EUROPEAN RESEARCH ON CETACEANS - 11

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EDITORS: P.G.H. EVANS, E.C.M. PARSONS & S.L. CLARK

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CONTENTS

INTRODUCTION

The Eleventh Annual Conference of the European Cetacean Society was held at the German Museum for Marine Research and Fishery in Stralsund, Germany between 10th and 12th March, 1997. It was attended by 250 persons from 27 countries. The Society is very grateful to Harald Benke, the staff of Stralsund Museum particularly Gerhard Schulze and Ines Westphal, and a team from the University of Kiel headed by Roland Lick and Ursula Siebert, for organising a very successful and enjoyable conference

This year we had a tremendous response from organisations and companies, and we thank the following for their generous sponsorship: Aqua-Concept, Arbeitsgemeinschaft Molenbau Warnemünde, Architekturbüro Jasper Hermann, Arkona Hotel Baltic, Autohaus Boris Becker GmbH & Co. KG, Bauunternehmung Jens W. Lorenz, Busunternehmen Möller, Coca-Cola Erfrischungsgetränke AG, Deutsche Bank AG, Deutsche Forschungsgesellschaft, Deutsches Museum für Meereskunde und Fischerei, Dresdner Kühlanlagenbau (NL Mecklenburg-Vorpommern), Elektrounternehmen Ing. Klaus Haack, Fa. Anton Müsing, Geld- und Sicherheitsdeinst Stralsund, Greenpeace, Hanse-Keller, Hansestadt Stralsund (Der Oberbürgermeister), Haus am Rügendamm "Touristen Pension", Holsten-Brauerei, Hotel Stralsund, Hotel zur Post, Ingenieurbüro E. Polz, Kulturhistorisches Museum, Ministerium für Landwirtschaft und Naturschultz des Landes Mecklenburg-Vorpommern, Nehmzow & Prothmann GbR, Nordmetallbau und Handel - Ing. Hans-A. Rossow, NORWAS, Ostseetherme Ahlbeck, Prince Denmark, Printus-Fachvertrieb, Provinzial Versicherungen, Schmeisser Bürosysteme, Speck-Pumpen, Spiegelblank, Stadt- und Kreissparkasse Stralsund, Stralsund-Information, Stralsunder Brauerei, Strela-Back, StrelaGas, Tagis-Aquarium, Trop-Elektronik Altena, Umweiltstiftlung WWF deutschland, Verein der Freunde und Förderer des Meeresmuseums Stralsund e.V., Weico-Produkte GmbH, Weil Industrieanlagen, and Wojtas Nachrichtentechnik.

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. 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.

The abstracts have been arranged broadly by subject, starting with Conservation since the theme for the invited key note lectures this year was "Behavioural Aspects of Cetacean Bycatch". In this context, I would like to take the opportunity to give warm thanks to the following invited speakers, some of whom had to travel great distances to address the society: Scott Kraus and Andy Read from the United States, Steve Dawson from New Zealand, and David Goodson and Jonathan Gordon from England.

Instructions for Contributors are given at the back of the Proceedings. Please follow these carefully. At present, very few are doing so, particularly with respect to headings, layout and the presentation of references. There is little point in citing an unpublished report unless the reader is given information on how he or she can obtain it. Those whose knowledge of the English language is limited are advised to ask a native English speaker to read through their submissions in advance.

A great deal of effort goes into the editing and production of these Proceedings. I should like to thank in particular Chris (Ed) Parsons and Sarah Clark for their invaluable help in typing and editing, Constanze Blödner for her help in the final production, and Roland Lick and the University of Kiel for organising its printing.

Peter G.H. Evans

CONSERVATION

PINGERS, PORPOISES AND POWER:
CAN WE USE ACOUSTICS TO REDUCE ENTANGLEMENT?

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Incidental mortality of dolphins and porpoises occurs in almost every marine gillnet fishery. Many tens of thousands of animals are killed annually in this manner worldwide (IWC, 1994). In several cases, this mortality threatens stocks and/or species with extinction (Reeves and Leatherwood, 1994). One of the species most frequently killed in such interactions in U.S. and Canadian waters, and in Europe is the harbour porpoise, *Phocoena phocoena* (Jefferson and Curry, 1994; IWC 1996). In several cases, bycatch levels are unlikely to be sustainable (Woodley and Read, 1991) and in one case may have caused changes in life history and distribution (Read and Gaskin, 1990).

Proposed solutions to the problem of bycatches in gillnets have taken several forms, including time/area fishery closures (e.g. Dawson and Slooten 1993). Potential solutions include passive enhancement of the acoustic detectability of gillnets to echolocation (e.g. Hembree and Harwood, 1987) and/or placing active pingers on the nets to warn animals of their presence (e.g. Hatakeyama *et al.*, 1994). Until 1995, neither passive nor active acoustic approaches had shown substantial or consistent reductions in entanglement rates (Dawson 1991, 1994; Todd and Nelson, 1994; Jefferson and Curry, 1996).

A recent experiment with active acoustic devices or "pingers" (Kraus *et al.*, 1996) was different from previous work in two ways: (1) it was carefully designed to give the best possible chance of detecting differences in catch rate between nets with and without pingers, and (2) unlike previous studies, nets with pingers had a substantially lower entanglement rate. The experiment was conducted using sink gillnets in New Hampshire coastal waters (on Jefferies Ledge) during autumn 1994. The pingers emitted a 300 ms pulse every 4 s, with a fundamental frequency of 10 kHz, but with harmonics that extended to beyond 80 kHz. Nets with active sound emitters caught two porpoises in 421 strings while nets with inactive emitters caught 25 porpoises in 423 strings.

What has happened since? Observers monitored the commercial use of pingers in the Jefferies Ledge area during the fall 1995 fishery; no porpoises takes were observed, confirming the experimental result of Kraus *et al.* (1996). In the spring fishery in this area, however, observers saw nine porpoises taken in 88 hauls - exactly the same average take rate as the previous five years. Similar trials in a spring fishery in Massachusetts Bay resulted in two takes observed in 171 hauls - also the same average take rate as in the previous five years.

The results from the Kraus *et al.* (1996) experiment have been partially replicated in two other areas. Gearin *et al.* (1996) placed 2.7 kHz pingers on bottom-set salmon gillnets in the Makah set gillnet fishery for salmon, in the coastal waters of Washington State. In both the 1995 and 1996 trials, porpoise bycatches were significantly reduced in nets equipped with pingers. Problems with the design of 1995 trials were rectified in the following year. Theodolite observations during the latter trial showed that porpoises avoided the area around the nets with pingers (Laake *et al.*, unpub ms). Theodolite observations of simulated net in Clayoquot Sound (British Columbia) showed that porpoises avoided 2.7 kHz pingers but did not avoid float-type passive reflectors (Koschinski and Culik, unpubl. ms).

Bycatch reduction via pingers - the key unknowns

1. *Can the results of the Kraus et al. experiment be generalised to other times/places?* Current studies suggest that pingers may be effective elsewhere. In New Hampshire, pingers may be effective only in the winter.

2. *What is the mechanism of deterrence?* It is possible that the pingers did not influence porpoises directly. The bycatch of Atlantic herring was 6.5 times lower in strings with active pingers than in those without, and many of the porpoises caught had been feeding on herring (Kraus *et al.*, 1996). Herring can hear the pinger frequencies (Nestler *et al.*, 1992) and may have reacted by moving away from the nets. If so, this method of bycatch reduction may not work in places where porpoises do not eat herring. Harbour porpoises in Washington State, the other area in which pingers have apparently reduced porpoise bycatch, also feed on herring (Gearin *et al.*, 1994).

3. *Habituation - will pingers lose effectiveness over time?* This question is currently unanswerable because of the limited duration (2 months) of the New Hampshire study and of those which followed it. Porpoises in New Hampshire are considered to be migratory, rather than resident (IWC, 1996). One would expect a much higher chance of habituation in areas where porpoises are resident, and thus exposed to pinger sounds more continuously.

4. *Can the results be generalised to other species?* We cannot generalise the New Hampshire results to other species. For example, no data are available to indicate whether pingers might reduce the gillnet bycatch of delphinids.

5. *Do they work in a real-life fishery?* Following the 1994 trial, gillnet fishers have continued to use pingers in times and areas where bycatches have occurred in the past. As noted above, porpoise bycatch in the same and similar fisheries during spring was not reduced below recent levels (IWC, in press). This raises important questions about whether pingers will be effective over the long-term, and emphasises the need for a cautious approach in the wake of the New Hampshire experiment.

These questions need to be addressed as a matter of urgency. Prior power analysis is an essential tool in designing such studies.

The importance of statistical power analysis The most pressing issue is whether the result achieved in the New Hampshire experiment can be repeated for the same area, and for harbour porpoise populations in other areas. Ideally, the decision of what reductions are needed should be set following quantitative population assessment, or via the statutory requirements of the law (e.g. the U.S. MMPA). Once the goal for bycatch reduction is known, straightforward power analyses can provide very useful guidance.

It is obvious that large reductions in bycatch rates are easier to detect than small ones, and hence require experiments on a smaller and less expensive scale (Fig. 1). Less obvious is that such simple power analysis can provide guidance on what species tests should be conducted, in what areas, and during which times. For example, it is clear that very large-scale trials are required if the probability of entanglement in unmodified (control) nets is low (below about 2%; Fig. 2).

Before considering tests in other areas and for other species, it is crucial to have data on entanglement rates in nets without pingers. Our simple power analyses show that unless entanglement rate in control nets is high, the scale of experiment needed to detect a difference will be very large, and hence expensive. Such studies cannot be carried out cost-effectively in areas or times of low entanglement rate, or on species with low entanglement rates. This is an important constraint since the low reproductive rate of dolphins and porpoises makes small populations vulnerable even at low levels of entanglement.

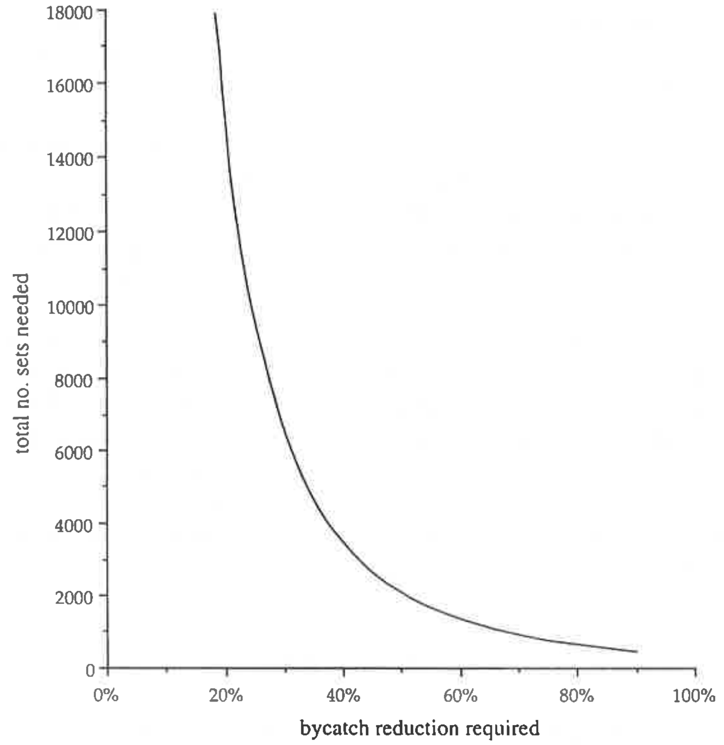

Fig. 1. The approximate total number of sets of net strings (1:1 ratio of modified:unmodified) needed to demonstrate with 0.80 power (p.<0.10, 1 tailed) a bycatch reduction of given magnitude, assuming a probability of entanglement per control set of 0.025. Computations are via the normal approximation to Fisher's exact test.

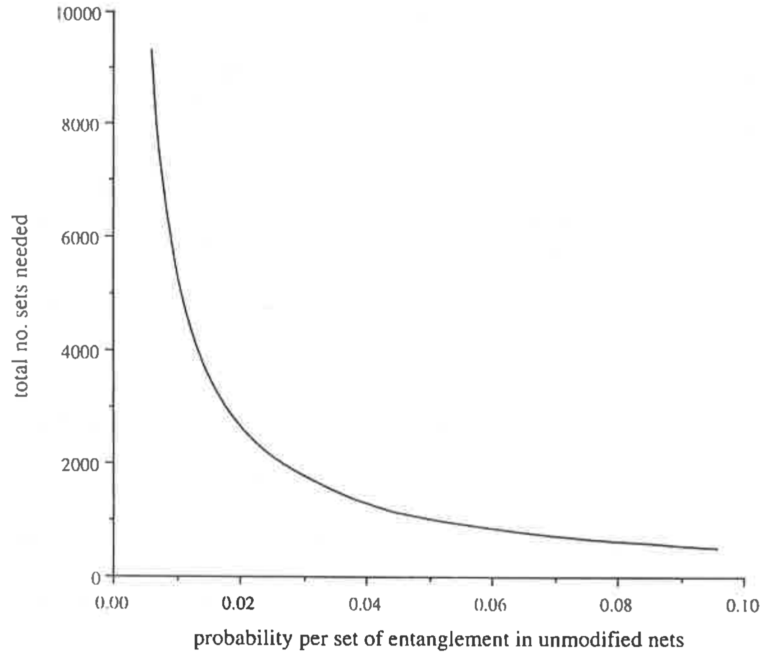

Fig. 2. The approximate total number of sets of net strings (1:1 ratio of modified:unmodified) needed to demonstrate with 0.80 power (p.<0.10, 1 tailed) a 50% bycatch reduction given various probabilities of entanglement in unmodified strings.

Management recommendations Pingers should not become part of the bycatch mitigation strategy for any fishery/marine mammal interaction until their effectiveness is statistically validated in that fishery, or in a very similar one.

Pingers should not be deployed without a comprehensive scientific monitoring program. Current concerns about the use of pingers in commercial fisheries are sufficiently substantative that we cannot assume that they will be effective over the long term. It is imperative to continue to monitor the incidental mortality rate of porpoises and other non-target species to document the effectiveness of these devices over time.

Even if pingers are effective in reducing incidental mortality by 90%, as suggested by the results of the New Hampshire experiment, their widespread use may not be sufficient to prevent population declines, or to meet legislative goals (e.g. the Zero Mortality Rate goal of the U.S. MMPA). Managers, scientists and fishers should continue to explore other ways of reducing bycatch, including area closures and alternative fishing methods. Although we are cautiously enthusiastic about their promise, there is currently no justification for adopting pingers as a panacea for the problem of incidental mortality of small cetaceans in gillnets.

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THE POTENTIAL FOR ACOUSTIC DETERRENTS TO MITIGATE FISHERY / MARINE MAMMAL CONFLICTS

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One well-controlled fishery experiment, and several playback experiments have demonstrated that, in some circumstances, porpoises and dolphins avoid underwater acoustic signals. In some cases, these signals will be useful in reducing marine mammal entanglements that occur in a variety of fisheries. However, carefully controlled experiments are critical to determine whether these techniques will work on a particular species of porpoise or dolphin. Furthermore, questions about habituation to repeated signals, or the possibility of exclusion from important habitat remain unanswered. Although it may be possible to alter acoustic deterrent signals (i.e., lowering sound source levels and randomising sound patterns) to eliminate these concerns, acoustic deterrent advocates should proceed extremely cautiously in developing this technology for use in any fishery, for the reasons stated above.

THROUGH THE LOOKING GLASS: THE BEHAVIOUR OF HARBOUR PORPOISES IN RELATION TO ENTANGLEMENTS IN GILL NETS

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Incidental mortality, particularly in gill net fisheries, is perhaps the most pervasive threat to populations of small cetaceans. Technological solutions to this conflict have proven elusive, because little is understood of the causes of entanglement. Our knowledge is limited because entanglement is seldom witnessed in the wild and the behaviour of dolphins and porpoises around gill nets cannot be observed directly. It is possible, however, to make inferences about the behaviour of small cetaceans from indirect means, such as telemetry. Here, research conducted on the behaviour of harbour porpoises in relation to entanglement using a variety of telemetry approaches is reviewed, and future research directions that may improve our understanding of this vexing problem are outlined.

REDUCING BY-CATCH OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) IN GROUNDFISH GILLNETS: AN INCLUSIVE APPROACH

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INTRODUCTION Worldwide, human use continues to increase pressure on ocean resources while returns steadily decline (Lien, 1996). Ensuing conflicts between resource protection and human impact are frequent. Incidental entrapment of cetaceans in fishing gear illustrates this global problem (Perrin *et al.*, 1994; see also this volume). However, agreement on solutions is rare. Typically, solutions have focused on biological aspects of the problem. Human dimensions are less commonly considered.

In 1994, an estimated 101 harbour porpoises were incidentally caught in groundfish gillnets in two areas off Grand Manan Island, Bay of Fundy, Canada (Trippel *et al.*, 1996b) (Fig. 1). The Whale Research Group co-operated with fishers from Grand Manan Island in a research project to mitigate harbour porpoise by-catch and to develop an inclusive approach to the by-catch problem.

METHODS Randomly chosen nets were equipped with active, acoustic devices ("alarm") (Lien and Hood, 1994). Alarms produced pulsed sounds of approximately 2.5 kHz at 115 dB re 1µPa at 1 m which lies within the hearing range of harbour porpoise (Kastelein *et al.*, 1995). Gillnets were fitted with four alarms in 1994 and with ten alarms in 1995. Concentrating on the Swallowtail area only (Fig. 1), trained volunteers monitored catches of harbour porpoise in experimental and control nets.

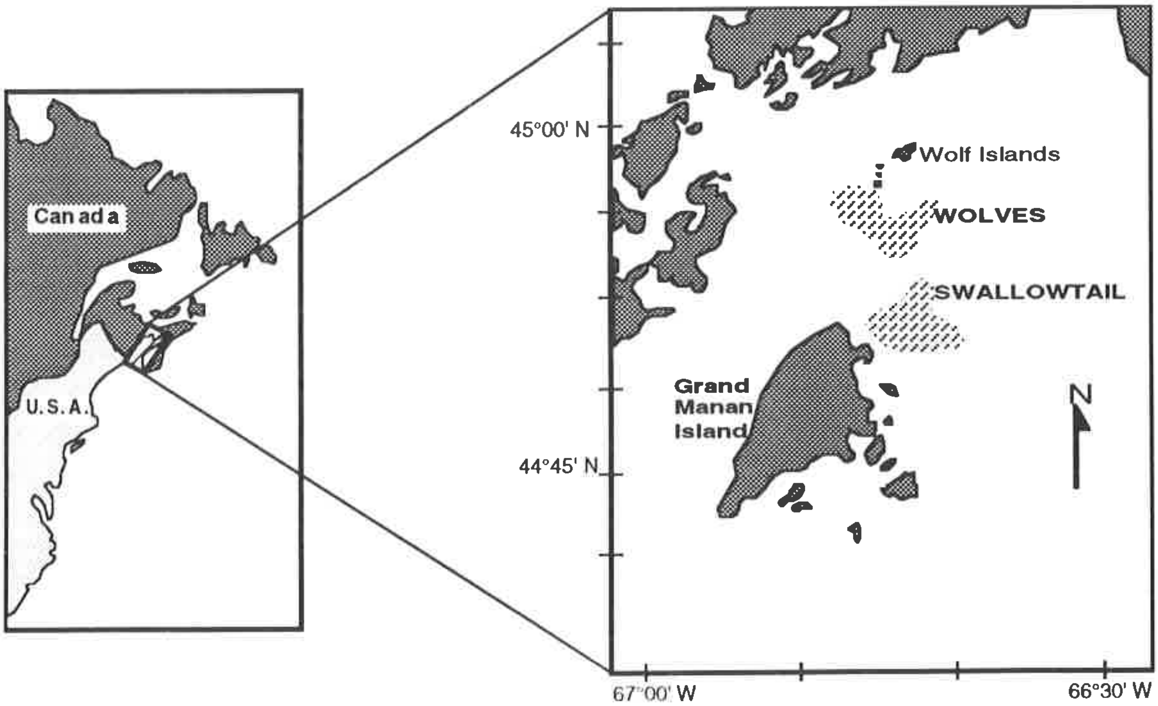

Fig. 1 Map of the Bay of Fundy study region, showing hatched areas in which harbour porpoise by-catch occurs in right hand figure.

A five-step approach characterised the co-operation with fishers (Lien *et al.*, 1995):

(1) Education and Information; (2) Trust building; (3) Implementing solutions;
(4) Developing and testing solutions; and (5) Ensuring recognition.

RESULTS The 1994 fishing season lasted from 9 July to 10 September during which 678 nets (alarmed: n = 270, 40%; control: n = 408, 60%) were monitored. Alarmed nets caught 11 porpoise (26%) (mean weekly catch rate per net ± 1 SE = 0.04 ± 0.01). Control nets caught 32 (74%) porpoise (0.08 ± 0.02) (Fig. 2). Catch rates did not differ (two-sample t-test; t = 1.64; df = 14; p = 0.12). The odds of catching a porpoise in control nets was 2.09 (95% Confidence Interval: 1.05-4.18) times higher than in alarmed nets.

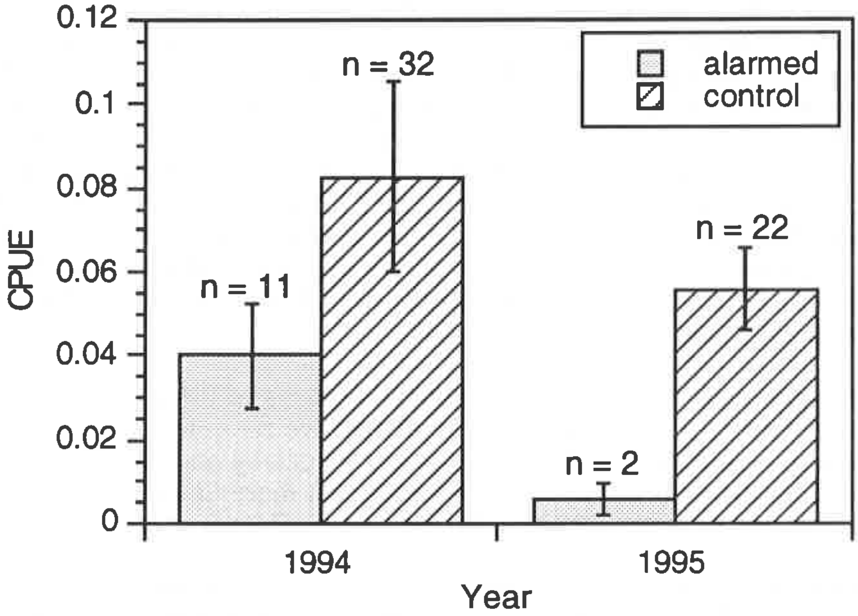

Fig. 2 Catch Per Unit of Effort (CPUE) of harbour porpoise in alarmed and control nets in 1994 and 1995. Error bars reflect ± 1 standard error. n = number of porpoises.

In 1995, the season lasted from 3 July to 26 September. Fishing was suspended during August due to quota regulations. A total of 504 nets were monitored and 24 harbour porpoise were retrieved. Alarmed nets (n = 178, 35%) caught two porpoises (8%) (0.006 ± 0.004 porpoise/net) while control nets (n = 326, 65%) caught 22 porpoises (92%) (0.06 ± 0.01 porpoise/net) (Fig. 2). Catch rates differed (two-sample t-test; t = 4.69; df = 9; p = 0.001). The odds of catching harbour porpoises in control nets was 7.45 (95% CI = 1.99-27.94) times higher than in alarmed nets.

The inclusive approach resulted in marked improvements in relationships and communication between stakeholders, utilised knowledge basis, feedback, and management characteristics (Table 1).

DISCUSSION Alarms reduced by-catch of harbour porpoise in groundfish gillnets in the Bay of Fundy. High background noise might have reduced the effectiveness of alarms in 1994 (Lien and Hood, 1994). The increased number of alarms in 1995 could have raised sound level enough to reduce masking.

Table 1 Comparison between management aspects before and after use of the inclusive approach

	Before	**After**
Relationship between stakeholders	none or tense	working relationship, friendship
Knowledge basis used	scientific	scientific and traditional
Communication	little, top-down, regulations	frequent, open, dialogue, discussion
Feedback	none	essential
Management characteristic	reactive, conservative, short-term	preventative, adaptive, long-term

We do not know how the alarms worked. Alarm sounds likely represented a novel stimulus for harbour porpoise, which they tended to avoid (Kastelein *et al.*, 1995). Harbour porpoise could have explored the sound source (Kastelein *et al.*, 1995). Thus, porpoises might have been aware of the net and avoided entanglement. Lastly, alarm sounds could have been aversive to harbour porpoise and functioned similar to Acoustic Harassment Devices (AHD's) (Jefferson and Curry, 1994). Although sound levels produced by single alarms are much lower than those of AHD's, output of multiple alarms might affect porpoise distribution (Trippel *et al.*, 1996a). Therefore, it is currently impossible to predict long-term effects of active acoustic devices on the behaviour of harbour porpoise. Nevertheless, positive results from this study warrant further research to answer such questions.

Our inclusive approach was effective in preventing many of the problems of traditional management practices (Lien, 1996). It is an alternative for conflicts in which resource protection has to be balanced with its human use. Focusing on communication, mutual agreement and partnership allows management to act more quickly, in a more fair and adaptive fashion, and to better achieve long-term goals (Reeves *et al.*, 1996).

ACKNOWLEDGEMENTS The co-operation, hard work, and dedication of the fishers from Grand Manan Island and our volunteers made this project possible. Thanks to all of them. I also owe thanks to Jon Lien and Catherine Hood for letting me take part in this study.

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IMPROVING ACOUSTIC DETERRENTS TO PROTECT HARBOUR PORPOISES FROM SET GILLNETS

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The level of mortality of harbour porpoises (*Phocoena phocoena*) in inshore and continental shelf set gillnet fisheries on both sides of the North Atlantic and North Pacific requires that an effective method of keeping these small odontocetes away from fishing gear be developed. This unacceptable level of mortality is now recognised, but the real causes have yet to be explained. Very few behavioural studies attempt to look at porpoise behaviour underwater and study methods need to be developed to do this. In addition, the bycatch problem appears to be different in different fisheries and the effect of local variations in fishing gear design and local environmental factors, e.g. tide flow and seabed characteristics, must be considered.

That a technical solution exploiting sound should be possible - at least in the short term - is evidenced by the pioneering work of Lien *et al* (1995) in Canada, and by the rigorous field studies of Kraus *et al* (1995) in the Gulf of Maine. However, "habituation" and other effects may eventually make such devices less effective. A number of such concerns are discussed in the report of the NMFS/MMC Acoustic Deterrents workshop (Reeves *et al*, 1996). Why active acoustic devices work and whether it is the porpoise, or simply its preferred prey, that is affected by an "alarm" raises questions that have to be resolved. The choice of signal characteristics to induce a safe avoidance behaviour, using the least possible source energy, concerns a number of parameters, e.g. waveform, frequency, duration and mark/space ratio, some of which were studied with a rehabilitated (ex-stranded) porpoise in Holland (Kastelein *et al*, 1997). A more flexible approach to acoustic deterrent design (Newborough *et al*, 1997) will be required in future.

This paper reviews the problems from the cetacean and fisherman's perspective. New tools and innovative study methods will be required if we are to understand the root causes of the bycatch problem. The limitations of existing methods need to be clearly understood. Relying solely on "body count" statistics can restrict the evolution of better devices and apparent short-term "success" introduces a risk of creating a "technology trap" through legislation.

REMOTE SENSING METHODS FOR CETACEAN INTERACTIONS WITH PELAGIC TRAWL FISHING GEAR

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INTRODUCTION Some incidental catch of small cetaceans in fishing gear occurs in almost every type of fishery. Pelagic trawls are large moving nets usually deployed mid-water at depths designed to capture mid-water fish such as mackerel (*Scomber scombrus*) and scad (*Trachurus trachurus*). These trawls are typically towed at speeds of around five knots. Although the evidence is sparse, it is believed that, at certain times of the year, there is a by-catch of pelagic dolphins, particularly species such as common dolphins (*Delphinus delphis*), white-sided dolphins (*Lagenorhynchus acutus*) and white-beaked dolphins (*Lagenorhynchus albirostris*) (Morizer *et al.*, 1996).

The problems given to the fishing boat by even a single by-caught mammal are quite significant as the fish-handling technique can be obstructed, and clearance frequently difficult and dangerous. It is not yet understood why these animals are caught and, without this knowledge a solution is difficult to develop.

Developing new study methods to answer these questions is one objective of the EC funded project CETASEL, which includes researchers from Holland, France, England, Sweden and Denmark. Work on passively tracking bottlenose dolphins (*Tursiops truncatus*) has been in progress in Loughborough for a number of years (Morphet and Woodward, 1994). The original methods used for static, shallow water, two-dimensional studies have now been extended to work on a moving platform in a deep water environment to obtain three-dimensional tracks of echolocating animals in the vicinity of the trawl.

MATERIALS AND METHODS Few non-intrusive methods are available to study the behaviour of cetaceans swimming in close proximity to a fishing trawl some 800 m behind the fishing vessel and some 100 m below the water surface. In this study, an ROV (Remotely Operated Vehicle) equipped with a scanning sonar and TV cameras was available to examine the trawl but its presence was judged acoustically intrusive and images from similar systems show that the dolphins may be more interested in the equipment than fish in the vicinity of the trawl.

The use of low light TV at these depths is possible during daylight but cetacean by-catch more frequently occurs at night. The study method chosen exploits a sparse array of hydrophones that are attached to the entrance of the moving trawl. A configuration of five hydrophones (Fig.1) was chosen to permit sound sources such as echolocation signals in the general vicinity of the trawl to be localised in three dimensions in order to study the dolphin's behaviour as it manoeuvres at close range.

Other vocalisations, i.e. whistles, are captured by a wide-band hydrophone and this can in some conditions provide longer range detection and some target localisation in both range and depth (Kaschner *et al.*, 1997). All the captured signals have to be processed underwater to extract the relative time-of-arrival of a sound at each hydrophone and modulate this data, together with an audio (base-band) signal, so that it can be transferred up a single coaxial cable to the ship where it is recorded and processed into a real-time track plot display (Fig.2).

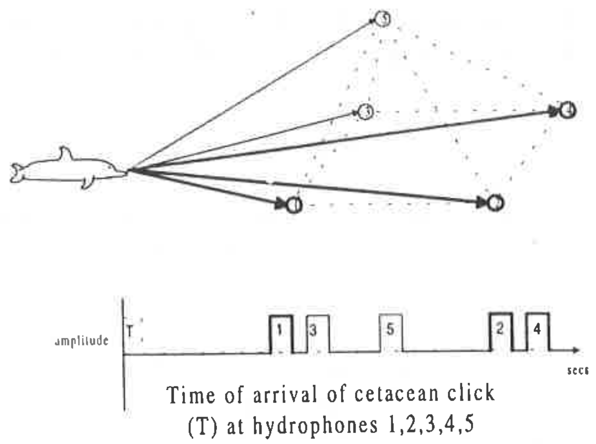

Fig.1 Relative time of arrival of a signal received on a sparse array of five hydrophones used to localise the signal source position in 3 dimensions

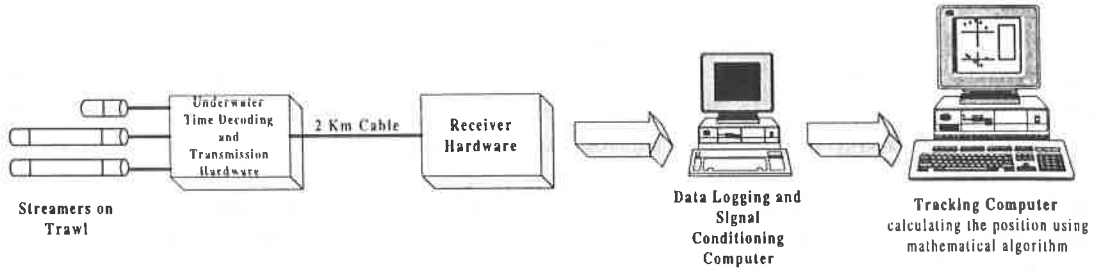

Fig.2. Block diagram of the real-time tracking system

RESULTS The sea trials so far have been mainly concerned with the technical development of the 3D tracking system and establishing its performance in a variety of sea state conditions. Unforeseen problems included collision damage by the ROV while inspecting its stability and the detection of wide-band impulsive noise generated by the fishing gear itself which initially caused false triggering of the system. Few dolphins have actually approached close to the gear during these trials although we are confident that echolocating animals within a 100 m radius could not be missed regardless of their orientation to the hydrophones. Whistles and echolocation signals have been detected at ranges in excess of 500 m and some vocalisations recorded from animals at well over a kilometre. These signals have been resolved by careful filtering through the continuous high level of self-noise generated by a 72 m long research trawler (operating at nearly full engine power) while towing the fishing trawl.

The positioning accuracy of the 3D tracking technique depends critically on the stability of the hydrophone array and this has proved difficult to achieve as the hydrophones are 'streamed' from positions on the headrope of the fishing gear. The system has therefore been engineered to self-calibrate at regular intervals. Further technical problems were introduced by the limited bandwidth of the cable connection to the ship. The precision algorithms originally developed for this work (Woodward & Coggrave, 1995) demanded data rates in excess of the cable capacity. The limitations of the system and the trawl mean the original mathematical algorithms (Hardman & Woodward, 1984) have had to be comprehensively adjusted and due to their complicated nature a look-up table approach has been implemented to generate quantified detection zone 'cubes' around the gear. This approach allows the system to display positional data in real-time but the definition (size of the spatial cubes) is severely limited by the bandwidth of the transmission medium. In future, a fibre-optic wideband communication channel will be needed to exploit the full potential of the system.

CONCLUSIONS The system has been deployed from a fishery research vessel and operated along the Atlantic continental shelf break between Ireland and Spain in water depths of 200m but, to date, very few close-up interactions between dolphins and the net have been observed. The pelagic trawl used has an aperture 100 m wide x 50 m high but for most of these tests the net's length was truncated (cut back to about a third) leaving a wide open end to minimise risk to the dolphins. Although much analysis of the data still has to be completed, one early by-catch hypothesis has been discarded as the results suggest that dolphins are unlikely to be simply 'run over' by these nets. Dolphins will be well aware of the approach of these trawls as the fishing gear headropes 'strum' and vibrate various metal components and in general the net appears as a wide spectrum noise source.

It now seems more probable that dolphin victims may have been attracted to fish being aggregated by the gear in the outer part of the trawl and have learned to exploit this. By-catch in this situation is now thought to result from additional factors, i.e. gear hauling or a vessel course change, both of which result in the net envelope altering its shape dramatically and thus making the 'safe' exit route to the surface difficult for the dolphin to find. Supplementary methods of detecting the underwater behaviour of these animals include the use of a single hydrophone monitoring technique as in these water depths the multi-path echoes can provide clues to range and depth.

Passive acoustic tracking methods appear to be the only non-intrusive technique applicable in this difficult environment, however, the problems of deployment will probably restrict the 3D application of the technique to research vessels as it is unlikely that a commercial pelagic trawler could accept the additional constraints created by the hydrophone array as these create interruptions to normal working procedures while attaching and removing the underwater parts of the system.

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ANALYSIS AND INTERPRETATION OF CETACEAN SOUNDS OBTAINED FROM A HYDROPHONE ATTACHED TO A PELAGIC TRAWL

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INTRODUCTION Very little is known about the underwater behaviour of cetaceans. An EC funded project (CETASEL) has been undertaking a study in water depths approaching 200 m, working close to the continental shelf edge using a Dutch fisheries research vessel (FRV Tridens). Study methods included a surface observer team, passive underwater acoustic listening, a 3D passive acoustic tracking array and an ROV equipped with a scanning sonar, and low light TV cameras. Surface observations were made from a vantage point above the ship's bridge, and all cetacean sighting were logged with time, vector from the ship, and estimated range. Hydrophone systems attached to a pelagic trawl provided the underwater acoustic data. The trawl net was typically 'flown' some 500 m behind the vessel and at a controlled depth, typically 60-80 m, below the surface. Real time spectral analysis (22 kHz) enabled weak cetacean vocalisations to be resolved from background noise and these sequences were recorded onto RDAT with a time code. During any close encounters with cetaceans, simultaneous data were also processed from the 3D tracking array (Connelly *et al*, 1997). The ship's electronic log recorded a comprehensive set of environmental and positional data which was updated every 2.5 minutes.

Acoustic analysis has been used to confirm and correct visual sighting data regarding minimum group sizes, and the underwater vocalisations are also being examined for species specific characteristics to aid future acoustic identification when working in low visibility conditions. Intensity differences and repeated 'signature' calls were also used to distinguish between different groups of cetaceans that may be within the detection range of the hydrophone at the same time. In these water depths, the whistle vocalisations from a diving cetacean will sometimes create strong reflections from the seabed and from the water surface which arrive, measurably time delayed, at the hydrophone. An estimate of the range of the vocalising animal to the hydrophone and its position in the water column can be determined based on these reverberations. Successive range estimates (circles) plotted with time can help define the cetacean's track relative to the vessel and the point of closest approach to the net.

PASSIVE ACOUSTICS - MATERIAL & METHODS During the October 1996 trial, acoustic data used for this analysis were obtained from a hydrophone (Benthos AQ4) attached to a pelagic trawl. The signals were preamplified, buffered, and transmitted through a 1.8 km long netsonde coaxial cable to the ship (Fig. 1). The hydrophone preamplifier frequency response was rolled off below 4 kHz to reduce the masking effect of the towing vessel's self-noise and the data further band-limited to 20 kHz when recorded onto a Sony TCD-D7 digital recorder.

Information about the species, estimated group sizes and swimming direction of cetaceans that were sighted at times corresponding to the recordings were either taken directly from the visual observer log or deduced from the information available (e.g. swimming speeds between sightings were estimated). The ship's computer log normally includes precise values of a wide range of parameters relating to the ship's position, course and speed, temperature, salinity, and other environmental factors and the parameters relating to the fishing gear. The example illustrated in Fig. 3 and Fig. 4 was recorded in a changing water depth reducing from 200 m to 162 m with a hydrophone depth of 80 m.

DATA ANALYSIS The RDAT tapes were analysed in the laboratory using a high resolution spectrograph (LSI). The extracted whistles were classified into groups of closely associated animals with the help of specially written signal processing software developed by Sturtivant (1996), and these acoustic results compared with the visual data. The speed of the vessel and the swimming speed of the animals were additional factors which assisted in discriminating between these groups, and it has proven possible to establish the relative track of the identified groups (and individuals) over a period of time.

Time delays between the arrivals of multipaths signals were extracted using the spectrograph's cursor facility. A software program (PKMP) was developed to use these delay times to estimate the range and depth of the animal (Fig. 2). This program simplifies the propagation paths by presuming that the strong reverberations observed originate from specula reflections of the source via the sea surface and the seabed (dolphin whistles have low directivity) and by employing an isothermal constant sound velocity profile with c derived from the logged water temperature and salinity (Francois & Garrison, 1982).

Under certain circumstances there will be an ambiguity for the resulting positions (affecting the depths estimates more than the range estimates in most cases), due to the fact that it can be difficult to determine which time delayed signal was produced by the surface reflection and which by the seabed reflection. It is possible to distinguish between the two however, if information about the parameters that define the scattering strength of the surfaces (e.g. angle, roughness of sea surface, seabed types, etc.) is available (Urick, 1967). In a few cases, where a good range estimate was available, the source level of the whistle was calculated. This parameter can help confirm detection range estimates and typical values need to be established for different species.

RESULTS The combined visual and processed acoustic data sets allow the changing relationships over time to be reconstructed in considerable detail. The general movements estimated for three groups of common dolphin (*Delphinus delphis*) are plotted in Fig. 4 and the distribution of different groups in range has been plotted against time in Fig. 3.

In one case, a very distinctive isolated whistle with strong reverberations was encountered over a period of 2 min, which was assumed to have been produced by the same animal. The changes in the estimated ranges and depths were plotted in a graph against time, so that an actual track was obtained.

LIMITATIONS OF METHOD The time delays between the arrival of the reverberations at the hydrophone are affected mainly by the depth of the water. Since the resolution of these timing differences depends on the measuring system, limits are created outside which depth or range changes cannot be established. The existing method seems to produce good results in water depths between 50-350 m with maximum useable ranges in the order of 1,000 m. Seabed absorption rates attenuate the bottom echo path and will also alter the maximum useable range. At short range, the near vertical incidence of the signal reflections at the seabed and surface will minimise errors due to small variations in sound velocity. However, at greater ranges the sound velocity profile will need consideration as refraction effects due to temperature and salinity variations can become significant (Clay & Medwin, 1977).

CONCLUSIONS The comparison of the information deduced from the acoustic data and the surface sighting data showed that parallel acoustic monitoring can improve the accuracy of population estimates. Furthermore, it enables us to visualise the underwater movement in the water column as well as any changes in behaviour that may occur in the vicinity of the fishing net.

IMPROVEMENTS OF METHOD Accuracy is improved when the ship's log of the water depth and hydrophone depth is available from netsonde measurements. Any variations in the exact depth of the hydrophone may also be monitored by attaching a TDR (Time Depth Recorder) at this position. The deployment of an additional, spatially separated hydrophone, will remove any ambiguity in the target's depth - however, a tetrahedron hydrophone array could also resolve azimuth information. Timing precision will be greatly improved by the use of correlation signal processing. The reverberation range prediction software will be further improved if integrated with a correlation measurement system, and the range estimation process can become largely automatic.

ACKNOWLEDGEMENTS We would like to thank Paul Connelly and everybody else working on the CETASEL project for providing the raw data and Chris Sturtivant for his help with the group identifications.

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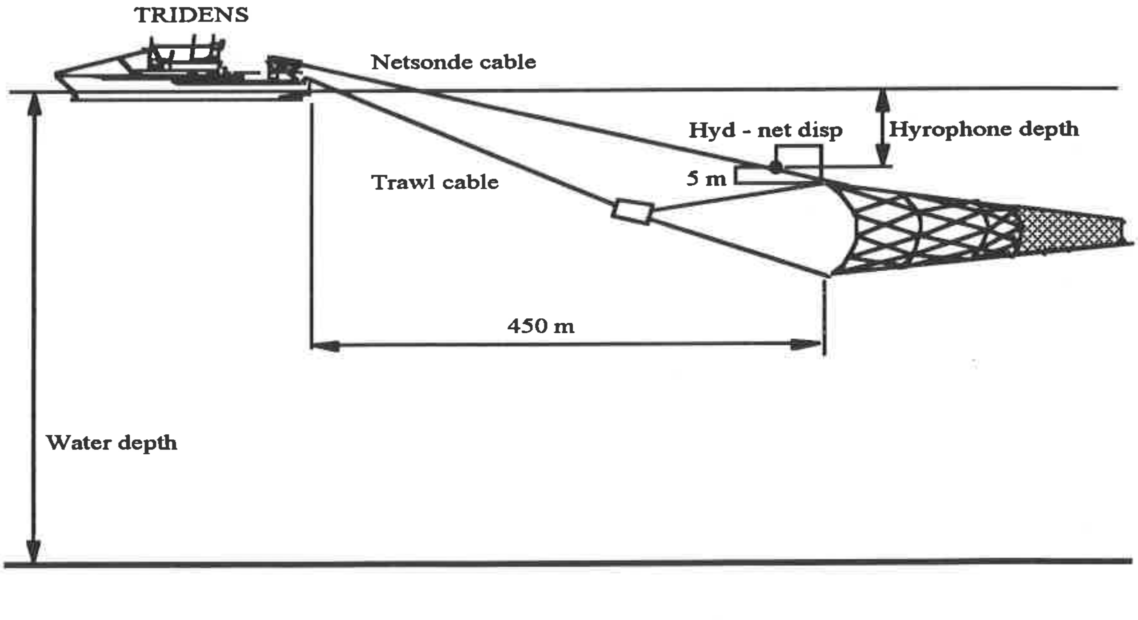

Fig. 1 Trial setup for the CETASEL trials showing the position of the hydrophone

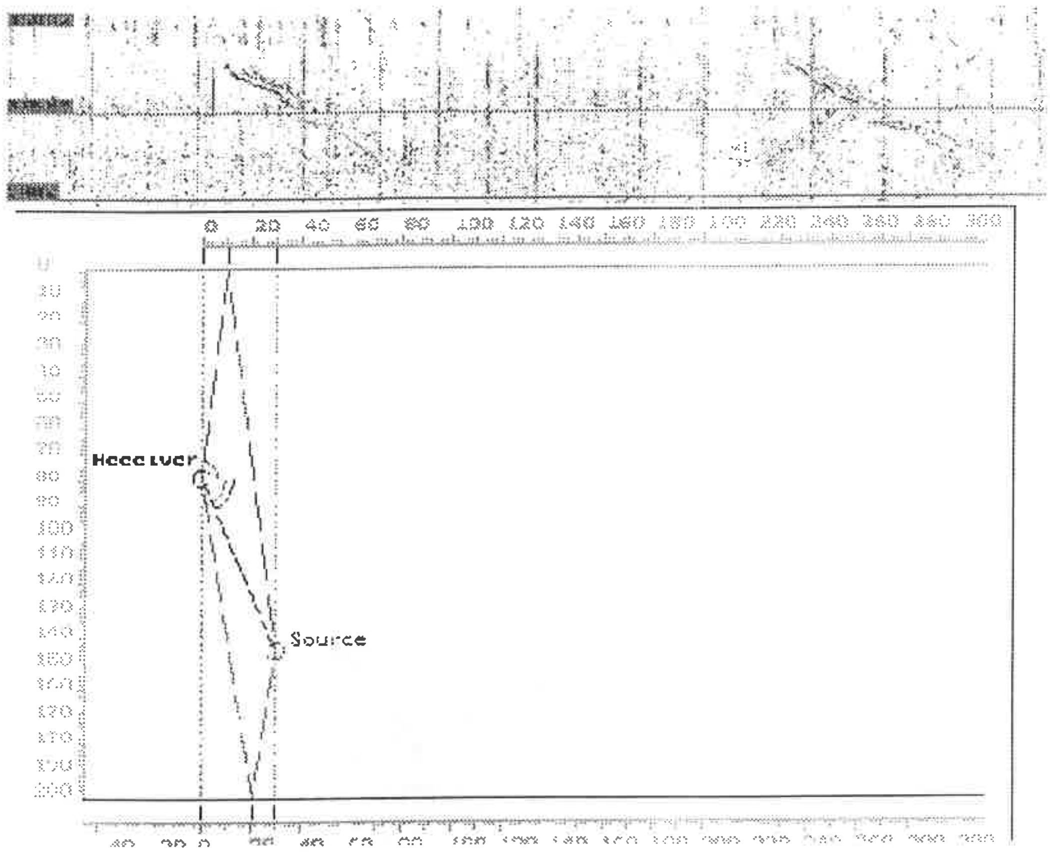

Fig. 2 Reverberation software showing the resulting position for measured time delays of the reverberations that can be seen in the spectrogram above (71 ms and 101 ms time delays suggest a distance of 41 m from the hydrophone at a depth of 143 m)

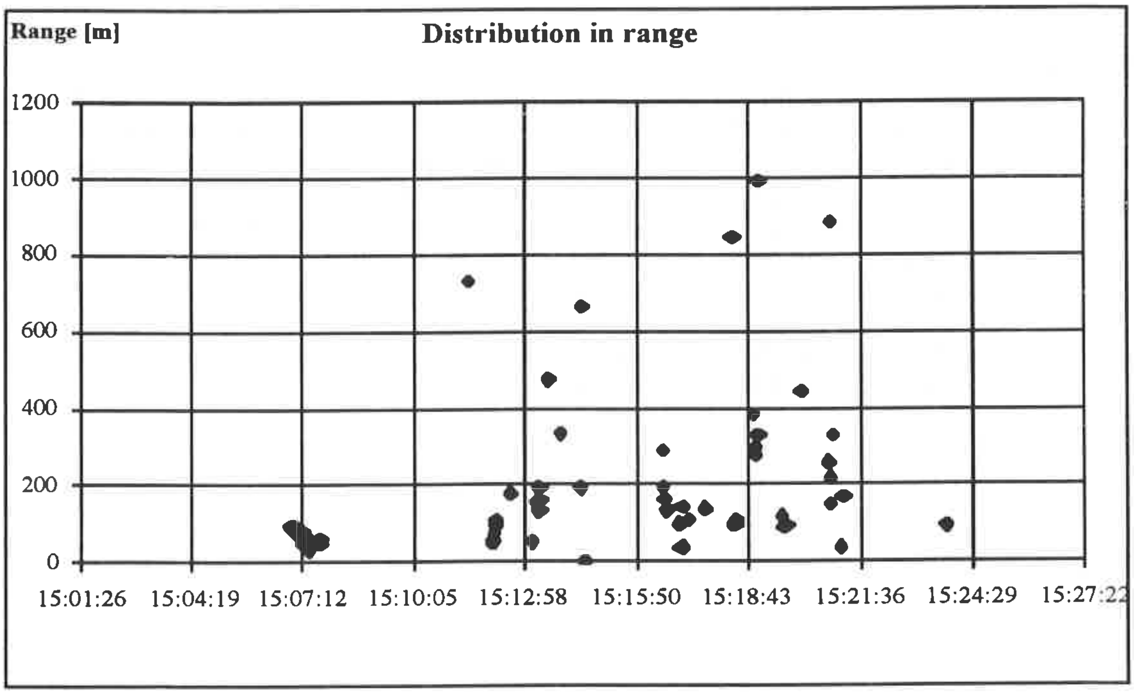

Fig. 3 Distribution in range for 27 min. of analysed data, that was recorded on the 10.10.96. Each symbol represents an animal vocalising at that specific range.

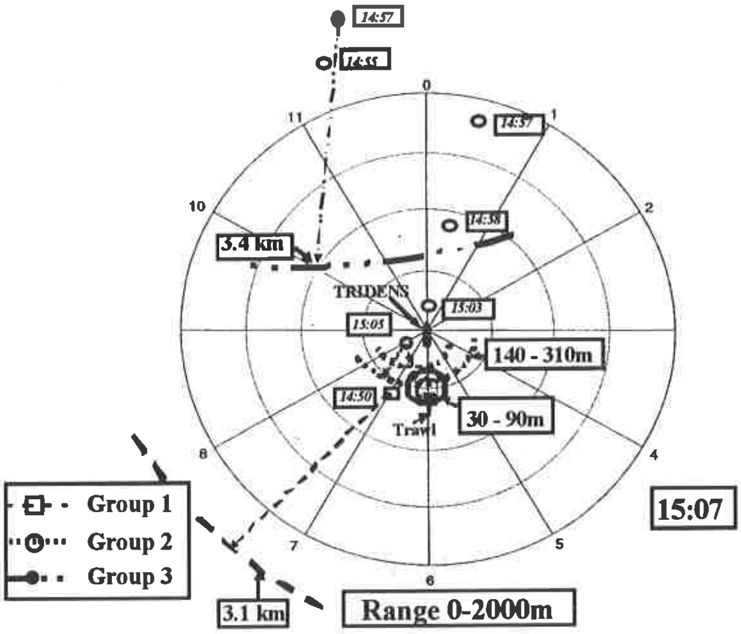

Fig. 4 Visualisation of group movements at 15:07. This example illustrates how the range estimates based on the multipaths signals (solid circles around the hydrophone attached to the trawl gear) can be used to further clearify group movements. The different symbols represent the various sightings of different groups, the semicircles show the respective possible positions for each group at 15:07 (distances are refering to the position of the last sighting and were calculated assuming a constant swimming speed and direction for the animals and taking the ship's movement into consideration). As demonstrated in this figure there was only one group (Group 2) in the area at this particular point in time which possibly could have produced those multipaths signals.

PERSONAL SPACE AND THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*): OPTIMISING PASSIVE DETERRENT DEVICE SPACINGS FOR FISHING NETS

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We observed the harbour porpoise's reactions to nine vertical-line structures with the distance between vertical lines ranging from 0.7 to 2.0 m. Behaviour was significantly affected by the distance between the vertical lines ($X^2 = 599.4$, df = 8, $p < 0.0001$). The porpoise rarely swam between lines positioned less than 0.7-0.8 m apart. These results, which represent a habituated behaviour, may help in the design of reflecting structures that may be attached to fishing nets to reduce the incidental catch of this species.

INTRODUCTION The problem of the unacceptably high mortality of small cetaceans in gillnet is internationally recognised, and acoustic methods of reducing entanglement have been reported (Hatakeyama *et al.*, 1994; Goodson *et al.*, 1994a,b; Au & Jones, 1991). As discussed in Goodson *et al.* (1994a), one approach to the problem has been to investigate efficient ways of making nets more detectable to the animal's echolocation sense. Goodson *et al.* (1994b) suggest that, to be effective, any devices added to the gillnet mesh zone must return strong echoes directly back towards the source. In addition, the minimum distribution of discrete echo-enhancing devices across the face of the net must be perceived by a small cetacean as an impenetrable barrier. Our objectives were to study a captive harbour porpoise's reactions to a reflector enhanced barrier constructed with thin vertical supporting lines in the water column, and to determine the maximum spacing between these vertical lines that would deter a porpoise from swimming through this structure.

MATERIALS AND METHODS We conducted the study in a pool (depth: 2.5 m, length: 23 m, width: 9 m) at the Otaru Aquarium in Japan. The porpoise's size is 1.6 m and 55 kg. Air-chambered, hard-plastic P20 floats of the type used by Goodson and Mayo (1995), were used as acoustic reflectors. These reflectors were attached, with their long axis vertical, at 0.5 m intervals to supporting vertical lines (Fig. 1). Each barrier structure, comprised a series of these reflecting lines spaced apart by the selected interval chosen for the test. The barrier was then placed across the middle of the pool to obstruct the frequented swimming path of the porpoise. We observed the porpoise's reaction to nine of these vertical-line structures with the spacing between vertical lines ranging from 0.7 to 2.0 m. Each experimental barrier was then tested for about one hour.

We recorded the porpoise's behaviour through the window of the pool using an 8 mm video camera and these pictures were subsequently analysed for details of the porpoise's behaviour. The porpoise's reaction to these vertical line barriers was divided into two behaviours: i) penetrating through the structure and swimming the normal unobstructed route around the whole pool; or ii) turning to avoid the lines and swimming in the restricted half size area (Fig.1).

RESULTS The porpoise's reaction to the experimental barriers, when faced with different spacings between the vertical lines, is shown in Fig. 2. When there was no test barrier in the pool, the porpoise habitually swam through the centre of the pool at a rate of 4.0 N/min. When the spacing between the vertical lines was 1.0-2.0 m apart, the porpoise's penetration rate was 1.75-3.23 (N/min).

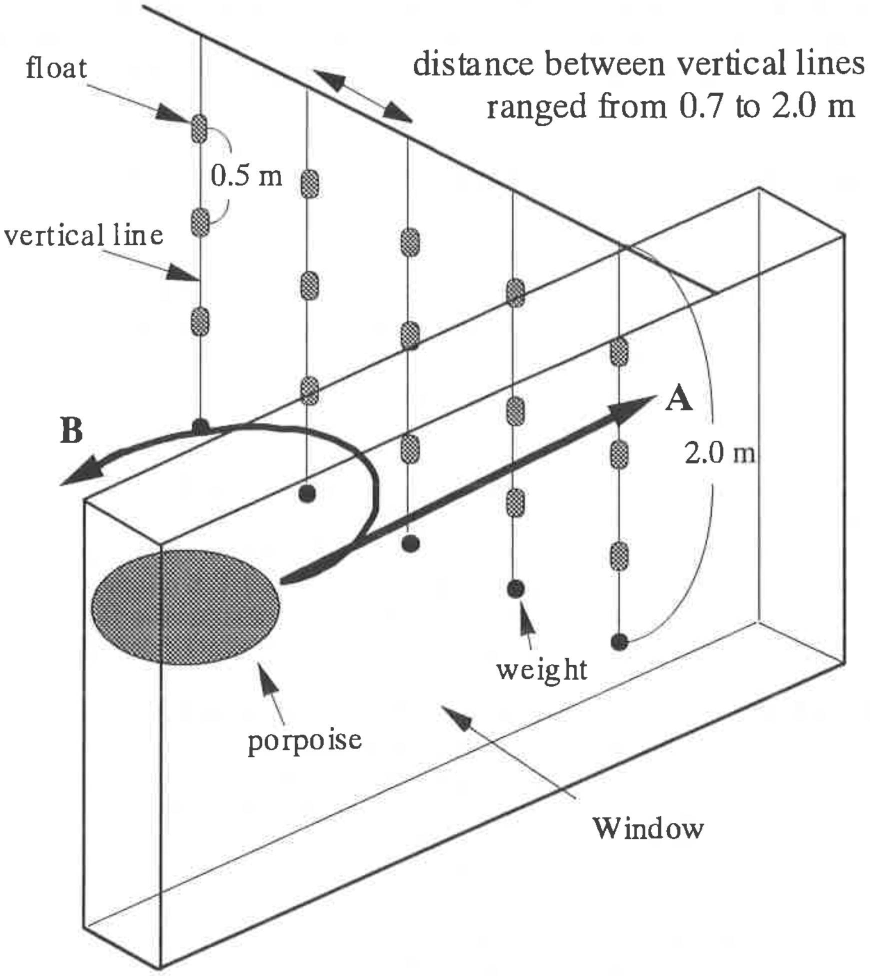

Fig. 1. Diagram of vertical-line structure with attached floats and weights, and the two observed swimming behaviours: A) swimming through the lines, and B) turning to avoid the lines.

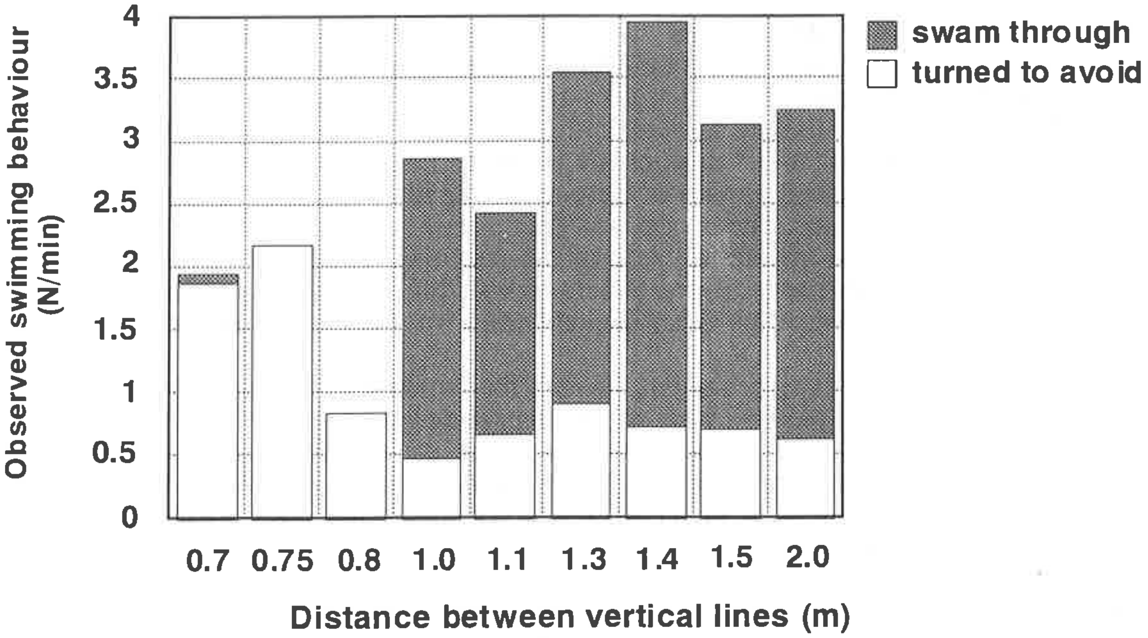

Fig. 2. Porpoise's reaction to experimental structures with different distances between vertical lines. Swimming behaviour was significantly affected by changes in the distance between vertical lines ($X^2 = 559.4$, df = 8, $p < 0.0001$). The observation period for each net was 60 minutes, except for the 0.75-m net (55 minutes) and the 1.1-m net (45 minutes).

When the spacing interval between the vertical lines was reduced to 0.7-0.8 m apart, the number of turns to avoid the barrier was much greater than the number of penetrations. In addition, the approaching rate decreased when the lines were positioned 0.7-0.8 m apart. In two of the tests, (0.8 m and 1.1 m spacings), the porpoise's body was seen to touch a part of the barrier line structure. After this experience, the porpoise appeared to avoid the experimental structure during the remaining part of the session. These results indicate that the porpoise's behaviour was significantly affected by the distance between the vertical lines ($X^2 = 599.4$, df = 8, $p < 0.0001$).

CONCLUSIONS Silber *et al.* (1994) in a clifftop study quantified wild harbour porpoise's reactions to vertical line barriers constructed with various materials and configurations suspended from a floating headrope. However, their deployment method was restricted to two spacing intervals (1.5 and 3.0 m apart using 6.32 mm diameter polypropylene line) so they were unable to examine the effect of the separation distance between the vertical lines. We examined a range of spacings below 1.5 m apart, and showed that the porpoise rarely swam through barriers constructed with lines of reflectors positioned less than 0.7-0.8 m apart. Our results, which represent a habituated behaviour, are intended to help improve the design of deterrent structures needed to reduce the incidental mortality of porpoises in gillnets.

However, this initial study was conducted under light conditions, and eyesight may be a contributing factor. Further studies are needed which will examine the porpoise's sonar behaviour to such vertical reflector enhanced line structures under low light and turbid conditions before we can directly apply these data to a modified gillnet.

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BEACON MODE DETERRENTS FOR GILLNETS

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INTRODUCTION The marking of bottom-set gill-nets to reduce the accidental by-catch of the harbour porpoise (*Phocoena phocoena*) can be considered in a variety of ways. These range from the non-intrusive passive echo enhancement of the acoustically 'invisible' mesh zones to the use of very high power sound sources, similar to those being deployed at many aquaculture sites to reduce seal predation.

Very low power acoustic 'beacons' have the potential to reduce by-catch but such devices need to be used in quite large numbers if they are to guide small cetaceans away from a gill-net along its length. The first and second generation of simple (empirically designed) cw 'pinger' devices have been tested in the USA with encouraging results, (Kraus *et al.*, 1995) although concerns about the long-term effectiveness of such an approach are being expressed, as porpoises are expected to habituate to their presence with time.

A new generation of low power acoustic beacons has been developed at Loughborough which transmit acoustic deterrent signals carefully optimised for the harbour porpoise. These operate with improved electro-acoustic efficiency and have a long operating life. These beacons produce multiple signal waveforms, similar to those which were shown to generate a good avoidance response in the harbour porpoise at low sound pressure levels (Kastelein *et al.*, 1997). An 'interactive-mode' device has also been developed, initially for a pelagic trawl application, which is triggered into activity by the sound of an approaching echolocating animal. A recent field test with wild harbour porpoises in Scotland, confirmed the effectiveness of the beacon-only device and its activation produced an immediate behaviour change in the porpoises' swimming behaviour and a sustained displacement during the test period to a distance some 640 m away from the signal source (Fig. 1). As the digital technology employed in these beacon devices is programmable, a number of desirable features intended to minimise habituation have been incorporated.

DESCRIPTION The beacon mode deterrent developed at Loughborough University employs a 'smart card' type 8-bit micro-controller to synthesise the output waveforms (Fig.2). The device activates automatically when totally immersed in water and has no external contacts to corrode or catch in the net. It operates from one alkaline 'D' cell battery, and in a battery life test has already exceeded 200 days continuous operation. In practice, this operational life is expected to approach or exceed a year in most commercial fisheries as the life relates to the actual soak times of the fishing gear.

The peak Source Level ($\cong$ 150 dB re 1 μPa at 1m) remains constant throughout the life of the device but when the battery voltage falls below a preset threshold the electronics produces a modified output and this distinctive change can be recognised on a ship's echo sounder. This 'Low Battery' condition signal continues to act as an aversive sound to porpoises until the actual failure point is reached. To reduce 'habituation' effects, these devices transmit eight (or more) different signal outputs with a pseudo-random time interval between the sound pulses. The varying intervals between the pulses are maintained between selected limits to ensure that a porpoise swimming at its maximum speed cannot reach the fishing net without hearing several emissions. The complete device is encapsulated in tough polyurethane and is formed in a 15 cm long by 4 cm diameter cylinder (Fig. 3). For maximum reliability, these devices have been 'potted solid' and the battery in this experimental version is not changeable.

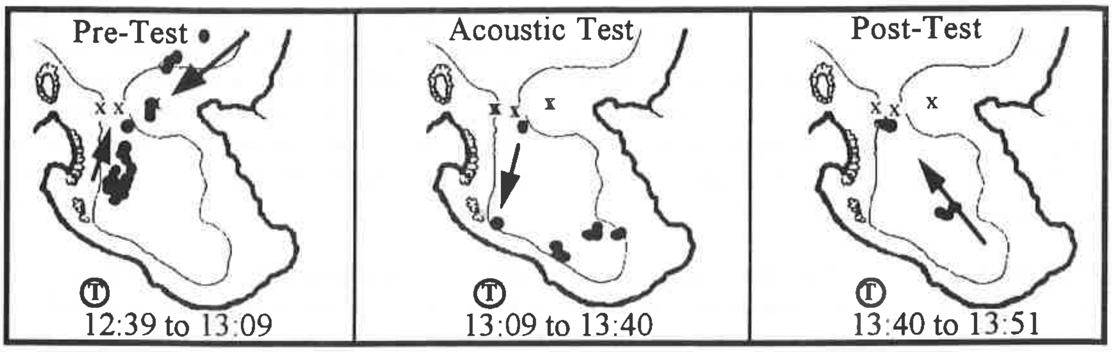

Fig 1 Sea Loch Test - Surfacing positions of two porpoises responding to the activation of three beacon mode pingers. The animals immediately reversed their swimming direction and reappeared over 640 m away and remained at this range for the 30 minutes duration of the test. The porpoises departed rapidly as soon as the beacon signals were removed. 'X' marks the 3 pinger positions, 'T' theodolite survey position, the 10 m depth contour has been plotted for reference.

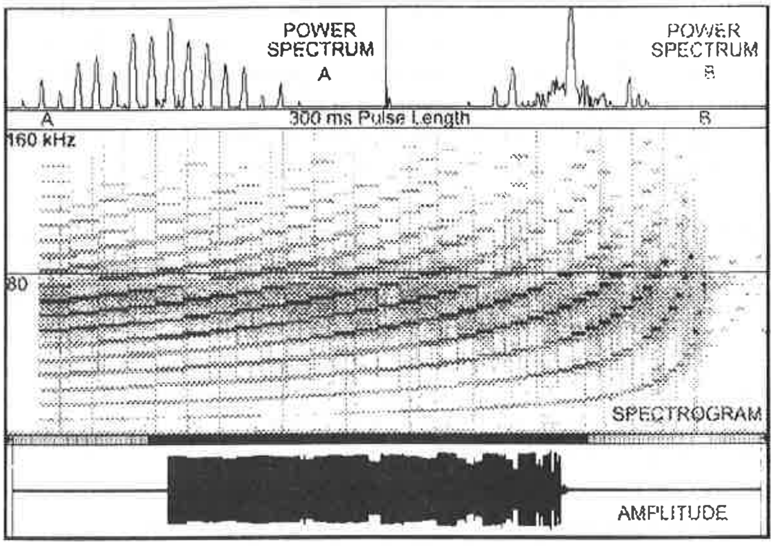

Fig 2 Example wave-form and spectrum - Frequency Sweep 20 kHz to 160 kHz - 300 ms pulse length

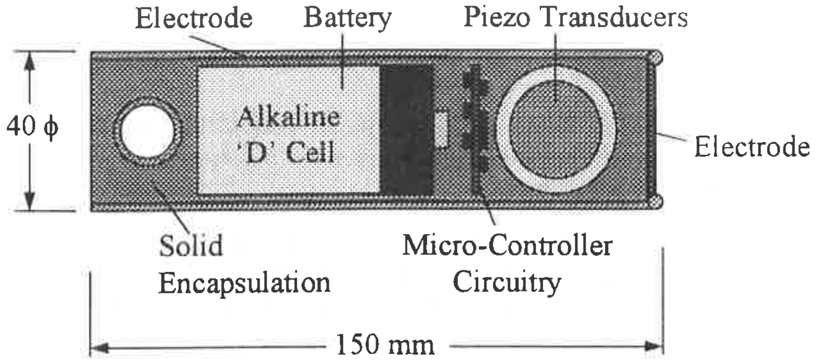

Fig. 3 Construction of a long-life programmable acoustic beacon

Prototypes of an 'interactive' version of these alarms have also been developed. In this case, the beacon signals are acoustically triggered by the approach of an echolocating animal. These devices remain silent until triggered - which will minimise acoustic 'pollution' of the environment and more significantly reduce any 'dinner bell' effect for pinnipeds - but clearly solitary non-echolocating animals may remain at risk, so the possibility of emitting a 'beacon mode' ping at much longer intervals as a 'wake up' stimulus remains an option.

RESULTS The first successful field tests with wild harbour porpoises (*Phocoena phocoena*) took place in calm conditions in a quiet Scottish sea loch in September 1996. Figure 2 shows the spectrum of one of the two beacon mode sounds used in this study - a frequency modulated 'sweep' lasting approximately 300 ms extending from 20 kHz to 160 kHz. Theodolite tracking data from that trial demonstrated that the porpoises were promptly displaced away from an initial position 100 m from the nearest sound source until they were constrained by the shoreline of the bay, after which their surfacings maintained a minimum displacement of 640 m from the sound sources while these remained active. At this range, the Sound Pressure Level (SPL) has fallen significantly and the sound levels experienced by the porpoise were probably less than 88 dB re 1μPa. Since this SPL represents an 'aversive' threshold to these specific signals, some adjustment of the transmitted power can be considered as there is a trade off between the numbers of devices, the spacing along the fishing net needed to be effective, and the acoustic power. More tests of this type are planned to try to quantify this aversive threshold in terms of a sound pressure level for each type of sound signal presented. This parameter is important when planning deployment on commercial fishing nets as it allows the size of the intended 'porpoise-free zone to be estimated.

CONCLUSIONS This new generation of digital beacon deterrent devices was designed to solve several problems which were recognised in earlier studies, including the need to maximise battery life, achieve an optimum displacement effect on harbour porpoises, and to minimise the rate of habituation etc. The target species was the harbour porpoise (*Phocoena phocoena*) and the intended application currently limited to commercial bottom-set gill-nets. A large scale field study in such a commercial fishery is now being planned for the autumn of 1997. Although it is too early to predict benefits in other cetacean by-catch situations, the digital micro-controller technology in this design allows considerable flexibility. Alternative applications can be considered in future as different signal characteristics can be synthesised by upgrading the software and can be tested relatively easily without changing the hardware design.

ACKNOWLEDGEMENTS This work has been supported by the UK Ministry of Agriculture, Fisheries and Food, the UK Department of the Environment, the European Commission (DG XIV), and the Danish Institute for Fisheries Research.

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PASSIVE ACOUSTIC INVESTIGATIONS OF HARBOUR PORPOISES ON FISHING GROUNDS

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INTRODUCTION The bycatch of harbour porpoises (*Phocoena phocoena*), mainly in bottom set gill nets, is widely considered to be one of the most acute threats facing this species. This is a conservation problem, in that, in most cases where adequate studies have been conducted into fisheries with a significant by-catch, the local porpoise populations do not seem to be able to withstand the levels of mortality revealed. It seems likely that fisheries interactions have led to substantial population depletion in many areas. By-catch is also a serious animal welfare issue. It is difficult to think of a more horrible way for a diving mammal to meet its end.

Although the extent of by-catches is now beginning to be appreciated, thanks largely to a number of observer schemes, we understand very little about how and why by-catches happen. This lack of understanding hinders attempts to alleviate the problem.

Some research teams are beginning to address some of the sensory and behavioural questions related to by-catch using captive animals in aquaria (for example, see the volume edited by Nachtigall *et al.*, 1995), or experiments conducted in inshore waters (for example, Koschinski and Culik, 1997). These are yielding useful insights, but such confined and controlled locations are very different from the offshore fishing grounds and deep waters in which by-catches actually occur, and it is important to discover whether findings from these studies apply in real fishing conditions. There are many practical and logistical problems inherent in studying a small, shy, diving animal like the porpoise, in inhospitable offshore waters. The work described here is an attempt to assess the feasibility of investigating porpoise distributions and behaviour on the offshore fishing grounds of the Celtic Shelf using passive acoustic monitoring techniques.

The extent and size of the by-catch on the Celtic Shelf has been documented by Tregenza *et al.* (1997). Their estimate of annual porpoise mortality for the English and Irish hake fishery was 2,200. (This estimate did not include any contribution from several other fishing fleets and classes of vessel which are also likely to have a porpoise by-catch in this area) Comparing this figure with the population estimate of 36,000, for the Celtic Sea from the SCANS survey (Hammond *et al.*, 1995) indicates that this annual by-catch accounts for at least 6% of the population, far in excess of the 2% value widely accepted as unacceptable.

METHODS Fieldwork was made possible by the goodwill of Cornish gill netting fishermen based in Newlyn, and we are very grateful for the co-operation that they showed us. Surveys were conducted during August and September 1996 using "Song of the Whale", a 46 ft ketch owned and run as a research vessel by the International Fund for Animal Welfare. While "Song of the Whale" was at sea, the LOGGER data-logging program was run continuously; this collected information on the vesselfs location every 2.5 minutes and on weather conditions every hour. Changes in survey effort were entered as and when they occurred. Porpoises were detected using automated acoustic detection equipment (Chappell *et al.*, 1996), and data from this were collected by a second computer.

Fig. 1 shows the vessel's tracks and the location of all acoustic detections with porpoises. The vertical line indicates our demarcation between "offshore" and "inshore"/Scilly Isles waters. The analysis presented here is based only on the offshore data. Porpoise density was higher in the inshore waters, especially around the Scilly Isles and clearly gill netting should be discouraged here.

At the end of the field season, data files from the porpoise detector were analysed, allowing "acoustic encounters" with porpoises to be identified. It was assumed that, as the boat was moving quickly in comparison to typical porpoise swimming speeds, and detections were quite sparse, each of these acoustic encounters was with a different group of porpoises. Previous work (Chappell *et al.*, 1996) had shown that porpoises are detected acoustically within between 200 and 400 m of the vessel. After the field work was completed, computer files, were merged so that for each 2.5 min. section of logged time, the acoustic effort status and number of detentions were combined with values for environmental factors such as wind speed and sea state.

