changing their diet according to seasonal changes in prey abundance (Collet, 1981; Pascoe, 1986; Young and Cockcroft, 1994).

The present study provides a preliminary assessment of the diet of common dolphins in Portuguese waters, and examines the relationship between dietary composition and prey occurrence and abundance. Possible competition with commercial fisheries is also discussed.

MATERIALS AND METHODS The stomach contents of 26 common dolphins stranded along the Portuguese coast from January 1987 to October 1995, were examined.

Stomachs were frozen soon after collection, and samples were thawed and washed through a 1 mm sieve. Prey remains (otoliths, vertebrae and other fish bones, and cephalopod beaks) were identified to the lowest possible taxonomic level, using reference collections and published guides (Härkönen, 1986; Clarke, 1986).

The minimum number of each fish prey in a stomach was determined by the maximum number of left or right otoliths or the maximum number of each vertebral or bone type. Whenever distinction between left and right otoliths could not be made, their total number was halved. The mean number of lower and upper beaks was used as an estimation of the number of cephalopods present in each stomach.

Percentage number of a prey in relation to total prey numbers (N%), and percentage number of stomachs in which a given prey occurs (F%), were used to assess the relative importance of each food item in the diet. In order to assess the importance of the main prey species of common dolphins in Portuguese fisheries, their percentage weight in total landings from 1987 to 1993 (data available) was compared to their frequency of occurrence in the stomachs.

RESULTS Prey remains were observed in 20 of the 26 stomachs examined. A total of 1,158 fish and 123 cephalopod individuals were estimated, corresponding to 90.4% and 9.6% respectively of the total number of food items taken (Table 1). Fish remains were present in 95% of the stomachs examined, while cephalopods only occurred in 35% of the samples. Eleven fish species belonging to ten different families, and four cephalopod species from three families, were identified.

Blue whiting (*Micromesistius poutassou*) was the most important prey species in terms of numbers (39.2%), followed by sardine (*Sardina pilchardus*) (29.7%) which was also the most frequent prey (80%). Three fish species (*Engraulis encrasicolus*, *Myctophum* sp. and *Atherina* sp.) were recorded only once, and together accounted for 1.5% of all food items consumed.

Of the three cephalopod families identified, Loliginidae was the most important in number, corresponding to 60% of the cephalopods taken. The Ommastrephidae family was represented by only one individual.

Figure 1 shows the estimated percentage weight of the main prey species in total landings in the Portuguese continental coast. The frequency of occurrence of the main prey species in the diet of common dolphins is shown in Figure 2. Although a comparison between these data has no statistical value (since the methods chosen to measure the relative importance of each species were different), it was clear that the most frequently encountered species in the stomachs of common dolphins were also some of the most important species taken in commercial fisheries.

Sardine was the most common food item found in the diet, and was also the most important fish resource in Portuguese waters during that period (1987-93), comprising 37.4% of total landings (Fig. 1). *Trachurus* spp. contributed the second highest percentage by weight (11%) of all specimens landed, and Atlantic hake (*Merluccius merluccius*) was the most valuable species (INE, 1987-1993) (Figure 1). These two prey gave a significant contribution to the diet, not only for their high percentage of occurrence in the stomachs (Fig. 2), but also in terms of their numbers (Table 1).

DISCUSSION Although the number of samples examined in this study was small, a considerable variety of food items was found. The data showed that common dolphins feed predominantly on fish, with cephalopods contributing less than 10% of the total number of prey taken. Blue whiting and sardine were the two most important prey species, and together accounted for almost 70% of all prey items recorded.

The most important cephalopod species in the diet of common dolphins exhibit a continental shelf distribution. However, five oceanic species were present in the stomachs. This predominance of neritic over oceanic species is in agreement with the results obtained to the Spanish Atlantic coast (González *et al.*, 1994).

The importance of sardine and blue whiting in the diet of common dolphins should not be taken as an indication of prey preference or selection, since these two species are very abundant. Instead, it should be seen as evidence for an opportunistic feeding behaviour. Furthermore, the wide range of food items consumed suggests that common dolphins were feeding on the more frequent and easily caught species, rather than selecting a specific prey.

In fact, common dolphins prey were amongst the most abundant of species off the Portuguese coast, and their frequency of occurrence in the diet is highly related to its likely abundance and availability (Fig. 3): sardine was one of the most important prey items, and occurred in stomachs from dolphins stranded along the entire coast, a result that is consistent with its great abundance and wide distribution in Portuguese coastal waters; blue whiting was only found in stomachs from individuals stranded in the north and central regions, where this species appears to be more abundant (Cunha, 1989); snipefish *Macroramphosus* sp. was recorded in stomachs from individuals stranded in the area around Lisboa and Setúbal. According to Serrão (1989), the great abundance of *Macroramphosus* is one of the distinctive features of this region.

Although some of these prey usually occur at greater depths (e.g. blue whiting and Atlantic hake), studies of their behaviour indicate that they undergo nocturnal vertical migrations towards surface waters (Bakanev, *et al.*, 1981; Dardignac *et al.*, 1988). Evidence of night-feeding activity in common dolphins has already been reported for other areas (Evans, 1994; Waring *et al.*, 1990), a behaviour worth further investigation along the Portuguese coast.

Contrary to what had been previously reported for other areas of the North-east Atlantic (see Collet, 1981), common dolphins on the Portuguese coast prey on many commercial target species. In general, the main prey species of common dolphins are also important resources to the fisheries. The only exceptions to this pattern were the blue whiting and snipefish, which could be easily explained if we consider that these species are not captured for direct consumption, and their potential use to the fish processing industry was recognised only a few years ago.

As reported for other regions (Pascoe, 1986; Orsini Relini and Relini, 1993; Young and Cockcroft, 1994), common dolphins in Portuguese waters prey mostly on small epipelagic and mesopelagic shoaling fishes. Their opportunistic feeding behaviour coincides with commercial fishing activities, and this conflict is probably responsible for a considerable proportion of the observed mortality of common dolphins in Portuguese waters.

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Table 1 Number and frequency of occurrence of prey species found in twenty common dolphin stomachs

Species	Numbers N	Numbers N%	Occurrence F	Occurrence F%
Fish				
Engraulidae				
Engraulis encrasicolus	1	0.1	1	5
Clupeidae				
Sardina pilchardus	380	29.7	16	80
Gadidae				
Micromesistius poutassou	502	39.2	6	30
Trisopterus spp.	24	1.9	3	15
Carangidae				
Trachurus spp.	59	4.6	8	40
Merluccidae				
Merluccius merluccius	30	2.3	4	20
Scombridae				
Scomber spp.	47	3.7	5	25
Myctophidae				
Myctophum sp.	17	1.3	1	5
Sparidae				
Boops boops	2	0.2	2	10
Macroramphosidae				
Macroramphosus sp.	81	6.3	4	20
Atherinidae				
Atherina sp.	1	0.1	1	5
unidentified bony fishes	14	1.1	5	25
Totals (Fish prey group)	1158	90.4	19	95
Cephalopods				
Loliginidae				
Loligo sp.	29	2.3	1	5
Alloteuthis sp.	17	1.3	1	5
unidentified Loliginidae	27	2.1	3	15
Sepiidae				
Sepia sp.	30	2.3	3	15
unidentified Sepiidae	15	1.2	2	10
Ommastrephidae				
Ilex coindetii	1	0.1	1	5
unidentified oceanic species	4	0.3	2	10
Totals (Cephalopod prey group)	123	9.6	7	35
Totals	1281	100	20	

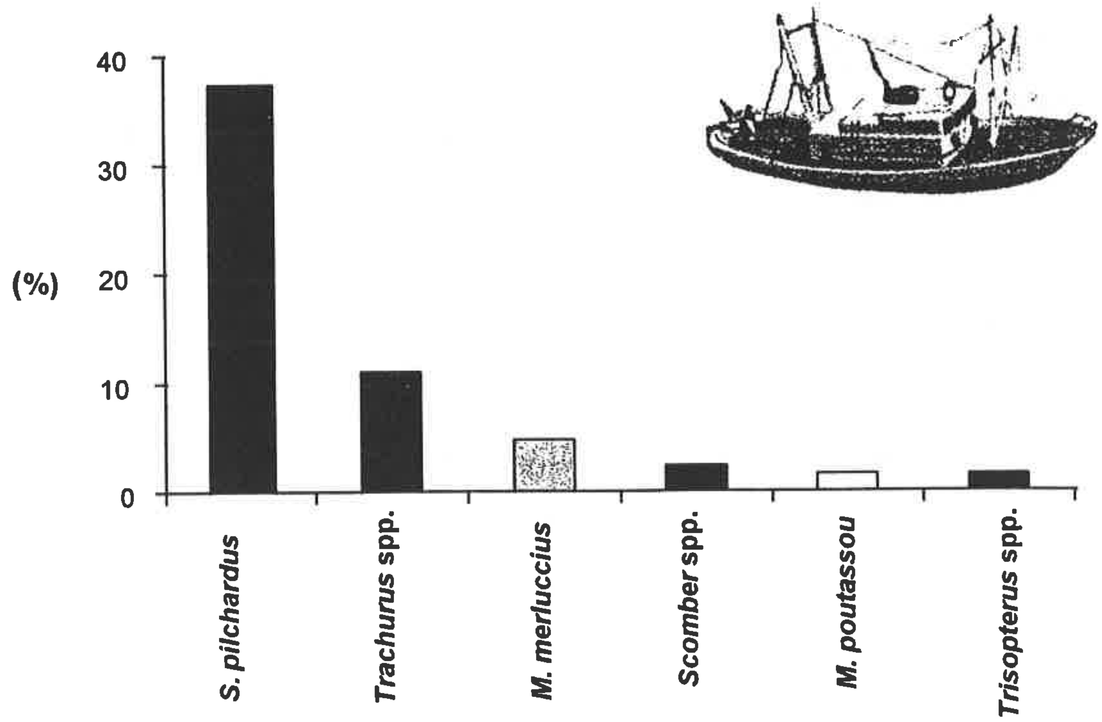

Fig. 1. The relative importance of the common dolphin main prey species in Portuguese fisheries was estimated using their percentage wet weight in total landings from 1987 to 1993

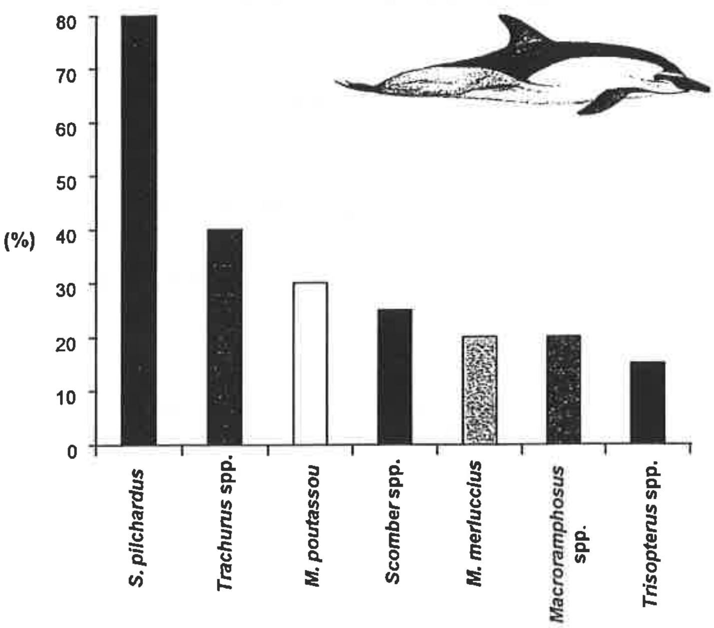

Fig. 2. Frequency of the main prey species found in 20 stomachs of common dolphins examined between 1987 and 1995

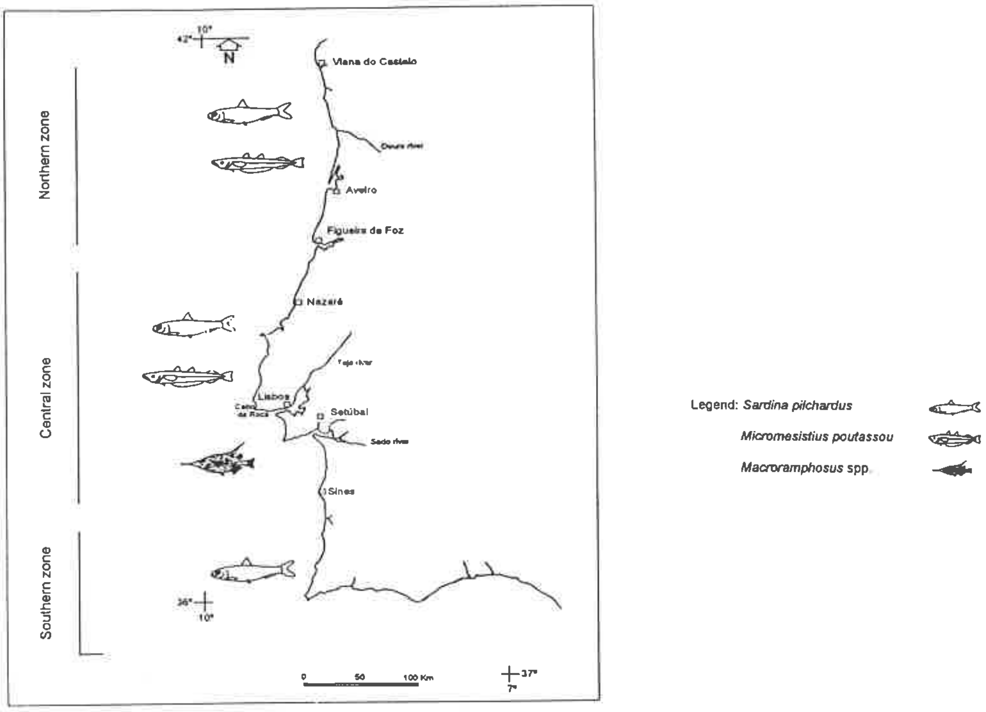

Fig. 3. Geographical distribution of the prey species that exhibited a pattern of occurrence in the diet coincident with their regional availablity.

FOOD COMPOSITION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN POLISH WATERS OF THE BALTIC SEA

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Between 1986-95, 23 specimens of harbour porpoise were recorded in the Polish zone of the Baltic Sea. Among these, sixteen were caught in nets and examined for food contents: 11 females and 5 males. Thirteen animals were caught in Gdansk Bay, which is a shallow water area. The other three were captured in the open sea.

In two individuals, no food occurred in the stomach, the rest representing low values of food contents in the stomach. Mean values for females and males were 2.0 and 1.25 respectively, ranging between 0-4. In total, seven species of fish and one species of mollusc have been noted as food composition. Gobidae represent 41% of occurence, cod - 21 %, herring - 15%, sprat - 12%, and others (including porcupine fish, sandeel, eelpout and unidentified species) - 10%.

The most common food item (represented by the highest number in the stomach) was herring, then Gobidae, sprat, porcupine fish, cod, sandeel, and eelpout.

It appears that the main food resources for harbour porpoise in the Polish Baltic Sea are: cod, Gobidae and herring. New species of Gobidae (*Neogobius melanostomus*) round fish have spread over the last three years in the Gulf of Gdansk, and have become the new food resource for porpoises, seals and various species of fish.

SEASONAL VARIATION IN DIET OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE KATTEGAT AND SKAGERRAK SEAS

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We examined the prey composition in stomachs of 119 harbour porpoises bycaught year-round in the Swedish Kattegat and Skagerrak fisheries between 1989 and 1991. Most specimens were bycaught in bottom set gillnets for cod. Relative prey importance was assessed using numerical measures and estimated weight of each species.

Gobies (family Gobidae), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and whiting (*Merlangius merlangus*) were the most frequently occurring prey species. However, using weight as the comparative measure, herring was the most important prey species contributing 50.2% of the total intake, followed by sprat (14.4%) and whiting (8.9%). Herring was important year-round, while the contribution of sprat and whiting varied seasonally. Gobies often occurred in large numbers but had a small influence by weight on the total intake, except in calves. It is plausible that the average size of gobies make them a suitable prey for porpoise calves.

Hagfish (*Myxine glutinosa*), cephalopods, and crustaceans were found in 21, 17 and seven stomachs, respectively. The relative importance by weight for these species has not yet been estimated. However, nine out of ten adult females bycaught in the summer had consumed hagfish, indicating that this species may be a seasonally important prey to this group. Furthermore, in females, herring accounted for 86.8% by weight during winter, while during summer, herring, *Trisopterus* spp. and *Pollachius* spp. contributed about one-third each. The observed variation in prey composition in females may be the result of habitat preferences dictated by their association with young calves.

SPATIAL DISTRIBUTION OF THE HARBOUR PORPOISE AND FISH PREY AND THEIR ASSOCIATIONS IN SOUTH-EAST SHETLAND, N. SCOTLAND

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INTRODUCTION Many organisms have different distributions (aggregated, regular, or random) of abundance on a wide variety of space and time scales. Depending upon sampling, we can obtain an impression of the space-time scales of these patterns.

In studies of associations between predators and prey, Schneider and Piatt (1986) mentioned the importance of the measurement distance, as a function of the transect size and the sampling unit, since some of the correlations could pass undetected, due to the correlation dependency to the distance.

The objectives of the present study were to determine the spatial distribution of porpoises and their main fish prey, investigating whether there is any relationship between them, taking into account the measurement distance (different "sampling units").

METHODS During July - October 1992 and June - September 1993, 24 and 21 transects respectively were made in the coastal waters of South-east Shetland (between 60° 12'30" and 59° 50'00" N, and 01° 30'00" and 00° 50'00" W, following a standardised route around the Island of Noss, southward passing through Mousa Sound and on to Sumburgh Head.

Porpoise abundance was determined by counting the numbers sighted (n°/km) and the potential prey (sandeels, gadoids, herring and mackerel) by echosoundings, with later relative quantification of the shoal area (echo integral values/km). The data were divided into five-min. intervals (c. 1 km travelled), corresponding to the sampling unit and therefore the first measurement distance studied.

The spatial distributions of both porpoise and potential prey were determined using an index of dispersion (I′), according to Schneider and Piatt (1986), for nine distances or "sampling units" ranging from 1 to 40 km, using a computer program "VM" developed by Dr. Erzini, University of the Algarve.

The associations between porpoises and prey were investigated using the Pearson Correlation Coefficient, for the first five measurement distances (since $n < 5$ at a distance of 20 km).

RESULTS AND DISCUSSION The results in both years suggest that porpoises have a highly aggregated distribution, and that the aggregations are more visible, i. e. more extensive, the longer the distance. This reflects the concentration of porpoises found in Mousa and Noss Sounds, and around Sumburgh Head (see Evans and Borges, 1996). In relation to fish prey, the spatial distribution analysis suggests a regular distribution during both years, and again at all distances studied.

The correlation between porpoises and fish prey in both years show a general increase with distance, although the majority are not significant. The results suggest that porpoises at a smaller scale are not directly associated with fish, or are seldom associated. However, all porpoise sightings, independently of their activity, were used in the correlation analysis, introducing error in the associations between predator/prey at small scales. At a larger scale, porpoise activities lose significance and, therefore, a general pattern of aggregation is more clearly shown, which probably depends upon external factors, such as prey abundance (namely sandeels where the correlation values are high and statistically significant), or the abiotic conditions (such as sheltered areas with shallow waters and strong tidal flows) existing in this area.