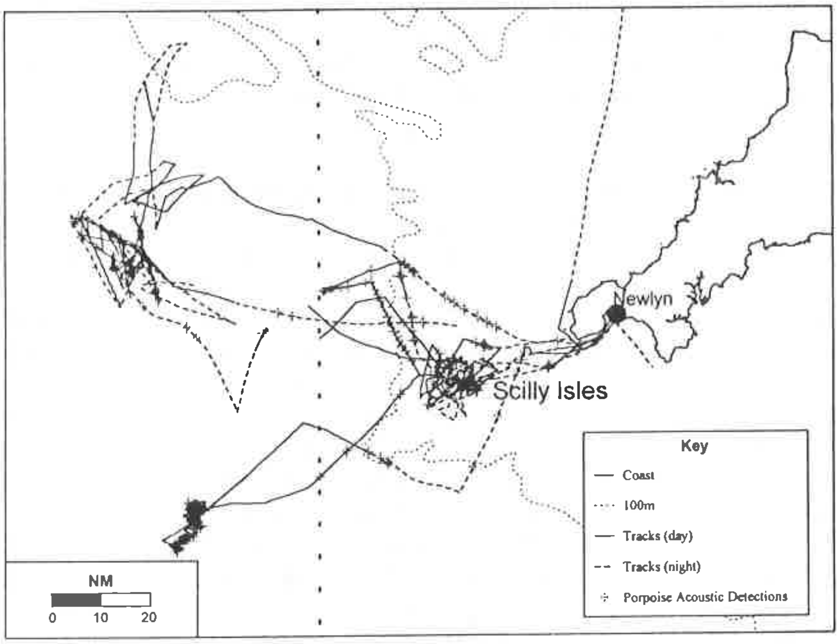

Fig. 1 Vessel tracks and acoustic detections of porpoises on Celtic Shelf. Vertical line at 7°W indicates demarcation between onshore and offshore waters

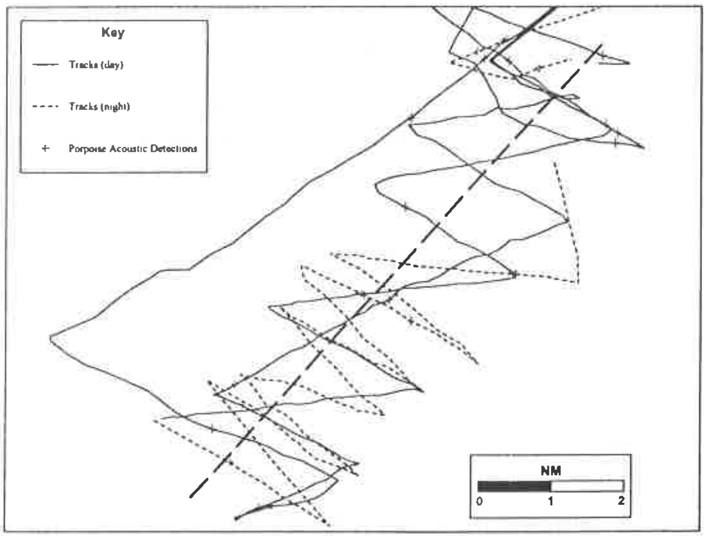

Fig. 2 Example of "zig-zag" survey within a mile of set gill net. Dotted line indicates assumed net location based on position of set provided by fishermen

The Cornish gillnet fleet is not able to set fish in the stronger currents that run during spring tides, and they thus work alternate weeks. The "Song of the Whale" research team usually worked around the Scilly Isles during non-fishing weeks, and would co-ordinate with fishermen to rendezvous with them on the fishing grounds some 100-150 miles offshore at the beginning of fishing weeks.

It was intended to address a number of different questions relevant to understanding the process of by catch. It has been suggested that porpoises are attracted to set nets, and to test this, we examined how the distribution of porpoises varies with range from set nets on a scale of less than a mile. After nets had been set, the location of the beginning and end of each string of nets was given to us by fishermen, and we assumed that the nets extended in a straight line between these two positions. The research vessel then sailed a zig-zag course within a corridor extending out to a mile either side of the assumed net position (Fig. 2). During later analysis, the range of the midpoint of each 2.5 minute effort segment from the assumed net position was calculated so that detection rates could be investigated as a function of range from the net. To investigate whether porpoise abundance on fishing grounds was higher or lower than in other areas it was first necessary to determine the locations of the fishing grounds

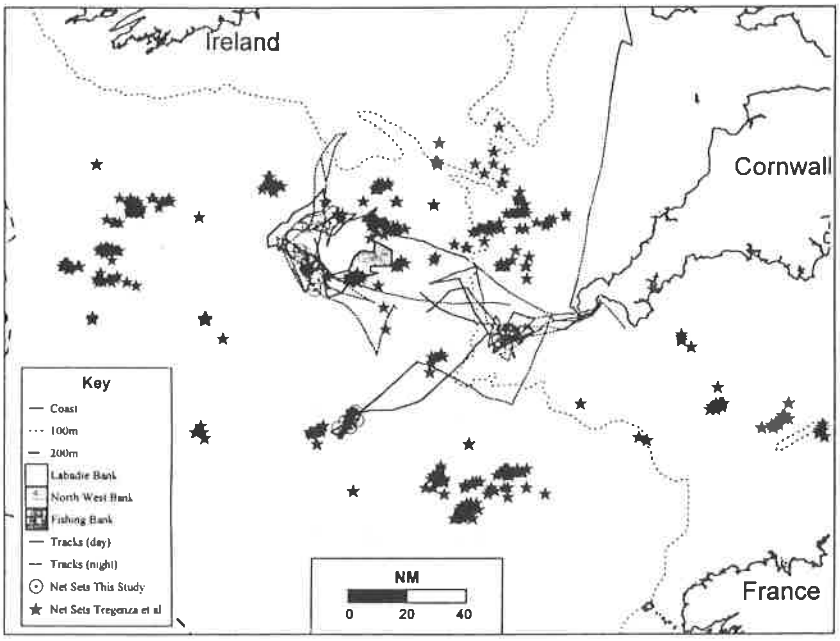

Fig. 3 Locations of all net sets from Tregenza *et al.*, 1997 and observations made during this study. Fishing banks plotted on nautical charts are also indicated

Although fishermen often spoke about going to particular banks which were marked on nautical charts to fish, our experience, and an examination of fishing locations recorded by Tregenza *et al.* (1997) indicated that fishing locations were quite dispersed and did not coincide well with the banks shown on navigational charts. Consequently, it was decided to take the actual positions of all net sets recorded by Tregenza *et al.* (1997) and from this study, as indications of the preferred fishing areas, and calculate the range from the closest of these fishing gear locations for each effort segment. In this way, porpoise detection rate at different ranges from fishing areas could be compared. The locations of these net sets is shown in Fig. 3.

RESULTS Analysis of these data is ongoing, and consequently results and discussion will only be presented here in a general manner.

There was evidence of a significant diurnal variation in detection rate, with rates being low during the morning, between 9 am and 12 am approximately.

There were no significant differences in detection rates with fine scale (<1nm) range from nets, providing no support for the hypothesis that porpoises are attracted towards them. There were also no significant differences in detection rates with range from known fishing locations, indicating that preferred fishing grounds do not seem to be areas of significantly higher or lower porpoise densities.

DISCUSSION This was a short-term, small-scale study intended primarily as a pilot project, and its main value has been in investigating techniques and working practices. The porpoise detection equipment functioned well. It proved practical to collect data with it working continuously day and night, from a modest vessel, in often poor weather conditions, and to work offshore in collaboration with fishermen without impeding their work.

Passive acoustic techniques thus offer a promising way of collecting information on distribution and behaviour of porpoises in offshore waters. This should lead to a better understanding of the by-catch process and could help to shape management strategies for alleviating this problem. However, it is also evident that much of the other data that are needed for such investigations have not been collected. Fine scale information on the distribution of fishing effort would be relatively easy to collect but it is not recorded and there seem to be no plans to do this. Attempts to relate porpoise abundance to physical features such as bottom type, which might allow the location of high density areas to be predicted, will also be hampered because the information that is available has not yet been prepared in a computer-readable format.

ACKNOWLEDGEMENTS This research would have been impossible without the goodwill and co-operation of the Cornish Fish Producers and Cornish gill net fishermen from Newlyn. We are grateful to them for all their help and friendship, both ashore and at sea. We are also greatly indebted to Nick Tregenza for helping us in Newlyn, for providing access to some of his data, and for many useful insights.

This work was funded by the International Fund for Animal Welfare. We acknowledge the hard work and dedication the crew of "Song of the Whale".

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HOW TO DETER HARBOUR PORPOISES (*PHOCOENA PHOCOENA*): BEHAVIOURAL INVESTIGATIONS USING A THEODOLITE

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By-catch of harbour porpoises (*Phocoena phocoena*) occurs throughout their range. Past experiments with modified nets (with reflectors or pingers to enhance detectability) often did not achieve statistically significant bycatch reduction due to small sample sizes. Behavioural data obtained by theodolite tracking of harbour porpoises using inoffensive experimental "nets" readily produce larger sample sizes. Three different device types (two types of reflectors and a pinger) mounted on a floatline were tested for their potential bycatch reduction. For this purpose, behavioural response (avoidance and closest approach) of porpoises to these devices were compared to a control (floatline without devices).

A total of 335 sightings (distributed in almost equal proportions for all treatments) were recorded; 92.4% of porpoise groups avoided the pinger equipped floatline whereas only about half of the groups avoided the other stimuli (reflectors: 48.6% and 58.9%; control: 51.8%). This difference was significant.

Closest observed approach distances were 34 m (SD = 32.9) for the control, 33 m (SD = 31) and 30 m (SD = 28.9) for the reflectors and 133 m (SD = 67.7) for the pingers, the difference between pingers and all the other stimuli being significant.

Since porpoise density in the area did not decrease after permanent use of pingers for six days, there is no indication for long term avoidance of the area.

CAUSES OF MORTALITY AND SUSPECTED BY-CATCHES BY GROSS POST-MORTEM EXAMINATION OF CETACEAN STRANDINGS ON THE GALICIAN COAST (NW SPAIN)

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INTRODUCTION Interactions between cetaceans and fisheries in Galician waters have not been studied in detail, but these interactions must occur very often because cetaceans feed on commercially fished species and cetacean populations frequent fishing areas. The aim of this study is to determine the influence of fisheries upon cetacean mortality rates, and the percentage of stranded cetaceans which are the result of by-catch.

MATERIALS AND METHODS The recording of strandings in Galicia is made by the CEMMA network that includes expert personnel, public institutions, collaborators, and a coastal survey scheme. Additionally, non-systematic contacts are made with fishermen to detect by-catches. Almost all the strandings are identified and examined by trained expert personnel. The following signs upon the cetacean body are appraised as signs of fishing interactions: mutilations of the body, cuts, ropes around the tail, and net marks.

RESULTS 856 strandings and catches were recorded in Galicia from 1990 to 1996. A total of 11 odontocete species and 3 mysticete species were recorded. The most commonly stranded species (49%) is the common dolphin (*Delphinus delphis*). In 182 cetaceans, the following by-catch signs were confirmed. The percentage of affected individual for species is given in Figure 1, and recording areas on Galician coast in Figure 2.

1- Fluke or lobes missing totally or partially: 83 animals. 29% of them were not considered as by-catch because the decomposition and/or terrestrial carnivore action on the carcass prevented confirmation that their tails had been cut. Even so, this is the most significant sign of by-catch because 59 confirmed cases make up 39% of the total (see Figs. 1, 3, and 5). One stranded common dolphin without a tail was found still alive. Five species are involved: 40 common dolphin, 7 bottlenose dolphin (*Tursiops truncatus*), 2 harbour porpoise (*Phocoena phocoena*), 8 Risso's dolphin (*Grampus griseus*), and 2 long-finned pilot whale (*Globicephala melas*).

2- Cuts in the body: 39 cetaceans with important cuts made with sharp objects. There is suspicion from gross post-mortem examination that these cuts were the causes of death in some cases. Four species are involved: 30 common dolphin, 2 bottlenose dolphin, 5 harbour porpoise, and 2 striped dolphin (*Stenella coeruleoalba*).

3- Confirmed catches: 16 cetacean catches were confirmed. All of them were incidental entanglements in nets during fishing activities. Five species are involved: 9 common dolphin, 3 bottlenose dolphin, 2 harbour porpoise, 1 long-finned pilot whale, and 1 minke whale (*Balaenoptera acutorostrata*).

4- Back missing: A total of 20 cetaceans were used for food and some of them were sold at fishing markets (see Fig. 4). Only ten are considered as bycatch because in seven cases, back extraction indicated they were stranded animals (1 Risso´s dolphin, 1 striped dolphin, 4 common dolphin and 1 harbour porpoise) and three cases involved animals included in confirmed catches (2 common dolphin and 1 harbour porpoise). One species is involved in fish markets: 10 common dolphin.

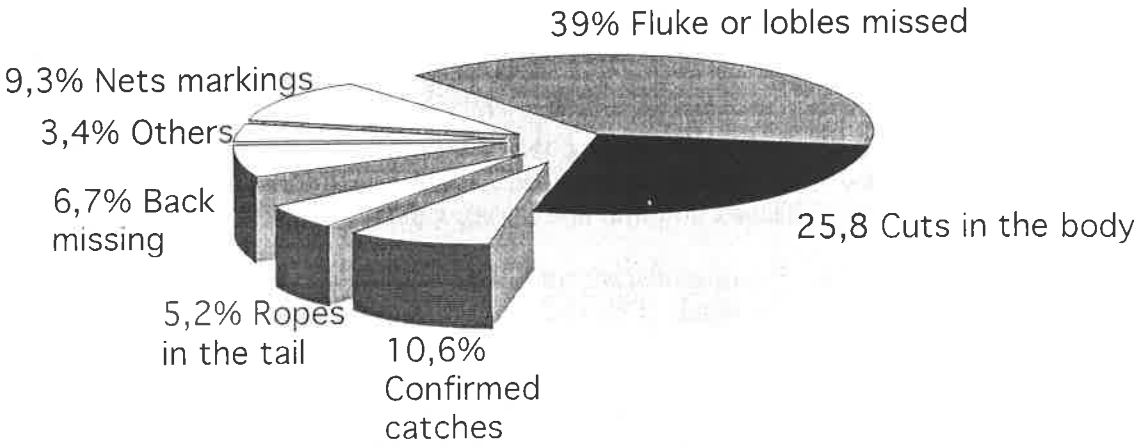

Fig. 1 Percentage of affected individuals by species

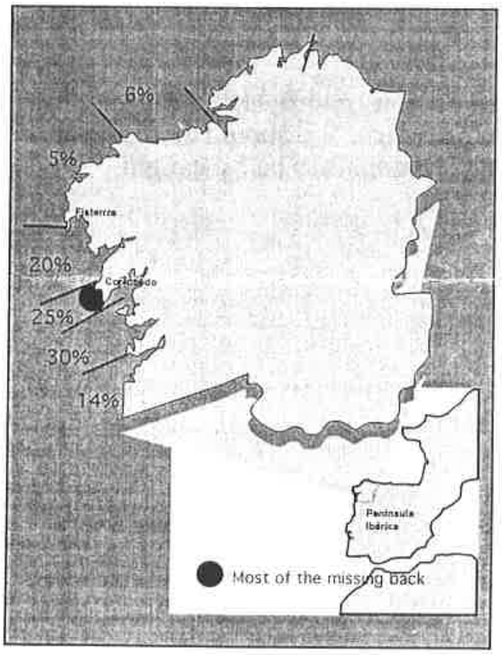

Fig. 2 Areas of Recording on the Galician coast

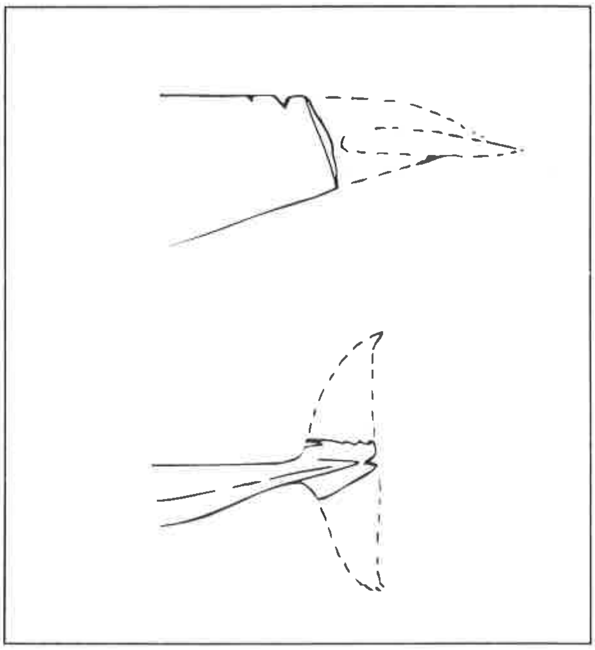

Fig. 3 Fluke or lobes missing

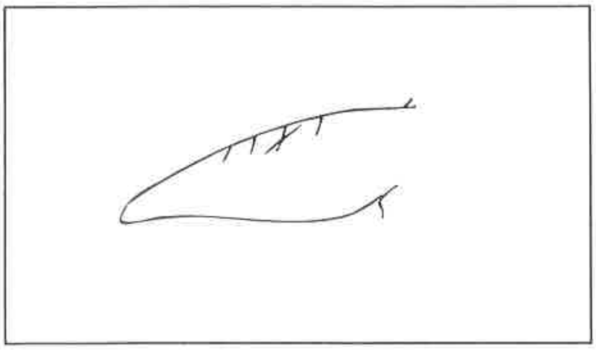

Fig. 4 Example of net marks upon the flipper

5- Net marks: 14 cetaceans had net marks on head flippers (see Fig. 4). Only fresh animals are considered. Two species are involved: 11 common dolphin, and 3 harbour porpoise.

6- Ropes: 8 cetaceans had ropes around the tail. Some of them had unspecific marks, possibly net marks. Five species are involved: 3 common dolphin, 1 bottlenose dolphin, 1 harbour porpoise, 1 Risso's dolphin, and 2 long-finned pilot whale.

7- Others: Shooting: 3 common dolphins. Direct killing of one common dolphin. Propellor damage: 1 sperm whale (*Physeter macrocephalus*).

CONCLUSIONS According to these results, at least 21.7% of strandings recorded in Galicia are a consequence of fishing interactions with cetacean populations. Furthermore, this percentage is probably much higher due to:

1.- Bycatch signs are difficult to recognise in carcasses in an advanced stage of decomposition.

2.- An indeterminate number of bodies do not end up on the coast. However, many natural deaths will also not result in strandings.

The most important interaction between cetacean populations and fisheries detected by CEMMA must occur in areas where coastal fisheries take place. We should also consider that disease or behavioural abnormalities may pre-dispose animals to be by-caught.

EVIDENCE OF DOLPHIN BEHAVIOUR FROM DRIFTNET BY-CATCHES IN THE UK ALBACORE TUNA FISHERY

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MATERIALS AND METHODS Observers were placed on UK boats in the North-east Atlantic albacore tuna drift net fishery to assess cetacean by-catch.

RESULTS Nine trips were observed. Boats set 2.5 km long mono-filament nylon drift nets. The nets were 120 meshes deep with 180 mm stretched mesh length, giving a working depth of about 15m. Nets were set each evening and hauled the following morning. Sixty-two nets set caught 29 striped dolphins (*Stenella coeruleoalba*), and 17 common dolphins (*Delphinus delphis*).

The 46 dolphins caught were in 21 of the 62 hauls. Eleven hauls contained more than one dolphin and four nets caught four or more dolphins. The distribution of by-catches per haul is fitted well by a negative binomial distribution.

A north/south trend was evident with common dolphin by-catches being mainly north of 48° 30'N and striped dolphin by-catches being entirely south of 49°N. Only one net caught both species.

Body temperatures of 28 animals (recorded using a piercing thermometer) ranged from 19.3° C to 30.2° C. Water temperatures were close to 18° C. The two coolest dolphins were in the same net, and five of the six warmest were in two nets. In two nets there were dolphins with markedly disparate temperatures.

Nearly 40% of the dolphins in the eleven nets that caught more than one dolphin were more than 200 m from the nearest other dead dolphin , and in some cases they were one km or more apart.

Captures of individual dolphins are clearly clumped, but the capture of groups, at the scale 'sampled' by the net, may be distributed more randomly. If so, the most probable distribution giving captures in 21 of 62 hauls would be of 26 groups, distributed as follows:

Dolphin groups per haul	0	1	2	3
Expected number of hauls	40.8	17.1	3.6	0.5

Thus, only four hauls caught more than one group. This compares favourably with the observed data.

The vertical distribution of by-catch was recorded. One-third of entanglements involved the headline, another third were in the top third of the net, and only one animal was assessed as being entangled in the bottom third of the net. None was entangled with the foot-rope. Dolphins were never seen leaping over nets.

Seven by-catches were close to major irregularities caused by twisting or tearing of the net. One particularly large section of torn net hung well out of the line of the net and had dolphins entangled, not in it, but in the net beside it, twice in one trip. This finding has not been reported from other studies and no method was in place for quantifying net irregularity, but such major irregularities were considered to be few in number.

By-catches were more frequent in sea states greater than Beaufort 4 and showed a significant correlation with minimum sea state prevailing during the net soak.

DISCUSSION Three pieces of evidence suggest that groups of dolphins encounter nets and lose more than one member: the clumped distribution of by-catch in nets; the sharp segregation of species in the nets; and the temperature distribution of by-caught dolphins which suggests that multiple by-catches mostly have a similar cooling time after death.

It might be expected that animals from the same school would be close to eachother in the net, perhaps no further apart than the normal spacing of a school. However, 40% were spaced over 200 m apart. One explanation of the grouping of by-catches near major net irregularities is that dolphins may swim along the weak acoustic image of a regular net, but when this becomes irregular they become confused or classify the net differently and may then turn into it. The lower by-catch rate in calm seas may be a result of the acoustic screening of the net by bubbles that is known to occur in rougher seas, perhaps augmented by the acoustic image from a moving net being confused with small fish. Taken with the vertical distribution of entanglement, this suggests that these dolphins tend to be close to the surface when they encounter nets, that they have some difficulty in recognising the net, and that they then swim along the net remaining near the surface, but losing further members of the group, especially at sites of net irregularity.

The study is not conclusive but if the findings were supported by further observation the implications would be: lowering the head line by 5 m might have a major effect on by-catch; gaps in the net ('dolphin doors') may have some capacity to reduce those by-catches that arise when dolphins have started to swim along the net; and a small reduction in by-catch might be obtained through careful net handling and repair practices by fishermen to avoid major irregularities in the net as it hangs in the water.

Unfortunately an IFREMER research project on the effect of lowering the headline below the surface in the French tuna driftnet fishery was aborted by the fishermen who felt that it was reducing their albacore catch significantly (Loic Antoine, *pers. comm.*). A study of the effectiveness of 'dolphin doors' organised by UK fishermen in 1996 has not reported any numbers because 'the fishery was too small and too poor' in that year (Cornish Fish Producers Organisation, *pers. comm.*).

ATTRACTION OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) TO BOATS SETTING GILLNETS

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MATERIALS AND METHODS Volunteer observers spent 328 days at sea with Irish and English hake netters. Records were made of cetacean bycatch, sightings and behaviour, and of environmental and operational variables.

RESULTS The nets observed were mainly hake nets, which have floats on the headline and a leaded footrope weighing 15 or 23 kg per 220 m. The stretched mesh diagonal was 100-150 mm. Most net is 30 meshes deep and is set on average for 20 hours. The depths of nets set are shown in Figure 1.

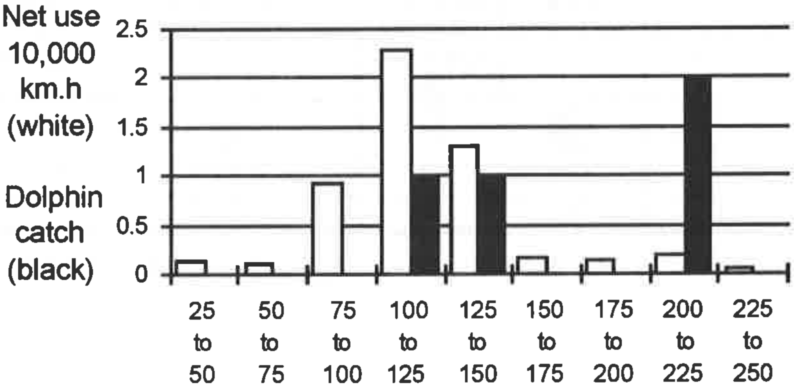

Fig. 1 Sea depths (m) in which nets were set and by-catches occurred

Common dolphin (*Delphinus delphis*) sightings (Table 1) were much more frequent from September to March with a peak in November and December (χ^2 test, $p < 0.001$). This seasonal pattern was evident even though sea states were lower in summer. In summer, dolphin groups also stayed around boats for shorter periods. Mean stay in minutes and 95% confidence limits for each quarter were: Dec-Feb, 19 (9-29); Mar-May, 18 (9-27); Jun-Aug, 4 (1-7); Sep-Nov, 32 (17-47).

A total of 123 groups of common dolphins with a mean group size of 9.4 (SE = 1.1) were recorded from UK boats and 85% of these groups were first seen within 50 m of the boat. Eighty-seven percent of groups approached the boat, and half of these engaged in bow-riding at some point.

During the shooting of nets, dolphin groups arrived significantly more frequently than during other activities ($p < 0.05$) (Table 2). This observation could not be explained by other operational or environmental variables recorded, such as boat speed, daylight, or sea state. Four common dolphin catches occurred between 20.10.93 and 20.1.94, giving a by-catch rate of 1.4 dolphins per 1,000 km of net set.

Table 1 Dolphin sightings per month from UK boats in the Celtic Sea

MONTH	DAYLIGHT HOURS AT SEA	MEAN NUMBER OF GROUPS PER 10 HRS
JAN	179	0.9
FEB	319	0.3
MAR	422	0.4
APR	181	0
MAY	77	0.1
JUNE	258	0
JLY	340	0
AUG	309	0.2
SEP	280	0.3
OCT	208	0.6
NOV	194	1.1
DEC	9	1.1

Table 2 Dolphin groups seen arriving during main boat activities in daylight

BOAT ACTIVITY	TYPICAL SPEED RANGE NM / H	HOURS OBSERVED	DOLPHIN GROUPS ARRIVING (*N*)	DOLPHIN GROUPS ARRIVING / 10 HR	PROBABILITY OF GETTING *N* OR GREATER (POISSON)
Hauling net	0 - 2	866	29	0.33	0.62
Patrolling	2 - 4	892	27	0.30	0.80
Shooting net	4 - 8	177	13	0.73	0.01*
In Transit	8 - 10	780	26	0.33	0.62

Over 90% of time for each activity was within the speed range shown.

DISCUSSION

Mechanism of common dolphin by-catch Three pieces of circumstantial evidence suggest that common dolphins become entangled while the net is being shot or hauled, rather than while it is set on the bottom. One of the four common dolphins was alive when the net was hauled, indicating capture during or just before hauling. This contrasts with none alive out of 46 dolphins in a recent study of tuna drift nets (SMRU, 1995), and one alive out of 43 porpoise by-catches observe in this study (Tregenza *et al.*, 1997).

In two of the three by-catch events, common dolphins had been seen around the boat either during or within 15 minutes of the shooting of the net in which a by-catch occurred. The observation of common dolphins being attracted to boats and of playing around nets makes it possible that by-catches can occur with disproportionate frequency during the relatively short period of shooting and hauling. This contrasts with harbour porpoises which showed no detectable attraction to boats.

Mitigation of common dolphin by-catch Fishermen remarked that 'dolphins appear just when you don't want them to', that is, after shooting of the nets has started. A pause in this process cannot take place to wait for them to go away as the boat is liable to drift and wrap the net around the propeller.

A possible explanation for dolphin attraction during shooting is the loud rhythmical tonal clatter of the headline floats striking the steel hoop which is used to spread the net at the stern of the boat. This possibility was indirectly supported on two occasions when deliberate hammering on the boat's hull appeared quickly to attract distant common dolphins at a range of up to 800 m.

If further study confirmed that ‘float clatter’ is a significant factor in attracting dolphins to boats during net shooting, it could be reduced by installing a ‘skirt’ in front of the net hoop. The floats would strike this at a lower angle of incidence and slither over it, making less noise and suffering less impact damage. This may be a case in which by-catch mitigation could directly benefit all parties.

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BY-CATCH AND OTHER CAUSES OF MORTALITY IN CETACEANS STRANDED ON THE COASTS OF ENGLAND AND WALES IN 1990-1996

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Cetaceans in Europe are exposed to a number of potential threats, including: entanglement in fishing gear (by-catch), prey depletion, pollution and disease. Between August 1990 and December 1996, necropsies were conducted on 515 cetacean carcasses of 13 species, stranded around the coasts of England and Wales. These comprised 284 harbour porpoises (*Phocoena phocoena*), 166 common dolphins (*Delphinus delphis*) and 65 individuals of 11 other cetacean species.

A diagnosis of cause of death was made in 77% of all necropsies. Of the cases in which cause of death was established, by-catch was diagnosed in 94 (43%) harbour porpoises, 103 (80%) common dolphins, and eight (17%) individuals of other species. The proportion of common dolphin necropsies where by-catch was diagnosed was consistently high, except during 1995, but the proportion of by-caught harbour porpoises increased throughout the period of study. Physical trauma was diagnosed as the cause of death in a further 40 animals, including 26 (12%) harbour porpoises.

Neonatal starvation, pneumonias and generalised infections accounted for a further 59 (27%) of the diagnosed causes of death in harbour porpoises. Live-stranded harbour porpoises tended to be seriously diseased, whereas, live strandings of other species were often healthy.

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INCIDENTAL CATCHES AND STRANDINGS OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA* LINNAEUS 1758) IN THE COASTAL WATERS OF ANGELN AND SCHWANSEN, SCHLESWIG-HOLSTEIN, GERMANY, FROM 1987 TO 1996

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INTRODUCTION The unintentional capture of German harbour porpoises was referred to by Alfred Brehm in 1877. Furthermore, Schultz (1970) mentioned the accidental capture of harbour porpoises in fishing nets and, at the same time, he pointed out a reduction of the population without establishing a causal connection. Gaskin (1984) saw a threat to the world-wide population of harbour porpoises in the use of gill-nets made of nylon monofilament, but could not obtain any exact figures for the Baltic Sea, especially for German waters.

The growing concern about the diminishing population of harbour porpoises in both the North and Baltic Seas led to the international meeting in Bremerhaven, which was being held in June 1986 at the Alfred-Wegener-Institut under the title "the harbour porpoises in the Baltic and North Sea". At this occasion, Schulze was the only attendee to present data from by-catches, sightings and strandings of harbour porpoises in German waters. He did this for the waters belonging to the former German Democratic Republic (GDR), summarising data which has been collected by the Meeresmuseum Stralsund since 1946. One of the first surveys investigating cetaceans in German waters (including harbour porpoises), was conducted by Kremer and Schulze (1990).

Since 1990, two projects with government support have been initiated; their target was to gather information on population figures, health and migratory patterns, as well as monitoring of small cetaceans in German waters. Various papers have been published documenting the results of these research projects (Kock & Benke, 1995; Benke *et al.*, 1996). Although there are a stock size estimates for harbour porpoises in the Western Baltic Sea, which have been gained through aerial surveys and the SCANS project in 1994, it could not determined whether the number of harbour porpoises in this stock were diminishing, or not. This current paper supplements and updates information on harbour porpoise by-catches documented by Benke *et al.* (1991) for the Western Baltic Sea.

MATERIALS AND METHODS Between 1987 and 1996, harbour porpoise by-catches have been monitored and documented for a limited area of the Western Baltic Sea. This area extends from the Eckernförder Bucht in the south (54° 27'N) to the Flensburger Förde in the north (54° 53'N) and to the waters of Ärö (10° 30'E) in the east.

Fishing is carried out from the ports of Eckernförde, Damp, Maasholm, Kappeln, Arnis, Schleswig, Gelting, and Langballig by approximately 30 professional fishermen and about 50 part-timers. The respective authorities were advised of all by-catches documented and their circumstances, for example the fishing gear utilised, water depth, location, and weather conditions. The by-caught animals were measured, weighed and photographed immediately if possible.

Since 1994, blood has been taken directly from the ventricle of recently dead animals in order to carry out specific investigations on toxicology and blood chemistry. Afterwards, the harbour porpoises were handed over to the Institut für Haustierkunde, University of Kiel, for further research. Since 1990, stranded animals from between Eckernförder Bucht and Flensburger Förde were also taken into consideration and were integrated into the research study.

RESULTS Between January 1987 and December 1996, there have been 74 by-catches of harbour porpoises reported in the aforementioned research area (see Appendix). In four cases, the entangled animals could be released from the nets alive; in five other cases, the animals were not available for further research due to the fact that their carcasses fell out of the net as it was being hauled in. The size data given for these harbour porpoises are based on fishermen's estimations. In another eleven cases the exact location of the by-catch could not be determined, so the port of discharge was given instead. One harbour porpoise had been discarded in February 1991 but unfortunately the exact date of capture could not be given afterwards. Except for three cases, all the reported animals had been entangled in gill-nets. The first exception was an adult male (22), which had been trapped in a trawl net and showed a large infected wound ventrally. One adult female (27) was captured in a fish basket and another harbour porpoise (29) could successfully be released from a pond net.

From 1990 to 1996 17 harbour porpoises have been washed ashore (see Appendix). Of these, two animals (50 and 87) had recently died, while all others were exhibiting various stages of decomposition. Most of them showed lacerations indicative of fishing net wounds. The number of by-catches varied from year to year, but has clearly diminished during the period of research. The highest number of by-catches was documented for 1987, with 16 harbour porpoises, and the lowest in 1995 with two (Fig. 1). The number of harbour porpoises washed ashore annually appeared to range from two to four, except for 1996 when the number of strandings was even higher than the number of by-catches (Fig. 1).

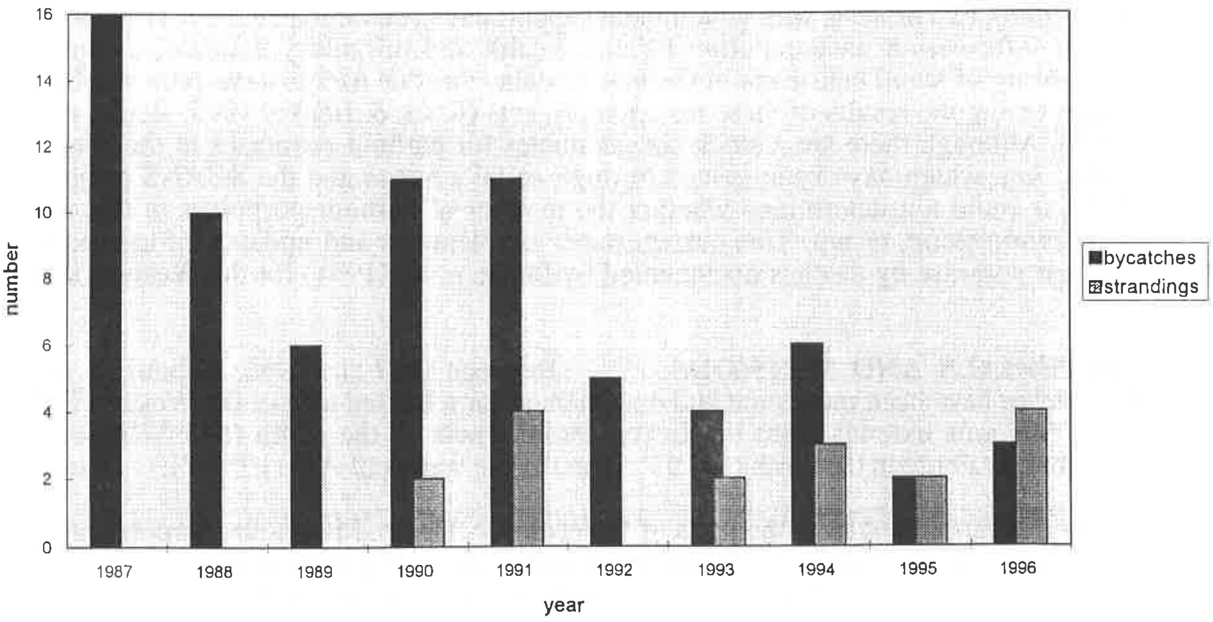

Fig. 1 Number of incidental catches and strandings of harbour porpoises in the years 1987 to 1996

When it comes to seasonal distribution, the number of by-catches differs. Almost 72% of all by-catches occur between August and November, coinciding with the cod fishing season (Fig. 2). The majority of strandings are also reported during the second half of the year, although, in July, the number of strandings is higher than the number of by-catches.

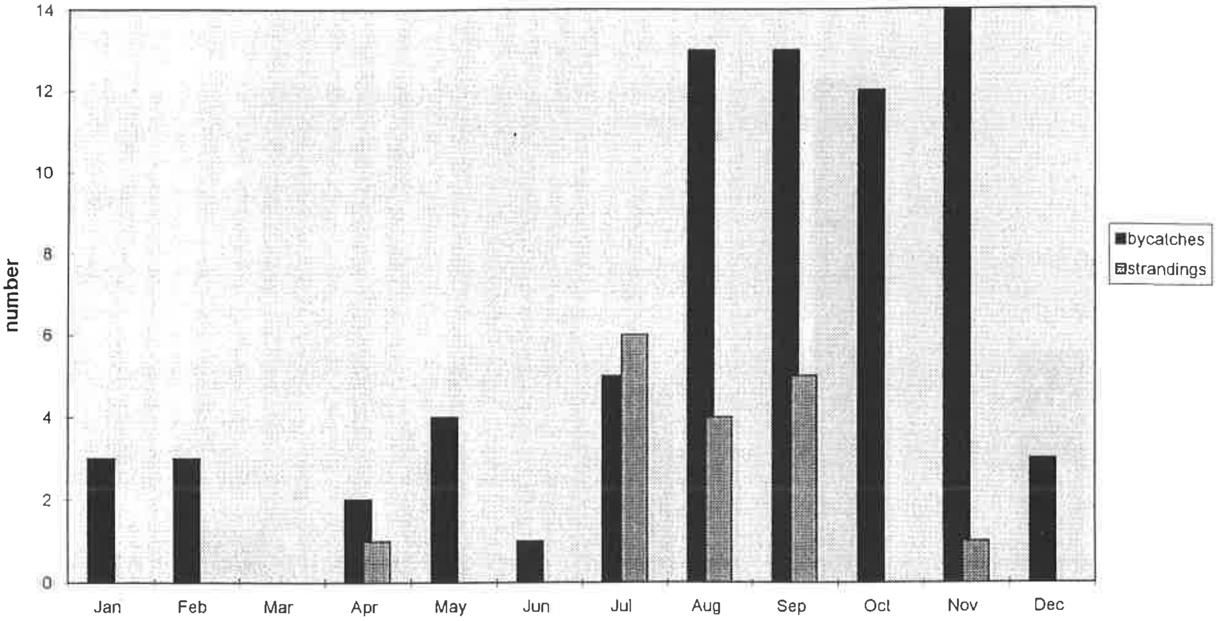

Fig. 2 Number of incidental catches and strandings of harbour porpoises in the different months from 1987 to 1996

In order to be consistent with the information presented previously by Benke *et al.* (1991), the animals were split into five weight categories and four size categories. This division showed that most of the sampled animals were of a weight less than 35 kg and a length less than 135 cm (Figs. 3 & 4) - which implies that mainly sub-adults swim into the nets. Considering the sex ratio, there is a slight predominance (54%) of males when compared with females (46%) (Fig. 5); however, this is not statistically significant. On the other hand, the fact that out of fifteen stranded animals, thirteen were male and only two were female, seems to be of significance.

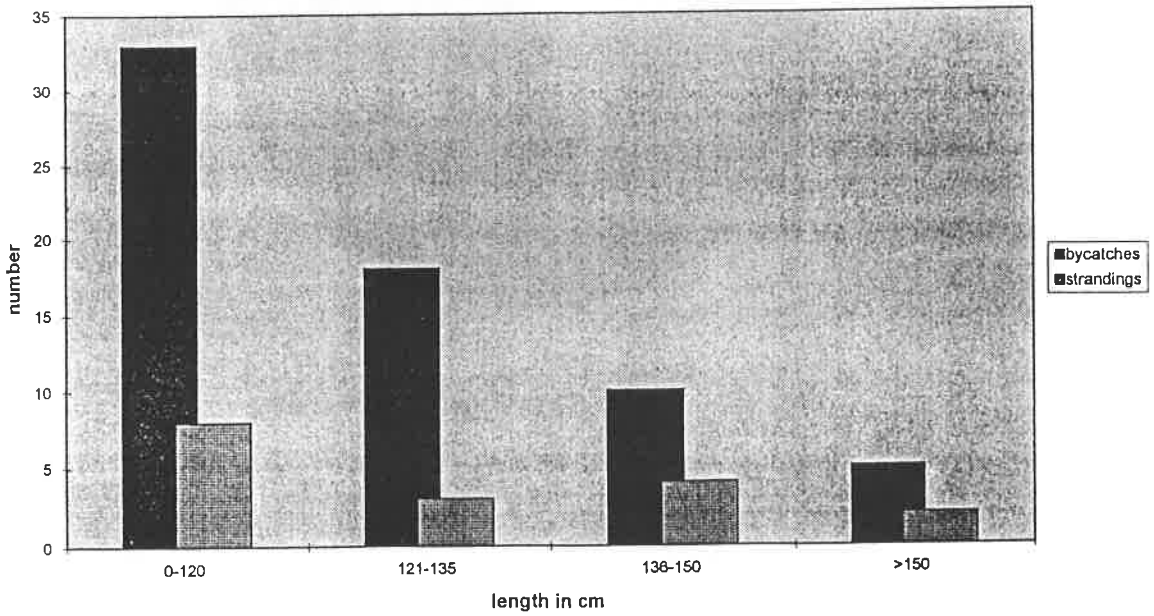

Fig. 3 Length distribution of harbour porpoises

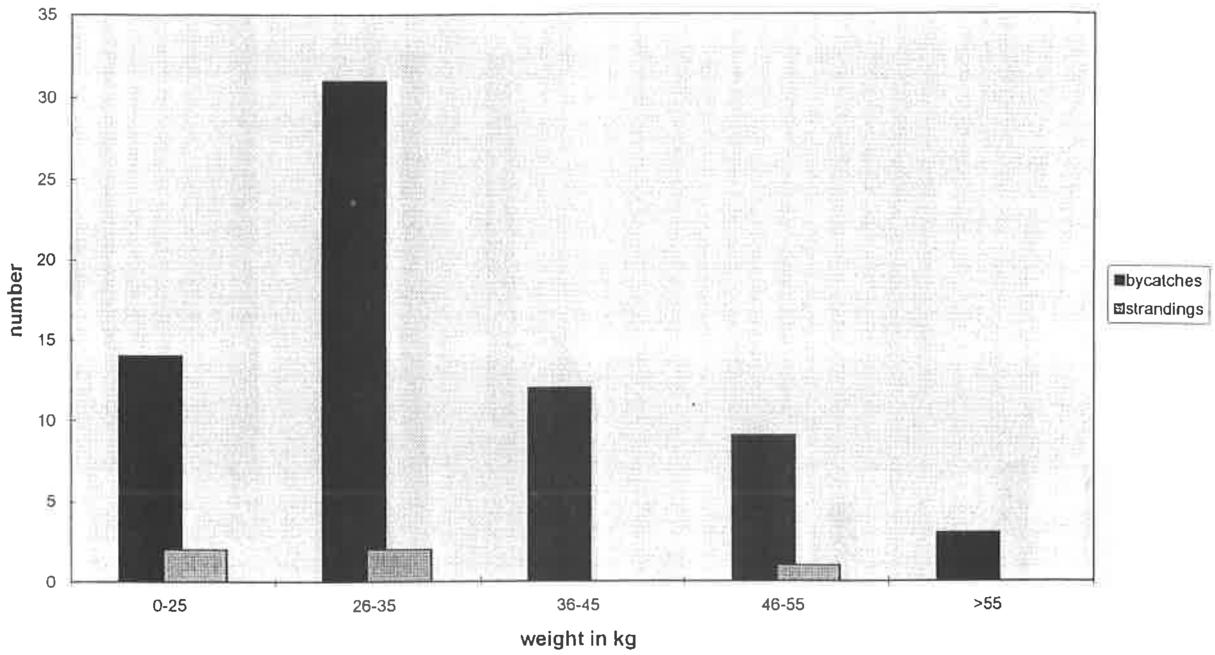

Fig. 4 Weight distribution of harbour porpoises

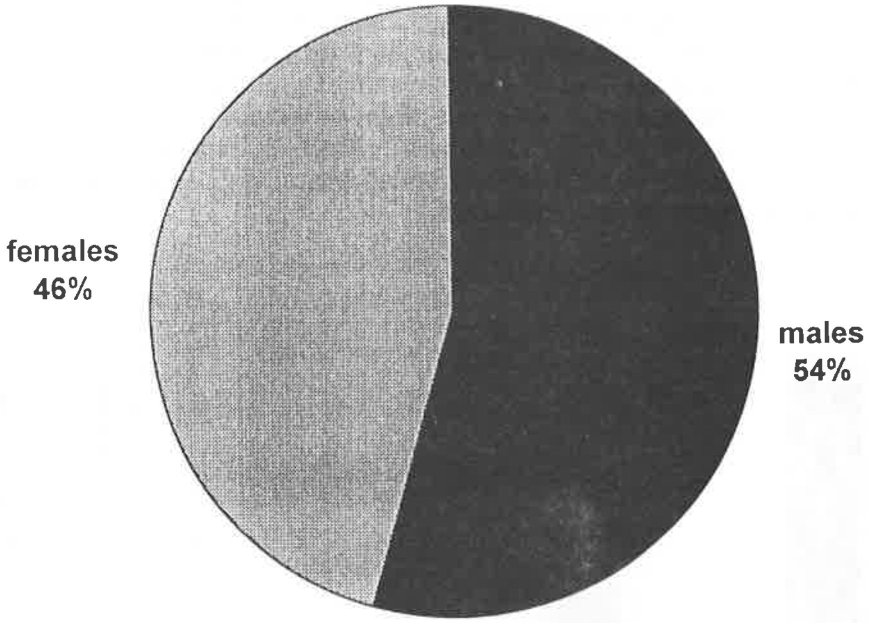

Fig. 5 Sex ratio of harbour porpoises

Gill net fishing is almost exclusively carried out during night-time. The gill nets are set in the evening and retrieved in the morning. An investigation of moon phases showed an extremely high proportion of hauls during nights of the full moon (17%) (Fig. 6), as the previous report by Benke *et al.* (1991) has already suggested. While by-catches during the crescent and convex moon phases were well represented (40%), only 2% of the by-catches occurred on nights with a new moon. The relation of dark nights (34%) to moonlit nights (66%) showed a clear trend for more by-catches on lighter than on dark nights (Fig. 7).

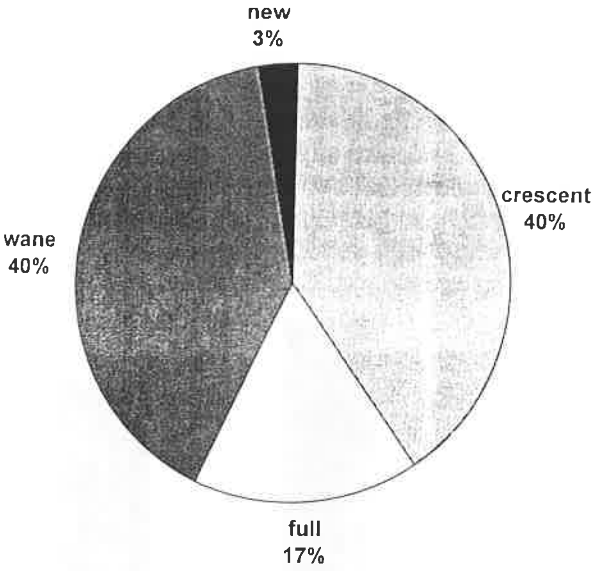

Fig. 6 Catches of harbour porpoises with regard to phases of the moon

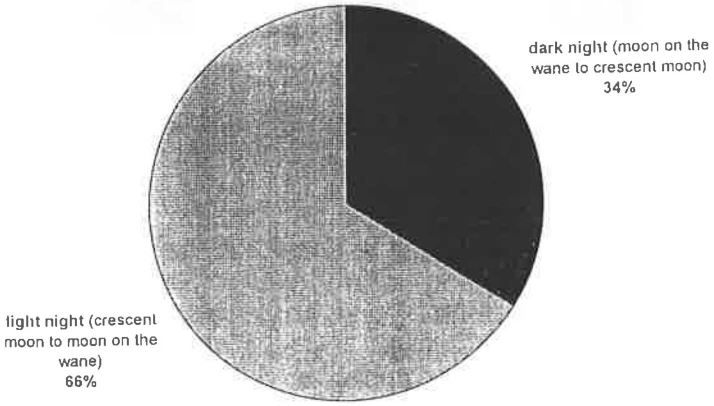

Fig. 7 Bycatches of harbour porpoises with regard to moonlight

DISCUSSION The analysis of over ten years of data on by-catches of harbour porpoises in the Western Baltic Sea have drawn the conclusion that they are intrinsically related to the amount of fishing activity. The first evidence for this are the clear seasonal patterns, the months with the highest number of by-catches being at the height of the cod season. Furthermore, the diminishing number of by-catches is closely related to a reduction in the cod fisheries quotas (Fig. 9). In addition, seasonal migration could be another reason for the reduced number of by-catches between December and March.

Most of the harbour porpoise strandings appeared to be predominantly by-catches which had been discarded. The clearest indication for this were the distinctive skin lacerations found on nearly all of the animals.

The majority (approximately 75%) of the harbour porpoises incidentally caught during fishing operations were juveniles. This has also been noted in other publications. One possible reason for this could be that young animals often swim into the nets, whilst older animals have gained enough experience to know how to avoid getting entangled (Kinze, 1990).

Light plays a important role in harbour porpoises by-catches. There is no other possible explanation for the exceedingly high number of by-catches during the full moon and moonlit nights. However, it is not yet clear how the bright moonlight shows its effect under the water in the depths of 5 to 15 metres that animals are mainly caught (Fig. 8). It is possible that it does have a certain influence on the activities of prey fish. Gaskin (1984) points out that the blinking of the floundering fishes in the nets might attract the animals, or, as Kastelein (1995) suggests from his experience with net experiments, that harbour porpoises are distracted and, therefore, forget about the presence of the net.

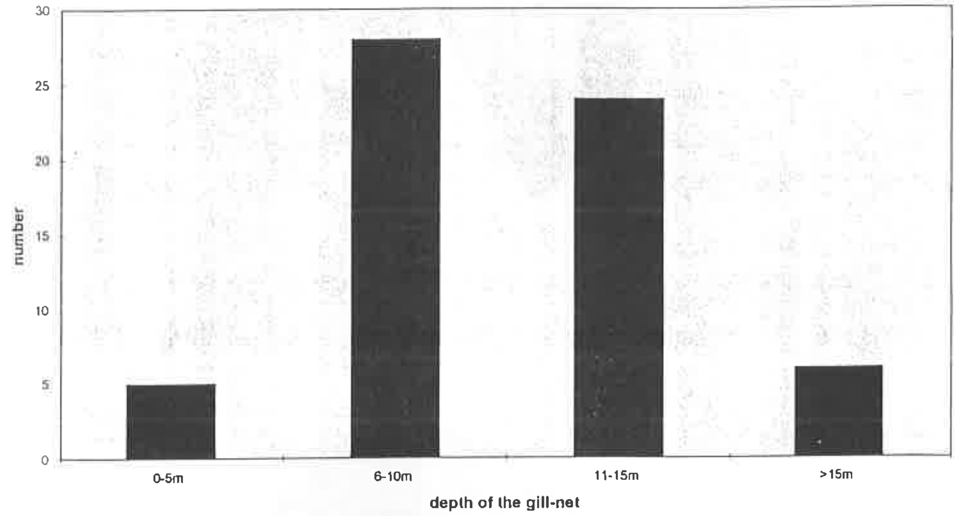

Fig. 8 By-catches of harbour porpoises depending on the depth of the gill-net

From the available data, it is not possible to comment on the population dynamics of harbour porpoises in the research area although the diminishing number of by-catches could be indicative of a reduction in harbour porpoise numbers. The continuation of this present monitoring scheme is merited and, in the future, additional parameters will be taken into consideration, e.g. submergence time of the fishing gear, yield, kinds of fish caught, and seabed topography and substrate. A long-term, accurate, and statistically confirmed analysis of data would enlighten us as to whether harbour porpoise by-catch in the Western Baltic Sea is sustainable or not.

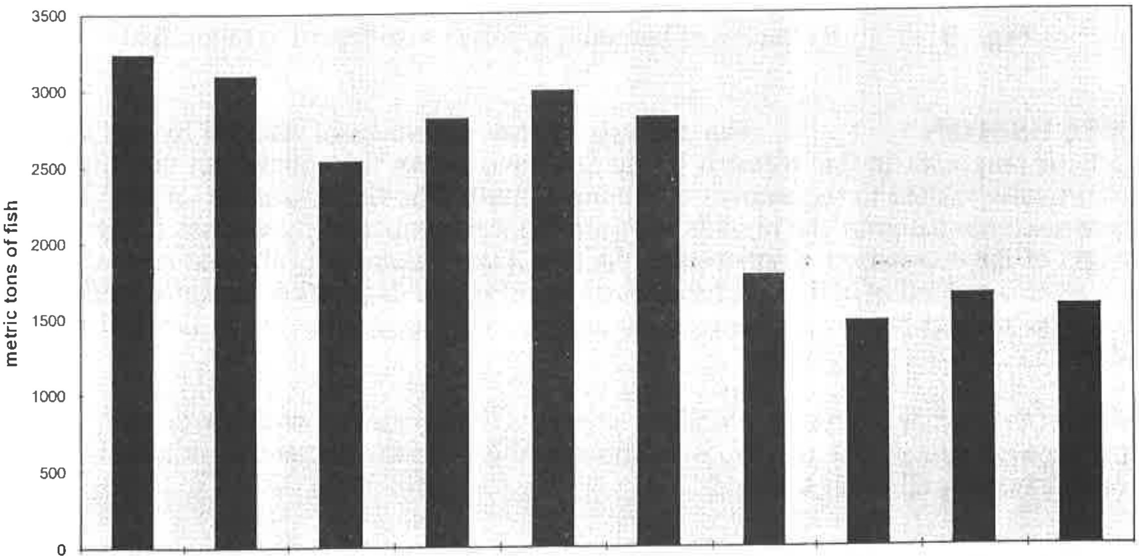

Fig. 9 Fishing activities in the western Baltic from 1987 to 1996

ACKNOWLEDGEMENTS We are grateful to the fishermen in the research area for their co-operation and their useful advice. We also wish to thank the Fishery Association at Maasholm and Kappeln and the Fishery Authority in Kappeln, especially Mr. Grunau. Special thanks are also dedicated to Mrs. Naeve for her patient co-operation and Mrs. Schmidt for the initial translation.

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Incidental catches and strandings of harbour porpoise (*Phocoena phocoena* Linnaeus 1758) in the coastal waters of Angeln and Schwansen (Schleswig-Holstein, FRG) from 1987 to 1996

No.	Date	Length	Weight	Sex	Depth	Location	Lightness	Moon
		[cm]	[kg]		[m]			[phase]
1	06.01.1987	128	30	m	-	Maasholm	between	crescent
2	14.07.1987	89	13	f	-	Kappeln	+	wane
3	05.08.1987	140	52	m	17	Schleimünde	+	crescent
4	12.08.1987	159	50	m	8	Falshöft	+	wane
5	02.09.1987	120	33	f	15	Neukrichengrund	+	crescent
6	20.09.1987	106	18	m	5	Geltinger Bucht	-	wane
7	29.09.1987	-	53	m	8	Olpenitz	-	crescent
8	02.10.1987	150	50	m	10	Kronsgaard	+	crescent
9	11.10.1987	117	28	m	11	Kalkgrund	+	wane
10	16.10.1987	-	27	f	12	Schleimünde	-	wane
11	24.10.1987	-	56	-	7	Falshöft	-	crescent
12	30.10.1987	106	28	f	15	Hasselberg	+	crescent
13	31.10.1987	-	35	-	10	Kronsgaard	+	crescent
14	06.11.1987	125	29	f	7	Damp/ Schuby	+	full
15	11.11.1987	123	29	f	-	Maasholm	+	wane
16	23.11.1987	150	60	m	8	Geltinger Bucht	-	crescent
17	15.01.1988	132	34	m	6	Boknis Eck	-	wane
18	03.05.1988	117	34	m	9	Schleimünde	+	full
19	24.05.1988	121	31	f	-	Maasholm	+	crescent
20	05.08.1988	116	27	f	-	Maasholm	-	wane
21	07.09.1988	83	20	f	10	Schleimünde	-	wane
22	22.09.1988	140	53	m	11	Stoller Grund	day	-
23	25.10.1988	110	28	m	8	Bredgrund	+	full
24	21.11.1988	105	25	f	10	Bredgrund	+	crescent
25	23.11.1988	114	27	f	14	Kronsgaard	+	full
26	23.11.1988	140	44	f	11	Schleimünde	+	full
27	05.07.1989	142	55	f	3	Boknis Eck	-	crescent
28	11.08.1989	105	22	f	14	Falshöft	+	crescent
29	10.09.1989	130	35	-	4	Schleisand	+	crescent
30	14.11.1989	113	30	f	-	Maasholm	+	full
31	17.11.1989	121	34	f	-	Maasholm	+	wane
32	14.12.1989	138	36	f	-	Eckernförde	+	crescent
33	05.01.1990	145	-	f	-	Maasholm	+	crescent
34	16.02.1990	131	42	f	-	Maasholm	+	wane
35	09.07.1990	120	-	-	8	Hasselberg	+	full
36	13.07.1990	123	30	m	10	Kalkgrund	+	wane
37	07.08.1990	160	68	f	14	Schleimünde	+	full
38	07.08.1990	104	19	f	14	Schleimünde	+	full
39	??.08.1990	140	-	-	*	Schönhagen	*	*
40	04.09.1990	107	22	m	13	Schleimünde	+	crescent
41	10.09.1990	141	35	m	7	Schönhagen	+	wane
42	14.09.1990	106	22	f	10	Falshöft	-	wane
43	25.09.1990	105	25	m	5	Schleisand	-	crescent
44	26.09.1990	114	24	m	*	Falshöft	*	*
45	19.11.1990	121	35	f	7	Mittelgrund	-	crescent
46	??.02.1991	-	45	-	10	Schleimünde	?	?
47	10.04.1991	119	39	m	13	Vejsnäs Flach	-	wane
48	05.07.1991	147	-	m	*	Kronsgaard	*	*
49	06.07.1991	114	28	m	16	Vejnäs Flach	-	wane
50	18.07.1991	124	31	f	*	Hasselberg	*	*
51	31.07.1991	79	8	m	*	Golsmaas	*	*
52	13.08.1991	123	37	f	14	Kronsgaard	-	crescent
53	21.08.1991	101	20	f	17	Falshöft	+	crescent

Incidental catches and strandings of harbour porpoise (*Phocoena phocoena* Linnaeus 1758) in the coastal waters of Angeln and Schwansen (Schleswig-Holstein, FRG) from 1987 to 1996

No.	Date	Length [cm]	Weight [kg]	Sex	Depth [m]	Location	Lightness	Moon [phase]
56	29.08.1991	103	22	f	15	Olpenitz	+	wane
57	07.10.1991	116	32	m	12	Golsmaas	-	new
58	16.10.1991	102	25	m	6	Langballig Bank	+	crescent
59	21.11.1991	111	30	m	12	Golsmaas	+	full
60	10.12.1991	106	-	f	-	Maasholm	-	crescent
61	05.08.1992	123	28	f	12	Bregrund	between	crescent
62	11.08.1992	96	17	m	11	Schleimünde	+	crescent
63	20.09.1992	140	-	-	6	Öhe	-	wane
64	16.10.1992	180	-	-	8	Öhe	+	wane
65	20.10.1992	-	30	-	8	Kalkgrund	-	wane
66	11.02.1993	122	36	f	15	Falshöft	+	wane
67	31.07.1993	125	-	m	*	Geltinger Birk	*	*
68	16.09.1993	94	-	m	*	Eckernförde	*	*
69	02.11.1993	120	28	m	6	Schönhagen	+	wane
70	02.11.1993	128	37	f	6	Schönhagen	+	wane
71	03.11.1993	128	34	m	9	Falshöft	+	wane
72	10.04.1994	116	-	m	*	Damp	*	*
73	25.05.1994	134	41	m	13	Bredgrund	+	full
74	29.06.1994	125	38	m	18	Geltinger Bucht	+	wane
75	18.09.1994	141	55	-	*	Weidefelder Strand	*	*
76	18.09.1994	107	26	m	8	Bredgrund	+	crescent
77	26.09.1994	123	32	f	15	Bredgrund	+	wane
78	07.11.1994	162	51	m	*	Aschau	*	*
79	09.11.1994	125	32	m	11	Falshöft	-	crescent
80	01.12.1994	158	50	f	17	Schleimünde	-	wane
81	26.04.1995	125	36	f	7	Langballigbank	-	wane
82	12.07.1995	152	-	m	*	Noer	*	*
83	28.08.1995	119	-	f	*	Damp	*	*
84	05.10.1995	129	38	m	5	Falshöft	+	crescent
85	26.05.1996	115	-	f	14	Westerholz	+	crescent
86	22.07.1996	112	-	m	*	Golsmaas	*	*
87	15.08.1996	153	49	m	6	Skelde Vig	-	new
88	20.08.1996	101	-	m	*	Kronsgaard	*	*
89	09.09.1996	107	-	m	*	Geltinger Bucht	*	*
90	12.09.1996	117	26	f	14	Hasselberg	-	wane
91	22.09.1996	127	29	m	*	Noer	*	*

Those marked with an Asterisk (*) were no bycatches but strandings.
With the exception of No. 29, 35, 63, 64 which could be released, all other animals were found dead.
No. 8, 11, 13, 46, 65 were discarded. The two harbor porpoises No. 37 + 38 were mother and calv.
No. 68 and 69 were caught 500 m away from each other.

ASPECTS OF BY-CATCH OF RIVER DOLPHIN IN THE PERUVIAN AMAZON

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By-catch is one of the main threats to all river dolphin species throughout their range. Even though the Amazon river dolphin or boto, *Inia geoffrensis*, appears to be the least endangered of the platanistid river dolphins, by-catch may have a negative effect on survival rates. The same applies to tucuxi, *Sotalia fluviatilis*, the other dolphin species in the Amazon river system.

Behaviour ecology and human impact on river dolphins were studied in 1994 and 1995 in three black water tributaries - R=EDo Samiria, R=EDo Pacaya and REDo Tapiche - of the Amazon in Peru. REDo Samiria and REDo Pacaya are part of the second largest nature reserve in the Amazon, the Pacaya-Samiria National Reserve, where only subsistence fishing and hunting of a limited number of species is allowed.

Nine surveys were conducted on the three rivers and their side streams. They included 165 days of field covering more than 5,000 kilometres of distance.

During the surveys, dead animals were examined and about fifty interviews with fishermen and park rangers were undertaken to learn about fishing methods and by-catch rates.

Both dolphin species, boto and tucuxi, are widespread and common with an average abundance of about one dolphin per kilometre of river in the three river systems.

The main human activities inside and around the reserve are fishing, hunting, fruit collecting and small-scale agriculture. Dolphins of both species are technically protected by law from direct exploitation by commercial as well as subsistence hunting. In addition, both species are protected very well due to the beliefs of supernatural attributes.

Many different fishing methods exist in the Peruvian Amazon: active types like hooks, spears and cast net fisheries and more passive methods like set gillnets, beach seine, and drop trap fisheries. With the introduction to the Amazon of nets made of synthetic fibre in the 1960s, gillnets - especially set gillnets and beach seine fisheries, became increasingly popular. The poison fishery, which was widespread and killed many dolphins inside the reserve in the late 1980s, seems to have been largely abandoned.

Nowadays, specially set gillnets and, in some areas, drop traps are responsible for most of the by-catch [drop traps are set during low water in narrow tributaries and inlets between rivers and lakes for manatees and paiche (Arapaima gigas)].

The results from the interviews were difficult to analyse. Statements regarding dolphin mortality or accidental catch range between "dolphins never get caught because they are too smart" to "I catch around 30 dolphins each year, mainly with drop traps." The truth is likely to be between these extremes.

Since botos are well known for stealing fish from nets and damaging fishing gear (Leatherwood, 1996), fishermen, who believe in supernatural powers, may run into conflicts. On the one hand, the may dread the supernatural repercussions from harming a dolphin, but on the other hand, they may be severely tempted to remove a competitor and destroyer of fishing gear.

Only three dolphin carcasses were found on more than 5,000 km of survey:

- one boto, which was shot
- one boto neonate, which was a still birth
- one boto in a very decomposed status so the cause of death could not be determined.

Steve Leatherwood (1996) found eight records of bycatch within the same area from 1991 to 1993; one was released, one killed in a drop trap, and six were likely killed by gillnets. Vera da Silva and Robin Best (1996), who worked in the Central Amazon in Brazil, found that of the 67 dolphins examined (33 boto, 34 tucuxi), 83% of *Inia* mortality is caused by beach seine gillnets; 38% and 35% of the tucuxi mortality were caused by drift and fixed gillnets, respectively.

At the present state of research, it is not possible to quantify the current rate of by-catch in the Peruvian Amazon. But with the development and employment of non-selective fishing gear, bycatch may become a serious threat to these animals.

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THE DEVELOPMENT OF WHALE-WATCHING IN THE CANARIES AFTER THE REGULATIONS OF 1995: A YEAR OF STUDY

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INTRODUCTION Whale-watching in the Canarian Archipelago, in particular between La Gomera and Tenerife, attracts more than half a million people every year (1996: 700,000 visitors) and is mainly targetted at "*calderones*", or short-finned pilot whales (*Globicephala macrorhynchus*). This figure makes the Canaries one of the most successful whale-watching locations, a fact which is, of course, a positive boost for the economy of the islands.

The paper presents an overview of the whale-watching industry in the Canaries, taking advantage of data collected by the "*Calderon*" (the Spanish name for the pilot whale), a patrol-boat belonging to the Government of the Canaries, which was commissioned as a result of a governmental decree (in 1995), to monitor and regulate whale-watching activities.

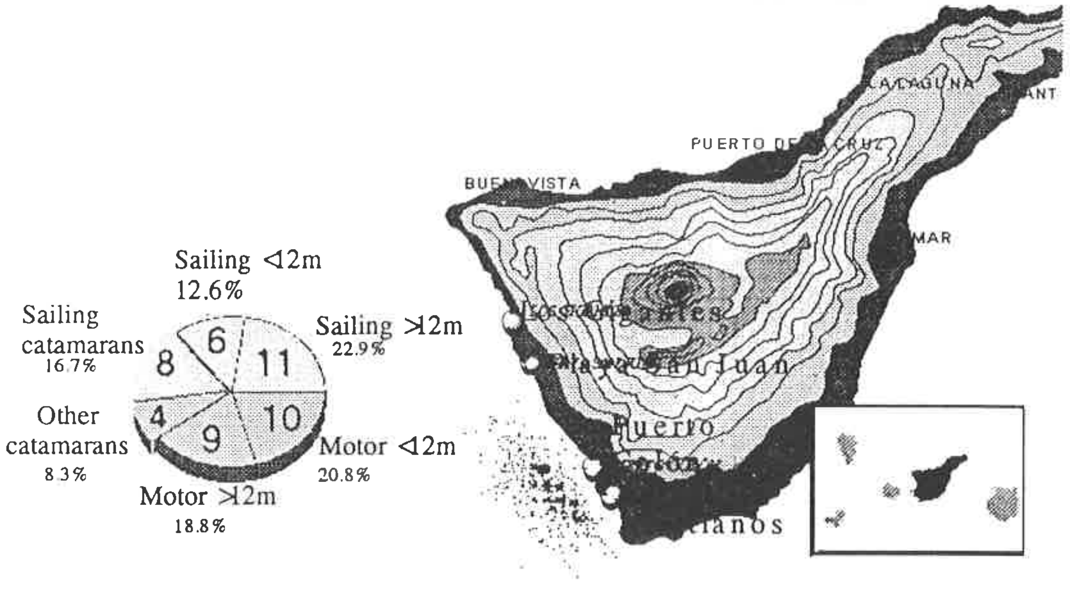

Fig. 1 On the left, the types and relative abundance of whale-watching are summarised. On the right, a map of Tenerife, in the Canary Archipelago, showing the survey area and the distribution of cetacean sightings.

MATERIALS AND METHODS The *Calderon* goes on patrol every day of the year (except 25th December and 1st May), between 10 am and 6 pm. The area surveyed for this current paper covers the south-western waters of Tenerife, which is due to the fact that most (83%) of the whale-watching activity takes place in this region. The survey area encompasses 250 km^2, which is only a portion of the total area patrolled by the

Calderon. Data collected outside of the aforementioned survey area has not been analysed in this paper.

During each survey, a member of the *Calderon's* crew filled in a form noting down the number of whale-watching boats at sea, as well as, every 15 to 30 minutes, the boat's position, observed cetacean species, the number of individuals present, and their behaviour.

This paper presents data collected over an entire year: from February 1996 until February 1997. To avoid biases, only days when more than three hours of data were collected, were considered to be "effort days". Only 100 sightings were outside of "effort days" and were, therefore, excluded from this study.

Table 1 The number and species of cetaceans sighted

SPECIES	SIGHTINGS
Globicephala macrorhynchus	1447
Physeter macrocephalus	11
Stenella attenuata/frontalis	11
Tursiops truncatus	108
Stenella sp. & *Tursiops truncatus* (mixed school)	3
Delphinus delphis	25
Pseudorca crassidens	3
Steno bredanensis	7
Balaenoptera edeni	2
Unidentified	4

The data collected were then divided into two categories: one encompassing information on the number of boats, and the other on the number of sightings made each day. Working with both sets of data allowed the extraction of more information, for example the temporal and geographical distribution of sightings and the frequency of types of behaviour. The data were inputted onto a Geographical Information System (GIS) (Fig. 1).

RESULTS & DISCUSSION The predominant cetacean species sighted was the pilot whale with nearly 1,500 sightings in one year. However, a total of eight different species of cetacean was recorded, which is remarkable when one considers the relatively small area surveyed (250 km^2) (Table 1).

Pilot whales were observed throughout the day, all year round. The seasonal abundance of pilot whale sightings in the survey area did not vary much throughout the year, a situation which is advantageous to the whale watching industry, i.e. whale watching trips can be run year round. Figure 2 summarised the temporal distribution of pilot whale sightings. Pilot whale are most abundant and, therefore, most easily observed by whale-watching boats in the morning, or during the late afternoon, whilst in the early afternoon there is less chance of observing animals (between 1-2 pm). The decrease in sightings between March and May was due to poor weather conditions and to mechanical difficulties with the survey vessel. The decrease in sightings between 1 pm and 2 pm may be due to the fact that the patrol-boat often returned to port to off-load and pick up crew members. However, when corrected for effort, the number of sightings each month are approximately uniform (Fig. 3).

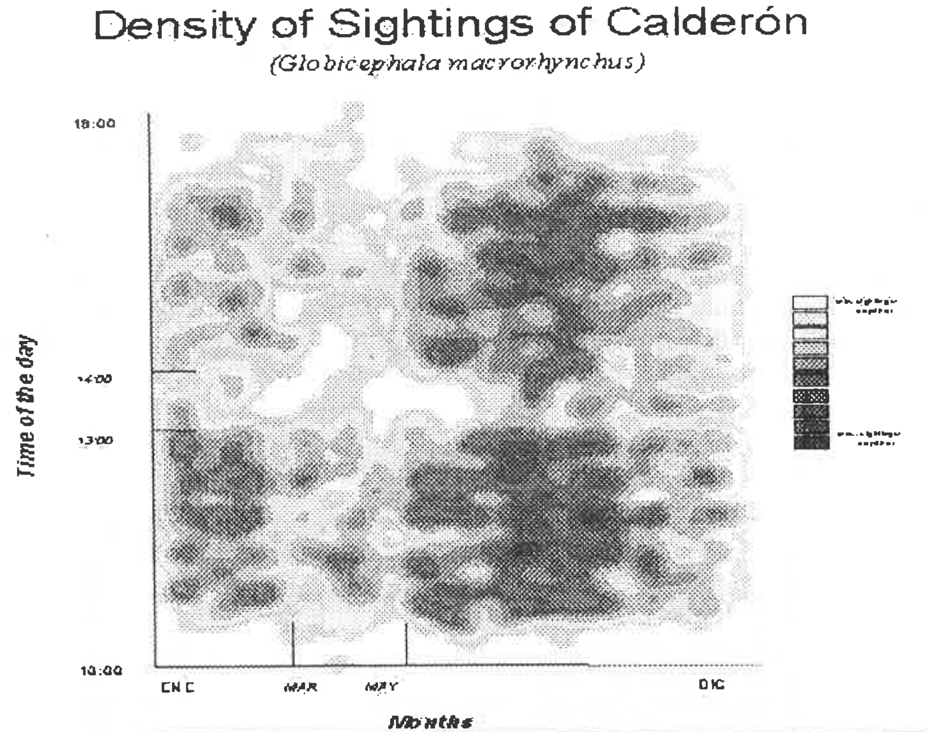

Fig. 2 The temporal distribution of pilot whale sightings

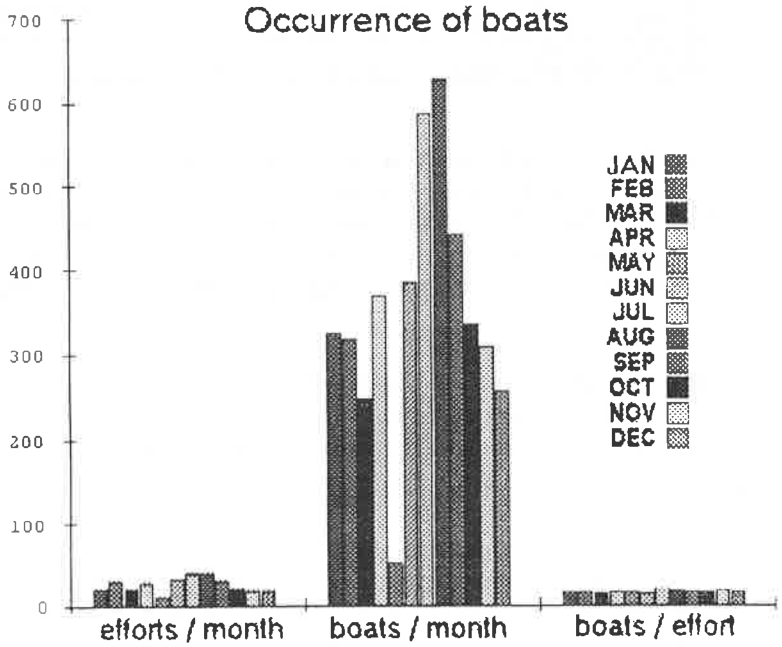

Fig. 3 Monthly variation in survey effort, cetacean sightings and the number of sightings each month when corrected for effort

Figure 4 summarises diurnal patterns in pilot whale behaviour. Behaviours exhibited primarily consisted of travelling, resting, or a combination of both. Feeding or mating behaviour was rarely observed, although when it was, there was no apparent diurnal pattern.

The results presented in this paper reinforce the findings of previous studies (Martin *et al.*, 1992; Heimlich-Boran & Heimlich-Boran, 1992), that there is a resident population of pilot whales in the coastal waters of the Canary Islands. The Canary Islands constitute an international focus for ecotourism, not only because of high species diversity but also because of the extraordinary opportunities for whale-watching. Conditions for whale-watching in the coastal waters of the Canaries are ideal: the area supports a high density of whale watching vessels, i.e. up to 29 boats simultaneously in the area) and the whale-watching season runs throughout the year, with a relatively constant output of whale-watching trips each month (Fig. 5). In addition, the close proximity of tourist resorts and facilities, with a high concentration of potential clients, makes whale-watching in the Canaries a safe investment.

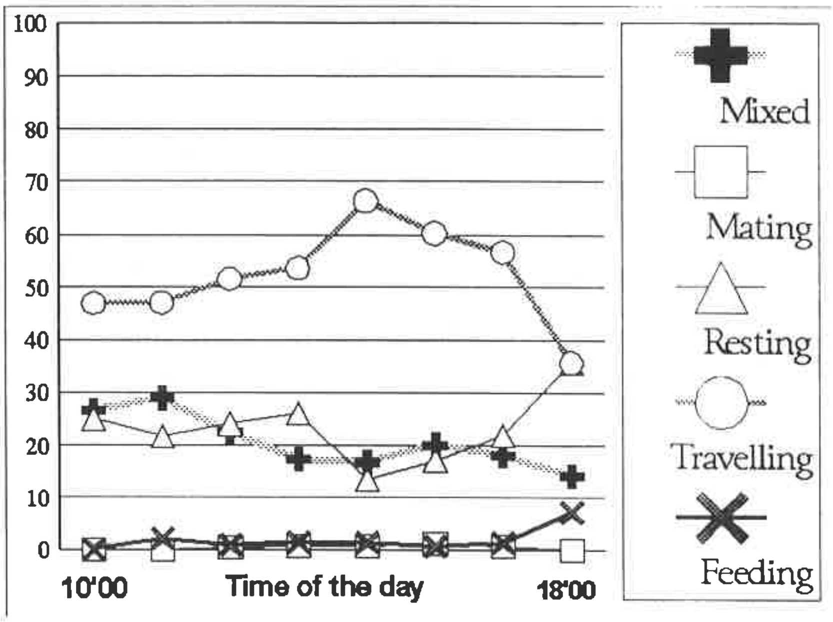

Fig. 4 Diurnal patterns in pilot whale behaviour

There were 48 whale-watching boats registered in 1996. Figure 1 and Table 2 summarise the different types and distributions of whale-watching vessels, with their respective capacities. Most of the smaller (<12m) catamarans and sailing-boats disembark from Puerto Colón, while the bigger vessels and motorised ships are moored in Los Cristianos.

Table 2 Distribution and capacity of whale-watching vessels

AREA	PORT	BOATS				CAPACITY			
		No.	%	No.	%	Capacity	%	No	%
South	Puerto Colón	25	52.1	40	83.3	915	38	2045	85
	Los Cristianos	15	31.3			1130	47		
North	Los Gigantes	5	10.4	8	16.6	181	7.5	359	15
	Playa San Juan	3	6.2			178	7.5		
	TOTAL	48				2404			

Unfortunately, during this survey data collection was not as systematic as it could have been. Many sightings had to be discounted from the data set as they were outside of the survey area, or the data was inaccurately recorded. However, the remainder of the data still provided a lot of information. For future studies, new sightings forms will be developed, survey routes will be more systematic and the methodology will be altered to improve both accuracy and homogeneity of survey effort. Further research projects could include monitoring the environmental impact of the whale-watching industry as well as documenting the habitat utilisation, feeding habits and reproductive behaviour of Tenerife's cetaceans.

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WHALE CARCASSES AS TOPICS FOR PRACTICAL SCHOOL LESSONS

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INTRODUCTION Biology as a natural science has undergone a dramatic change. Alongside technical innovations, modern ethics in biology have induced many students to refuse to do dissections on animals. It is, therefore, not surprising that many young biology teachers in Germany are not able to do preparatory work on animals and plants for use in class lectures. Even less are they able to lead a dissection as a practical school lesson. The pupils oblige their teachers; most would happily watch horror films but shudder at the thought, either because of biological or culinary reasons, of dissecting a dead animal. There are exceptions. The following report describes two different school groups that actively participated in dissection and preparatory work on whales.

RESULTS

I. Elementary school children prepare a harbour porpoise (*Phocoena phocoena*) skeleton and the flipper of a sperm whale (*Physeter macrocephalus*) An elementary class of the primary and secondary school in Oldendorf (Lower-Saxony) uses the whale as its school mascot. Since the beginning of the 1993 school year, pupils and teachers have been collecting everything to do with whales: stuffed animals, posters, drawings, books and videos about whales, whale vertebrae and scrimshaw carvings of sperm whale teeth.

The learning aims were formulated as follows: the pupils, together with parents and teachers, should learn that:

- there are many different types of whale presentations to be found in books, sculptures, and pictures;
- whales are mammals, whose anatomy and living habits are researched;
- the bones of the whale are very similar to those of humans;
- letter writing is worthwhile, because experts like to answer "schoolkids' questions" about whales;
- the environment of these mammals is endangered;
- many different forms of representation need to be found for exhibitions;
- even grade schoolchildren can confidently present their work to the public;
- communication media, such as newspapers, radio and television, report information differently;
- a project on a particular subject can be worked on over a period of four years and can used for discussion in other subjects, i.e. history, conservation, mathematics, geography, etc.

Looking for material that would bring the grade schoolchildren closer to the whales, in its second school year, the "whale class" (1994) received a dead harbour porpoise from Lower Saxony, from which they removed and prepared the skeleton. In the third school year (1996), the children received a flipper from a stranded Danish sperm whale, for preparation. These projects brought pupils, parents and teachers together. The preparatory work was explained in every detail by Mr. G. Behrmann from the Nordseemuseum, Bremerhaven. Parents helped with the construction of a showcase (sponsored by the Deutsche Umwelthilfe) in which the harbour porpoise skeleton is now displayed. Table 1 shows the activities of pupils, parents and teachers in these projects.

Table 1 The activities of pupils, parents, and teachers

HARBOUR PORPOISE (1994-1995)	Pupils (7-8 yrs old)	Parents	Teachers
On arrival	8/18	1	3
Tissue removal (practical)	0/18	1	3
Tissue removal (observing)	8/18	7	2
Bone cleaning and degreasing	9/18	0	1
Skeleton assembly	18/18	1	2
SPERM WHALE FLIPPER (1996)	Pupils (9-10 yrs old)	Parents	Teachers
On arrival	2/21	1	2
Tissue removal (practical)	1/21	1	2
Tissue removal (observing)	20/21	0	0
Bone cleaning and degreasing	19/21	8	2
Skeleton assembly	15/23	0	2
TV & RADIO APPEARANCES	Pupils	Parents	Teachers
NDR	20/21	6	2
Childrens program logo	10/23	4	2
Radio 1	18/18	0	1
Radio 2	19/19	2	2
Radio 3	21/21	16	2

Radio 1 = Antenne, a special program for the Greenpeace exhibition "the World of the Whales", 1995; Radio 2 = Küstenschnack Radio Bremen, 1995; Radio 3 = NDR 4, 1996

Throughout the project, the children, their parents, and the teachers learnt a lot about these mammals - their social organisation, behaviour, and the threats to their environment. At the beginning of the fourth school year, the class displayed examples of their fact-finding research and presented their "treasures" in three different exhibitions open to the public: in "Natureum" (the natural science museum of Stade); in the Kreissparkasse Oldendorf (Savings Bank); and in "Delphino", the public swimming pool in Bremervörde. The "Wattenmeerhaus" of the Lower-Saxony Wadden Sea National Park, in Wilhelmshaven, will present the work carried out by the "whale class" at its opening. In addition, the school children presented their whale work at a German "Youth Research" competition, where they received third prize. Also, their work was presented at the "Fritz-kids-club" environmental competition.

II. Preparing a sperm whale skeleton with the help of school children and students The "Seevogelrettungs- und Naturforschungsstation Sylt" (Seabird Rescue and Nature Research Station, Sylt) has, for some years, been offering practical experience, for adults and school children, in observing harbour porpoises and seals (*Phoca vitulina* and *Halichoerus grypus*, respectively) in the wild. Most mammal strandings on the German coast are washed ashore on the Island of Sylt (Stock *et al.*, 1996). Therefore, these participants have an ample opportunity to assist researchers with the retrieval of marine mammal carcasses from the beach and regularly show great interest in the dissection of the dead mammals and seeing what the animals look like inside.

On the 27th March 1996, sixteen dead sperm whales stranded on an island off the Danish coast, two of which were to be collected and prepared for the "Natura Docet" museum, in Denekamp, the Netherlands. On the 13th April 1996, a group of schoolchildren (13, 15, 17 and 18 years of age) and university students (24, 19 and 23 years of age) were taken to the stranding site. The youngsters had permission from their parents, as well as from the school authorities, to participate in the preservation of the skeletons, even though this required missing some normal school lessons.

In addition to the practical success of the work, a pedagogical target was also in the foreground. In the German education system, especially in the natural sciences, the pedagogic principle "head, heart, hand" is followed. The young people in our group already had a strong interest in whales; now, with this unique hands-on project, they were able to really learn about sperm whales. With their heads they digested the available literature; with their hearts was born the interest in these whales; with their hands, eyes, ears and noses they could, for the first time in their lives, really begin to understand what a large whale is all about.

The learning aims were formulated as follows: the pupils and students should

- learn from video how to dissect a sperm whale.

- learn which safety measurements are necessary: the handling of sharp knives, the necessity of tending even the smallest cut; or what to do when blood, tissue, fat, or other tissue fluids accidentally splash in the face or eyes; the dangers when climbing on the carcass (slipping, or the carcass bursting), what to watch for when working close to a tractor (tearing or slipping of the lines, no standing under the shovel or near the wheels) (see Geraci & Lounsbury, 1993).

- from the literature, obtain theoretical knowledge concerning the anatomy and physiology of sperm whales (Bateman, 1992; Behrmann, 1985, 1992, 1993; Cox, 1990; Deimer, 1977; Keller, 1988; Kremer, 1991; Martin, 1991).

- find the pelvic and thigh bones, determine their position in relation to the vertebrae, and explore the question of how one can determine the position of these small unattached bones from the outside (Deimer, 1977; Behrmann, 1985).

- find and to remove intact, the *bulla*, which is attached loosely to the wing-like *processus mastoideus* of the skull (Behrmann, 1992).

- locate the un-erupted rear molars and preserve them for the final skeleton preparation.

- save the upper jaw teeth, in the palate, as well as several embryonic teeth, each about the size of a pin head.

- prepare a sperm whale flipper without damaging the phalanges or cartilage between the bones.

- examine the blowhole, blubber thickness, and spermaceti organ, as well as any parasites found in the blubber.

- answer questions on the location of the skull in the head, ingestion, and the path of ingested food in relation to the skull, the respiratory tract, the position of eyes and *bullae*, and (from of the relative concentration of blood in the cranial bones) the orientation of the animal when it stranded.

- find out the exact location and size of the sperm whale's brain because, at first glance, the position of the brain is not immediately obvious.

- recognise variation of the cranial bones (some were long and small, while others were short and wide).

The sperm whales strandings, the extrication of the skeletons, as well as the discussed questions, were all documented with photographs and video. Each participant received a copy of the video and had to report immediately to friends, family, and school colleagues about their experiences with the sperm whale. One of the pupils was required to write a so-called "annual report" as an assignment for his school - he chose, of course, sperm whales and their stranding.

DISCUSSION It is certainly surprising, and also encouraging, that schoolchildren - especially a second grade class - show such an interest in the removal of a skeleton from a whale carcass, and the preparation and assembly of a harbour porpoise skeleton and sperm whale flipper. One should not forget, however, that practical work on carcasses such as this, can pose a health risk for humans. On the other hand, the dangers are well known and precautions can be taken to minimise the risks involved. All the schoolchildren and students worked calmly and with concentration.

The teaching goals set were accomplished for both groups. The available literature on whales could be scrutinised, and it was discovered that many books describing whales reported the dentition of a sperm whale's upper jaw to be non-existent or gave a completely false description. The participants could convince themselves of the truth by comparing the literature with a real-life model. Both groups had the opportunity to extricate cetacean skeletons and to compare their finds not only with available school book literature, but also with a school model of a human skeleton.

The presentation and assemblage of many whale skeletons in both the literature and in museums was discovered by the participants to be incorrect, because they had been able to experience the animal skeletons in their natural state. The second group searched for, and found, the pelvic and rudimentary thigh bones of the sperm whale. The tongue-bone was also found. These bones are absent from most displayed whale skeletons. Some whale skeletons are depicted in the literature and in museums without a breastbone or have falsely mounted pelvic bones (see, for example, Kremer, 1991). The second group was amused as they viewed an orca skeleton from a Museum of Natural History which showed pelvic bones mounted vertically to the vertebrae, and phalanges which were mounted directly onto the forearm (the carpals were missing). Also, the participants of the second group were always on the look-out for the bulla, which they typically found to be missing on most of the displayed whale skeletons.

Moreover, many schoolchildren, who had merely been spectators for the preparation of the harbour porpoise carcass, had developed into enthusiastic helpers by the time that the preparation of the sperm whale flipper was carried out.

The primary schoolchildren's unusual practical work, as well as their whale exhibition, received a lot of attention from the newspapers, radio, and television. The schoolchildren were able to use the media to spread their knowledge of whales and dolphins to other people. An interested public, from all over parts of Germany, were very impressed with the children's work and the exhibitions' guestbooks were full of well deserved compliments for both pupils and teachers. The children became multiplication factors in the spreading of information about whales and dolphins. Beginning with the 4- to 6-year olds, and ending with the adults, all have become messengers of a simple and clear idea: protect the whales. Both groups also learned that a purely emotional point of view is not the way to present a subject to the public; this is especially true when talking about whales or dolphins. They realised that even a dead whale can be a very positive experience.

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BACK TO THE BLACK: RELEASE OF A MALE BOTTLENOSE DOLPHIN INTO THE BLACK SEA AFTER SIX YEARS IN A SEMI-FREE ENCLOSURE ON THE RED SEA

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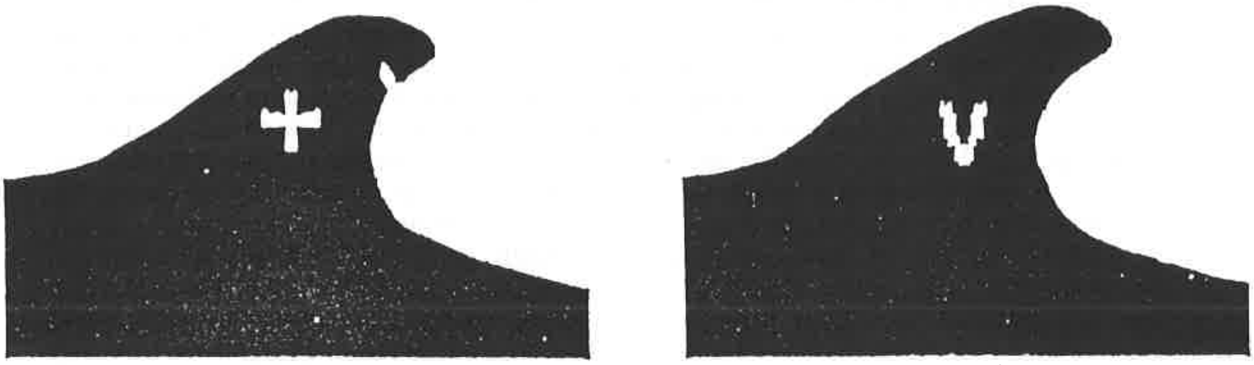
INTRODUCTION Throughout the past decade, numerous attempts have been made to release captive dolphins back to the wild, and the outcome of these projects was measured in post-release sightings or trackings. To our knowledge, there has been only one documented case of individual dolphins having successfully readapted to their natural environment after extended periods in captivity (Bassos *et al.*, 1991). Much criticism has been extended to programs where participating dolphins were not released at their original capture site, such as in the project 'Into the Blue' (McKenna, 1992, cited in Gales & Waples, 1993). The use of effective tracking devices to assess the fate of released animals was considered as another main issue in marine mammal release projects by Gales and Waples (1993).

In this paper we present details on the release of an adult male bottlenose dolphin, *Tursiops truncatus*, at his original capture site in the Black Sea, Russia, in August 1996. Prior to his release, the dolphin, named Dicky, had been kept for six years under semi-free conditions in the Dolphin Reef Eilat, Israel, as part of a colony of nine individuals. Details on both the site and the social behaviour of the group are given elsewhere (Todt & Hultsch, 1996; Veit & Bojanowski 1996). In order to prepare for his rehabilitation, Dicky had been exposed to different behavioural tasks and environmental situations directly related to problems that might be encountered in the open sea (Fritsch *et al.*, 1996, Heilsberg *et al.*, 1997). An entirely new method was applied in this project to facilitate the social readaptation by releasing him together with a recently captured female from the local population. All stages of the release project were documented by both behavioural and acoustic recordings.

PROCEDURE On August 20, 1996, Dicky was transferred from Israel to Russia by aeroplane and truck. The transfer took about 10 h. Throughout the whole time, Dicky was kept in a tank partly filled with water (constantly leaving his blowhole free of water) together with a human companion. In between the different transportation systems, Dicky was shifted by stretcher. Upon arrival at the Biological Station Utrich, Russia, Dicky was introduced into an open sea pen, where he joined an adult female caught from the local population in May 1996. Within less than 30 min., both animals were observed displaying affiliative behaviour and closely associating, for example by pectoral fin contact. There were no signs of aggression, neither behaviourally nor acoustically. Dicky accepted fish approximately one hour after introduction into the open sea pen. Until his release 3 days later, he consumed his normal amount of 8 - 10 kg per day. The day prior to the release, both animals were marked on their dorsal fins by removing dermal tissue in characteristic patterns (Fig. 1). On that occasion, the animals were also measured (Dicky: 270 cm/270 kg, female: 224 cm/158 kg), and blood samples were taken.

On 23 Aug, the animals were brought to the release site by truck, both stationed together in the same water-filled tank. In Taman Bay, they were taken out to sea on board an inflatable (Fig. 2). At a distance of c. 5 km from the coast, both animals were released over the side of the boat simultaneously. Both surfaced the first time at a distance of about 25 m, but were not sighted afterwards. Due to rough seas, observation conditions were difficult. However, their presence in the vicinity of the boat was assessed by vocalisations recorded over a period of c. 80 min. (estimated hydrophone range for dolphin whistles: 200 m).



DICKY FEMALE

Fig. 1 Markings on the dorsal fins (both sides) of the two released dolphins: a ' cross' labelling the male Dicky and a 'V' labelling his female companion

Two weeks post-release, the animals were sighted near the Crimean coast, at a distance of more than 200 km from the release site, on three successive days (Fig. 2). Both were observed foraging near fishing trawlers within a larger group of dolphins. Due to the migration patterns of bottlenose dolphins in the Black Sea, we do not expect re-sightings of the released animals along the northern Black Sea coast before spring 1997, when animals will be returning from wintering areas in Turkish waters (L. Mukhametov, *pers. comm.*).

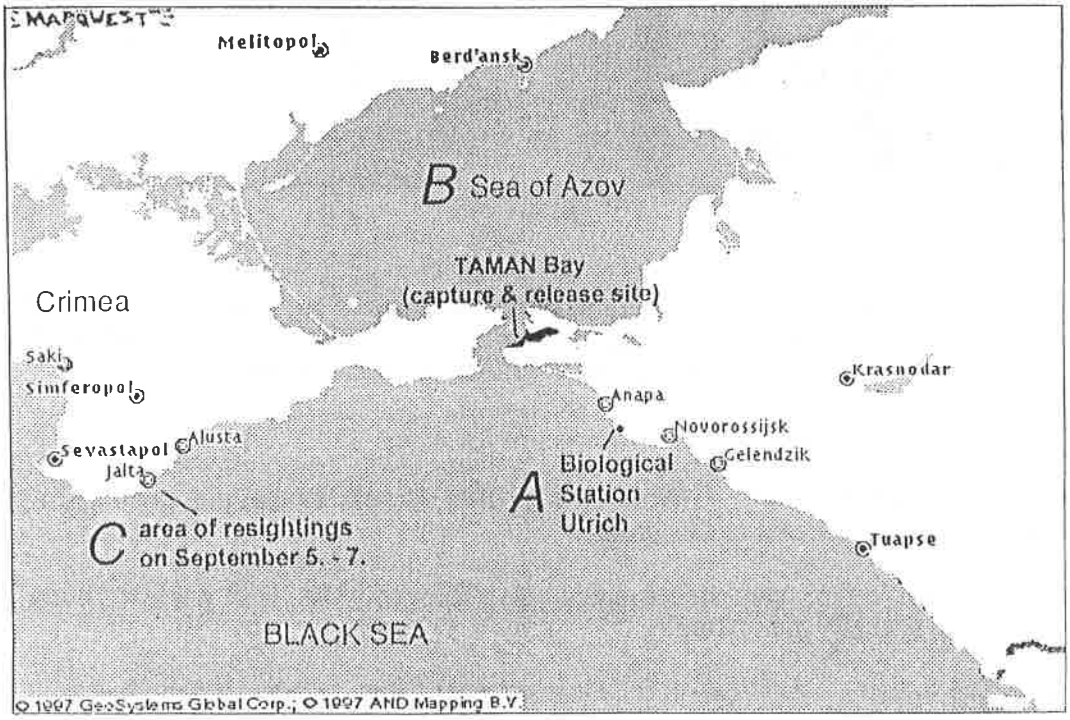


Fig. 2 Map of the northern part of the Black Sea showing the location of the Russian Research Institute (A), the area of release (B) and the area of sightings (C). See text for further details

Observations and systematic surveys for the released animals will be conducted in co-operation with local scientists. Additionally, information about the markings of both animals were given to fishermen along the coast, in order to obtain further information as to the whereabouts of the released animals.

VOCAL BEHAVIOUR DURING TRANSPORT Acoustic recordings were made during all stages of the project. During the transport, the dolphin's whistle rate was very high, often reaching more than 50 whistles per minute (each loop counted as a whistle). He often produced long series of uninterrupted loops with a maximum of 14 loops (Fig. 3). Analysis and categorisation of whistles revealed three different types of whistles, and two of them documented a remarkable variability. Nevertheless, we found one type showing a relatively stereotyped contour. According to an earlier definition, this type was accepted as Dicky's 'signature whistle' (Caldwell *et al.*, 1960). A striking feature of vocalisations was a high proportion of whistles uttered simultaneously with clicks. The clicks gave the sound a specific acoustic character that was clearly different from pure whistle vocalisations. In some samples, these whistle/click combinations concerned more than 40% of whistles. Clicks were typically emitted during the rising part of the whistle, with a mean rate of about 110 clicks per second. In the time domain, these whistles were typically shortened when compared with whistles with the same contour, but without clicks. We assume that the vocalisations which Dicky produced during his transport indicated a high degree of distress (see also Sidorova *et al.*, 1986).

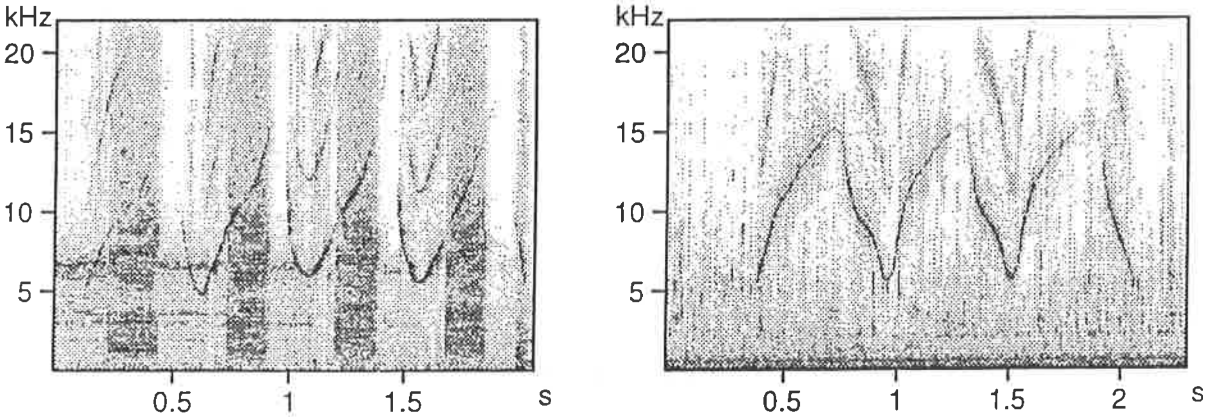


Fig. 3 Frequency spectrograms of two sections of vocalisations produced by the dolphin Dicky during his transport. Left: whistles overlapped by clicks. Right: signature whistle. See text for further details

CONCLUSIONS We consider five factors as having been particularly important for the success of this project:

(1) The individual: with an estimated age of eleven years, Dicky was a young, wild-born, sexually mature male.

(2) The housing conditions in the Dolphin Reef Eilat: the open sea enclosure allowed, for example, the catching of fish within the site. An 'open-sea-program' gave Dicky access to the open sea on a daily basis for the year preceding release. In the course of excursions to the open sea, Dicky reliably responded to an underwater signalling device (pinger) utilised for guidance and training.

(3) Release at the site of capture: this method is preferable for reasons of population genetics as well as the adaptibility of the animal to its original environment.

(4) Release together with a 'wild' conspecific: upon arrival at the Black Sea, Dicky was allowed to become accustomed to the new site by spending three days in an open sea pen, in which a conspecific female was also kept.

(5) No use of artificial tracking devices: such a device might affect the behaviour of its carrier and that of its potential social partners. As opposed to the original plan of attaching satellite tags, it was, therefore, decided to mark the two dolphins on their dorsal fins, and to conduct systematic surveys of their potential range, including Taman Bay and the Russian/Ukrainian coast of the Black Sea.

ACKNOWLEDGEMENTS The project was supported by Deutsche Umwelthilfe and the GSM.

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DISTRIBUTION & SURVEYS

PRELIMINARY STUDY ON DOLPHIN OCCURRENCE IN THE TURKISH STRAITS SYSTEM

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INTRODUCTION The Turkish Straits System (TSS), namely Istanbul (Bosphorus) Strait (31 km long), Marmara Sea (max. length 276 km, max. width 76 km), and Canakkale (Dardanelles) Strait (62 km long), is not only the world's busiest waterway, it is also a biologically important waterway for both Mediterranean (Aegean) and Black Sea faunas: it serves as a biological corridor, barrier and acclimatisation zone (Öztürk and Öztürk, 1996). For cetaceans, it is assumed to serve as a migratory path between the Aegean and Black Seas as they follow the schools of prey fish, as a natural 'trap' for catching the migratory fish, or as a physical and chemical barrier due to the heavy traffic and pollution in the TSS.

Understanding the seasonal occurrence and distribution of cetaceans in the TSS is crucial for the protection of these animals not only in the TSS but also in the Black Sea and Eastern Aegean Sea, since the animals from both seas may visit this area for feeding. In this paper, we compiled all data currently available to provide a basis for future research to enable appropriate protection measures to be implemented.

MATERIALS AND METHODS We distributed the observation sheets (modified from the CIESM cetacean data sheet) and drawings of the Turkish cetaceans, to fishermen, particularly shrimp trawlers, sailors, and other boat users in the TSS. Later, we collected the sheets from them and compiled observation data for 1985-1996. The observers reported the time and place of each observation, the species and number of animals. Besides these, some extra effort was made during our research cruise in the Marmara Sea in October 1996, and also from the fixed observation post on the Istanbul Strait in 1996.

RESULTS AND DISCUSSION A total of 180 observations were recorded. Because there were frequent observations in the Istanbul Strait, in spite of its size compared with the entire TSS, it is treated separately from the rest of the TSS, i.e. the Marmara Sea and Canakkale Strait (Table 1, Figs. 1 and 2).

The occurrence and distribution of dolphin observations reflected those of observers and effort rather than those of dolphins themselves. This was particularly evident in the observations made by our survey cruise in the Marmara Sea in October 1996, and in those made from the fixed post along the Istanbul Strait. The Istanbul Strait provided most of the observations since there is more public transport and more human activity along this narrow waterway, which contributed to the sighting effort compared with the other areas. Nevertheless, the result of the present study provided some general information about the dolphins in the TSS.

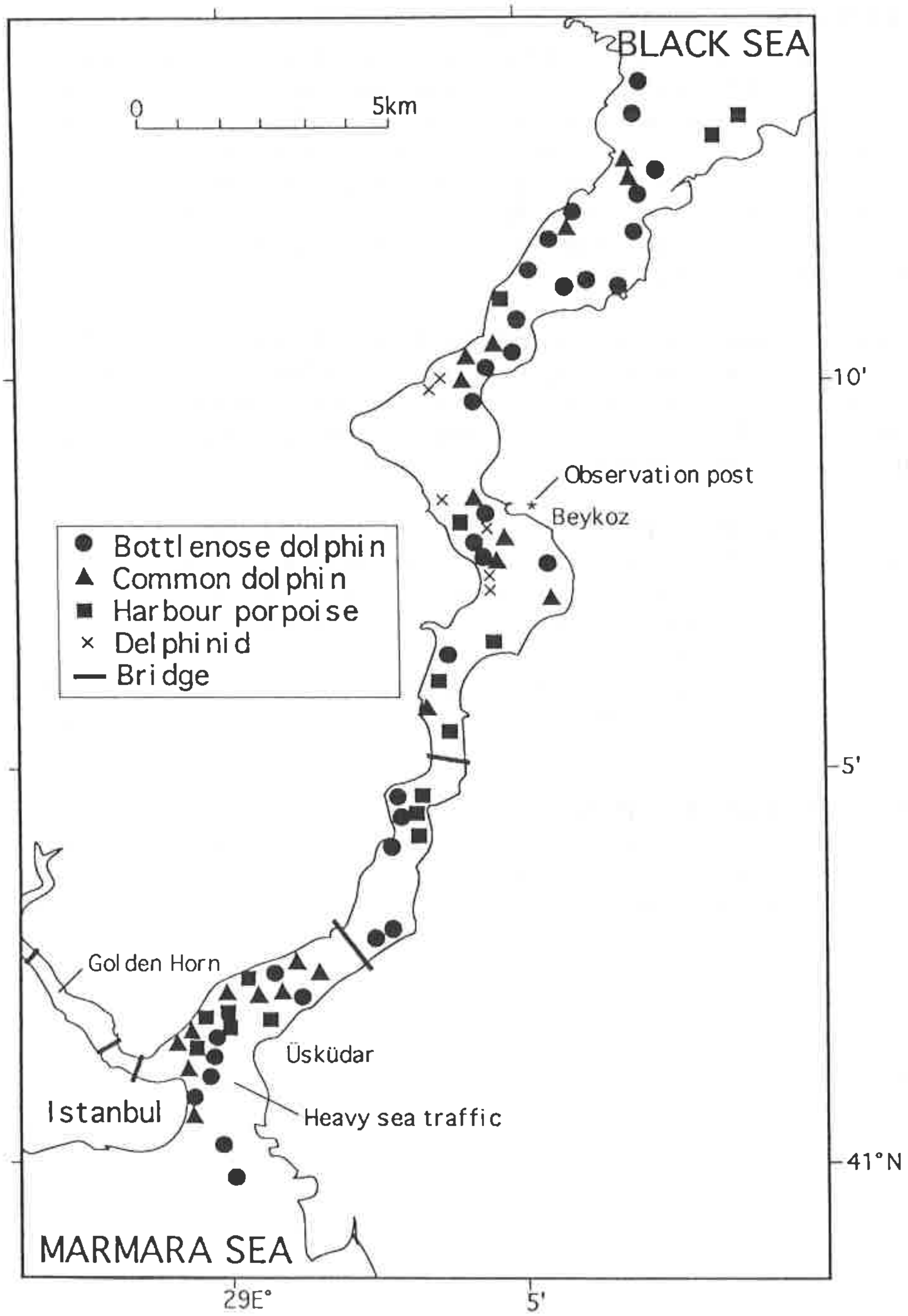

Fig. 1 Cetacean observations in the Istanbul Strait for 1985-1996

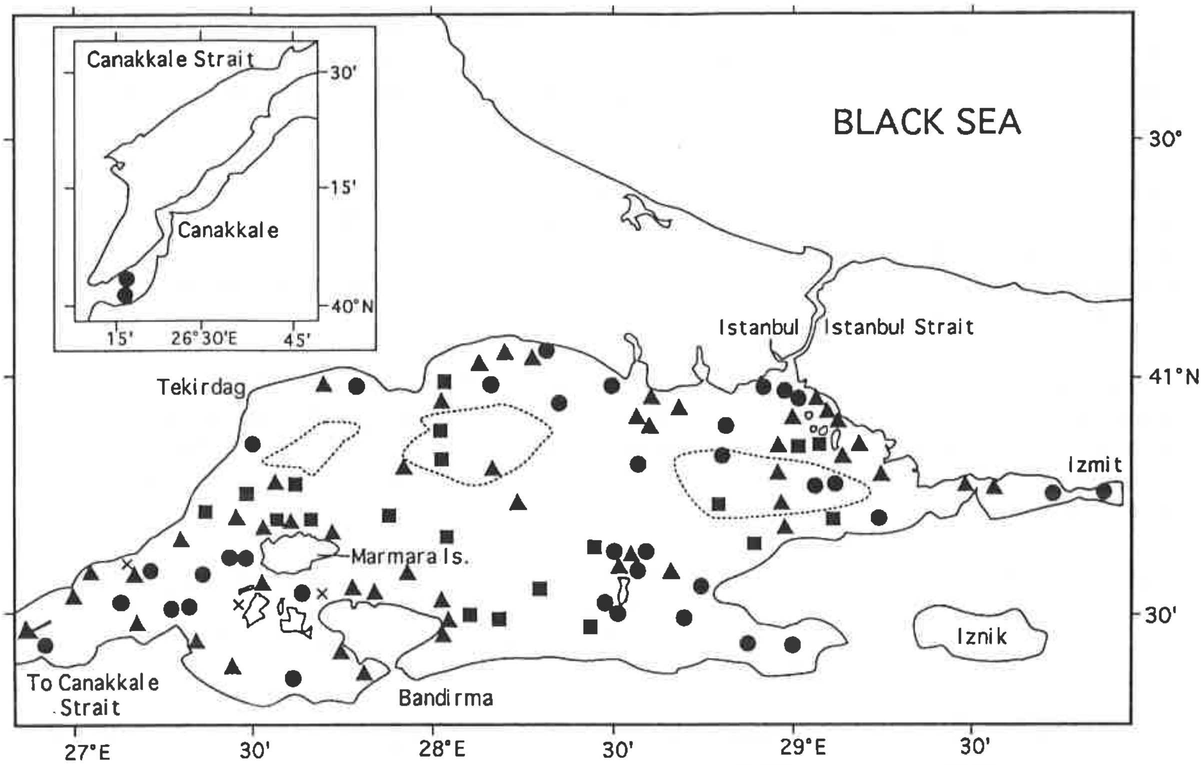

Fig. 2. Cetacean observations in the Marmara Sea and Canakkale Strait for 1985-1996. The dashed line shows the 1000m depth contour. See Fig. 1 for other signs.

Table 1. Number of cetacean observations in the TSS by month for 1985-1996.

The Istanbul Strait													
Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Common dolphin	-	-	-	7	3	7	1	1	1	-	1	-	21
Bottlenose dolphin	1	-	-	4	9	7	3	-	-	1	-	-	25
Delphinid*	-	-	-	2	4	-	-	-	-	-	-	-	6
Harbour porpoise	-	-	-	2	2	4	6	1	-	-	-	1	16
Total	1	0	0	15	18	18	10	2	1	1	1	1	68
The Marmara Sea and Canakkale Strait													
Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Common dolphin	-	3	6	14	8	3	2	9	5	3	1	-	54
Bottlenose dolphin	-	2	-	-	-	1	2	2	5	21	6	1	40
Delphinid*	-	-	-	-	-	-	-	1	-	1	-	-	2
Harbour porpoise	-	-	-	1	-	2	3	-	4	2	4	-	16
Total	0	5	6	15	8	6	7	12	14	27	11	1	112

Delphinid*: Either common dolphin or bottlenose dolphin.

There were three cetacean species observed in the TSS, namely, the common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), and harbour porpoise (*Phocoena phocoena*). The most common species was the common dolphin, followed by the bottlenose dolphin, and the least common was the harbour porpoise.

In the Black Sea, the common dolphin is the most common species, followed by the harbour porpoise, and then the bottlenose dolphin (Öztürk, 1996). Harbour porpoises seem to prefer colder water and less saline water since they were not observed in the Canakkale Strait nor in the shallow western part of the Marmara Sea where there is strong influence of Mediterranean water (Fig. 2).

Cetaceans occurred throughout the Istanbul Strait (Fig. 1). Many observations were made in the busy areas, especially near the city centre of Istanbul, in spite of the concern that heavy sea traffic may disturb dolphins. On the contrary, no resident population was spotted, as described by Tezel (1958), most probably due to the present heavy traffic and pollution.

Also in the Marmara Sea, cetaceans occurred over the entire area, except in the deepest parts where there was less fishing effort and less productivity (Fig. 2). They were observed more often around the islands, probably due to greater sighting effort there and also to the high productivity of the area.

Table 1 shows that there were more observations in spring and summer in the Istanbul Strait, and that there were observations throughout the year except during the winter months, with peaks in April and October in the Marmara Sea. Berkes (1977) reported that Mediterranean dolphins migrate through the TSS in spring to the Black Sea and back to the Mediterranean in autumn. The fishermen also know that dolphins wait for their prey fish migrating through the TSS during spring and autumn (Öztürk and Öztürk, 1996). The present study supported the presumption that dolphins tend to occur in spring, and possibly in autumn. However, larger and more systematically collected samples are needed to draw definitive conclusions on the seasonal occurrence of cetaceans in the TSS.

In the Canakkale Strait, in spite of there being only two observations (Fig. 2), the damage to fishing nets by dolphins has been claimed by fishermen, while net damage is very rare in the Istanbul Strait (unpubl. data). This indicates that dolphins probably occur in the Canakkale Strait more frequently than the present study showed.

In conclusion, the present study has provided some basic information on the occurrence and distribution of cetaceans in the TSS, which may be useful for designing more systematic surveys in the area in the future.

ACKNOWLEDGEMENTS We thank fishermen, yachtsmen, and local people for their co-operation. Our gratitude is also due to the crew of the research ship "Yunus" as well as to Dr. Susan Wilson for reviewing our manuscript, Ayhan Dede of Istanbul University, and Turkish Marine Research Foundation for financial support.

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TEN YEARS OF ACTIVITY OF THE ITALIAN CENTRO STUDI CETACEI

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The Centro Studi Cetacei (CSC, Centre for Cetacean Studies) was established in 1985 as a research group under the Italian Society for Natural Sciences, based at the Natural History Museum of Milan. One of the most important aims was to bring together all the Italian researchers and Institutions concerned with cetaceans, encouraging the continued study in this field. Nowadays, the CSC consists of 100 members belonging to Zoological Museums, University Departments and non-profit Institutions. The CSC is directed by a Committee of seven members (including the Co-ordinator) elected every four years during the Annual General Meeting.

The first project was to create a national network in order to collect data and material on Cetacea found stranded along the Italian coasts. This stranding project ("Progetto Spiaggiamenti") has been active since May 1986. In 1990, a special project was added, relating to the particular needs of cetaceans stranded still alive. The stranding network is based on the co-operation of many people and Official Authorities. The Italian coastline is divided into sixteen zones, each with a researcher (member of the CSC) that is responsible for operations concerning strandings. He has some collaborators, with specific competence in different subjects. The information on the stranding is usually first reported to a round-the-clock answering service in Milan (sponsored by the insurance company Europ Assistance Italia). From Milan the information is immediately transmitted to the researcher in charge of the zone in which the stranding has occurred. If the animal is still alive, everything is done to help it survive; if it is already dead, a post-mortem examination, tissue sampling and skeleton preservation are carried out, following a standard protocol. Data are then forwarded to the central co-ordination in Milan, and are subsequently listed in the annual report of Cetacea strandings, published yearly in the "Atti della Societa' Italiana di Scienze Naturali".

The stranding network gave the opportunity to carry out much research on the samples that are collected from each stranded specimen. The main subjects analysed during this decade are listed below:

- Levels of organochlorines and heavy metals in different tissues;
- Accumulation and detoxification systems of mercury;
- Bacterial and viral infections;
- Enzymatic systems;
- Parasites;
- Age determination;
- Stomach contents;
- Histo-physiology of the digestive apparatus;
- Histology of the lungs and of the liver;
- Osteology.

The most important results of the first ten years of activity are here summarised. The total number of strandings and by-catches that occurred from 1986 to 1995 is 2,025 (Fig. 1). In 1991 the total number was higher (550 specimens) presumably because of the morbillivirus infection that caused a striped dolphin die-off throughout the Mediterranean Sea. In Italy, the strandings were more numerous in the South. The average number of strandings in the other years (excluding also 1986 because data were collected only during six months) is around 180 specimens.

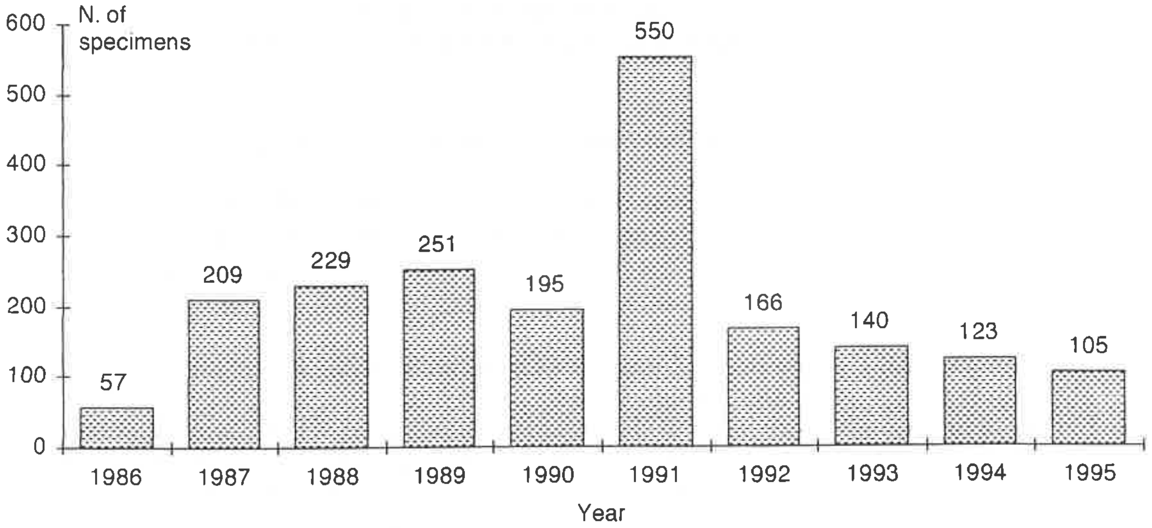

Fig.1 Total number of strandings and by-catches

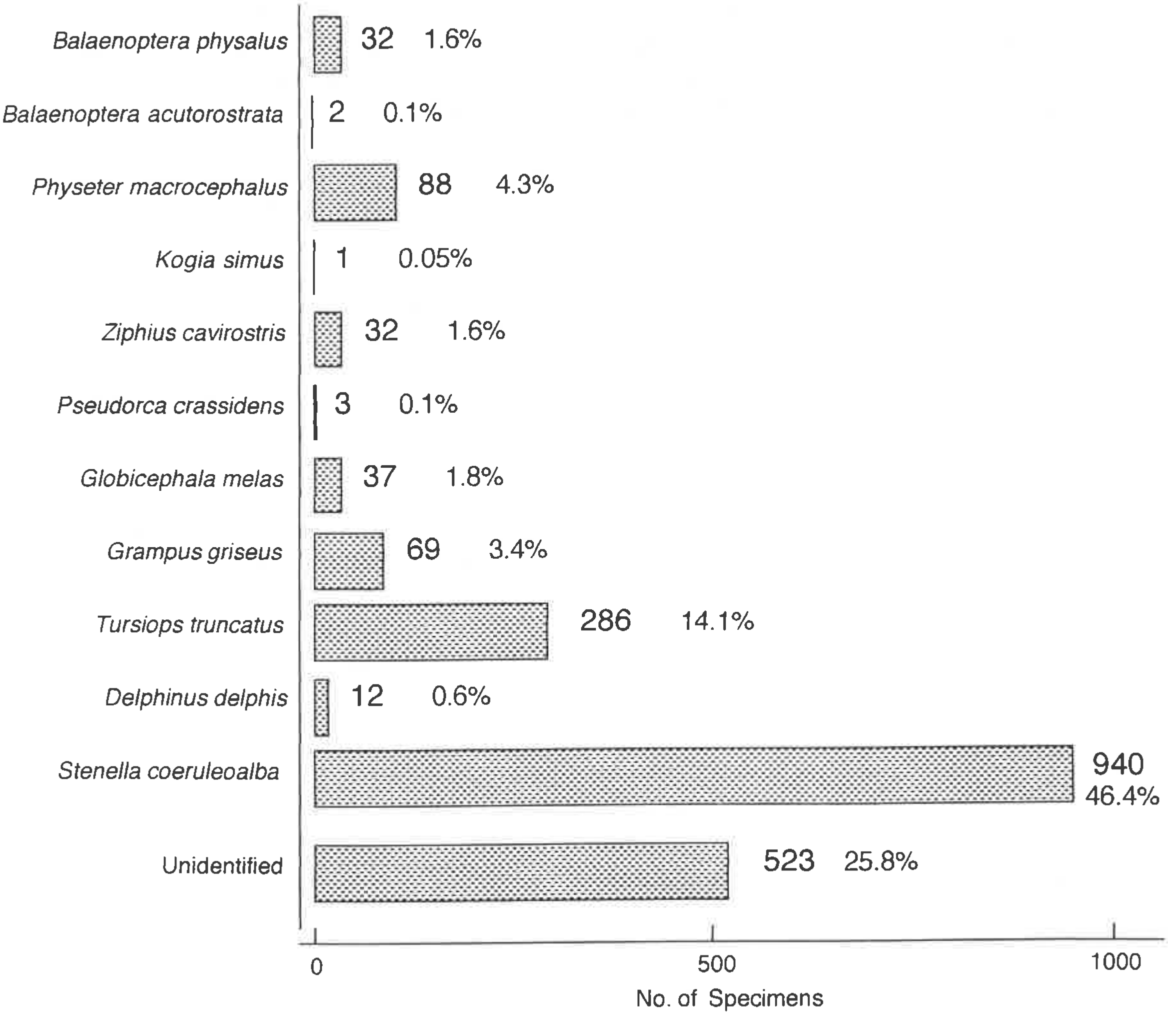

Fig.2 Total number and percentage of strandings and by-catches for each species

In Figure 2, the number of specimens (both strandings and by-catches) and the percentage for each species are shown. Among the eleven species reported, striped dolphin (*Stenella coeruleoalba*) is by far the most abundant, comprising nearly half of the total. The common dolphin (*Delphinus delphis*), that was once the more frequent dolphin, is very rare: only twelve specimens in ten years. Minke whale (*Balaenoptera acutorostrata*) and false killer whale (*Pseudorca crassidens*) are quite rare, while the dwarf sperm whale (*Kogia simus*) is the first specimen for Italian waters.

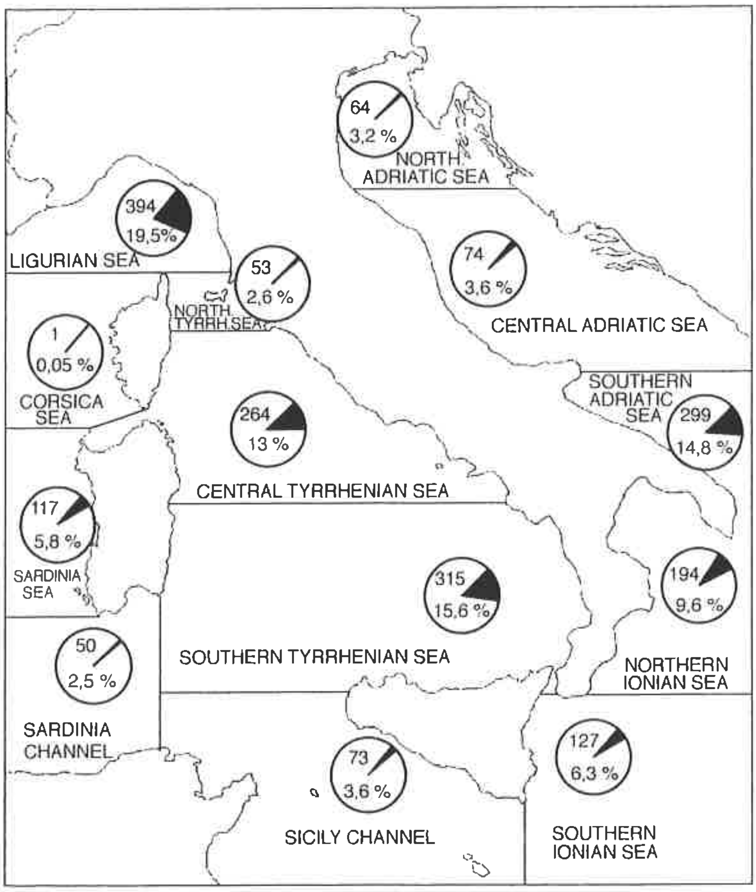

Fig. 3 Distribution of strandings and by-catches

The map in Fig. 3 illustrates the number and the percentage of strandings and by-catches in the different geographic areas in which the Italian seas are usually divided. The Ligurian Sea shows the highest number. In this area, cetaceans are abundant; furthermore, the total number of deaths has increased during the years 1988 and 1989 due to the by-catches in the pelagic drifting nets occurring in the area at that time. Cetaceans entangled in drift-nets were usually found already dead, but sperm whales (*Physeter macrocephalus*) were sometimes still alive. The researchers of the CSC with the help of the Harbour Offices and Customs and Inland Revenue Service have released from the nets about 15 specimens. The total number of by-catches in ten years is 395, even though this figure is not necessarily representative of the "total" number.

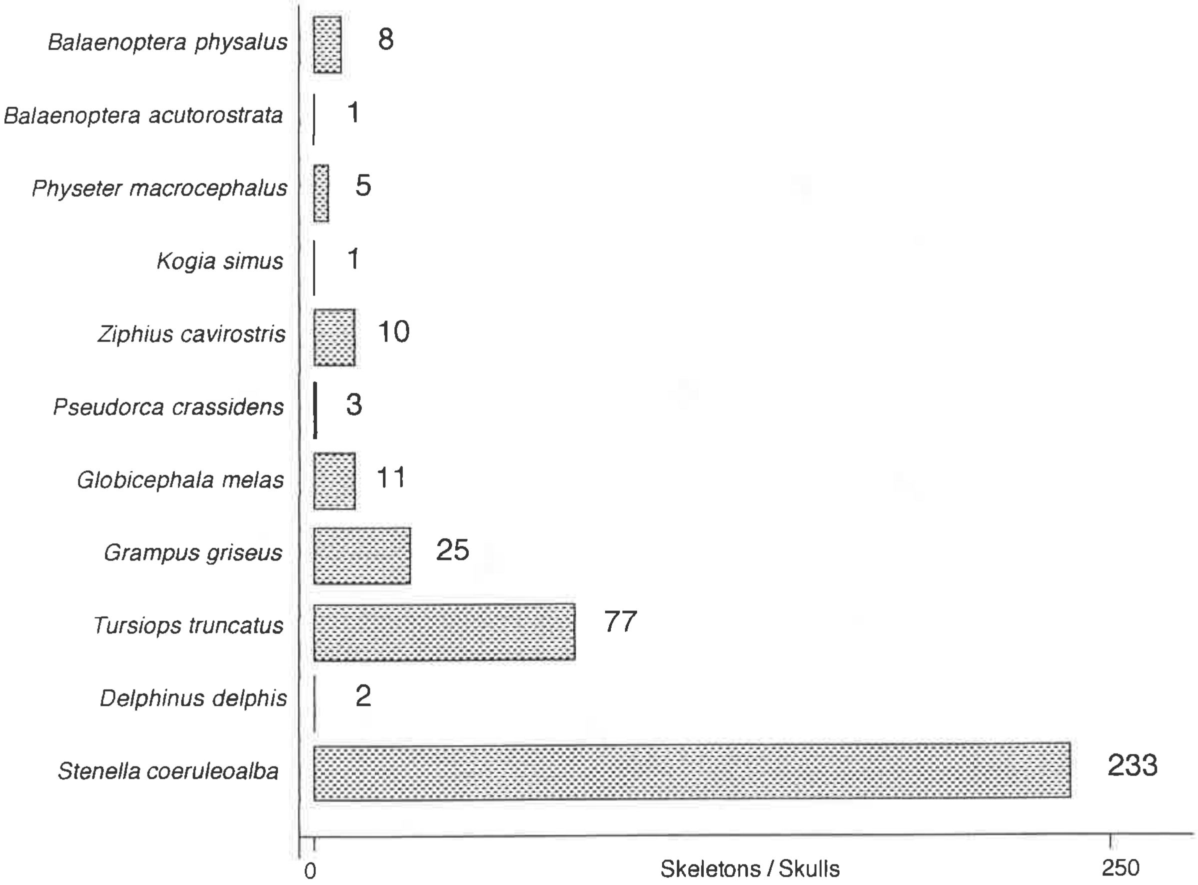

Fig. 4 Number of skeletons or skulls collected

Figure 4 gives the number of skeletons (or skulls) collected and preserved in the Italian Museums during the ten years of activity of the CSC. In this period the total number of collected skeletons (376) is equivalent to the total number collected up until 1985. The skeleton of the minke whale is one of very few preserved from the Italian coasts, while the dwarf sperm whale is the only specimen preserved from the whole Mediterranean Sea.

ACKNOWLEDGEMENTS The data presented are the result of the co-operation of the members of the Centro Studi Cetacei, of which this is paper No. 66. Many thanks to them and to all the people that helped during the field work. We would like to acknowledge Europ Assistance Italia for the great support in the answering service. Thanks also to Valter Fogato e Graziella Perini for their graphic work.

Reprints of the annual report of the Centro Studi Cetacei should be requested from Michela Podesta'.

"ONDE DAL MARE": AN UPDATE ON THE ITALIAN NETWORK FOR CETACEAN AND TURTLE SIGHTINGS

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WHAT WE ARE TALKING ABOUT...... Together with the WorldWide Fund for Nature (WWF), the Fondazione Cetacea started the project "ONDE DAL MARE" [Waves from the Sea] in 1993. This is a radio-telephone network (VHF Radio, channel 74 - 156.725 MHz; phone number +39-541-693675) operating throughout the year, between 9 am and 6 pm. It was established to make the communication of both cetacean and turtle sightings and environmental problems easier and, in general, to gather data for future conservation programs.

This project was sanctioned both by the Italian Department of the Environment and the Postmaster General. The society "M.A.R.E." has subsequently joined the project and has been charged with overseeing the communication of any environmental damage. Between 1993-96 we have also built a strong relationship with the Customs and Inland Revenue Service and with the Coastguard; this helps us to provide an effective service. Opportunistic records were contributed by other researchers, mariners and fishermen.

Since 1995, the project has received the vital support from WWF's Oasi Blu at Gianola, situated along the central Thyrrenhian coast, 80 km north of Naples, providing numerous reports from the western Mediterranean Sea.

.....AND WHY? The intentions of this project are to increase public awareness of the problems concerning our seas and their inhabitants, and to highlight areas of main conservation interest. The project "Onde dal Mare" also aims to fulfil the following goals:

- to give scientific and logistic support to the Italian Department of the Environment and on a larger scale to all the Public Institutions involved in the safeguarding of the environment;

- to set up long-term data collection that could help to define areas and phenomena of special interest concerning Cetacea in order to establish future research programs;

- to highlight the relationship between data coming in from strandings along a given coastal area and the data received from "Onde dal Mare" in the stretch of sea directly adjacent;

- to promote the planning of an EIS (Environmental Information System) aimed both at the management and control of marine environmental problems.

These aims are being implemented through the establishment of a database to help monitor the marine environment through real-time communications and through subsequent computer analysis.

AND HOW? In order to improve the effectiveness of the project, it was decided that selected public institutions should be lobbied (*e.g.*, the Fishery Co-operative Society, Harbour offices and Coastguard, Customs and Inland Revenue Service and the Italian Navy) via conferences, sighting cruises, videos and pamphlets.

Furthermore, for this project a special relationship was built up with the Customs and Inland Revenue Service, and with the Coastguard, since the collection of marine environmental data was already included among their official duties.

researchers or others working in the Mediterranean Sea - the main innovative feature of "Onde dal Mare" was an attempt to obtain data directly and immediately through a radio communication system and a specific ‘phone network.

Furthermore, considering the project’s aims, our data analysis took into consideration just a few reliable parameters - such as geographical position and species identification via good quality pictures and videos - taken from the huge amount of information stored in the database.

RESULTS The total number of communications received during this project are presented in Table 1, while communications regarding the identified cetacean species (15.54% of the total) for specific areas are presented in Table 2.

Table 1 The number of cetacean and turtle reports received by the “onde dal mare”project (figures refer to the number of communications; his does not necessarily correspond to the number of specimens)

	CETACEANS	TURTLES	COMMUNICATIONS
Total	251	170	421
Alive	227	68	295
Dead	22	107	129

Table 2 The number of cetacean and turtle related communications from specific areas

	Northern Adriatic Sea	Central Adriatic Sea	Southern Tyrrhenian Sea	Central Tyrrhenian Sea	Ligurian Sea	Corsican Sea	TOTAL
Tursiops truncatus	13	4					17
Stenella coeruleoalba	3	1			3	1	8
Grampus griseus	2			1			3
Delphinus delphis	1						1
Physeter macrocephalus			1				1
Balaenoptera physalus	3				2		5

In order to determine the importance of each category of contributor, the number of reports received annually from each observer category are summarised in Table 3.

Table 3 A summary of the sources of received reports

	1993	1994	1995	1996	TOTAL
Harbour offices	20	8	6	21	55
Forestry Services	8	9	3	8	28
Local Fishermen	3	19	58	16	96
Italian Navy	1	1	3	0	5
Research vessels	1	3	8	1	13
"Carabinieri"	0	0	1	2	3
Police	0	0	0	1	1
Fire Service	0	0	0	1	1
Customs & Inland revenue service	6	30	30	36	102

Disparities in the number of reports received from different geographical regions are a reflection of several factors including: the unequal distribution of VHF transceivers; stronger, established, relationships with both the local fishermen and institutions in certain areas; and the presence and activities of relevant NGO’s, such as "Fondazione Cetacea" and, recently, Gianola's "Oasi Blu".

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Out of 251 cetacean reports, the species was identified in 15.54% of the cases (see Table 2). When identification was not possible, the data were divided into simple categories in order to preserve ecologically meaningful data, and also to avoid bias due to inaccurate species identification. As is shown in Table 3, contributions to the network by observers such as the Customs and Inland Revenue Service, the Harbour Offices and local fishermen were relatively high in relation to the total number of records. An accurate analysis of each contribution has allowed the maximisation of the data collected. For example, disposable cameras were distributed to local fishermen and this resulted in an increased incidence of reliable species identifications.

Considering the relative success of the project so far, it is intended that the "onde dal mare" project should be extended to include other geographical areas of the Mediterranean Sea. Eventually, the utilisation of new technology such as GIS (Geographical Information System) mapping programs, Global Positioning Systems (GPS), and communications networks such as “onde dal mare”, research and monitoring of the marine environment will be greatly enhanced.

DISTRIBUTION AND FREQUENCY OF CETACEANS IN THE NORTHERN TYRRHENIAN SEA

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In the summer of 1996, a series of cruises was organised to monitor the northern Tyrrhenian Sea in order to frequency. The research was conducted from a sailing vessel between the islands of Elba and Corsica. Six cetacean species were encountered, in decreasing order of sighting frequency: striped dolphin *Stenella coeruleoalba* (37.04%), fin whale *Balaenoptera physalus* (18.52%), bottlenose dolphin *Tursiops truncatus* (11.11%), Risso's dolphin *Grampus griseus* (7.41%), sperm whale *Physeter macrocephalus* (7.41%) and common dolphin *Delphinus delphis* (3.70%).

Cetaceans were encountered at a distance range of 3-4 km from the nearest coast and in a depth range of 65-890 m. The above sighting frequency, resulting from 27 sightings in 62 hours of research effort, indicates a substantial presence of cetaceans in this area, and suggests the need to carry out further research, to widen the scope of this preliminary study and increase our knowledge of cetacean distribution and sightings.

NEW RESULTS ON THE SEASONAL VARIATION OF CETACEANS IN THE LIGURO-PROVENÇAL BASIN

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INTRODUCTION The Liguro-Provençal Basin is one of the areas of the Mediterranean Sea most densely populated by cetaceans. During the summer, high levels of abundance have been estimated in the area. However, the status of cetaceans during the rest of the year remains comparatively unknown, because unfavourable weather conditions prevent surveys of cetaceans. To get round this difficulty, data from seven years of sampling were pooled in order to obtain enough data to analyse seasonal variations in the abundance of two cetacean species in the region.

MATERIALS AND METHODS Surveys were conducted in the central region of the Liguro-Provençal Basin (Fig. 1) from a 9 m motorised yacht, cruising at a speed of five knots. The areas sampled were random and were influenced by weather conditions. Two or three observers searched a 180° sector directly ahead of the survey vessel, with the naked eye. Once cetaceans were detected, the position of the vessel and relative position of the animals (radial distance and bearing) were recorded. Binoculars were used to confirm species identification and, from 1994 onwards, the distance and bearing of the animals from the survey vessel. The choice to include or to reject a section of the survey was made on the basis of a visibility index which was dependent upon wind, light conditions and swell. Generally, sections surveyed with a sea state of less than, or equal to, Beaufort 3 were retained for analysis.

The total effective effort in the area amounted to 4,796 nautical miles, of which 3,131 were conducted in summer, 433 in autumn, 625 in winter, and 607 in spring. However, after the pooling of samples, there were three periods when no surveys of any kind were undertaken: 15th Sept. to 27th Oct. (autumn), 2nd Jan. to 14th Feb. (winter) and 9th May to 20th June (spring). An analysis of spatial distribution of the sampling effort indicated that only a portion of the study area was covered during these seasons. In summer, 53% of the effort was conducted offshore (beyond the 2,000 metres isobath), while during the cooler seasons this proportion amounted to 35-39% (Table 1). During spring and winter, the proportion of inshore effort was higher (32-34%) than during summer and autumn (22-24%).

Table 1 Distribution of sampling effort as a function of bottom depth (% of the total effort for each season)

DEPTH RANGE/SEASON	0-500 m	500-1000 m	1000-2000 m	> 2000 m
winter	20.0	12.5	31.8	35.8
spring	14.5	19.4	29.5	36.6
summer	15.1	7.3	24.0	53.6
autumn	17.6	7.2	36.2	39.0

All the surveys run during successive years were grouped for analysis in a stratum for every season. Relative abundance is computed from the abundance (Buckland *et al.*, 1993):

$D_i / D_r = (n.\ \underline{s} / L)i / (n.\ \underline{s} / L)_r / (\underline{esw_i} / \underline{esw_r})$

where n is the number of sightings for a given species, s is the estimated mean school size, L is the survey effort, and esw is the estimated effective search half-width.

The same formula was utilised for every season, taking the summer for reference and assuming esw is constant:

$$D_i / D_r = (N / L)_i / (N / L)_r$$

The coefficient of variation (CV) of D_i / D_r is computed to be:

$$CV^2(D_i / D_r) = CV^2(D_i) + CV^2(D_r)$$

A direct estimation of esw for different seasons and all cetacean species was not possible due to low sample sizes. As a general rule, the effective search width varied with the wind speed and sea state and potentially with the school size. Taking the summer detection data set, it was demonstrated that neither school size nor the visibility conditions (within the range retained for the effective effort) had a significant influence on the value of esw for both the fin whale (*Balaenoptera physalus*) and the striped dolphin (*Stenella coeruleoalba*) (Gannier, 1995). Consequently, the rates N/L_i were estimated with the software "Distance 2.0" (Laake *et al.*, 1993), and retained as indicators of the abundance. The relative seasonal abundances for each species are then expressed taking the respective summer level for reference.

RESULTS AND DISCUSSION During the summer, 464 observations of six species of cetacean were made (Table 2). Three species were also observed throughout the rest of the year: the striped dolphin (68 sightings), the Risso's dolphin (*Grampus griseus*) (13 sightings) and the fin whale (12 sightings). The pilot whale, the sperm whale, and the common dolphin are apparently absent from the area from November to April. The Risso's dolphin was frequently observed during the autumn and winter.

Table 2 Seasonal variation in the number of sightings for six species of cetacean (bottlenose dolphin excluded)

SPECIES/ SEASON	STRIPED DOLPHIN	PILOT WHALE	FIN WHALE	RISSO'S DOLPHIN	COMMON DOLPHIN	SPERM WHALE
summer	287	15	142	8	2	10
autumn	25	1	2	2	0	0
winter	29	0	3	5	0	0
spring	14	0	7	6	0	0

For the striped dolphin, a summer abundance index of 1.27 individual.mile^{-1} was calculated (Table 3). The abundance decreased steadily from its summer level to a relative minimum of 11% in spring (March/April). The results suggest that abundance increases between May and June (Fig. 2). The decrease of relative abundance was accompanied by the diminution of mean school size: from 17.3 in summer, to 15.0 in autumn, 9.1 in winter and 7.3 in spring. For the fin whale, estimates are impaired by a very high CV. Nevertheless, a slightly different pattern of seasonal abundance was apparent. From a summer value of 0.05 individual.mile^{-1} (Table 4), abundance decreases sharply to a relative value of 22.9% in autumn and 9.6% in winter, but a partial recovery in abundance was noted early in spring. For Risso's dolphins, the abundance index displays huge CVs, therefore, no patterns of seasonal variation could be determined at all. A comparison made with the results obtained by Marini *et al.* (1992) in the central Tyrrhenian Sea shows that seasonal variation in abundance is much higher in our area.

From an ecological point of view, our results on the seasonal variation in abundance seem reasonable: a proportion of the fin whale population may feed on euphausiid swarms assembled for reproduction in the north of the basin, since the krill *Meganyctiphanes norvegica* starts its breeding season in February to March. The striped dolphin, feeding on prey from higher trophic levels, are thought to have their greatest biomass later. Part of the striped dolphin population may migrate after the superficial temperature has increased in the north of the basin: the temperature stays below 14°C until April, and reaches a maximum in August.

Table 3 Index of abundance (N/L) of the fin whale and striped dolphin (number of individuals.mile^{-1}, CV in %)

SEASON	WINTER	SPRING	SUMMER	AUTUMN
fin whale	0.0048 (76)	0.0115 (44)	0.0501 (18)	0.0115 (81)
striped dolphin	0.41 (28)	0.14 (46)	1.27 (12)	0.83 (25)

Table 4 Relative abundance of the fin whale and the striped dolphin (% of the summer level, CV in %)

SEASON SPECIES	WINTER	SPRING	SUMMER	AUTUMN
fin whale	9.6 (78)	22.9 (48)	100	22.9 (83)
striped dolphin	32.3 (31)	11.0 (48)	100	65.3 (28)

CONCLUSIONS This research is a first step towards an understanding of the seasonal status of the different species within the basin and in adjacent waters. It raises interesting questions: for example, is there a true “resident” population of striped dolphin?

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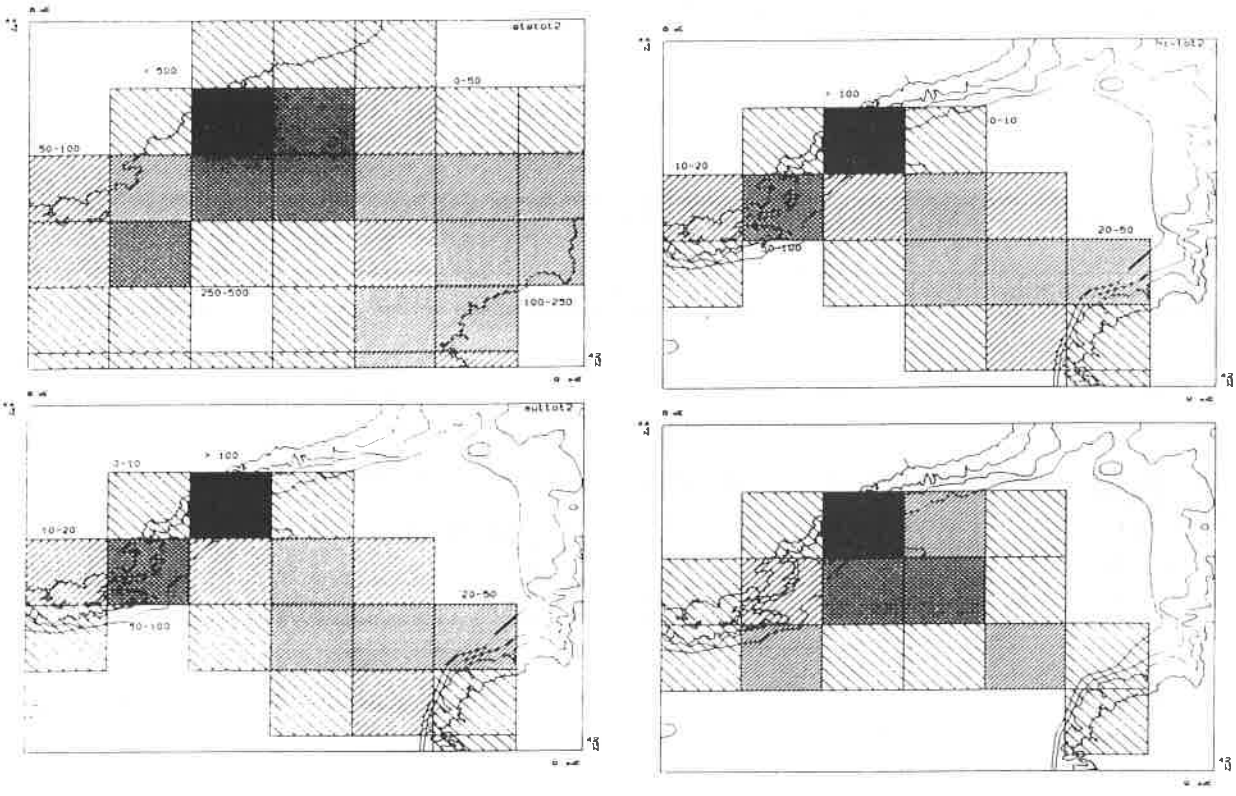

Fig. 1 Map showing the study area and regional variation in sampling effort (top left: summer; below left: autumn; top right: winter; below right: spring)

SUMMER ABUNDANCE ESTIMATES OF STRIPED DOLPHINS AND FIN WHALES IN THE AREA OF THE FUTURE INTERNATIONAL MARINE SANCTUARY (N.W. SPAIN)

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INTRODUCTION The tri-national agreement of March 1993 defined the limits of a future International Marine Sanctuary in the Ligurio-Provençal basin. During the summer of 1996, we made a survey to estimate the abundance of the fin whale (*Balaenoptera physalus*) and the striped dolphin (*Stenella coeruleoalba*) within these limits.

MATERIAL AND METHODS The platform is an auxiliary sloop of 12 metres with 80 HP diesel. The sampling was conducted on diesel propulsion at an average speed of six knots. The crew included six persons and the equipment consisted of two binoculars with compass and reticle, and two GPS. A towed hydrophone and a dual frequency echo-sounder were also used. The sampling was conducted from the wind speed, the light conditions, and the sea state (Table 1). Initially, a series of 10 legs was designed to cover the area off the 200 metres depth line from July 16th to August 15th. The meteorological conditions imposed to reduce the number of legs. A total effective effort of 1,399 km was achieved from July 16th to August 9th (Fig. 1). Four observers shared the frontal sector: one searched the +/- 45° sector from the front of the mast, two observers searching 30° to 90° each side from the top, and one observer in the cockpit (also secretary). A passing mode was preferred to study the response to the platform: with calm sea, the dolphin's movement was tracked until the group was abeam.

The Line Transect Method is used for the analysis of the data (Buckland *et al.*, 1993) We assume the probability of detection on the line is unity ($g_0 = 1$):

$$D = (n/L) \times (1/2.\underline{esw}) \times \underline{S}$$

Calculations were made with Distance 2.1 software (Laake *et al.*, 1994) and a bootstrap analysis (n = 1,000) was performed to estimate the variance and the confidence interval. A correction of the detection rate was necessary to account for low speed of the platform. The correction factor is calculated for both species, following a model presented elsewhere (Gannier, 1995, 1997). The average speed of the cetaceans was calculated from speed estimates made during the survey.

RESULTS 144 sightings of cetaceans were made during the survey, including 49 primary detections of fin whale, 89 primary detections of striped dolphin, two of Risso's dolphin, two of pilot whale and two of sperm whale. Groups of more than two fin whales and schools of more than 30 striped dolphins were rarely encountered (Figs. 2 and 3). The fin whales were not observed north-east of a line Cap Corse-Imperia and were less common south of Gulf of Sagone (42°N). They were essentially found off the 2,000 m depth line.

The striped dolphins were more evenly distributed in the area of study, although heterogeneously, and were sometimes found close to the coast (less than two miles). Abundance estimates were made by fitting a hazard rate function to the histogram of perpendicular distances, using the Akaike selection criterion.

Table 1: Definition of a visibility index from the environnemental conditions.

wind speed kts	0,1	2-5	6-10	11-16	17-21	22-35
basic visibility index	6	5	4	3	2	1
downgraded visibility index°	5	4	3	2	1	1

(°) the downgraded index is selected in case of cloudy weather, swell and low incidence sun rays (20 °)

Table 2: Estimate of abundance for the fin whale

FIN WHALE	point estimate CV (%)	confidence interval (95%)
effective search half width (meters)	813 (16.1%)	589 to 1122
mean group size (individuals)	1.14 (6.2%)	1.00 to 1.29
detection rate (school per nautical mille)	0.044 (26.6%)	0.023 to 0.082
density D (individual per km^2)	0.0167 (20.7%)	0.010 to 0.023
abundance N (individuals)	839 (20.7%)	between 522 and 1156

Table 3: Estimate of abundance for the fin whale

STRIPED DOLPHIN	point estimate CV (%)	confidence interval (95%)
effective search half width (meters)	622 (12%)	489 to 791
mean group size (individuals)	16.4 (10.2%)	13.3 to 20.1
detection rate (school per nautical mille)	0.077 (21.8%)	0.046 to 0.127
density D (individual per km^2)	0,55 (17.3%)	0.37 to 0.72
abundance N (individuals)	27445 (17.3%)	between 18538 and 36167

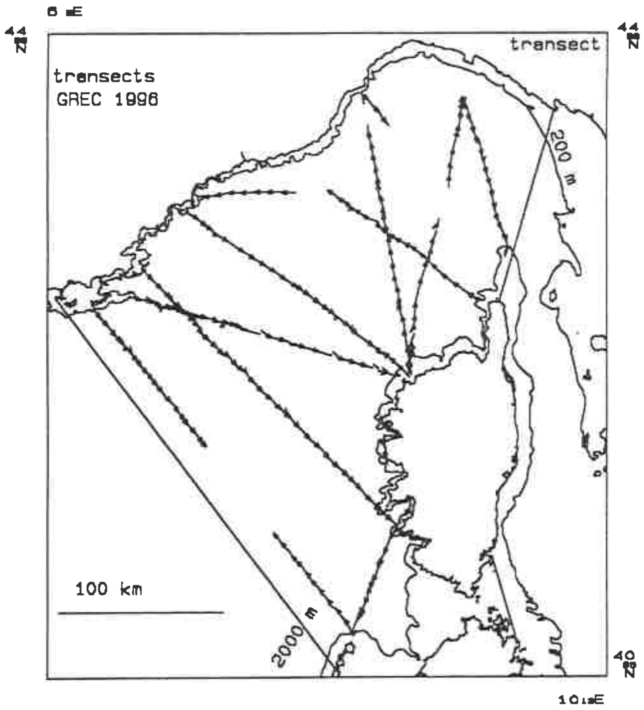

Fig 1: Area of study and sampling.