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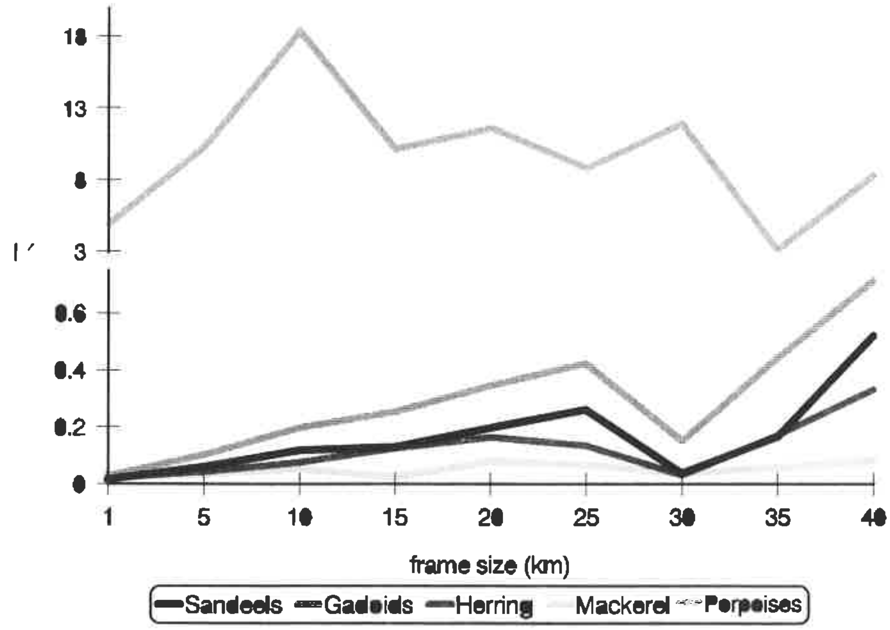

Figure 1 Index of dispersion, I′, for porpoises and fish prey as a function of the measurement distance in 1992

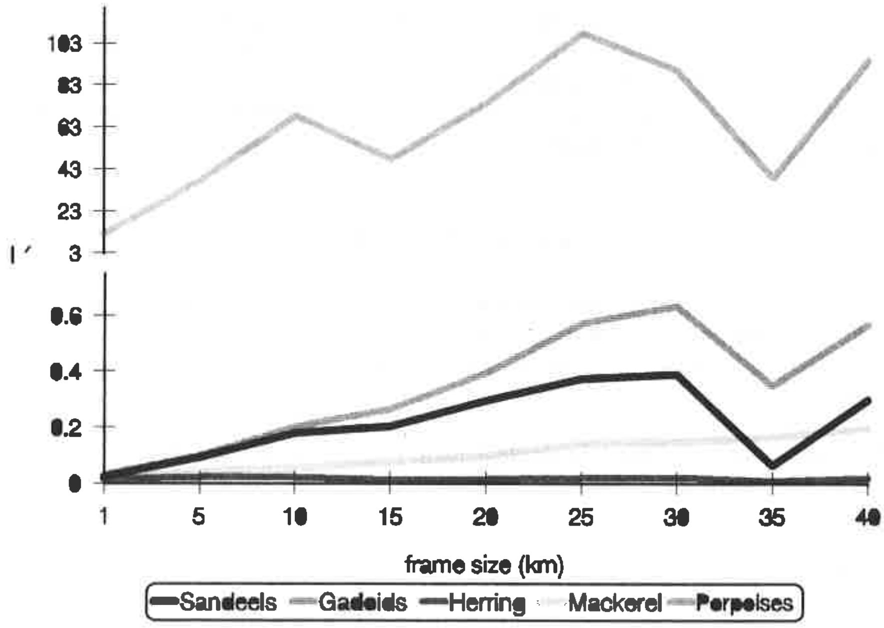

Figure 2 Index of dispersion, I′, for porpoises and fish prey as a function of the measurement distance in 1993

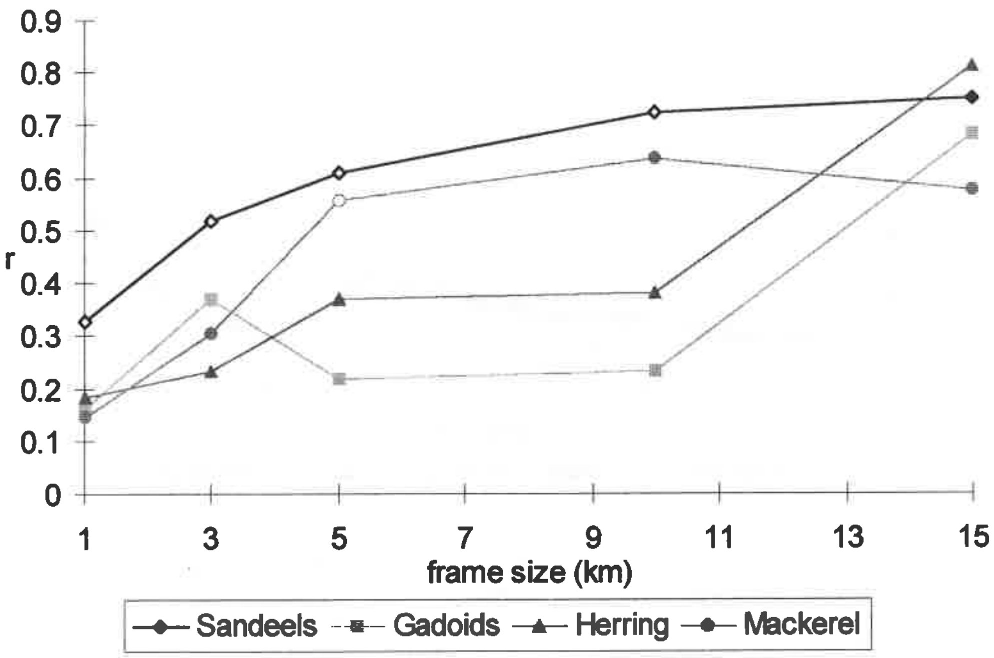

Figure 3 Pearson correlation coefficient, r, for porpoises vs. fish prey as a function of the measurement distance in 1992. Statistical significance indicated by open symbols ($p<0.05$)

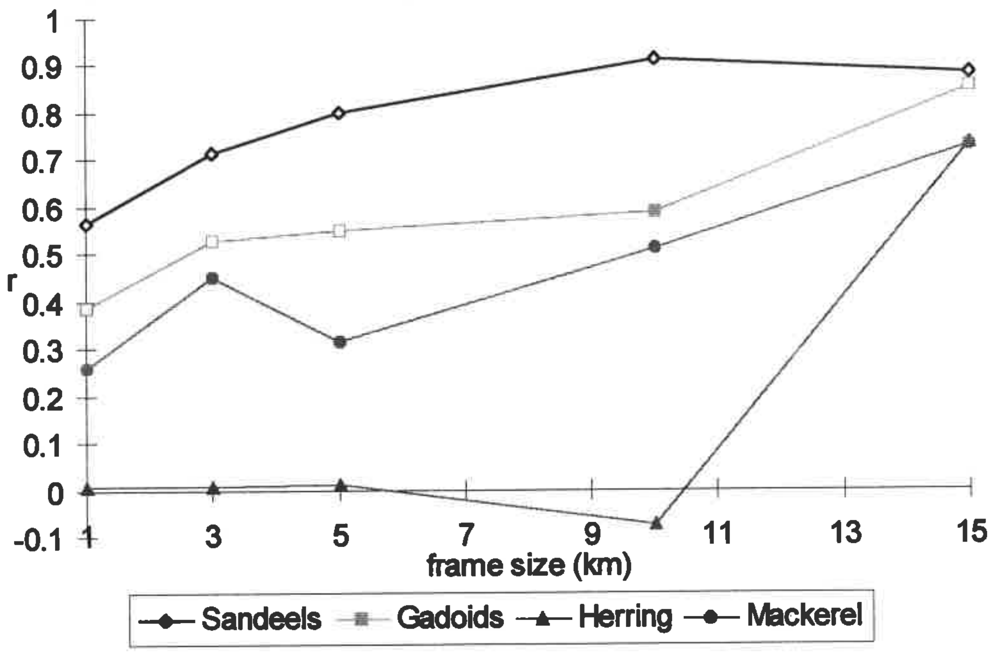

Figure 4 Pearson correlation coefficient, r, for porpoises vs. fish prey as a function of the measurement distance in 1993. Statistical significance indicated by open symbols ($p<0.05$)

PATHOLOGY OF THE SKELETAL SYSTEM OF CETACEANS FROM GERMAN WATERS OF THE NORTH AND BALTIC SEAS

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INTRODUCTION The German government has been funding research projects on small cetaceans at the University of Kiel and the University of Giessen since 1990, for the purpose of investigating the causes of decrease of cetacean populations in German waters, and to facilitate protective measures as a basis for future monitoring. During this time, 400 small cetaceans were examined systematicaly.

Investigations of the skeletal system of small cetaceans in large numbers are rare. Pathological findings on the skeletal system of harbour and grey seals from the Baltic Sea, such as parodontitis and exostosis of the alveolar bone, have already been related to environmental pollutants (Bergmann *et al.*, 1992, Mortensen *et al.*, 1992). We therefore completed the pathological and toxicological investigations on small cetaceans, and systematically examined the skeletons after maceration.

MATERIALS AND METHODS The carcasses of 172 subadult and adult cetaceans were macerated and skeletons were examined. The majority of the cetaceans were harbour porpoises - only fourteen were whitebeaked dolphins. 126 cetaceans originated from the North Sea and 46 from the Baltic Sea. Pathological examinations were carried out according to the recommendations of the First European Cetacean Society Workshop on Cetacean Pathology (Kuiken and Garcia-Hartmann, 1993). Tissue samples were taken for histological, microbiological, parasitological, and toxicological investigations.

RESULTS Pathological lesions of the skeletal system were mostly related to advanced age, inflammation, and trauma. The majority of the findings related to advanced age were spondylosis with or without ankylosis. In seven cases, there was spondylosis of vertebrae without ankylosis. Three cetaceans showed arthrosis or arthritis of the shoulder joint.

Inflammatory lesions were responsible for ten pathological findings, mainly caused by bacterial infections. In five harbour porpoises, there was chronic suppurative osteomyelitis due to *Staphylococcus aureus* and β-haemolytic *Streptococcus* septicemia. All animals with osteomyelitis also showed multiple abscesses of the muscles, and in four cases, suppurative lepto-meningitis was found. One harbour porpoise had gangrenous inflammation and a fracture of the lower jaw. Another animal had a suppurative inflammation of the mandibular joint caused by β-haemolytic, streptococcal infection extending to the ear and the eye.

In two cases, pathological changes of the jaw and ribs caused by trauma were found. One harbour porpoise and one white-beaked dolphin showed multiple fractures of the ribs with callus formation. It remains unclear whether these traumata were caused by other dolphins as reported from the coast of Scotland, or by boat accidents.

Four harbour porpoises, mainly older animals, showed structural changes of the alveolar bone with loss of the alveolar septa. Those harbour porpoises with structural changes of the alveolar bone had only few teeth left and the radix of the teeth was very short.

The ear of cetaceans, especially of harbour porpoise, is often heavily infested with nematodes (*Stenurus minor*). Changes caused by the parasites could be mechanical obstruction or inflammatory lesions, like erosion of bone structures or invasion of the inner ear. Investigations on the internal ear, the tympanic bulla, the periotic and the surrounding osseous less dense parts of the skull will therefore be performed in the future.

CONCLUSIONS Lesions of the skeletal system of cetaceans in the material from German waters are rare, especially in harbour porpoises. Kompanje *et al.* (1993, 1994, 1995) made similar conclusions from Dutch material. The majority of the pathological findings could be related to advanced age, bacterial infections, and trauma. None of the findings could be directly connected to environmental pollutants, as claimed for harbour and grey seals by a group of Swedish scientists (Bergmann *et al.*, 1992, Mortensen *et al.*, 1992).

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HARD PALATE AND SKIN ULCERS OF SPERM WHALES (*PHYSETER MACROCEPHALUS*) STRANDED ALONG THE BELGIAN AND DUTCH COASTS DURING WINTER 1994-95

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Four sperm whales stranded along the Belgian coast (18 November, 1994) and three along the Dutch coast (12 January, 1995). Necropsies were performed and samples for complementary investigations were collected. For histopathology, sections of formalin-fixed tissues were stained with hematoxylin eosin stain, and with Feulgen stain (for nucleic acid). Formalin-fixed tissues selected for electron microscopy were transfered to 2.5 % glutaraldehyde and then fixed with osmium tetroxide. Sections were examined with a Zeiss EM 910 transmission electron microscope.

Acute ulcers were observed on the hard palate and on the skin of both groups. Under the microscope, lesions were similar and diagnosed as acute to subacute ulcerative stomatitis and dermatitis. At ulcer edges, superficial epidermal cells were swollen, the cytoplasm being filled with pink edematous fluid typical of ballooning degeneration. In some cases, large eosinophilic bodies were present and these were weakly Feulgen positive. On transmission electron microscopy, basal epidermal cells had large nuclei and prominent, expanded nucleoli. In superficial cells, intracellular edema was prominent, with large vacuoles and nuclei pressed against cell margins.

Observations were suggestive of virus infection but no viral particle was seen. A cause could be poxvirus, but calicivirus, morbillivirus and herpesvirus also need to be considered in differential diagnosis.

SOME PROBLEMS OF INTERRELATIONS BETWEEN CETACEANS AND SKIN OVERGROWING MICROALGAE AND THEIR INVESTIGATION

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INTRODUCTION Algal skin coverings are known from fourteen species of cetaceans (Birkun and Gol'din, 1996). But it is probable that diatoms are growing upon the body surface in all cetacean species without exception (Yablokov *et al.*, 1972). Meanwhile, we have no comprehensive information on the taxonomy and distribution of microalgae or the reasons for their appearance. Furthermore, since 1913, interrelations existing between animals and algae have been only very poorly elucidated in the world scientific literature. Most attention has been paid to the parasitological, bioindicative and toxicological aspects of this problem. Some authors suppose that skin algae can indirectly bring some damage to the host because overgrowths may be conducive to intrusions of pathogenic micro-organisms and provide obstacles for the wound healing process. Besides this, microalgae and cyanobacteria sometimes provide evidence of the health status of the hosts and their environment (Ivashin, 1965; Heckman *et al.*, 1987). Until recently, all available data concerned whalebone whales (Mysticeti) mainly from the polar and circumpolar regions. Data was not only absent from Black Sea dolphins but also from cetaceans throughout the temperate zone. Our investigations in the northern part of the Black Sea are the first attempts to investigate this problem (Gol'din *et al.*, 1990; Gol'din and Plebansky, 1992; Gol'din, 1994, 1996).

MATERIALS AND METHODS For several years, more than thirty captive and free-living bottlenose dolphins *Tursiops truncatus ponticus* (Barabash-Nikiforov, 1940) were inspected in Karadag (Crimea) and Little Utrish (Caucasus) dolphinaria, and in the sea near Yalta and Temriuck where netting of wild dolphins also occurs. There were 139 algal samples selected by skin scrapings and smears from different parts of the body. Samples were then cultured on the Gol'dberg medium. or fixed (Lanskaya, 1971, 1975), and identified. Bacteriological investigations were conducted to determine the status of the animal's health. As a result, 120 expiratory (air-out) samples from 20 dolphins were selected and examined.

RESULTS AND DISCUSSION There were 24 microphytic algae species including 22 diatoms selected and identified during this research (Table 1). The distribution of algal growing on the skin surface was located as follows: flukes - 45% of cases; dorsal fin and lateral parts - 20% for each; tail trunk - 10%; and abdomen - 5% of cases. The greatest diversity of species was registered in the skin scrapings from the lateral parts of the body (10 species), flukes (8), dorsal fin (8), and abdomen (5). The algal skin growths occurred in nearly in all captive animals. By contrast, wild ones were free of algae in most cases. Only single cells of *Nitzschia hybrida* and *Licmophora* sp. were recorded in samples from twelve free-living dolphins examined during captures near Yalta in December 1990. Only two animals had these growths, whilst others lacked algae. We observed the same situation in the region of Temriuck where netted dolphins also had no growths.

As a rule, the greatest diversity of overgrowing algae correlated with the deteriorating health status of the host in dolphinaria (an ulcer type of skin damage, bacterial infection in most of expirative air-out samples, etc.). A comparable abundance of algal vegetation in skin growths could be related to periods of unfavourable conditions for the animals. On this occasion, the colonies of *Staphylococcus aureus*, *St. saprophyticus*, *Proteus mirabilis*, *P.vulgaris*, or mixed infections, were identified in the expiratory air-out samples taken from dolphins in Utrish and Karadag. Some animals had a twisted tail trunk and the most of those captured were covered with ulcerative skin lesions.

The algal vegetation on the skin surface of captured dolphins has its own specific features differing from the common species of overgrowing and benthic algae in the pools. Some species of algae are found primarily upon the skin of dolphins, occurring here most frequently, in greatest abundance, and for the longest periods of time. These include *Navicula pennata* var. *pontica*, *Licmophora ehrenbergii* and *Grammatophora marina*. Subsequently, they can provide an indication of the animal's health and status of the local environment.

CONCLUSIONS The skin growths of Black Sea bottlenose dolphins include 24 species of microalgae, 22 of which are diatoms. In almost half the cases (45%), overgrowing algae are inhabitants of tail flukes. Captive animals are more prone to the algal-settling process than their free-living relatives. The algal vegetation on the skin surface of captive dolphins is more abundant, and shows greater variety than on wild animals. There is a definite relationship between host sickness and the appearance of algal growths. The frequency of occurrence of some species on the surface of the skin of dolphins allows us to highligh the most typical ones. In our opinion, they can be applied as a criterion for estimating the health status of dolphins and status of the local environment.

ACKNOWLEDGEMENTS Our sincere thanks for the help in this work go to the staff of BREMA Laboratory and Institute of Biology of the Southern Seas. We are also very grateful to the scientific body, and all personnel of Karadag and Little Utrish dolphinaria.

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Table 1. The algal species isolated from skin surface of Black Sea bottlenose dolphins

NN	Species of Algae	Localization of algal overgrowings	Place and time of examination	
			Karadag	Utrish
	Bacillariophyta			
1	*Achnantes brevipes* Ag	dorsal fin	-	June
2	*A.longipes* Ag.	dorsal fin	-	June
3	*Amphora hyalina* Kutz.	abdomen, dorsal fin	March	-
4	*A. turgida* Greg.	flukes	March	June
5	*Berkeleya rutilans* (Trentep.) Cl.	flukes	April	-
6	*Fragilaria sp.*	flukes	-	June
7	*Grammatophora marina* (Lyngb.) Kutz.	lateral parts, flukes	April July	June Sept.
8	*Licmophora abbreviata* Ag.	flukes, trunckus, lateral parts	March, April	-
9	*L. Ehrenbergii* (Kutz.) Grun.	dorsal fin, abdomen, lateral parts	January, July	June
10	*Licmophora sp.**	dorsal fin, flukes	-	June, Sept.
11	*Melosira moniliformis* (O. Mull.)	dorsal fin	-	June
12	*Navicula cancellata* Donk.	lateral parts	-	June
13	*N. grevillei* W. Sm.	dorsal fin	-	June
14	*N. pennata* var. *pontica* Mer.	dorsal fin, left flipper, flukes	March, April, July	June
15	*Navicula sp.*	abdomen, lateral parts	March	-
16	*Nitzschia (Cylindrotheca) closterium* (Ehr.) W. Sm.	abdomen, lateral parts	-	June
17	*N. hybrida* f. *hyalina* Pr.-Lavr.*	dorsum		
18	*N. seriata* Cl.	flukes	July	-
19	*Nitzschia sp.*	lateral parts	March	-
20	*Pleurosigma rigidum* W. Sm.	lateral parts	-	June
21	*Striatella unipunctata* (Lyngb.) Ag.	abdomen, dorsal fin	-	June
22	*Synedra (Fragilaria) tabulata* (Ag.) Kutz.	lateral parts	-	June
	Chlorophyta			
23	*Ulothrix sp.*	lateral parts, left flipper	March	June
	Cyanophyta (Cyanobacteriales)			
24	*Anabaena sp.*	flukes	March	-

Note. * Species of algae isolated from dolphins during their catching near Yalta (Crimea)

LESIONS OBSERVED ON SPERM WHALES (*PHYSETER MACROCEPHALUS*) STRANDED ALONG THE BELGIAN AND DUTCH COASTS DURING WINTER 1994-95

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INTRODUCTION A series of sperm whale strandings occurred in the North Sea from the last months of 1994 to early 1995 (Fig. 1). Despite the fact that cetaceans have always stranded (Needham, 1993), the causes remain largely unknown. Pathological descriptions of large cetaceans are scanty, and not always easy to handle during mass strandings. Nevertheless, precise descriptions of lesions, as well as attempts to determine their origin, are fundamental to evaluate the cause of death, along with data from oceanography, ecology and toxicology.

Among the 1994-95 winter strandings, sperm whales beached along the Belgian and Dutch coasts were necropsied. This report describes the results of post-mortem investigations carried out on these animals.

CASE REPORT On 18 November, 1994, in the early morning, three beached sperm whales were discovered dead at Koksijde, a city along the Belgian coast. Stranding was considered to have occurred earlier the same day. A fourth sperm whale, probably from the same group, was found dead in shallow waters, near the beach of the city of Nieuwpoort, 10 km away from the first stranding area. It was observed at sea and eventually dragged ashore. On 12 January, 1995, three sperm whales were found alive on the beach of Scheveningen, on the Dutch coast. They died four hours after the stranding.

A standardised procedure, derived from the protocol for small cetacean necropsy (Kuiken and Garcia Hartmann, 1991) was used. Weights, when available, were corrected for body fluid loss during necropsy, and compared with expected weights using a predictive formula {000155}.