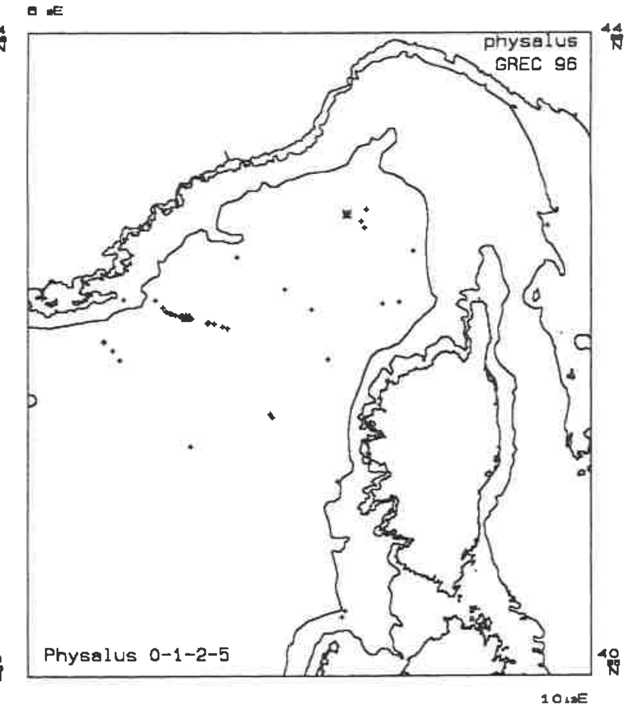

Fig. 2: Fin whale sightings (small cross= 1 ind., large cross= 2 ind., star= 3 or 4 ind.)

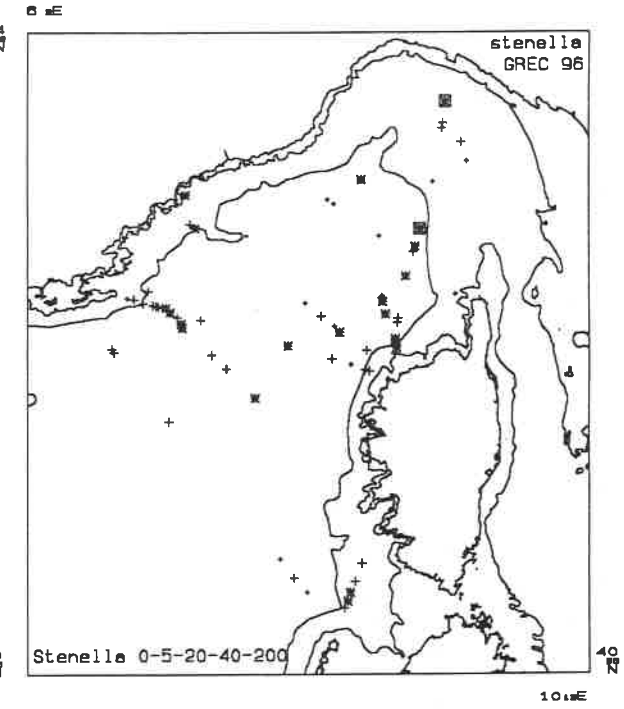

Fig. 3: Striped dolphin sightings (small cross= 0-5 ind., large cross= 6-20 ind., star= 21-40 ind., square= 41-200 ind.))

For the fin whale, an effective search half-width of 813 m was estimated, and density of 0.0167 whale per km^2 (CV = 20.7%) was found. The mean group size was only 1.14 (Table 2). For the striped dolphin, an effective search half-width of 622 m was estimated, and a density of 0.55 dolphin per km^2 (CV = 17.3%) was found (Table 3). The mean group size was 16.4. The analysis of 23 sightings indicated that the response to the platform was not significant.

DISCUSSION The fin whale density (0.017 indiv./km^2) lies within the range of estimates proposed in the litterature for nearby sectors: it is equal to that proposed by Natabartolo di Sciara *et al.* (1993). Forcada *et al* (1993) proposed a density of 0.024 (33%) for the western Mediterranean, Gannier (1995) showed that densities vary locally from one year to the next. The striped dolphin density (0.55) lies within the range of previous estimates in the region. It is higher than that of 0.43 given by Notarbartolo di Sciara *et al.* (1993), and lower than the density of 0.75, estimated by Gannier (1995) with sampling excluding the north-east of the basin.

The low school size obtained for whales (1.14 instead the usual value of 1.5) is intriguing: continuous measurements have shown that superficial temperature stayed 2°C lower than usually (22°C-26°C) during the survey. A continuous monitoring of the echo-sounder showed the rarity of large and compact scatterers (thought to be krill swarms) below the surface. Moreover, during the survey, red excrements of whale (indicators of krill ingestion) were not seen. The summer of 1996 was perhaps one of low trophic conditions, such as occurred in 1993.

CONCLUSIONS The results are the first available for the area of the future sanctuary, and are consistent with those obtained earlier in the same region. Annual monitoring of cetacean abundance in the area is feasible with an inexpensive platform and the existing methodology.

ACKNOWLEDGEMENTS I thank the Ministère de l'Environnement which funded this study, and the benevolent observers who made it possible, including very experienced persons like S. Arnaud, O. Gannier, L. David, and N. Di-Méglio (EPHE, Montpellier).

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THE THIRD WWF RESEARCH CAMPAIGN IN THE LIGURIAN SEA

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In the summer of 1994, 1995 and 1996, research campaigns were organised by WWF-Liguria to describe the species composition and distribution of cetaceans in the Ligurian Sea. The aim of this paper is to present the results of the summer '96 survey, and to compare these results with those of summer '94 and '95.

Two 14 m sailing boats surveyed the West Ligurian Sea from Genova to Bordighera. During 27 days of surveying, 149 hours of observation and 641 nautical miles of sailing, 14 sightings were made and six species identified: striped dolphins (*Stenella coeruleoalba*), bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*), Risso's dolphins (*Grampus griseus*), long-finned pilot whales (*Globicephala melas*) and Cuvier's beaked whales (*Ziphius cavirostris*).

Striped dolphins were sighted eight times; common dolphins were sighted once, in association with striped dolphins; solitary sightings of bottlenose dolphins, Risso's dolphins, long-finned pilot whales and Cuvier's beaked were recorded; and, for one sighting, it was not possible to identify the species.

Some differences were noted between data collected in summer '94 and summer '95. In summer '94, 23 sightings were recorded and three species were identified: striped dolphins, bottlenose dolphins, Risso's dolphins and, in addition, a single balaenopterid. In summer '95, 13 sightings were made, and three species were identified: striped dolphins, bottlenose dolphins, fin whales (*Balaenoptera physalus*) and, also, one unidentified balaenopterid.

FIRST AERIAL SURVEY IN THE NORTH-WEST MEDITERRANEAN: PRELIMINARY RESULTS

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INTRODUCTION If a few aerial surveys have been made in the Mediterranean to obtain several cetacean observations, no particular methodology has been applied up to now, to display the distribution of animals or to evaluate their populations. This proven technique, although expensive, is nevertheless applied successfully in different parts of the world. Having been given the opportunity to use a hydroplane for several days, it was decided that a preliminary systematic survey should be carried out on the distribution of cetacean species in the northern part of the western Mediterranean basin; these preliminary results are presented in this paper.

MATERIALS AND METHODS

Area sampled and survey period The surveyed zone extends over 60,000 km^2, bordered by the cities of Marseille, Perpignan, Ajaccio, and Cape Corsica and Cape Melle (Fig. 1). Diverse meteorological requirements, the need to obtain survey permission, and the availability of both the hydroplane and the observers dictated that the flights took place over four days: the 12th, 13th, 16th and 17th of July, 1996.

Methodology A 4-person hydroplane with two onboard observers was utilised. "Zigzag" strip transects were covered, beyond the 200 m isobar, covering a total distance of 1,540 nautical miles. The width of the surveyed strip was calculated utilising markers on the rigging and on the windows of the plane, i.e. a width of over 3,000 m (1,500 m on each side). After preliminary attempts, we decided to adopt a velocity of 100 knots and to fly at an altitude of 1,000 feet (305 m). The transects generally lasted no more than two hours and were carried out, for the most part, between 11 am and 1 pm, in good weather conditions, with a sea state of less than Beaufort force 3.

RESULTS Four species of cetacean were observed: fin whales, *Balaenoptera physalus* (28 sightings); striped dolphins, *Stenella coeruleoalba* (38); Risso's dolphins, *Grampus griseus* (5); and long-finned pilot whales, *Globicephala melas* (1). These animals were more common beyond a depth of 2,000 m and few were seen in the area surrounding Corsica.

Fin whales (Fig. 1) displayed a heterogeneous distribution: they were rare north-east of a line between Cannes and Porto. In the east of the surveyed area, the animals primarily frequented waters deeper than 2,000 m. An important concentration appears at the centre of the loop formed by the Liguro-Provençal current. In the Gulf of Lyon, numerous individuals ventured into waters between 1,000 and 2,000 m in depth. On the whole, the average size of the groups (1.25 individuals) was less than that found in previous years: 1.66 in 1994 (n = 66) and 1.57 in 1995 (n = 79). The total density (0.0075 individuals.km^{-2}, CV = 28.7%, Gannier *et al.*, in press) was low compared to that of 0.017 obtained for the same area by Notarbartolo *et al.* (1993), or Gannier (1995, 1997): a maximum of 0.018 in 1991, a minimum of 0.011 in 1993. This unusual distribution could be related to specific trophic conditions induced by a particularly unfavourable meteorological situation in the spring of that year. However, it could also reflect the fact that the animals may be taking deeper dives and, thus, are present on the surface for shorter intervals.

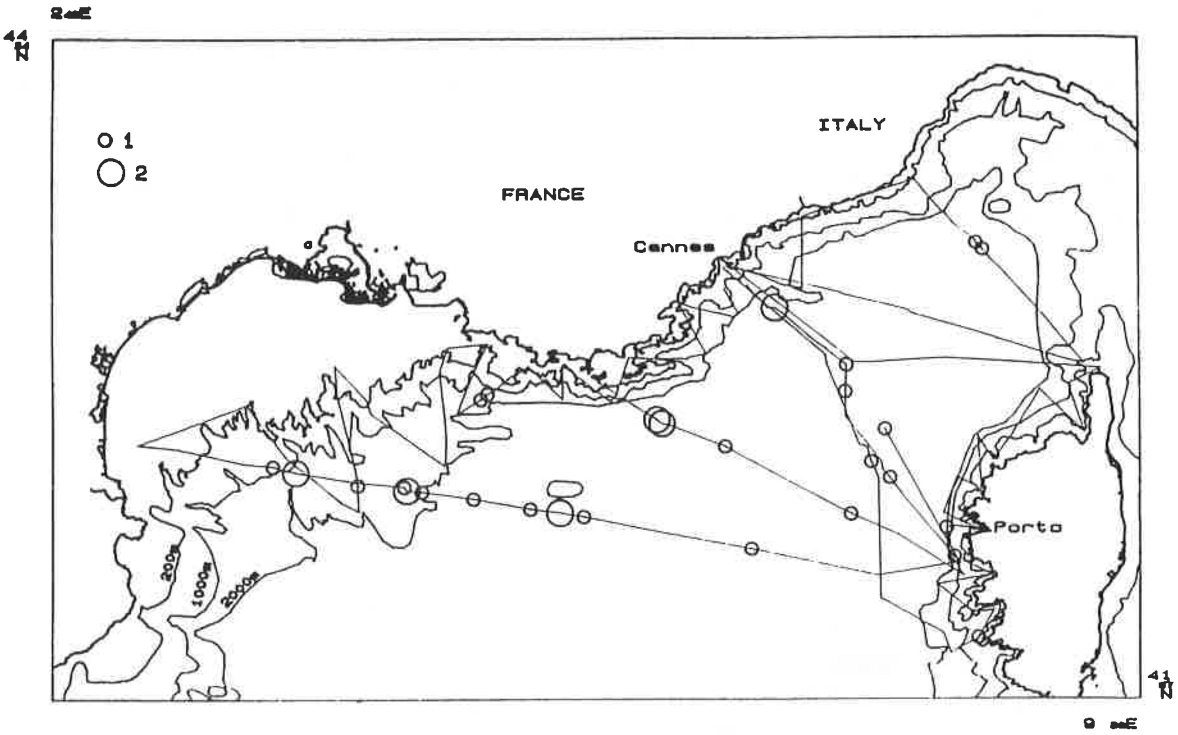

Fig. 1 The 28 sightings of *Balaenoptera physalus* during the aerial survey.

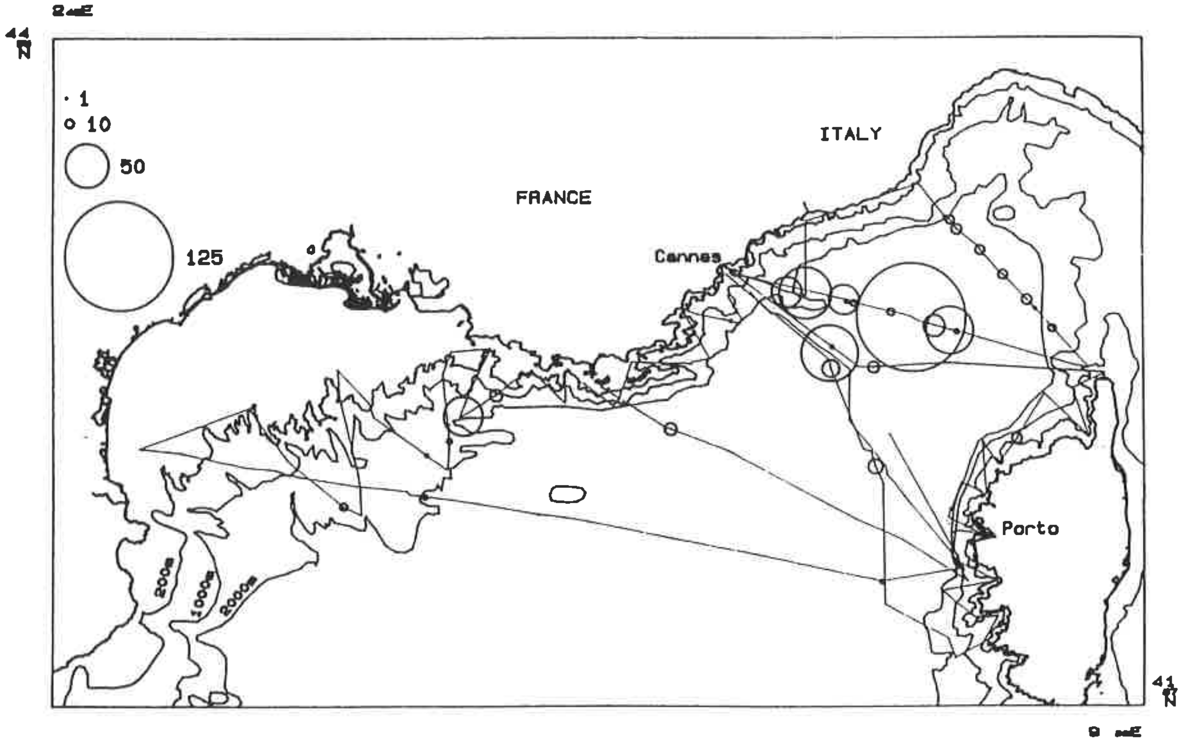

Fig. 2 The 38 sightings of *Stenella coeruleoalba* during the aerial survey.

The distribution of striped dolphins (Fig. 2) was the opposite to that of fin whales: they were concentrated north of the Porto-Cannes line and were less common further west. During the day, most striped dolphins frequent the open sea. The remainder were sighted above the deepest portions of the edge of the continental shelf. The mean group size of 17.94 individuals was congruent with average values recorded previously from boat surveys: 13.48 (n = 73 in 1995) - 19.11 (n = 139 in 1994). In addition, groups found furthest from the coast comprised more individuals (mean = 21.4, n = 25) than those found on the shelf-edge (mean = 11.3, n = 13).

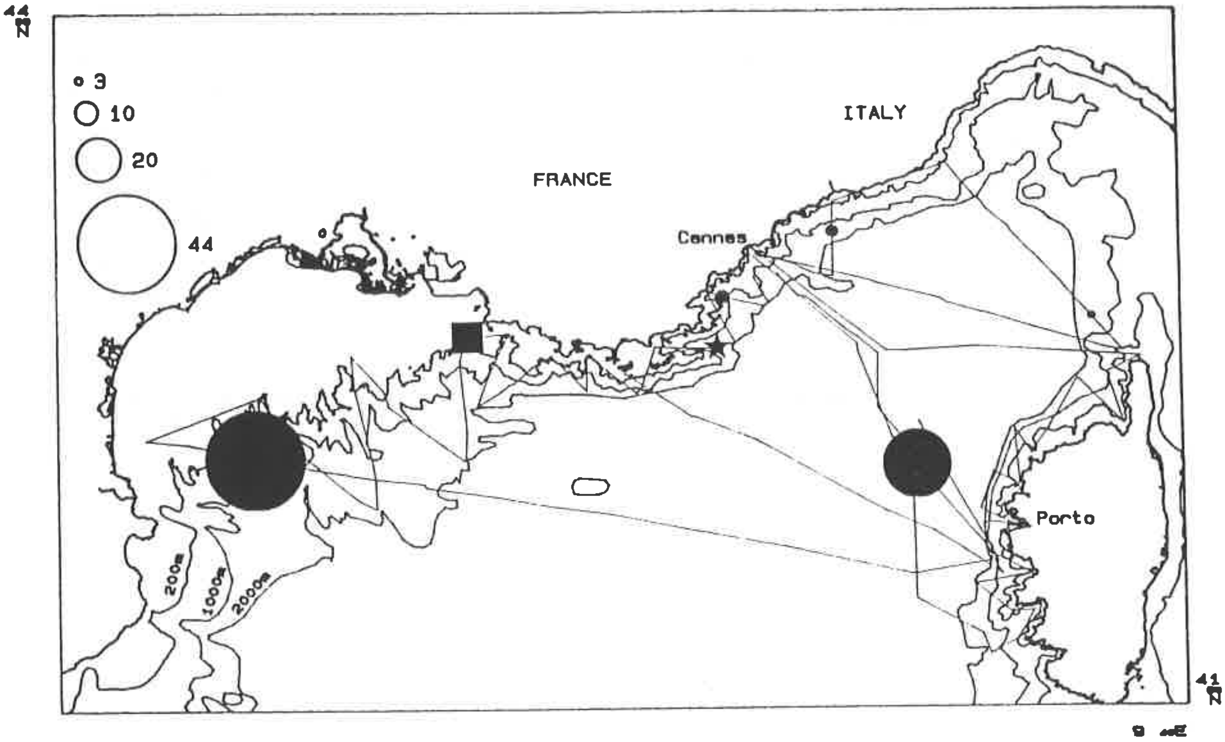

Fig. 3 The 5 sightings of *Grampus griseus* (circles), 1 of *Globicephala melas*(star) and 1 of *Tursiops truncatus* (square) during the aerial survey.

Apart from an important school noted a little off the coast of Corsica, all the groups of Risso's dolphins (Fig. 3) were recorded above the edge of the continental shelf, throughout the whole area, but showed a marked preference to areas above submarine canyons. Long-finned pilot whales (Fig. 3) were observed only once (a group of five individuals) above a submarine canyon off the coast of Provence (France).

The long-finned pilot whale (Fig. 3) was seen only once (a group of five individuals) in a canyon off the coast of Provence (in France).

An almost certain observation of 12 bottlenose dolphins (Fig. 3) occurred off the coast of Marseille, where individuals have been fairly often indicated these last few years.

CONCLUSIONS Aerial surveys permit the rapid sampling of a vast area and the usefulness of this kind of survey in the assessment and management of wildlife populations is proven . However, the use of this method in sea states of less than Beaufort force 3 seems to favour the chances of locating delphinids. The above study was immediately followed (17 - 30 July) by a line-transect boat survey. It is hoped that by comparing the results acquired by these two techniques, a clearer picture will be obtained of cetacean abundance in the north-west Mediterranean.

ACKNOWLEDGEMENTS We wish to thank the "Centre Océanologique Européen" (Monaco), Prince Khaled Bin Sultan Bin Abdulaziz (Saudi Arabia) and I.C.S.E.M. (Monaco) for their very considerable help.

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A LONG-TERM SURVEY ON DISTRIBUTION AND DYNAMICS OF CETACEANS ALONG THE SOUTH-EASTERN COAST OF SPAIN: FIVE YEARS OF RESEARCH, 1992-1996

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Since the beginning of this research programme in 1992, the "Toftevaag" has sailed 351 transects covering a total of 8,808 nautical miles under effort, in the region of the north-eastern Alboran along the coasts of Murcia and Almería (Spain).

In parallel to analysis carried out with the help of IFAW's "Logger" programme, unit effort calculations are made for each depth range within the predetermined quadrants and for different sea conditions. The encounter rate calculations only take into account effort with a sea state under 3 (Douglas). Photo-identification is used for several of the most common species encountered, as well as filming of behaviour and social structure both on the surface and underwater.

During the first five years of surveying, 745 sightings have been made, spending 425.5 hours on sighting data collection, photo-identification and behaviour recordings. The most frequently sighted species are the striped dolphin (*Stenella coeruleoalba*) and common dolphin (*Delphinus delphis*), followed by the long-finned pilot whale (*Globicephela melas*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*) and sperm whale (*Physeter catodon*). Fin whales (*Balaenoptera physalus*) have been seen on very rare occasions migrating through the area, as well as Cuvier's beaked whale (*Ziphius cavirostris*) and false killer whale (*Pseudorca crassidens*) which has been seen only once, during 1995. In 1996, the first sighting of northern bottlenose whale (*Hyperoodon ampullatus*) was made in the Mediterranean.

HARBOUR PORPOISE *PHOCOENA PHOCOENA* MONITORING ON THE DUTCH SECTOR OF THE NORTH SEA

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INTRODUCTION In December 1984, an aerial monitoring program was started by the Dutch National Institute for Coastal and Marine Management (RIKZ). The objective of these systematic surveys was to obtain information to map the distribution of seabirds and to quantify changes in their numbers and distribution on the Dutch Continental Shelf (DCS). These surveys appeared to be suitable also for sightings of cetaceans. Currently, it is the main Dutch programme to monitor (and collect basic information on) trends in abundance on the basis of systematic surveys. This is the only longterm systematic survey program conducted in this area.

METHODS The survey has been designed to monitor the DCS in three days. Counts were performed every two months using a fixed route (Figure 1). Strip transect methodology was used flying at an altitude of 150 ft. Two strips of c 150 m width were, weather permitting (i.e. sunglare), one on each side of the plane. For navigation we used GPS. Sampled area is calculated using transect-width and count-time, and is approximately 1km^2 per two-min. count.

RESULTS

Numbers Between Dec 1984 and Dec 1996, 367 harbour porpoises (*Phocoena phocoena*) in 278 groups were observed in the transect. The number of encounters increased during the 1990's (Figure 2). Bi-monthly numbers of harbour porpoise pods per 1,000 km^2 surveyed varied between zero and 35 up to June 1995. After this date numbers increased further, to a maximum of 113 groups per 1,000 km^2 in April 1996. Perhaps surprisingly, mean group size did not change and remained at c. 1.3 animals per pod.

From the counts in 1996, we extrapolated the number of harbour porpoises observed to the whole DCS-area, using Universal Block Kriging as a gridding-method. The numbers obtained in this way (Table 1) are uncorrected for animals not visible at the surface.

Table 1. Calculated numbers per two month period in 1996 on the DCS

1996 Period	02/03	04/05	06/07	08/09	10/11	12/01
Calculated numbers of Harbour Porpoise	1,564	10,965	6,626	3,297	712	2,401

Distribution The bi-monthly distribution is presented in Figure 3. When viewing the distribution maps, one should keep in mind that we used a fixed route. However, it is clear from Figure 3 that harbour porpoises were rarely encountered in the southern part of the DCS. There also seems to be seasonal shifts in distribution. During May through September, almost all pods were seen well away from coastal waters. From October onwards, an increasing number of pods were seen in the coastal zone, well inside the 20 metre depth line.

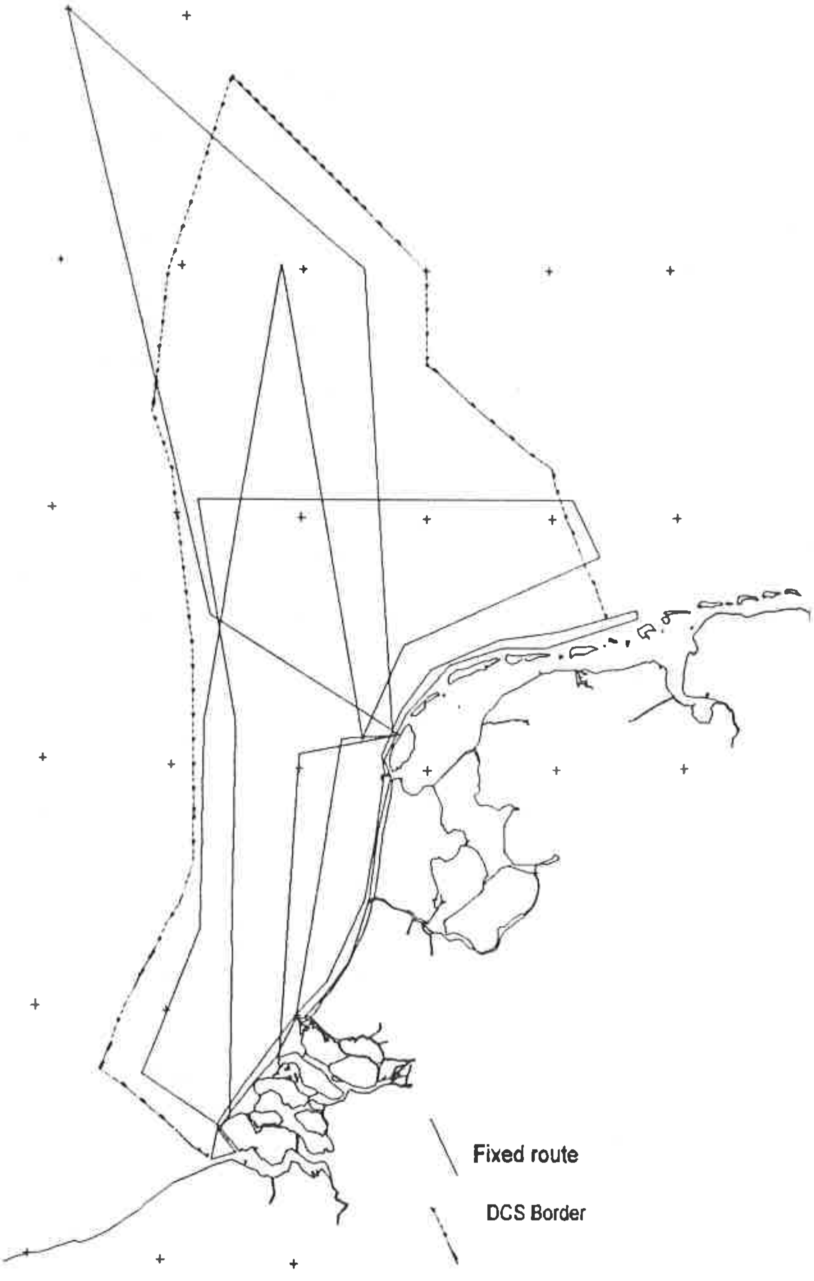

Fig. 1. Fixed routes used in the monitoring programme

DISCUSSION & PROBLEMS

There are three questions that need to be posed:
1) What fraction of harbour porpoises present do we actually see?
2) What factors influence the detectability of harbour porpoises?
3) What are the main influences upon the distribution on the DCS?

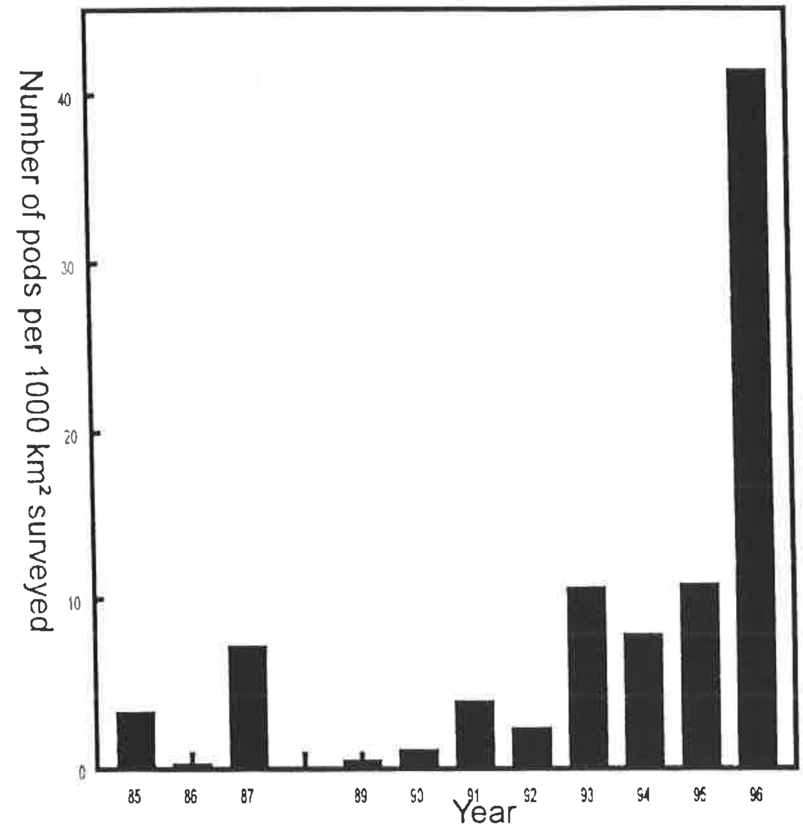

Figure 2 Number of pods encountered per 1,000 km^2 surveyed, per year

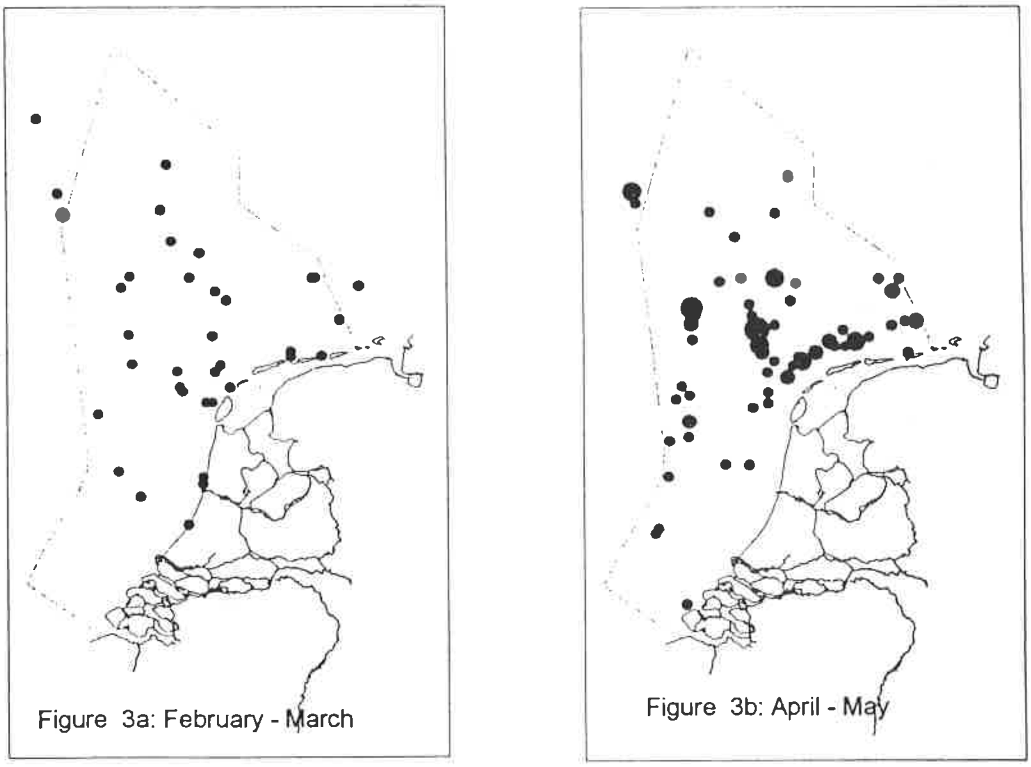

Figure 3a: February - March

Figure 3b: April - May

Fig. 3 Distribution of harbour porpoise pods (1985-96)
(a) Feb-Mar; (b) Apr-May

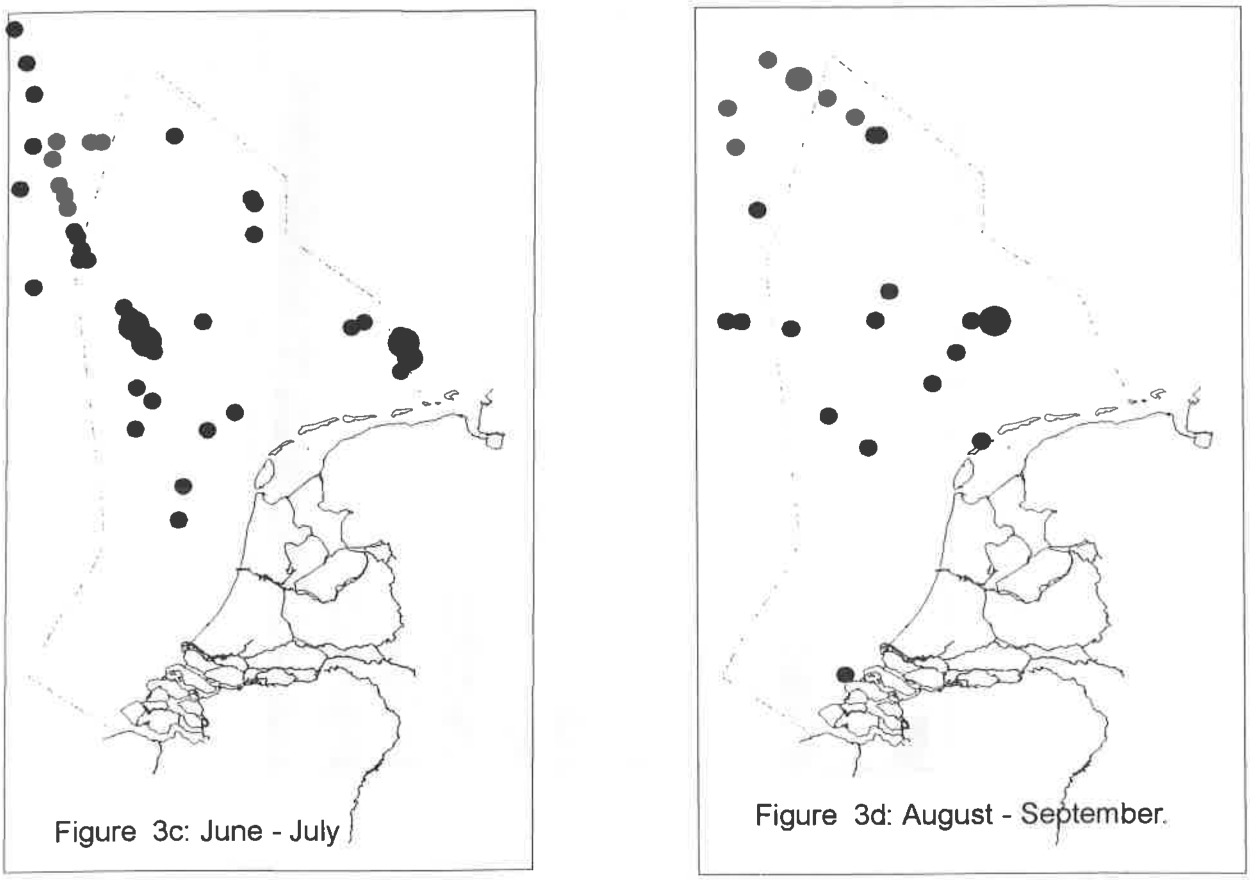

Figure 3c: June - July

Figure 3d: August - September.

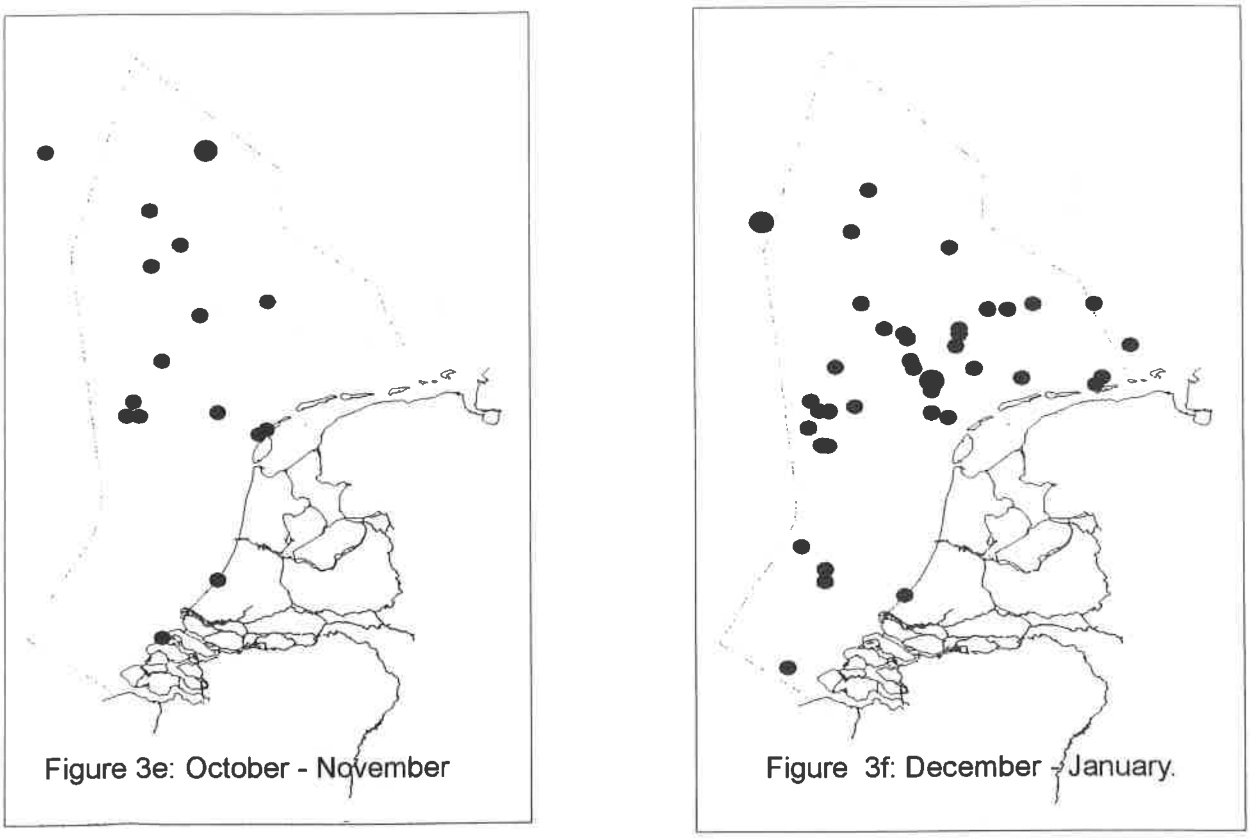

Figure 3e: October - November

Figure 3f: December - January.

Fig. 3 (cont.) Distribution of harbour porpoise pods (1985-96)
(c) June-July; (d) Aug-Sept; (e) Oct-Nov; (f) Dec-Jan

CETACEAN SIGHTINGS OFF THE EAST COAST OF THE ISLE OF LEWIS, SCOTLAND

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INTRODUCTION The Risso's Dolphin Project was initiated in 1995 to survey the coastal waters around the Eye Peninsula, Isle of Lewis, Scotland. The main research foci for this group were photo-identification, behavioural and acoustic studies upon the Risso's dolphin (*Grampus griseus*). However, during surveys for this particular dolphin several other species of cetacean were observed and the details of each sightings were recorded.

MATERIALS AND METHODS Boat surveys were conducted from a 24ft Hardy fishing boat, between 9th May 1996 and 3rd October 1996, covering the area between Tolsta Head (58° 21'N, 6° 09'W) and Kebock Head (58° 02'N, 6° 21'W). On four occasions, the surveys were conducted outside this area, as far south as the Isle of Skye. Survey effort and environmental data were recorded throughout the surveys using the LOGGER computer program (IFAW) on a laptop computer aboard the vessel. When cetaceans were encountered, the date, time, species, and number of individuals were noted, together with their general behaviour. Land watches from headlands were also conducted on days when the weather did not permit boat surveys. The locations of the sightings were analysed to investigate the habitat use of each species.

RESULTS A total of 48 boat surveys were conducted, with the total survey effort amounting to 262 h 45 min. Thirteen land surveys were conducted for a total effort of 62 hours. A total of 236 sightings were made, comprising seven species of cetaceans. There were 94 sightings of harbour porpoises (*Phocoena phocoena*); 64 sightings of Risso's dolphins (*Grampus griseus*); 54 sightings of minke whales (*Balaenoptera acutorostrata*); 19 sightings of white-beaked dolphins (*Lagenorhynchus albirostris*); three sightings of Atlantic white-sided dolphins (*Lagenorhynchus acutus*); one sighting of killer whales (*Orcinus orca*); and one sighting of common dolphins (*Delphinus delphis*). The number of sightings per month, for each species, are presented in Table 1.

DISCUSSION The above results demonstrate that the survey area is frequented by several species of cetacean. The ranges of all the species overlap, except for the common dolphin. However, there are also distinct areas which certain species favour. The main differences appear to be between Risso's dolphins and the other species. Risso's dolphins and harbour porpoises were regularly sighted in nearshore waters, in depths of 30 m or less; whereas the other species tended to be found in deeper water.

Table 1. Cetacean sightings off the eastern coast of the Isle of Lewis during summer 1996

Month	HARBOUR PORPOISE	RISSO'S DOLPHIN	MINKE WHALE	WHITE-BEAKED DOLPHIN	ATLANTIC WHITE-SIDED DOLPHIN	COMMON DOLPHIN	KILLER WHALE	No of surveys
May	4	10	1	-	-	-	-	11
June	13	5	15	6	-	1	-	13
July	33	3	15	7	-	-	-	6
Aug	33	17	19	2	-	-	-	15
Sept	11	27	4	4	3	-	1	14
Oct	-	2	-	-	-	-	-	2
Total	94	64	54	19	3	1	1	61

Risso's dolphins, in contrast to the other species, tend not to favour the area north of Tiumpan Head, up to Tolsta Head and beyond. Minke whales, harbour porpoises, and white-beaked dolphins were regularly sighted north of Tiumpan Head, especially around Tolsta Head.

The distribution of the different species will be largely influenced by the distribution of their prey species. Minke whales and harbour porpoises were often sighted in the same vicinity during the surveys. Dietary analysis of harbour porpoise strandings suggest that sandeels (Ammodytidae) are the main prey item during the summer months (Santos *et al.*, 1995). Sandeels form an important part of the food chain supporting many other fish species including herring, mackerel and gadoids such as cod, saithe, pollack and whiting. The diet of minke whales from Scottish waters is known to consist mainly of herring, mackerel, and sandeels (Stephenson, 1951).

The seabed sediment around Tolsta Head consists predominantly of sand, which is ideal for sandeels. The area close inshore around the Eye Peninsula and in the bays, especially Branahuie Bay, where the Risso's dolphins are regularly sighted, has a more rocky seabed. This is more suited to the octopus *Eledone cirrhosa*, which has been shown to be the major prey item found in the stomachs of stranded Risso's dolphins from Scottish waters (Santos *et al.*, 1995). Dietary analysis of white-beaked dolphins has shown that whiting, cod, herring and mackerel are the main prey consumed, although cephalopods are also important (Smeenk & Gaemers, 1987; Evans, 1987; Santos *et al.*, 1995). White-beaked dolphins were often seen in association with the Risso's dolphin, but not in the shallow inshore waters. Atlantic white-sided dolphins are primarily fish eaters with mackerel, silvery pout, blue whiting, whiting, and herring mainly recorded, but cephalopods are also consumed (Smeenk & Gaemers, 1987; Evans, 1987; Berrow & Rogan, 1997). These two species have overlapping distributions, but Atlantic white-sided dolphins tend to occupy the continental slope, whereas white-beaked dolphins mainly inhabit the continental shelf.

The distribution of the common dolphin is broadly allopatric with those of the white-beaked dolphin and the Atlantic white-sided dolphin. During the surveys, common dolphins were only seen once: when the survey extended beyond the usual area, towards the Isle of Skye. The results of this survey has further highlighted the richness of the Hebridean waters for cetaceans.

ACKNOWLEDGEMENTS We would to thank the following for their help with finance, equipment and support: the Whale and Dolphin Conservation Society, the Mammal Conservation Trust, The Manifold Trust, the Scottish International Education Trust, the Carnegie Trust for the Universities of Scotland, the Sea Watch Foundation, Dr. Jonathan Gordon (International Fund for Animal Welfare), Clive Menhenett (Magrec Ltd.), David and Louisa Henriques, Rene Swift, Lori Lawson, Sara MacFarlane and Carla Benoldi.

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CETACEAN SIGHTING SURVEY IN THE ANTARCTIC PENINSULA REGION

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INTRODUCTION Cruise ANT XIV/2 of the German research vessel R/V "Polarstern", from 12th November 1996 until 1st January 1997, was conducted in the region of the South Shetland Islands. The main objectives of this cruise were to conduct oceanographic, fishery and krill research around Elephant Island. During this cruise, a group of four students were able to use the ship as a so-called "platform of opportunity" to conduct a cetacean survey along the ship´s track. In addition, the ship´s helicopters were utilised for aerial observations. This paper presents the first results of the survey. The data collected will be analysed in detail in a diploma thesis by H. Pankow.

MATERIALS AND METHODS

Shipbound Survey The ship was used as a "platform of opportunity", i.e. the survey design and methodology had to be adjusted in order not to interfere with the main objectives of the cruise. As a consequence, a modified line- and point-transect survey was carried out. Observations covered the whole daylight period, weather permitting. The observation platform was the ship's crow's nest which was at a height of 27 m above sea level.

Aerial Survey Aerial helicopter surveys were carried out in addition to the shipbound survey. Flights were conducted at an altitude of 500-1,000 ft and a speed of 100 knots. Using the line-transect method, the transects were designed in the shape of a square with a leg length of approximately 25 nautical miles. When animals were sighted, the helicopter approached the whales in order to determine species and the number of animals present.

Table 1 The number of animals sighted during the cruise, comparing the sightings gathered from seaborne and aerial survey techniques

NUMBER OF ANIMALS	FROM SHIP	FROM HELICOPTER
Identified animals	97	85
Unidentified animals	147	0
Total	244	85

RESULTS A total of 329 animals were sighted throughout this survey. Some species were detected either during aerial survey or shipbound survey only (Fig. 1). All whales observed from the helicopter could be identified, whereas from the ship only 40% of all animals could be determined to species level (Table 1). Of all the individuals identified, almost 50% were fin whales *Balaenoptera physalus*, whilst humpback whales *Megaptera novaeangliae*, were the second most abundant species. They were mainly found as solitary animals or in groups of two in coastal areas. Fin whales were often seen in groups of several animals at a latitude of approximately 60° S. It was assumed that a large number of unidentified groups of whales north of Elephant Island were also fin whales.

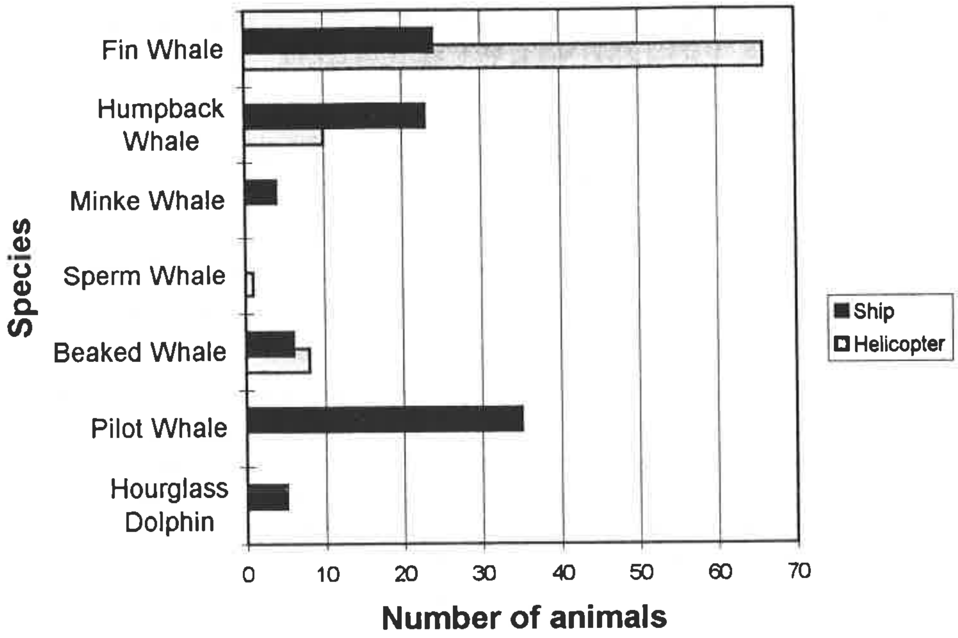

Fig. 1 The number of animals identified to species level during the cruise

CONCLUSIONS Participation in the cruise ANT XIV/2 provided an excellent opportunity to collect information on whale distribution and abundance in relation to bathymetric and oceanographic features and plankton distribution. Also, adaptations of the standard line- and point-transect survey methods were required. The use of helicopters turned out to be an excellent addition to the shipbound survey. The identification of whales encountered during the survey was facilitated and, furthermore, areas off the ship´s track could also be covered.

ACKNOWLEDGEMENTS We would like to thank the AWI (Alfred Wegener Institute for Polar and Marine Research, Germany) for providing us with the opportunity to join the "Polarstern" cruise, as well as for allowing the use of the ship´s helicopters for this project.

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CETACEANS IN THE INDONESIAN ARCHIPELAGO: A PRELIMINARY CHECKLIST

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Indonesia is an island nation, comprising over 13,700 islands and extending from approximately 6° N to 10° S and from about 95° E to 142° E. Although Indonesia is known as a former whaling ground for sperm whales, hunted by "Yankee" whalers in the 19th century, the abundance and distribution of cetaceans in Indonesian waters is very poorly known. A number of reports have been published on individual species in Indonesian waters, for example on the Irrawaddy dolphin (*Orcaella brevirostris*), but there has been no comprehensive account of this area's cetacean fauna.

Reports of 29 species of cetaceans from the Indonesian Archipelago have been gleaned from published and unpublished sources, representing five families: Phocoenidae (1 species), Delphinidae (16), Ziphiidae (3), Physeteridae (3), and Balenopteridae (6). The presence of 25 species could be confirmed by skeletal material in museum collections, photographs or documentation by specialists. Pending irrefutable evidence, the occurrence of four species is regarded as still unconfirmed.

NOTES ON THE GENUS *KOGIA* IN THE INDONESIAN ARCHIPELAGO, AND A REVIEW OF RECORDS IN SOUTH-EAST ASIAN WATERS

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Only since 1966 have two species of *Kogia* been generally recognised: *Kogia breviceps* Blainville, 1838, the pygmy sperm whale, and *Kogia simus* Owen, 1866, the dwarf sperm whale. Because whales of the genus *Kogia* are only rarely identified at sea, and then usually not to species level, it is difficult to establish the distribution of the two known species.

In South-east Asian waters the genus *Kogia* has been recorded from: China, Hong Kong, Malaysia, Vietnam, the Philippines, (Taiwan), and Thailand. Only three records of *Kogia* are known from the Indonesian Archipelago: *Kogia simus* has been described by skeletal material, collected at Lamalera, Lembata Island, Eastern Nusa Tenggara; *Kogia breviceps* is known from Sarawak, Northern Borneo and north of Doberai Peninsula, Irian Jaya.

Four sightings of *Kogia simus* were recorded by the author during two field studies in Indonesian waters in 1993 and 1995. Three sightings were made in Manado Bay, north-eastern Sulawesi, in 1995. Group size ranged between one and four animals. Two animals were observed in the waters adjacent to the whaling village of Lamalera, Lembata Island, in 1993. A mandible of a specimen, captured in summer 1993 by fishermen in the village of Lamalera, was measured, photographed and identified as *Kogia simus*.

MARINE MAMMALS IN SINGAPORE AND NEARBY WATERS

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The Singapore Wild Marine Mammal Survey (SWiMMS) was started in May 1996. Its objectives are to determine species, numbers and health of local marine mammals, and to study the impact of coastal development on marine mammal habitats. In its first stage, a one-page sighting form was designed to collect standardised reports about location, species, numbers and activity of observed animals. The sighting form was distributed to diving centres, yacht clubs and maritime governmental bodies. It was later included in a Web page on the Internet where it can be filled in on-line. Publications were submitted to local newsletters and marine oriented magazines to educate the public about local marine mammals and publicise SWiMMS efforts. More than one hundred sighting forms have been received so far. A summary of the data is presented.

Four dolphin species are present in Singaporean waters: the Indo-Pacific humpback dolphin (*Sousa chinensis*), the bottlenose dolphin (*Tursiops truncatus*), the finless porpoise (*Neophocaena phocaenoides*) and the Irrawaddy dolphin (*Orcaella brevirorostris*). Their ecology and behaviour is discussed briefly. Dugongs (*Dugon dugon*) have been sighted occasionally and may constitute a breeding population. Most sightings occur north-east of Singapore around Ubin and Tekung Islands, as well as around the Southern Islands, located south of Singapore. A summary of sighting locations will be shown and potential observer bias will be examined. A visual survey is now underway on these locations to confirm sighting reports and evaluate marine mammal abundance. Preliminary results are presented.

SWiMMS is supported by Shell Eastern Petroleum.

ECOLOGY

PHOTO-IDENTIFICATION OF FIN WHALES IN THE WESTERN MEDITERRANEAN: THE FRENCH CATALOGUE

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INTRODUCTION A photo-identification catalogue aims to evaluate and study a definite population, on the basis of recognisable animals. At present, the photographs of fin whales (*Balaenoptera physalus*) in the western Mediterranean are being collated the Groupe de Recherche sur les Cétaces (GREC), Antibes (since 1989) and Montpellier University.

MATERIALS AND METHODS Fin whales were photographed a 9 m yacht, using both black and white prints and colour slides. Attempts were made to photograph both sides of an animal, but the right side of the head, the lower lip, and the front third of the whale's body was always photographed first. This was because pigmentation patterns were both broader and bolder on the right side when compared to the left. The dorsal fin was also photographed. As in Agler *et al.* (1990, 1992), a code was adopted for classifying dorsal fin types: **A**: large and broad; **B**: long, thin, pointed; **C**: triangular and massive; **D**: bent posteriorly, very hooked or falcate; **E**: short and low; **F**: with a hump on the back of the whale, at the insertion point of the dorsal fin; **O**: all remaining fin types, without a dorsal fin or unclassified. To every classification code, an "**n**" was added if the dorsal fin was nicked.

Scars and marks on both sides of the animals were also documented. These were essentially coded in relation to their shape, angle, colour and, eventually, probable cause. The most common marks were: **l**, linear and narrow scars; **r**, rails, *i.e.*, double linear marking; **f**, ladder type (linear scar intersected by perpendicular lines); **z**, slashes, small area of scars in every direction; and **c**, circular. The location of these marks on the whales were recorded by dividing the body into eight areas, four on each side: dorsal fin (right: **Δd**/ left: **Δg**); head, to the chevron (right: **1d**/ left: **1g**); flank, from chevron to dorsal fin (right: **2d**/ left: **2g**); peduncle, from dorsal fin to tail fluke (right: **3d**/ left: **3g**). This arrangement allowed for a precise description of the location of the markings and classification of the records. Ideally, all of the above eight areas should be photographed for each whale. However, as a minimum, photographs of the right side of the head (**1d**) and dorsal fin (**Δd**) were required in order to identify a fin whale. Without these photographs, a particular animal could not be included in the photo-ID catalogue, unless other markings or pigmentation patterns were particularly distinctive.

Whale sightings were given a quality index: *, **, ***, according to their increasing reliability. The more areas of the whale that are photographed, the higher the quality index would be. With a quality score of "*", re-identification of the animal could be difficult because photographs were either of too poor a quality or too few were taken to enable a subsequent match (for example, conspicuous marks could located on a part of the whale which is difficult to photograph, such as the peduncle or the left side). With a quality score of "**", the whale is identifiable, with a sufficient set of pictures, and pigmentation patterns are documented. However, the animal might not be identifiable during subsequent re-sightings. Sightings with a quality score of "***", possess many conspicuous characteristics, distributed all over the body, so it would certainly be recognised if seen again, regardless of which part of the whale is photographed.

RESULTS The GREC has by now classified 130 fin whales in the photo-identification catalogue. Montpellier University added a further 51 during 1994, of which approximately half were ** or *** records. Each whale was documented alongside precise information on sighting conditions. An average of five photographs were filed for each whale, for a total of 110 black and white prints and 487 colour pictures effectively included in the catalogue. Of the eight areas of the body, the most frequently photographed were **Δd**, **Δg**, and **1d**, followed by **2d**, **2g** and **1g**. Both sides of the whales were photographed in approximately the same proportions (Table 1). The most common dorsal fin type was type **B** and 33.8 % of the fins had one or more nicks and notches (Table 2). Out of the 130 whales recorded in the catalogue, 51 (39%) were recorded with a *** quality score. The type **A** dorsal fin shape, if not the most common, was the less conspicuous one: only eight whales were recorded with a type **A** dorsal, bereft of nicks or notches, and filed with a *** quality index. The quality index was also dependent upon the accuracy of descriptions of particular marks or scars. The number of whales having distinctive scars (types: **r, l, c & z**) on their right side are presented in Table 3: the front and centre part of the body usually featured the most distinctive markings.

Table 1 Distribution of effort in relation to the body area

Area of the body	Δd	1d	2d	3d	Δg	1g	2g	3g
number of whales pictured	77	63	61	28	70	53	60	28

Table 2 Frequency of dorsal fin types and nicks

N=130	type A	type B	type C	type D	type E	type F	type O
without nick	A : 27	B : 33	C : 5	D : 7	E : 3	F : 9	O : 2
with nicks	An : 9	Bn : 15	Cn : 6	Dn : 4	En : 1	Fn : 4	On : 5
total	tot **A**: 36	tot **B**: 48	tot **C**: 11	tot **D**: 11	tot **E**: 4	tot **F**: 13	tot **O**: 7
frequency	27.6%	36.9%	8.4%	8.4%	3%	10%	5.3%

Table 3 The distribution of marks and scars on the right side of the whales catalogued

body area code	Δd	1d	2d	3d
number of cases	11	12	25	8
frequency	19.6%	21.4%	44.6%	14.2%

DISCUSSION The dorsal fin classification system proposed in Agler *et al.* (1990, 1992) could be enhanced by adding class **F** fin types as an identification criterion. In addition, it is recommended that photographs be taken of both sides of an encountered animal, because scars and marks are equally shared between both sides.

Obtaining photographs of only the chevron and blaze (**1**) and dorsal fin (**Δ**) is unsatisfactory as most of the particular scars are situated on the flank (**2**) and peduncle (**3**) of the whales. An interesting question is: are the characteristics used for identification stable enough to be used for identification over many years (Agler, 1992).

Slooten *et al.* (1992) showed that in a Hector's dolphin population, newly acquired scars and markings rarely led to the misidentification of an individual with highly recognisable dorsal fin characteristics or pigmentation. Slooten *et al.* (1992) also recommended that the survival rate of a population should be calculated utilising the most distinctive individuals in the analysis, rather than the whole population.

Since the fin whale population of the western Mediterranean comprises over 2,000 individuals, a large amount of time-consuming survey effort will be required in the next few years, in order to obtain sufficient re-sightings of identified individuals, so that the status of the population can be ascertained.

ACKNOWLEDGEMENTS This research was funded by the French Ministry of the Environment to whom we are thankful.

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PRELIMINARY OBSERVATIONS OF FIN WHALES (*BALAENOPTERA PHYSALUS*) OFF NORTH-WESTERN SARDINIA

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INTRODUCTION In recent years, several studies have highlighted the importance of the Corso-Ligurian Basin, one of the most productive areas of the Mediterranean Sea (Jacques, 1990), as summer feeding grounds for the Mediterranean fin whale (*Balaenoptera physalus*) (Forcada *et al.*, 1995; Zanardelli *et al.*, 1992; Notarbartolo di Sciara *et al.*, 1993). Moreover, Berubé *et al.* (1994) indicated that Mediterranean fin whales constitute a separate population from North Atlantic fin whales. Nevertheless, no conclusive information on migratory habits and winter breeding grounds are available yet. The survey, which started in 1994 (Lauriano and G. Notarbartolo di Sciara, in press), reviewed in this paper, outlines the presence of a relevant number of fin whales in this area and represents the first attempt to investigate fin whale habitat use and relationships between individuals summering in the Ligurian Sea and those off north-western Sardinia.

MATERIALS AND METHODS The area covered by the survey ranges from the continental coast of north-western Sardinia to the offshore waters of the Sardinian and Corsican Seas. Research cruises were conducted aboard 12 to 15 m long sailing vessels between July 15 and Sept. 2, 1994; July 15 and Sept. 16, 1995; and July 7 and Sept. 6, 1996. Water depth, distance from the nearest coast and group size data were analysed on all fin whale sightings. Sighting frequencies (sightings/hours x 100) were computed only on sightings which occurred with a sea state equal to or below Beaufort 3 (wind speed of 5.4 m/s). Moreover, given the huge scope of the neritic areas inside the Gulf of Asinara, search time in areas lower than 50 m in depth was discarded from the sighting frequency calculation. Ninety-five percent confidence intervals (95% C.I.) were computed, considering ratios of sighting frequencies during different months over average sighting frequency, under the hypothesis of a Poisson distribution of sightings. For purposes of photo-identification, an auto-focus F 90 Nikon camera with a Nikkor 80-200 mm f 2.8 lens and equipped with Kodak T-max 400 ASA black and white film was used.

RESULTS Forty-four fin whale sightings, totalling 62 individuals in 75 days, were recorded. Table 1 shows the distribution of water depth and distance from the nearest coast. Group size ranged from 1 to 3 individuals (mean = 1.44; SD = 0.6) (Fig. 1). Sighting frequencies varied across years and months of observation (Table 2). A significantly lower sighting frequency was observed for the months of July (95% C.I. =0.2 - 55) compared with average sighting frequency (10.5 = 30 groups over 286 hours of observation x 100).

Table1 Distribution of water depth and distance from the nearest coast of fin whale sightings off north-western Sardinia

	DEPTH (m)	DISTANCE (km)
Mean	1649.5	21.1
Std. Dev.	732.5	13.2
Mode	1000.0	14.8
Range	150-2800	3-70.4

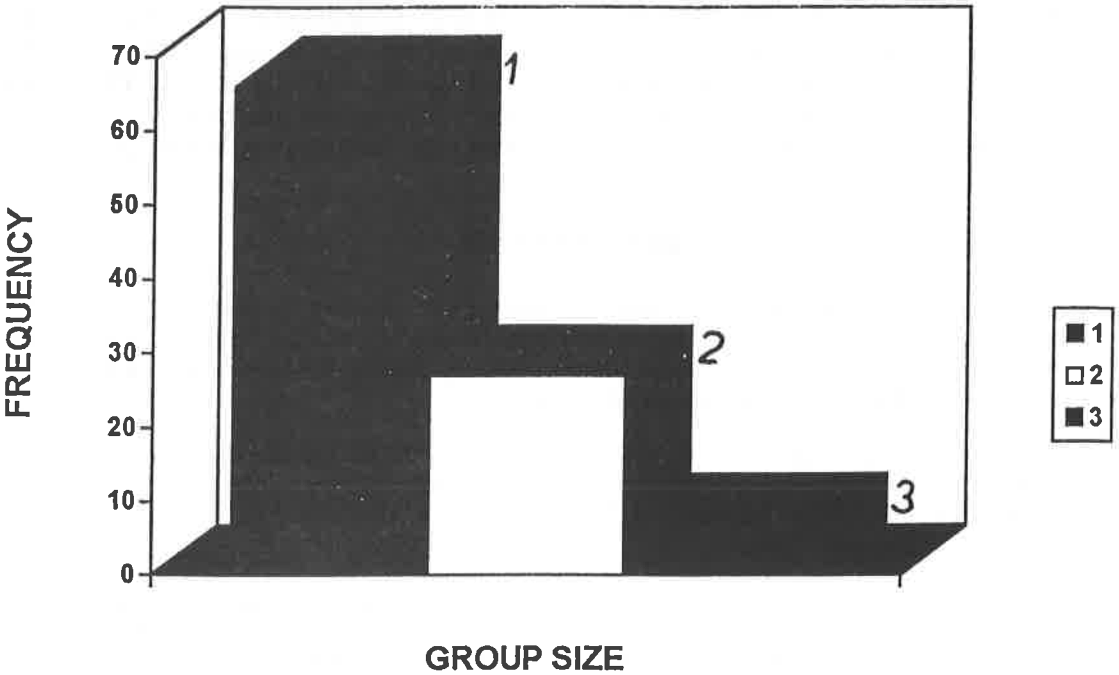

Fig.1 Group size of fin whale sightings off north-western Sardinia

Table 2 Sighting frequencies (sightings/hours of observation x 100) by month and year of research off north-western Sardinia.

	1994	1995	1996	TOTAL	95 % C.I.
July	4.41	12.94	0.0	0.82	0.2-55
August	5.12	18.41	14.05	13.52	66-212
September	0.0	15.68	0.0	12.77	66-212
Total	4.74	16.00	6.30	mean = 10.5	

Among 62 fin whales sighted, 40 (64.4%) were photographed; 32 could be identified individually according to the North Atlantic Fin Whale Catalogue criteria (Agler *et al.*, 1990). Only one fin whale was re-sighted once, with a sighting interval of four days, within 0.5 miles of the first sighting. Two fin whales already identified in the Ligurian Sea in 1991 and 1992 were re-sighted, in 1995 and 1996 respectively. Moreover, the individual identified in 1992 was also re-sighted in 1994 in the Ligurian Sea. A young calf was sighted once in 1995 in association with an adult.

DISCUSSION Results derived from these three years of research indicate a significant number of fin whales off north-western Sardinia. The average sighting frequency of fin whales is roughly similar to that estimated for fin whales summering in the Ligurian Sea, the major summer feeding ground for Mediterranean fin whales. The survey area constitutes the southern boundary of the Corso-Ligurian Basin and although no conclusive evidence can be provided, data available suggest that the survey area could also belong to the feeding ground. Likewise, the re-sightings of two recognisable individuals from the Ligurian Sea is suggestive of individual site fidelity to the summering ground. The presence of fin whales in the feeding ground is influenced by the patchy distribution of their main prey, *Meganictiphanes norvegica* (Orsi-Relini *et al.*, 1992), and this could explain the conflicting results, so far as sighting frequencies and mean depth at sighting location are concerned, between this study and the one undertaken in the Ligurian Sea (Zanardelli *et al.*, 1993). No conclusive results on abundance and distribution could be asserted.

ACKNOWLEDGEMENTS This research was funded and managed by Europe Conservation. I wish to thank all the volunteers who participated in the cruises, Livia Lucentini for gathering part of the data and Carolina Casini, Valeria Fano and Elisabetta Schifano for their precious help in data organisation. Thanks are due to the Cormorano Marina of Porto Torres and to the Nautilus of Stintino for their support and hospitality.

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HUMPBACK WHALES (*MEGAPTERA NOVAEANGLIAE*) BREEDING OFF THE COAST OF MANABI, ECUADOR

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INTRODUCTION Like other baleen whales, the humpback whale (*Megaptera novaeangliae*) leaves its feeding grounds in the cold waters of the Arctic or Antarctic for breeding grounds in the warmer waters of the tropical zones. Therefore, its presence in tropical waters is seasonal (Matthews, 1937; Nishiwaki, 1959). Off the coast of Manabí, Ecuador, humpback whales have been reported from the May until the end of September (Felix & Haase, 1996).

Between July and September 1996, a preliminary study was conducted around the Isla de la Plata and in the area from Puerto Lopez (1°33´50´´S / 80°48´50´´W) to Puerto Cayo (1°21´25´´S / 80°43´80´´W), in order to investigate the significance of this region for humpback whales.

MATERIALS AND METHODS The observations were conducted from a local whale watching boat, a 10 m fibreglass vessel. The humpback whales were approached up to a distance of 100 m with moderate speed. If the whales approached the vessel, the motor was always turned off to avoid possible injuries by the propeller.

For each sighting the behaviour was observed and described using one of the following behavioural categories (Herman & Forestell, 1977).

Travelling	Directional swimming with regular surfacing intervals at a moderate or fast speed.
Milling	One or more whales surfacing regularly and in different directions in the same area.
Resting	Slow swimming with regular surfacing intervals or surfacing on more or less the same spot without any abrupt or fast movement.
Breaching	The whale emerges from the water at any angle up to 70 degrees with respect to the surface and lands on its dorsally, ventrally or laterally.
Courtship	This category includes various surface activities. The following observed behaviours were considered courtship behaviour:
Peduncle position	One whale lies with its back upon the surface, often waving or slapping the pectoral fins. The second whale floats perpendicular to this whale, its head pointed to the peduncle or genital area.
Pursuing	One whale follows another whale at a moderate speed.
Parallel position	One whale drifts upon its back, mostly without any aerial movement of the flippers, while anther whale lies with its ventral side displayed to the drifting whale.
Multiple animal posturing	One whale, the nuclear animal, lies upon the back of another animal in the peduncle position and a third whale circles the pair at a distance of less than three metres.
Flipper waving	The whale lies on its back and raises its flippers vertically into the air.
Lob tail	The whale surfaces very fast, turns upon on its side and moves its tail horizontally.

Singing position	The whale floats just below the surface at an angle of about 30 degrees, with the flukes lying horizontally upon the surface.
Snout up	The whale's rostrum breaks above the surface.
Dorsal position	The animal floats on its back, either flipper slapping, flipper waving or with its flippers just stretched out.
Tail waving	Vertical movement of the tail back and forth in the air without touching the surface
Blocking	One whale positions itself perpendicular to the swimming direction of another whale

In addition, group size and composition were recorded. The positions of the sightings were taken with a GPS (global positioning system). A photo-identification study on the humpback whales was also started using natural marks of the flukes and fins as described in Hammond *et al.* (1990). A camera with a 200 mm lens and 100 ASA, 200 ASA slide films or 200 ASA, 400 ASA black and white films were used.

RESULTS Between 30th July and 7th September 1996, a total of 89 hours of observations were made during 22 trips. A total of 100 sightings of humpback whales were made in the area between the Isla de la Plata and the coastal area off Puerto Lopez (Fig. 1). The mean group size was 2.16 animals.group^{-1} with a maximum group size of eight animals. A total of 216 animals were seen.

Most of the sightings displayed travelling behaviour (52%). In 13% of the sightings courtship behaviour was observed. Breaching behaviour was seen in 31% of all sightings whereas resting or milling was seen in only 2% of the sightings (Fig. 2).

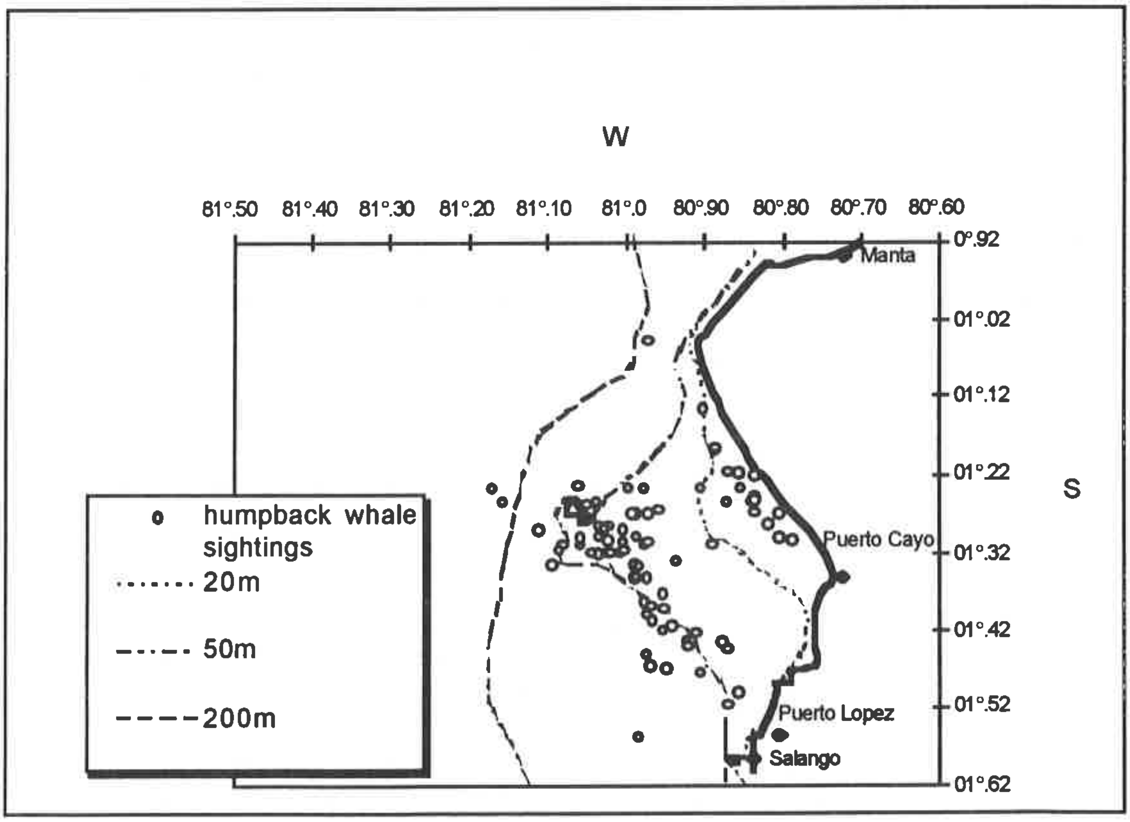

Fig. 1. Map showing the study area and incidental sightings of humpback whales off the coast of Manabí, Ecuador

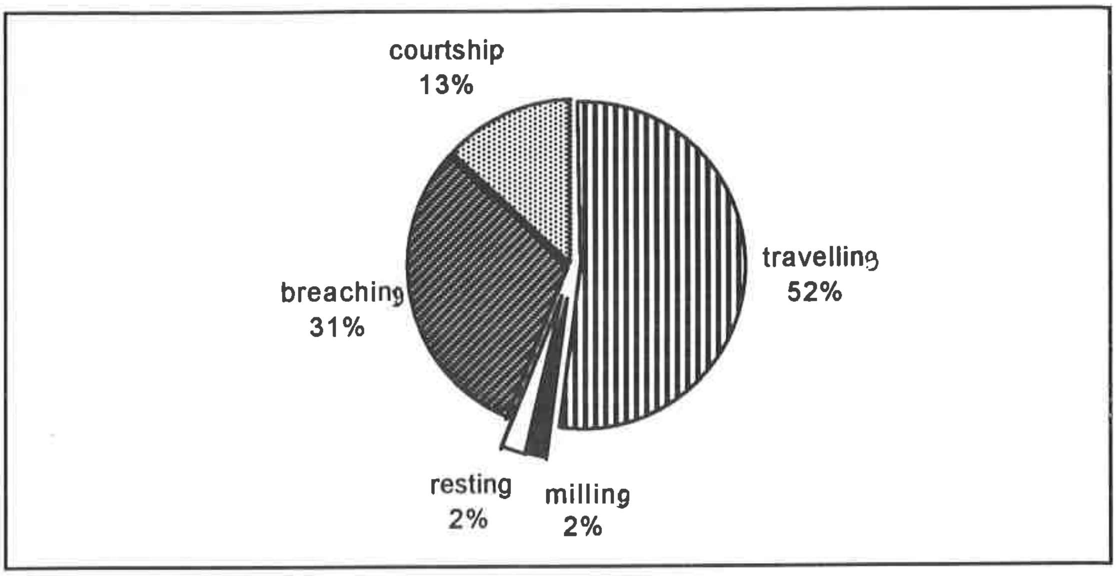

Fig. 2. Behaviour of humpback whales sighted off the coast of Manabí, Ecuador from July to September 1996

The majority of the humpback whales sighted were adults (89 %) with 9% of the animals being juveniles and 2% calves (Fig.3). Identification photographs of the flukes and fins of the humpback whales are still being analysed. So far, at least four individual animals were re-sighted during the study period.

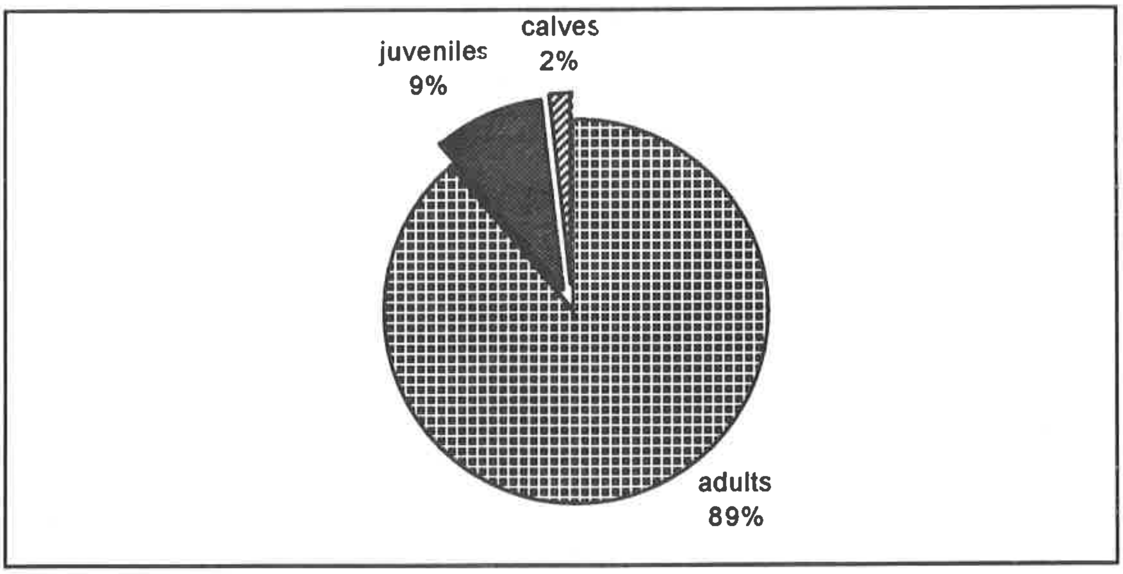

Fig. 3. Age composition of humpback whale sightings off the coast of Manabí, Ecuador from July to September 1996

DISCUSSION Throughout the world, humpback whales utilise large shallow banks, with water temperatures of around 25° C, for mating and calving (Winn and Reichley, 1989). The results of this study indicate that the marine area off the coast of Manabi, in Ecuador, is used by humpback whales as a breeding ground during the southern winter months. Thirteen percent of the humpback whales showed definite courtship behaviour over the observation period. In addition, a high percentage of humpback whales were observed breaching. This behaviour is associated with many possible functions, one being general excitation and territorial behaviour (Herman and Forestell, 1977; Payne, 1978) which possibly plays a part in the courtship behaviour.

Humpback calves measure 4 to 5 m at birth and grow about 45 cm each month (Katona *et al.*, 1993). Sightings of small calves indicate that they were born only shortly before or during the time the study was conducted. No births were observed, although anecdotal evidence exists that local fishermen have seen a birth of a humpback calf close to the Isla de la Plata. Re-sightings of individuals over a two-month period show that the area is not just used for travelling through as has been previously suggested (Felix and Haase, 1996). The first analysis of the data collected gives evidence that the whales are not only travelling through but staying in the marine area off the Machalilla National Park, Manabí, indicating that this area is used as a breeding ground for the humpback whale.

So far, most of the observations were made with the help of the local whale-watching community and were, thus, only incidental. Future systematic research is needed to determine the exact extension of the breeding ground and the number of humpback whales that use this area each year. Behavioural studies and studies on the interference of whale-watching vessels should be carried out to help to establish rules of conduct and to increase the awareness of the captains, guides and tourist operators. In the last two years whale-watching has become a tourist attraction in the region between the Isla de la Plata and Puerto Lopez. The whales are an important source of income for the local people in this region of Ecuador. Only a regulated use of this resource can protect the population of humpback whales in their breeding ground.

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SPATIAL DISTRIBUTION OF DIFFERENT AGE GROUPS IN HUMPBACK WHALES ALONG THE ECUADORIAN COAST

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INTRODUCTION Every year humpback whales (*Megaptera novaeangliae*) are present along the Ecuadorian and Colombian coasts during the austral winter (June - October). They belong to one of the six southern hemisphere stocks and migrate along the west coast of South America between their feeding grounds in Antarctic and their breeding grounds in tropical waters (Dawbin, 1966). In spite of the fact that this south-eastern Pacific population was heavily exploited from the end of the last century in the Antarctic and to a lesser extent along the west coast of South America (Chapman, 1974; Clarke, 1980), it continues to be one of the least known southern stocks.

With the goal of determining the current status of this sub-population, in 1991 a long-term study was initiated on the central coast of Ecuador. Initially, the research effort was low but increased steadily every year, producing important information on behaviour, movements, reproductive rates, and group structure. These surveys have also identified 150 different whales by utilising differences in the coloration pattern on the ventral side of their flukes (Haase and Félix, 1993; Félix and Haase, 1996a; 1996b).

The study area covers approximately 500km^2, and was located in the triangle formed by two coastal villages (Puerto López and Puerto Cayo) and La Plata Island (01°24'"S, 80°55'W) (Fig. 1). Part of the study area is located inside the Machalilla National Park.

MATERIALS AND METHODS Between 25th May and 28th September 1996, 50 research trips were carried out aboard commercial whale-watching boats from Puerto López and Puerto Cayo (25 km apart). The trips generally headed north-west towards La Plata Island, located at approximately 30 km from the coast. Usually, a small shallow shelf named Bajo de Cantagallo was traversed halfway en route to La Plata (Fig. 1). The total navigation time was 253 hours, of which 53 hours were spent with the animals. A total of 256 whales were sighted in 108 different groups. The observation times were between 5 and 160 minutes (Mean = 31 min).

When whales were sighted, the boat approached cautiously in order to make more detailed observations. During these observations, information on group size, composition, and behaviour was documented. Exact positions were obtained using a GPS for 56% of the sightings (n = 61), and only those data were used for the current analysis.

According to their relative size, whales were classified as adults, subadults, or calves. To describe their composition, groups were divided into six age categories (see Table 2).

RESULTS Sighting Distribution Although whales were sighted throughout the study area, three locations contained the majority of sightings: i) around La Plata Island; ii) around the Bajo de Cantagallo and iii) the north-western coastal waters off Puerto Cayo. Along the Puerto López - La Plata Island route, sighting density was nearly constant until reaching within 8 km around the island, where the sighting rate increased by a factor of three, by comparison with the rest of the route. Likewise, observations in Bajo de Cantagallo (6 km in diameter) exhibited a higher rate than for the rest of the route. Along the Puerto Cayo - Bajo de Cantagallo route, a more homogeneous distribution of sightings was obtained; most sightings were made between 5-10 km off the coast in a northwesterly direction. Sightings then decreased, but some 16-18 km offshore increased again around the Bajo de Cantagallo (Fig. 1).

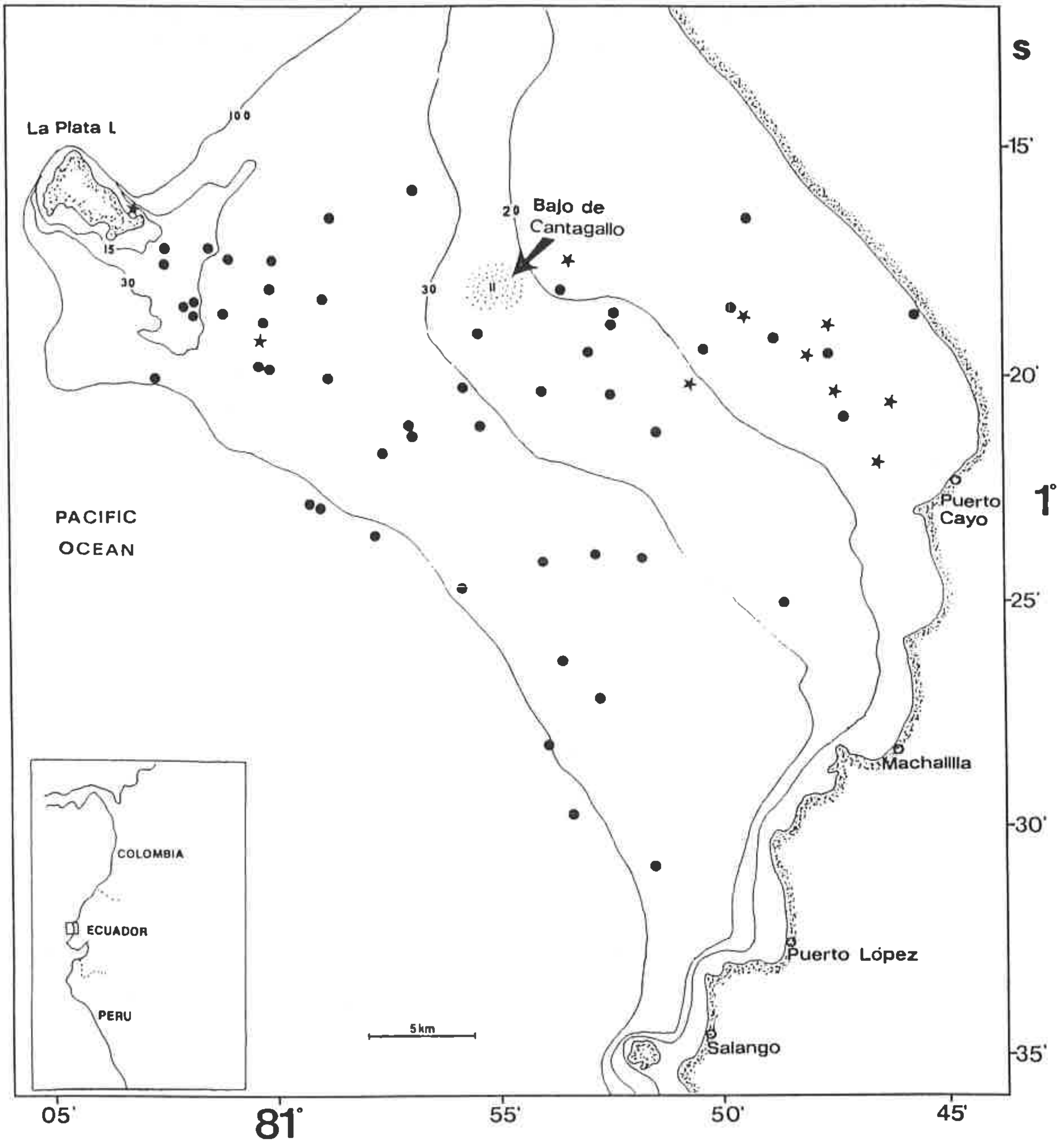

Figure 1. The study area. Black dots indicate the exact sighting positions. Stars indicate the locations where groups containing a calf were sighted.

Group Size Group size ranged between one and 11 individuals (Mean = 2.47, SD = 1.56) with two being the modal size (46%). Table 1 records the group size at the observation site. Groups sighted around La Plata Island were the largest on average, groups containing three or more individuals accounting for 47% of the total groups observed and only once (5%) was a solitary individual whale recorded in this area. By contrast, at Bajo de Cantagallo, group size was the smallest, and solitary individuals accounted for 44% of the total sightings. In both cases, however, the difference in mean group size was not statistically significant (ANOVA $F_{1,59} = 1.2$ and 1.1, $P > 0.05$). In Puerto Cayo, groups were smaller than average, and 56% of the groups contained two individuals (Table 1).

Table 1 Group size per observation site. Sightings determined by GPS (n = 61)

GROUP SIZE (whales)	LOCATION								TO TAL	
	LA PLATA IS.		B. CANTAGALLO		PUERTO CAYO		OTHER		n	%
	n	%	n	%	n	%	n	%		
1	1	5	4	44	2	22	7	29	14	23
2	9	47	3	33	5	56	11	46	28	46
3	6	32	1	11	2	22	2	8	11	18
4	2	10	1	11			2	8	5	8
5	0	0					1	4	1	2
>5	1	5					1	4	2	3

GROUP SIZE (mean)	2.79, SD=1.22	1.94, SD=1.06	2.05, SD=0.68	2.52, SD=2.05	2.47, SD=1.56

Group Composition Table 2 summarises group composition at the observation site. Clearly, the all-adult class was the most abundant in the study area (overall 56%), except near Puerto Cayo, where the mother-calf (MC) class dominated (44%). The latter (MC) was the second most abundant (17%) class overall. Sub-adults were evenly recorded either alone or with adults in the study area. The distribution of females accompanying a calf was highly correlated with water depth; 80% of the groups containing calves (n = 10) occurred where the depth was 20 m or less (see Fig. 1).

Table 2. Group composition per observation site. Only sightings positioned with a GPS (*n*=36) were considered. A= all adults, S= all sub-adults, AS= adults and sub-adults, MC= mother with calf, ME= mother with calf and escort, M+= mother with calf, escort and others.

AGE CLASS	LOCATION				TOTAL	
	LA PLATA IS.	B. CANTAGALLO	PUERTO CAYO	OTHER	n	%
A	6	6	2	6	20	56
S		1	1	1	3	8
AS	1			2	3	8
MC	1	1	4		6	17
ME	1		1	1	3	8
M+			1		1	3

DISCUSSION Although the number of sightings for a detailed statistical analysis is insufficient, our results indicate that whales are not randomly distributed in the study area. There were three sites where whales were particularly abundant, with a different class prevailing in each site. Around La Plata Island, the groups were the largest and were formed mainly by adult animals. Around Bajo de Cantagallo, group size was the smallest and single adult whales were the predominant class. Off Puerto Cayo, whales were found closer to shore, more evenly distributed, and there was a higher number of mothers with calves. The data suggest that whales are using different sites for different activities, for example La Plata Island seems to be an area for meeting and socialising; the Bajo de Cantagallo is preferred by solitary adult whales, most likely singers, and Puerto Cayo is an important region for nursing. Differences in distribution of group sizes and in the concentration of calves in particular areas have also been reported in humpback whales breeding in Hawaii (Mobley and Herman, 1984).

Depth seems to be a major factor in producing the age-class distribution pattern, and is more evident in the groups of females with calves. Along the Ecuadorian coast, these groups concentrate in waters of 20 m depth or less, close to shore, where they are protected from predators such as sharks and killer whales. Flórez (1991) also reported that mothers with calves were observed mainly in shallow waters and in protected beaches on the east side of Gorgona Island, Colombia.

Because the whale-watching industry has been growing steadily in the area since 1994 (see Félix *et al.*, 1994; Félix and Haase, 1996a, b), our findings are providing new information for local authorities for appropriate management of this population.

ACKNOWLEDGMENTS We would like to thank all FEMM volunteers and co-workers who helped us as field assistants during the trips. We are grateful to the directors and crew of the companies Mantaraya, Whale Tours, and Galamazonas, who kindly allowed us on board their boats to do the research. Jay Davis checked the English spelling. We are also grateful to the Whale and Dolphin Conservation Society (WDCS) for the financial support of our research project.

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ABUNDANCE AND DISTRIBUTION OF GRAY WHALES (*ESCHRICHTIUS ROBUSTUS*) IN THE WINTER GROUNDS OF SAN IGNACIO LAGOON (SOUTHERN CALIFORNIA AND MEXICO)

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INTRODUCTION The object of this study was to elucidate aspects of the biology of the gray whale (*Eschrichtius robustus*) in San Ignacio lagoon (Fig. 1). This area is one of the most important breeding sites for gray whales in Mexican waters (Rice *et al.*, 1981; Jones and Swartz, 1984). Because there were no detailed investigations of gray whale abundance in Mexican waters over the last years (Urbán Ramirez, 1995) a specific goal was to estimate abundance and spatio-temporal distribution of the whales. This research was part of the Mexican gray whale project "Ballena Gris en la Biosfera del Vizcaino". The results of this study will help in setting new conservation baselines for gray whales in San Ignacio. The project was considered necessary with respect to plans for the construction of a salt production facility and the growing tourism in the area. Both activities might affect the winter abundance of the gray whales in this region.

MATERIALS AND METHODS Field research began on 17 January and finished on 27 March in 1996. Abundance and spatio-temporal distribution of whales were estimated each week on a total of 19 days with line transects conducted by boat (Fig. 1). Transects were run along an imaginary line of approximately 29 km drawn in the middle of the lagoon from the northern end to the coastline near the lagoon inlet. For a detailed analysis of spatio-temporal distribution of the whales, the lagoon was divided from south to north into three sections with altogether six zones related to depth: lower lagoon (zone U1 and U2), middle lagoon (zone M), and upper lagoon (zone O1, O2 and O3) (Ludwig, 1996) (Fig. 1). Whales of the northern end (zone O3) (Fig. 1) were observed from the middle of the zone. Transects were conducted at a constant velocity of 11km/h. All whales sighted from the boat were counted when they were approximately level with the boat. Following Jones and Swartz (1984), female-calf pairs were considered as a single unit, counts of these pairs being equivalent to calf counts. Single whales refer to females without calves, adult males, or subadults. These whales often occurred in pairs or in groups. Where possible, counts were made twice a day. Transects were discontinued when wind and wave conditions exceeded Beaufort Sea State 3 (wind >11 km/h).

RESULTS **Abundance** The seasonal maximum of the combined count was found on 3 March, when 206 adult whales and 94 calves were seen (Fig. 2). Maximum counts of abundance of single whales (whales without calves) and of female-calf pairs occurred on the same day. Between 17 January and 3 March, single whales comprised 65% of the sightings in the lagoon.

When fieldwork began, the number of mother-calf pairs was low. After the maximum combined count, the proportion changed. The number of single whales decreased rapidly, 84% of the population being female-calf pairs after 9 March. The last sighting of single whale occurred on 21 March, but on 27 March there were still 51 female-calf pairs in the area (Fig. 2). There was no significant difference between counts made twice a day (Wilcoxon-test: $W = 21.5$; $p = 0.17$) (Fig. 3).

Spatio-Temporal Distribution For nearly all counts, the abundance and density of the whales was greatest in the lower lagoon (Fig. 4), followed by the middle and upper lagoons. Between 7 February and 3 March, when abundance was highest, there was a significantly different distribution of single whales (Kruskal-Wallis-test: $H = 7.26$; $p < 0.05$) and female-calf pairs ($H = 6.12$; $p < 0.05$) between the various zones.

significantly different distribution of single whales (Kruskal-Wallis-test: $H = 7.26$; $p < 0.05$) and female-calf pairs ($H = 6.12$; $p < 0.05$) between the various zones.

Abundance (Fig. 4) and density of single whales was greatest in the lower lagoon with a maximum density in zone U2. The density of single whales increased significantly with increasing lagoon depth (Pearson-r correlation test: $r = 0.94$; $p < 0.05$) The highest number of mother-calf pairs occurred in the upper lagoon (Fig. 4). Density of female-calf pairs was greatest in zone U2 and O1. With the departure of single whales (4-27 March) mother-calf pairs tended to move into the lower lagoon (zones U1 and U2) (Fig. 4).

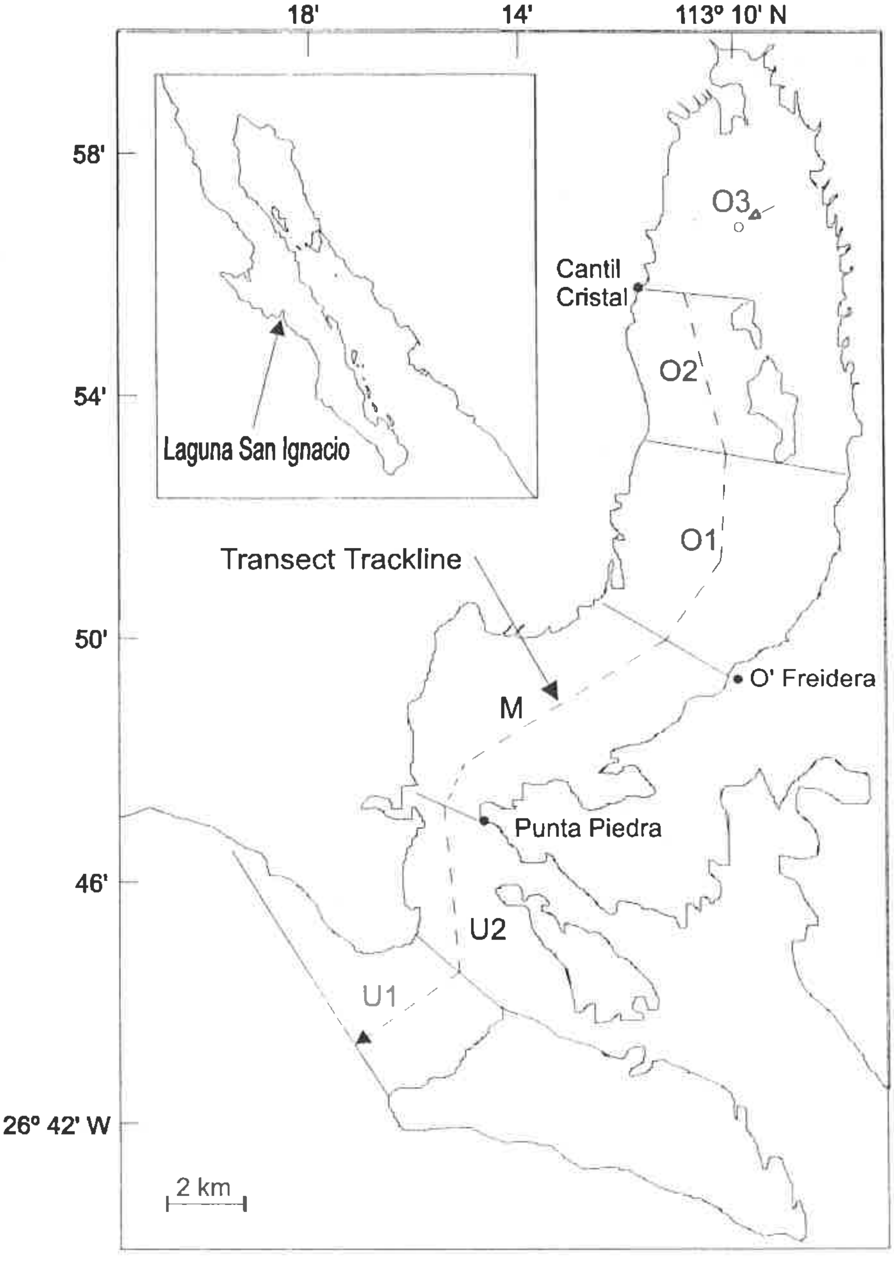

Fig. 1. San Ignacio Lagoon (Baja California, Mexico), showing the transect trackline through the lower (zone U1 and U2), middle (zone M) and upper lagoon areas (zone O1, O2 and O3).

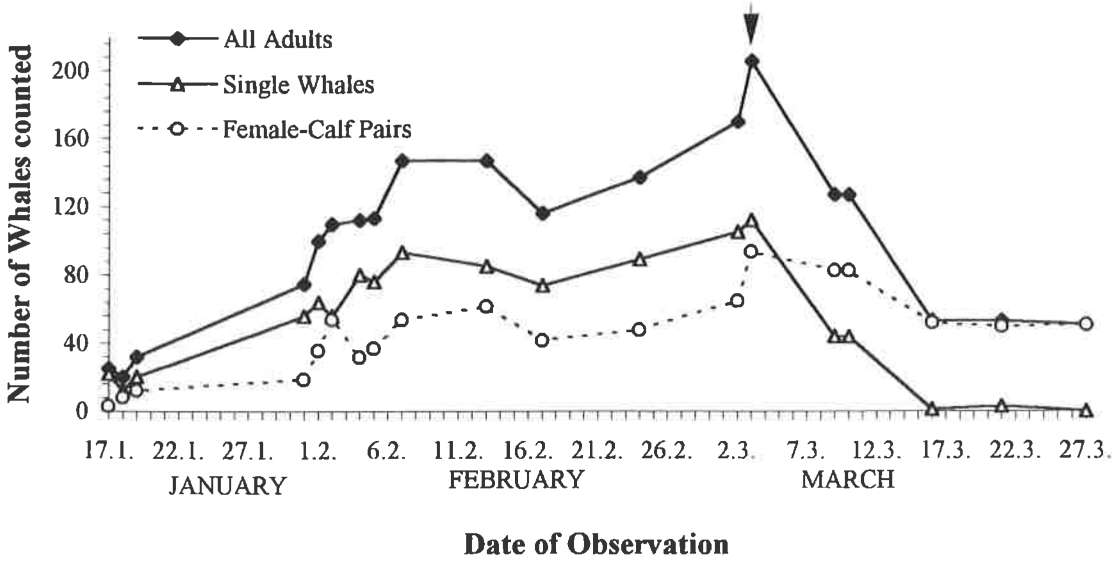

Fig. 2. Abundance of gray whales counted in 19 boat transects of San Ignacio lagoon from January 17 to March 27. The vertical arrow represents the date of the maximum count on March 3.

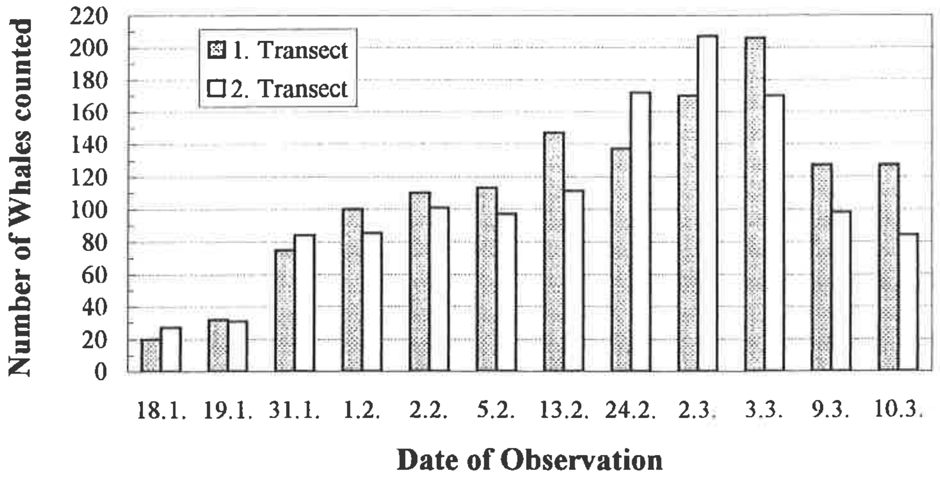

Fig. 3. Comparison of the two daily boat transects counted in 19 days of San Ignacio lagoon from January 17 to March 27.

CONCLUSIONS The number of gray whales counted in 1996 in San Ignacio lagoon (206 adult whales and 94 calves) was lower than counts from previous years 1978-82 and 1985 (maximum 1982 with 407 adults and 137 calves; Jones & Swartz, 1984; Jones *et al*, 1988). One explanation is that the gray whale population has outgrown its traditional breeding areas to the south of Baja California and is now utilising areas previously not used, or re-occupying breeding sites utilised before stock depletion. Support for this theory is given by increased sightings of gray whales in the southern coastal waters of Baja California over the last few years (see Swartz, 1990) Another reason for the lower number of whales in San Ignacio could be fluctuations between the different breeding areas in successive years. Photo-identification studies from Jones (1989) showed that some identified gray whales came to San Ignacio in successive years, while other individuals were found in other lagoons (Ojo de Liebre, Guerrero Negro, Bahía Magdalena) in subsequent years. Further work on the gray whale project using photo-identification, together with telemetry studies, should elucidate the scale of the fluctuations between breeding areas in Mexican waters.

Single whales use different habitats to those occupied by female-calf pairs. The results of the spatio-temporal distribution work showed that single whales prefer the deeper lower lagoon (zone U1 and U2) for courtship, while the majority of female-calf pairs use the shallower middle and upper lagoons (zone M-O3) as a nursery area. Females with calves avoid the courtship area when the calves are young. An important new finding with respect to plans for the construction of a salt production facility is that zone U2 is the main courtship region and zone O1 has the highest density of mother-calf pairs. Changes in the lagoon area could influence the reproduction and breeding of the gray whales in San Ignacio.

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AGE AND SEX DISTRIBUTION OF SPERM WHALES DURING THE BREEDING SEASONS OFF THE GALAPAGOS ISLANDS

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The breeding grounds of sperm whales (*Physeter macrocephalus*) are situated in tropical waters. Due to the fact that the difference in mating seasons between the northern and southern hemispheres is six months, the populations and mating behaviour between the hemispheres are distinct. The Galapagos Islands are physically and ecologically on the equatorial boundary between the northern and southern Pacific Sea. Previous reports from both the whaling era and modern behavioural studies, indicate that sperm whales in these waters belong to the northern hemisphere's breeding stock. The sperm whale is extremely sexually dimorphic - because of this, body length can be used as a means of determining sex. Their mating system is believed to be polygynous, and, during the mating season, males arrive at lower latitudes to compete for mates, in areas with a high density of social females.

The length and sex distributions of sperm whales off the Galapagos Islands were analysed from an expedition, in 1993-94, to the area. Two expected mating seasons of the sperm whale were covered. Body length was photo-telemetrically estimated. The identity of individuals and groups were sampled by photo-identification. Behavioural and scan sampling data were also analysed for additional information about sex and social structure.

Preliminary results indicate that there are two breeding season peaks - one in March-April and one in September-October; and that the mating system is either polygynous or promiscuous. The waters off the Galapagos Islands may be used by populations from both northern and southern hemispheres.

STOMACH CONTENTS FROM SPERM WHALES STRANDED IN DENMARK

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INTRODUCTION Diets of sperm whales stranded in the North Sea and adjacent areas have previously been described by Lick *et al.* (1995), Santos *et al.* (1995, 1996) and Clarke (in press).

On the 27 March 1996, a group of 16 sperm whales stranded at Rømø Island, in the Danish Wadden Sea. To date, this is one of the largest mass strandings in the North Sea and is the largest number of whales ever found beached on the Danish coastline.

The present paper describes the findings from dietary analysis on these animals, together with stomach contents from three other whales stranded in previous years in Denmark. Results from Danish strandings are compared with results from previous mass and single strandings in Scotland.

MATERIALS AND METHODS The group of 16 sperm whales stranded at Rømø Island was discovered several days after the whales had beached and was therefore in an advanced stage of decomposition. All of the whales were measured and samples of blubber, skin and teeth were collected. Food remains, consisting mainly of cephalopod beaks and a fish bone in one case, were collected from four whales. It was not possible to obtain more samples or to examine the entire digestive tract in any of the cases. The remaining three samples were collected from single animals stranded in Denmark in previous years:

- a single whale stranded near Nymindegab on 17th November 1990
- a single animal stranded near Fanø on 1st December 1991
- a single stranding near Skagen on 25th January 1996

All the stomach contents collected were returned to the laboratory, washed clean, and stored in 70% alcohol. Cephalopod beaks were identified using reference collections and published guides (Clarke, 1980, 1986). Standard measurements (rostral length for squid species; Clarke, 1986) were taken on both upper and lower beaks using a binocular microscope fitted with an eyepiece graticule. Mantle length and body weight of the animals were estimated using regressions from Clarke (1986). The relative importance in the diet for each prey type was estimated as proportion of total prey weight.

Whale weight was estimated from whale length using a published regression (Lockyer, 1976). The quantity of food required by each sperm whale per day was calculated using the figure 3.0-3.5% of body weight per day (Lockyer, 1981). The number of days feeding represented by food remains in the stomachs was estimated by comparing these numbers with the estimated prey weight.

RESULTS All the whales were males, 11-13 m in length. The age of the whales from the mass stranding ranged from 20 to 34 years. The age of the remaining animals has not yet been estimated.

RESULTS All the whales were males, 11-13 m in length. The age of the whales from the mass stranding ranged from 20 to 34 years. The age of the remaining animals has not yet been estimated.

Of the cephalopod remains found in the whales from the mass stranding (1,170 upper beaks and 619 lower beaks), the squid *Gonatus* sp. (probably *Gonatus fabricii*) was the most important prey item (Table 1) making up 99.78% of the diet by weight. Beaks of other oceanic species such as *Teuthowenia megalops* and *Histioteuthis bonnellii* were also found. In two cases, fish remains were found (a fish bone and an eye lens). *Gonatus* sp. was the only prey identified in the single strandings.

Table 1. Main prey species of the Danish sperm whales (Whale A: stranded 11/90 near Nymindegab, B: stranded 12/91 near Fanø, C: stranded 1/96 near Skagen, 1, 5, 12: mass stranding 3/96; UB: upper beaks, LB: lower beaks)

PREY	SINGLE STRANDINGS			MASS STRANDINGS			
SPECIES	Whale A	Whale B	Whale C	Whale 1	Whale 5	Whale 8	Whale 12
Gonatus sp.	279 UB 121 LB	1 LB	670 UB 642 LB	-	98 UB 19 LB	1 UB	1064 UB 594 LB
Histioteuthis bonnellii	-	1 LB	-	-	-	-	2 LB
Teuthowenia megalops	-	-	-	-	-	-	4 LB
Unidentified cephalopod	-	-	-	-	2 UB	-	5 UB
Fish remains	-	-	-	fish (?) bone	-	-	1 eye lens

The days food represented by the prey found never surpassed 1 day (Table 2). The dorsal mantle length estimated of the majority of *Gonatus* varied between 185-275 mm (Fig. 1).

DISCUSSION Over the last few decades, there has been an apparent increase in the number of sperm whales stranded in the North Sea. Some authors suggest that this increase could be due to a recovery of population numbers of sperm whales after the cease of whaling for this species in 1985 (Smeenk, in press).

The squid *Gonatus* was the main prey recorded in several other strandings of sperm whales in the North Sea (Table 3). In the Scottish strandings other species such as the deep-sea octopus *Haliprhon atlanticus* were also found, together with the coastal species *Loligo forbesi* and the octopus *Eledone cirrhosa*.

Table 2. Food consumption of the Danish sperm whales (D5, D12: whales from the mass stranding, DA: 17/11/90 near Nymindegab, DC: 25/1/96 near Skagen)

WHALE CODE	TOTAL LENGTH (M)	WHALE WEIGHT (TONS)	DAILY FOOD INTAKE (KG)	WEIGHT PREY (KG)	DAILY RATIONS
D5	12.95	21.87	710.84	24.95	0.03
D12	12.15	18.36	596.88	246.88	0.41
DA	11.85	17.15	557.36	60.55	0.11
DC	13.10	22.57	733.62	162.26	0.22

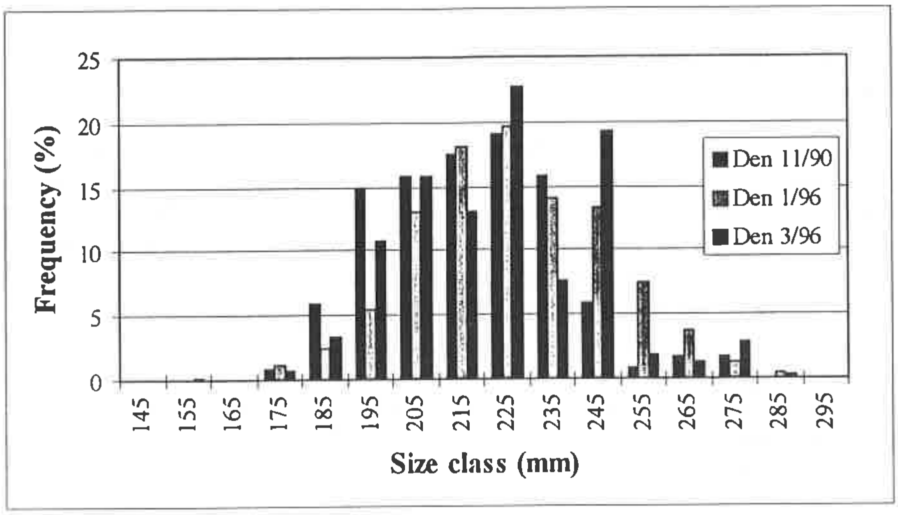

Fig. 1. Size distribution for *Gonatus* sp. (Den 11/90: single stranding on November 1990, Den 1/96: single stranding on January 1996, Den 3/96: mass stranding on March 1996).

Gonatus fabricii is a schooling squid species considered to be the most abundant squid in the Arctic and Subarctic area of the North Atlantic (Kristensen, 1983). Juvenile squid (mantle length < 50 mm) are caught in the surface layers. At mantle length of 50-70 mm *Gonatus* disappears from the surface, probably moving to deeper waters. At a pen length of about 200 mm, and 2 years of age, the males are probably mature. Females mature at about 2-3 years and mantle length larger than 200 mm. Females probably die after spawning while males could survive one spawning and breed twice. The main spawning period takes place from December to April. Areas of spawning have not been identified (Kristensen, 1983, Bjørke, 1995).

The length estimated of the majority of *Gonatus* corresponded with the size of mature, possibly spawning animals. Similar results were found for the two mass strandings in Scotland (Fig. 2).

Table 3. Main prey species in the stomach contents of sperm whales stranded in the North Atlantic

Stranding	**1 whale**	**1 whale**	**1 whale**	**11 whales**	**1 whale**	**1 whale**	**6 whales**	**16 whales**
Date	17 Nov 90	3 Nov 94	4 Nov 94	7 Dec 94	1 Mar 95	25 Jan 96	28 Jan 96	27 Mar 96
Place	Denmark	Holland	Germany	Scotland	Scotland	Denmark	Scotland	Denmark
Sample size	1	1	1	4	1	1	5	4
Gonatus sp.	670	2000	186	17 - 4260	1439	279	72 - 1432	0 - 1064
Other prey	-			Fish egg capsule		-	Fish lens, egg capsule	Fish bone + eye lens
Teuthowenia megalops	-	7	-	1 - 3	60	-	1 - 31	0 - 4
Histioteuthis bonnellii	-	-	1	1 - 3	2	-	0 - 84	0 - 2
Todarodes sagittatus	-	-	-	-	-	-	3 - 10	-
Haliphron atlanticus	-	3	5	1 - 3	3	-	1 - 5	-
Source	This paper	Clarke, in press	Lick *et al.* 1995	Santos *et al.*, 1995	Santos *et al.*, 1995	This pape	Santos *et al.*, 1996	This paper

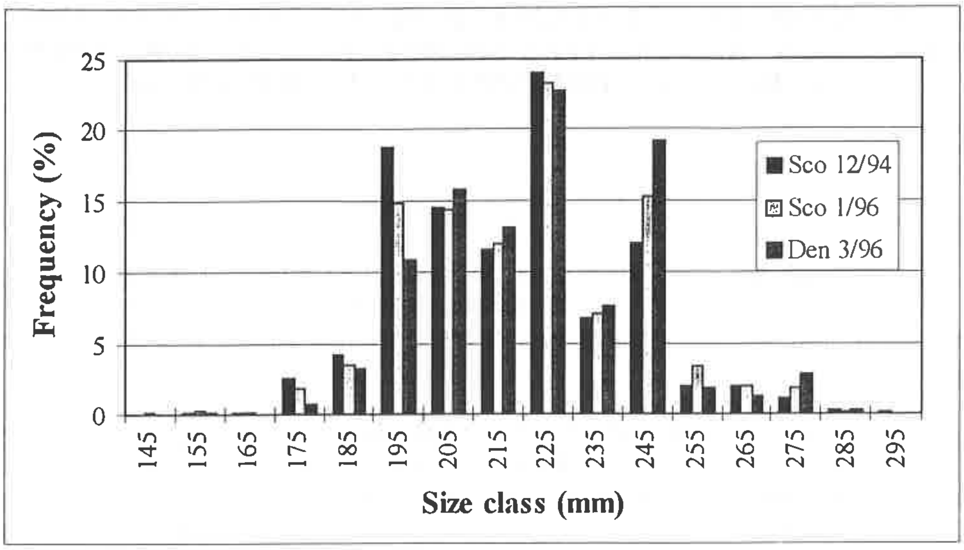

Fig. 2. Size distribution for *Gonatus* sp. (Sco 12/94: mass stranding in Scotland on December 1994, Sco 1/96: mass stranding in Scotland on January 1996, Den 3/96: mass stranding in Denmark on March 1996)

All the stomach contents analysed from sperm whales stranded in the North Sea have contained beaks of mature *Gonatus* sp., and very little else. Most of the strandings have taken place during the winter months. This seems to suggest that sperm whales are feeding on *Gonatus*, probably on spawning aggregations, just prior to their migratory trip back to the breeding grounds. On their way south, instead of following their normal migratory route west of the British Isles, following the deep basin in the North Atlantic they come into the North Sea. Waters in the North Sea are too shallow for this species (in the southern section of the North Sea less than 50 m depth; Smeenk, in press), making it difficult to navigate, which may account for the strandings.

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CEPHALOPODS IN THE STOMACH OF A BOTTLENOSE WHALE, *HYPEROODON AMPULLATUS* (FORSTER, 1770), STRANDED ON THE ISLE OF HIDDENSEE IN THE BALTIC SEA

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The stomach of a female northern bottlenose whale, *Hyperoodon ampullatus* (Odontoceti: Ziphiidae) stranded at the island of Hiddensee, western Baltic Sea, on 23 August 1993 contained 7,465 cephalopod beaks (4,934 upper and 2,531 lower). The lower beaks were identified, their rostral lengths were measured and used to estimate size and mass of the cephalopods consumed by the whale.

All lower beaks belonged to one species, the Boreo-atlantic gonate squid *Gonatus fabricii* (Cephalopoda: Teuthoidea), indicating a mean squid mantle length of 21.9 cm and a mean squid wet mass of 220.7 g. The total squid biomass in the whale's stomach represented by the lower beaks was 598.6 kg. Assuming that all upper beaks belonged to *G. fabricii* the squid biomass taken by the whale was estimated to be 1,089 kg. Besides the beaks, partly digested squid gladii, spermatophores, and fifteen specimens of the fish parasite *Sphyrion lumpi* (Crustacea: Copepoda) occurred in the stomach. No fish remains were found. A fuller description of the stomach contents of the stranded animal is given in Lick and Piatkowski (1997).

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STOMACH CONTENTS OF *ZIPHIUS CAVIROSTRIS* STRANDED ON THE WESTERN MEDITERRANEAN COAST

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Samples from the stomachs of two Cuvier's beaked whales were studied: one female (3.83 m) and one male (5.10 m), stranded on 25th and 26th February 1996, respectively, off the coasts of Valencia (Spain). Prey remains correspond to cephalopod beaks; neither cephalopod flesh nor crustacean remains were found. A total of 385 and 88 prey items were examined for the male and female beaked whales, respectively. Twelve different species belonging to nine families were identified. The table below shows percentage number (N) and weight (w) of each cephalopod species recorded in the stomach contents of each animal.

	N (male)	N (female)	W [g] (male)	W [g] (male)
Todarodes sagittatus	6.2	9.9	4.3	36.7
Histioteuthis reversa	63.1	20.4	24.7	4.0
Histioteuthis bonnellii	7.5	8.1	35.0	37.6
Octopoteuthis sicula	2.3	5.6	1.7	4.1
Chiroteuthis veranyi	1.8	26.1	0.6	5.0
Galiteuthis armata	9.3	1.1	1.2	0.1
Taonius pavo	2.8	3.4	0.9	0.1
Cranchiidae sp.	0.2	12.5	0.5	11.9
Ctenopteryx sicula	5.4	1.1	0.5	<0.1
Ancistrocheirus lesueuri	0.5	0.0	0.1	<0.1
Heteroteuthis dispar	0.5	0.0	<0.2	<0.1
Gonatus fabrici	0.0	2.2	0.0	<0.1
TOTAL	**385**	**88**	**115538.5**	**47858.3**

The main food items are represented by the families Histioteuthidae and Ommastrephidae, as in previous beaked whale records from the Mediterranean. Luminous and ammoniacal cephalopod species represent 90-93% and 87-89% of the total number, which responds to 63-65% and 65% of the total weight, for the male and female, respectively.

Cuvier's beaked whale feeds mainly on cephalopods, but as an opportunist, it could include fish or crustaceans in its diet. However, the results of this present study support the idea of an exclusively teuthophagous diet in specimens coming from the Mediterranean. All the cephalopod species recorded in this study were known to be oceanic and meso- or bathypelagic and, moreover, luminous and ammoniacal species were important in the diet of the studied animals.

FOOD COMPOSITION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) BY-CAUGHT IN POLISH WATERS OF THE BALTIC SEA

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From 1986 to 1997, 58 specimens of harbour porpoise have been noted from the Polish zone of the Baltic Sea. Stomach contents from 27 porpoises by-caught between 1986 and 1996 were analysed for food composition. Most of the animals (15) came from the Gulf of Gdansk, which is a shallow water area.

Eight stomachs (30%) were completely empty and only four (15%) contained cephalopod remains. Nine fish and two cephalopod species were identified. The number of prey species present in a single stomach varied from one to five.

Herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and gobies (Gobiidae) were the most frequently encountered species (74%, 58% and 58% frequency of occurrence, respectively).

Gobies were the most numerous species (50% of all identified fish), while herring (11%) and sprat (22%) were represented in fewer numbers. There were no significant differences in food preference between and females, except for eelpout (*Zoarces viviparus*), which was only found in the stomachs of males.

INVESTIGATION OF THE COASTAL WATERS OF SCHLESWIG-HOLSTEIN (GERMANY) FOR DELPHINIDS, WITH EMPHASIS ON WHITE-BEAKED DOLPHINS (*LAGENORHYNCHUS ALBIROSTRIS*)

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INTRODUCTION Little is known about white-beaked dolphins (*Lagenorhynchus albirostris*) in the North Sea, although they are the most abundant cetacean species after the harbour porpoise. During the SCANS-survey an abundance of about 7,850 white-beaked dolphins was estimated for the North Sea. They were sighted in the area between northern England, Scotland and Denmark but with none in German waters (Hammond *et al.*, 1995).

Betweeen 1990 and 1996, white-beaked dolphins were the most abundant delphinid species reported along the coast of Germany. By comparison with three records of common dolphins (*Delphinus delphis*) and one pilot whale (*Globicephalus melas*), we found eighteen white-beaked dolphins, stranded in Schleswig-Holstein, Germany. Data on these strandings are presented in this paper.

MATERIALS AND METHODS As part of a national research project on the abundance, health status, and migration of cetaceans in German waters, stranded and by-caught cetaceans were collected along the coast of Schleswig-Holstein. The age of each dolphin was estimated from cross-sections of teeth, according to Myrick *et al.*, 1983. To determine the reproductive status, all gonads were investigated histologically. Pathological examinations were carried out according to the proceedings of the first ECS workshop on cetacean pathology (Kuiken & Hartmann, 1993). Eight white-beaked and one common dolphin were preserved well enough to allow complete sampling for further investigations. Samples were taken from each organ and investigated histologically. Parasites were collected, fixed in 70% ethanol, and identified. The stomach contents were analysed for their food remains, based on the identification and measurement of fish otoliths. (Härkönen, 1986; Lick, 1991).

RESULTS Between 1990 and 1996, eighteen white-beaked dolphins, three common dolphins and one pilot whale were found along the coast of Schleswig-Holstein, Germany. All animals stranded along the North Sea coast with the exception of one common dolphin from the island of Fehmarn in the western Baltic, (Fig. 1). There was no seasonal peak of dolphin strandings. All adult white-beaked dolphins were female, ranging in length between 241 and 275 cm and in age between 5 and 27 years. None of them was lactating, and the smallest animal was carrying a 35 cm long foetus weighing 757 g. The animal stranded alive on November 9, 1993 and died shortly after. There were no adult males, only three subadults ranging in length between 197 and 232 cm.

Unfortunately the heads of two common dolphins were stolen. The third animal was a female adult measuring 204 cm, which stranded on Fehmarn.

Morphometric data of both sexes were combined and non-linear regressions between flipper length and body length were performed. The results were as follows:

Flipper length = $-11 + 0.49 * \text{body length}^{0.87}$

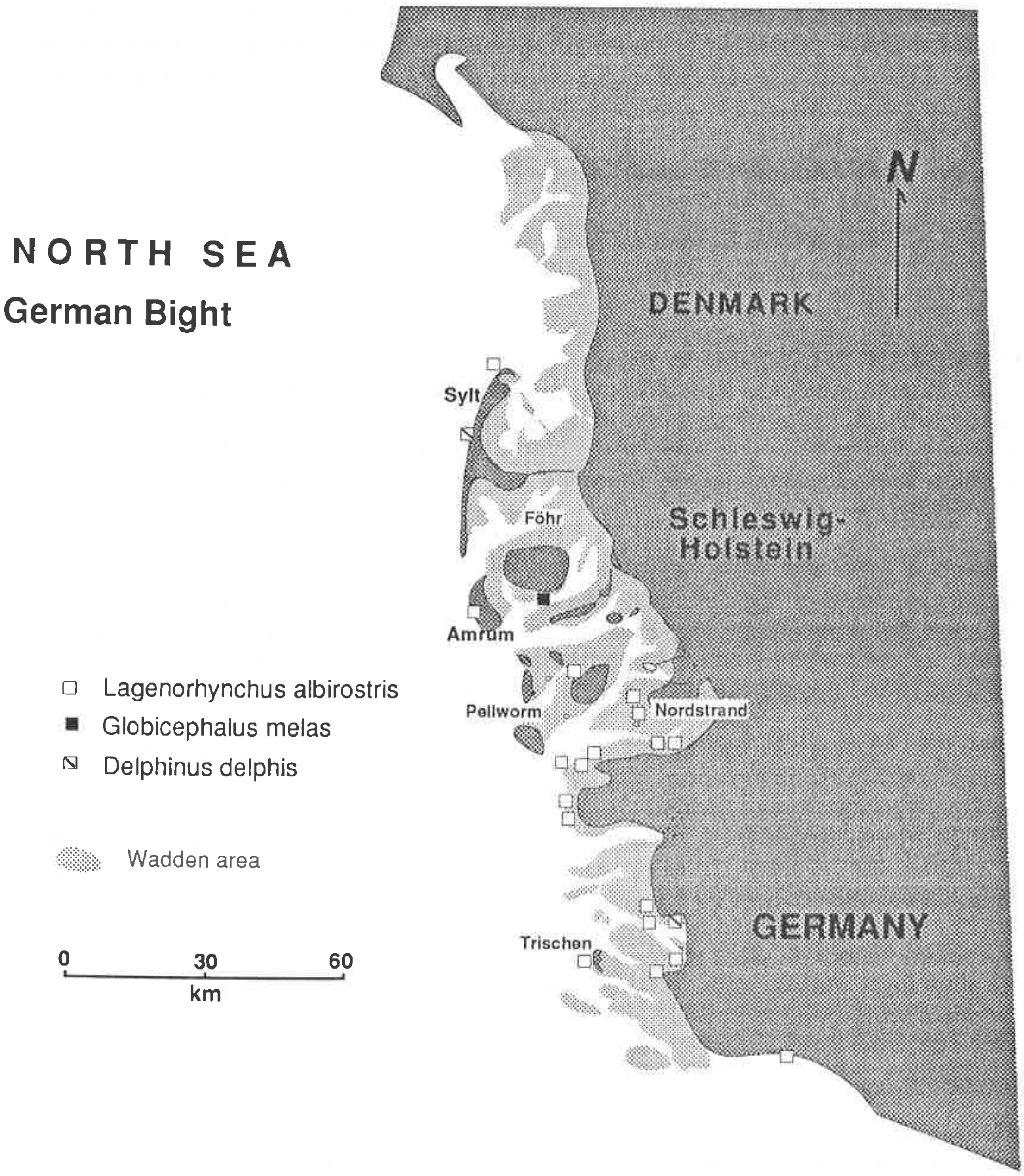

Fig.1 Stranded dolphins along the coast of Schleswig-Holstein, Germany, between 1990 and 1996

At necropsy, two white-beaked dolphins were emaciated, while six animals were in a moderate nutritional condition. The nutritional status of the others could not be judged. The majority of the pathological lesions were found in the respiratory tract, the alimentary tract, and the locomotory system. In seven animals, pulmonary oedema and in three, pulmonary congestion, was noted. Three animals displayed interstitial pneumonia, and one focal fibroplastic pleuritis. One whitebeaked dolphin had old multiple fractures of the ribs and the lower jaw, with callus formation. In another animal, arthrosis of the shoulder joint and ankylosing spondylosis of vertebrae were found.

In six individuals, the alimentary tract showed an infection of *Anisakis simplex.* Four of them were highly infected averaging 1,600 nematodes per animal. One dolphin was found with whale lice (*Isocyamus delphini*).

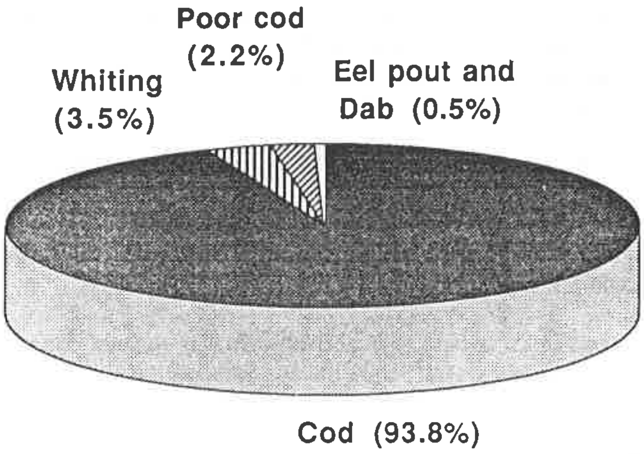

Fig.2 Relative proportions of fish weights in the diet of white-beaked dolphins

In four out of eight white-beaked dolphins examined, food remnants could be found, consisting of five fish species (Fig. 2). The cetaceans fed almost exclusively on gadids. The predominant species was cod (*Gadus morhua*) (c. 94% concerning fish weight). Other identified species were whiting (*Merlangius merlangus*), poor cod (*Trisopterus minutus*), dab (*Limanda limanda*) and eel pout (*Zoarces viviparus*). Beside these species remains of some invertebrates could be found. They were considered as secondary food items and not identified down to species level. The common dolphin examined had otoliths of 391 smelt (*Osmerus eperlanus*), one sandeel (*Ammodytes tobianus*) and 12 gobies (*Pomatoschistus* spp.) in the intestines, with almost none in the stomach.

DISCUSSION White-beaked dolphins were never sighted during aerial surveys in the Wadden Sea (Hammond *et al.*, 1995, Sonntag *et al.*, in prep.), and only a very low number of incidental sightings were reported from German waters. Therefore, it could be assumed that the Wadden Sea is not part of their normal range, and it is possible that the majority of dolphins come into the Wadden Sea due to dis-orientation, and strand alive on large tracts of seabed exposed during low tide, in this unusual habitat for this species.

The results of the above pathological investigations support this hypothesis. Compared with stranded harbour porpoises from the North Sea, the white-beaked dolphins showed an overall low incidence of parasites and only mild pathological lesions. The pathological changes of the jaw and ribs were most probably caused by trauma. It remains unclear whether these traumata were caused by other dolphins or by boat-related accidents (Siebert *et al.*, 1996). The vertebral lesions described above were also reported from white-beaked dolphins in the Netherlands (Kompanje, 1995).

The stomach contents of the white-beaked dolphins consisted almost exclusively of gadids, with cod (*Gadus morhua*) being the dominant species (94% by weight). All of the identified food species were benthic feeders. This supports Gaskin's hypothesis that white-beaked dolphins are bentho-ichthyophagous (Gaskin, 1982).

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STOMACH CONTENT ANALYSIS OF A BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) FROM THE ADRIATIC SEA

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In the Mediterranean, studies on feeding habits of bottlenose dolphins *Tursiops truncatus* based on examination of stomach contents are very limited in number, and for the Adriatic Sea there are no published data. The stomach contents of a bottlenose dolphin caught in a fishing net in the middle part of the Adriatic Sea near Sibenik in December 1995 (male, 278 cm, 237 kg, healthy and in a good state of nutrition) were examined. Stomach contents were collected and stored according to standard procedures.

Prey consisted mostly of fish, and only one cephalopod beak. Because predatory fish species were present (*Merluccius merluccius*), it may be assumed that some smaller fish remains got into the stomach as secondary prey. The following prey remains were distinguished: a) partly digested fish bodies: evidence of recent feeding; b) mandibles, vertebrae, and other fish bones: remains of meals from one or two days before; and c) otoliths: several days old. Fish bones, otoliths and cephalopod beaks were identified to the lowest possible taxonomic level. The maximum number of left and right mandibles, otoliths, and upper and lower cephalopod beaks was used as an indication of the total number of prey. Biomass of the prey was analysed.

PRELIMINARY RESULTS ON THE OCCURRENCE OF BOTTLENOSE DOLPHIN *TURSIOPS TRUNCATUS* ALONG LAMPEDUSA ISLAND COASTS

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INTRODUCTION Several studies have examined the social system, ranges, behaviour, and other aspects of the life history of bottlenose dolphins *Tursiops truncatus*. Some specific surveys have been undertaken on this species in the Mediterranean Sea. However, the dolphins' occurrence along the Lampedusa Island coasts (Sicily, Italy) had previously not been investigated.

A long-term research program on bottlenose dolphins began on Lampedusa Island (Sicily, Italy) during summer 1996. Information gained from this period forms the basis of this study; the aim being to investigate and verify the presence, abundance, and dynamics of the population along the island, and their possible interactions with human activities. Data on the occurrence, photo-identification, group size, composition, distribution and behaviour of bottlenose dolphins are presented.

The primary goal of the present study was to collect data in order to provide a better understanding of the ecology of this coastal species. Moreover, as the behaviour of bottlenose dolphins is closely tied to the local ecology, and behavioural pattern changes take place according to ecological factors, such as prey distribution, it is possible to begin comparing aspects of dolphin biology and behaviour in different areas.

MATERIALS AND METHODS A preliminary survey was conducted from July to September 1996 along the Lampedusa Island coast. Data was collected over an area of approximately 200 km^2 centred around the southern and eastern coasts of Lampedusa Island. Sightings of bottlenose dolphins were recorded off a 4.5 m outboard-powered inflatable, and photographs were taken with a 35 mm camera using a 70-210 mm lens. Photographic surveys allowed recognisable dolphins to be re-identified later, in order to define the home range and number of dolphins in the study area.

Because groups were typically small, it was possible to record the visible behaviours of all individuals simultaneously every three minutes (instantaneous sampling and *ad libitum* sampling, Altmann, 1974) using a check-list and a tape-voice recorder. Data recorded included date, time, location, direction of travel, distance between and orientation of individuals, relative speed of travel, group size and composition (numbers of adults, juveniles and calves), dive duration, and occurrence of discrete behaviours. Sea conditions, other environmental factors, and the number and type of nearby vessels were also noted.

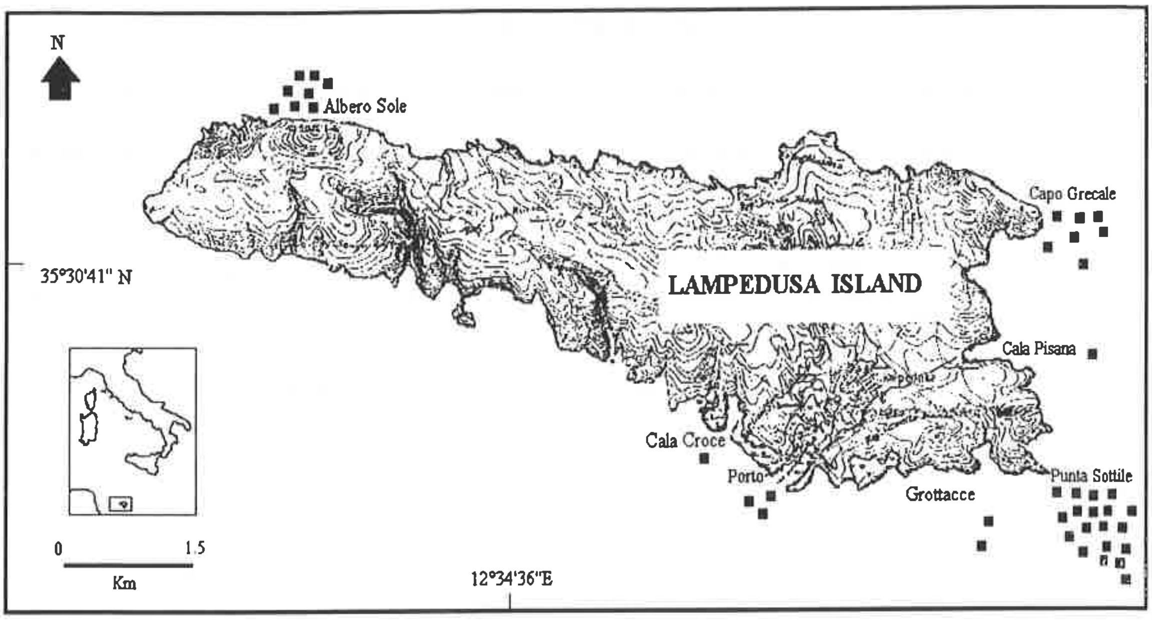

Fig.1. Sightings of bottlenose dolphins along the Lampedusa Island coast

RESULTS AND DISCUSSION Bottlenose dolphins were reported within the study area on 41 occasions (Fig. 1), with the recording of 127 animals, and 27 recognisable individuals were catalogued by the photo-identification method. Group size ranged from 1 to 12 individuals, but the most frequently recorded group size was three.

Approximately 21 hours of behavioural observations were recorded during these encounters. All major behavioural states, such as feeding, socialising, milling and travelling (defined according to Shane, 1990) were observed.

Animals were more abundant off the south-eastern part of the island, where fishery activities were more frequent. This point was carefully checked to focus and measure the possible influence of the fishing operations on cetacean feeding behaviour. A close association between the animals and the trawling boats was observed with a total frequency of 30 times (78%) and the presence of trawling boats seemed to influence the dolphins' behaviour. In fact, when trash fish were discarded at the end of a trawl, dolphins close to the boat obtained an easy access to feeding resources.

Other authors have already reported that dolphins follow fishing boats, adapting their behaviour to take advantage of human activity (Norris & Prescott, 1961; Leatherwood, 1975; Corkeron *et al.*, 1990; Shane, 1990).

Although these observations are preliminary, the recorded data suggest more detailed studies on this bottlenose dolphin population are required.

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DISTRIBUTION OF BOTTLENOSE DOLPHIN AROUND THE ISLAND OF ASINARA (NORTH-WESTERN SARDINIA)

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INTRODUCTION During a boat-based survey conducted from 1994 to 1996 to assess the distribution, relative abundance, and ecological relationships of cetaceans off northwestern Sardinia (Lauriano & Notarbartolo di Sciara, in press), it was possible to collect data on bottlenose dolphin (*Tursiops truncatus*) inhabiting the neritic waters adjacent to the Island of Asinara. Ecology and biology of one of the most common cetacean species (Notarbartolo di Sciara *et al.*, 1993) were investigated in an area characterised by intensive fishing activities and commercial boat traffic.

MATERIALS AND METHODS The study area (roughly 1,100 km^2) is easterly and westerly delimited by the lines intersecting the 200 m isobar from Capo Falcone (40° 58' 30" lat. N - 008° 12' 10" long. E) and Punta Tramontana (40° 52' 90" lat. N - 008° 37' 90" long. E) (Fig.1). The depth ranges from 0 to 200 m. The easterly portion (Gulf of Asinara) is characterised by a mud seabed, while a rocky sea bottom is prevalent in the west.

Twelve- to 15-m long sailing vessels were used to survey for bottlenose dolphin; research cruises took place from July to September 1994, 1995, and 1996 for 49, 63, and 63 days respectively. Water depth, distance from the nearest coast, group size and behavioural data were collected on all bottlenose dolphin groups sighted.

Sighting frequencies were computed only for groups encountered with sea state equal or below Beaufort 3 (wind speed of 5.4 m/s). Furthermore, in order to analyse the habitat utilisation and distribution of bottlenose dolphin groups, taking into account depth, the study area was post-stratified in two sub-areas: area A wide from the shore to 50 m depth, and area B from 50 to 200 m depth.

Photo-identification of the bottlenose dolphins was based on longterm natural marks (Würsig & Jefferson, 1990); the camera used was an autofocus Nikon F90 equipped with a Nikkor 80-200 mm f 2.8 lens and Ektachrome EPR 64 ASA color trasparency and Kodak T-max 400 ASA black and white films.

RESULTS Over a period of 86 days, 31 bottlenose dolphin groups were encountered between 0.4 and 18.5 km from the nearest coast (mean = 8.2; mode = 5.6; SD = 5.3) and in a depth range of 20-155 m (mean = 56.9; mode = 50.0; SD = 23.6). Overall, 145 individuals were observed including 23 sub-adults (15.9%) (sensu Shane, 1990). Density value, defined as the number of dolphins per km^2 was 0.13.

Average group size was 4.7 (mode = 2; range = 1-16; SD = 3.6). Mean group size in sub-areas A and B was 4.9 (n = 17; range = 1-16; SD = 4.13) and 4.4 (n = 14; range = 1-8; SD = 2.84,), respectively. Feeding related activities such as "Dive", "Dive travel" and "Follow fishing-boat" (D,DT,FFB) were prevalent (81%) when compared with others such as "Travel", "Socialise" and "Social/travel" (T, S, ST) (19%) (Table 2).

Considering only the time spent looking for dolphins under good weather conditions (215 h 6'), 21 bottlenose dolphin groups were sighted within the entire study area (sighting frequency = 9.74 sightings/100 h). Table 1 shows the searching time under good weather conditions by subarea. Table 2 shows the distribution of behavioural budget in the area under study. A total of 12 individuals were photo-identified. Resightings only occurred within a period of a few days from the initial sighting.

Table 1 Searching time by sub-area and years of research

AREA (depth)	A (>50 m)		B (500-200 m)		TOTAL	
	n	h	n	h	n	h
1994	2	35.21	4	27.00	6	62.21
1995	5	29.20	4	42.10	9	71.30
1996	3	46.04	3	35.09	6	81.13
TOTAL	10	110.47	11	104.19	21	215.06
n/hx100	9.052		10.55		9.76	

Table 2 Behavioural budget in areas under study (%)

AREA (depth)	A (<50 m)	B (500-200 m)	TOTAL
Feeding activities (D, DT, FFB)	52	28	81
Others (T, S, ST)	9	10	19
TOTAL	61	39	100

DISCUSSION This study represents the first attempt to investigate the biology, ecology and habitat use of bottlenose dolphins in the Gulf of Asinara. The research yielded results similar to those produced by other studies conducted in inshore habitats. Bottlenose dolphin group size were smaller than those reported by Bearzi and Notarbartolo di Sciara (1992) for the Island of Tavolara (Sardinia) and by Bearzi *et al.* (1993) for the Island of Losinj (Croatia), and agree with those previously reported for this species in the Gulf of Asinara (Ferreccio *et al.*, 1992). The smaller group size observed may be related to prey abundance and may ensure the maximisation of energy rquirements given prey availability. Some of the difficulties in approaching dolphins could be attributed to the hostility of some local fishermen towards dolphins. This may also explain the low number of photo-identified individuals in spite of the fact that a large number of them had natural marks.

No difference in sighting frequency was observed in areas of different depth; however, dolphins seem to prefer shallower water to search for food, given the higher frequency of feeding related activities in area A over socialising and travelling. Given the huge extention of the neritic area, there was no correlation between sighting location, depth, and distance from the nearest shore; this might explain why no differencies in sighting frequencies from the two areas were observed between the two areas. The density value (0.13) was double that reported for the same area by Ferreccio *et al.* (1992). No conclusive results can be provided on biology and habitat use, and therefore studies on relative abundance, seasonal occupancy, and behaviour should be carried out.

ACKNOWLEDGEMENTS This research was funded and managed by Europe Conservation. I wish to thank all the volunteers who participated in the cruises, Livia Lucentini for gathering part of the data and Carolina Casini, Valeria Fano, and Elisabetta Schifano for their precious help in data organisation. Thanks are due to the Cormorano Marina of Porto Torres, and to the Nautilus of Stintino for their support and hospitality.

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DIET OF THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) IN THE GULF OF VALENCIA (WESTERN MEDITERRANEAN)

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The stomach contents of 17 bottlenose dolphins (8 males, 7 females and 2 of unknown sex) stranded along the Gulf of Valencia, from August 1983 to October 1995, were examined. Dolphins of this sample were all, with the exception of one, adults with a total length of between 145 and 306 cm (Mean = 250 cm). The vacuity index was 11.8%.

A total of 1,275 fish otoliths (1,247 identified), 35 upper and lower cephalopod beaks, and some remains of crustaceans were collected. The identified otoliths belonged to five species of eight families, the cephalopod beaks to seven species of five families, and the crustaceans to one family and one infraorder.

The fish were represented by 42.42% *Merluccidae*, 15.15% *Clupeidae*, 12.27% *Congridae*, 8.37% *Ophidiidae*, 7.21% *Cepolidae*, 5.05% *Gadidae*, 4.04% *Sparidae*, 2.89% *Carangidae* and 2.6% unidentified fish. Numbers of cephalopods accounted for 52% *Octopodidae*, 20% *Ommastrephidae*, 16% *Loliginidae*, 4% *Sepiolidae*, 4% *Sepiidae*, 4% unidentified cephalopods, and, amongst crustaceans, 87.5% were *Caeridae* and the remaining 12.5% *Grapsidae*. The length and weight of one of the most abundant prey species in the diet of this odontocete, the hake *Merluccius merluccius*, were also obtained by a regression method using samples from the same area. The mean predicted length was 23.82 cm (SD: 8.16, range: 6.64 - 58.3), and the mean predicted weight was 127.6 g. (SD: 173.59, range: 1.57 - 1580.8). The fish with minimum length and weight probably correspond to secondary prey.

The results indicate that off the Spanish Mediterranean coast, this dolphin feeds primarily on fish, the main prey consisting of neritic, mesopelagic, demersal and benthic species. Generally, it is assumed that the bottlenose dolphin is an opportunistic feeder, which is reflected by the local prey abundance and availability. The total number of prey species of the bottlenose dolphin off the Spanish Mediterranean coast was 13. All of these except three are commercial species and represent most of the biomass. There is competition between dolphins and fishermen in the study area. This has to be taken into account in order to elaborate management programmes for the conservation of this protected cetacean species.

LONG-TERM PREFERENCES FOR PARTICULAR HABITAT SUB-AREAS BY BOTTLENOSE DOLPHINS IN THE SADO ESTUARY

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Bottlenose dolphins (*Tursiops truncatus*) enter the Sado Estuary on a daily basis, spending many hours feeding, travelling and socialising. The estuary has a city harbour, a vast industrial area and also some less polluted and noisy areas which are used by people for fishing and recreation.

Several studies have shown that the dolphins spend comparatively more time in less degraded areas, whose importance in terms of conservation of fauna must be stressed.

It is now possible to use a greater span of observations to show that the animals' preference for certain areas (the South Channel and the river mouth) has been very stable from 1988 to 1996.

THE DISTRIBUTION AND MOVEMENTS OF RESIDENT BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE SHANNON ESTUARY, IRELAND

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The river Shannon (western Ireland) contains one of the few known resident populations of bottlenose dolphins in Irish coastal waters. A project is currently underway to study the abundance, distribution, habitat use and social structure of the population using land-based and boat-based collection procedures.

The ultimate aim of the project is to devise a sustainable conservation strategy for the population.

Standardised boat-based photo-ID studies have been collecting data since June 1996, and approximately 75 animals have, to date, been individually recognised. Dolphin groups have been sighted throughout the survey area and re-sightings of animals photographed in 1993 show fidelity of at least some animals of the population to the estuary.

A theodolite was used to track groups of dolphins from the shore. Together with casual dolphin sightings, collected data showed a seasonal change in abundance for animals using the river, with peaks in numbers during the spring and summer months. Group sizes ranged from 1 to 22 animals (n = 453), with 41.5% of groups containing calves.

The tidal cycle had a marked effect on distribution with concentrations of animals found in areas with strong currents.

PREY AND FEEDING PATTERNS OF BOTTLENOSE DOLPHINS RESIDENT IN SARASOTA BAY, FLORIDA

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The trophic relationships of a resident community of bottlenose dolphins from the Sarasota Bay area were studied to examine the potential factors leading to their demonstrated patterns of habitat use. Prey composition and size class were analysed, and correlated with the feeding behaviour of identifiable dolphins of known histories.

The examination of stomach contents of 16 stranded dolphins revealed a diet composed exclusively of fish (at least 15 species), most of which are associated with seagrass meadows in varying degrees. Dolphins usually feed solitarily or in small groups, and on non-obligate schooling prey.The main prey species are also somniferous, an indication that passive listening may be important in prey detection.

Long-term (multiple years) observation records show that feeding behaviour typically occurs in shallow (2-3 m) waters and on, or near, seagrass meadows. The close agreement between the fish species represented in the stomach contents and the prey habitat as indicated by feeding observations in this study suggest that stomach content analysis is a reasonable approach for studying dolphin prey and feeding patterns.