RESULTS Necropsy All sperm whales were adult males, about 15 m long for the 6 animals stranded at Koksijde and Scheveningen, 18 m long for the sperm whale of Nieuwpoort. Blubber thickness was about 16 cm on Belgian sperm whales, less than 12 cm on Dutch animals. Observed, corrected and expected weights are given in Table 1. Similar chronic skin lesions, specifically parallel and round scars on the head, and ulcerations were also present on the lower belly and on the tail of the animals of Koksijde and Scheveningen. Unusual lesions were, on two Belgian sperm whales, three to four acute ulcers on the midline on the hard palate. Lesions were round to oval, 2 to 10 cm long. Similar lesions were observed on the 3 Dutch animals, some up to 30 cm long. In addition, haemorrhagic acute skin ulcers were also observed on the tail stock of one Belgian sperm whale and on the head of one Dutch animal. On one Belgian and the three Dutch sperm whales, external ulcerative acute and chronic otitis was noticed.

Observations on bodily cavities were similar in all animals. muscle layers were evenly dark red to black. Livers were entirely dark red, almost black, with rounded edges. Renal cortices were dark red, medullae were brick red. The omentum and the serosal surface of the intestine was severely congested, with prominent blood vessels. Several dozens of nematodes were observed in the gastric lumen of 5 animals. On 2 sperm whales, dozens of flat hematomas were spread on various segments of the intestinal serosa, bleeding upon incision. Gastric and intesinal lumens were almost empty. Lungs, when observed, were evenly pinkish red without foam, or blood on the cutting edge.

Additional investigations Under the microscope, acute ulcerative lesions in the mouth confirmed the diagnosis of acute to subacute ulcerative atomatitis. The skin lesions observed on one Belgian animal were an ulcerative subacute dermo-epidermitis characterised by lymphocytis infiltration. Skin lesions on one Dutch sperm whale were an acute dermatitis. Ear lesions were similar in both groups and diagnosed as severe diffuse ulcerative subacute to chronic external otitides.

Electron microscopy investigations were done on hard palate ulcers. Keratinocytes in basal layers were severely vacuolated, nuclei were large and pale. In more superficial layers, intracellular edema was prominent. In less affected cells, cytoplasma was rich in polyribosomes. Despite the supposed infectious nature of lesions, no viral particle was observed.

Ages were determined by counting the teeth growth layers (Lockyer, pers comm) The animal in Nieuwpoort, the largest was over 29 years old. Some teeth crowns were worn and age was therefore unprecise (Table 1).

DISCUSSION AND CONCLUSIONS Three groups of lesions were identified. In the first group were the round scars. They resulted from the attachment of squid tentacles. Longitudinal parallel scars on the head resulted from fights between males (Evans, 1993). Both lesions are considered as normal findings in adult male sperm whales,

In the second group, round and ulcerative lesions observed on the skin and in the mouth suggested viral infection. Likely candidates would be poxvirus (Cheville, 1994; Yager & Scott, 1993) or morbillivirus (Domingo et al., 1992; Duigan et al., 1992). Herpesvirus and calicivirus also need to be considered. Ulcerative subacute to chronic external otitis was observed on both Belgian and Dutch sperm whales. The potential extension of such lesions to the middle and inner ear is reported in domestic animals. In those species, progression through the eighth cranial nerve is frequent and can lead to meningitis and encephalitis (Wilcock, 1993). Unfortunately, there was no possibility to investigate a potential extension of the lesions in the skull of the whales. Two animals had a severe weight deficit (32% and 37%). In addition, blubbers were thinner than reported in healthy animals (Lockyer, 1991). Both observations suggested a poor nutritional state and a chronic debilitating process.

The third group of lesions included erosions on the lower bellies and on the flukes and probably were mechanical abrasions due to rubbing of animals on the sand during agony. That lesion was not observed on the animals which died at sea. Passive congestion of livers, kidneys, intestines and lungs, and disseminated hemorrhages of intestinal serosa confirmed an acute circulatory collapse as the cause of death. The most likely process appeared to be cardio-vascular failure which could lead to shock. The shock process is on of the most frequent consequences of marine mammal strandings (Needham, 1993).

Weight losses and blubber thickness reductions were chronic processes while all other observations were acute to subacute. It is possible that debilitation, occurring first, predisposed sperm whales to secondary viral infections. Progressive weakness may have carried one or some leader animal to shallow waters, along the Belgian and the Dutch coasts, which are characterised by complex topography and sand banks. The possible final step may have been the strong social cohesion of a group trapped in a "cul-de-sac" by falling tides (Needham, 1993; Rice, 1989).

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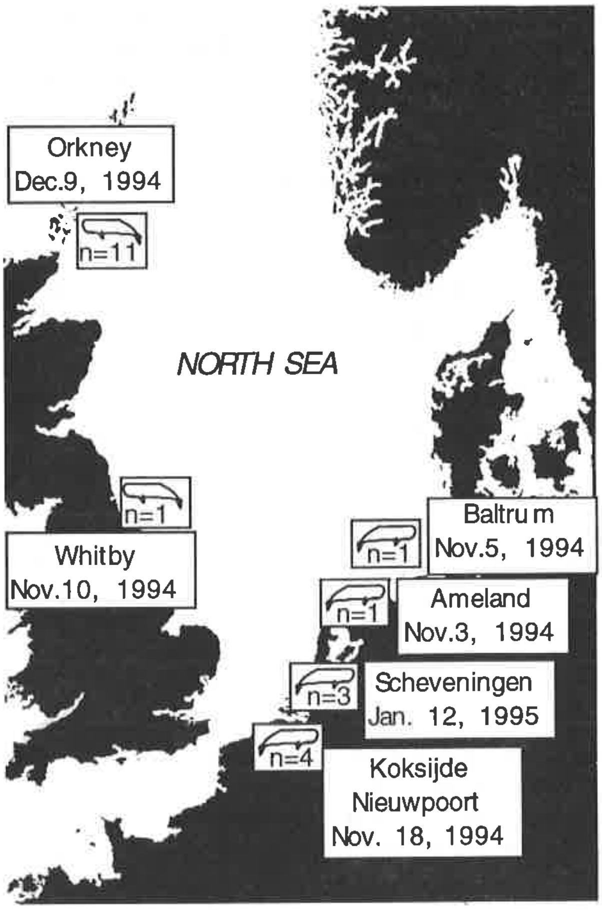

Fig. 1 Sperm whale strandings recorded in the North Sea during winter 1994-95

Table 1 Length, age and body condition of sperm whales stranded along the Belgian & Dutch Coasts during winter 1994-95. (GLG=Growth Layer Group)

	Length *(m)*	**Blubber** (mm)	**Age** (Dentinal GLG count)	**Weight** *(kg)*	**Predicted weight** *(kg)* $W = 0.0218 \times L^{2,74}$
Koksijde					
Sperm whale 1	15,4	160	>24	} 70,000	74,800
Sperm whale 2	14,9	160	>>22		
Sperm whale 3	14.40	150	28	21,940	32,500
Nieuwpoort					
Sperm whale 4	18.20	150	>29	39,000	61,800
Scheveningen					
Sperm whale A	15.2	110	>31		
Sperm whale B	15.4	120	>>26		
Sperm whale C	15.35	106			

IMMUNOLOGY OF CETACEANS AND ITS USE FOR MONITORING HEALTH AND PREDICTING EFFECTS OF ENVIRONMENTAL POLLUTION

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In the last few years, numerous questions have arisen about the competence of the immune system of cetaceans. The numerous marine mammal die-offs of the last decade have raised concerns about the possible immunosuppressive effects of environmental contaminants. Unfortunately, most of these questions remained unanswered because of a lack of basic knowledge in cetacean immunology.

A multilaboratory effort has been organised to develop assays and reagents to evaluate various immune functions in different species of cetaccans. The assays developed to date include: quantification of peripheral blood lymphocytes (PBL) by immunophenotyping, activation of PBL by quantification of IL-2 receptor expression levels, proliferation of PBL by invitro blastogenesis in response to mitogen stimulation, functionality of blood neutrophils by evaluating phagocytosis and oxidative burst, natural killer (NK) activity by tumor cell cytolysis, and IL-6 and C-reactive protein (C-RP) for detection of the early phase of inflammation.

These assays have been applied in different situations. In a healthy and immune monitoring programme, immunophenotyping, expression of IL-2 receptor and blastogenesis have been shown to correlate with disease processes, and serum IL-6 levels were shown to be a useful indicator of an ongoing inflammatory process on some occasions. In addition, in vitro exposures of beluga whale lymphocytes to different environmental contaminants have been performed. Exposure to mercury and cadmium, as well as to some PCB and DDT congeners and mixtures of congeners, all at concentrations in the range of those found in tissues of St. Lawrence belugas, have been shown to decrease lymphocyte proliferation.

These studies indicate the usefulness of evaluation of immune functions in cetaceans, and support the hypothesis that environmental contaminants could impair immune functions in these animals.

A 1990-95 FOLLOW-UP OF THE STRIPED DOLPHIN *MORBILLIVIRUS* EPIZOOTIC AT THE CATALONIAN COAST

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With the aim of monitoring the evolution of the morbillivirus epizootic, we have investigated striped dolphins stranded at the Catalonian coast from August 1990 to December 1995 for the presence of dolphin morbillivirus (DMV) induced lesions and viral antigen.

Records of strandings reached their highest level in September 1990, declining to a low level in December 1990. The severe signs of systemic morbillivirus infection, characterised by bronchiolo-interstitial pneumonia, encephalitis, and lymphoid depletion, with secondary opportunistic infections, were not observed after December 1990, which supports the view that the epizootic infection vanished at the end of that year from the Catalonian coast.

From December 1990 to the end of 1995, seven dolphins showed encephalitis with DMV-antigen in the brain. These lesions were of chronic character, with very low amount of viral antigen by comparison with the cases of encephalitis in the epizootic phase. These lesions are very similar to cases of the human disease "Subacute Sclerosing Panencephalitis" (SSPE), and the so-called "old dog encephalitis", both caused by specific morbilliviruses.

At least for SSPE, it is well known that the initial viral infection is acquired early in childhood, remains latent for years, and re-activates by unknown triggering factors, following a fatal course. The change in distribution pattern of lesions and DMV-antigen, and the temporal relationship between the two forms of the infection suggest that these chronic cases are probably a re-activation of DMV-infections in dolphins exposed in 1990.

ANTIBODIES TO *BRUCELLA* IN MARINE MAMMALS AROUND THE COAST OF ENGLAND AND WALES

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Following the isolation of previously unrecognised species of *Brucella* from a range of stranded seals and cetaceans in Scotland, a serological survey was carried out to assess the range of marine mammal species exposed to *Brucella*, the prevalence of infection, and the geographical distribution of seropositive animals.

153 serum samples collected from 153 stranded marine mammals in England and Wales were tested by competitive and indirect ELISA. Positive titres were recorded for 10% of grey seals (*Halichoerus grypus*), 8% of common seals (*Phoca vitulina*), 32% of harbour porpoises (*Phocoena phocoena*) and 31% of common dolphins (*Delphinus delphis*) tested. Single positive titres were also found in a striped dolphin (*Stenella coeruleoalba*), a bottlenose dolphin (*Tursiops truncatus*), a killer whale (*Orcinus orca*), and a long-finned pilot whale (*Globicephala melas*).

Seropositives were found in widespread locations around the UK, and the earliest seropositive was from a common dolphin in 1990. The results of this study indicate the widespread nature of *Brucella* exposure within a range of marine mammal species in British waters.

THE COMET ASSAY FOR THE EVALUATION OF THE GENOTOXIC HAZARD OF POLLUTANTS ON MARINE MAMMALS. METHYLMERCURY TOXICITY IN THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) LYMPHOCYTES IN VITRO

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As terminal consumers, delphinids are the typical end-points of the biomagnification of persistent pollutants such as methyl mercury (Gaskin, 1982). The dietary exposure to methyl mercury has been estimated as about 1 mg/day for dolphins living in the Mediterranean Sea (Nigro and Leonzio, 1993). Dolphins are known to be able to detoxify a large part of the organic mercury consumed through the food, and to accumulate inorganic mercury as insoluble granules composed of mercury selenide in macrophages (Nigro, 1994). However, the potential genetic risks of such a high methyl mercury exposure has never been investigated in these organisms.

In the present study, the single cell electrophoresis (Comet Assay) has been extended to evaluating the genotoxicity of metal mercury in the bottlenose dolphin. Samples of blood were obtained from dolphins reared at the Adriatic Sea World (Riccione, Italy). Lymphocytes were treated in suspension culture for one hour with different methyl mercury concentrations (1-8 mg/ml) before being subjected to individual cell electrophoresis. Moreover, the cytotoxicity of methyl mercury was assessed by dye exclusion technique performed on aliquots of the cell culture.

Our preliminary results demonstrated that methyl mercury has a genotoxic effect on cultured lymphocytes in a dose-related manner, inducing more than a 4-fold increase in the proportion of the damaged cells, at the maximum dose (8 mg/ml), with respect to controls ($p<0.0001$). Moreover, the degree of induced DNA fragmentation was comparable to that of reduced cell viability (8mg/ml, viability >79%).

Results were compared with data from the literature on the effects of methyl mercury in human and rat lymphocytes (Betti *et al.*, 1993). The comparison showed that at low doses (0-1 g/ml), the effect of methyl mercury on human, rat, and dolphin lymphocytes were similar. Otherwise, at doses >1 mg/ml, both the cytotoxic and genotoxic effects of methyl mercury were significantly less in dolphin lymphocytes than in human and rat cells. This finding might be explained by the presence of two different lymphocyte populations in dolphins, namely: "sensible" ones (whose response to methyl mercury is similar to that of human and rat cells), and "resistant" lymphocytes which were still viable at a dose of 8 mg/ml.

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TISSUE TRACE METAL CONTENT IN DOLPHINS OFF THE MEDITERRANEAN COAST OF ISRAEL

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The extent of assimilation of trace metals into cetacean tissues has so far not been documented in the Eastern Mediterranean basin. This study is an ongoing attempt to fill this gap.

The quasi-endemic coastal population of bottlenose dolphins *Tursiops truncatus* was selected. Samples of skin, blubber, muscle, liver and kidney from four accidentally entangled and one freshly stranded animal were obtained within 12 hours of death, and assayed for Cd, Cu, Fe, Zn, and Mn by flame and, for Hg, by cold vapor atomic absorption spectrophotometry.

Selective values [median and (range) in µg.g-1 wet weight] are liver mercury - 161 (48-491); muscle mercury - 13.2 (3.5-38); kidney cadmium - 1.6 (0.3-4.2); liver iron - 263 (220-457); and skin zinc - 236 (157-266). Mercury content increased with estimated age (length/weight) and its tissue ranking was blubber < skin < muscle = kidney < liver. The stranded adult had the highest mercury levels, especially in the blubber (12 compared with <4 in all the rest).

Once standardised, the observed values and trends resemble those reported elsewhere for the North-western Mediterranean, supporting the contention that natural rather than industrial sources account for the high levels in Mediterranean fish, marine birds and mammals. More data are needed to test the possible association of stranding with extra-high tissue contents of trace metals.

ORGANOCHLORINE COMPOUND LEVELS IN STRIPED DOLPHINS FROM THE WESTERN MEDITERRANEAN SEA DURING THE PERIOD 1987-93

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INTRODUCTION The main objectives of the present study were to assess the composition and amount of the main organochlorine compounds present in Mediterranean striped dolphins, and to investigate the existence of time-trends in both the amount and composition of organochlorine loads. In order to attain these objectives, we analysed 142 blubber samples, obtained by means of biopsy techniques from free-ranging, apparently healthy, western Mediterranean striped dolphins during the period 1987-93, with the exception of the year 1990 when no samples were collected because of the impossibility of distinguishing healthy individuals from those affected by the viral disease that affected this population (Aguilar and Borrell, 1994).

METHODS

Sex The determination of sex of the dolphins sampled was carried out on a portion of the biopsied skin, using a technique based upon amplification by PCR of ZFX and ZFY where two specific sex chromosomes DNA regions present slight differences in their nucleotide sequence (Palsboll *et al.*, 1992).

Organochlorine compound analysis Quantification and identification of DDT's and PCB's in blubber samples were carried out by gas chromatography on a SPB 5 capillary column with an electron capture detector, following the procedures and techniques described by Aguilar and Borrell (1994). Since organochlorines are highly apolar compounds, organochlorine concentrations in this report are expressed as parts per million (ppm), calculated on the basis of the weight of the extracted lipids (lipid basis). Total DDT (tDDT) levels are expressed as the sum of all DDT forms (pp'-DDE, pp'-DDT, op'-DDT, and pp'-TDE). The DDE percentage (DDE/tDDT) was calculated as pp'-DDE*100/tDDT, and the tDDT/PCB ratio as tDDT*100/PCB.

Statistical analysis Differences between groups (year of capture) and sexes were examined using a one-way analysis of variance followed by the Tukey multiple comparison test at $p<0.05$. Regression analyses were carried out between log tDDT, log PCB, log DDE/tDDT and log tDDT/PCB and year of capture. All statistical calculations were carried out using the SPSS-X statistical package.

RESULTS AND CONCLUSIONS

a) Concentrations Table 1 shows the means of lipid content, concentration of organochlorine compounds (expressed in ppm) and their associated ratios (x100), for the total sample and for each sex separately.

The PCB levels are in the same order of magnitude as those reported by Alzieu and Duguy in 1979 (267 ppm), in stranded animals of the same species on the French Mediterranean coasts. However, they are higher than levels found in animals from the Ligurian Sea also sampled with biopsy darts (51 ppm) (Focardi *et al.*, 1992). The tDDT levels (135 ppm) are lower than those found in animals from the French coast (344.2 ppm) but higher, as for PCB, than in individuals from the Ligurian Sea (27 ppm).

Such levels are much higher than those typically found in populations of the same species, inhabiting other water masses (O'Shea *et al.*, 1980; Tanabe *et al.*, 1984; Kawai *et al.*, 1988; Morris *et al.*, 1989; Loganathan *et al.*, 1990; Cockcroft and Ross, 1991). The individuals that died during the 1990 epizootic along the Mediterranean Spanish coasts, which are not included in this study, carried even higher levels of both DDT's (440 ppm) and PCB's (778 ppm), for which reason it was suggested that such elevated concentrations may have triggered the development of the viral process (Aguilar and Borrell, 1994).

Figure 1 depicts the percent contribution of each PCB congener to the total PCB load in males and females. No significant differences were observed between both sexes either in concentrations, ratios or congener composition. However, it should be taken into account that the number of samples of known sex was limited (29) and that some of the sampled individuals were probably immature females, and thus had not yet transferred PCB's to their offspring through gestation or lactation, and therefore are unlikely to display the sex-related differences commonly observed in the adult population.

b) Trends

Time trends of tDDT and PCB concentrations Table 2 shows the means of lipid content, concentration of organochlorine compounds (in ppm) and their associated ratios (x100), distinguishing between years of capture. As shown in Fig. 2, organochlorine concentrations (PCB and tDDT) appear to have decreased with year of sampling.

Overall trends in pollutant levels suggest that tDDT and PCB levels in terrestrial and aquatic organisms have declined in the most polluted areas, usually located close to the point sources of pollution, whereas they have remained stable or slightly increased where they were previously low or absent. This effect would be more apparent in organisms located low in the food chain because of the immediatedness of the process in the lower trophic levels. In relative terms, a decrease in concentrations was first noted for DDT, and later for PCB's, a fact which is consistent with the history of production, use, and subsequent restriction of these two groups of organochlorine compounds (OC's) and their persistence in the ecosystem (Peterle, 1991; DeVoogt and Brinkman, 1989).

For a top predator, oceanic species such as the striped dolphin, in principle it would be expected that concentrations of these pollutants, particularly of PCB's, continue to increase with time at least for some decades. However, our results indicate that the reduction in organochlorine pollutant levels observed in the highly contaminated coastal areas are also extending to offshore regions, and to high levels of the food chain, therefore reaching animals like striped dolphins.

Time trend of DDE/tDDT and tDDT/PCB As shown in Fig. 2, the ratios DDE/tDDT and tDDT/PCB have increased significantly during this period of study.

Once DDT compounds are released into the environment, the relative amount of pp'DDE to tDDT increases progressively with time, due to progressive metabolisation at which the compounds are subjected by the different trophic levels of the ecosystem and different organisms. Because the use of DDT has been discontinued since the late 1970's, the relationship between the "age" of the DDT and the DDE/tDDT ratio has previously been observed, and is considered an overall process in marine ecosystems (Aguilar, 1984). This effect is clearly reflected in the results of our study, in which the DDT load of the striped dolphin appears to become progressively "older" as times passes.