DAY AND NIGHT DISTRIBUTION OF THE STRIPED DOLPHIN (*STENELLA COERULEOALBA*) IN THE AREA OFF ANTIBES (LIGURIAN SEA)

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INTRODUCTION The striped dolphin (*Stenella coeruleoalba*) is the most frequently occurring cetacean in the northern Mediterranean Sea (Beaubrun, 1995). Although its abundance varies seasonally, the striped dolphin is present off the French Mediterranean coast all year round (Gannier, 1995). Since the start of this study, it has been observed that coastal schools of striped dolphins were exhibited a nocturnal-diurnal migration cycle. The dolphins moved offshore during the day and migrated inshore, onto the continental shelf, during the night. In summer 1996 a study was instigated in order to examine this phenomenon.

MATERIALS AND METHODS A 12 m motorised yacht with an 80 HP diesel engine was used as the survey platform. Surveys were conducted with a sea state equal to or less than Beaufort 3, at an average speed of six knots. The yacht had a crew of six, equipped with pairs of binoculars (with compass and reticule), two GPS's, a towed hydrophone, one analog and one digital recorder and a dual-frequency echo-sounder.

During the day, both visual and acoustic surveys were carried out: three observers scanning the frontal sector (one searched the +/- 45° sector in front of the mast, two observers searched each side, from 30° to 90° from the front of the mast). Each sighting was recorded using the standard line transect methodology; particular attention was paid to the movement of the cetaceans. The fourth crew member operated the hydrophone. One minute of acoustic effort was recorded at two-mile intervals, during which the engine speed was reduced to 1,000 rpm and the propellor was de-clutched. The level of recorded background noise and, eventually, the level of the dolphin sounds, were recorded (on a three point scale). Additionally, if dolphin vocalisations were heard, acoustic effort was prolonged until the species could be identified and a recording made.

Visual surveying ceased during the night. The acoustic sampling rate was maintained or increased to one minute of effort every mile or half-mile travelled, depending on the bottom topography. Dawn (2.5 hrs before sunrise) and dusk (2.5 hrs after sunset) were treated as intermediate periods.

The data were later recorded onto DBASE 4 files. Most of the processing was performed with "Oedipe-Karto" software (Massé & Cadiou, 1993), which enabled spatial stratification, mapping and calculation of basic indicators such as effort, number of cetaceans sighted and sighting rates. An average movement vector was computed by summing the size weighted vectors of the different schools. The acoustic identification of species relied upon previous experience and data analysis performed by the GREC (Sylvie Arnaud, 1995; Gilles Coquet, 1996). The assumption was made that every delphinid not identified as a Risso's dolphin or a pilot whale, was a striped dolphin.

RESULTS AND DISCUSSION Between 26 June and 22 August, a total of 722 miles were surveyed. Of this effort, daytime (both acoustic and visual) surveys account for 447 miles, while dawn and dusk account for 102 and 81, respectively, and night for 92 miles. Sampling mainly took place between the coastline and the 2,000 metre isobath (Table 1).

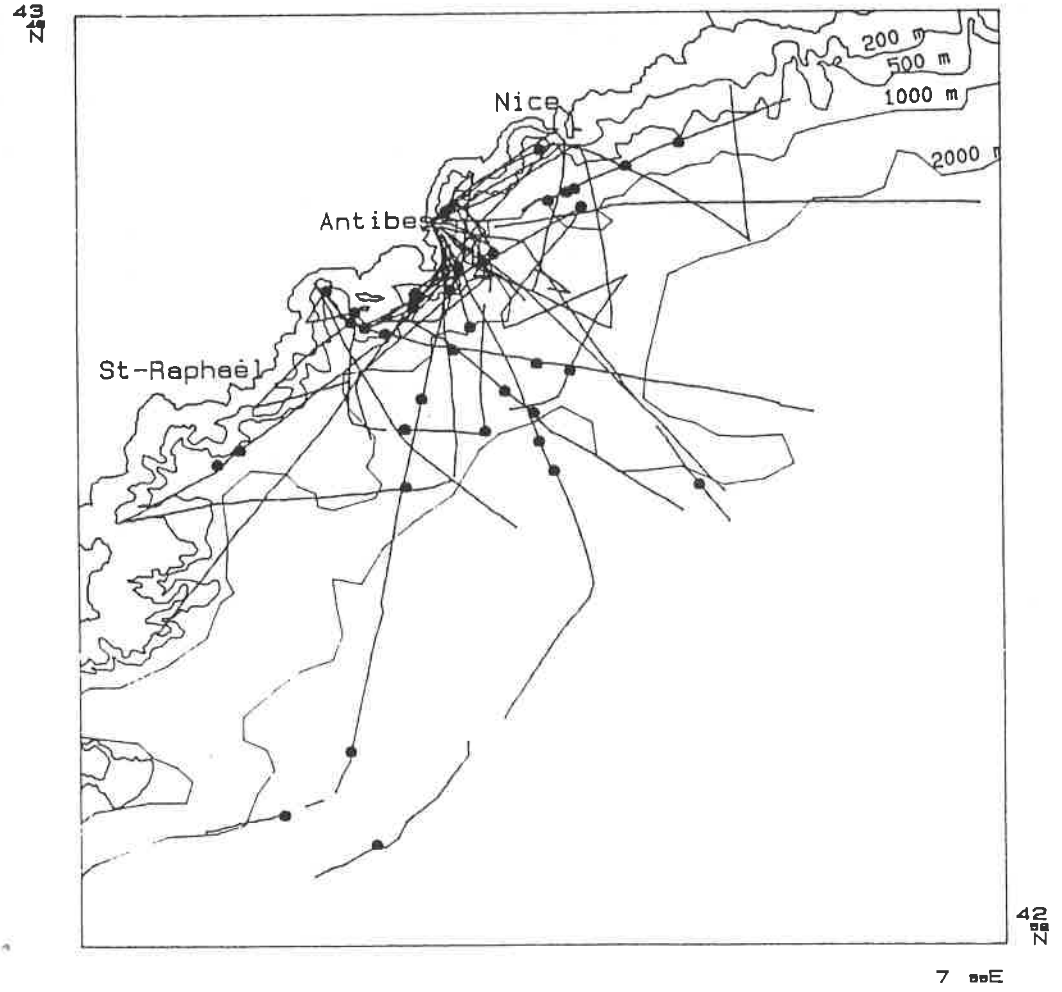

Fig. 1 Daytime sampling and visual sightings of striped dolphins

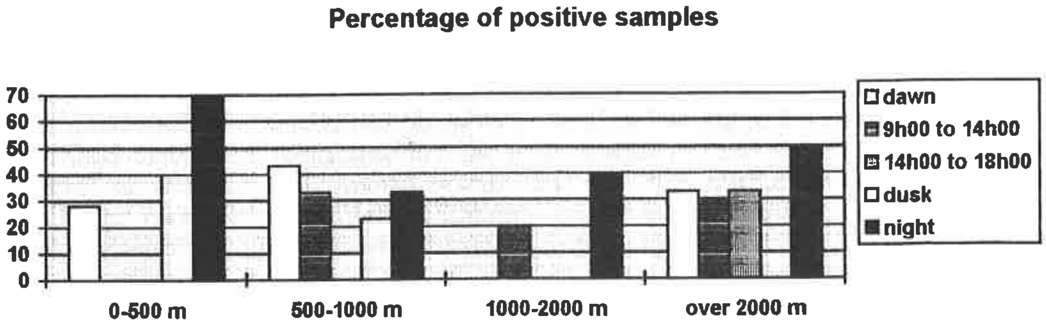

Fig. 2 Acoustic results versus the depth strata and the period of the day (% of positive samples on the total number of samples for every period and stratum)

Table 1 Distribution of sampling effort versus the bottom depth and time of day (no. of miles per depth stratum and for each period of the day and night)

BOTTOM DEPTH	STRATUM	DAWN	DAY	DUSK	NIGHT
0 - 500 m	near shelf	51	97	16	21
500-1000 m	upper slope	24	116	31	40
1000-2000 m	deep slope	16	161	22	22
over 2000 m	open sea	11	73	12	9

Thirty-eight sightings of striped dolphins were made during daylight and twilight hours (Fig. 1). On the near-shelf stratum, the sighting rate shows a sharp decrease from dawn (1.20 indivs.mile^{-1}) to day (0.25 indivs.mile^{-1}) (Table 2). For the upper slope, a similar decrease occurred from dawn (1.96 indivs.mile^{-1}) to day (0.37 indivs.mile^{-1}), which is followed by a subsequent increase from the daytime to dusk (2.13 indivs.mile^{-1}) (Table 2). For the deep slope, the variations are less pronounced, but an increase of the sighting rate from daytime to dusk was discernible (Table 2). For the open sea, the fluctuations are not significant because the sampling effort was low during dawn and dusk. Hence, the presence of the striped dolphin in the 0-500 and 500-1,000 m bottom depth strata is greatest during the hours of dawn and dusk.

Table 2 Variations of sighting rate versus the bottom depth and time of day (in individuals per mile of effort for each depth stratum and for three periods of the day)

BOTTOM DEPTH	STRATUM	DAWN	DAY	DUSK
0 - 500 m	near shelf	1.20	0.25	0.25
500 - 1,000 m	upper slope	1.96	0.37	2.13
1,000 - 2,000 m	deep slope	0.56	0.62	0.91
over 2,000 m	open sea	2.55	0.88	1.17

The acoustic surveys results are summarised in Table 3. Whereas 28% of the samples are positive in water depths of 0-500 m at dawn, animals were absent (0%) during the day, whilst at dusk 40% and at night, 69% of the surveys demonstrated a positive presence of dolphins (Fig. 2). A similar, but attenuated, picture was observed for the upper slope: 43% were positive at dawn, 0% between 14:00 and 18:00 h, and 33% at night (Fig. 2). Dolphins were absent from above the deep slope at dawn; 20% of the survey effort was positive during the 09:00-14:00 h period; they were absent again during the 14:00-18:00 h period and at dusk whilst 50% of the survey effort was positive at night. By comparison, a more neutral situation was apparent offshore in the open sea (Fig. 2). Hence, the acoustic results show an offshore shift of striped dolphins schools during the day.

Table 3 Results of acoustic sampling versus the bottom depth and the time of day. (number of positive and negative samples, separated by a dash)

BOTTOM DEPTH	DAWN	09:00 to 14:00	14:00 to 18:00	DUSK	NIGHT
0- 500 m	2 - 5	0 - 2	0 - 1	2 - 3	11 - 5
500-1000 m	6 - 8	1 - 2	0 - 2	3 - 10	12 - 24
1000-2000 m	0 - 6	7 - 28	0 - 8	0 - 2	6 - 9
over 2000 m	2 - 4	7 - 16	4 - 8	0 - 3	3 - 3

The study of the dolphin movements is made for the four daylight and twilight periods. Before 09:00 h and between 14:00 and 18:00 h, the average vectors are of small amplitude, indicating random direction of movement. Between 09:00 and 14:00 h, the resulting vector is of large amplitude and clearly directed offshore (Fig. 3a). After 18:00 h, the resulting vector is of medium amplitude and directed towards the coast (Fig. 3b).

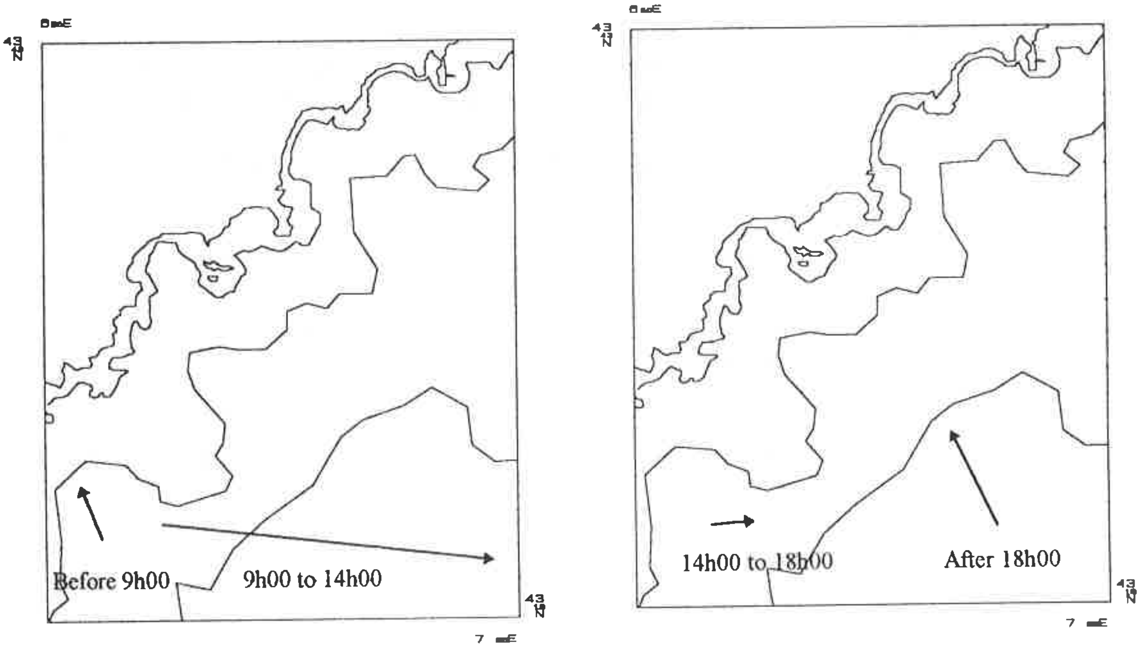

Fig. 3 Movements during the morning (A) and during the afternoon (B)

From these three aspects of our results, we can propose a description of the distribution shift of these striped dolphins: schools are frequent close to the shelf break during the night, where they feed (this latter point is clear from the acoustic recordings). During the morning, an offshore directed travel results in the dolphins moving into deeper waters, where their movement is randomly distributed. During the late evening and dusk periods, an inshore directed movement occurs, resulting in an increased presence of dolphins over shallower waters.

CONCLUSIONS The daily migration cycle of striped dolphins identified here is likely to be related to the vertical migration cycle of some prey items. Further research is needed to fully understand the reasons for this movement.

ACKNOWLEDGEMENTS We thank the Région Provence-Alpes-Côte d'Azur for funding this research and the benevolent observers who made it possible.

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WINTER PRESENCE OF RISSO'S DOLPHINS, *GRAMPUS GRISEUS*, IN THE WESTERN PART OF THE LIGURIAN SANCTUARY

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INTRODUCTION Risso's dolphins (*Grampus griseus*) are observed in the western Ligurian Sea throughout the year. Despite a summer observation peak (Beaubrun, 1995), those who regularly cruise this area consider Risso's dolphins to be more frequent in winter. To verify this assumption, a systematic survey was organised with the support of the French Ministry of the Environment and the National Park of Port-Cros.

MATERIALS AND METHODS From 1 October 1989 to 31 July 1996, an area of 350 square nautical miles was regularly patrolled in search of *Grampus* (Fig. 1). The work was done under standardised conditions: sea level zero and the same survey vessel boat and observers. The time necessary to cover the whole area was less than four hours depending on disturbances such as surface activities of large fish (for example tuna and swordfish) or other species of dolphin. For each cruise, time until the first encounter with Risso's dolphins was noted and then collated monthly and compared. At each encounter, photographs were taken of as many individuals as possible, with a minimum of ten photographs per animal.

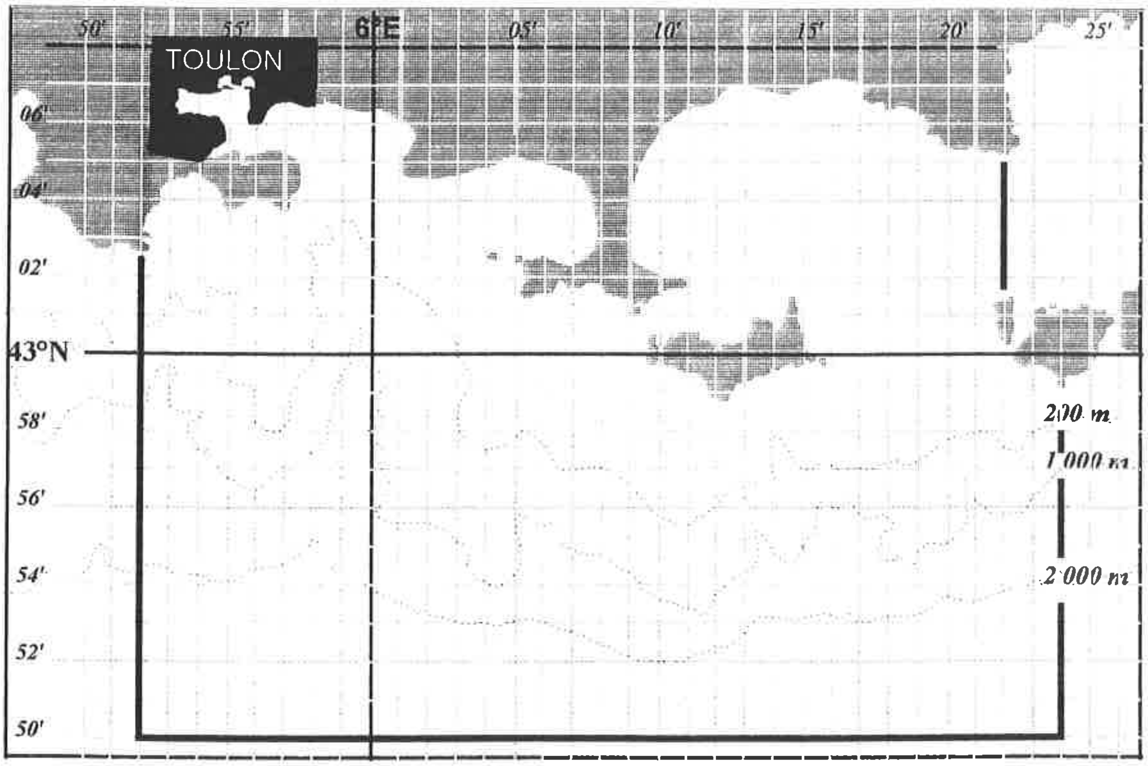

Fig. 1 The study area

RESULTS During the survey cruises, Risso's dolphins were encountered eleven times, principally during the autumn and winter. No encounters were recorded from the beginning of May (the last sighting being 1 May 1995) to the middle of September (the earliest sighting on 17 September 1992), despite a great number of cruises and some observations outside of the survey cruises. Few surveys were carried out in February or March due to bad weather conditions. This surveying inconsistency may explain the lack of observations during this period (Table 1).

Table 1 Survey effort and encounter rate

MONTH	ACCUMULATED SEARCH TIME (*HOUR*)	ENCOUNTERS	ENCOUNTERS PER HOUR OF SURVEY EFFORT
January	8.5	1	0.118
February	16.1	0	0
March	5.3	0	0
April	21.6	1	0.046
May	27.2	1	0.037
June	24.3	0	0
July	39.9	0	0
August	18.8	0	0
September	22.1	1	0.045
October	10.6	3	0.283
November	10.4	2	0.192
December	10.0	2	0.200
TOTAL	214.8	11	0.051

However, the presence of Risso's dolphins was significantly greater during autumn and winter than during spring, and especially, during summer (Table 1 and Fig. 2).

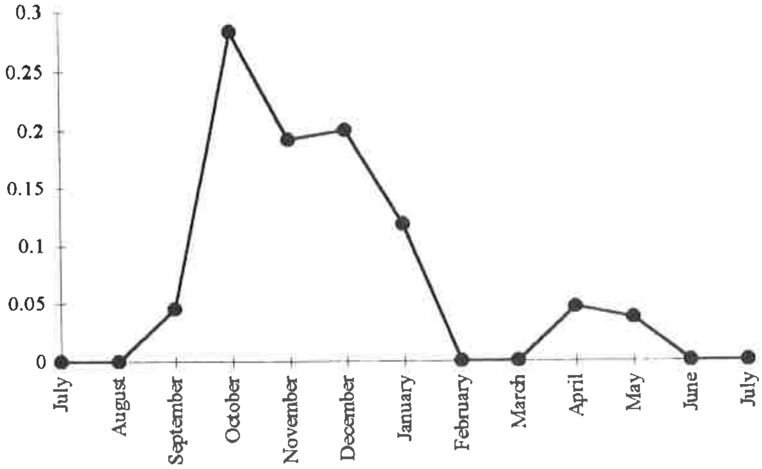

Fig. 2. Observation frequencies of Risso's dolphins (as in Table 1)

Almost everywhere that comparable studies have been carried out, observers have also noted similar periods of high abundance (Mizue and Yoshida, 1962; Hussenot, 1985; Kruse, 1989). What is surprising, however, is the differences in peak abundance between two closely situated areas in the Mediterranean. The increase of Risso's dolphin observations in the western Ligurian Sanctuary during the winter is contrary to observed patterns of abundance less than 100 km to the east. In 1826, Risso himself wrote that *Grampus griseus* "arrived off Nice in Spring and were observed until fall". Viale (1977) also noted a peak in abundance, north of Corsica, during the summer.

CONCLUSIONS Within the Ligurian Sanctuary, could there be a movement of Risso's dolphins from east to west during the autumn, and from west to east in spring? To answer this question, a photo-identification catalogue was started in 1991. Today more than 250 individuals have been photo-identified within the study area (with approximately 10% of them re-sighted from two to four times, and intervals between contacts with the same animal ranging from 21 to 1695 days). With the aim of analysing the movements of Risso's dolphins, it is intended to collect as many photographs of individual dolphins as possible from the surrounding zones, and especially in the Ligurian Sea itself.

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SIGHTINGS OF RISSO'S DOLPHIN IN THE LIGURIAN WATERS

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INTRODUCTION Risso's dolphin, *Grampus griseus* (G. Cuvier, 1812), is common in the Italian seas. Strandings (Annual Report by Centro Studi Cetacei) and sightings suggest a greater concentration of the species in Tyrrhenian and Ligurian waters (Cagnolaro *et al*., 1986; Di Natale, 1982; Marini *et al*., 1992; Notarbartolo *et al*., 1993; Palazzoli, 1983).

The social organisation and the surface behaviour of this species is poorly known. Herds of large size have been reported in oceanic waters, while in Italian seas, observations of small groups are more frequent (Di Natale, 1982; Evans, 1987; Viale, 1985).

Although data on Risso's dolphin feeding habits are quite scarce (Bello and Bentivegna, 1994; Clarke and Pascoe, 1985; Evans, 1987; Podesta' and Meotti, 1991), its preference for cephalopods is evident.

This work has the aim to describe the surface behaviour of Risso's dolphins observed in a small area located a few kilometres from the Italian coast, in the waters off Capo Noli (Savona), Ligurian Sea. The area is characterised by deep waters close to the shore. These waters are known to be rich in cephalopods (Torchio, 1966).

MATERIALS AND METHODS The research was based on daily cruises using a small outboard motorboat. The study area (about 10 square kilometres) comprised the nearshore waters between Spotorno and Finale Ligure (Fig. 1). The choice of this area was suggested by some incidental sightings made in the previous years.

From 1983 to 1989 (excluding 1988), we carried out bi-monthly surveys in July, August and September. Each daily survey lasted about 6 hours. During that time, we covered at random the study area to sight cetaceans. When encountered, Risso's dolphins were followed as much as possible. Photographs were always taken in order to analyse colour patterns of sighted specimens and to apply tentatively the photo-ID technique.

RESULTS Forty percent of daily surveys were successful. Usually, each sighting lasted around two hours. Groups sighted comprised an average of ten individuals, except once when we observed a herd of about 40 animals. The sizes of the Risso's dolphins (2.5 m to 3.5 m) suggested that the groups were mixed, with sub-adult and adult specimens. The more characteristic features of Risso's dolphin behaviour during these sightings are briefly described below.

Resting. The group stayed in the same area, only rarely showing surface activity. Often the Risso's dolphins floated without evident movement, keeping only the dorsal fin and a small part of the back out of the water. On some occasions they passed swimming slowly under our boat with their bellies upwards. At times, one of them spyhopped, maintaining this position for about 4-5 seconds. In a different, often observed movement, the dolphin came vertically out of the water with the tail and part of the body, only for few seconds. On these occasions, the school was very scattered. For some specimens easily identified by their pigmentation, we observed a maximum diving time of five minutes.

Social Interactions. The group was swimming always in the same area; the animals were very active at the surface. Risso's dolphins swam in pairs, surfacing together and remaining always very close to each other. They swam alternatively slow and fast. The individuals we could observe swimming under our boat were close to eachother, and mutually rubbed one another persistently. Often the pairs gathered together forming more numerous groups, crossing and rubbing eachother while swimming, and then separating. At different times we observed an individual coming to the surface with the tail vertically upwards; the same action was simultaneously performed by more adults. At times, an individual violently slapped the water with its flukes. On some occasions, a specimen was observed breaching.

Travelling. The Risso's dolphins were swimming almost continually (at a speed of about 4-5 km/h) following one direction. The shape of the school was variable: on some occasions, the animals were close to each other, on other occasions they were scattered. The largest animals were often swimming at the head of the school, 10-20 metres in front of it, followed by the others. These animals were nearly white.

Calves. On three occasions we observed the presence of calves in the group (two or three animals each time). The calf was always close to an adult, surfacing together and keeping physically in contact with it. Often two other adults were swimming near the calf and the adult, one before and one behind the pair. When we tried to get closer, one of the two adults placed itself close to the pair, between our boat and them, changing its direction and making the observation of the calf quite difficult. At other times, while we were approaching the calf and the adult, they immediately dived, and then surfaced far from us.

DISCUSSION These repeated sightings in the same area suggest a significant presence of the species. The abundance of cephalopods, which move vertically along the edge of the continental shelf, might be one of the reasons, even though we never observed Risso's dolphins feeding at the surface. As we never sighted the same specimen on two different days, we cannot suggest that Risso's dolphins are permanent in this area. It is interesting to underline the behaviour and the shape of the school described as travelling, with the largest individuals apparently leading the school. For the actions carried out by the two adults which accompanied the adult and the calf, we can suppose a situation of "defence" and "vigilance". The presence of the calves during the summer suggests births in this period of the year.

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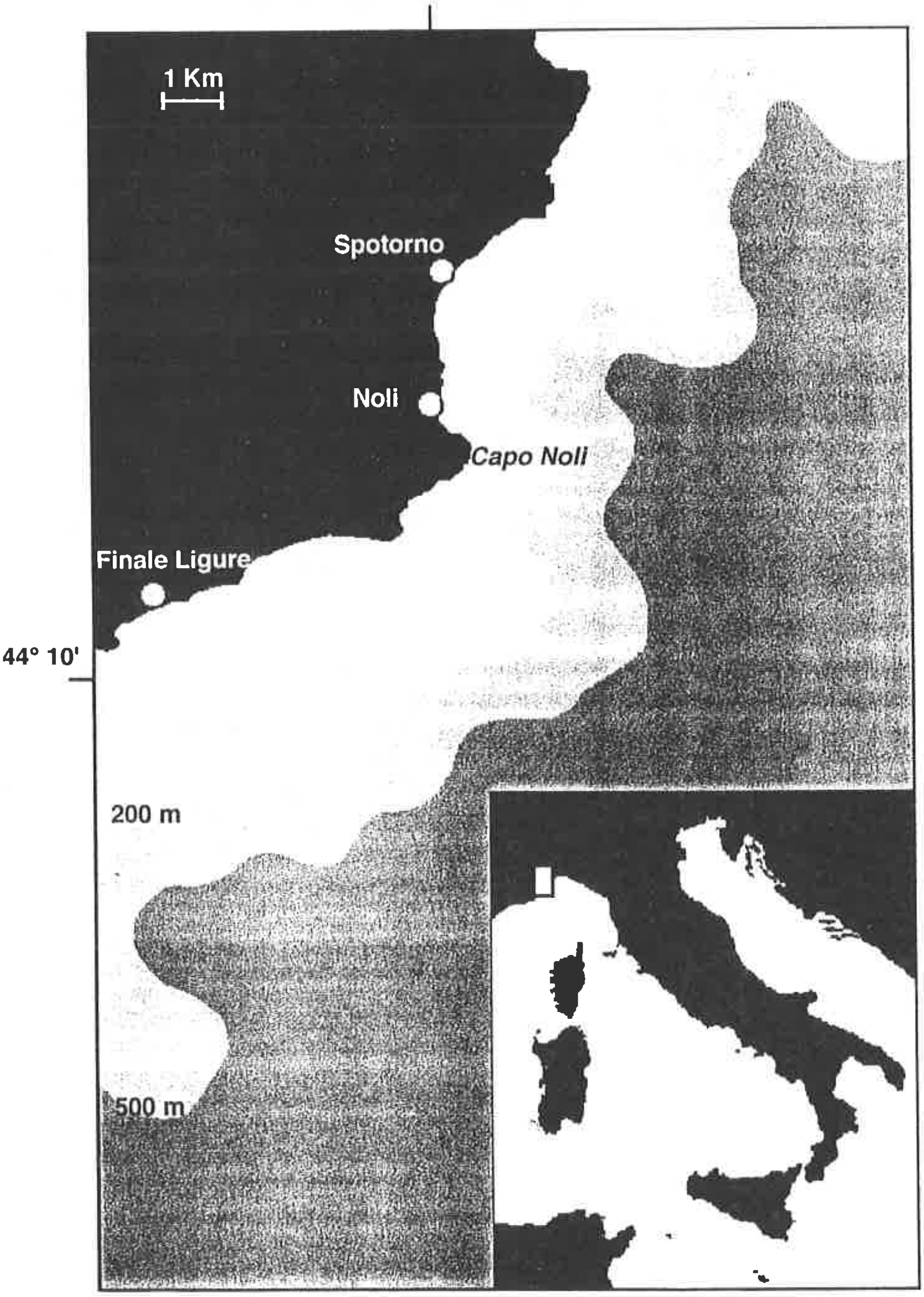

Fig. 1 The study area

A PHOTO-IDENTIFICATION STUDY OF RISSO'S DOLPHINS (*GRAMPUS GRISEUS*) IN THE COASTAL WATERS OF THE EYE PENINSULA, ISLE OF LEWIS, SCOTLAND

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Cetacean surveys conducted by the Sea Watch Foundation over the last five years have highlighted that Risso's dolphins (*Grampus griseus*) are regularly sighted in the coastal waters of the Eye Peninsula, Isle of Lewis, Scotland, particularly during the months of August and September. A pilot photo-identification study was conducted during the months of August and September 1995 in the coastal waters from Kebock Head (58°02'N, 6°21'W) to Tolsta Head (58°21'N, 6°09'W) seaward yo the 100 m depth contour (a sea surface area of c. 170 km^2). At least 106 indidividuals were catalogued.

Further work was conducted from May to September 1996. Photo-identification studies were undertaken, and both environmental variables and surface behaviours recorded. Acoustic data were also collected and are currently being analysed at the Centre of Bioacoustics and Environmental Research, University of Pavia, Italy.

A total of 115 hours has been spent encountering Risso's dolphins from a total of 358 hours of boat survey effort. Data analyses are still underway. The photo-ID catalogue presently shows at least 142 individuals with at least 48 individuals re-sighted from 1995. Group size has ranged from 1 to 80+. Modal group size is 6-10.

Individuals which were identified as a 'group' have been re-sighted as a 'group' in 1996 with many of the same individuals present, suggesting that longer term affiliations may exist within more fluid group structures. Groups are also sometimes segregated by age and sex. This contribution will also illustrate and describe percussive and other surface behaviours observed, and relate these to environmental, spatial and temporal variations.

DEMOGRAPHIC STUDIES ON THE AMAZON RIVER DOLPHIN (*INIA GEOFFRENSIS*), IN THE CUYABENO RESERVE, ECUADOR

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INTRODUCTION The Cuyabeno Wildlife Reserve (Reserva de Produccíon Faunística Cuyabeno) was first created in 1979. It is situated in the Province of Sucumbìos in the Amazonian Lowland of Ecuador and includes 603,000 ha of pristine rainforest, large tracts of which are flooded. Two "blackwater" rivers were studied, the Cuyabeno in the south-west of the reserve and the Lagarto Cocha, which forms a natural border to Peru 100 km further east. Both the Cuyabeno and the Lagarto Cocha are tributaries to the Aguarico, which is the main river in the reserve and a tributary to the Rio Napo, that flows into the Amazon river further downstream, in Peru.

Numerous studies have revealed that the Cuyabeno reserve is a zone of high biodiversity (EcoCiencia, 1994). Concerning the cultural aspects, Cuyabeno region is traditionally used by native Indians such as the Siona-Secoyas, Cofanes, and Quichuas.

These indigenous peoples have various myths about river dolphins and do not hunt them (*pers. obs.*); nevertheless, the population status of these dolphins is largely unknown. In January 1992, Herman, von Fersen and Solangi undertook an expedition to the Lagarto Cocha river and sighted *Inia* throughout the 60 km stretch surveyed (Herman *et al.*, 1996). Until now, only base-line data was available about *Inia* in the Lagarto Cocha (Herman *et al.*, 1996; Utreras, 1996), and nothing was known about the population size and the abundance of *Inia* in the Cuyabeno river. This paper presents the preliminary findings of an ongoing project in this region.

Part of the project is to estimate the population size and to determine the abundance of *Inia* in the Cuyabeno and Lagarto Cocha by undertaking line-transect surveys and by building a photo-ID catalogue. During observations, the behavioural traits of the animals, i.e. travelling, milling, feeding, travel feeding, socialising and resting, are recorded in order to gain information on habitat utilisation. This data is still being analysed.

Other aquatic mammals, such as the Amazon manatee (*Trichechus innunguis*), the Amazon river otter (*Lutra longicaudis*) and the giant otter (*Pteronura brasliensis*), are present in the Cuyabeno Reserve. The Amazon manatee and the giant otter are almost extinct and sightings were rare during the study. While surveying the dolphins, sightings and positions of these species were also recorded. In the Cuyabeno reserve, manatees were encountered on six occasions, the Amazon river otter on four, and the giant otter on one occasion.

In addition to studies concerning *Inia*, water samples were taken from both rivers and several tributaries of the Cuyabeno, measuring pH, temperature, oxygen, visibility and conductivity. The Aguarico, a "whitewater" river, has its source in the Andes whereas the Cuyabeno and the Lagarto Cocha rise in flooded forest. Tannin from fallen leaves is washed out, giving a tea-like colour to the water, and resulting in acidic pH values (c. 5.3) and low conductivities (c. 30 mS) which are typical values for "blackwater" rivers (Fittkau, 1975; Sioli, 1984).

MATERIALS AND METHODS Between May 1996 and February 1997, a total of 114 days were spent in the field. The Cuyabeno was studied from the estuary up to the Lagunas Grandes, a system of five lagoons 87 km upstream. The Lagarto Cocha was surveyed from the estuary to the Laguna Imuya, 20 km upstream. Both rivers are approximately 30 m wide, and their depth varies with rainfall.

During the high water period, the Cuyabeno has a depth of 5 m at the exit of the Laguna Grande, and the Lagarto Cocha a depth of 9 m upstream of the Dolphin Cocha. From the main rainy season in April to July to the dry season in December to February, the water level can vary by 3 m in the Cuyabeno and 4 m in the Lagarto Cocha. During the dry season, the Cuyabeno runs almost dry in its upper reaches.

Observations were made from a 10 m dugout canoe with a 25 hp out-board motor, travelling at a speed of 10 to 15 km/h, from shore or from a 6 m paddled, dugout canoe. A total of 271 hours of observations were made from the motorised canoe, 132 hours from the dugout, and 41 hours from land. The Cuyabeno was observed for a total of 389 hours, with 171 sightings of *Inia*, and the Lagarto Cocha for 55 hours, with 66 sightings.

One observer scanned the river in front of the canoe, and a second observer scanned the waters behind the canoe. Sightings were investigated, group sizes estimated, and size classes determined. Animals were classified into three classes according to their estimated size: calves (up to 1 m), intermediates (1 to 2 m) and adults (larger then 2 m).

RESULTS The distribution of *Inia* shows that in the Lagarto Cocha most sightings were of solitary individuals (42%). Groups with two or three individuals were sighted in 27% or 20% of the sightings, respectively. Groups with four or more animals were rare and only seen in 3% or 8% of the sightings, respectively. In the Cuyabeno, single animals were seen less frequently than in the Lagarto (29%), whereas groups consisting of two, three, or four animals were seen more often (34, 25 and 25%, respectively). Large groups of more than four animals were rare (4%) (Fig. 1).

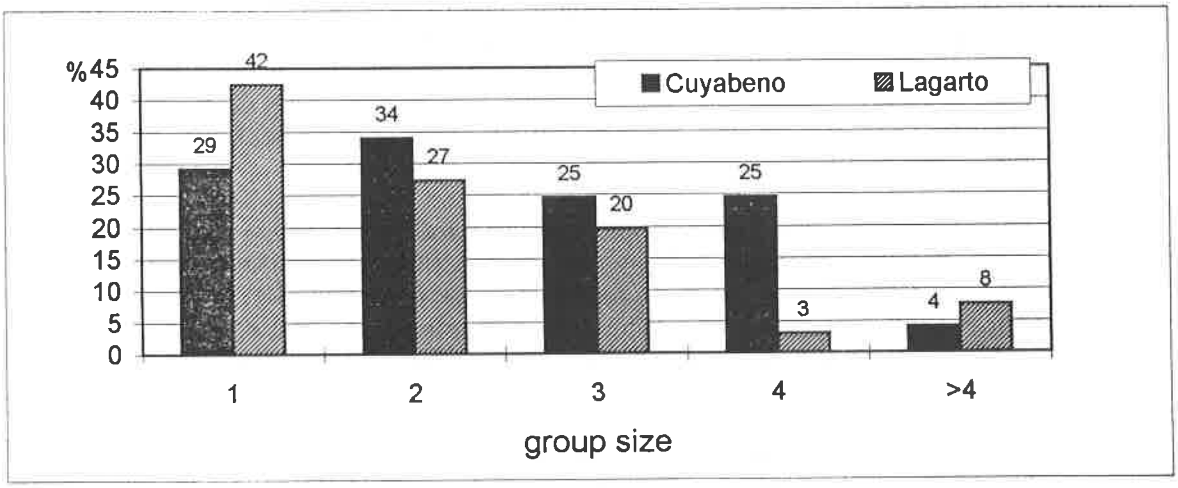

Fig. 1 Distribution of group size of *Inia geoffrensis* in the Cuyabeno and Lagarto Cocha

More adults were observed in the Lagarto Cocha than in the Cuyabeno. For the intermediate class and calves, the percentages were more or equal in both rivers. The intermediate class was the most frequently observed size class in both rivers (50% in the Cuyabeno and 46% in the Lagarto Cocha), whereas adults were seen on few occasions (14% in the Cuyabeno and 20% in the Lagarto Cocha). The percentage of calves was fairly high for both rivers (35% in the Cuyabeno and 34 % in the Lagarto Cocha) (Fig. 2).

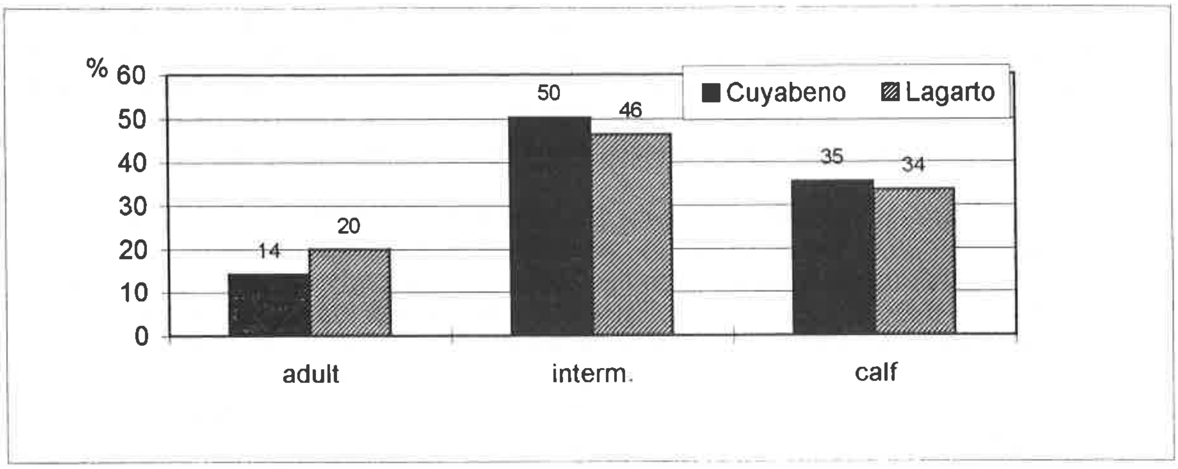

Fig.2 Age distribution of *Inia geoffrensis* in the Cuyabeno and Lagarto Cocha

Upon close examination of group composition, it is obvious that calves are mainly observed together with animals of intermediate size (35% in the Cuyabeno and 24% in the Lagarto Cocha). Groups of all size classes, i.e. adults, intermediate and calves all together, are frequent in both rivers (13% in the Cuyabeno and 17% in the Lagarto Cocha). In the Lagarto Cocha, 18% of the sightings were solitary calves, whereas in the Cuyabeno, single calves were observed in only 4% of the sightings. Solitary intermediate-sized animals were very frequent in both rivers (31% in the Cuyabeno and 21% in the Lagarto Cocha). Solitary adults were rarely recorded (5% in the Cuyabeno and 9% in the Lagarto). Groups with adults and intermediate-sized animals or groups with adults and calves (6% in the Cuyabeno and 8% in the Lagarto Cocha; 7% in the Cuyabeno and 3% in the Lagarto Cocha) were also rarely observed (Fig.3).

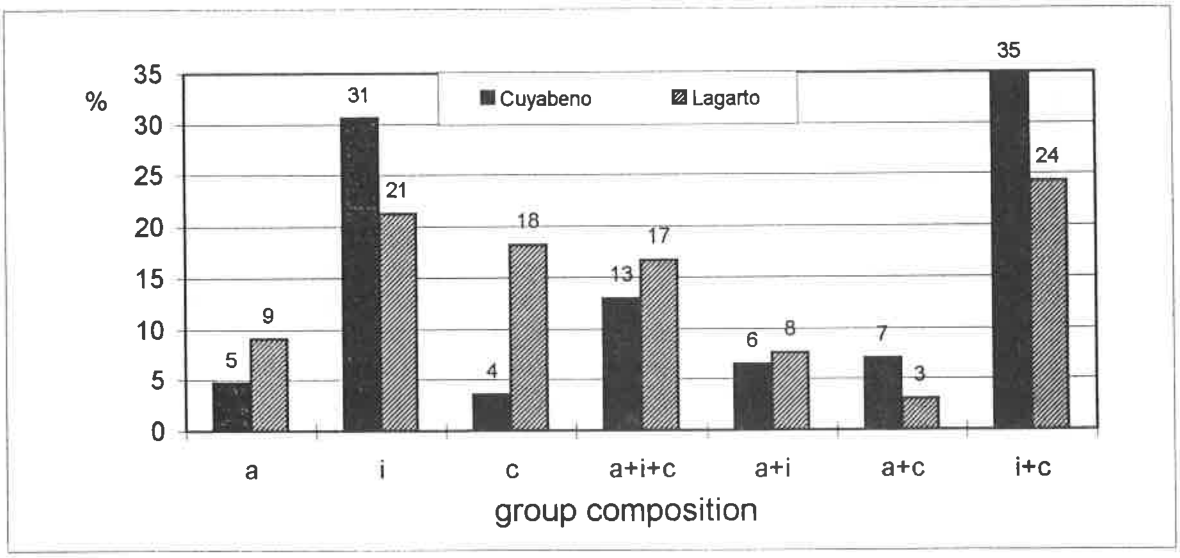

Fig.3 Group composition of *Inia geoffrensis* in the Cuyabeno and Lagarto Cocha (*a:* adult, *i:* Intermediate, *c:* calf)

DISCUSSION Examination of *Inia* reproductive organs from the Central Amazon, near Manaus, have shown that females mature at a body length of 1.80 m and males at a length of 1.93 m; calves are born at a length of 0.81 m (Best and Da Silva, 1984; Brownell, 1984).

Best and Da Silva (1984) estimated the neonatal growth rate of *Inia* calves to be 2.5 cm per month. According to these studies, the intermediate class consists of juveniles older than one year and young mature females up to a length of 2 m. This explains the high proportion of intermediate-sized animals in both rivers, and the high percentage of calves swimming with intermediate-sized animals, undoubtedly mother-calf pairs.

Previously, *Inia* was considered to be a solitary animal (Brownell, 1984), but in the Cuyabeno it appears in groups of two to four animals. In the Lagarto Cocha, sightings of solitary *Inia* were more frequent than in the Cuyabeno, but every second sighting was of a group. Hence, the Cuyabeno and the Lagarto Cocha appears to be a habitat for "social" *Inia*. Conditions in the Cuyabeno seem to be more suitable for groups than the Lagarto Cocha. However, animals in the Lagarto Cocha can face predators in various lagoons, or in the "gremalotes" (floating islands of thick grass), meanwhile the Cuyabeno has less lagoons and no "gremalotes". Therefore, the larger groups in the Cuyabeno may be reflective of a greater risk of predation. Further studies are required, including research upon prey abundance, in order to determine the reasons behind these patterns in group structure.

Brownell (1984) mentioned that 73% of *Inia* caught for live presentations measured less than two metres. Only 6% of these animals were calves with a length less, or equal to, one metre. Best and Da Silva (1984) note that only two out of 21 captured animals measured 1 m or less. In both studies, calves represented less than 9% of the animals caught. The high percentage of intermediate-sized animals and calves in the Cuyabeno and Lagarto river indicate that this may be an important area for juveniles and calves. The fact that almost all animals seen were smaller than 2 m may indicate that these animals are quite young, according to the data collected by Brownell (1984) and Best and Da Silva (1984). Another possibility is that the animals of the Cuyabeno and Lagarto Cocha are generally smaller than animals further downstream in the central Amazon region.

This first field period leaves quite a few questions unanswered, but it could be concluded that both rivers are an important habitat for calves, as many calves were sighted. To find out more about sex and age distribution, and the body length of *Inia* in the Cuyabeno Reserve, more studies, including DNA analysis, are necessary and will hopefully be carried out in the future.

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STOMACH CONTENTS OF MARINE MAMMALS STRANDED ON THE PORTUGUESE COAST

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INTRODUCTION Assessment of the feeding habits of marine mammals is not only important for the knowledge of the biology of the species, but can also provide a better understanding of their role in marine ecosystems (Pierce & Boyle, 1991), position in the trophic chain, habitat use and interspecific relationships (Desportes, 1985).

The present study intends to be a preliminary report on the diet of marine mammals off the Portuguese coast.

MATERIALS AND METHODS The stomach contents of 19 cetaceans and one pinniped stranded on the Portuguese coast between April 1989 and February 1997 were examined. The entire stomachs were collected and the contents were washed through a 1 mm sieve. Sampling problems during the necropsy of the minke whale did not allow the collection of the whole stomach. Otoliths, vertebrae, and other skeletal structures were identified using a reference collection. A published guide (Harkönën, 1986) was also used in the case of the otoliths. Cephalopod beaks were identified using reference collections, and according to Clarke (1986) and Pérez-Gándaras (1986). Regression equations relating fish length and weight to some otolith or vertebral dimension (Granadeiro & Silva, in prep.) were used to determine the contribution by weight of the more frequent and numerous fish prey species. For cephalopods, dorsal mantle length and wet weight were estimated from lower beak dimensions using regressions described by Pérez-Gándaras (1986) and Clarke (1986). Results were expressed as percentage number (%N), frequency of occurrence (%F) and percentage weight (%W) (when determined), of each prey species in the diet.

RESULTS Twelve of the 20 stomachs examined contained traces of food items. These include the stomachs of five striped dolphins (*Stenella coeruleoalba*), four bottlenose dolphins (*Tursiops truncatus*), one Risso's dolphin (*Grampus griseus*), one minke whale (*Balaenoptera acutorostrata*), and one juvenile hooded seal (*Cystophora cristata*) (Table 1). Data on the common dolphin (*Delphinus delphis*) have been presented elsewhere (Silva & Sequeira, 1997).

A total of 32 prey items belonging to nine different species and nine families were identified in the stomachs of the striped dolphins. Cephalopods were the most important food item, representing 84% of the total number of prey items ingested and 90% of the reconstituted weight. *Chiroteuthis* sp. was the main prey on a weight basis, comprising more than 60% of the weight of all prey items taken, but other oceanic squids were also present (*Histioteuthis* and *Brachioteuthis*). The estimated length of striped dolphin fish prey ranged from 8.5 to 17.4 cm and the mean estimated length of the cephalopods taken was 6.3 cm, with a minimum of 1.6 cm and a maximum of 18.6 cm.

Thirteen different prey species were identified in the stomach contents of the four bottlenose dolphins. Fish items were found in all the stomachs examined and comprised more than 99% of the total number of prey items. Snipefishes (*Macroramphosus* sp.) were the most important prey in numbers, with 486 individuals weighing 4.845 kg, followed by blue whiting (*Micromesistius poutassou*) (8%). Common sea bream (*Diplodus vulgaris*) was only the fifth most numerous prey species but was found in 75% of the stomachs examined.

Table 1. Number, frequency and weight of the prey species found in the stomach contents of marine mammals stranded on the Portuguese coast.

		S. coeruleoalba (N=5)						*T. truncatus* (N=4)					*G. griseus* (N=1)			*B. acutorostrata* (N=1)	*C. cristata* (N=1)			
PREY SPECIES		Number		Occurrence		Weight		Number		Occurrence		Weight	Number		Weight	Number	Number		Weight	
		N	%N	F	%F	W	%W	N	%N	F	%F	W	N	%N	W	N	N	%N	W	%W
Fish																				
Congridae	*Conger conger*							4	0.6	1	25									
Clupeidae	*Sardina pilchardus*																3	75	127.4	75.4
	unidentified Clupeidae							1	0.2	1	25									
Argentinidae	*Argentina sphyraena*							4	0.6	1	25									
Gadidae	*Micromesistius poutassou*	3	9.4	1	20	12.6	2.4	48	7.6	1	25	1934.4								
	Gadiculus argenteus							35	5.6	1	25									
Merluccidae	*Merluccius merluccius*							3	0.5	1	25	50.4								
Macrouridae	unidentified Macrouridae							2	0.3	1	25									
Macroramphosidae	*Macroramphosus* sp.	1	3.1	1	20	13.8	2.6	486	77.1	1	25	4845.4								
Sparidae	*Diplodus vulgaris*							14	2.2	3	75									
Mugilidae	*Liza aurata*							16	2.5	2	50					9				
	Liza ramada							6	1.0	1	25									
Scombridae	*Scomber* spp.	1	3.1	1	20	25.6	4.8													
	Scomber japonicus																1	25	41.6	24.6
unidentified fishes								9	1.4	2	50									
Total (fish group)		5	15.6	2	40	52.0	9.8	628	99.6	4	100					9	4	100	169	100
Cephalopods																				
Sepiolidae	unidentified Sepiolinae	7	21.8	1	20	11.8	2.2													
Loliginidae	*Alloteuthis* sp.	5	15.6	2	40	30.1	5.7													
Histioteuthidae	*Histioteuthis reversa*	2	6.3	1	20	31.5	6.0													
Ommastrephidae	unidentified Illicinae	3	9.4	1	20	57.4	10.9													
Chiroteuthidae	*Chiroteuthis* sp.	4	12.5	2	40	329.9	62.4													
Brachioteuthidae	*Brachioteuthis* sp.	4	12.5	1	20	15.7	3.0													
Octopodidae	*Octopus vulgaris*												7	25.0	19525.5					
	Eledone moschata												4	14.3						
	unidentified Octopodidae												17	60.7						
unidentified cephalopods		2	6.3	1	20															
Total (cephalopd group)		27	84.4	3	60	476.4	90.2						28	100						
Crustaceans																				
Crangonidae	*Crangon crangon*							1	0.2	1	25									
Portunidae	*Carcinus maenas*							1	0.2	1	25									
Total (custacean group)								1	0.4	1	25									
Totals		**32**	**100**	**5**	**100**	**528.4**	**100**	**630**	**100**	**4**	**100**	**6830.2**	**28**	**100**		**9**	**4**	**100**	**169**	**100**

All prey items found in the Risso's dolphin stomach belonged to the Octopodidae family. Seven individuals identified as common octopuses (*Octopus vulgaris*) amounted to a total weight of 19.526 kg, with a single individual, 30.3 cm long, weighing 11.346 kg. It was not possible to estimate the weight contribution of the four musky octopuses (*Eledone moschata*) because only upper beaks were found.

Three sardines (*Sardina pilchardus*) and one chub mackerel (*Scomber japonicus*) were identified in the hooded seal stomach. The estimated length of the fishes ingested ranged from 16.6 to 19.7 cm.

DISCUSSION Observation of striped dolphin stomach contents revealed a wide range of prey species consumed. Although both cephalopods and fish were present in the stomachs, cephalopods were the main prey, both on a numeric and on a weight basis. The size distribution of fish prey items suggests that striped dolphins fed on small and immature individuals. Similarly, most of the cephalopods taken were smaller than the average length at sexual maturity (Guerra, 1992). Striped dolphins seem to prey both on benthic and pelagic organisms, living over the continental shelf or in more oceanic waters. The results reported are consistent with findings from other areas (Würtz & Marrale, 1993; Blanco *et al.*, 1995).

Two bottlenose dolphins examined in this study belonged to the Sado Estuary population (Gaspar, *pers. comm.*). Their diet composition is in accordance with their coastal habitats. Mullets (*Liza aurata* and *L. ramada*) are estuarine and coastal pelagic species, usually found on sandy or muddy bottoms, and are quite abundant in the Sado River and adjacent waters. The common sea bream is a benthic fish that occurs most frequently over rocky bottoms on coastal, shallow waters. These results suggest that bottlenose dolphins of the Sado Estuary population can explore resources provided by different coastal habitats. Cockcroft and Ross (1990) described a similar feeding behaviour in the bottlenose dolphin population off Natal. The stomach contents of the other individuals not recognised as Sado Estuary dolphins, besides coastal species, contained several pelagic and mesopelagic fishes usually found in more oceanic waters (snipefish, blue whiting and Atlantic hake (*Merluccius merluccius*)), indicating more offshore foraging habits.

Although Risso´s dolphins feed mainly on oceanic cephalopods, neritic octopods and squid are often mentioned as important food items in their diets (Carlini *et al.*, 1992). The stomach contents examined in this study consisted entirely of neritic octopods of the Octopodidae family. The common octopus has also been identified in stomachs of Risso's dolphins from Galicia (González *et al.*, 1994) and octopuses of the genus *Eledone* seem to be a frequent prey of this cetacean in many regions (Carlini *et al.*, 1992; González *et al.*, 1994).

In the North Atlantic, minke whales feed on several pelagic fishes (Nordøy & Blix, 1992). The minke whale stomach observed here contained the remains of only one prey species- *L. aurata*, a pelagic fish that occurs on shallow coastal waters.

Described as pelagic animals, capable of performing deep dives, hooded seals are known to feed on deepwater prey (Sergeant, 1976). Although such deepwater species, like the redfish (*Sebastes marinus*) and squid (*Gonatus fabricii*), are common and abundant off the Portuguese coast, none was observed in the stomach contents of the juvenile hooded seal. Instead, two epipelagic fish species living over the continental shelf were identified. Because the animal examined in this study was found outside (and very far from) its normal distribution range, the diet composition described does not correspond with the typical feeding habits of healthy hooded seals. Nevertheless, the analysis of the stomach content of this individual could contribute to a better understanding of the feeding behaviour of the hooded seal.

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BEHAVIOUR

SPECIES RECOGNITION: AN ADDITIONAL FUNCTION FOR TEETH OF BEAKED WHALES OF THE GENUS *MESOPLODON*

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INTRODUCTION Members of of the genus *Mesoplodon*, as well as other species of beaked whales (Ziphiidae), have an unusual dentition for odontocete cetaceans. There is a reduction in the number of teeth, probably related to a diet specialising in squid. In the genus *Mesoplodon*, this tooth reduction is extreme; there is generally only one pair of functional teeth which are in the lower jaw (Mead, 1989). These teeth only erupt from the gums and become functional in adult males. Since teeth are not functional in females or in immature males, it seems unlikely that these teeth are required for feeding (Heyning, 1984). The question arises as to what is the function, or functions, of these sexually dimorphic teeth. Function is defined as "...those consequences of a trait through which natural selection acts to spread or retain the trait in the population." (Clutton-Brock, 1982).

At present, the only widely accepted theory for the function of teeth in the genus *Mesoplodon* is that teeth are used in male-male aggressive interactions, presumably over females (Heyning, 1984), and the evidence of high levels of intraspecific scarring on adult males provides support for this theory (Heyning, 1984; Mead, 1989). However, this paper proposes that another function may have also shaped the evolution of teeth in the genus *Mesoplodon*. This function is species recognition of males by females due to the position of the teeth in the jaw and the shape of the teeth.

The genus *Mesoplodon* has a very conservative body plan, with little difference between species (Mead, 1989). In general, an adult male with erupted teeth is required to identify an observation of this genus to species level, at least from a human point of view. This is because the major external variation between species is the shape and position of teeth in males. Why the position and shape of teeth vary so much between species is not entirely answered by functional requirements of fighting. Species with teeth in the tip of the lower jaw appear to be just as effective at inflicting injuries on other males as species with teeth in a more posterior position. Why then should teeth shape and position vary so greatly between species?

An additional function for teeth in the genus *Mesoplodon* The reason for the variation in shape and position of teeth may be the need for females to ensure they mate with males of their own species, and not another sympatric species of the genus with a superficially similar appearance. For a female, the result of such a mating could be the production of an non-viable, or relatively unfit, hybrid foetus that uses up resources which are then unable to be used for production of a viable or more fit, non-hybrid foetus.

Hybridisation between species appears to be possible for a large number of odontocetes and may occur in the wild, although most hybridisation undoubtedly takes place in captivity (Reyes, 1996). Since the ability to hybridise (this does not mean that it is a common event, just that it is possible, and that species isolating mechanisms are likely to evolve) appears to be a widespread phenomenon in odontocetes, the ability to hybridise may also be present in *Mesoplodon*. If this is the case, there will be strong selective pressure on females to ensure that they mate within their species. There will not be the same selective pressure on males because a male can re-mate again in the same breeding cycle after fertilising a female of another species, but a female who has been fertilised by a male of the wrong species loses out on reproduction in that cycle and has to wait until the next breeding cycle, as well as losing the resources invested in a non-viable, or relatively unfit, foetus.

Since it is important for females to be 'choosy' about which males they mate with, they will exert a selective pressure on males to advertise their species in some way. It is logical that species recognition (a species isolating mechanism) will be linked with a trait present in males which is readily visible to females. The most obvious candidate for this is the teeth. So long as adaptations for species recognition do not affect other functions of teeth, such as their use as weapons, males are 'free' to evolve teeth to serve other functions, such as species recognition under the selective pressure of 'choosy' females. The position of the teeth in the lower jaw and the shape of the teeth, both of which vary widely between species, may have evolved under this selective pressure and function as species recognition characteristics.

Evidence for this hypothesis can be found when sympatric species are examined. For example, amongst North Atlantic species of *Mesoplodon*, four are known at present. Females of these species are, from a human point of view, virtually indistinguishable in external appearance. Males, however, vary in the position and shape of the teeth and are relatively easy to separate based on this feature. Similar differences are found if sympatric species from other oceanic areas are examined. It is interesting to note that the most widespread species, the dense beaked whale (*Mesoplodon densirostris*) has one of the most recognisable tooth positions. This may relate to the need for males to differ from all other species of *Mesoplodon*, being sympatric with every other species of the genus.

It has been suggested that teeth moved from an anterior to a posterior position to reduce risk of damage to the jaw and the shape changed as a result (Heyning, 1984). If variation in tooth position and shape is related to the function of intraspecific fighting, as suggested by Heyning (1984), similar variation would be expected in some/all other genera of beaked whales which use teeth in aggressive intraspecific interactions since similar selective pressure would be exerted to reduce risk of damage. If variation in tooth position and shape function as species recognition characters, it would be expected that variation would only occur in genera where sympatric species occur. It is thought that in all genera of beaked whales (*Berardius*, *Hyperoodon*, *Mesoplodon*, *Tasmacetus* and *Ziphius*), teeth function as weapons. However, variation in tooth shape and position occur only in the genus *Mesoplodon*, all other beaked whale genera having conical teeth at the tip of the jaw. *Mesoplodon* is also the only genus with similar sympatric species, and therefore the only one requiring a species recognition mechanism. This provides further evidence to support the hypothesis that in this genus, species recognition occurs as a function of variation in tooth position and shape.

CONCLUSIONS The great variation in the morphology and position in the jaw of teeth in members of the genus *Mesoplodon* does not appear to relate to the function of teeth as weapons for male-male competition since teeth of different shapes and in different positions appear to be just as effective at inflicting injury, and it is only found in the genus with similar sympatric species, and not other genera of Ziphiidae. Another functional explanation is therefore required to explain these features of dental morphology in *Mesoplodon*. The variation in shape and position of teeth in the lower jaw has probably evolved to aid species recognition between otherwise similar sympatric species rather than as adaptations for the use of teeth as weapons for male-male competition.

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BEHAVIOURAL PATTERNS IN THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) OFF SYLT, GERMANY

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INTRODUCTION The harbour porpoise (*Phocoena phocoena*) is the only cetacean that is known to breed in German coastal waters. After a severe decline due to unknown reasons in the middle of this century, harbour porpoises can now be observed increasingly frequently at least in parts of the German Bight. Since then, their distribution, life history, and pathology have been extensively studied. As yet, however, little is known about the habitat use and activities of harbour porpoises in the German Bight. The main reason for the lack of behavioural studies on harbour porpoises in German waters is methodological difficulties: harbour porpoises are not what one could call numerous, anywhere along the German coast, and their elusive behaviour does not facilitate the observer's task to evaluate the function of an observed behaviour. In this study, a different approach was chosen to investigate the behaviour of these animals. In the field, any observed behaviour was recorded in terms of structural features. After the observation, the data were analysed for patterns. An interpretation of the observed behaviour was attempted on the basis of these patterns.

MATERIALS AND METHODS Observations were conducted from a beach overlooking an area of approximately 1,000 m long by 500 m wide, north of the island of Sylt, from May to September 1996, an area known to be frequented by harbour porpoises. Data were collected by continuous recording the behaviour of focal animals. As soon as a harbour porpoise was detected, this animal was chosen as the focal animal. The location, duration, distance, and direction of all dives of this animal were recorded in chronological order. Dive times were measured in seconds, the distances between surfacing points were estimated as being smaller than 5 m, between 5 m and 50 m, or greater than 50 m, and dive directions were classified with respect to coastline and tidal current. In addition to these data, surfacing times and directions were taken at the beginning of the study, but were excluded from the final analysis as they showed no specific patterns.

RESULTS During 251 hours of surveying, porpoises were present in the study area for 8.1 hours. A total of 655 dive times, 369 distances, and 89 dive directions were recorded. Dive times varied from 2 seconds to 116 seconds. Three dive time classes were distinguished: ultrashort dives (1 s to 15 s), medium dives (15 s to 30 s), and long dives (45 s to 120 s) (Fig. 1). In the temporal order of the dive times, two different patterns could be found: harbour porpoises either dived frequently longer than 45 seconds with an interval of 5 to 60 seconds between the long dives, or long dives were more irregular with an inter-dive interval of 90 to 420 seconds. When long dives were frequent, the porpoises showed, almost exclusively, ultrashort dives between two consecutive long dives. In contrast, when the porpoises took long dives on an irregular basis, there were significantly more medium dives between them (Fig. 2).

As in the temporal order of the dive times, different movement patterns could be found: distances between surfacing points were frequently less than 5 m when porpoises moved less than 200 m in one direction. When the porpoises moved for 200 m or more into the same direction, the proportion of dive distances less than 5 m was significantly smaller (Fig. 3). These long moves in one direction were orientated against or with the tidal current, but seldom perpendicular to it. Therefore, three different movement patterns were distinguished: non-directional movements, movements against the tidal current, and movements with the tidal current.

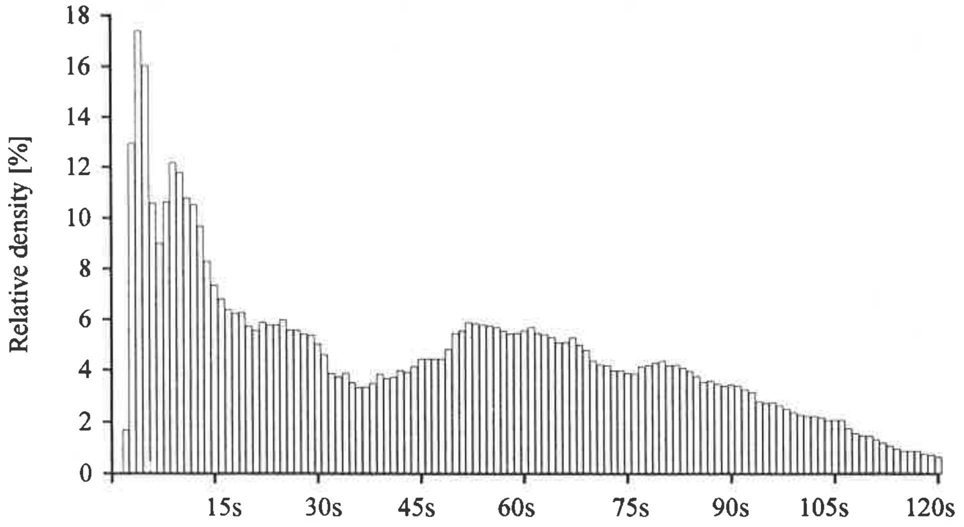

Fig. 1 Distribution of the relative density of dive times. The relative density around a dive time t is defined as the percentage of recorded dive times falling into the interval from t - (1/6 t) to t + (1/6) t.

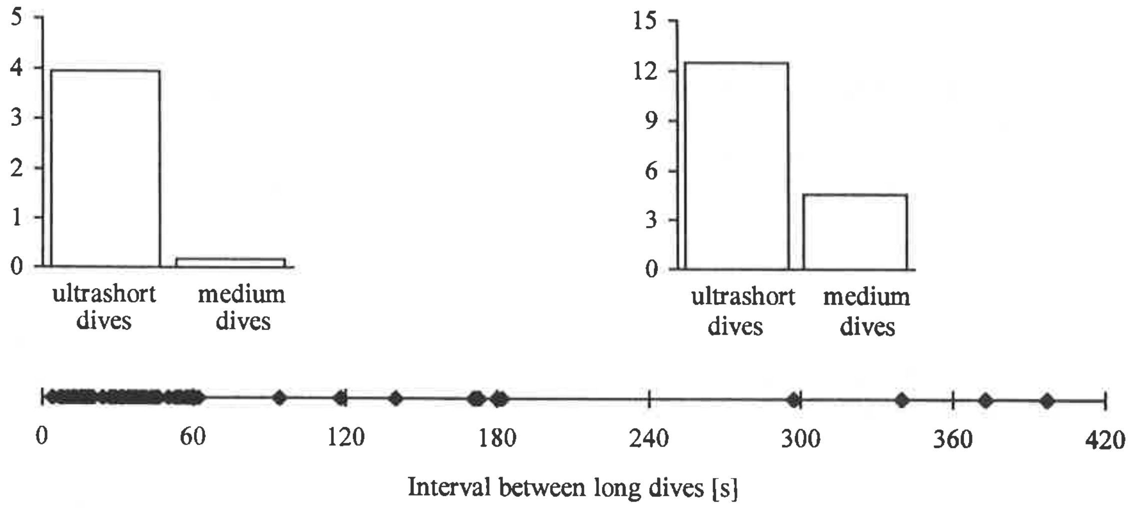

Fig. 2 Intervals between long dives, and average number of short and medium dives between two consecutive long dives for intervals <60 secs (top, on the left) and intervals >90 secs (top, on the right), respectively

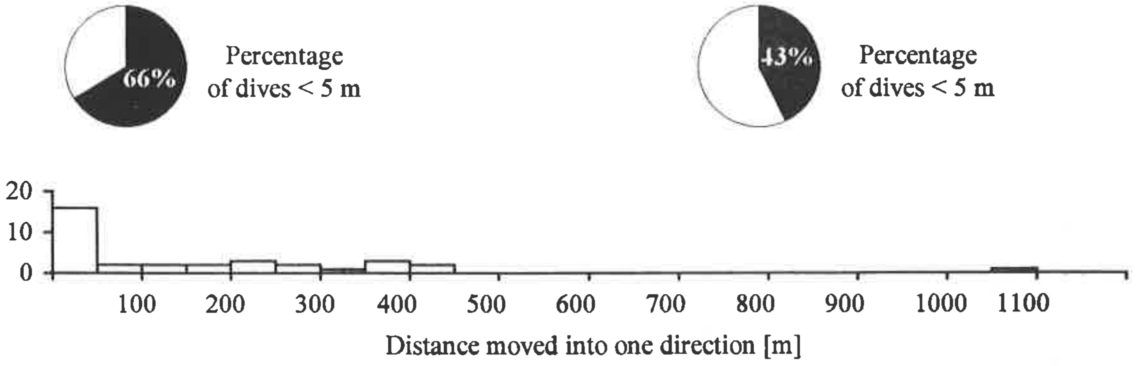

Fig. 3 Distances moved in one direction and av. percentage of dive distances < 5 m

Since dive times, dive distances, and dive directions were generally recorded simultaneously, the function was determined for each observed dive time/movement pattern combination. Frequent long dives were often combined with non-directional movements or movements against the tidal current. Watson and Gaskin (1983) suggested that long dives in harbour porpoises serve as either a foraging or a social function, and since cetaceans generally stay at one place or orientate themselves against the current when foraging, the porpoises were deemed to be foraging on these occasions. One animal displayed a series of long dives combined with non-directional movements whilst swimming closely together with another animal. This behaviour was interpreted as socialising. Irregular long dives with many medium dives could be observed with all three movement patterns. When combined with non-directional movements these dives were interpreted as resting, and when combined with directional movements, as travelling.

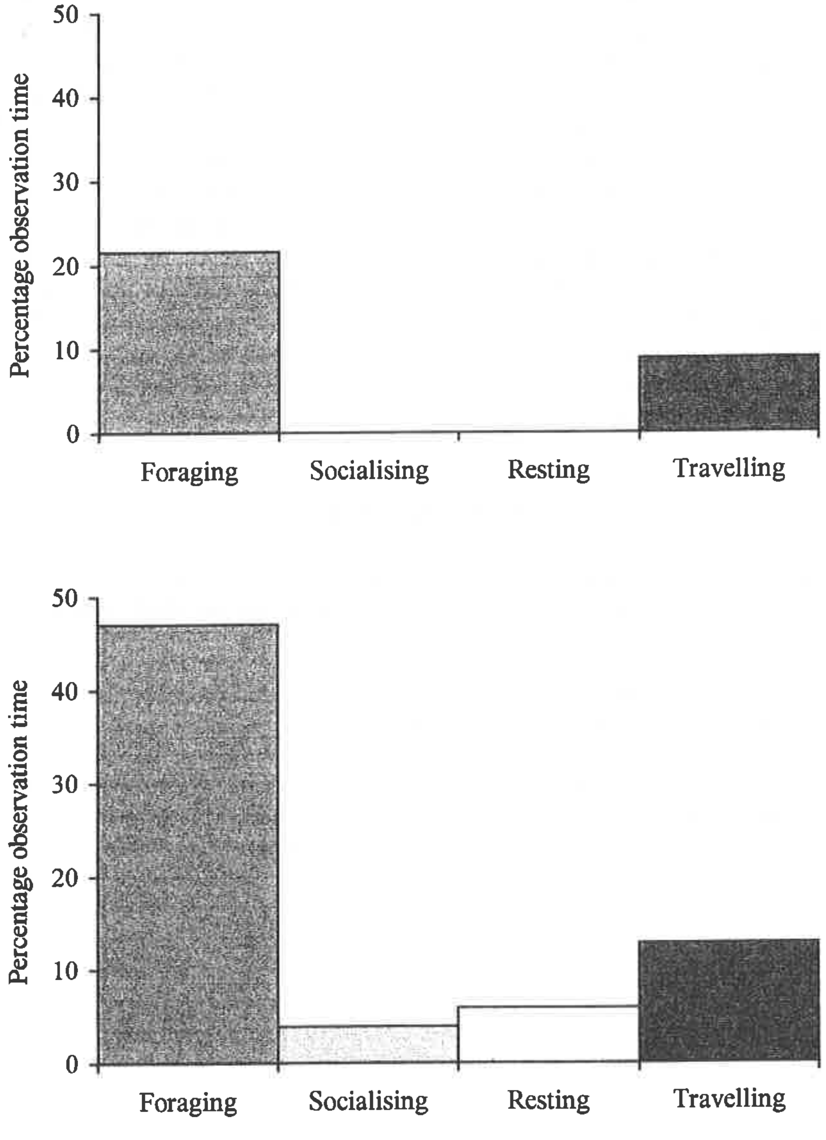

Fig. 4 Frequency of occurrence of the different behavioural patterns at different sites in the study area: between the beach and a sandbank (top) and at the sandbanks (bottom)

The patterns interpreted as foraging accounted for 65% of the observation time, patterns interpreted as travelling for 21%, resting for 10%, and socialising for 4%. The frequency of occurrence of the different patterns was unevenly distributed between different sites of the study area. While patterns that were interpreted as travelling were observed about equally often at different sites, patterns that were thought to represent foraging behaviour were observed more often close to a sandbank than between the sandbank and the beach (Fig. 4).

DISCUSSION AND CONCLUSIONS This study demonstrates that recording and analysing the temporal order of dive times, dive distances, and dive directions can reveal useful information on harbour porpoise behaviour in a certain area, even when the total amount of collected data is relatively small.

A comparison of the data collected in this study with the data collected in other studies is difficult, however, because many authors tend to give a description of their impression of what is going on rather than describing what is actually happening. One study that describes the diving behaviour of harbour porpoises in detail was carried out by Watson and Gaskin (1983) in the Bay of Fundy. The porpoises observed by these authors showed exactly the same first dive time pattern combined with non-directional movements as observed in this study. In contrast, in the Bay of Fundy, harbour porpoises tended to travel long distances without any long dives, whereas off Sylt, medium dives were always interspersed with long dives. This difference could be due to differences in prey distribution between the two areas: in the Bay of Fundy, harbour porpoises feed mainly on schooling species which occur in high densities at distinct places (Recchia and Read, 1989), whereas demersal fish such as sole (*Solea solea*) and dab (*Limanda limanda*) form a major part of their diet off Sylt (Lick, 1991). For future studies on harbour porpoise behaviour, it would be beneficial to use standardised, observer-independent methods such as those applied in this study to enable comparison of the results of different studies.

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DID HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) TRY TO PROTECT THEIR NEWBORN CALVES FROM STRANDING?

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INTRODUCTION Up to 50% of all dead harbour porpoises (*Phocoena phocoena*) discovered on the German North Sea coast are found on the Island of Sylt (see Kock & Benke, 1996). These carcasses are collected by the German Stranding Network for further studies at the University of Kiel. Since 1988, several live strandings of harbour porpoises have been reported by this network, and this paper discusses instances which have occurred on the Island of Sylt, Germany.

METHODS AND RESULTS In this paper, two live strandings of harbour porpoise calves on the Island of Sylt are documented. Both calves had distinctive injuries upon one of their flippers, injuries that were markedly different from other marks found on the skin.

Table 1 Detailed information on the two live-stranded calves

	CALF 1	CALF 2
DATE	11 June 1996	17 June 1996
WATER TEMPERATURE	12.9°C	14.8°C
SEX	Female	Female
LENGTH	715mm	730mm
WEIGHT	6.05kg	*
UMBILICAL CORD?	Yes	Yes
FOETAL FOLDS?	Yes	Yes
RIGID FLUKES?	Yes	Yes
INJURY ON FLIPPER	Left	Right
NUMBER OF WOUND GROUPS	Two	One
MOTHER OBSERVED?	No	No

Calf 1 This animal (Table 1; Fig. 1) was discovered by tourists, at which time it was still breathing, and moved for several minutes after it was initially discovered. First observations showed two clearly separate dermal lacerations on one of the flippers. One laceration (Mark A) was close to the trunk of the body overlying the radius and ulna. The laceration presented five grooves aligned in a row, both antipodal dorsally and ventrally. The shape of each individual incision was elliptical. The distance between the grooves was, on average, 3.6 mm. A further, more indistinct, dermal laceration was also visible close to the trunk. This second laceration also presented parallel ventral and dorsal wounds, which were directly adjacent to the more conspicuous Mark A.

Mark B was noted near the tip of the flipper where phalanges II and III were visible through the skin. The skin injuries were likewise located antipodean dorsally and ventrally on the flipper. The dorsal lesions were, as above, five oval lesions, all aligned in a row and the same distance from each other. Additionally, there was a tear from the second depression (seen from the front side of the flipper) which ran over the forefinger and terminated as an uneven injury to the skin almost transverse to the tear. On the ventral side, seven antipodean marks were visible, all in a row and the same distance apart. Counting from the front of the flipper, the first four marks were connected with a tear in the dermis. In addition, at incisions three, four and five, three dermal scratches were visible. The fifth scratch terminated with a dermal laceration.

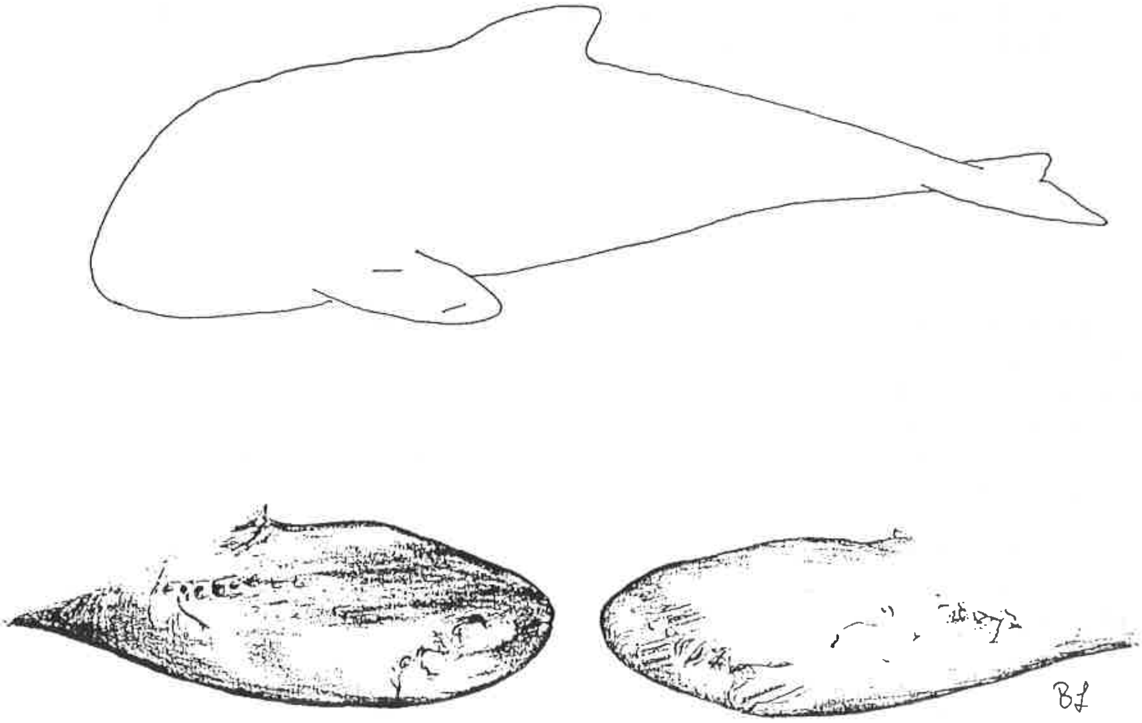

Fig. 1 Calf 1, which stranded on 11th June 1995, with bite wounds on its left flipper. The detailed drawing shows left, the dorsal side; and right, the ventral side with deep teeth impressions.

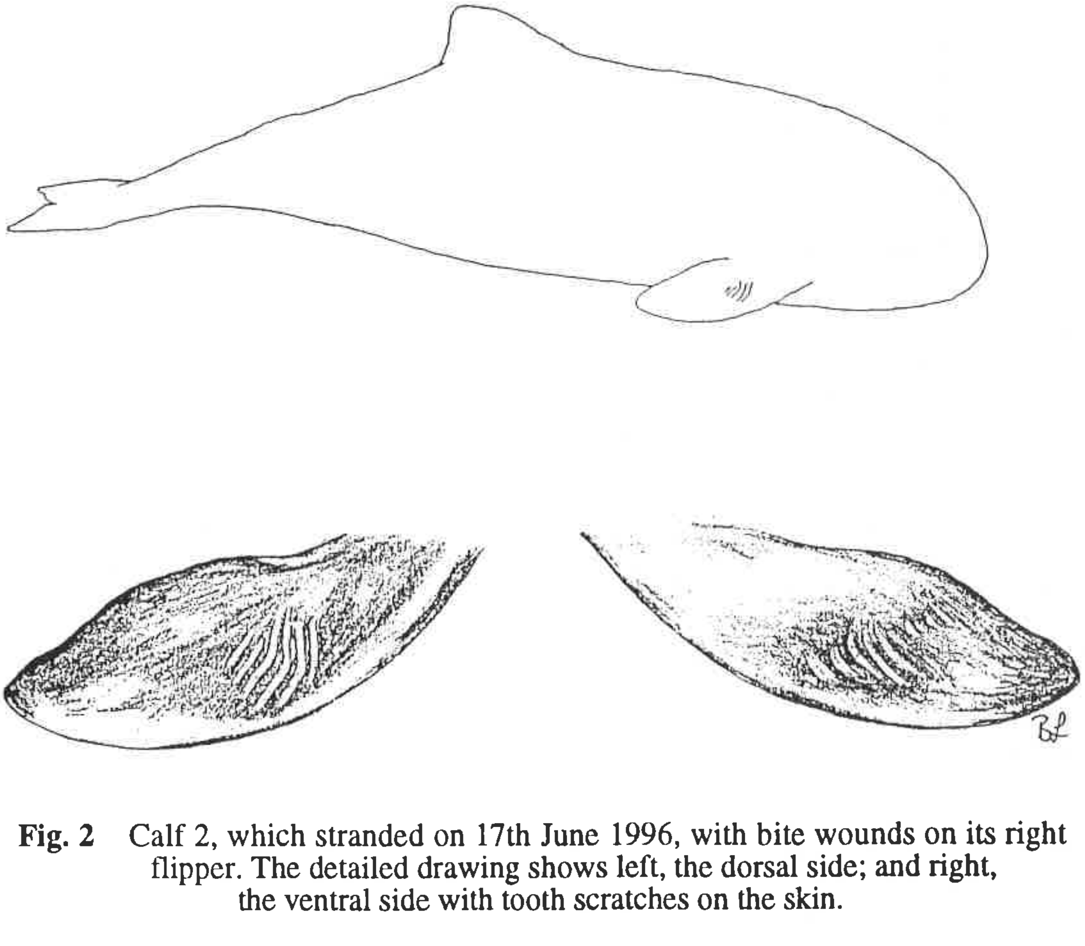

Fig. 2 Calf 2, which stranded on 17th June 1996, with bite wounds on its right flipper. The detailed drawing shows left, the dorsal side; and right, the ventral side with tooth scratches on the skin.

Calf 2 The second harbour porpoise calf (Table 1; Fig. 2) was discovered by a lifeguard who supported the animal when it entered into shallow water. This animal also displayed lacerations: parallel lines antipodean dorsal and ventral on the flipper. These were not as distinct as the lacerations observed upon the first calf and no elliptical incisions or dermal tears were present. Six dorsal and eight ventral lines were visible, all of which were the same width and were, on average, 3.5 mm apart. The markings clearly began near the middle of the flipper and became fainter at the tip.

DISCUSSION Both of the above newborn harbour porpoise calves cases occurred during similar weather and water conditions, with both animals stranding live but ultimately dying on site. Umbilical cord remnants suggest that the animals were only one or two days old. The atypical markings described above were both similar and were clearly dissimilar to net and stranding injuries. The most revealing feature of the lacerations were the identical nature of the markings on both the dorsal and ventral surfaces of the flipper and, thus, their clear antipodence suggests that they were attributable to the same cause. The elliptical incisions and the wide streaks noted on both sides of the flippers were of an equal depth suggesting forces applied both dorsally and ventrally were of a similar intensity.

Similar markings on harbour porpoises found on the coast of Scotland have already been described by Ross (1993), as well as Ross and Wilson (1996). These papers also describe the prescence of "holes", similar parallel tears and streaks deep in the skin and on the body of the porpoise. Ross and Wilson (1996) also give inter-tooth distances for various different cetacean species - an average distance for the harbour porpoise was given as 3.61 mm. The distance between the grooves described for the lesions upon calf 1 were, on average, 3.6 mm and 3.5mm for calf 2. This correlates well with the data provided on the dentition measurements of harbour porpoises.

The elliptical and not round "holes" observed on calf 1 support the conclusion that the injuries were caused by harbour porpoise teeth and that the described markings are bite wounds. Also, the wide streaks by mark B (ventral) in connection with the oval markings (dorsal) support the conclusion that these injuries were caused by a long round object, rather than a pointed one. This is also the case with the lesions observed on calf 2. The dorsal and ventral corresponding positions and course of the markings clearly show the character of a bite wound. The spatula-like tooth form of the harbour porpoise also support the conclusion that the bite wounds were caused by harbour porpoise teeth.

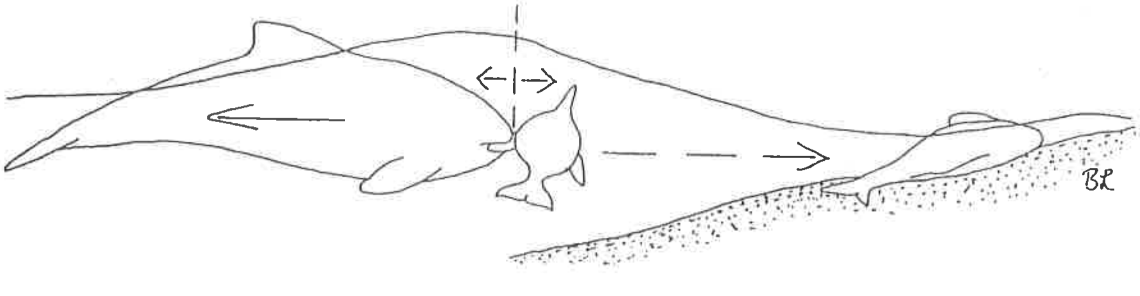

Fig. 3 Diagram demonstrating how a harbour porpoise mother could grab the flipper of a weak calf, to prevent the young animal from stranding

It is conceivable that weak harbour porpoise calves are born in coastal waters. So far as we know, harbour porpoises, like all cetacean species, show a very close mother-calf association. Schulze (1996) noted several authors who have described epimeletic (succourant) behaviour by harbour porpoises. It is not surprising that with such a strong mother-calf bond and tendency for epimeletic behaviour, a mother would certainly try to free a calf from a life-threatening situation, i.e., a calf about to strand and unable to heed the calls of its mother is in such a situation. Is it possible that the mother porpoise might grasp her calf by the flipper with her mouth in an attempt to try to pull the calf out of harm's way (Fig. 3)?

The holes observed in the flipper of the calf 1 show evidence of strong grasping and holding. A possible explanation for the above mark as well as for mark B is that the mother harbour porpoise, despite her firm grip with her teeth, was unable to hold the calf, the teeth then causing the aforementioned streaks and tears as the calf slipped out of the mother's mouth. Likewise calf 2 may have been injured in the same manner. Here, it seems that another harbour porpoise, most likely the mother, tried, using its teeth, to hold the weak calf by the flipper but was unable to do so. This explanation is made even more plausible because both calves were live strandings.

Nevertheless, this behaviour should not be used to give harbour porpoises or dolphins unique mystical qualities or to represent them as extremely social or helpful creatures. Television films have repeatedly documented similar behaviour for both crocodiles and rats. The harbour porpoise's maternal instinct seems to be in this respect comparable to other animal species.

ACKNOWLEDGEMENTS We wish to thank the finders of the two live-stranded harbour porpoises, the Kurverwaltung on the Isle of Sylt, as well as the environmental groups for the prompt reporting of the stranded harbour porpoises. Also we thank Monika and Jörn Harström for the photos documenting the first harbour porpoise stranding (11 June 1995), Britt Laner for the drawings, the Bundesamt für Seeschiffahrt und Hydrographie for the water temperatures, Manuel García Hartmann for the critical examination of the manuscript, and Gregory Baber for the English translation. Our research was financially supported by the Deutsche Umwelthilfe.

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ARE LIVE STRANDINGS OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) CALVES MERELY ACCIDENTS?

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INTRODUCTION Live strandings of cetaceans are largely an unexplained phenomenon (Evans, 1987). Schulze (1996) writes that when considering the harbour porpoise, very few cases could actually be classed as strandings. He explains that real strandings of living animals are a result of faulty navigational systems, sickness, or defective behaviour of lead animals, problems which rarely occur with harbour porpoises. The paper describes two live strandings of harbour porpoises and postulates a reason for these strandings.

RESULTS Two, very similar, live strandings of harbour porpoise calves were reported from the Isle of Sylt, in the North Sea. Stranding A occurred on 19 Sept, 1996 (2 h. 35 min. before high tide), stranding B a few days later on 22 Sept, 1996 (3 h. 35 min. before high tide). The distance between the two locations is only 2.2 km. The weather conditions were similar on both days: easterly winds and overcast. This means there were very few waves which broke, with a maximum height of 50 cm, directly in front of the beach. The beach profile (sand only) in both areas was also similar (Fig. 1).

Before these strandings, both mother and calf had been swimming for some time in close proximity to the beach. The mothers were foraging, with the calves swimming several metres from them. The calves came too close to the shoreline and were washed ashore by small breakers. Lying on the beach, both calves immediately tried to free themselves from their stranded situation by vigorously moving their tail-flukes up and down.

In stranding A, the calf was able to free itself directly after stranding. A breaking wave provided the calf with ample water to use its tail-fluke and was soon able to free itself. The mother positioned herself close to the shoreline, swam between the calf and the beach, and nosed the calf three times. She first pushed the calf in the tail-fluke area towards the open sea, the second push followed in the middle of the calf's body, and the third push was in the breast-head region. Both animals then headed for deeper waters and were joined by two other harbour porpoises farther offshore (see Figs. 1 & 2).

In stranding B, mother and calf were observed for some time as they swam, sometimes slowly, sometimes quickly back and forth. Directly before stranding, the calf had been lying on the surface of the water displaying "sleep" or "rest" behaviour (Schmidt & Hussel, 1993, and Schulze, 1996, respectively) parallel to the beach. Moreover, the calf had positioned itself directly before the breaking waves, where it was lifted by an incoming wave and was washed ashore. As it lay on the beach, several photographs were taken. In this instance, the calf had to wait for a while until a large breaking wave provided enough water so that it could free itself from the beach. Immediately, mother and calf joined other harbour porpoises farther out to sea. Contrary to stranding A, the mother showed no supportive behaviour towards her calf.

DISCUSSION In the waters around the Island of Sylt, it is perfectly normal to see harbour porpoises swimming within several metres of the shoreline (Amundin & Amundin, 1975). In calm conditions they regularly swim into knee-deep waters and can be observed regardless of time of day or tidal condition (Schmidt & Hussel, 1996). In particular, harbour porpoises with offspring seek out the coastal waters for calving and raising their offspring (Schulze, 1996). It could be assumed that the harbour porpoise "knows" the dangerous borders associated with its living space and is able to deal in a particular way with these dangers.

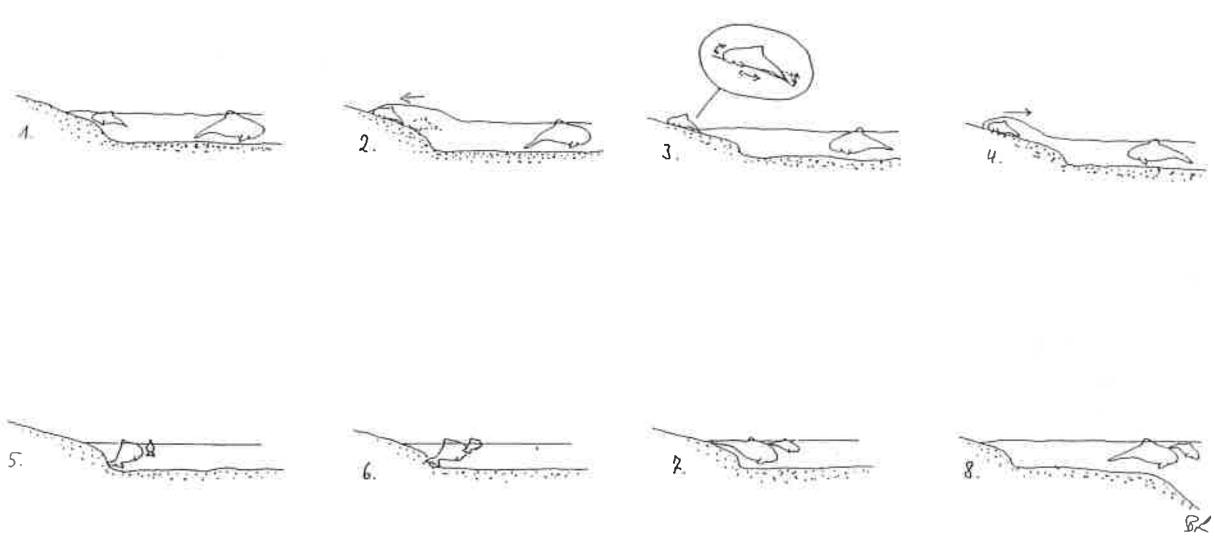

Fig. 1 The sequence of stranding A as seen in profile. While the mother hunts close to the beach, the calf swims into the surf area (1). Here it is lifted by a wave on to the beach (2), where it tries to free itself by strongly moving its tail up and down (3). As another wave provides enough water enabling the calf to swim again (4), the mother nears the calf and pushes it from behind, away from the dangerous beach area (5, 6, and 7). Both animals then swim away from the beach (8).

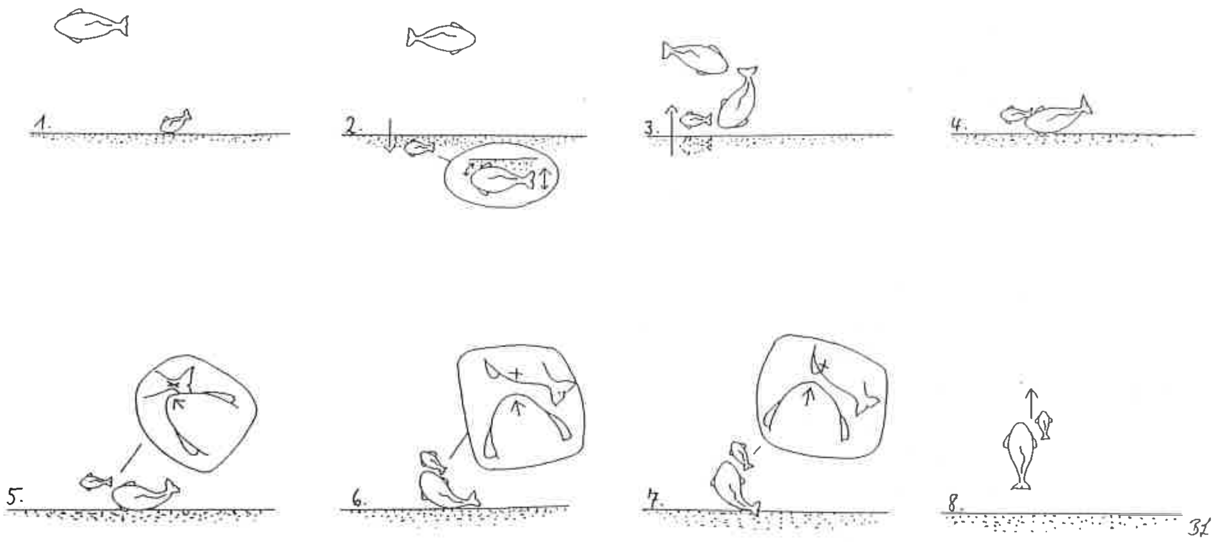

Fig. 2 The sequence of stranding A as seen from above. While the mother hunts close to the beach, the calf swims into the surf area (1) and strands (2). As it manages to free itself, the mother nears from behind (3), positions itself between calf and beach (4). The cow pushes the calf three times, once in the tail area (5), then in the stomach region (6) and lastly in the head-breast area (7). Both animals swim then farther out to sea (8).

In recent years, research projects upon the Island of Sylt have noted several instances of harbour porpoise live strandings. Some of these live strandings died before they could receive veterinary attention (Schmidt & Hussel, 1997). Others died during, or a short time after, their rescue, whilst others lived for days or weeks in the Dolphin Rescue and Research Centre of the Harderwijk Dolphinarium, Netherlands. Several live strandings have immediately been put back into the water by tourists or lifeguards. In several instances, a harbour porpoise calf was transported with a surfboard several hundred metres from the beach and then released, although it is uncertain whether these latter animals survived.

There are reports from local residents of live strandings from the 1940's - 1950's. Usually the animals were found in flat pools in ebb tide channels. These metre long harbour porpoises were considered welcome additions to the daily diet of the locals. Likewise, stranded harbour porpoise calves are quickly discovered by seagulls which sometimes kill and eat these animals. Even red foxes have been described seizing an already dead calf (Schmidt & Hussel, unpubl. data).

Just a few weeks after birth, the calf and mother bond relaxes, and calves may roam dozens of metres from their mothers (Amundin & Amundin, 1975). It seems that, at these times, calves often swim, play, and rest without giving full attention to their environment. So it is quite possible that accidents could occur and that the inattentive calf could be washed ashore, as in the two strandings described earlier.

The behaviour exhibited by the mother of stranded calf A, i.e. positioning herself between the beach and her calf and pushing the calf out of the danger zone, is a similar behaviour observed in dolphinaria from bottlenose dolphins (*Tursiops truncatus*), that is to say, these latter dolphin mothers "realise" that the walls of pools present a danger for their young. Repeated occurrences have been observed where the mother intercepts the calf or "forces" the calf to swim on her side facing the middle of the pool (pers.obs.). Kinze (in Schulze, 1996) observed harbour porpoise mothers position themselves between their calves and boats, providing a swimming protective shield. Another form of assistance shown by a harbour porpoise mother towards her (stranding) calf is described by Schmidt and Hussel (1997).

The previous examples seem to suggest that even coastal water inhabitants accustomed to shallow waters, such as harbour porpoises, are susceptible to live strandings without necessarily being diseased. The aforementioned harbour porpoise calves merely suffered an accident in which a healthy animal was hit by a chain of unfortunate circumstances which caused it to become stranded upon the beach. If they are lucky, calves caught in this situation can free themselves; if not, they will lie upon the beach until their injuries take their toll. This could be a more common occurrence than previously thought.

ACKNOWLEDGEMENTS We wish to thank two Sylt life-guards: Carmen Eckloff and Hauke Harms, as well as the owners of the café-restaurant "Seeblick", Axel Dombek and Jan Krüger, for immediately reporting and supplying an exact description of the live strandings. Our special thanks goes out to Astrid Schlüting who photographed the live stranding, even though her first reaction was to help the calf return to the water. We thank her also for letting us use this exceptional photo documentation and of course for her first hand account of the live stranding. Also we thank Britt Laner for doing the drawings and Gregory Baber for the initial translation into English. Our research was financially supported by the Deutsche Umwelthilfe.

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OBSERVED SURFACING BEHAVIOUR OF WILD HARBOUR PORPOISES

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INTRODUCTION The authors have been conducting a programme of research aimed at reducing the bycatch of harbour porpoise (*Phocoena phocoena*) in gillnets. As part of this programme, a population of these animals was observed in a Scottish deepwater sea loch. Observations were made from a number of vantage points varying from 17 m to 210 m above sea level. On two consecutive days (5th and 6th September 1996), the same vantage point (with an elevation of 175 m) was used, and these results are given in this paper.

METHODS For any observation, a team of two persons was employed. The surfacing of any particular animal was sighted through the telescope of a total station (Sokkia Set 5) using the cross hairs, and the data were recorded in a Husky Hunter. The method previously developed and reported by the team (Mayo & Goodson, 1993) was used. Subsequent analysis then produced a positional plot of the surfacings with associated inter-surfacing times, enabling calculation of the straight-line speed without allowance for any tide movement.

OBSERVATIONS During the total period of observation, over 2,000 surfacings were recorded. 1,180 of these were on the 5th and 6th September, from the single vantage point 175 metres above sea level. The surfacings were at ranges from 375 m to 2,930 m, with an average of 1,019 m, as shown in Figure 1. The Set 5 reads to 10 seconds of arc which represents a potential error of +/- 2.8 m in range and +/- 0.15 m in azimuth. These values of course do not take into account any error caused by the telescope not being pointed in the right direction, although viewing conditions were virtually perfect, with animals leaving a pronounced footprint after surfacing.

The behaviour of the animals was as we expected, with a mixture of travelling in a straight line and milling round in the same area as if they were foraging. At some times, the animals were seen "logging" - simply resting at the surface, and on one occasion a calf was observed suckling. Inter-sighting intervals included repetitive surfacings at approximately 10 seconds, interspersed with dives of two or three minutes, generally with a mixture of these.

Considering all 1,180 sightings, they result in a total tracked distance of 21.22 km over a period of 5 h 50 min. Figure 2 shows the distances between surfacings, which have an average of 19.1m and a standard deviation of 57.8 m. The corresponding time intervals (Fig. 3) are 18.9 sec. average and 59.5 sec. standard deviation. These two sets of values can be combined to produce speeds (Fig. 4) with an average of 1.07 m./sec. and a standard deviation of 0.5 m./sec.This corresponds well with the values previously reported for porpoises observed in the Cromarty Firth, Scotland (Mayo & Goodson, 1995).

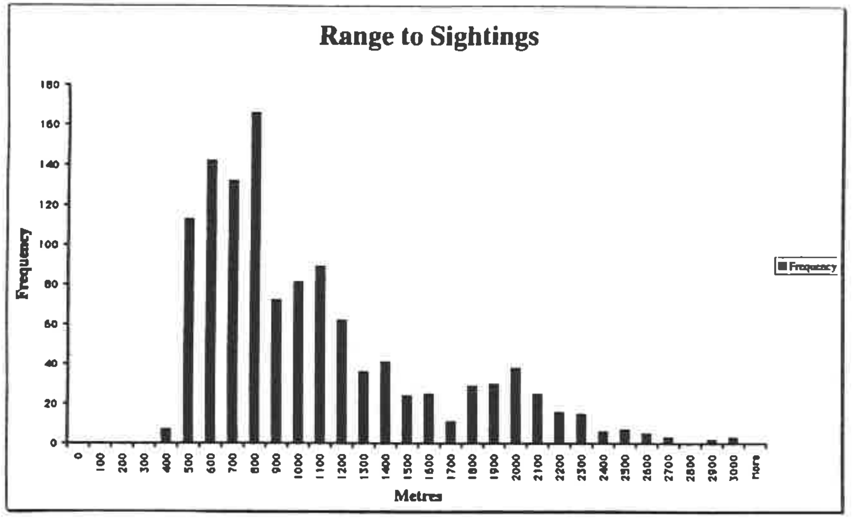

Fig. 1 Range of distances to sightings of harbour porpoises

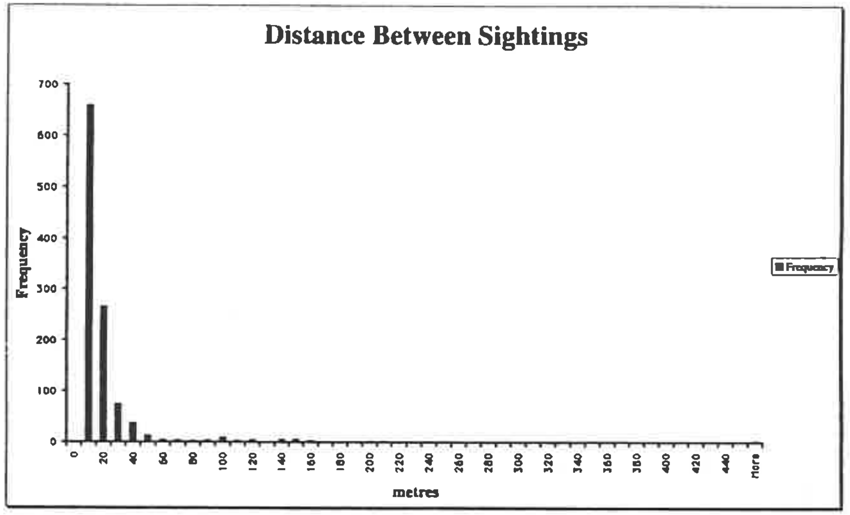

Fig. 2 Distance travelled between surfacings

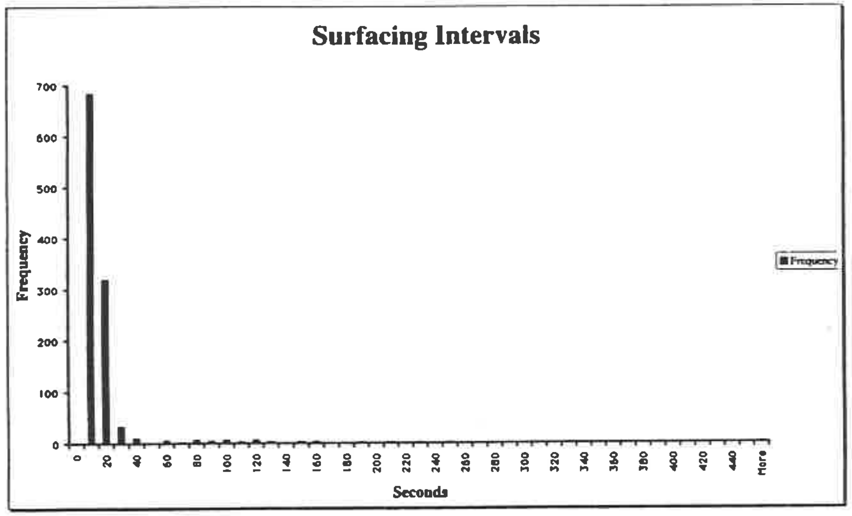

Fig. 3 Time intervals between surfacings

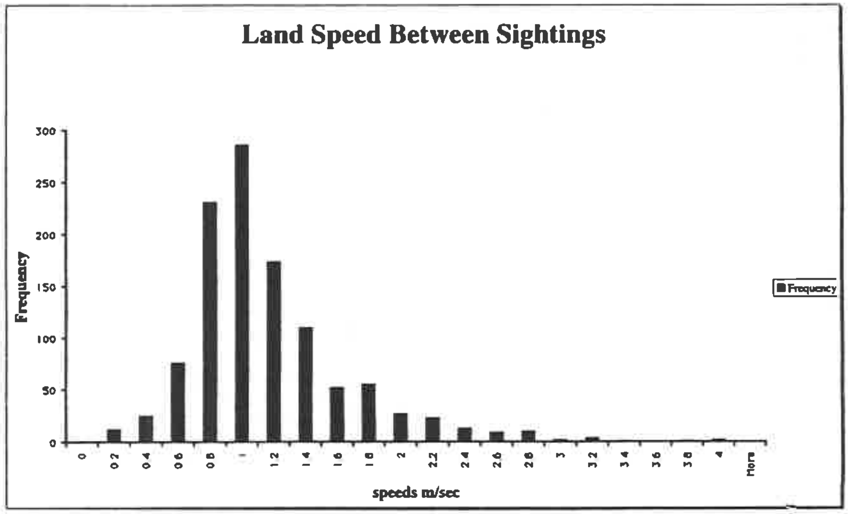

Fig. 4 Harbour porpoise speeds between surfacings

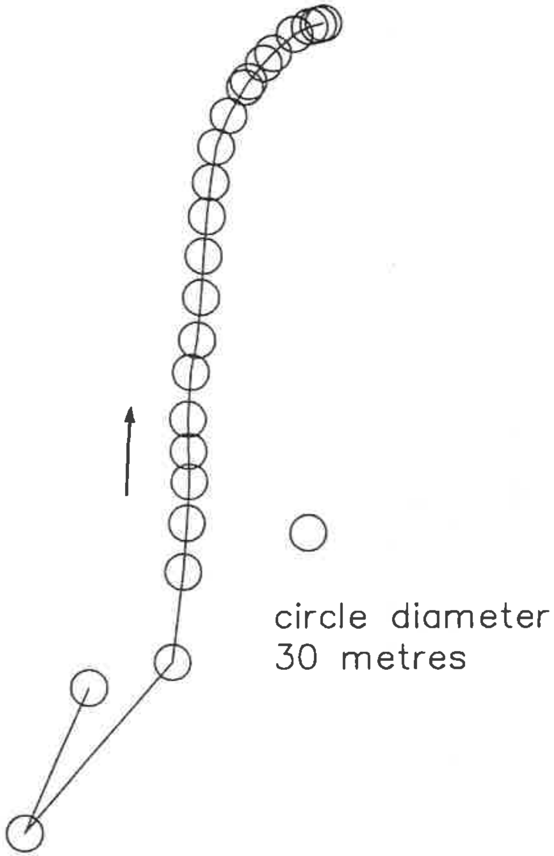

Fig. 5 Regular track of harbour porpoise surfacings

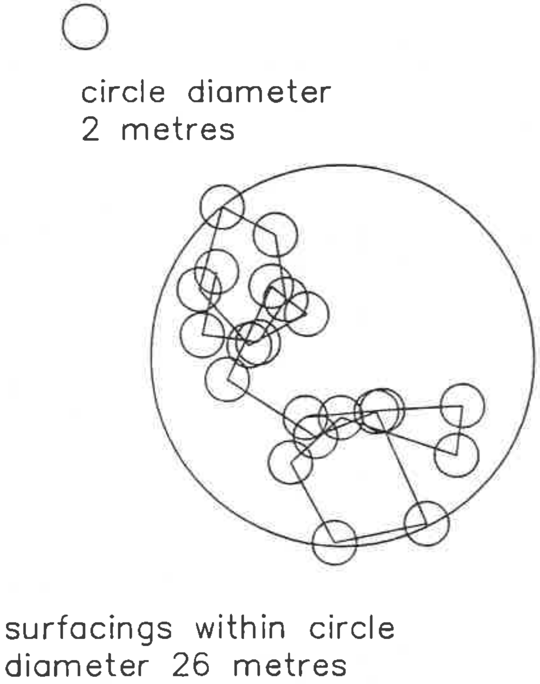

Fig. 6 Erratic track of surfacings of mother-calf pair

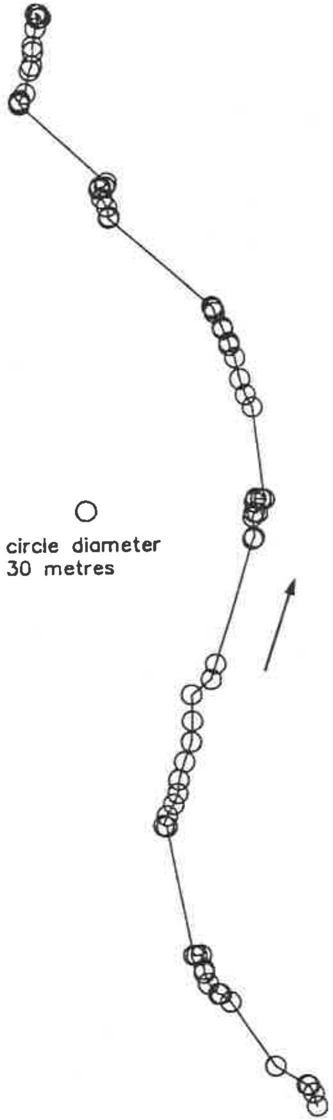

Fig. 7 Track involving both short long interval dives

On examination of the speed results, sequences can be observed with fairly consistent values of about 2 m./sec. The most marked of these is shown in Figure 5, with the surfacing positions marked with circles which, at full size, would be 30 m diameter. Between the first and second surfacings, the distance is 130 m and the speed 1 m./sec.; between the second and third, the values are 185 m. and 0.28 m./sec. There then follows a sequence of 14 surfacings where the average distance is 34.7 m. (SD 12.2 m.) and the average speed 2.1 m./sec. (SD 0.28 m./sec.), before the animal surfaces at closer intervals and the speed reduces.

At the other extreme is the behaviour of a mother-calf pair, as shown in Figure 6, where 21 surfacings took place within a circle of diameter 26 m. over a period of 138 sec. These surfacings have an average distance of 5.3 m. (SD 1.5 m.) and an average time interval of 6.9 sec. (SD 1.5 sec.). The corresponding speeds are 0.77 m./sec. average and 0.15 m./sec. standard deviation. These speeds are the minimum possible, however, as they assume the animals swivelled on the spot at each surfacing to head for the next. If a freehand smooth curve is drawn through the surfacing points, the speed rises to 0.82 m./sec. average (standard deviation unchanged), although these values assume a two-dimensional travel path. If the extra distance swum while diving is included, the values will rise further.

As mentioned above, tracks involving several short interval dives interspersed with a longer one were observed. Figure 7 shows the most marked of these, comprising 67 sightings over nearly 24 min. and 1,950 m. The average surfacing distance is 29.6 m. (SD 47.2 m.), time interval 21.3 sec. (SD 34.3 sec.) and speed 1.28m./sec. (SD 0.41 m./sec.) This track includes six long dives over two minutes duration (average 126.2 sec., SD 24.0 sec.) with average distance 171 m (SD 32.2m.) and average speed 1.37m./sec. (SD 0.18 m./sec.).

Relating the tracks to the charted water depth, the first point of the track shown in Figure 5 was in 100 m. of water, the second in 30 m. and the remainder from 100 m. to 70 m. The animal began to slow down as the depth started to decrease to 50 m. The track shown in Figure 6 was in 115 m. of water. The track shown in Figure 7 had the first long dive in 11 m., the second starting in 30 m. and ending in 70 m. and the remaining four in 100 m. For these last four, this would mean an average minimum swimming speed of 2.11 m./sec. for the animal to reach the bottom of the loch in a V-shaped dive, and of 2.97 m./sec. for a square dive.

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DIVING BEHAVIOUR OF A HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) IN DANISH WATERS

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A pilot study using data storage tags on harbour porpoises in Danish waters showed that the method is applicable in this area. It is hence possible to fit tags to animals, discharge and retrieve the platform, obtaining a substantial amount of dive data even for short monitoring periods. The transmitter was localised from a distance of 3 nm by an aeroplane equipped with VHF receivers, flying at 3,000 feet. The following day, the tag was retrieved by boat on the small island of Hesselø using a hand-held directional receiver. The VHF signals were tracked even though the transmitter was completely covered in wet seaweed.

A juvenile harbour porpoise weighing 30 kg and measuring 121 cm in length was fitted with a tag north of Fyn, Denmark, on 16 October 1996. A TDR/VHF transmitter mounted to the dorsal fin collected dive and surfacing data from 351 dives during a period of 10 hours and 12 minutes.

Within the monitored period, the average dive depth was 10.5 m ranging from 2 to 22 m. The dive duration ranged from 0.03 to 2.4 minutes, averaging 1.1. minute. The dive duration and depth of dive were positively correlated. The animal spent 34% of the time in the uppermost 2 m of the water column, indicating that aerial counts of harbour porpoises should be multiplied by a factor of 3 to correct for submerged animals. The surface time was positively correlated with the previous dive duration.

The study also showed that the harbour porpoise fed at the bottom, where it spent 36% of its time. Conservative estimates of descent and ascent swimming speed ranged between 0.1 and 4.0 m/s, with means of 0.9 and 0.7 m/s respectively.

BOTTLENOSE DOLPHINS FOLLOWING BOTTOM TRAWLERS IN THE KVARNERIC (NORTHERN ADRIATIC SEA)

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MATERIALS AND METHODS Data presented here are part of a larger effort focusing on the social ecology and behaviour of a bottlenose dolphin (*Tursiops truncatus*) community frequenting the area, carried out since 1987 (Bearzi *et al.*, in press).

The study area is shown in Fig.1. The study period extended from July 1990 to September 1994, and observations were made in daytime only (08:00-21:00 h).

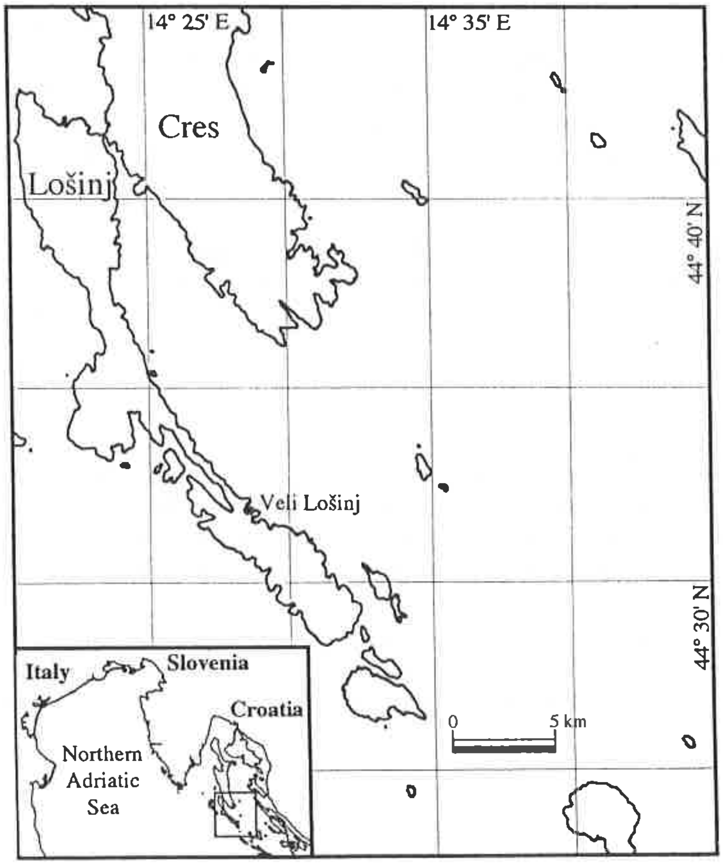

Fig. 1 The study area

Research effort involved 374 surveys totalling over 1,600 h at sea. Bottom trawlers in the study area were opportunistically approached when encountered during navigation, in order to check for the presence of dolphins in the proximity of the trawling net. Only boats engaged in trawling (i.e. dragging the net at an average speed of 2-4 knots) were considered. The presence of the dolphins was inspected by stopping the boat near the wake of the fishing boat, at about 200 m from its stern, carefully observing the sea surface for a minimum of 5 min. The number of dolphins composing the group and their age classes were assessed according to Bearzi *et al.* (in press). Group size analysis was based on 3-min sampling intervals (Notarbartolo di Sciara, 1994; Bearzi *et al.*, in press). Behavioural sampling followed Shane (1990).

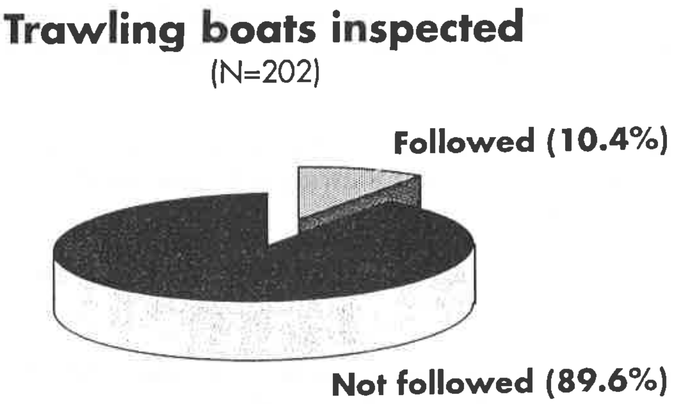

Fig. 2 Percent of inspected trawling boats that were followed by dolphins in 1990-94

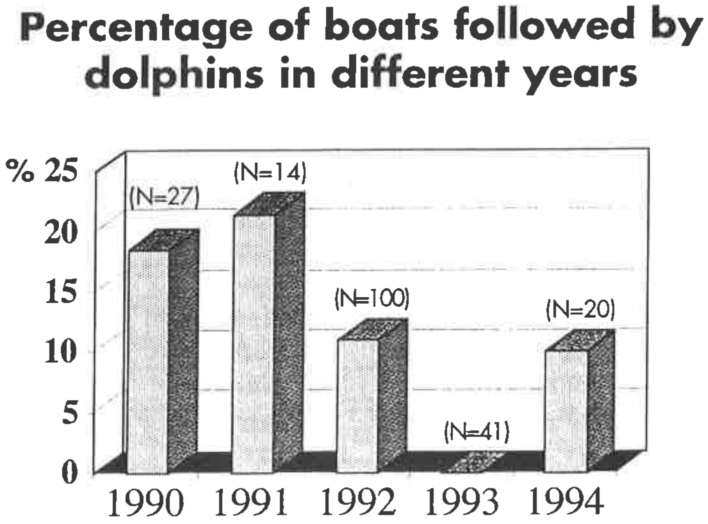

Fig. 3 Percent of inspected trawling boats that were followed by dolphins in 1990-94

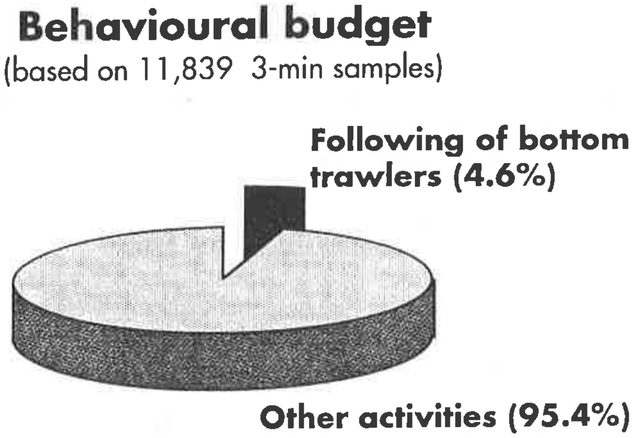

Fig. 4 Percent of time devoted to the following of bottom trawlers during the day (1990-94)

RESULTS A total of 202 operating trawling boats were inspected in 1990-94: 10.4% (N=21) were followed by dolphins (Fig. 2). Inter-annual variations are shown in Fig. 3.

A total of 592 hours were spent in direct observation of dolphin behaviour in 1991-94, totalling 11,839 3-min samples. The following of bottom trawlers accounted for 4.6% of the total behavioural budget (Fig. 4).

Groups averaged 4.1 individuals (SD = 2.66, SE = 0.11, N = 545, range 1-11, mode = 2).

Groups following bottom trawlers were smaller compared with groups engaged in other behavioural activities (t = 10.83, df = 1, $p < 0.001$).

Groups were mainly composed of adults, with a lower occurrence of calves compared with groups of similar size range (1-11 individuals) engaged in other activities (t = 8.30, df = 1, $p < 0.001$).

The chance of finding dolphins behind trawling boats did not vary significantly according to time of day ($\chi^2 = 2.32$, df=3).

Trawling boats followed by dolphins operated at a bottom depth averaging 72 m (SD = 11.35, SE = 2.48, N = 21, range = 49-91). There were no significant differences in bottom depth for boats that were followed or those that were not followed by dolphins (t = 1.863, df = 1, $p > 0.05$).

CONCLUSIONS Travelling behind bottom trawlers represented an alternative way of foraging (Leatherwood, 1975) that covered a small percentage of the dolphins' daily behavioural budget. High yearly variability indicates that local bottlenose dolphins followed the trawlers on a rather opportunistic and hence poorly predictable basis.

ACKNOWLEDGEMENTS We especially thank Elena Politi, Laura Bonomi, Giancarlo Lauriano, Caterina Maria Fortuna, and Mario Matesic for their contribution to data collection and/or analysis. The research was largely supported by Europe Conservation and the Whale & Dolphin Conservation Society. The main inflatable boat was sponsored by Novamarine.

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HOW DOES A MALE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) COPE WITH THE CHOICE OF SWIMMING IN FAMILIAR CONFINEMENT OR IN THE OPEN SEA?

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INTRODUCTION For several years, many institutions which house captive bottlenose dolphins (*Tursiops truncatus*) have received serious criticism as the result of their poor housing conditions. As a consequence of a growth in public awareness towards animal welfare, efforts to release dolphins back to the wild have increased. Strong social relationships between dolphins and humans, the fact that dolphins are accustomed to eating dead fish, as well as a lack of stimuli from the natural environment, could cause all problems in the wild. Recent experiences have shown the importance of specially designed rehabilitation programs and appropriate scientific documentation (Barros *et al.*, 1991; McKenna, 1992; Gales & Waples, 1993). Unfortunately there are only a few releases of dolphins which have been successfully documented (Veit *et al.*, 1997). As part of a project on dolphin rehabilitation, the spatial behaviour and social interactions were studied of a male bottlenose dolphin (age: eleven years, named Dicky) living under semi-free conditions which meant that he was allowed to leave his enclosure for daily excursions to the open sea. The special emphasis of the study was on the occurrence of foraging behaviours. In addition, the food preferences of the dolphin were experimentally assessed.

METHODS Data were collected in March and April of 1996 at the Dolphin Reef Eilat, Israel, where a group of nine bottlenose dolphins lived under semi-free conditions (Todt & Hultsch, 1996). The group consisted of two adult males, three adult females and four juveniles. Since the summer of 1994, the Dolphin Reef has run an "open-sea-program". Dicky passed through a gate for excursions to the open sea guided by an acoustic signalling device (pinger), first on an irregular basis and since summer 1995, on a daily basis. The dolphin was allowed to pass through the gate to the open sea in the morning and was given the opportunity to return to his familiar enclosure in the late afternoon. The time the dolphin spent in the open sea averaged around seven hours per day. Three times a day, Dicky was trained and fed from an outside platform in the open sea in a manner similar to the other dolphins inside the enclosure (the duration of each training session, including feeding, averaged approximately four minutes).

For data sampling, the open sea adjacent to the area of the Dolphin Reef was divided into equal parts (Fig. 1, zones I - VI). The zones were combined into three parts: the shallow northern area (I and II), the deep central area (III and IV), and the shallow southern area (V and VI). Close to the net, the northern and southern zones had an approximate depth of 5-8 m, the central area 12-16 m. Data were collected at one-minute intervals with daily observation periods lasting about 45 min. and a total observation time of 33.5 h for the spatial distribution (n = 2,010). Choice experiments (live fish versus defrosted fish) were carried out to test Dicky's food preference. During the training session one of the trainers offered live and defrosted fish (seabass, family: Sparidae) simultaneously in the water. The experiments took place on three consecutive days twice a day with a total amount of 4 kg fish.day^{-1}. The trials were documented from above the surface as well as from underwater by video.

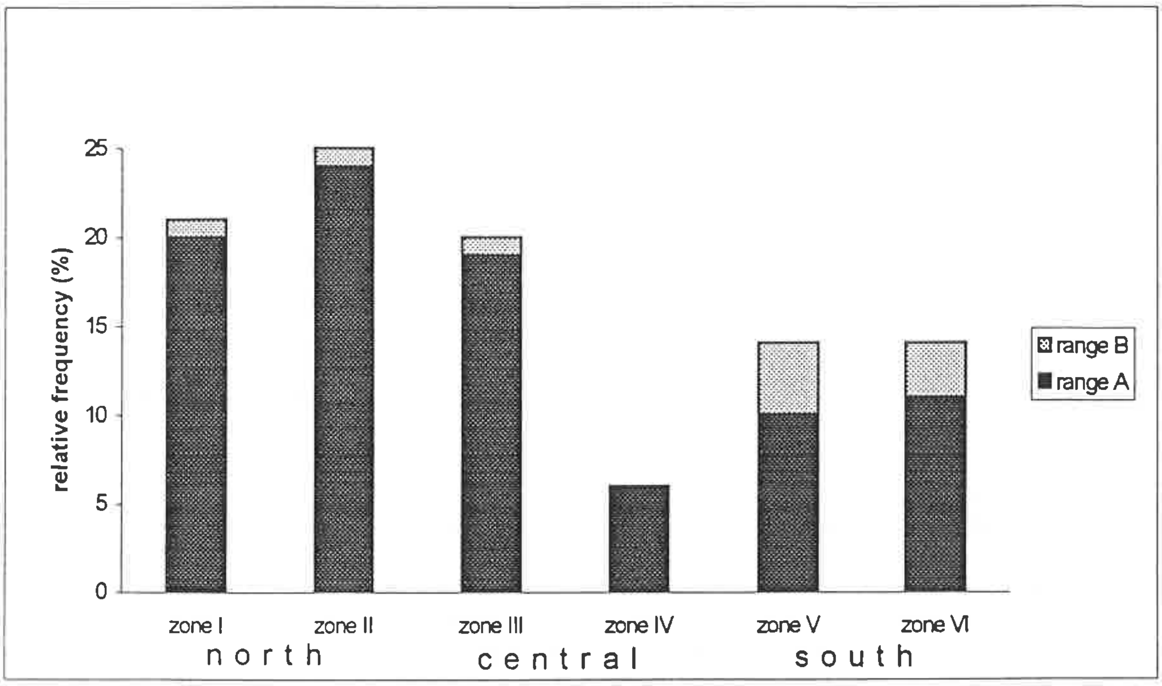

Fig.1 Representation of the Dolphin Reef Eilat with the observation areas outside the Reef site used for data sampling in the open sea (not to scale). Zones I and II represent the shallow northern area, zones V and VI the shallow southern area. Zones III and IV are combined to form the deep central area. Range A: a distance of <16 m from the net; range B: a distance of >16 m from the net.

RESULTS In the morning, Dicky passed through the gate to the open sea before being called by the pinger. In the late afternoon, just before the gate was opened, he often jumped close to the gate or approached it at high speed. This indicated a high level of arousal. Furthermore, he was always observed entering his enclosure at high speed.

Spatial distribution in the open sea The dolphin was sighted for almost 75% of the observation time in shallow areas (north and south). He was significantly more frequently observed in the northern areas (χ^2 =184,5; n =1435; df = 5; p <0,05) where he spent almost half of the observation time (46%). This was also the training area and feeding platform. His frequent approach to swimmers in the open sea also indicated his strong interest in humans and showed his readiness to cross deeper areas (Fig.2). The central part (26%) was mostly used for passing from north to south and for interactions with other individuals through the gate. In 91% of sightings, Dicky was observed within a range of 16 m from the net (range A) - which allowed close proximity to the group. The sightings at a distance of more than 16 m from the net (range B) mostly occurred right after he passed through the gate and in this range he was often observed swimming at high speeds. Close to the net, the dolphin was most commonly seen swimming at slow speed (71%). He was observed motionless 14% of the time, often with scanning movements of his head. Occasionally, Dicky was observed chasing fish in the southern part of the site.

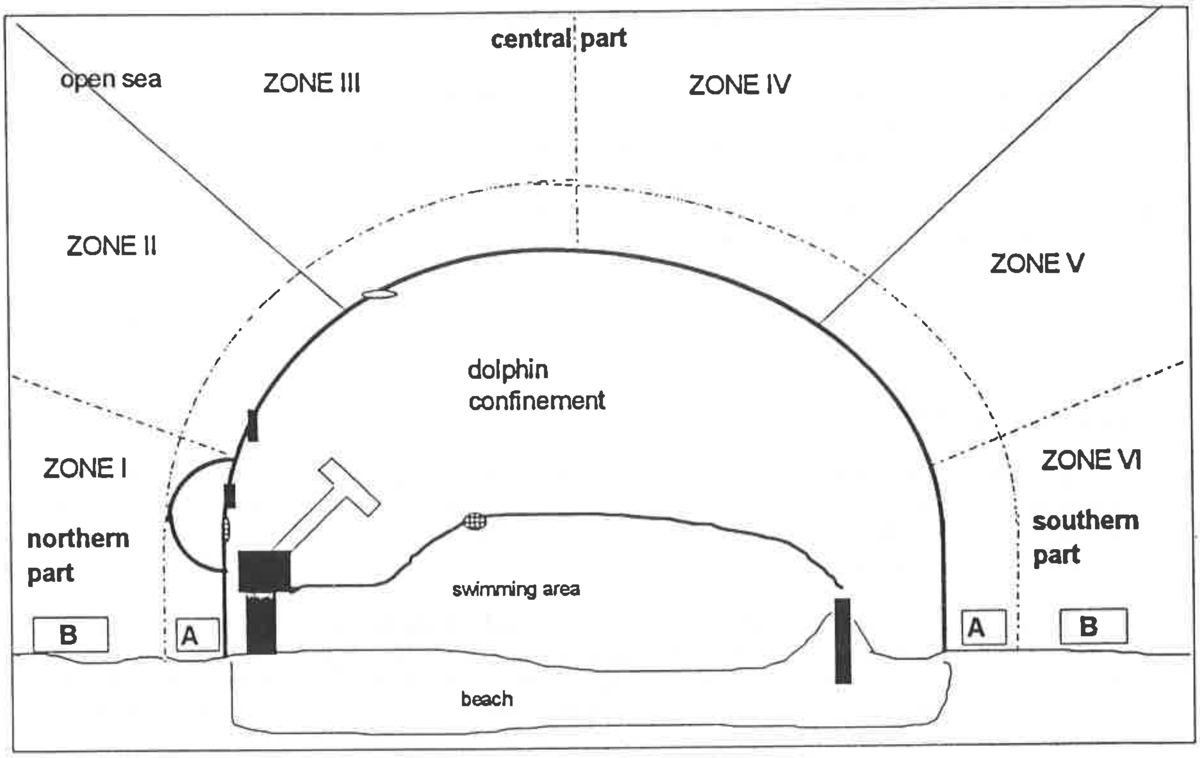

Fig. 2 The spatial distribution of Dicky in the open sea with the six columns representing the zones I to VI. Additionally the distance to the net is shown within each column: range A: <16 metres to the outside net; range B: >16 metres to the net.

Experiments with fish In 19 out of 25 cases, the dolphin first moved towards the live fish and then ate it. In three cases, the fish escaped before he was able to swallow it. In one of these cases he followed the fish in order to catch it. The analysis of the underwater videos showed a strong effort of sonar combined with lateral head movements during the approach towards the prey. The dolphin showed a clear preference for live fish.

Relationships to group members During the observation period, Dicky preferentially associated with two adult females, Dana and Domino. In addition he was frequently engaged in playful activities with their offspring. In the open sea, Dicky spent about 25% of his time in close proximity to group members (compared to almost 90% inside the enclosure). Furthermore, underwater observations showed a number of interactions at considerable depths, therefore invisible from the surface. These interactions typically consisted of the dolphins facing each other through the net accompanied by an exchange of acoustic signals (Heilsberg & Schuster, 1997).

CONCLUSIONS The most surprising result was the fact that the dolphin, despite being in the open sea, spent most of his time close to the enclosure. We conclude that this points to a particular demand for social contact. Therefore, we suggest the provision of opportunities for social contact if dolphins are released into the wild.

ACKNOWLEDGEMENTS This study was supported by the Gesellschaft zum Schutz der Meeressäuger and the Deutsche Umwelthilfe.

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NOTES ON THE NATURAL MARKINGS ON RISSO'S DOLPHINS (*GRAMPUS GRISEUS*) PHOTOGRAPHED IN THE COASTAL WATERS AROUND THE EYE PENINSULA, ISLE OF LEWIS, SCOTLAND

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Risso's dolphins (*Grampus griseus*) are born with a dark chocolate brown coloured body, a creamy white ventrum, and an anchor-shaped patch between the pectoral fins. As calves grow, the upper body turns silver grey then darkens to a dull gunmetal grey. With age, the colour lightens and the head, abdomen and flanks may turn white. Those changes occur in conjunction with the accumulation of characteristic linear body scars, and these accumulate throughout life. The cause of this extensive scarring is primarily teeth rakes from other Risso's dolphins. This appears paradoxical because the species has reduced dentition specialised for taking cephalopod prey. Typically there are no teeth in the upper jaw and only 2-7 pairs of teeth in the lower jaw. The teeth are conical and relatively large (3.5 to 4.0 cm long and 1.5 cm in diameter).

Between August - September 1995 and May - September 1996, boat surveys were conducted in a study area of 170 km^2. Total boat effort amounted to 358 hours, of which 115 hours were recorded encountering Risso's dolphins. Approximately 3,000 photographs of the dorsal fins and bodies were taken for photo-identification.

A variety of natural markings were noted, including white teeth rake scars, black teeth-rake scars, epidermal lesions, depigmentation, and body contour deformities. This contribution illustrates each type. Re-sightings of identified individuals has provided information on the persistence of scars and rate of accumulation. Monitoring of these markings is used to investigate which types persist for longer than two years, and therefore can be used for photo-identification. Monitoring identified individuals photographically over several years may also reveal other biological and behavioural aspects of the causes and significance of these natural markings.

INTERSPECIFIC INTERACTIONS BETWEEN ATLANTIC SPOTTED DOLPHINS (*STENELLA FRONTALIS*) AND BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE BAHAMAS, 1985-95

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Free-ranging Atlantic spotted dolphins, *Stenella frontalis*, and bottlenose dolphins, *Tursiops truncatus*, were observed in Bahamian waters from 1985-95. Interspecific interactions between these two species were documented and are reported here. Of 1,246 encounters with dolphins, over 15% were mixed groups containing both species. Of these encounters, 60% were affiliative, 34.9% were aggressive and 4.8% involved foraging activity. Compared with single species, mixed species encounters were longer in duration and involved larger group sizes.

Mixed species encounters that were affiliative in nature were significantly shorter in duration and smaller in group size than aggressive encounters. The ratio of spotted dolphins to bottlenose dolphins was significantly less during foraging activity than it was in other behaviours.

Mating, with penile intromission, was observed between adult male bottlenose dolphins and juvenile spotted dolphins of both sexes. Young adult males of both species engaged in inter-specific high-energy bouts of sexual activity and aggression. The antagonists in these encounters were often conspecific coalitions of spotted dolphins and solitary or small groups of bottlenose dolphins. Mixed-sex, mixed-species adult groups (including pregnant females) were seen foraging together and travelling together. Inter-specific coalitions of males were observed during inter-specific and inter-individual (intra-specific) conflicts. Alloparental behaviour, between a young, adult, female spotted dolphin and an emaciated bottlenose dolphin calf was also observed.

The costs and benefits of interspecific associations merit discussion, including: protection from predators, competitive and co-operative feeding strategies, shared repertoire of vocal and gestural signals, and the question of species division and hybridisation.

ACOUSTICS

AN ACOUSTIC AID FOR POPULATION ESTIMATES

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INTRIDUCTION Investigation into the problem of the bycatch of small cetaceans in fishing gear require studies of the change in behaviour that any device produces, whether the device be active or passive, acoustic or visual. Since the target animals spend greater than 95% of their time below the water in poor visibility, traditional photography is impossible. Loughborough University has developed techniques to track cetaceans underwater by their vocalisations, and combined with visual observations from the surface, provides an excellent method to determine the dolphins' courses through a study area. However, if such devices are designed to remain in the sea for extended periods, habituation behavioural changes need consideration. Monitoring habituation requires identities for groups of animals that have come into contact with the devices.

Automated pattern recognition software has been developed for group identification of small odontocetes using signature whistles, which several species are known to employ. During analysis of interactions of groups of common dolphin (*Delphinus delphis*) with a trawl in field research for the CETASEL project, indiviual groups could be distinguished with a high confidence from relatively few whistles. This paper presents these results, and discusses the applicability of whistle analysis as an aid for determining numbers of dolphins in nearby areas.

EQUIPMENT AND DATA Vocalisations were recorded on an RDAT recorder (Sony TCD-D7) with a 22 kHz bandwidth. Signals from a trawl-mounted hydrophone were pre-amplified (with a Benthos AQ4/AD743) before being sent via a coaxial cable some 450 metres back to the ship. Observers aboard the ship made records of encounters, including details of sighting times, species, number of animals, sighting position relative to the ship, and direction of travel.

Subsequently, the data were sampled to disk using an IBM 486DX2 66MHz computer, a Creative Labs Sound Blaster 16 sound card, capable of sampling rate of 44.1 kHZ with a 16-bit resolution. The whistle analysis software reduced any background impulsive noises (mostly from the trawl net, rather than echolocation clicks), extracted the frequency-time contour of the whistle, and encoded the contour into shape segments to aid pattern recognition and classification.

THE AUTOMATED CLASSIFICATION PROCESS Whistle classification was based on two features: firstly, the sequence of segments (identified as contour areas of broadly rising, falling, flat frequencies, or signal absence); and, secondly, the contour's detailed shape within each segment. Pattern recognition of segment sequences employs hidden Markov models to represent all possible segment sequences within each class with associated probabilities. More detailed comparison is made by taking three measures between corresponding segments using quadratic equation parameters, resulting in values for differences in frequency, frequency slope, and rate of change of slope. The standard deviations of these calculated differences can be found for each class, and since they form a Gaussian distibution, the degree to which a candidate whistle is representative of a class can be found as a percentage. The product of this probability and that from the hidden Markov model indicates the probability that a whistle contour is a member of the specified class.

Bayes's theorem for conditional probability can be used to calculate the probability for each class membership by assigning a probablity that the whistle might belong to an as yet undiscovered class. The whistle is then placed in the class with the highest membership probability or a new class if this is indicated.

FIELD RESULTS Whistles were noted between 15:06 and 15:17 on 10th October, 1996 in the acoustic log. Logs from the visual observers aboard Tridens indicated three groups of common dolphin during that time, although not all were in range simultaneously. The recordings for this time were split into three periods, separated by quiet intervals. The periods, labelled A, B, and C, contained 7, 12, and 30 extractable whistles respectively. The signal to noise of some whistles was too low for satisfactory extraction, but all other whistles were classified according to the automated classification procedure for each period, the resulting classes being shown in Figure 1.

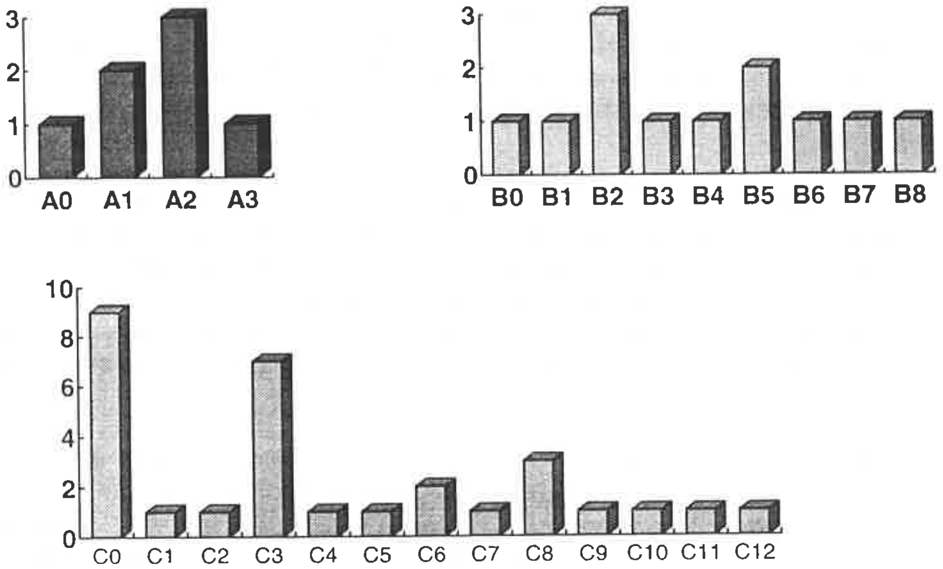

Fig. 1 Distribution of whistles into classes for three groups of common dolphin

After classification, the group from period A was found to contain four classes, B contained nine, and C contained thirteen. Some classes contained just one whistle, possibly aberrant, whereas several contained higher numbers. Those classes with more than one whistle were termed the 'major' classes for a group. In order to assess the amount of whistle type overlap between classes, the classes formed from one group were used to attempt classification of whistles from the other two. Chi-squared analysis was used to determine the probability for each pair of groups having the same whistle distributions (Table1).

A similar chi-squared analysis was also carried out for those classes where more than one whistle was classified from any of the groups (the overall 'major' classes) (Table 2).

DISCUSSION AND CONCLUSIONS The results in the Table 1 suggest that group A had distinct whistles from both groups B and C, whereas these latter groups shared serveral common whistle types. In Table 2, it was found that classes B2 and C0, B3 and C2, and B5 and C8 all contained the same whistles, suggesting that these class pairs were identical, although classes C3 and C6 contained no whistle from the other group. Excluding C3 and C6 in Table 3, the probability that the two groups contained the same whistle type distribution was 94.4%. One explanation is that the two groups of dophins were recorded simultaneously for a time, and whistles from C3 and C6 belonged solely to the second of the two groups.

Table 1 Chi-squared probabilities for pairs of groups having the same distribution of whistle types

	A0	A1	A2	A3	B0	B1	B2	B3	B4	B5	B6	B7	B8
Group A	1	2	3	1	0	0	0	0	(2)	0	0	0	0
Group B	0	0	0	0	1	1	3	1	1	2	1	1	1

$\chi^2 = 16.9$, 12 d.f., $p = 15\%$

without (2) misclassified, $\chi^2 = 19.0$, $p = 8.9\%$

	A0	A1	A2	A3	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Group A	1	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Group C	0	2	1	0	9	1	1	7	1	1	2	1	3	1	1	1	1

$\chi^2 = 27.9$, 16 d.f., $p = 3\%$

	B0	B1	B2	B3	B4	B5	B6	B7	B8	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Group B	1	1	3	1	1	2	1	1	1	3	0	1	0	0	0	0	0	2	0	0	0	0
Group C	0	0	9	1	0	3	1	0	0	9	1	1	7	1	1	2	1	3	1	1	1	1

$\chi^2 = 21.0$, 21 d.f., $p = 44.5\%$

Table 2 Chi-squared probabilities for 'major' classes from each pair of groups having the same distribution of whistle types

	A1	A2	B3	B4	B8
Group A	2	3	0	(2)	0
Group B	0	0	2	2	2

$\chi^2 = 8.98$, 4 d.f., $p = 6.1\%$, (2.7% without (2))

	A1	A2	C0	C2	C3	C6	C8
Group A	2	3	0	0	0	0	0
Group C	2	1	9	1	7	2	3

$\chi^2 = 17.4$, 6 d.f., $p = 0.8\%$

	B2	B3	B5	B6	C0	C2	C3	C6	C8
Group B	3	1	2	1	3	1	0	0	2
Group C	9	1	3	1	9	1	7	2	3

$\chi^2 = 5.91$, 8 d.f., $p = 65.8\%$

Table 3 Whistles, classes, and average classes per individual for the three groups. Figures in parentheses are for groups B and C combined

	No. whistles	No. classes	'Major' classes	Time period (seconds)	Animals observed	class/obs.	'major'/obs
Group A	7	4	2	52	7	0.57	0.29
Group B	12	9	2	148	12	(0.94)	(0.36)
Group C	30	13	4	299	7	(0.94)	(0.36)

It was suspected that there might be some relationship between the number of animals in a group and the number of whistle classes identified, which would lead to an additional estimate of group size based on whistle analysis during research into population estimates. When groups B and C were combined, the results (Table 3) indicated values for the number of classes per individual in the group increasing with the time for which they were recorded, with an average over the whole trial of 0.35 classes per individual. Although a much larger sample would be required for verification, the use of whistle classification in population estimates might be practical.

One last conclusion is that the common dolphin uses whistles that are group specific, and possibly specific to individuals within that group. This suggests that this species might be added to the list of those small cetaceans that employ signature whistles. This area should receive further research, since little is known for this oceanic species.

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THE SEA ANIMAL NOISE DATABASE SYSTEM (SANDS)

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SANDS is a multimedia database for the storage, search and display of data relating to underwater mammals. It is a research tool aimed primarily at providing sonar operators with a training aid and reference set on vocal animals likely to be encountered. The system has been developed using Microsoft FoxPro on a Macintosh computer. It contains timeseries examples of the sounds, plus some stills and video for identification purposes. The system also includes detailed statements on 18 different subjects for each species at three levels of detail (summary, layman and researcher).

Facilities are provided to search the database on the behavioural, vocal and physical characteristics of the species, and search the examples relating to a particular species on details of the recording and the animals featured. The system has been populated with data for thirty species identified as being the most vocal in the human aural range, present in the northern hemisphere.

Data have been provided by numerous organisations, but primarily through the Woods Hole Oceanographic Institution, USA, and the Wildlife Conservation and Research Unit, Oxford University, UK. A large amount of data have been amassed, but CDA (UK) are still seeking certain information and examples relating to particular species.

SPERM WHALES (*PHYSETER MACROCEPHALUS*) OFF THE NORTH-WEST COAST OF CORSICA, FRANCE, IN SUMMER 1996: ACOUSTIC AND SURFACE BEHAVIOURS

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INTRODUCTION In September 1996, a 12-day cruise was conducted in the Ligurian Sea and the north-western coastal waters of Corsica. This area was well known, both in literature and from previous experience, to possess an abundance of cetacean populations. The target species for this present study was the sperm whale (*Physeter macrocephalus* L.), due to the ease with which it can be detected acoustically and because of the chance to, once detected, acoustically track the animals and simultaneously make standard zoological observations, i.e. photo ID studies and ethology.

MATERIALS AND METHODS A hydrophone dipole-array was towed at 150 metres from a 16 m schooner, which travelled at a speed up to 6 knots, in weather conditions up to Beaufort force 3-4. Due to bad weather conditions, effective survey effort was limited to only 7 days. The hydrophone was towed for a total of 73 hours and at least 5 minutes of acoustic effort was conducted every half an hour, on a 24 hour basis. When sperm whales were detected, acoustic monitoring and recording became continuous. The animals were tracked and eventually approached in order to take photographs of individuals.

RESULTS AND DISCUSSION Biological underwater sounds were recorded during 90 out of about 140 periods of acoustic monitoring, and a total of 32 hours of effective recording was taken. Striped dolphins, Risso's dolphins, bottlenose dolphins, sperm whales, fin whales, and unidentified dolphins (possibly including pilot whales) were identified from these recordings.

Acoustic detection and tracking of sperm whales. During this survey the best observations were made from the northern Corsican coast (Fig. 1, area A), i.e. whales were first acoustically detected and most of them were consequently sighted.

Two days later, two more sperm whales were acoustically detected in front of San Remo (Fig 1, area B). However, tracking was not possible because free-drifting nets blocked the ship's course and the hydrophone had to be removed from the water to avoid possible entanglement. Ultimately, 7-10 sperm whales were audio recorded; six of which were sighted off the north-west coast of Corsica in depths ranging from 650 to 1,000 m (Fig. 1, area A). The longest continuous track of a single whale lasted for 8 hours and 20 minutes.