The ratio tDDT/PCB varies between years, depending on the time-related variation of the concentrations of tDDT and PCB in the region. In some geographical areas, PCB's have declined more rapidly than those of tDDT (Addison *et al*, 1986), so the tDDT/PCB ratio increased with time (Addison *et al*, 1984), while in other locations tDDT has decreased while PCB's have remained stable or have even increased (Norstrom *et al.*, 1988), therefore producing the reverse trend in the ratio between the two pollutants. Indeed, differences in time trends of the ratio reflect time-related changes in the predominance of organochlorine contamination from industries (PCB) or from agriculture (DDT). As we can see in Fig. 2, the levels of PCB in the population studied have decreased more than those of DDT during the period 1987-94.

Time trends of congeners/PCB Figure 3 shows the mean percentage of each PCB congener in relation to the total PCB for the years 1991, 1992, and 1993, the time period when appropriate analytical techniques were available to determine congener specific concentrations. No trends with time are observed during these three years. Samples from 1992 seem to have a different profile from those of the two previous years, but significant differences cannot be observed.

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	% LIPID	pp'DDE	pp'TDE	op'DDT	pp'DDT	tDDT	PCB	% DDE/ tDDT	% tDDT/ PCB
MALES n=21	59	58	7	5	7	76	97	74	78
FEMALES n=8	57	55	7	5	7	74	107	74	70
TOTAL n=142	58	94	12	12	18	135	240	66	59

Table 1: means of lipid content, concentration of organochlorine compounds (ppm lipid weight) and associated ratios (x100) considering the total sample, males and females.

	% LIPID	DDE	TDE	opDDT	ppDDT	tDDT	PCB	%DDE/ tDDT	%DDT/ PCB
1987 n=32	56	139	13	17	23	193	334	64	52
1988 n=46	61	92	16	16	22	146	309	61	46
1989 n=10	59	78	8	12	17	115	237	67	49
1991 n=17	60	99	11	9	19	138	172	69	82
1992 n=3	38	36	6	5	18	66	147	55	45
1993 n=34	58	60	7	5	7	79	104	74	76

Table 2: means of lipid content, concentration of organochlorine compounds (ppm lipid weight) and associated ratios (x100) distinguishing between years of capture.

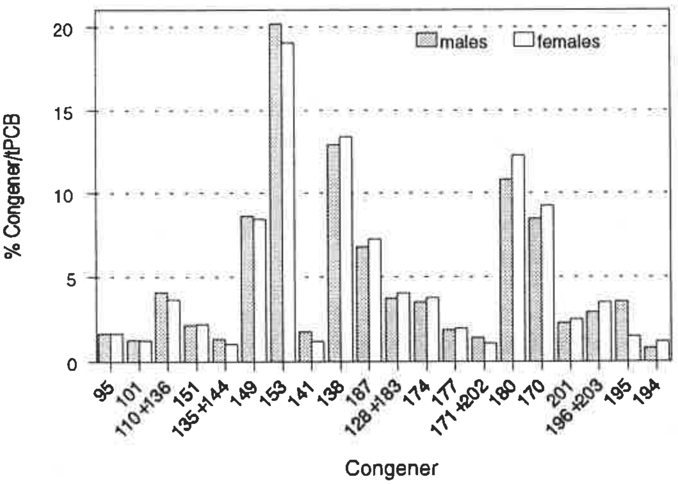

Figure 1. Mean percentage of each PCB congener in relation to total PCB for males and females.

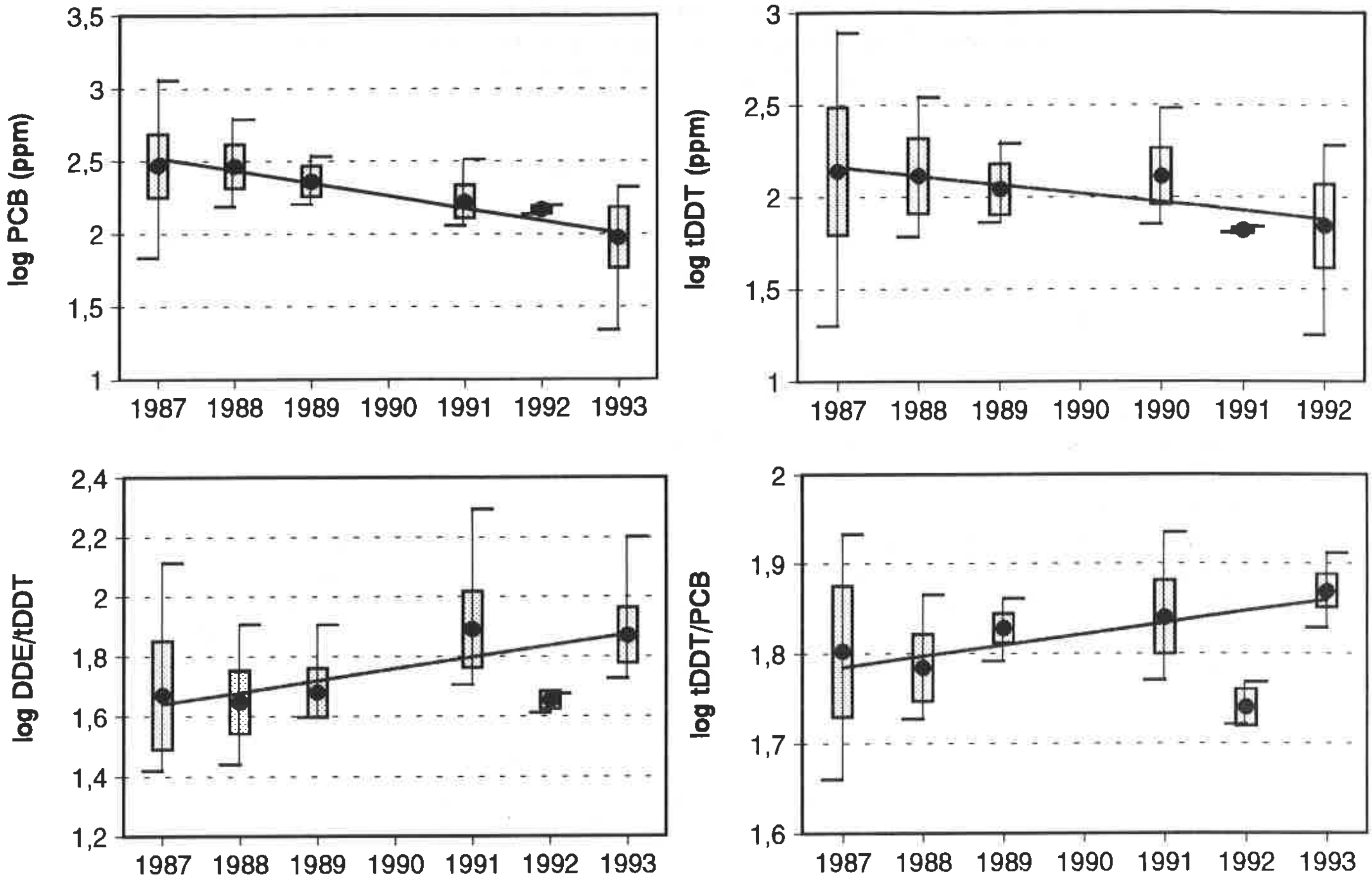

Figure 2. Mean levels of PCB, tDDT, DDE/tDDT and tDDT/PCB in relation to year of capture.

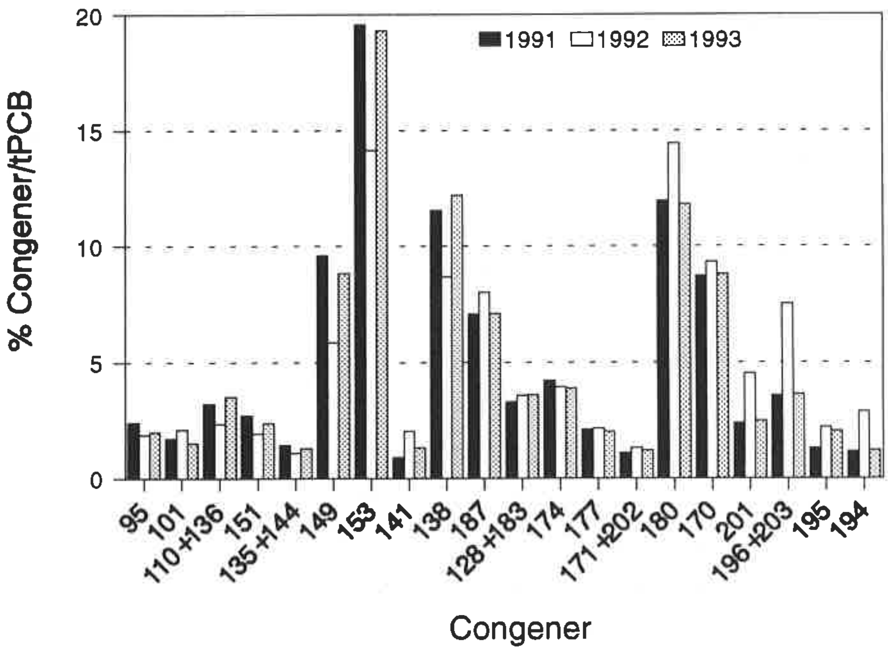

Figure 3. Mean percentage of each PCB congener in relation to total PCB for 1991, 1992 and 1993.

PCB METHYL SULPHONES: TOXICOLOGICAL IMPLICATIONS FOR THE RESPIRATORY AND REPRODUCTIVE SYSTEMS OF MARINE MAMMALS

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INTRODUCTION Methyl sulphones (MSFs) are metabolites of PCB formed via liver microsomal cytochrome P450-dependent detoxification enzymes and the mercapturic acid pathway in mammals. Introduction of a sulphone group into the biphenyl skeleton increases the water solubility (polarity) and therefore excretability of the parent molecule (Bergman *et al.*, 1994). MSFs have been found in the blubber of a variety of marine mammal species, including harbour seals (*Phoca vitulina*), ringed seals (*Pusa hispida*)(Haraguchi *et al.*, 1992), and beluga whales (*Delphinapterus leucas*) (Bergman *et al.*, 1994). MSF accumulation in the lung, liver, prostate, testis, adrenal, kidney, and brain of male grey seals (*Halichoerus grypus*) (Haraguchi *et al.*, 1990) and liver of beluga whales (Bergman *et al.*, 1994) have, to date, been reported.

PCB-MSFs competitively bind intra-cellular protein receptors involved in the binding of steroids and other endogenous ligands, causing them to accumulate in lung (Bergman *et al.*, 1982; Brouwer and van den Berg, 1986), uterus (Lundholm, 1988), and testes (Baker, 1983) of mammals. MSFs have a higher binding affinity for these proteins than do their natural ligands, preventing them from carrying out vital biological functions (Lund *et al.*, 1985) causing reproductive and pulmonary toxic effects. Due to the toxicological significance of these poorly studied contaminants to the conservation of marine mammals, the concentration of PCB-MSFs in blubber of several cetacean species, so far unstudied, was determined. Accumulation of PCB-MSF in the lungs of harbour seal and striped dolphin morbillivirus victims and in harbour seal uterus was also investigated.

MATERIALS AND METHODS The sample preparation procedure is described in Troisi *et al.* (in prep.). Briefly, uterus and lung samples (5-30 g) were homogenised with Na_2SO_4 extracted by soxhlet with 250ml anhydrous dichloromethane (DCM) for six hours at 65°C. Extracts were spiked with 960 ng internal standard (3-$MeSO_2$-4-Me-2',3',4',5,5'-pentachlorobiphenyl) in 1 ml iso-octane, concentrated, and resuspended in 5 ml DCM:hexane (8:92%). Extracts were cleaned up with 15 x 1 cm i.d. columns loaded with 3 g of 100% activated alumina. PCB's/pesticides and MSF fractions were eluted with 50 ml DCM:hexane (8:92%) followed by 50 ml 100% DCM. Blubber samples were treated in this same way, except for an additional clean-up prior to alumina fractionation using HPLC with Bio-Beads S-X3 (200-400 mesh, 50g) in hexane:DCM (50:50) packed column, eluted with DCM:hexane (50:50%). All MSF fractions were concentrated, re-suspended in iso-octane, and analysed by GC-ECD and GC-MS.

GC Injector and detector were set at 250°C and 330°C. GC column used was a *J&W Scientific* DB-5, 60 m x 0.25 mm i.d., temperature programme; 70°C for 2 mins, then 240°C at 20°C $min.^{-1}$ and finally to 290°C at 4°C min^{-1} for 20 mins. Nitrogen was the carrier (30 $cm.sec^{-1}$) and make-up gas (30 $ml.min^{-1}$). Methyl sulphone metabolites were identified and calibrated by comparison of retention times and peak areas with those of reference compounds. GC-MS was used for confirmation analysis - EI mode set for multiple ion detection monitoring for mass/charge ratios 370, 404 and 438 for tetra-, penta- and hexachlorobiphenyl methyl sulphones, respectively.

RESULTS & DISCUSSION In this study, PCB-MSFs were detected in the blubber of five species of cetacean from the Irish Sea: harbour porpoise (*Phocoena phocoena*), Atlantic white-sided dolphin (*Lagenorhyncus acutus*), long-finned pilot whale (*Globicephala melas*), Risso's dolphin (*Grampus griseus*) and common dolphin (*Delphinus delphis*); in striped dolphin (*Stenella coeruleoalba*) morbillivirus victims from the Aegean Sea, and also in east coast of England and German Wadden Sea harbour seals (*Phoca vitulina*), emphasising the ubiquitous occurrence of these contaminants in marine mammal tissues (Fig. 1). The lipid weight concentrations of PCB-MSFs in harbour seal lung and uterus tissues and striped dolphin lung were 1.6, 5.7 and 6.5 times higher than those detected in the blubber (Figs. 2 & 3). This is due to the high binding affinity of PCB-MSFs for uteroglobin (Lund *et al.*, 1985) and the more polar lipid composition (phospholipid and non-esterified fatty acids) of lung and uterus tissues compared with blubber, which comprises predominantly apolar triglyceride lipid (Kawai *et al.*, 1988).

Victims of the North European seal epizootic and the Mediterranean striped dolphin epizootic suffered severe secondary bacterial infections of the lung (Raga *et al.*, 1991; Munro *et al.*, 1992). PCB metabolites can bind the carrier protein transthyretin, preventing transfer of retinol and thyroxin to target epithelia during the immune response and increasing susceptibility to infection (Brouwer and van den Berg, 1986). In addition, sputum PCB concentration from humans poisoned with PCB during the Yusho disaster, were negatively correlated with blood immunoglobulin concentration and high incidence of pulmonary bacterial bronchitis-like infections (Shigematsu *et al.*, 1978). Although morbilliviruses are immunosuppressive, lung PCB-MSFs probably exacerbated the susceptibility of infected animals to secondary pathogenic infections, resulting in greater mortality of those with higher PCB burdens. e.g., harbour seal populations from more polluted waters such as the Wadden Sea, suffered higher PDV-associated mortalities during the 1988 epizootic compared with those from cleaner waters (Troisi and Mason, 1996).

Studies have already demonstrated the reproductive toxicity of organochlorines such as PCB's in the harbour seal. Disturbance of progesterone balance at implantation was believed to have been involved in organochlorine-induced reproductive toxicity via implantation failure in seals fed more PCB-contaminated fish (Reijnders, 1986). Since PCB-MSFs preferentially accumulate in uterine tissue, they can out-compete progesterone for binding sites on uteroglobin. Progesterone is vital to preparation of the uterus for attachment of the fertilised blastocyst. Progesterone-bound uteroglobin also prevents over-exposure of the blastocyst to progesterone and associates with the blastocyst surface to prevent rejection and attack from maternal lymphocytes (Savouret and Milgrom, 1983). At the molecular level, therefore, uteroglobin binding of methyl sulphones is most likely to be the mechanism of organochlorine-induced reproductive toxicity by inhibition of progesterone and uteroglobin functions in the pre-implantation uterus.

Since PCB-MSFs are increasingly being found to be ubiquitous contaminants of marine mammals, the reproductive and pulmonary toxicity of PCB-MSFs warrant further attention. It is imperative that future pollution monitoring studies incorporate sampling of lung and reproductive tissues for methyl sulphone analysis, to elucidate the importance of PCB and their metabolites in the recruitment and health of marine mammal populations already under pressure from fisheries interactions, direct mortality, and other forms of habitat destruction.

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Figure 1: Blubber PCB-MSF Concentration in Several Species of Marine Mammal.

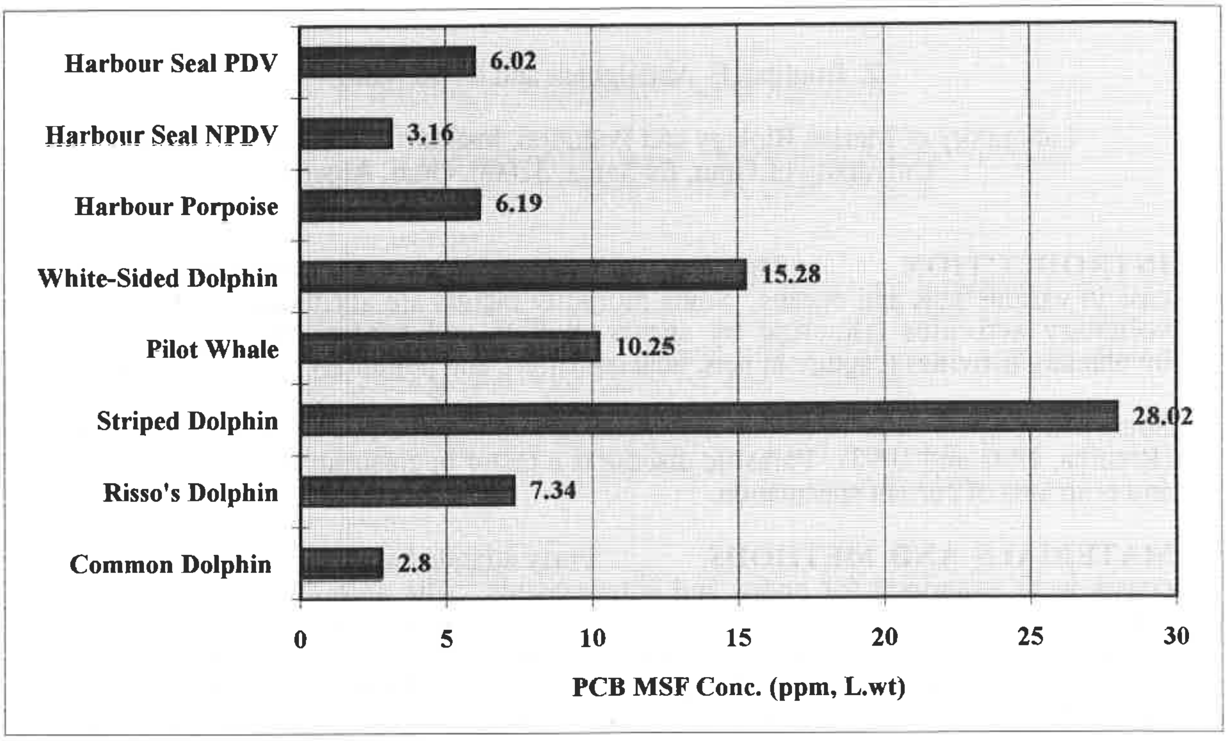


Figure 2: Inter-Organ PCB-MSF Accumulation in Harbour Seals.

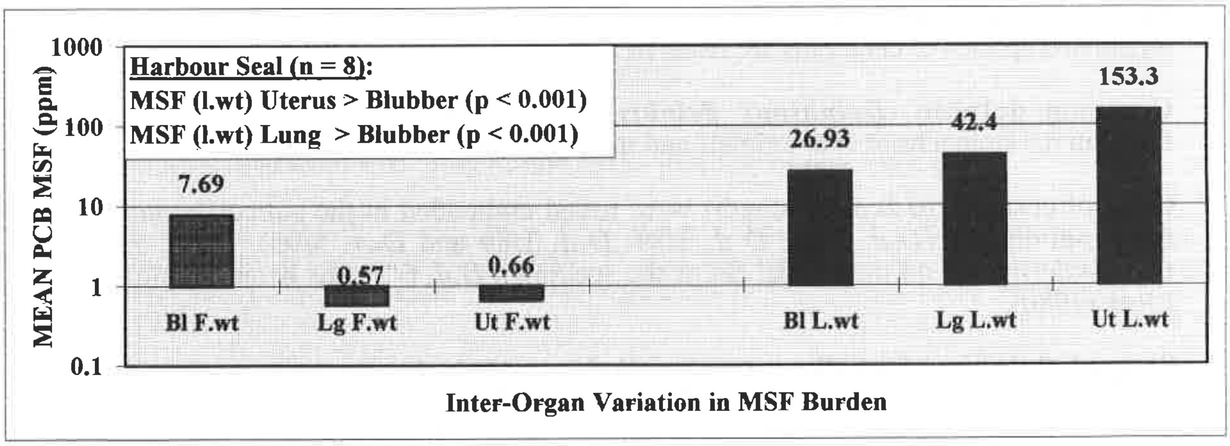
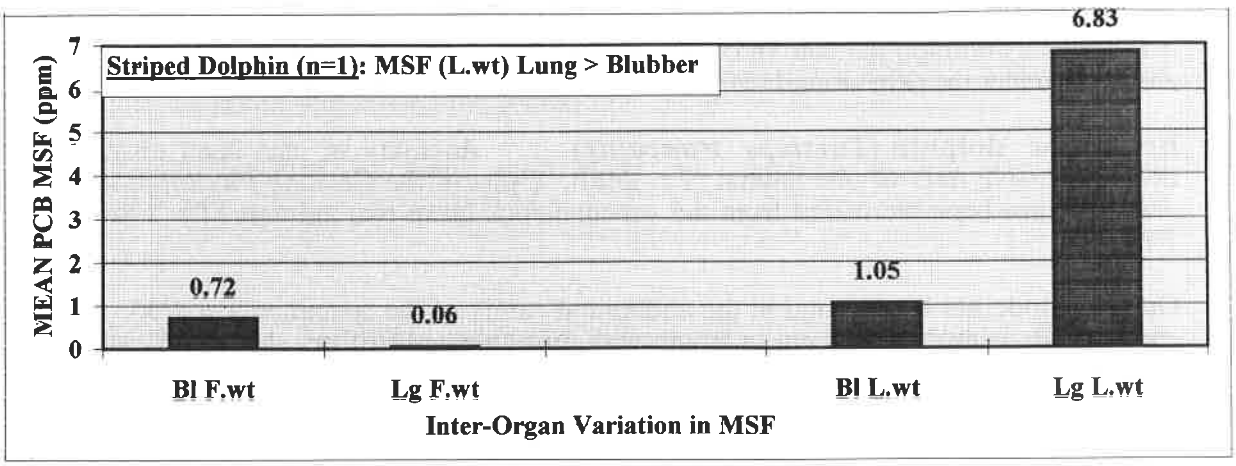


Figure 3: Inter-Organ PCB-MSF Accumulation in Striped Dolphin



PARASITOLOGICAL INFORMATION ON CETACEANS FROM THE ALGERIAN COAST

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INTRODUCTION The cetaceans in Algerian waters are threatened, as is the case in various seas and oceans. Some mortality factors are attributed to either man's voluntary activities (shooting by spears, bullets and explosives...) or to man's involuntary activities (capture in nets, boat collisions, and pollution).

Some pathological cases of certain individuals are considered as a cause of the mortality (Boutiba, 1992 and 1993). Parasitic disease is a factor in cetacean stranding behaviour and is an area of current speculation.

MATERIALS AND METHODS Forty stranded animals along the Algerian coasts were examined for endo- and ectoparasites. The animals belonged to four cetacean species (common dolphin *Delphinus delphis*, striped dolphin *Stenella coeruleoalba*, bottlenose dolphin *Tursiops truncatus* and Cuvier's beaked whale *Ziphius cavirostris*). The identification of parasite species was undertaken in the Laboratory of Parasitology, Institute of Natural Sciences, University of Oran, Algeria, with the help of the Natural History Museum, Paris, France and Dr. J. A. Raga, Department of Animal Biology, Faculty of Biological Sciences, University of Valencia, Spain.

RESULTS AND DISCUSSION Parasites recovered from the four above-mentioned species of cetaceans are listed in Table 1.

Common dolphin (*Delphinus delphis*) Nematode *Anisakis* sp. has been found in the stomachs of four animals and in the intestine of one animal.

Cysts of cestodes (0.5cm of length) were found embedded in the subcutaneous fat of four individuals (*D.d.* 7/86. *D.d.* 3/89; *D.d.* 1/89 and *D.d.* 5/95). One cirriped *Conchoderma* sp. on the caudal fin of the specimen *D.d.* 6/79 has been mentioned by Lloze (1980).

Striped dolphin (*Stenella coeruleoalba*) *Anisakis* sp. was recovered from the digestive tracts of two animals (*S.c.* 7/87 and *S.c.* 8/90). Cysts of cestodes with length of 0.5-1.0 cm were found in subcutaneous adipose tissue and in the peritoneum of animal no. 7/89.

According to Viale (1977), those cysts of Cestoda contain larvae of the cestode *Phyllobotrium delphini*. Duguy and Toussaint (1977) reported that the cestode *P. delphini* is a common parasite in common dolphin and striped dolphin, where it forms abscesses under the skin around the genital split and in the abdominal cavity.

Bottlenose dolphin (*Tursiops truncatus*) *Anisakis* sp. has been observed in the digestive tract of one animal (*T.t.* 2/90). Cysts of the Cestode *Phyllobothrium delphini* have been recovered from the subcutaneous fat of two animals (*T.t.* 7/86 and *T.t.* 5/87).

One nematode has been found in the abdominal cavity of the specimen *T.t.* 2/90. This endoparasite is more than 8 cm in length with unsegmented filiform shape and covered by cuticle.

Three ectoparasite species have been observed. The cirriped *Xenobalanus globicipitis* was attached to the caudal fin of the specimen *T.t.* 2/90, copepod *Pennella balanenopterae* was attached to the skin of the specimen *T.t.* 7/88, and *Conchoderma* sp. has been seen by Lloze (1980) attaching to the skin of *T.t.* 4/77.

Cuvier's beaked whale (*Ziphius cavirostris*) The single animal examined (*Z.c.* 1/94) was heavily infected by the ectoparasite *Xenobalanus globicitis* which was attached to the skin of both sides. Cysts of Cestoda were found in the digestive tract, heart, lungs, and in subcutaneous fat. The heavy infection of this animal might have been the cause of its death.

CONCLUSIONS The results show that 17 from 40 examined cetaceans belong to four species were parasitised. It seems that common dolphins were more infected with both endoparasites (cysts of cestodes in the digestive tract, lungs, heart and subcutaneous fat) and with ectoparasites attaching to its sides and fins.

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Table 1 Parasites found in the studied cetacean species.
M = male F = female ? = undetermined sex

N° of the host	*Sex*	*Length (cm)*	*Weight (Kg)*	*Location of the parasite in the host organism*	*Parasites*
Delphinus delphis					
1. D.d. 7/75	F	160	43	digestive tract	Nematode: *Anisakis sp.*
2. D.d. 9/79	F	195	70	digestive tract	Nematode: *Anisakis sp.*
3. D.d. 7/86	F	171	64	subcutaneous fat	Cestode: Cysts (*Phyllobotrium delphini*)
4. D.d. 3/89	F	210	82.3	subcutaneous fat	Cestode: Cysts (*Phyllobotrium delphini*)
5. D.d. 5/90	F	223	94	digestive tract	Nematode: *Anisakis sp.*
6. D.d. 6/79	F	180	80	caudal fin	Cirriped: *Conchoderma sp.*
7. D.d. 1/94	F	190	51	subcutaneous fat, digestive tract, caudal fin	Cestode: Cysts Cirriped:*Conchoderma sp.*
8. D.d. 5/95	F	176	48	digestive tract	Cestode: Cysts (*Phyllobotrium delphini*)
Stenella coeruleoalba					
9. S.c. 7/87	F	135	30	digestive tract	Nematode: *Anisakis sp.*
10. S.c. 7/87	F	180	66	subcutaneous fat	Cestode: *Cysts (Phyllobotrium delphini)*
11. S.c. 7/87	F	194	77	digestive tract	Nematode: *Anisakis sp.*
Tursiops truncatus					
12. T.t. 7/86	F	265	210	subcutaneous fat	Cestode: *Cysts (Phyllobotrium delphini)*
13. T.t. 5/87	M	305	-	subcutaneous fat caudal fin	Cestode: *Cysts (Phyllobotrium delphini)* Cirriped: *Xénobalanus globicipitis*
14. T.t. 7/88	?	170	66	skin	Copepod: *Pennella balaenopterae*
15. T.t. 2/90	M	310	-	digestive tract, caudal fin	Nematode: Anisakis sp. Cirriped: *Xénobalanus globicipitis*
16. T.t. 4/77	M	256	-	skin	Cirriped: *Conchoderma sp*
Ziphius cavirostris					
17. Z.c. 11/94	F	550	3000	stomach	Cestode: *Cysts (Phyllobotrium delphini)*
				left side and caudal fin	Cirriped: *Xénobalanus globicipitis*

PARASITOLOGICAL FINDINGS IN SMALL CETACEANS FROM GERMAN COASTAL WATERS

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Under the Government funded-project "Investigations on small cetaceans as a base of a monitoring", we had examined 106 harbour porpoises and eight white-beaked dolphins from the German coasts of Schleswig-Holstein and Mecklenburg-Vorpommern for its parasitic fauna. Eighty-eight of the animals came from the North Sea and eighteen from the Baltic Sea. The white-beaked dolphins were all found on the coast of the North Sea. The animals were collected in the years 1993 and 1994, and were found dead on the beach or were incidentally bycaught in fishing nets, whereas most bycatches occurred in the Baltic Sea.

Harbour porpoises in German coastal waters are mostly infected by nematodes and trematodes in different organs. Cestodes in the intestine occur very rarely. Acanthocephalans, which in other marine mammals are frequently present in the intestine, were missing in harbour porpoises. Ectoparasites also could not be found. The prevalences of infection are shown in Figure 1.

The most frequently infected organs were the lung, liver, and ear sinuses. In the lung, two species of nematodes, *Pseudalius inflexus* and *Torynurus convolutus*, could be identified. The first species was most common. The prevalence of infection was found to be 45% in the North Sea and 56% in the Baltic Sea for *Pseudalius inflexus*, and about 35% in both areas for *Torynurus convolutus*. A semi-quantitative analysis (dividing intensity of infection into "low", "middle", and "high") revealed that most of the animals are infected by a "middle" number of both parasite species.

In the liver, one species of trematode, *Campula oblonga*, was present. Harbour porpoises younger than one year were free of these parasites. In older animals, the prevalence of infection of harbour porpoises was 27% in the North Sea, and 53% in the Baltic Sea. *Campula oblonga* was also present in the pancreas. Also in this case, animals younger than one year were free of these trematodes. The infection prevalence in older whales was clearly lower by comparison with the infestation of the liver (12% North Sea; 29% Baltic Sea).

In the heart, nematodes of the species *Pseudalius inflexus* were also present; these normally occur in the lung. However, the prevalence of infection was much more lower (20%, depending on the age and place of finding). Furthermore, the intensity of infection was very low, with a mean number of 1.5 nematodes per infected whale. It is not clear whether the heart is a natural place of occurrence of this parasite, or whether the nematodes move after the death of the host from the lung through the blood vessels to this organ.

In the ear sinuses of harbour porpoises, the nematode *Stenurus minor* frequently could be found. Animals older than one year were infected by 58% in the North Sea, and by 71% in the Baltic Sea. The mean intensity of infection was found to be about 600 nematodes per whale. The maximum number of nematodes was 3,200 in a three-year old animal of the North Sea. These parasites are considered to be responsible for a disorientation of the host by disturbance of the echolocation system. But nematodes do not occur in the ear sinuses of every whale species. For example, in the sperm whale, there are no parasites known in the ear sinuses. So at least in that whale species, parasites of the ear cannot be responsible for stranding.

In the stomach, two species of nematodes could be found. The first species was *Stenurus minor*, which normally can be found in the ear sinuses. This species was present only very rarely and in low numbers. Thus they may be swallowed incidentally by leaving the ear through the Eustachian tube.

The other species was *Anisakis simplex*, the so called herring worm. This nematode has become famous for causing the fish worm crisis in Germany in 1987. At that time, fish products were shown on the television containing living larvae of these nematodes. As a consequence, the sale of fish products decreased very rapidly.

The life cycle of anisakid nematodes is well known. The nematodes mature in the stomach of marine mammals. The eggs pass through the intestine into the sea, where the first larvae develop. They are then fed on by crustaceans where they develop to the second and third larval stage. The crustaceans themselves are eaten by various fish species leading to the *Anisakis*-larvae infecting their flesh and viscera. The fish will be fed upon by other fish which function as a transport host, or directly by marine mammals where the life cycle will be closed. Man is not a true final host of anisakid nematodes. If *Anisakis* is swallowed alive, the nematode will bore into the stomach wall, and cause a reaction of the tissue, which can be very painful.

The prevalence of infection with *Anisakis simplex* was found to be about 5% in harbour porpoises of the North Sea. In the Baltic Sea, the infection prevalence was much higher. This may be due to the animals feeding upon herring in this area. On the other hand, harbour porpoises do not feed on this fish species in the coastal waters of the North Sea, where it is a main intermediate host of *Anisakis* in German waters (Lick, 1991a,b). The intensity of infection was 1 to 73 nematodes per infected whale, depending on the age group.

Cestodes (*Diphyllobothrium* sp.) in the intestine occurred only in two harbour porpoises from the North Sea. In three animals from the North Sea and two from the Baltic Sea, worm knots could be detected in the intestine. The parasites which were probably responsible were trematodes of the species *Hadwenius nipponicus* or *Pholeter gastrophilus*.

In a few cases, in the air sacs and larynx, nematodes of the species *Torynurus convolutus* and *Stenurus minor* were found. These nematodes usually occur in the lung and ear sinuses. They had probably moved out of these organs after the host's death.

In white-beaked dolphins, four out of the eight animal examined were infected by *Anisakis simplex* in the stomach. A mean intensity of 1,750 nematodes were counted per infected stomach. This is much higher than in harbour porpoises where a mean number of about 50 nematodes per infected individual was found. In one case, larvae of another stomach nematode, *Contracaecum osculatum*, were also found in low numbers. In one white-beaked dolphin, a few whale lice of the species *Isocyamus delphini* were found on the body surface.

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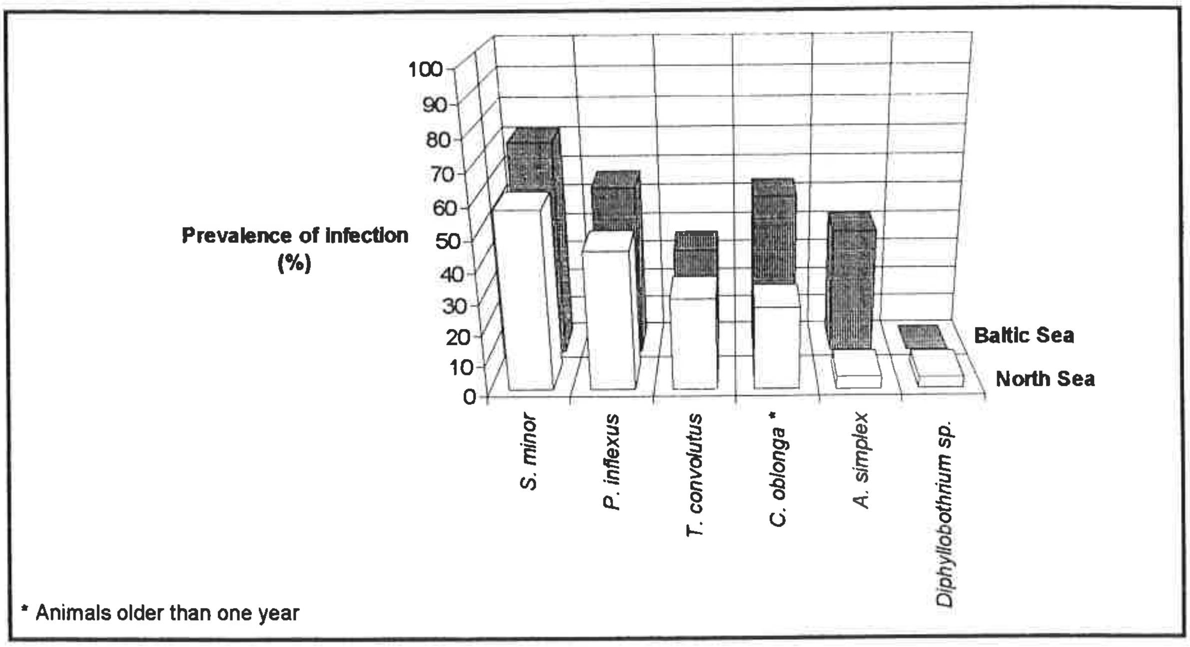

Fig. 1: Prevalence of infection with different parasites in harbour porpoises of German coastal waters, 1993-94.

THE ROLE OF LUNG HELMINTHS IN BLACK SEA DOLPHIN MORTALITY

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INTRODUCTION The helminth fauna of Black Sea dolphins and porpoises was investigated most completely in the 1940-50's (Delamure *et al.*., 1945, 1955) during the period of commercial mass killing of cetaceans. Extensive parasitological studies were then suspended until the end of the 1980's. The resumption of regular helminthological research continuing to the present time has coincided with the Black Sea cetacean mass die-off in 1989-90 (Birkun *et al.*, 1992; Krivokhizhin and Birkun, 1993). Previous and contempory authors underline an important role of lung worms in cetacean mortality, but accessible data are not yet summarised.

Common dolphins Pulmonary nematodosis caused by *Skrjabinalius cryptocephalus* was considered as the main natural mortality factor for common dolphins *Delphinus delphis ponticus* (Kleinenberg, 1956). This conclusion was based on the results of 611 necropsies: 29% of 604 animals killed in 1948 were infected by the above-mentioned lung worm, and seven stranded dolphins had severe, indeed fatal, verminous pneumonia (Delamure, 1955). During 1989-95, we have examined lungs of 22 stranded and two bycaught common dolphins, but found no signs of *S.cryptocephalus*. In the meantime, six animals had small spiral calcifications in the lung tissue, a probable consequence of *Halocercus kleinenbergi* invasion.

Harbour porpoises Two nematode species, *Halocercus taurica* and *H.ponticus* were recognised as etiological factors causing chronic pneumonia in harbour porpoise *Phocoena phocoena relicta* (Delamure, 1955; Temirova and Usik, 1968), but not a cause of the animal's death. On the other hand, we observed *Halocercus* spp.-induced fatal destructive lesions in 100% of dissected lungs in 39 harbour porpoises stranded on the Crimean coast in 1989-90. In subsequent years (1991-95), we indicated *Halocercus* spp. in one individual out of three animals examined. Sometimes (nine cases in total), we have also found the third nematode species, *Stenurus minor*, in porpoise bronchi. However, this parasite was present in small numbers and, obviously could not have led to lethal complications.

Bottlenose dolphins One nematode species, *Stenurus ovatus*, is known as a lung parasite of Black Sea bottlenose dolphins *Tursiops truncatus* (Delamure, 1955), but any indices of the extent of this invasion and an opinion on the role of this helminth in animal mortality have not been published. We did not find parasites in the lungs of five stranded bottlenose dolphins, althogh there were calcified residues (probably caused by nematodes) in two cases.

CONCLUSIONS Some representatives of the family *Pseudaliidae* (Nematoda) could be estimated as potential factors causing the mass mortality of Black Sea common dolphins (*S.cryptocephalus*) and harbour porpoises (*H. taurica* and *H.ponticus*). They may re-induce cetacean die-offs known in the past, and possibly in the future. Such dangers are not so obvious for local populations of bottlenose dolphins, since there is no comparable precedent.

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INCIDENCE OF *ANISAKIS SIMPLEX* (RUDOLPHI, 1809, DET. KRABBE, 1878) IN COMMON DOLPHINS (*DELPHINUS DELPHIS L.*)

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Twenty-five common dolphins found stranded or bycaught between 1992 and 1995 on Irish coasts were examined. Seventeen harboured *Anisakis simplex* in their fore-stomachs, giving a prevalence of 68%. Seven harboured the parasite in their piloric stomachs giving a prevalence of 28%.

Intensity of infection with A. *simplex* in the fore-stomachs did nor vary with sex or length of the host. Comparisons between stranded and bycaught animals showed no differences in parasite burdens or proportions of the different stages of parasites. No variation was observed for proportions of the stage of parasites with length or sex of the hosts.

Ulcers examined revealed both adult and larval A. *simplex* associated with them. A sub-sampling method, using weights, was attempted in order to count the numbers of parasites in larger samples.

PARASITES ASSOCIATED WITH THE CRANIAL SINUSES OF A GROUP OF 19 WHITE-SIDED DOLPHINS THAT MASS STRANDED IN KILLALA BAY, IRELAND

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A mass stranding of nineteen Atlantic white-sided dolphins (*Lagenorhynchus acutus* Gray) occurred at Ross Strand, Co. Mayo on 19 September, 1994. For the purpose of this study, parasites identified as *Stenurus globicephalae* (Baylis and Daubney, 1925) were removed from the cranial sinuses, employing a new method by which estimated time for removal of all parasites could be determined.

In total, 18,686 parasites were found in eighteen of the animals examined, resulting in 94.75% prevalence. Mean parasite burden for the group was 983.47. Variance was calculated to be 727,164.9, confirming the over-dispersed nature of the parasite population. A significantly positive correlation was found to exist between parasite burden and host length. No significant difference was found between parasite burdens of the left and right sides of the head.

Using the timed extraction method, it was found that more than 96% of parasites were removed from adult male and female hosts within the first ten minutes of washing, and more than 98% were obtained in the same time from juvenile individuals.

INTESTINAL HELMINTH COMMUNITIES OF THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) FROM DANISH WATERS

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In recent years, the historical and ecological determinants structuring helminth communities of cetaceans have received increasing attention. Current evidence suggests that the intestinal communities show extremely low species richness, formed mostly by some representatives of only three helminth groups: digeneans of the genus *Hadwenius*, acanthocephalans of the genus *Bolbosoma,* and cestode species of four genera of Tetrabothriidae. It seems likely that *Bolbosoma* and Tetrabothriidae have a pelagic origin, showing little ecological diversity throughout the subsequent host-parasite associations. If this view is correct, the most depauperate communities should be found in coastal cetaceans, showing at best *Hadwenius* species, and some generalist helminths acquired from other sympatric vertebrates at the same time. At present, however, very little data is available on helminths from adequate cetacean samples to test this hypothesis.

We analysed the intestinal communities of a coastal cetacean species, the harbour porpoise (*Phocoena phocoena*) in Danish waters. The intestines of 72 specimens stranded or bycaught during 1988-90 were examined for parasites. A single species, the cestode *Diphyllobothrium* sp., was found with very low prevalence (2.77%) and intensity (1 ± 0). The intestinal community of the harbour porpoise represents the most depauperate hitherto recorded in a cetacean species. Although not identified at specific level, the helminth species found belongs to a very generalist genus. These results seem to conform with the above hypothesis. However, appropriate data from many more cetacean species are necessary to test it rigorously.

MOLECULAR PHYLOGENETICS OF CETACEANS: IMPLICATIONS FOR MORPHOLOGICAL HOMOPLASY

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The separation of toothed whales (Odontoceti) and baleen whales (Mysticeti) into two reciprocally monophyletic lineages is a long-accepted phylogenetic hypothesis. However, our phylogenetic analyses of DNA (3 mitochondrial-gene fragments) and amino-acid (myoglobin-gene) sequences contradict this taxonomic subdivision. One group of toothed whales, the sperm whales, appears to be more closely related to the morphologically highly divergent baleen whales than to the other odontocetes. Therefore, these molecular studies challenge the conventional scenario of a long, independent evolutionary history of odontocetes and mysticetes, and prompt a major re-interpretation of the evolution of morphological, physiological, and behavioural characters (such as blowhole anatomy, cranial/facial asymmetry, and echolocation) in cetaceans. For example, re-assessment of anatomical characters supports our hypothesis that echolocation is a shared ancestral character for all whales, and that this complex function was lost or greatly reduced in baleen whales.

Furthermore, using a sensitivity analysis approach that identifies portions of the multidimensional parameter space where phylogenetic signal can be reliably recovered, we demonstrate that a controversial cytochrome *b* data set strongly supports our hypothesis of sister relantionship between sperm whales and baleen whales.

GEOGRAPHICAL POPULATION STRUCTURE OF FEMALE SPERM WHALES ASSESSED BY MITOCHONDRIAL DNA VARIATION

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The geographical population structure of sperm whales (*Physeter macrocephalus*) is unclear. However, tagging data from whaling, and matching of fluke markings, indicate limited movements (c. 1,000 km) of females over time-scales up to ten years. In this study, we used mitochondrial DNA (mtDNA) variation to examine the genetic stock structure of female sperm whales, and make inferences about their movements.

The mtDNA control region from female and immature sperm whales in the Pacific (N=139), Atlantic (N=23), and Indian (N=19) Oceans was amplified, and 500-600 bp were sequenced directly. There were fourteen variable nucleotide positions in this region which defined 13 mtDNA haplotypes.

Groups of whales showing behavioural co-ordination were dominated by one mtDNA haplotype, and individuals within groups had significantly fewer changes in their control regions (mean of 1.0 differences) than individuals in different groups but in the same place in the ocean (mean of 1.5). These results suggest that grouped females are often relatives, and are consistent with the groups being composed of matrilines.

There was little evidence of geographical structure overlying these genetic differences between groups. An Analysis of Molecular Variance (AMOVA) allocated only 10% of the variation among South Pacific sperm whales to consistent differences between three broad ocean areas (c. 7,000 km apart). The number of changes in the control region of two ungrouped whales was not significantly different, whether the whales were in the same place in an ocean (1.5 changes), different areas of an ocean (1.8 changes), or different oceans (1.5 changes). This lack of differentiation both within and among oceans suggests extensive movements of female sperm whales, at least over large temporal scales.

POPULATION STRUCTURE OF STRIPED DOLPHINS (*STENELLA COERULEOALBA*) IN EUROPEAN WATERS BASED ON MITOCHONDRIAL DNA

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A total of 95 frozen muscle tissues samples from striped dolphins (*Stenella coeruleoalba*) stranded in European waters have been analysed by means of mitochondrial DNA (mtDNA) restriction analysis. The distribution of the samples cover the Mediterranean and Atlantic European waters (Spain, Italy, Greece, Israel, Portugal, France, Ireland and United Kingdom). The mtDNA obtained was digested with 15 restriction endonucleases that yielded a total of 67 restriction sites, 20 of then being polymorphic. The combination of individual restriction enzyme patterns gave a total of 30 different haplotypes. No haplotype is shared between individuals stranded on the Mediterranean and Atlantic coasts.

The number of nucleotide substitutions per site were estimated among haplotypes and their phylogenetic relationships were established following different phylogenetic procedures (i.e. neighbour joining, parsimony, etc). The analysis of population structure showed a clear genetic differentiation between Atlantic and Mediterranean samples. In addition, there was no statistical evidence for population subdivision in the Mediterranean samples, whereas population subdivision was found in the Atlantic samples, mostly due to the individuals stranded on the French coast.

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SEX DETERMINATION IN STRIPED DOLPHINS (*STENELLA COERULEOALBA*) BY RESTRICTION ANALYSIS OF AMPLIFIED DNA FRAGMENTS

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We determined the gender of 95 striped dolphins (*Stenella coeruleoalba*), ten of which were biopsy samples (of unknown sex), in European waters, using the polymerase chain reaction for amplification of the sex chromosome specific region ZFY/ZFX. By means of restriction analysis with 16 endonueleases, a differential pattern between sexes was established with *Rsa*I.

A total correspondence between sexing by means of necropsy and by molecular techniques was found. To ascertain the global application of this technique, the same region in other cetacean species was also amplified and digested with *Rsal.* The restriction pattern is specific for striped dolphin, because no differential sex pattern was observed in other cetacean species with the same restriction enzyme. On the other hand, a restriction site polymorphism in ZFX region was found with *Taq*I restriction enzyme, generating two alleles (ZFXa and ZFXb) which were found at different frequencies (74.8 and 25.2%, respectively) in the striped dolphin individuals analysed. Thus restriction fragment length polymorphism between sexes is applicable to the investigation of many wildlife management and research questions.

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MITOCHONDRIAL DNA SEQUENCE PATTERNS INDICATE LIMITED MATERNAL GENE FLOW INTO THE BALTIC SEA POPULATION OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*)

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To investigate the degree of genetic differentiation between the harbour porpoise (*Phocoena phocoena*) populations of the North and the Baltic Seas, a total of 39 individuals (20 from the Baltic and 19 from the North Sea) were screened for sequence polymorphisms at a highly polymorphic part of the mitochondrial DNA control region. DNA was extracted from liver or skin samples of stranded animals. After PCR amplification and direct sequencing, 420 bp were scored.

Nine haplotypes were found, differing by one to four transitions. Haplotypes separated out into two clusters A and B by a specific nucleotide substitution. All Baltic harbour porpoises showed type A haplotypes, which was only found in 45% of the North Sea specimens. This difference was statistically significant (Fisher's exact test; $p<0.001$). Nucleotide and haplotype diversities were much lower in the Baltic than in the North Sea population. Haplotype composition and nucleotide divergence suggest a colonisation of the Baltic Sea several thousand years ago, and a limited genetic exchange since then.

The observed genetic differentiation between Baltic and North Sea populations of harbour porpoises is corroborated by published data both on skull character differences and enzyme polymorphisms. Regarding conservation, Baltic harbour porpoises should possibly be considered as a distinct population.

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SOME MORPHOLOGICAL FEATURES OF HARBOUR PORPOISE *PHOCOENA PHOCOENA* TAIL FLUKE IN TERMS OF HYDRODYNAMICS

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INTRODUCTION The well-streamlined shape of the dolphin's body and fins has certainly been extensively studied, as has the histology and mechanical properties of the skin of dolphins (Hertel, 1969; Sokolov, 1982; Pershin, 1988). Results of this research have formed a base for further biological investigations (Pershin, 1988). Nevertheless, the relationship between the shape of cetaceans and the local distribution of skin features remains generally unclear, particularly in the harbour porpoise.

MATERIALS AND METHODS Cross-sections and skin samples of the tail fluke of a stranded harbour porpoise carcass was studied. The left fluke fixed in 10% neutral formalin was cut by ten cross-sections with equal 1 cm intervals. Profile length, profile thickness, and the distance from the leading edge to the maximum profile thickness were measured in each cross-section. Profile thickness as well as thickness of the main body or fluke central core in each cross-section was determined at 20 points with 5% of profile length interval. At these points, values of epidermal thickness, the thickness of the subpapillary layer of the dermis, and blubber thickness, were determined from vertical histological sections. At the same points, the following measurements were made on horizontal histological sections: numbers of dermal papillae per unit area; the angles formed by the longitudinal axis of the body with dermal ridges; and angles formed by the longitudinal axis with structures of subpapillary layer. Data obtained were processed and analysed statistically.

RESULTS AND DISCUSSION All the morphological characters studied were closely linear inter-related (Fig.1). Thickness of a fluke central core has the highest correlation coefficient with all other characters. Relative profile thickness (% profile length) and relative profile length (% fluke length) decreases from the base of the tail fluke to the top. At the same time, the distance increases from the leading edge to the relative maximum profile thickness (% chord length). Such a trend in profile thickness distribution may lead to the reduction of pressure differences on the leading edge, as well as to reduce the adverse pressure gradient on the cross-section profiles of the fluke, from the base to the top (Lang, 1966). According to the relationship between profile thickness and flow characteristics, flow separation is most likely to occur at the base of a fluke. Morphological characters mentioned above have maximum values at this site. Since the epidermal thickness of small cetaceans is correlated with the height of dermal papillae (Pershin, 1973) containing capillaries with a variable interior pressure (Babenko, 1980), and reaches a maximum density of dermal papillae and blubber thickness at the same site, the skin at the base of the tail fluke should have the widest range of tough, resilient properties. The arrangement of dermal ridges on the tail fluke shows a zone which runs parallel to the body's longitudinal axis at the base of the fluke. It apparently indicates the direction of water flow (Purves, 1963; Sokolov *et al.*, 1968; Surkina, 1971). Dermal ridge directions probably have an influence on local water flow.

According to the results of factor analysis, two factors determining 85% of the variance of six characters were found. The first factor determining 65% of the variance, and primarily affecting the thickness of subpapillary layer, blubber thickness, dermal papillae number per unit area, and thickness of epidermis, may be interpreted as a factor influencing pressure distribution on the fluke. The second factor determining 20% of the variance, primarily affects the angles formed by the longitudinal axis of the body with dermal ridges, and the angles formed by longitudinal axis of the body with structures of the subpapillary layer, which seem to be a factor affecting water flow direction.

CONCLUSIONS There are close relationships between the shape and histological structure of the harbour porpoise tail fluke which indicate a high degree of adaptation to flow characteristics. The integrity of skin features is closely related to the fluke thickness and may promote a dampening of disturbances in the boundary layer and its stabilisation on otherwise unstable flow sites.

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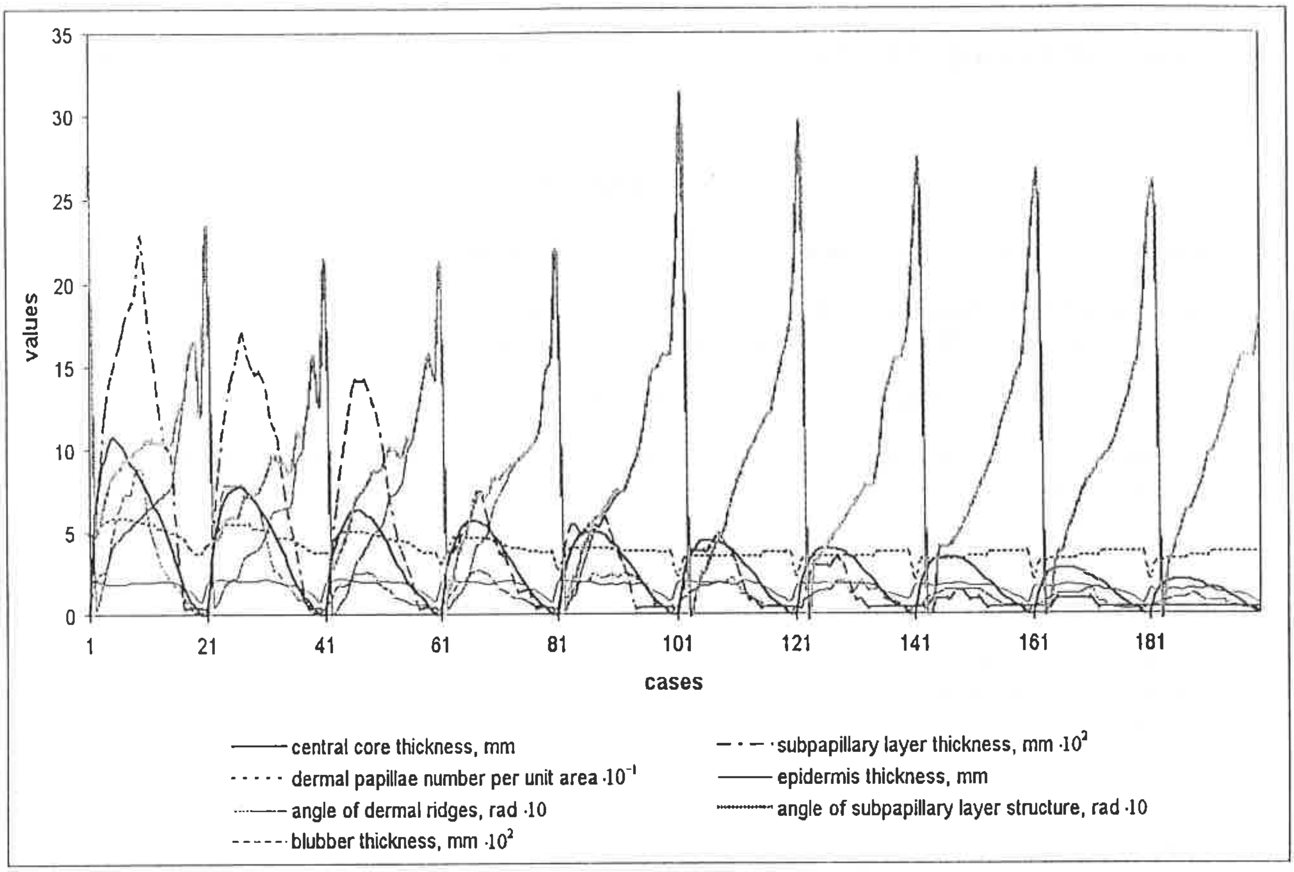

Fig. 1. Variation of harbour porpoise tail fluke morphological attributes

A ROLE FOR NASAL PIGMENTATION IN ODONTOCETE SPECIES

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INTRODUCTION The nasal region of odontocetes is a complex system composed of the upper nasal passage and a series of blind diverticulae called air sacs, all covered by stratified squamous epithelium (Evans and Maderson, 1973; Mead, 1975; Curry, 1994). The epithelium of the nasal sac system of odontocetes is characterised by an irregular distribution pattern of dark pigmentation. This feature has been previously noted in the literature (Schenkkan, 1973; Heyning, 1989; Curry, 1992), but to date, nothing has been reported on its possible origin and function. In the light of this region's anatomical importance in sound production and regulating respiratory air flow, this study examines sac pigmentation in a comparative manner with the pigmented nasal passages of two species of terrestrial mammals.

MATERIALS AND METHODS The nasal cavities of six species of delphinids (12 striped dolphin *Stenella coeruleoalba*, one common dolphin *Delphinus delphis*, five Atlantic white-sided dolphin *Lagenorhynchus acutus*, three white-beaked dolphin *L. albirostris*, one Pacific white-sided dolphin *L. obliquidens* and one northern right whale dolphin *Lissodelphis borealis*) two phocoenids (five harbour porpoise *Phocoena phocoena* and one Dall's porpoise *Phocoenoides dalli*) and one ziphiid (one Cuvier's beaked whale *Ziphius cavirostris*) were examined and compared with those of terrestrial mammals of the canid (*Canis familiaris*) and bovid (*Ovis aries*) families.

Conventional dissection and serial sectioning was used to study gross nasal morphology, and Hematoxilin/eosin (H/E) and Giemsa/acid orcein staining techniques were applied to examine the histological characteristics of the epithelium.

RESULTS Within the epidermis of the nasal sacs, melanocytes were distributed along the stratum germinatium, and melanin granules could be found sparsely in the cytoplasm of the cells in layers leading up to the stratum externum. Gross pigmentation patterns were found to be inconsistent both between members of the same species and between different species.

In odontocetes, the parakeratinised polystratified squamous epithelium of the diverticulae was continuous with the epidermis of the skin. In the two terrestrial mammals, this condition was only found in the anterior portion of the nasal cavity, or the so-called nasal vestibule.

DISCUSSION AND CONCLUSIONS From an evolutionary point of view, the occurrence of pigment in tissue not exposed to any significant amount of sunlight, is difficult to explain in an adaptive context (Becker, 1946; Pathak *et al.*, 1965). The degree of intraspecific variability encountered in nasal sac pigmentation patterns would suggest that there is a lack of selective pressures acting on the coloration of this tissue. Given that melanocyte distribution in this area's epidermal layers is ectodermal in character, and that histologically the epithelium of the nasal sac system is simply a continuation of the outer skin (Palmer and Wedell 1964, Geraci *et al.* 1986), it would appear that the entire system originated as an invagination of the ectodermal epidermis. This is consistent with the ectodermal origins of the olfactory, respiratory, and squamous epithelia of terrestrial mammalian nasal tracts (Nickel *et al.*, 1981; Scott, 1988; Evans, 1993). Thus, based on the observed homologies and divergences that we found in pigment pattern and distribution both between and within species, we conclude that nasal sac pigmentation represents an artifact of the evolutionary origin of the system, and that in all likelihood it does not possess a functional or adaptive purpose.

Further comparative histological analyses between terrestrial taxa and the Odontoceti should provide more detailed insight into the finer aspects of this subject's evolutionary process.

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A WALRUS STRANDING ON THE ATLANTIC COAST OF FRANCE

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On 18 February, 1996, a walrus *Odobenus rosmarus rosmarus* (Linnaeus, 1758) was observed resting on a beach on the southern coast of Oleron Island (close to La Rochelle, middle of the Bay of Biscay coast). Two days later, the animal was found stranded 50 km southwards, on La Palmyre beach. He showed obvious signs of cachectic and prostration stage, and was extremely thin, with the skin covered by bullet impacts. After being anaesthetised with ZOLETIL[ND], the walrus was euthanased with T61[ND]. The post-mortem examination revealed a general septicaemia.

The specimen was a 320 cm long adult male, his estimated weight was only about 400 kg. This is the second walrus reported on the French coast since the beginning of the century. The previous one was also an adult male sighted in October 1988 on the Banc d'Arguin (250 km south of La Rochelle), and reported a couple of weeks later off the Basque Spanish coast.

THE CURRENT STATUS OF THE MEDITERRANEAN MONK SEAL IN TURKEY

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The Mediterranean monk seal, *Monachus monachus*, is one of the most highly endangered species in the world. A national research project was conducted on Mediterranean monk seals in Turkish waters during 1987-95. A total of 44 seals was identified by direct observation. In the Black Sea and Marmara Sea, the monk seal was on the verge of extinction, with only two animals remaining for each sea. The numbers of seals identified in each region along the Aegean coast were as follows: three in the northern Aegean Sea, five between Foça and Karaburun, seven between Karaburun and Kusadasi, two in Kusadasi National Park, and six on the Bodrum Peninsula. The numbers of seals along the Mediterranean coast are as follows: five between Bodrum and Kadirga Cape, one between Kadirga Cape, three between Kas and Alalya, seven between Alanya and Tasucu, and one between Tasucu and Iskenderun.

Twenty-four seals were found dead between 1987 and 1995. Twelve of them were deliberately killed, in spite of the public awareness campaign made to stop such kills; six were drowned in nets; and for the rest it was not possible to identify cause of death.

The results of the study showed that the monk seal population in Turkish waters was not stable and *in situ* protection measures must be enforced seriously. Moreover, effective protection strategies must be applied to the National Parks, with also the provision of better equipment for the wardens.

VARIATION WITH AGE AND SEX OF PELAGE COLORATION IN MONK SEALS *(MONACHUS MONACHUS)* FROM CABO BLANCO

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INTRODUCTION The world population of the Mediterranean monk seal (*Monachus monachus*) probably does not exceed one thousand individuals. Because its low numbers, it is considered to be one of the rarest and most threatened animal species in the world (Reijnders *et. al.*, 1993). To study the species in the field, Marchessaux and Müller (1987) established a classification of age-classes according to the standard length of the seals estimated at distance (juveniles = <1.20 m; subadults = 1.50 - 2 m; adults = >2 m). This was later arbitrarily modified by Francour *et al.* (1990) into: juveniles = <1.50 m; subadults = 1.50 - 2 m; adults = >2m. When we started our study, we found that this criterion did not consider significant traits of the seals (sex, size, behaviour, moult, etc.), and that a precise determination of the body size, as these authors had suggested, was not feasible without direct handling of the individuals. Therefore, we developed a new classification system ascribing the individuals to different categories according to their sex, body size, and external coloration, and appearance. In this communication, we provide a new system to classify seals at a distance.

METHODS Procedures for developing the categories were as follows (Table 1):

- The body size of individuals, measured as its total length (straight line), was obtained from 42 dead seals, and from 12 live pups that were tagged;

- The physical appearance was categorised, with the assistance of the photo-identification of individual seals, according to the following morphological traits:

i) Head shape. The head of some large individuals was wide and noticeably big in relation to the rest of the body;
ii) Pelage colour. Three categories were established: black, greyish, and brown;
iii) Presence of a white patch on the belly;
iv) Presence of scars. Three categories were established: abundant (numerous and visible), occasional (some visible), un-noticeable (hardly visible);
v)Presence of cutaneous folds on the base of the head, chin pouches, and a whitish ruff;
vi) General body appearance: plump (fat and wide), or slim.

- The sex of individuals was established by direct observation of the belly during counts and photo-identification sessions, by post mortem examination, and by their involvement in distinctive sexual behaviour, such as copulation, birth, gestation and lactation (Table 2).

RESULTS These characteristics led to the establishment of six categories or seal morphological types which are shown below.

LARGE BLACK MALES (LBM) Large body (one measured 2.66 m), with broad head disproportionately large for its body size. Overall black pelage, with a large white patch on the belly near the umbilicus, and a wide and whitish well-developed throat with abundant cutaneous folds on the base of the head. Numerous scars. All specimens of this class sexed, were males. These are considered to be adult males.

LARGE GREY SEALS (LGS) Large body (range: 2.30-2.75 m). Large head, but not as wide as in LBM. Variable colour from greyish to brown, with little contrast between the colour of the back and that of the belly. Numerous scars, especially visible on the back. A large proportion of this type sexed were females, although some males also were found to belong to this category. In four cases, we have confirmed that LGS individuals moult to BLM.

MEDIUM-SIZED SEALS (MSS) Smaller body size than LBM and LGS (range 1.85-2.30 m). Head smaller and proportionate to the body. Variable pelage colour as in LGS. Fewer scars than in previous types. About half the specimens of this type sexed were female and half male. These are considered to be mostly subadults of both sexes, although some sexually mature, but still not fully grown females, may be included in this category. Few individuals were seen lactating pups.

JUVENILES (J) Smaller body size than type MSS (range: 1.61-1.77 m). They are usually thinner than MSS and their body shape is more elongated. Pelage is brown to dirty greyish. Few visible scars.

YOUNGSTERS (Y) Similar or smaller body size than J (two measured individuals were 1.17 and 1.40 m long). Rounded appearance. Grey or whitish-grey pelage, with hardly any visible scars. They have been observed suckling. These are considered to be pups being weaned and which have recently moulted.

PUPS (P) Small (range: 0.74-1.38 m). Black pelage and a white or yellowish big patch around the umbilicus, also with whitish grey pelage at the start of the moult. Often accompanied by the mother and frequently observed suckling. These are considered to be pups that have not yet finished their first moult.

This classification system was followed during the counts and used to understand composition of seal aggregations and use of habitat by the various population components. However, the GGS and MSS categories were difficult to tell apart on land, for wich reason they were grouped for subsequent studies.

ACKNOWLEDGEMENTS We thank the numerous people who assisted in the fieldwork. The European Commission LIFE project B4-3200/94/0000/D2 funded this study.

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González, L. M., Aguilar, A., López-Jurado, L. F. and Grau, E. 1994. Status and distribution of the Mediterranean Monk Seal *Monachus monachus* on the Cabo Blanco Peninsula (Western Sahara-Mauritania) in 1993-1994. Unpubl. Report.

Table 1 Individuals sexed by direct observations

		LBM	LGS	MSS	J	Y	P
MEASURED BODY SIZE	mean	2,66	2.52 2.30 2.75	1.85 1.99 2.30	1.66 1.61 1.77	1.40 1.17	1.10 0.74 1.38
	n	1	13	4	5	2	29
ADSCRIBED BODY SIZE	large	X	X				
	medium			X	X		
	small					X	X
PELAGE	black	X					X
	grey		X	X	X	X	
	brown		X	X	X		
WHITE PATCH		X					X
SCARS	abundant	X	X	X			
	occasional				X		
	unnappreciable					X	X
CUTANEOUS FOLDS		X					
APPEARANCE	plump	X	X	X		X	
	slim				X		X

Table 2 Distribution of sexually identified individuals according to their morphological type

	TYPE LBM		TYPE LGS		TYPE MSS	
	male	female	male	female	male	female
COUNTS IN CAVES	100%	0%	1.6%	98.4%	52.9%	41.7%
	n = 7		n = 250		n = 17	
AUTOPSIES	100%	0%	0%	100%	100%	0%
	n = 1		n = 2		n = 1	
COPULATIONS	100%	0%	0%	100%		
	n = 15		n = 15		n = 0	
BIRTHS			0%	100%		
	n = 0		n = 1		n = 0	
PREGNANCIES			0%	100%		
	n = 0		n = 1		n = 0	
NURSING			0%	100%		
	n = 0		n = 17		n = 0	
PHOTO-IDENTIFICATION	100%	0%	17,85%	82,14%	66,66%	33,33%
	n = 8		n = 28		n = 9	

DIVING ACTIVITY OF LACTATING AND RECENTLY WEANED PUPS OF MEDITERRANEAN MONK SEAL ON THE CABO BLANCO PENINSULA

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INTRODUCTION Time depth recorders (TDR's) are commonly used to study underwater seal activity. In particular, several authors have deployed TDR's on pups of various phocid species during the nursing period in order to gain an understanding of the transition from milk feeding to solid food. However, this aspect has never been studied in Mediterranean monk seals. In this study, we present preliminary results on diving activity and lactation events in three juvenile Mediterranean monk seals (*Monachus monachus*) from the colony at Cabo Blanco.

MATERIALS AND METHODS The study was conducted on the Cabo Blanco peninsula, Western Sahara (21° 02'N, 17° 03'W). Between July and November 1995, Time Depth Recorders (Wildlife Computers, Woodinville, Washington, USA), were attached to four juveniles identified as M-11, M-16, M-20 and M-21 (Table 1). Two of the individuals (M-11 and M-16) had been marked with plastic tags when they were pups, and their approximate age was therefore known. Captures were made at random between those individuals considered by their body size and morphology to be post-moulted pups. Preliminary observations suggested that weaning occurs in that cohort.

The TDR's were fixed to a specially-designed attachment plate, consisting of a system of plastic bridles fixed to a plastic saddle which was glued to the fur of the seal. For the recovery of the device at the end of the sampling period, the plastic bridles were cut and the TDR retrieved. This operation did not require a second immobilisation or manipulation of the seal. The plastic saddle remained glued onto the back of the animal until it moulted. All the TDR's were successfully recovered, with the exception of seal M-20, which lost its TDR only six days after the attachment, due to the accidental breakage of the plastic bridles. Dates of attachment and deployment of the TDR's and morphological information of the seals studied are shown in Table 1.

The TDR's were programmed to sample depth every ten seconds, with a resolution range of ± 0.5m. After their recovery, the data collected were analysed using software from Wildlife Computers (Zero Offset Correction and Dive Analysis). The seal's activity was assigned to three categories: "*Diving*", a category which included TDR recordings of depths greater than two metres and of a duration longer than 20 secs; "*At surface*", with the TDR in the water, but readings of depths no greater than two metres and "*Hauled out*", when the TDR was out of the water.

During the study period, daily observations on the nursing behaviour of the seals were carried out with a video camera installed on the roof of the main breeding cave where the seals hauled-out.

RESULTS AND DISCUSSION Data collected from video observations showed that M-21 was suckling throughout the study period, M-16 had been weaned only a few days before the capture, and M-11 had been weaned many weeks before (Table 1).

The TDR's recorded a total of 1,106 h. of activity and 9,526 dives. Differences between the three animals were observed in their activity budget (Fig. 1). Thus, the suckling individual (M-21) spent 79.3% of its time resting or porpoising on the surface, while it only spent 5.8% of its time diving; most of these dives were shallow and of short duration (Table 2). However, the time spent on the surface by the two weaned seals was much shorter: only 52.6% in the recently weaned pup (M-16), and 43.6% in the other animal (M-11) (Fig. 1). Diving activity considerably increased in these two individuals as compared with the suckling pup (Table 2).

Differences in dive profiles (Fig. 2) between the suckling individual (M-21) and those weaned (M-11) was apparent, while the dive profile of the recently weaned pup (M-16) suggested that deep dives began only some days after the attachment of the TDR. Only M-11 and M-16 showed typical U-shape (flat-bottomed) dives, which are associated with bottom-feeding (Fig. 3). When these dives were analysed in detail, it became apparent that dives deeper than 10 metres and of a duration longer than 30 seconds were carried out between dusk and dawn (Fig. 4), suggesting that feeding follows a nocturnal pattern.

CONCLUSIONS This is the first study on diving activity of moulted pups of Mediterranean monk seals. The results suggest that:

(1) As weaning occurs, time spent resting or at the surface decreases whereas diving activity increases;

(2) Diving activity increases progressively in post-moulted pups after weaning, supporting the idea that transition to solid food takes place within this age category;

(3) Flat-bottomed, deep dives occurred between dusk and dawn, suggesting nocturnal feeding.

ACKNOWLEDGEMENTS Thanks are due to the members of the fieldwork team that participated in the attachment and deployment of the TDR's and in the monitoring of the animals in such a difficult environment: E. Grau, E. Badosa, F. Aparicio, M. Cedenilla, J. Fernández, V. García, S. Hildebrant, E. Ries, H. M'bareck and K. Ahmed. The author also wishes to thank the assistance of Luís Cappozzo, Alex Aguilar, Luís Mariano González, Luís Felipe López-Jurado, Jennifer Moss and the personnel of Wildlife Computers for their assistance at various stages of the study. The European Commission LIFE project B4-3200/94/0000/D2 funded this study.

Table 1 Attachment and deployment dates of TDR's and lactation observation

Seal No	Sex	First capture	TDR removed	Sampling period (d)	Last lactation observed
M-11	M	July 18	August 13	16,8	weaned
M-20	F	August 2	August 8 (TDR lost)	..	September 3
M-21	F	August 4	August 13	9,1	October 11
M-16	M	October 13	November 2	20,1	October 10

Table 2 Dive duration and depths recorded for three monk seal youngsters

Seal No	Total recorded activity time (h)	No. of dives	Duration mean ± SD (s)	Maximum duration (s)	Depth mean ± SD (m)	Maximum depth (m)
M-11	404	5409	112,9 ± 65,1	330	8,7 ± 9,1	40,5
M-21	219	888	51,6 ± 27,5	320	2,7 ± 1,2	12,5
M-16	483	3229	91,1 ± 56,1	590	6,8 ± 4,9	21,5

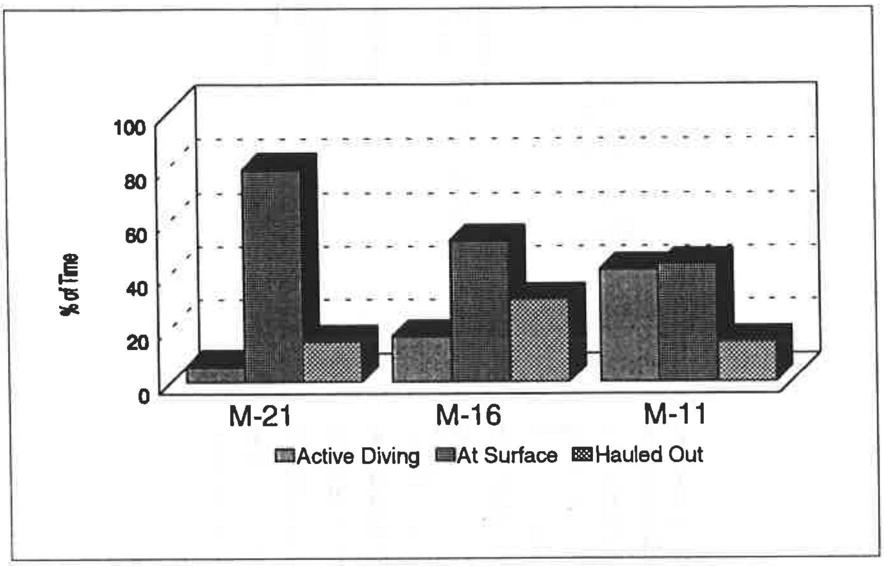


Fig. 1 Activity budget based on 1,106 h. of recorded activity

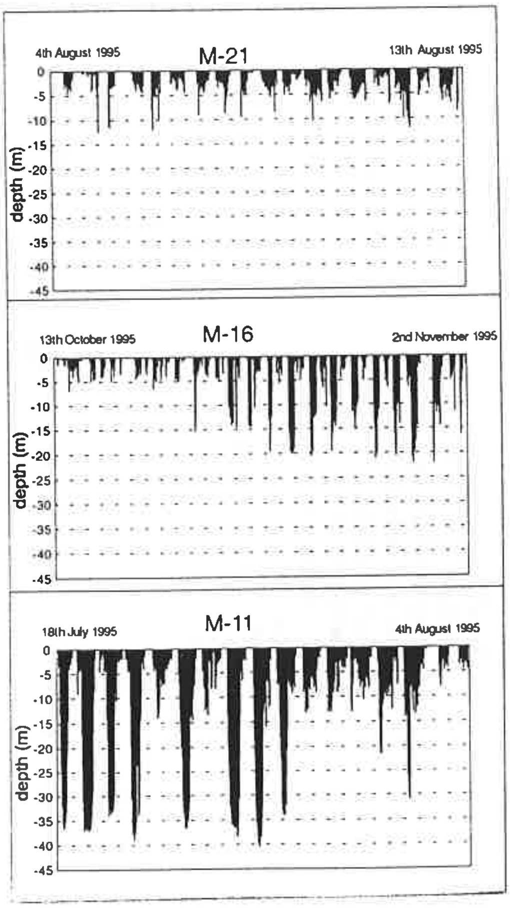
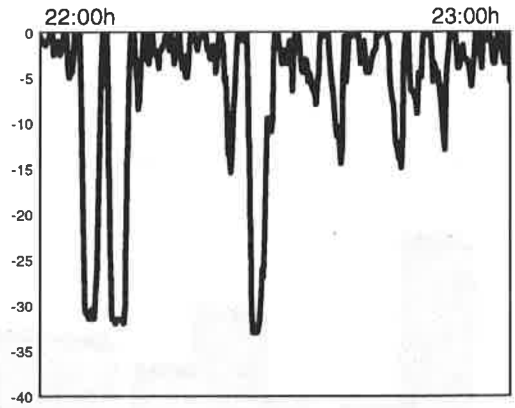


Fig. 2 Dive profiles from studied individuals between sampling period



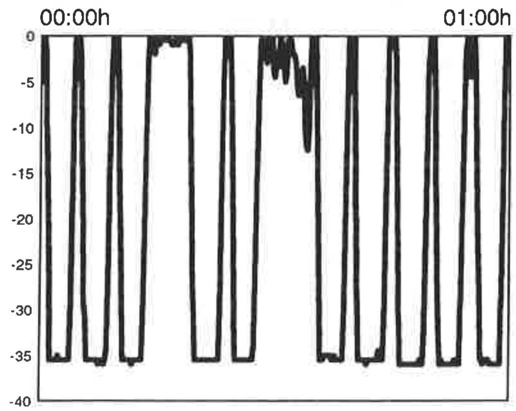


Fig. 3 One-hour sample intervals showing "V" (up) and "U" (down) shape profiles

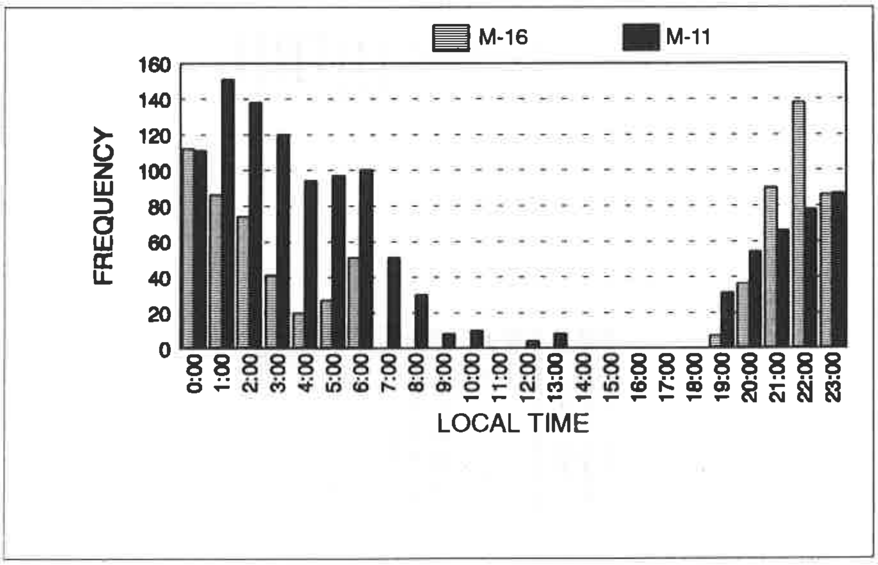


Fig. 4 Diurnal variation in the dive records of two youngsters

DNA MICROSATELLITES IN MEDITERRANEAN MONK SEALS

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INTRODUCTION The Mediterranean monk seal (*Monachus monachus*) is one of the most endangered mammals in the world. The species was initially distributed throughout the whole Mediterranean Sea, Black Sea and adjacent waters of northern Africa and Portugal, but was drastically reduced due to direct exploitation, aggression from fishermen, fishery interactions, and overall habitat destruction. Today, the world population of the species is estimated to be between 300-500 individuals, concentrated in three main areas: the Greek and Turkish Islands (c. 100-150 indivs.), the Mediterranean coastline of Morocco and western Algeria (c. 20-40 indivs.), and the Saharan coast (200-300 indivs.).

The present study focused on the population inhabiting the Cabo Blanco Peninsula (Western Sahara) (Fig. 1), which appears to concentrated mainly upon two caves (circles on the map), no more than 3 km apart. The aim was to start a data set for the genetic identification of individuals, which in the longterm would prove useful for the recognition of carcasses or individuals, normally made difficult because after moulting, the pattern of natural marks on individuals changes. Therefore, we have needed to identify individuals by analysing a family of nuclear markers termed DNA microsatellites. Microsatellites are repeated di-, tri-, tetra- nucleotides which are scattered along all mammalian genomes, and which usually possess a high level of variability (typically between two and ten alleles), making them one of the most powerful nuclear markers for individual identification. Furthermore, microsatellites are segregated in a Mendelian fashion, which means that offspring receive half of their alleles from their mother, and half from their father. Thus, it is possible to estimate the degree of relatedness between two individuals.

To date, no genetic studies on this species have yet been reported. Our first aim was, therefore, to check if we could profit from the studies carried out on a related species, the grey seal (*Halichoerus grypus*) and, in such a case, to start the analysis of our samples.

MATERIALS AND METHODS

Samples Skin samples from 17 pups of Mediterranean monk seals obtained from the rear flippers by means of notching pliers at the Peninsula of Cabo Blanco (Caves 1 and 3) from the "Cuevecillas" area (21° 02'N, 17° 03'W) during 1994 and 1995. The notches of skin were preserved in tubes containing 20% DMSO saturated with salt, and, once in the laboratory, they were frozen until analysis.

DNA extraction A standard protocol was used, involving a Proteinase K digestion followed by phenol/chloroform extractions and a final precipitation with ethanol (Maniatis *et al.*, 1982).

DNA microsatellite analysis We used a panel of seven pairs of primers isolated by one of us (P. Allen) in the grey seal (*Halichoerus grypus*) in which they have proved to yield variability, and one isolated from harbour seal *Phoca vitulina*, kindly donated by S. Goodman from the University of Cambridge. The eight microsatellites analysed are displayed in Table 1.

PCR reactions were set up in 10 µl volumes in the presence of 1 µl of DNA (~50 ng), 1 µl of PARR Excellence buffer (Advanced Biotechnologies), 0.1 mM concentrations of dGTP, dTTP and dATP, 10 µM dCTP, 2 pmol of each primer, 0.05 µl of Taq polymerase, 0.025 µl of [a^{32}P]-dCTP and sterile distilled water to 10 µL. These were overlaid with mineral oil, and amplification was performed in a Hybaid OmniGene thermal cycler using microtitre plates. A 2-min. denaturation step at 93°C was followed by: 7 cycles of 30 s denaturation at 93°C, 60 s annealing at "a" and 30 s of extension at 72°C, and then 25 cycles of 30 s denaturation at 89°C, 60 s annealing at temperature "b", and 30 s of extension at 72°C. Samples were mixed with 0.5 volume of formamide dye solution, denatured for 2 min at 95°C and then 2.5 ml were loaded on a 6% acrylamide gel. Samples already analysed from grey seals were run next to each locus for sizing of alleles. The result of the electrophoresis was visualised by autoradiography.

Null alleles Non amplifying alleles, which are usually termed null alleles, are thought to arise from point mutations in one or both of the primer sites (Pemberton *et al.*, 1995). As a result, no product is visible and, hence, true heterozygotes (null heterozygotes) appear as homozygotes. Any homozygote excess can be interpreted either as a deviation from the Hardy-Weinberg equilibrium, or as the presence of null alleles. If the former occurs, then the deviation from Hardy-Weinberg equilibrium should be found in all the alleles studied. Conversely, if the latter occurs, it is possible to calculate the frequency of null alleles which would best fit the data. An iterative program which does this, was written by W. Amos (unpubl. data) and was used to determine the frequency of null alleles in the Hg3.6 microsatellite.

RESULTS The autoradiographs obtained from the microsatellite (Hg4.2 and Hg3.6) analyses indicate that all the pups analysed were monomorphic for Hg4.2 but polymorphic for Hg3.6. The latter appeared to have a null allele with a frequency of 0.089.

The comparison between the variability of the microsatellites, in terms of number of alleles, between the grey seal and the Mediterranean monk seal, is reflected in Table 1.

Three out of eight microsatellites tested (Hg8.9, Hgdii and Hg6.3) did not amplify at all for the monk seal. Two microsatellites (Hg4.2 and Hg8.10) were shown to be monomorphic, and three (Pv9, Hg6.1 and Hg3.6) appeared to be polymorphic, with 2, 2 and 5 alleles, respectively.

The results for the pups born in 1994 and those born in 1995 are shown in Table 3. Pups #2 and #10 on one hand, and #5 and #8 on the other, are indistinguishable at present because they show the same result for the three microsatellites analysed.

DISCUSSION The non-amplification in the Mediterranean monk seal (Monachinae) of three microsatellites out of eight (37.5%), originally isolated from the grey seal (Phocinae), conforms with other results obtained for other cross-species reactions, such as between *Bos taurus* (cattle) and *Capra hircus* (goat) (38.5%) (Pépin *et al.*, 1995). It is probably caused by a mutation in the priming site, which is a consequence of the phylogenetic divergence between species.

The smaller number of alleles found in the Mediterranean monk seal as compared with the grey seal (Table 1), can be explained by several factors:

Firstly, and because of the phylogenetic divergence between the two species, interruptions in the dinucleotide sequences could have arisen, and may hamper the mechanism of DNA slippage, the processes by which new alleles are thought to be formed (Pépin *et al.*, 1995).

Secondly, the bias in our samples (i.e. only pups) from a species whose reproductive strategy is still unknown, but which is likely to be polygynous, can lead to a reduction in the representation of the alleles of the whole population, if several of the pups shared the same father.

Thirdly, since the species has suffered from several bottlenecks, and the effective population size is quite small, a decrease in the genetic variability would be expected.

CONCLUSIONS As the level of variability found in the microsatellites so far analysed in Mediterranean monk seal is not high enough either to identify all the individuals or to estimate the relatedness between them, our next step is to increase the number of microsatellites analysed until a suitable number of usable microsatellites have been determined.

ACKNOWLEDGEMENTS We wish to thank the numerous people who assisted us with the fieldwork. The European Commission LIFE project (B4-3200/94/0000/D2) funded this study.

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Table 1. Microsatellite comparison between grey seal and Mediterranean monk seal

Locus	Number of alleles (sizes range in bp)	
	Grey seals N = 1134	M. monk seals N = 17
Hg4.2	8 (139-165)	1 (143)
Hg3.6	8 (85-101)	5 (85-99)
SGPv9	7 (160-172)	2 (160-166)
Hg8.9	11 (197-217)	-
Hgdii	8 (111-141)	-
Hg6.1	6 (150-166)	2 (144-158)
Hg8.10	10 (183-201)	1
Hg6.3	6 (219-229)	-

Table 2. Results of microsatellites Pv9, Hg6.1 and Hg3.6 analysis
<u>Alleles</u>:Pv9: 160, 166   Hg6.1: 144, 158   Hg3.6: 85, 87, 95, 97, 99

Results of microsatellites Pv9, Hg6.1 and Hg3.6 analysis

Alleles: Pv9: 160, 166 Hg6.1: 144, 158 Hg3.6: 85, 87, 95,97,99

1994 1995

# IND.	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	18	19
CAVE	3	3	3	3	3	3	3	3	1	3	3	3	3	1	1	1	1
Pv9	160	166	160	160	160	160	160	160	160	160	160	160	160	160	160	166	160
	160	166	166	166	160	166	166	160	160	166	160	166	166	166	166	166	166
Hg6.1	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
	158	144	158	144	144	144	144	144	158	144	158	144	144	144	144	144	158
Hg3.6	87	95	95	85	85	95	85	87	87	87	87	85	95	87	95	87	99
	95	99	95	95	99	95	95	87	95	87	97	99	99	97	97	99	99

Individuals No. 2 & No.10 and No. 5 & No.8 cannot be distinguished from each other

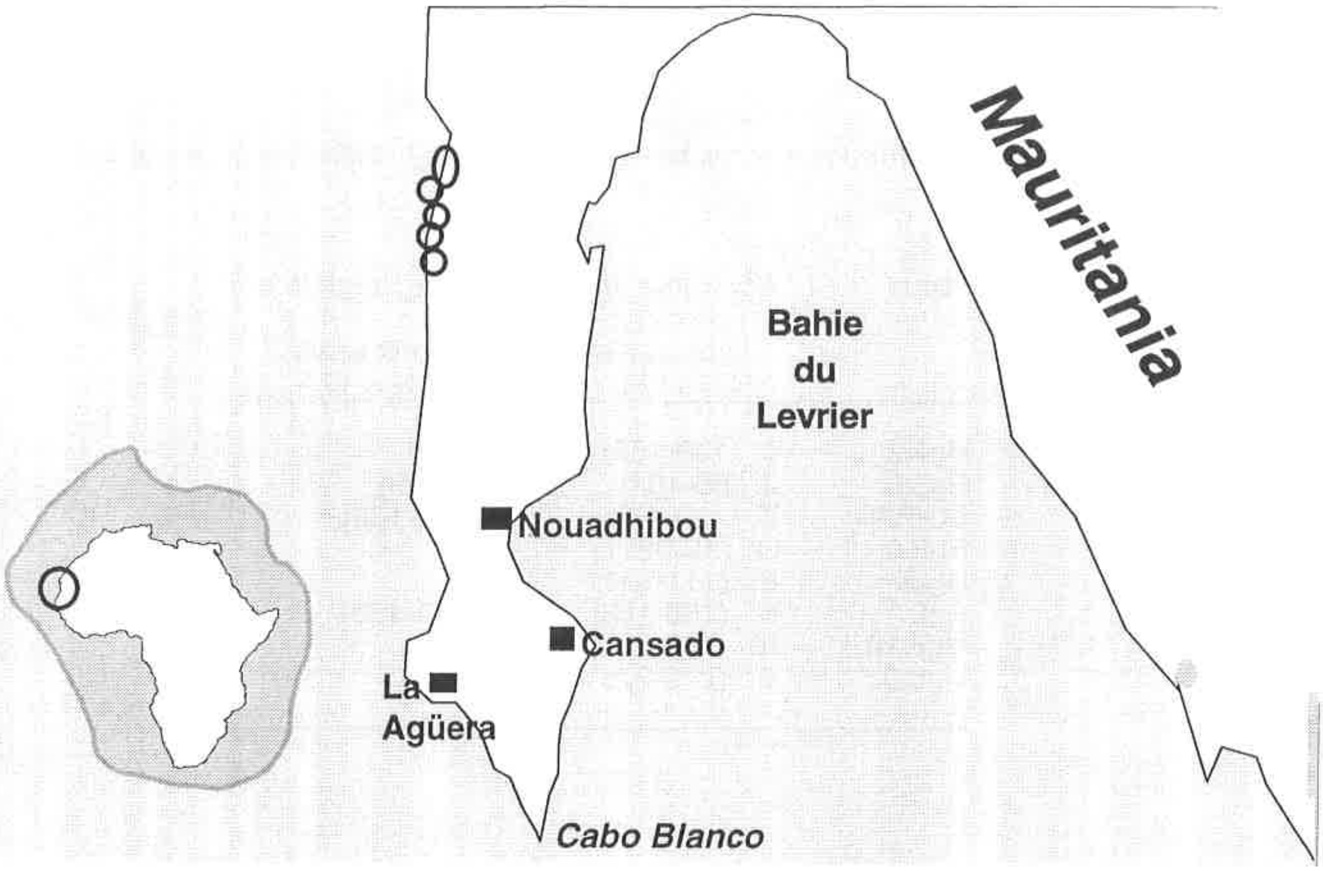

Fig. 1. The Peninsula of Cabo Banco. The circles indicate the area of caves where the pups are sampled

THE WEST WALES GREY SEAL CENSUS

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The West Wales coast and islands, between Aberystwyth and Tenby, was surveyed by sea between September 1991 and August 1992 for potential grey seal pupping sites. In 1992, 1993 and 1994, regular visits were made to count pups at these sites from August to December. Adult female seals were photographed in order to identify individual seals by natural pelage markings.

The number of pups counted in each year was 1,298, 1,363 and 1,332. The all-age population was estimated at approximately 5,000 seals. Pups were recorded at up.to 225 sites in each year: most were located under cliffs, among boulders, or in caves. In each year, consistently higher numbers of pups were recorded at the same key sites. The mean date of pupping was 4 October, but was about one week earlier in caves compared with beaches.

Over 380 breeding females were photographically identified. The recapture rate at a post-breeding haul-out, thought to comprised entirely adult females, was used to arrive at an estimate of 1,290 breeding-age females: the close correspondence of this result with counts of pup production suggests that this is an appropriate method of applying photo-identification to estimate overall abundance of the population breeding in West Wales.

WEST WALES GREY SEAL DIET STUDY

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The aim of this study was to investigate the diet of grey seals around West Wales. The objectives were to estimate relative quantities of prey consumed by grey seals over several years, assess annual, seasonal, and regional variation, and compare diet results with M.A.F.F. fishing survey data.

252 faecal samples were collected. Diet composition was estimated by calculating prey weight and length from otoliths and cephalopod beaks, after correcting for digestion.

Gadoids and flatfish (mainly whiting, sole and *Trisopterus* species) dominated the diet, making up 70% by weight.

Elasmobranchs were the major species by weight caught in the fishing survey, but were poorly represented in the seal diet, possibly due to complete digestion. Histograms comparing prey consumption with prey availability suggested that elasmobranchs were likely to have been a major component of seal diet, but associations were not shown by Chi-square analysis.

For the main commercial species identified in the seal diet, i.e. whiting, sole, and plaice, a wide range of fish sizes were consumed. Most whiting and sole were within relatively broad size-groups which included fish both greater and smaller than the M.A.F.F. minimum landing sizes. Most plaice were within a relatively narrow size group, greater than the M.A.F.F. minimum landing size.

The results agree with previous UK studies in that gadoids and flatfish were the dominant prey, but contrasted in that sandeels were virtually absent, and dragonet contributed a relatively large proportion: 11% by weight.

DIET COMPOSITION OF GREY SEALS (*HALICHOERUS GRYPUS*) IN THE NORTHERN GULF OF ST. LAWRENCE

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The North-west Atlantic grey seal population (*Halichoerus grypus*) is increasing at a rapid rate (>8% per yr), raising concerns that they are having a negative impact on commercial fish stocks. In order to assess this impact, information on diet composition is required.

Diet composition was determined by identification of otoliths in a sample of 242 food-containing grey seal stomachs, collected primarily from Anticosti Island in the northern Gulf of St. Lawrence.

A total of 21 species of fish were identified, of which three species (herring, cod and capelin) accounted for 69% of the prey consumed by frequency of occurrence, 39% by weight, and 48% of the total energy.

Marked seasonal or inter-annual differences were observed in the diet of animals collected from Anticosti Island. In 1988, samples were obtained primarily during May - July. In this sample, capelin was the most important prey, comprising 44% by energy of the reconstructed diets, while herring (3.3%) and cod (6.4%) were only minor components. In 1992, when samples were collected during August - September, cod and herring comprised 39% and 14% respectively of the diet, while capelin declined to 0.6%.

Differences between samples were also observed in the length frequency composition of capelin, herring, and cod. In 1988, 82% of the capelin consumed were 10-15 cm long, 10% of herring were >30 cm, and 37% of cod were >40 cm long. In 1992, with the exception of capelin, larger fish were consumed. In this sample, 70% of the capelin consumed were 5 to 11 cm long, 29% of herring were >30 cm, and 51% of cod were >40 cm, with the largest cod being 67 cm in length; 77% of mackerel ingested were 35-45 cm long

FIRST RECORD OF HARBOUR SEALS IN THE WESTERN MEDITERRANEAN SEA

J. Mas[1], J. Jimenez[2] and J. A. Raga[3]

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Two individuals of harbour seal, *Phoca vitulina*, were detected sporadically along the Spanish Mediterranean coasts (Murcia and Valencia regions) during August 1994. Several pictures, as well as some detailed descriptions about the coloration and morphology of the animals given by some bathers, allowed a correct identification. The two specimens were first seen on 8 Aug, 1994, in 'Cueva Lobos', Murcia (37° 33'40" N, 01° 19'24" W), an old monk seal cave. Between 9 - 15 August, only one individual appeared along several Murcian shores. Later (on 24 August), and more than 200 km to the north, a harbour seal was observed again in the beaches of the Natural Park of El Saler (39° 18'55" N, 00° 7'34" W) on two days in succession.

There are a number of sporadic records of vagrant individuals of pinnipeds in the Atlantic waters of the Iberian Peninsula. However, no seals other than the monk seal have been recorded in the Mediterranean, and the nearest geographic record of a harbour seal is in Huelva, within the South Atlantic Spanish area adjacent to Portugal. Thus, this is the first record of harbour seals in the Mediterranean. The record also represents the farthest observation of any wandering harbour seals from their breeding grounds, and in waters much warmer than usual for the species.

NINTH ANNUAL REPORT OF THE EUROPEAN CETACEAN SOCIETY: 1995

Paid-up members of the European Cetacean Society for the year 1995 numbered 341, plus three institutional members, from twenty-six European and thirteen non-European countries. The highest representation came from Italy (72), Germany (58), United Kingdom (57), Switzerland (48), Spain (16), and France (16). Other member countries include Austria, Belgium, Croatia, Czech Republic, Denmark, Faroe Islands, Finland, Greece, Iceland, Ireland, Monaco, the Netherlands, Poland, Portugal, Romania, Russian Federation, Slovenia, Sweden, Switzerland, and Ukraine within Europe, and Algeria, Argentina, Australia, Canada, Ecuador, Hong Kong, Japan, Kenya, Mexico, Peru, South Africa, Tunisia, and the United States elsewhere.

The conference held in Lugano between 9-11 February 1995, on the theme "The Acoustic World of Cetaceans" was very successful, with an attendance of 270 participants from 21 countries. Five invited speakers addressed the society: Chris Clark and Bill Watkins from the United States, John Ford from Canada, David Goodson and Jonathan Gordon from the United Kingdom. The day before the conference, a workshop on ethograms was held by Denise Herzing, and one on Bioacoustic Techniques was held by Jonathan Gordon the day after the conference. The abstracts of the meeting are published as proceedings under the title "European Research on Cetaceans - 9", edited by Peter Evans and Helen Nice.

Three Newsletters were produced during the year, reviewing recent research and news items in Europe and elsewhere in the world, conservation issues, cetacean meetings and publications, and Society business. One of these formed a special newsletter reporting the findings of the workshop on *Tursiops*. During the course of the year, Peter Evans received editorial support from Marjan Addink, Paula Barnett, and Victoria Turner, to whom the society is very grateful.

In developing further links between the ECS and the European Association for Aquatic Mammals (EAAM), the annual conferences of the respective societies, both to be held in Portugal in March 1996, were organised adjacent in time to one another, and advertised in the respective newsletters of the two societies.

Finally, the European Cetacean Society has continued to provide advice to government departments and non-governmental organisations in European countries, and specialist information for various public enquiries, with representation at ASCOBANS and ACOMABS.

BEATRICE JANN
(Hon. Secretary)

FINANCIAL REPORT FOR THE YEAR UP TO 7 MAR 1996

	DM	£
Balance as of 3 February 1995	**(= 3121,50)**	**1,387.32**

Income	German account DM	British account £
Membership fee for 1995, Conference in Lugano	10,380.00	
Membership fee for 1995 to the German account	2,714.93	
Membership fee for 1996 to the German account	1,391.93	
Profit from the Conference in Lugano	1,976.90	
Other payments to the German account	33.59	
Oxford account (savings)		432.09
Oxford account (Income: Lugano Conf., Membership fees)		1,773.27
Total Income	**16,497.35**	**2,205.36**

Expenses	German account DM	British account £
Travel expenses board meeting San Remo, Oct. 95	1,265.00	190.00
ECS-Newsletters		589.02
ECS-Proceedings (Lugano), typing costs		300.00
Proceedings expenses (Pathology workshop 1994)	3,833.41	
Postage Expenses ECS Conference Lisbon 1996	1,928.50	
Secretarial expenses at SMRU		192.50
Bank account expenses	200.50	7.00
Computer Support Group (Internet costs)	503.41	
Total Expenditure	**7,730.82**	**1,278.52**

	DM	£		DM
Balance as of 7 March 1996	**8,766.53**	**926.84**	**=**	**11,355.33**

ROLAND LICK
(Hon. Treasurer)

EUROPEAN CETACEAN SOCIETY - 1996

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 a new group (covering the Mediterranean Sea) has 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, nine 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; and Lugano (Switzerland) in 1995. At intervals, workshops are also 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) in 1988; no. 10 - a sightings workshop held in Palma de Mallorca (Spain) in 1990; no. 17 - a workshop to standardise techniques used in pathology of cetaceans held in Leiden (Netherlands) in 1991; no. 23 - a workshop to review methods for the field study of bottlenose dolphins held in Montpellier (France) in 1994; and no. 26 - a workshop for the diagnosis of by-catches in cetaceans held in Lugano (Switzerland) in 1995.

Membership is open to *anyone* with an interest in cetaceans. The annual subscription is **DM 60** for full and institutional members, or **DM 35** for those who are 25 years of age or younger, full-time students or unwaged. 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. 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.

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