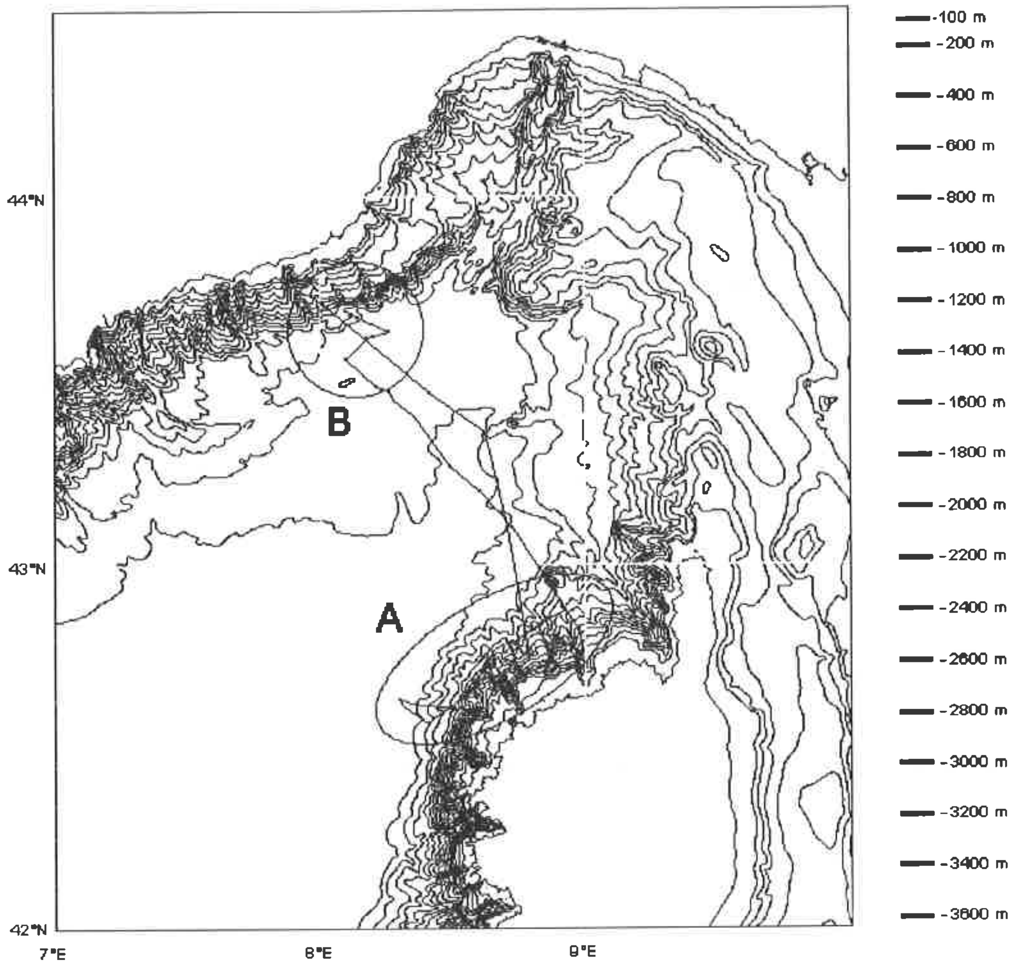

Fig. 1 Cruise tracks with the towed hydrophone deployed.
Whales were heard and sighted in area A and only heard in area B.
Map created with OceanMap and the IBCM bathymetric digital data.

Surface observations This study presented the opportunity to follow and observe a group of three sperm whales, quite an uncommon encounter in the Mediterranean Sea, and to recognise remarkable behaviours described in other sperm whale populations. These whales were photographed and their surface behaviours (i.e. lobtail, spyhop, sidefluke and fluke up - see Whitehead & Weilgart, 1991), were observed and video-taped.

Acoustics Thirty-two hours of underwater recordings were analysed, catalogued, and included in a cetacean sound library. The sperm whale recordings lasted for a total of 29 hours, which included sounds from a minimum of seven animals, and 54 codas, emitted by at least three distinct whales, matching the Mediterranean pattern (/// /).

The sizes of the sighted whales were calculated by analysing the structure of their clicks. Gordon (1991) explained that sperm whale clicks consist of an initial intense direct pulse and a number of subsequent echoes generated in the head of the whale. The interpulse interval (IPI) of the main echo is deemed to be correlated with the size of the spermaceti organ and thus with the size of the whale. Recently, Goold (1996) developed a cepstrum-based method to accurately measure IPIs and, thus, to assess the size of sperm whales based upon the first six minutes of the first dives of four whales.

A program was developed, based on a custom real-time Digital Signal Processing Workstation (Pavan & Borsani, 1997), to show in real-time the cepstrogram, optimised for this special purpose, of the recorded clicking sequences. Analysis parameters were set to match IPIs ranging from 2 to 8 ms.

Whenever possible, the analysis of the data from the three sighted, identified and tracked whales was extended to more than the initial six minutes and to consecutive dives; IPI measurements (Fig. 2) were consistent throughout entire dives and, thus, were used to calculate the sizes of the emitting whales (Table 1).

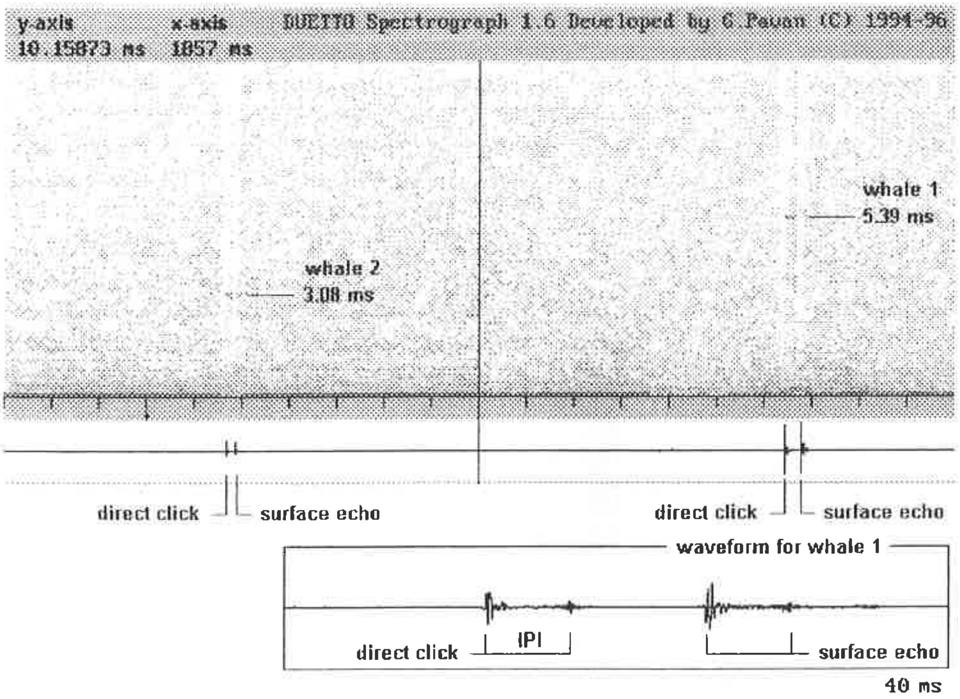

Fig. 2 Spectrogram of two whales of different size. The y positions of the darker dots correspond to their IPIs. Clicks from both whales have strong and well spaced surface reflected echoes. The waveform for whale 1 shows that well spaced echoes do not interfere with IPI measurement.

Both Clark's and Gordon's equations (Gordon, 1991) were applied to the data and it was noted that both seemed to be unsatisfactory when small whales (less than 10 m in size) are measured. This was due to a lack of knowledge as to the relationship between the spermaceti organ and total body size in young animals.

The acoustically derived length data were comparable to visual assessments for whales 1 and 2, while the acoustic estimate for whale 3 was less than the visual assessment. Further investigations are in progress utilising previously collected recordings in order to expand the current data set, and a more reliable method for in-field visual estimation of sperm whale length is needed.

By analysing the entire current data set of recordings, which included click sequences from distant whales, it was noticed that the cepstrogram was able to reveal clicks otherwise difficult to see on traditional spectrograms. However, most of the clicks from distant whales were not reliable for IPI measurements due to the short interval between direct signals and surface reflected echoes.

Table 1 The IPI measurements produced the following size estimates

		IPI (msec)	BODY SIZE (m)	
			Clarke, 1978	Gordon, 1991
Big nose (12-13m)	N	334		
	AVG	5.376	11.990	12.615
	MIN	5.120	11.550	12.246
	MAX	5.440	12.106	12.708
	STD	0.049	0.088	0.070
Niño (8-9m)	N	90		
	AVG	3.067	9.540	9.280
	MIN	2.530	9.367	8.503
	MAX	3.260	9.627	9.559
	STD	0.144	0.050	0.208
Big head (17-18m)	N	274		
	AVG	5.153	11.605	12.293
	MIN	5.030	11.407	12.116
	MAX	5.440	12.106	12.708
	STD	0.058	0.096	0.083

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AN ACOUSTIC SURVEY FOR SPERM WHALES IN THE SOUTHERN OCEAN

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An acoustic survey for sperm whales in the Southern Ocean has been carried out from the Australian ice breaker, the "RSV Aurora Australis". The survey covered the area between 80°E and 150°E, extending north to 63°S and south to the edge of the sea ice. A simple, low cost, hydrophone was deployed which was sensitive in the bandwidth 300 Hz to 35 kHz. The array design and survey method were similar to those developed on the International Fund for Animal Welfare's research yacht "Song of the Whale". The study formed part of an integrated physical/biological survey by Australian National Antarctic Research Expeditions (ANARE).

The survey method used requires the measurement of bearings to whales from stations spaced at regular intervals along the track line. In order that the survey could be conducted by a single individual over an 11-week period, conventional DAT recorders were interfaced to a computer to automatically make a short (20 second) recording every two minutes. New click detection software has been used to analyse the recordings in order to extract bearings to sperm whales from each station. These bearings contain the basic information necessary to calculate the density of sperm whales in the area surveyed.

FROM AN ACOUSTICALLY-AIDED VISUAL SURVEY IN THE MEDITERRANEAN SEA TO A FUTURE ACOUSTIC SYSTEM

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INTRODUCTION Acoustics is an important area of technology for research on cetacean ecology, and it has been developed more recently as a complementary method for ship-borne abundance surveys (Gordon & Chappell, 1993; Evans & Chappell, 1994). The Groupe de Recherche sur les Cétacés has practised acoustics research techniques since 1990, for the documentation of odontocete vocalisations. Thanks to the assistance of the International Fund for Animal Welfare and the loan of a towable hydrophone during the summer of 1994, an opportunity was given to participate in a full-scale experimental survey in the Liguro-Provençal Basin and surrounding waters. Acoustic surveys were made in conjunction with a visual line-transect surveys, and the compatibility of the two methods was evaluated. The combined survey lasted one month, from 21st July to 22nd August, and led to interesting, and sometimes unforeseen, results which could influence the future development of an integral acoustic census system for odontocetes.

MATERIAL AND METHODS The survey platform was a 9 m yacht with a 16 hp diesel engine, giving a cruising speed of 5 knots. The hydrophone was a dual channel towable unit: its sensitivity was about 89.10-6 mV per Pa and its frequency response was linear (+/- 2 dB) from 1 Hz to 25 kHz. A preamplifier with a built-in 200 Hz high pass filter provided a stereo signal to either a loud-speaker or a Sony TCD-30 cassette recorder. The survey was conducted in the Liguro-Provençal Basin and the Tyrrhenian Sea (north of 41°N). Simultaneous acoustic and visual sampling was carried out in the open sea over a period of 18 days (199 hrs) (Fig. 1). Acoustic sampling was also conducted over several night-time periods. During the "on-effort" part of the transect, the survey vessel was usually engine-driven.

The sampling method consisted of one minute acoustic recording being taken for every thirty minutes of visual line-transect survey effort. The survey effort amounted to a total of 381 acoustic samples. Acoustic recordings were taken while the survey vessel was still under power, although the speed was usually reduced to four knots to decrease the amount of background noise. If a very weak acoustic signal was detected, then the boat stopped briefly to further reduce the amount of background noise. Acoustic sampling was interrupted during the following conditions: if less than three miles from the coast, if the force of the wind exceeded Beaufort 6, if intense fishing activity was present, or if a military exercise area was crossed. The acoustic survey results were noted in a special log book, describing any unusual or interesting events. A total of 480 minutes of acoustic recordings were kept for further analysis and processing in an acoustic laboratory, where various digital signal analysers could be utilised to obtain more detailed information.

RESULTS AND DISCUSSION During the one-month survey, 105 sightings were made. However, some of these sightings were of fin whales (*Balaenoptera physalus*) and others were made whilst the hydrophone was not in operation. These latter encounters were excluded and total of 64 encounters of odontocetes, visual, acoustical or both, were analysed in this current study (Table 1): 25% of these encounters were exclusively visual, 33% were purely acoustical, and 42% of the encounters were detected both by hydrophone and by visual observation.

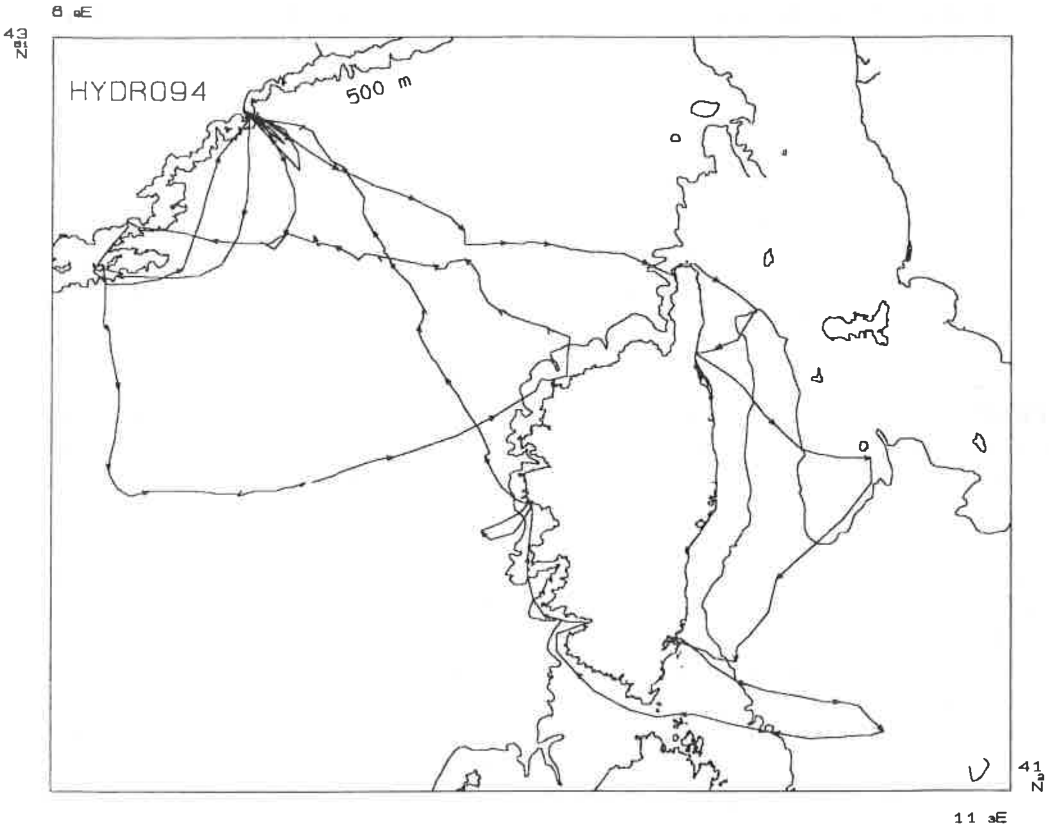

Fig. 1 Map of the combined acoustical and visual survey (summer 1994)

The analysed encounters predominantly involved striped dolphins, although four other species were also detected and observed. An encounter was declared to be not detected acoustically if it was not noticed during the acoustic samples preceding the visual sighting (case V). A detection was declared to be exclusively acoustic if no cetacean had been sighted after a series of positive acoustic samples (case A). Among the cases of combined detection, 70.4% of the schools were first detected by hydrophone (case Av) and the rest was first detected visually (case Va). Several parameters were investigated to explain these results (Table 1) for the striped dolphins. The mean radial distance of detection for each case (V, Av and Va) was found to be weakly variable. On the other hand, group size seemed to influence the process of detection, i.e., group size was smaller when animals were not detected acoustically (S = 11.4) than in cases of combined detection (S = 32). Groups containing newborn calves or juveniles tended to be detected exclusively by acoustic means, but this parameter could partly be attributable to group size. On the whole, smaller groups without calves were less conspicuous acoustic sources than larger groups with calves.

Case V was not reported by Gordon and Chappell (1993) for a combined survey on harbour porpoise *Phocoena phocoena*. The examples of case V encounters in this present study may be a consequence of the survey methodology, i.e. the amount of acoustic effort was considerably lower than the amount of visual effort, therefore increasing the probability that encounters would be detected visually as compared with acoustically. In addition, engine noise may have masked vocalisations from quieter groups and, moreover, some odontocetes are known to make use of their echolocation system only intermittently (Dawson, 1991) and, therefore, may not emit much in the way of detectable acoustic signals.

The visibility conditions were a strong influence on cetacean detectability. Visibility was recorded on a six point scale during the survey which ranged from 6 (excellent) to 0 (nil). For encounters where animals were detected acoustically but not visually, the mean visibility index was 4.1 which was much lower than the mean value of 4.7 calculated for cases Va and Av.

Table 1 The combined results of the visual and acoustic surveys (mean group size and radius of visual detection only applies to *Stenella coeruleoalba*, propulsion mode only applies to small delphinids)

CASE	VISUAL ONLY	VISUAL THEN ACOUSTIC	ACOUSTIC THEN VISUAL	ACOUSTIC ONLY
number of sightings	15 *Stenella coeruleoalba* 1 *Tursiops truncatus*	9 *Stenella coeruleoalba*	17 *Stenella coeruleoalba* 1 *Delphinus delphis* 1 *Globicephala melas* 2 *Physeter macrocephalus*	14 *Stenella coeruleoalba* 2 *Physeter macrocephalus* 1 *Tursiops truncatus* 3 unidentified
mean radius of visual detection	611 m	633 m	616 m	unknown
mean visibility index	4.8	4.5	4.8	4.1
mean school size	11.4	31.6	32.0	unknown
mode of propulsion	14 motor 2 sail	4 motor 5 sail	13 motor 6 sail	6 motor 9 sail

The survey vessel's mode of propulsion also has an influence: in cases V, the vast majority of encounters were obtained whilst under diesel propulsion, while in cases A, the boat was mainly under sail, i.e. cruising under sail means a lower level of background noise, which could mask acoustic signals, and a higher wind speed, which causes a reduction in visibility. Both of these reasons could explain the better acoustic performance during sailing and illustrates that an acoustical radius of detection can be greater than the visual one.

Ultimately our ambition is to build and experiment with an integrated system whose field results are compatible with visual line-transect survey software and which could automatically determine species, group size, radial distance and bearing. Various intermediate approaches could be considered as well: acoustically-aided visual transects (as in this pilot study); acoustically-complemented visual transect; the development of an acoustic abundance index inter-calibrated with the results of a visual transect; and an acoustic survey complemented with visual determination of species and school size.

CONCLUSIONS This pilot survey shows the compatibility of acoustic surveys with small survey platforms and the feasibility of a future acoustic census system. However, it is apparent that numerous points need to be studied during the development of such a complex device.

ACKNOWLEDGEMENTS We gratefully thank the city of Antives and the Région "Provence-Alpes-Côte d'Azur" for their suppport in 1994. Thanks also go to Jonathan Gordon and I.F.A.W. for the loan of a hydrophone and their assistance during the study.

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MASKED HEARING THRESHOLDS OF BELUGA WHALE (*DELPHINAPTERUS LEUCAS*) VOCALISATIONS IN SHIP NOISE FROM BEHAVIORAL EXPERIMENTS

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INTRODUCTION Noise pollution of the world's oceans due to increasing ship traffic plays an important role in marine mammal habitat degradation. Not only can noise disturb animals and scare them away from their current location, but it has the potentially more devastating effect of interfering with their communication signals. Many marine mammal species have complex communication systems, and masking of their vocalisations to the point of incomprehensibility, for example in the case of emitted warning signals, can have fatal results. An experimental approach to assessing the masking effect of icebreaker noise in the Canadian High Arctic on beluga whale (*Delphinapterus leucas*) vocalisations is described.

EXPERIMENT DESCRIPTION At the Vancouver Public Aquarium, one female beluga whale, Aurora, aged 10, was trained to detect a typical beluga call in three different noises. This vocalisation was obtained from recordings of a wild beluga population in Lancaster Sound. The spectrogram is shown in Fig. 1. Noise recordings were made from an icebreaker in Beaufort Sea. Bubbler system noise (Fig. 2) is created when an icebreaker forces high pressure air into the water in order to blow floating ice debris away. Propellor cavitation noise (Fig. 3) originates from the propeller. It is most violent when an icebreaker fails to break an ice ridge and is stopped, although the propeller still revolves at full speed. Naturally occurring ice cracking noise (Fig. 4), induced by local pressure and temperature changes, is studied for comparison. All the four signals were normalised to the same root-mean-square (rms) [pressure] amplitude over their two-second-sample-length, i.e. the gray scale of the spectrograms denotes relative pressure rather than absolute underwater pressure. The vocalisation was digitally mixed with the three noises in various signal-to-noise ratios. The rms pressure of the mixed signals was kept constant at a level which was believed "comfortably loud" for the whale in the pool. Therefore, with decreasing signal-to-noise ratio, the call became quieter and the noise louder. The two-second-long mixtures were stored on the hard drive of a portable PC. Figure 5 depicts the experimental set-up.

Aurora initially stations with one whale trainer at the far side of the experiment pool. She is then sent over to a second trainer who is placed next to a J9 underwater projector. The experiment conductor stands behind a wall of rocks out of view of the whale and the two trainers to avoid passing on any cues to the animal. As soon as Aurora stations against the bar in front of the J9, the second whale trainer says "steady". At a random time of 5-30 s thereafter, the experiment conductor transmits a mixture of the beluga call and one of the three noises. If Aurora hears the call in the noise, she breaks away from the target with a reaction time of <1 s. The whale trainer says "break", the experiment conductor says "call" and the first whale trainer, thus knowing that Aurora broke upon transmission of a mixed signal, recalls Aurora for reward. If she cannot hear the call in the noise, Aurora holds station. Five seconds later, the experiment conductor says "call" to indicate to the trainers that a sound was played, and the first trainer recalls and rewards Aurora for not breaking on a signal in which she assumingly failed to detect a call. If Aurora breaks before or >2 s after a signal was transmitted, she receives no positive reinforcement. The same holds for wrong reactions to catch trials, i.e. a break on a pure noise signal or a station on a pure vocalisation. The latter was not observed once. The whole experiment is based on the fact that it is simply more exciting for Aurora to break as soon as she hears a call in noise rather than hold station for half a minute.

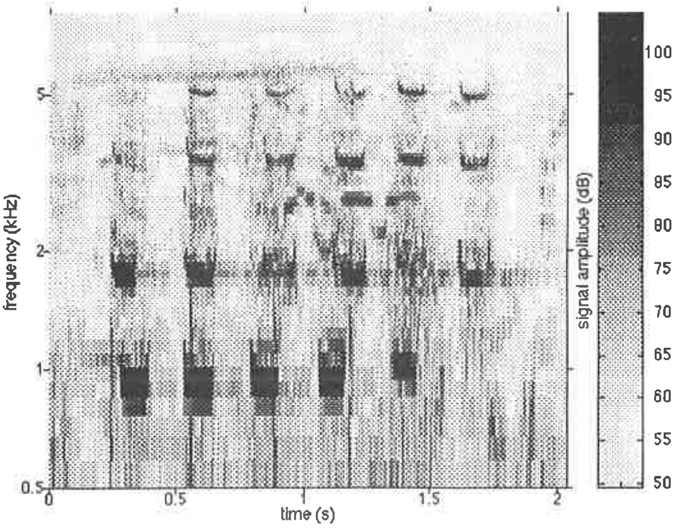

Fig. 1 Beluga Vocalization

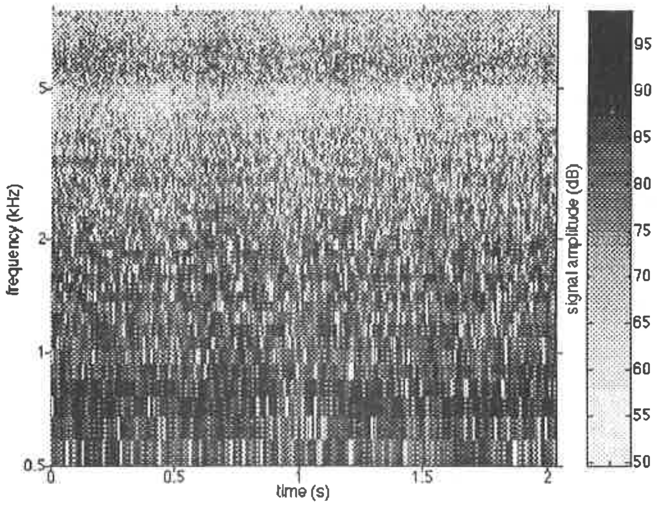

Fig. 2 Bubbler System Noise

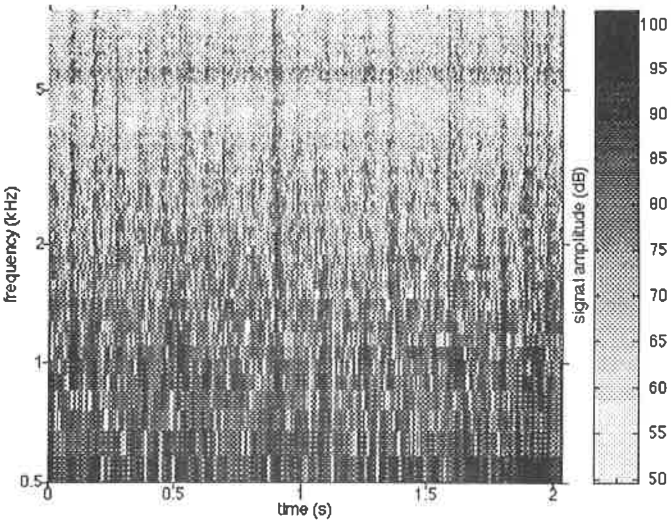

Fig. 3 Propeller cavitation noise

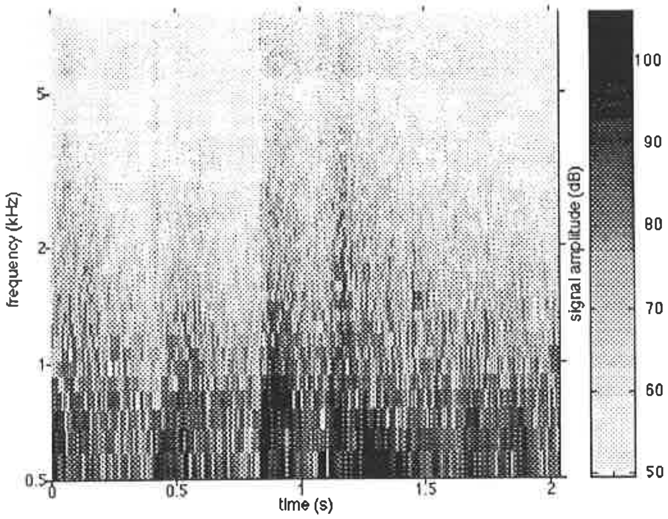

Fig. 4. Natural Icecracking Noise

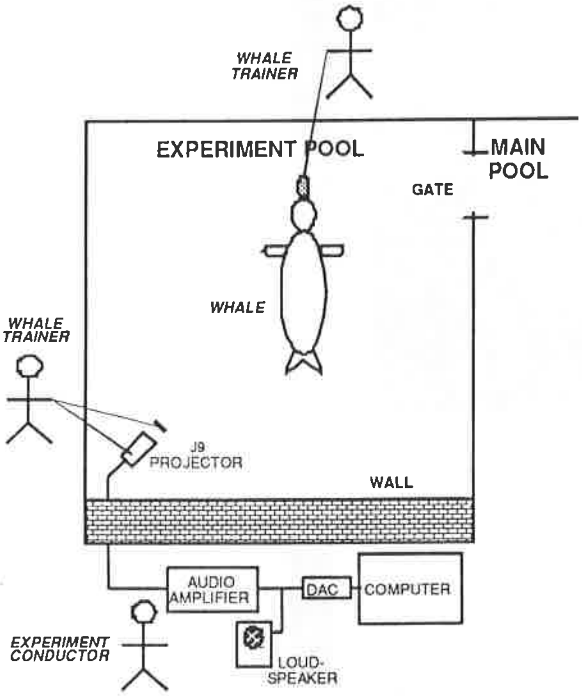

Fig. 5. Experiment Setup

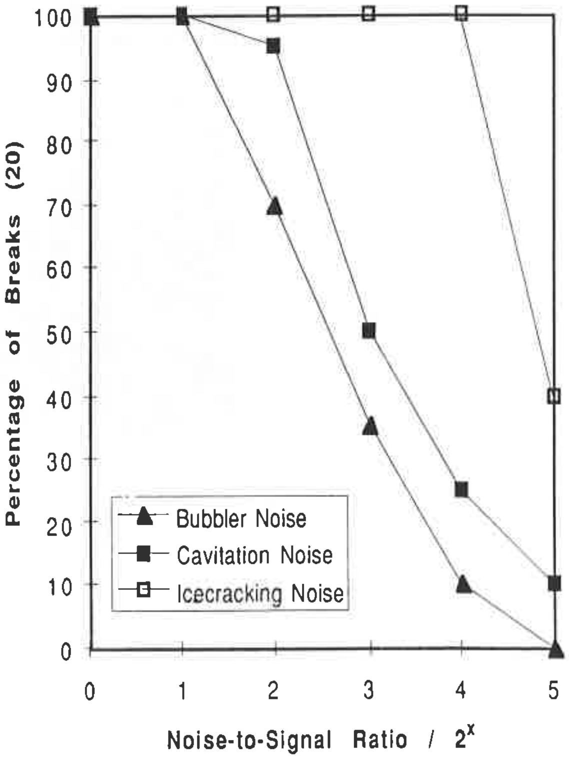

Fig. 6. Masked Hearing Thresholds for the Three Noises

Data with bubbler system noise, propeller cavitation noise, and natural icecracking noise were collected during separate sessions. The signal-to-noise ratio was changed in three different ways. The first method was a so-called titration starting at the loud-call/quiet-noise end and gradually increasing the noise over the call until Aurora stopped breaking on one mixture. The signal-to-noise ratio was then increased until Aurora started breaking again, which was usually on the previous mixture. The signal-to-noise ratio was then decreased for the second time until she stopped breaking. Stepping up and down in signal-to-noise ratio was continued until the masked hearing threshold remained the same three times in a row. This value was taken down. For each of the three noises, this titration was conducted ten times. Data were also collected in a titration starting at the quiet-call/loud-noise end and successively increasing the signal-to-noise ratio. The thresholds were exactly the same. The third method tested involved random jumps on the signal-to-noise scale and produced the same thresholds again. In total, for each of the three noises, twenty masked hearing experiments were carried out.

RESULTS Data are plotted in Fig. 6. The x-axis denotes the noise-to-signal ratio (the inverse of the signal-to-noise ratio) on a logarithmic scale. At point 0, the noise-to-signal ratio is 2^0, i.e. one. Therefore, the rms pressure amplitude of the call is equal to that of the noise. At point 1, the noise-to-signal ratio is 2^1, i.e. two. At point 2, the noise is four times as loud as the call, at 3 it is 8 times as loud and so on. The y-axis denotes the percentage of times that Aurora heard the call in the particular mixture. Each mixture was played 20 times, e.g. at point 2 on the x-axis, the cavitation noise has a detection probability of 95%. This means that out of the 20 trials, Aurora broke 19 times on this particular mixture.

CONCLUSIONS One can conclude that bubbler system noise has the strongest masking effect. Aurora consistently hears the call in the noise only up to a noise-to-signal ratio of 2. Natural icecracking noise as ambient in the Arctic ocean masks this particular beluga vocalisation only for noise-to-signal ratios greater than 16. Propeller cavitation noise though exhibiting the same threshold for 100% recognition, seems to lie somewhat in between. It shall be noted that this experiment resembles the worst possible case, when noise and sound come from the same direction. Directional hearing abilities of the whales will most likely shift thresholds to higher noise levels. Furthermore, the measured masked hearing thresholds express the relative degree of masking by the three noises. In real life, thresholds will be a function of the absolute loudness of call and noise, i.e. the distance of the listening whale from the speaker and the noise source.

ACOUSTIC BEHAVIOUR OF FREE-RANGING BOTTLENOSE DOLPHINS IN THE KVARNERIC (NORTHERN ADRIATIC SEA)

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A long-term study focusing on the social ecology and behaviour of a bottlenose dolphin community living in the coastal waters near the islands of Losinj and Cres (Croatia) has been carried out by the Tethys Research Institute since 1987. The behavioural budget showed a predominance of activities characterised by long dives over behaviours such as socialising and travelling. The present study was conducted in order to describe the local bottlenose dolphin repertoire and provide an insight into underwater activities that could not be interpreted based on observations conducted from above the surface.

From 1992 to 1995, 32 hours of dolphin vocalisations were recorded underwater from a small inflatable craft, together with a synchronous spoken commentary on a second channel. A total of 1,370 1-min. samples were analysed. The pulsed sounds which occurred were grouped according to their click rates, referred to as single clicks, slow click trains, creaks, moans, and buzzes. Click intervals >30 ms were related to search or orientation, 7-30 ms intervals to hunting, and intervals <7 ms to "locking on" a target. Tonal sounds like whistles, brays, etc. were also considered, as well as "bangs" and percussive sounds.

Based on the different speed sequences during the click emissions, a large amount of time spent by dolphins performing long dives could be related to food search. Fast click rates, suggestive of actual foraging, were predominant during the activities defined as Dive and Dive-Travel, as well as during Surface Feeding. The fact that dolphins in the area spent such a large percentage of their time engaging in feeding-related activities suggests that food resources were scarce.

FOOD-RELATED CALLING IN BOTTLENOSE DOLPHINS

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Food calls have been reported for a variety of animals that feed on plants. However, there is very little evidence for such calls in predators. This study describes a unique low frequency call of wild bottlenose dolphins (*Tursiops truncatus*) recorded in the Moray Firth, Scotland, and investigates possible functions. To be able to correlate calling with surface behaviour, a passive acoustic localisation technique was used. By applying this method, the location of a calling individual could be determined by comparing the differences in the time at which the sound arrived at different hydrophones. The call consisted of two parts and had a multi-band structure, with most energy between 200 and 4,000 Hz. The call occurred mainly in June and July, when dolphins were frequently seen feeding on salmon (*Salmo salar*) or sea trout (*Salmo trutta*).

The results demonstrated that dolphins produced low frequency calls in 94% of all observed feeding events. The first calls were always emitted at the location where feeding activity occurred. Later in the year, when bottlenose dolphins only fed on smaller fish species, no calling was recorded. The results suggest that bottlenose dolphins in the Moray Firth have a specific food call associated with feeding on large fish. Fast chases are required to capture salmonids. Calling may be used to alter prey behaviour, to increase the food intake of close relatives, or to recruit conspecifics to approach and, thus, chase fish back towards the caller. Further studies are needed to determine the specific function of food-related calling behaviour.

RISSO'S DOLPHIN (*GRAMPUS GRISEUS*) ACOUSTIC SURVEY IN THE HEBRIDEAN WATERS, SCOTLAND

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INTRODUCTION The "Risso's Dolphin Project" was initiated in 1995 by Alison Gill and Tim Atkinson, to study Risso's dolphins in the eastern waters of the Isle of Lewis, Outer Hebrides, Scotland. Photo-ID has been used from the beginning to verify abundance and distribution, while acoustic equipment was used during the summer of 1996 in order to understand more about the behaviour of this little-studied species. Risso's dolphins, *Grampus griseus* (Cuvier, 1812), are usually considered to be a pelagic species, which is related to the fact that their diet primarily consists of cephalopods that live at high depths. This perhaps explains the lack of studies on this species up to now. Coastal waters off the Isle of Lewis, were revealed to be an ideal location to study Risso's dolphins because depths reach 100 m close to the coast.

MATERIALS AND METHODS The survey area was situated between Tolsta Head (58° 21' N, 6° 09' W) and Kebock Head (58° 02' N, 6° 21' W) and seawards to the 100 m isobath, covering an area of approximately 175km^2. Recordings were made from a 7 m fishing boat, using two hydrophones connected to a pre-amplifier and a DAT recorder. The HP/30 general purpose hydrophones used in this study were designed to capture sounds in the audible frequency range. The acoustic equipment was powered by two 12 v batteries. Animals were slowly approached, the engine was stopped and the hydrophones lowered into the water to a depth of approximately 6m, to be sure that the hydrophones were above the thermocline.

During the period from mid July to the end of September, surveys took place on 18 days when the sea state was less than Beaufort 3. During each encounter, the behaviour of the animals was described orally and recorded on a portable tape recorder or a video camera. Underwater recordings were analysed with the real-time Digital Signal Processing Workstation developed by Dr. G. Pavan (Pavan, 1994). Single sounds were named according to our acoustic perception, grouped by visual inspection of the spectrograms and quantified by measuring their mean duration, pulse repetition rate and frequency range. Harmonics were used to measure the repetition rate (Watkins, 1967).

RESULTS Risso's dolphins were observed and recorded for 12 days, collecting about seven hours of useful recordings. Risso's dolphins were not vocalising on only two occasions. During both of these encounters they were in small groups (2-6 individuals), travelling fast and disappeared immediately - which may have been due to adverse sea states. All the recorded vocalisations were grouped into categories in order to create a catalogue which would be both easy to consult and which could be compared with other recordings. Risso's dolphins basically produce three categories of sounds: clicks in discrete series, fast sequences of pulses and whistles.

The first two categories are broad-band click trains with variable repetition rates. Table 1 shows percentages of each type of these calls, their duration and repetition rate. Echolocation click trains were measured according to their percentage duration during a seven hour period, because it was not possible to count and measure the duration of a single specific train, due to the presence of too many animals at the same time.

Table 1 A summary of recorded vocalisations

CALL TYPE	NUMBER	%	MEAN DURATION	PULSE RATE
SQUEAK	1057	44.13	143.6 ms	400-1031/sec.
CREAK	1043	43.54	663.1 ms	
BUZZ	191	7.97	402.4 ms	250-625/sec.
other	38	1.58		
MOAN	33	1.37	1578 ms	187-560/sec.
GRUNT	21	0.87	104.5 ms	37-78/sec.
SQUEAL	12	0.5	542.2 ms	2000-3750/sec.
total	2395	99.96		
CLICK		42.80%		2-94/sec.

- Clicks in discrete series can be grouped into echolocation trains, creaks and grunts: their repetition rate allows the discrimination almost each pulse in the spectrogram.

Echolocation clicks: the most frequent type of sound produced, present during approximately three hours out of the seven recorded. Their repetition rate varied between 1.9 and 93.9 pulses per second, showing a great variability, possibly related to their utilisation for different tasks.

Creaks: trains of clicks with a higher repetition rate and a shorter duration than echolocation clicks. About 17% of creaks were associated with short whistles uttered immediately before and/or after the creak (Fig. 1).

Grunts: very short sequences of broadband pulses. Their pulse rate ranged between 37.5 and 78.1 pulses per second, with a mean duration of 104.5 ms.

- Fast sequences of pulses can be grouped into buzzes, squeaks, moans and squeals: their repetition rate is so high that our ear perceives them as a unique sound instead of a sequence of pulses and harmonics are apparent on the spectrogram.

Buzzes: “thick” trains of pulses with a rather constant duration of about 400 ms. Most of the buzzes recorded are of a strong intensity and always heard in association with echolocation clicks, although it is possible to hear clicks without buzzes (Fig. 2).

Squeaks: brief sequences of very fast pulses with a pulse rate of between 457.4 to 1,007 pulses per second. On a few occasions, which were related to the presence of many animals (30-40), long sequences of repeated and overlapped squeaks were recorded. These were sequences were called “chattering”. At the same time a number of surface behaviours were observed: breachings and half breachings on both sides, spyhops, porpoising, tail slapping and fluking up (Fig. 3).

Moans: long and sometimes very long sort of "*lament*" with a maximum duration of about 8,000 ms (Fig. 4).

Squeals: represented only 0.5% of the vocalisations recorded, with a maximum repetition rate of about 2,000-4,000 pulses per second. Their mean duration was approximately 500 ms (Fig. 5).

- Whistles, i.e. tonal sounds with frequency modulation, recorded eight times during twelve days of observations of Risso's dolphins. Whistles connected with creaks had a mean duration of 153.8 ms. Other whistles, being very variable in shape, duration and frequency range, were grouped into one category until further recording can be collated to provide a data set suitable for analysis (Table 2).

Table 2. Whistle durations and frequency ranges

CALL TYPE	MEAN DURATION	FREQUENCY RANGE
Whistle with creaks	153.8 ms	3,900-6,500
Other whistles	658.3 ms	7,363-12,035

CONCLUSIONS The analysis of vocalisations in the audible range, from Risso's dolphins presented in this study, confirm previous research by other authors (Caldwell *et al.*, 1969; Schevill & Watkins, 1962; Watkins *et al.*, 1994). In order to confirm and to expand upon our preliminary data, new recordings will be collected in Hebridean waters next spring and summer, while an accurate comparison will be carried out with recordings from the Mediterranean Sea, belonging to the Sound Library of the Centro Interdisciplinare di Bioacustica e Ricerche Ambientali, University of Pavia.

ACKNOWLEDGEMENTS The hydrophones and DAT recorder were provided by Dr. J. Gordon (IFAW) and the Defence Research Agency. Funding for the fieldwork was provided by the Whale and Dolphin Conservation Society, The Carnegie Trust for Universities of Scotland, The Manifold Trust, The Scottish International Education Trust, and Università degli Studi di Milano. The boat was lent by Mr and Mrs Henriques. Special thanks are due to Alison Gill, Tim Atkinson and Lori Lawson, for their help with fieldwork and to Guido Gnone for his encouragement.

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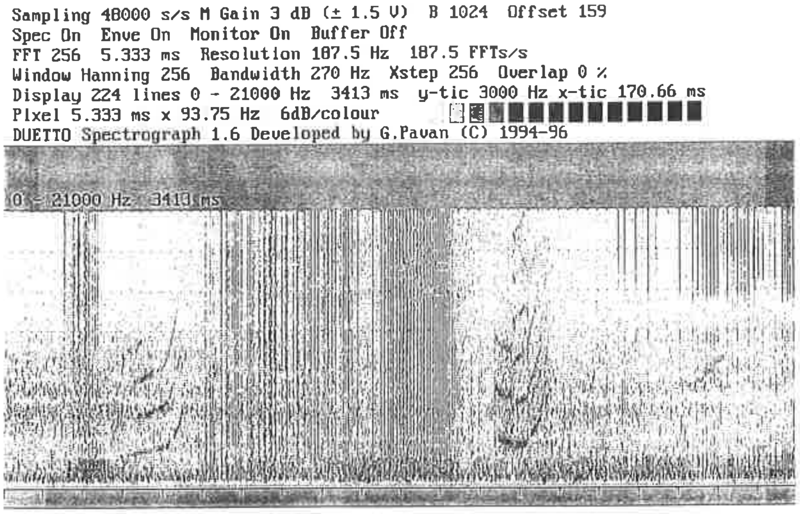

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DUETTO Spectrograph 1.6 Developed by G.Pavan (C) 1994-96
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Fig. 1. Creaks and whistles

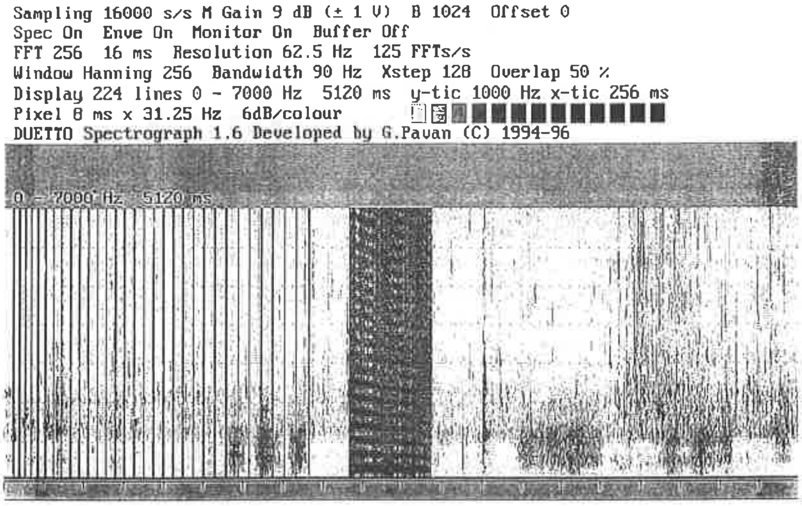

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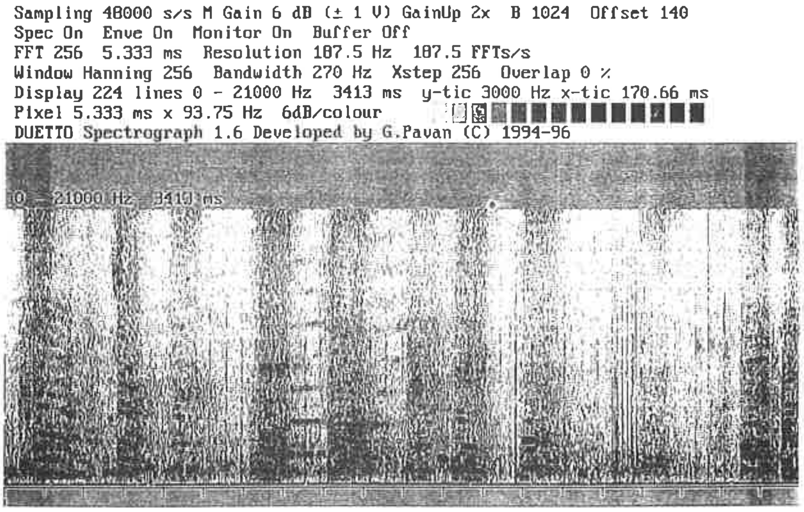
Fig. 2 Buzz



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DUETTO Spectrograph 1.6 Developed by G.Pavan (C) 1994-96
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Fig. 3 Sequence of squeaks: "chattering"

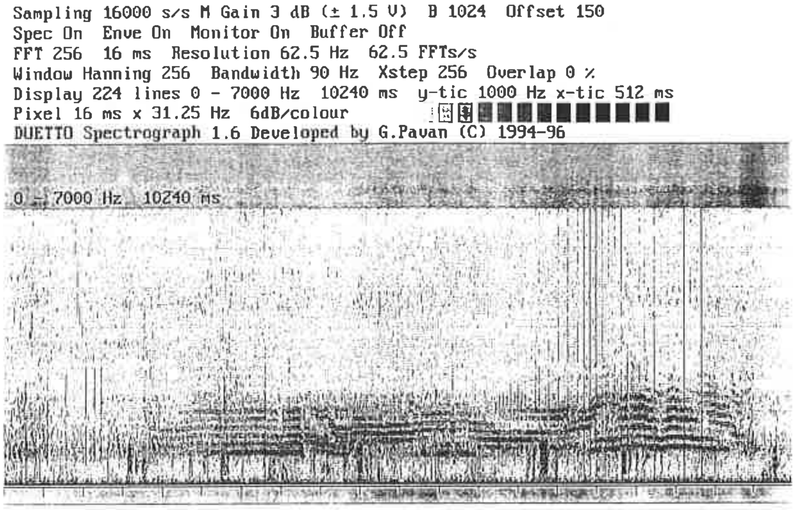

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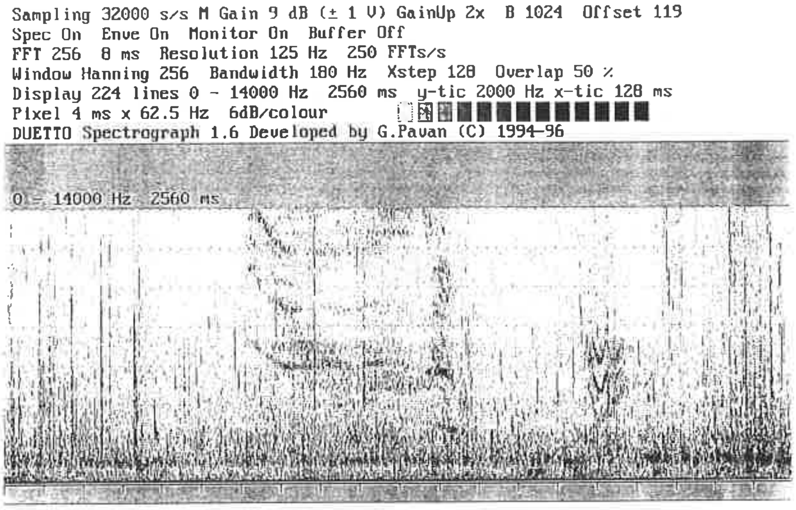
Fig. 4 Moan



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Display 224 lines 0 - 14000 Hz  2560 ms  y-tic 2000 Hz x-tic 128 ms
Pixel 4 ms x 62.5 Hz  6dB/colour
DUETTO Spectrograph 1.6 Developed by G.Pavan (C) 1994-96
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Fig. 5 Squeal

LIFE HISTORY, PHYSIOLOGY & ANATOMY

AGE, GROWTH AND REPRODUCTIVE BIOLOGY OF PYGMY (*KOGIA BREVICEPS*) AND DWARF (*KOGIA SIMUS*) SPERM WHALES OFF THE SOUTH AFRICAN COAST.

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Little is known about the natural history of the genus *Kogia*, which encompasses the pygmy and the dwarf sperm whale. Since South Africa has the second highest stranding record in the world for these two species, it offers a great research opportunity to discover more about these uncommon creatures.

For this present study, the reproductive organs from 39 pygmy sperm whales *Kogia breviceps* and 43 dwarf sperm whales *K. simus*, and teeth from 58 pygmy sperm whales and 36 dwarf sperm whales, which had been stranded along the South African coastline over the last 33 years, were examined histologically in order to determine reproductive status and age. For pygmy sperm whales, the females reached sexual maturity at 262 cm and 4.5 growth layer groups (GLGs), whereas males reached sexual maturity at 233 cm and 4.3 GLGs. Physical maturity was reached at 307 cm and approximately 15 GLGs. For dwarf sperm whales, the females were found to reach sexual maturity at 215 cm and 5.6 GLGs and males reached sexual maturity between 201 and 204.5 cm and 3-5 GLGs. Physical maturity was reached at 252 cm and about 15 GLGs, in this species. Furthermore, females were found to ovulate in both ovaries and sperm morphology was found to be similar to that of the sperm whale, *Physeter macrocephalus*.

TWIN PREGNANCY IN A RISSO'S DOLPHIN (*GRAMPUS GRISEUS*)

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A female Risso's dolphin (*Grampus griseus*) was found dead near Port Arthur, Co. Donegal, Ireland. A post-mortem examination was carried out. It is thought that the cow died after giving birth to one animal. The remaining calf was found in breach position.

THE PHYLOGENY OF THE HOMODONTAL SET OF TEETH AND THE DENTITION OF TOOTHED WHALES (*ODONTOCETI*)

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In all mammals, two sets of teeth are developed, but up to now a second set of teeth in archaeocetes and cetaceans has been unknown. Boschma (1938a) first discovered rudimentary tooth generations in sperm whales. He also found a deviation from the normal dentition of mammals in a longitudinal section through one tooth of the lower jaw: "On peu observer une formation intéressante d´ostéodentine dans une dent d'origine inconnue qui se présenté ici en coupe longitudinale." (Boschma, 1951, p. 10).

The examination of several toothed whale species and sperm whales proves that, in dolphins, the mammal-like vestigial set of milk-teeth becomes the permanent set of teeth, and that the second set is very poor and disappears in the postnatal phase. The second set of the harbour porpoise shows premolars with two supplying nerves and two embryonic teeth like a multiple-crowned tooth (Fig. 1): this is a heritage from the ancient whales. The great number of teeth in the common dolphin *Delphinus delphis* Linné, 1758 seems to be evidence for the presence of many embryonic teeth, which can be restored if there is enough space in the jaw. But more embronic teeth than necessary are found in the jaws of toothed whales.

Fig. 1 Harbour porpoise *Phocoena phocoena* L.: an alveolus of the second set of teeth containing a rudimentary tooth, 25x

The development of the set of teeth in sperm whales (Fig. 2) with a great number of polycronic teeth (Boschma, 1938b) shows many relationships to the archaeocetes and to their ancestors, and reminds us of the development of teeth in reptiles (Peyer, 1968). In contrast to mammals, the tooth buds of the replacement teeth of reptiles originate below the first tooth buds (Edmund, 1969). Secondly, in reptiles many more embryonic teeth are formed than in mammals. The set of teeth in sperm whales represents a transitional stage, where the replacement teeth do not grow out. Instead, they are preserved and may become very large. Below the teeth of sperm whales, in the tissue of the alveolars, one can find many small teeth.

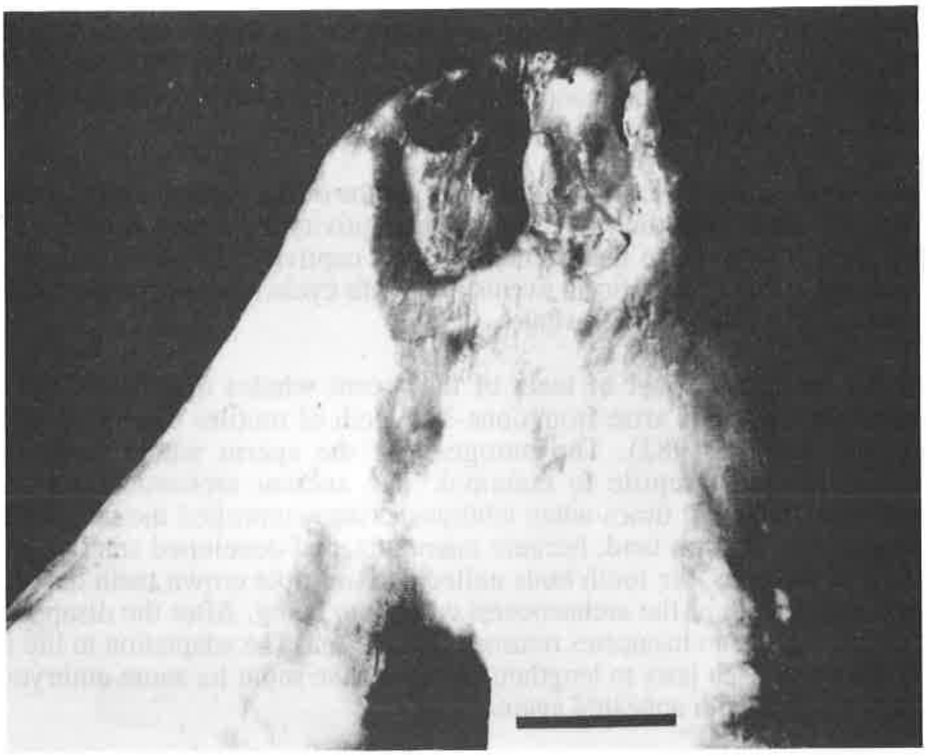

Fig. 2. *Physeter macrocephalus* L.: two incisors grown together, scale 1 cm. In each tooth a multiple crown core-tooth is enclosed

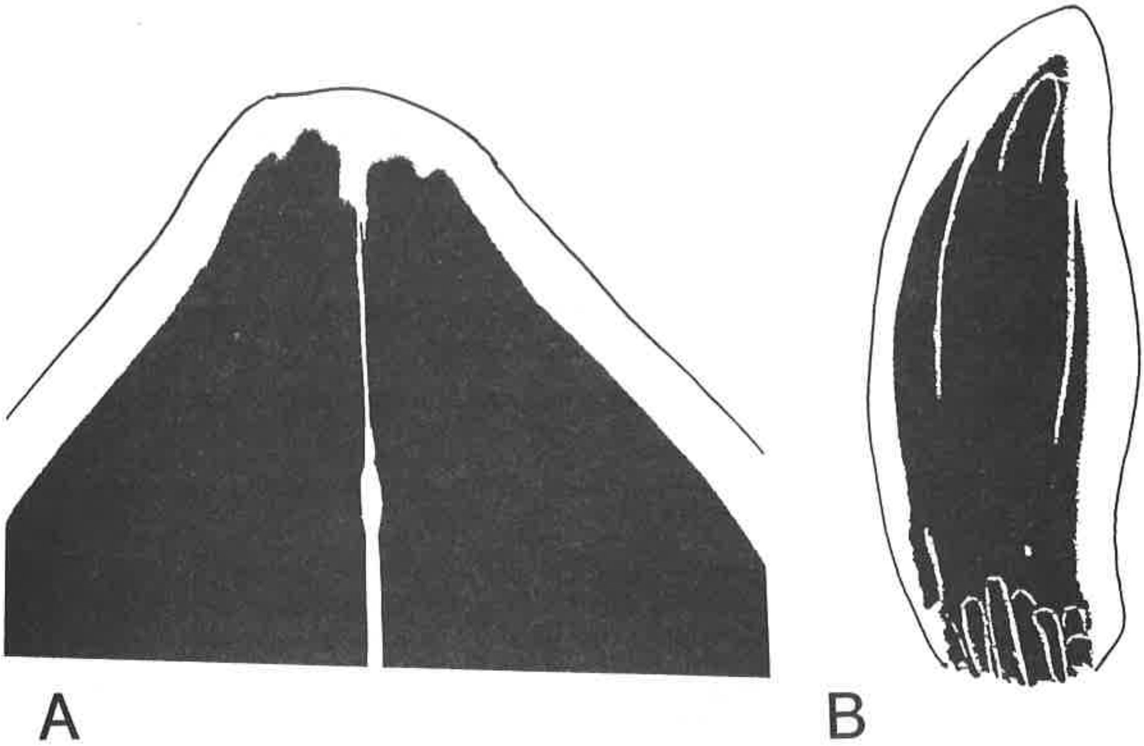

Fig. 3 Sperm whale *Physeter macrocephalus*:
A: X-ray photograph of both incisors (Fig.2), irradiation 40 KV, 45 min.
B: X-ray photograph of a molar with replacement teeth, irradiation 40 KV, 60 min.

The multiple-crown core teeth of the sperm whales have a shape comparable to the one which Kükenthal (1889) discovered in embryos of baleen whales (Mysticeti). The thick layer of enamel covering the dominant and multiple-crown teeth is comparable to the thick enamel cover of the milk-teeth in mammals.

The determination of age in toothed whales by means of the growth-rings of the teeth is not possible. The teeth of bottlenose dolphins, in captivity for a long period, do not form any further growth-rings from the moment of their captivity. The formation of growth-rings depends upon diet or significant events in the life cycle, as confirmed by Albert *et al.* (1988) who studied a captive killer whale.

How does the homodontal set of teeth of the recent whales originate? The multiple crowned teeth of mammals arise from cone-like teeth of reptiles through unification of embronic teeth (Stark, 1982). The ontogeny of the sperm whale teeth shows all transitional stages from reptile to mammal. The ancient archaeocetes possessed a homodontal set of teeth. At times when ichthyosaurians controlled the sea, the ancestors of the archaeocetes went on land, became mammals, and developed smaller jaws. With the reduction of the jaws, the tooth buds united and multiple crown teeth developed; the heterodontal set of teeth of the archaeocetes came into being. After the disappearance of the ichthyosaurians, the archaeocetes returned into the sea. The adaptation to life in the sea and to seafood caused the jaws to lengthen and thus gave room for more embryonic teeth; the homodontal set of teeth appeared again.

When more embryonic teeth were formed, more teeth grew out, but many embryonic teeth remained. As these relics can be restored if teeth find a place, sets developed with more than 280 teeth such as in the common dolphin.

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WAVELET TRANSFORMS FOR FLUKE TRAILING EDGE REPRESENTATION

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The objective of this study was to find a mathematical representation for trailing edge contours of sperm whale flukes, enabling digital storage and, based on this, to develop an automated search algorithm to identify individual whales from their trailing edge contours.

Andenes Whale Centre, Norway, provided photographs of sperm whale flukes, which were digitised. Using Matlab routines, the background was filtered out and the contour was normalised to account for deformations in the photograph. The resulting one-dimensional signal was transformed into its wavelet coefficients, which were to conclude if two contours were, or were not, from the same individual. A high percentage of matching contours could be achieved.

The existing methods for automated photo-identification, as described by Hiby and Lovell (1990), Mizroch *et al.* (1990) and Whitehead (1990) are obviously adequate for the purpose that they were designed for. However, to enable long-term comparisons or to communicate contours over the internet, data representation methods, which do not lose information, seem to be preferable.

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NON-SPECIFIC EPIDERMAL STRUCTURES IN THE SKIN OF COMMON DOLPHINS (*DELPHINUS DELPHIS*)

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The round-shaped structures, described by Khadzhinsky (1972) from the skin of three Black Sea cetacean species, were classified as epidermal "pearls". New data for these "pearl" distributions in common dolphin skin were obtained. "Pearl" distribution was not restricted, as previously suggested, to the anterior of the rostrum and between the axilla and anal slit. "Pearls" were found on the melon and the flukes of Black Sea common dolphins. "Pearl" density, size, shape and structural features were highly variable. As a rule, they were localised in the stratum intermedium over the tips of dermal papillae.

In several cases, the location of "pearls" coincided with dermal ridges. Apart from this exception, the location of the "pearls" was irregular. Taking into account the random nature of "pearl" distribution in dolphin epidermis and the wide variability of their morphological characteristics, it could be assumed that these "pearls" have a minimal influence upon the hydrodynamics of dolphin skin. These structures could be the result of a mechanical influence of water flow upon dolphin skin.

CYSTS OF THE THYMUS GLAND IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM GERMAN AND GREENLANDIC WATERS

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In the context of the examination of the causes of death of harbour porpoises from the German Baltic and North Seas between 1991 and 1996, about 100 thymus glands were examined histologically. Furthermore, the thymus glands of 14 harbour porpoises originating from Greenlandic waters were investigated.

Macroscopic cysts of the thymus glands were only found in animals more than seven years old from German waters. There was no sex preference. The cysts were always multiple, usually spherical, and measured up to 4 cm. They were lined by a single layer of cytokeratin-positive flat epithelium and were filled with gelatinous opaque material.

Microcysts of the thymus were detected in animals of both groups. These cysts were observed in your animals being weaned, but were more frequent in adolscent individuals, without any sex preference. Microcysts were located in the periphery of the thymus lobes and consisted of narrow irregular spaces. They were lined at least partially by a single layer of cubic or high columnar cytokeratin-positive epithelium, and sometimes contained cells and small amounts of a globoid eosinophilic material.

Furthermore, cysts of the thyroid gland were observed in two harbour porpoises. The genesis and importance of cysts of the thymus glands is unknown.

GENETICS

GENETIC STUDIES IN HARBOUR PORPOISES FROM THE NORTH AND THE BALTIC SEAS USING RAPD MARKERS

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INTRODUCTION AND BACKGROUND This paper gives a brief report on our studies on population genetics in harbour porpoises. The aim of these studies was an investigation into whether the porpoises living in German waters of the North and the Baltic Seas represent two different stocks and to what amount gene flow occurs between these two regions. A previous study made use of sequencing the mitochondrial genome (Tiedemann *et al.*, 1996). Here, we apply the RAPD-PCR-method (Williams *et al.*, 1990). Both studies were essentially performed on the same samples.

As in other regions, harbour porpoises in German waters suffer a high mortality. Conservation management of this, as with any other species, should consider genetic variability within the species (Greig, 1979). For this and other reasons, knowledge of this variability and of the possible existence of sub-populations and ecotypes seems to be of outstanding importance.

There is anecdotal evidence for migrations of porpoises from the Baltic into the North Sea during the winter months and in the opposite direction during spring (Kinze, 1985; Schulze, 1996) and thus gene flow may occur between these regions. Kinze (1985) compared morphological characteristics in porpoises from different sites in the North Sea, including Skagerrak, and from the Baltic, including Kattegat. He observed highly significant differences between specimens from the Baltic and the Dutch coast, and suggested the existence of a separate Baltic population. Skulls sampled during the winter in the northern North Sea showed a great affinity to samples from the Baltic, and a complex mixing of porpoises from different areas, mainly from the Baltic, was thought to occur during the winter in the northern North Sea. Börjesson and Berggren (1996) were able to distinguish porpoises from the Swedish Baltic and Kattegat/Skagerrak morphometrically. Andersen (1993) studied the population structure of porpoises from the inner Danish waters and the North Sea using isozyme electrophoresis. She observed an effect of season and locality on the genotypic distribution. A significant difference was found between samples collected in summer from the inner Danish waters and the North Sea. More recently, however, based on DNA-microsatellites Andersen *et al.* (1995) were not able to differentiate between porpoises from these two regions.

In RFLP studies on mitochondrial DNA, Wang and Berggren (1997) analysed porpoises from the Baltic, the Kattegat/Skagerrak Seas and off the west coast of Norway. Pair-wise comparisons of frequency distributions revealed only marginal differences (i.e., $p = 0.1$). They suggested the use of techniques with a higher resolution, such as sequencing the control region of mtDNA. This was done by Tiedemann *et al.* (1996) on samples from the Baltic and North Sea coasts of Schleswig-Holstein. They identified nine distinct mitochondrial haplotypes. Based on sequence similarity, the genotypes could be arranged in two clusters: A and B. Genotypes belonging to cluster B did not occur in the Baltic. With the exception of one all cluster A haplotypes were detected in the North and the Baltic Seas. Genetic variation in terms of nucleotide and genotype diversities were much lower in the Baltic than in the North Sea samples. Haplotype composition and nucleotide divergences suggest a colonisation of the Baltic Sea several thousand years ago and a limited genetic exchange since then. Since mitochondrial DNA is inherited maternally, gene flow mediated by migrating males remains undetected. Both male and female mediated geneflow can be detected when genetic variation of nuclear DNA is considered. Therefore, in order to include the male mediated gene flow between the North and the Baltic Sea, this study utilised the RAPD-PCR technique.

MATERIALS AND METHODS The term RAPD (Random Amplified Polymorphic DNA) denominates a genetic marker system, which combines the properties of PCR (Polymerase Chain Reaction) and DNA-fingerprinting. The RAPD-PCR follows the principles of a usual PCR. Instead of a specific target sequence, DNA fragments randomly distributed in the nuclear genome are amplified. Therefore, primers with randomly chosen sequences are used. Compared to usual PCR-primers, RAPD-primers are shorter, thereby increasing the probability for the existence of several binding sites having different distances from each other. Since the segments between two binding sites are copied, this results in amplification products of different sizes. These products are separated on agarose gels electrophoretically and are visualised with ethidiumbromide in UV-light as bands. Some amplification products are present in some individuals but absent in others. They represent the polymorphisms that serve as genetic markers. Usually the RAPD is performed using several primers which are commercially available. Reaction conditions have to be optimised for each primer-genome combination in order to get reproducible banding patterns.

The absence and presence of each polymorphic band was examined to measure genetic differences between pairs of porpoises. Differences were estimated by determining the fraction of mismatches (both present or absent bands) in all pair-wise comparisons.

To detect possible genetic sub-structuring between the two regions the program AMOVA (Excoffier *et al.*, 1993) was used. This program calculates variance components within and among regions based on both the genetic differences between the specimens sampled and the geographic distribution of genotypes.

This study utilised both skin and liver tissue samples, which had been taken from stranded or by-caught harbour porpoises in the study regions.

RESULTS AND DISCUSSION At present, this paper can only present the preliminary results from these studies. As a first step, 60 primers (Operon Technologies, Alameda, California) were screened for delivering polymorphic banding patterns in each four animals of the two regions. Seven of these primers showed clearly distinguishable polymorphisms. These were reproducible in several incubations using different concentrations of sample DNA. In accord with other publications, this should allow a reliable evaluation. So far, RAPD analyses have been performed with the primers GHO-2 and OPA-9. On 72 samples, 24 from the Baltic Sea and 48 from the North Sea, banding-patterns capable of evaluation were obtained. Five polymorphic bands were subjected to statistical analyses.

Genetic variation was higher in the sample from the North Sea than from the Baltic (sum of squares: 37.98 and 12.19, respectively), which accords with the findings on mitochondrial DNA. But our analyses showed that less than 1% of the existing variability was due to differences between the regions. In other words, these results, based on the findings with the two primers, do not allow the genetic separation of porpoises from the Baltic and the North Sea. Although these results comment upon only preliminary data, they do support other studies which have demonstrated low levels of differentiation with nuclear markers, whereas a high degree of isolation is suggested by studies investigating mitochondrial DNA. In humpback whales from the central and northeastern North Atlantic, Larsen *et al.* (1996) noted genetic separation between localities in mitochondrial DNA but not in the nuclear genome. A recalculation of the sequence data of Tiedemann *et al.* (1996) using the same method of calculation as in our study showed that 20.55% of the variability in mitochondrial characters are due to differences among the regions (Tiedemann, pers. comm.). Comparing the results of the two studies, the genetic homogeneity in nuclear RAPD-markers might be explained by a potentially high degree of male dispersal behaviour, whereas the strong differentiation in maternally-inherited mitochondrial DNA could be the result of female site fidelity.

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ARE BALTIC HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) GENETICALLY ISOLATED?

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Since the Baltic Sea in its present appearance as a brackish sea was formed only about 8,000 years ago, its colonisation by harbour porpoises certainly took place after the last glaciation. A seasonal migration of Baltic harbour porpoises out of the area in winter is known from historical records. However, recent findings on skull characteristics, allozymes, and mitochondrial DNA suggest the existence of a separate Baltic population of harbour porpoises, though these marker systems do not necessarily provide an unbiased estimate of gene flow: firstly, phenotypic differentiation in morphology or allozymes may be either adaptive or linked to adaptive characteristics, hence promoting differentiation and under-estimating gene flow; secondly, mitochondrial DNA only reflects maternal lineage and may thus be unsuitable to precisely determine amounts of gene flow through migrating males.

In this framework, a stochastic, individuum-based simulation model was developed to examine the impact of definite migration schemes on levels of both nuclear and mitochondrial genetic variation. The model estimates the amount of sex-specific migration into and out of the Baltic Sea, which may be underlying the genetic separation reported for allozyme and mitochondrial marker systems. It aims at providing further evidence on the status of the Baltic harbour porpoise population.

PATHOLOGY & MEDICINE

MASS STRANDING OF SPERM WHALES AT RØMØ IN THE DANISH PART OF THE WADDEN SEA AND REVIEW OF DANISH SPERM WHALE STRANDINGS 1572-1996

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The circumstances of a mass stranding of 16 young sperm whales (*Physeter macrocephalus*) on 27 March 1996 between the islands of Romø and Manø in the Danish part of the Waddensea are reported. All animals were young sexually mature bulls, ranging in length from 1,175 cm to 1,320 cm with a mean of 1,262.5 cm (SD 43.7) and in age, from dentinal GLGs in mandibular teeth, from 20-34 years (GLGs) with mean of 23.75 yrs (SD 3.58).

Included in the Romø stranding, information on 54 Danish sperm whale specimens representing 27 stranding incidenta for the period 1572 to 1996 were compiled. All of them were males. 63% (34 of 54 individuals) were involved in mass strandings, and 88% of them (30 of 34 individuals) occurred in the Waddensea. Most strandings occurred in the months November through March (90%, 43 of 48 individuals).

DISEASES, PARASITES AND INCIDENTAL LESIONS IN SMALL CETACEANS IN IRISH COASTAL WATERS

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A study is currently in progress to examine the health status of small cetaceans in Irish waters. Thirty animals were collected for post-mortem examination between July 1995 and December 1996.

Of the thirty animals recovered, nine were harbour porpoises (*Phocoena phocoena*), nine were common dolphins (*Delphinus delphis*), seven were striped dolphins (*Stenella coeruleoalba*), three were Risso's dolphins (*Grampus griseus*), one was a white-beaked dolphin (*Lagenorhynchus albirostris*), one a white-sided dolphin (*Lagenorhynchus acutus*) and one a long-finned pilot whale (*Globicephala melas*).

Standard post-mortem examination procedures were carried out on all animals, with tissues sampled for histology, contaminants and genetic studies. The animals were measured, sexed, aged, and reproductive condition and diet evaluated.

A variety of parasites were found, including: *Anisakis* sp., *Monorygma* sp., *Crassicauda* sp., *Pseudalius* sp., *Stenurus* sp., *Halocercus* sp., and various other cestodes and trematodes which were not identified.

Pathological findings included: pneumonia, a fractured jaw, stomach ulcers, skin lesions, malnutrition and cachexia, dystocia and gastric ulceraton.

EVIDENCE FOR MORBILLIVIRUS INFECTION IN DUSKY, BOTTLENOSE AND LONG-BEAKED COMMON DOLPHINS FROM THE EASTERN PACIFIC

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Between 1990-92 a dolphin morbillivirus (DMV) killed several thousands of Mediterranean striped dolphins (*Stenella coeruleoalba*). Since then, serological, immunohistochemical and molecular studies have shown that DMV, or closely related viruses, commonly infects many other species of odontocetes and mysticetes from the North Atlantic.

This report covers the detection of morbillivirus-specific antibodies in serum samples from Peruvian dusky dolphins (*Lagenorhychus obscurus*), offshore bottlenose dolphins (*Tursiops truncatus*), and long-beaked common dolphins (*Delphinus capensis*) by indirect ELISA and/or virus neutralisation assays. The sera from six dusky dolphins, one common dolphin and three bottlenose dolphins were positive on a coat of DMV antigen in the iELISA. Several of these sera were also positive when tested against *peste des petits* ruminants and rinderpest virus antigen.

Porpoise morbillivirus (closely related or identical to DMV) and/or DMV neutralising antibodies were detected in the sera of two bottlenose and three dusky dolphins which reacted positively with DMV antigen in iELISA and also in the serum of a common dolphin which was negative in the iELISA.

These results strongly suggest that a virus closely related, or identical to, the cetacean morbilliviruses present in Atlantic waters infects several species of Delphinidae from the south-east Pacific. It is hypothesised that the disease may be less severe in these species and/or that the virus has constituted an enzootic infection for some time.

HEAVY METAL CONCENTRATIONS IN SOME ORGANS OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) OFF THE WESTERN ALGERIAN COAST

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The level of heavy metal contamination in Algerian waters is not well known, although some scattered studies have been conducted on marine organisms. Cetaceans are found at the top of the marine food chain. Therefore, studying heavy metal concentrations in cetacean tissues will provide information on marine contamination in a given area, the bio-accumulative nature of given metals and, finally, will show the expected risk to humans of such metals in the marine environment.

Six by-caught and stranded common dolphins from the western Algerian coast, obtained between 1990 and 1995, were analysed in this study. The concentrations of iron, lead and nickel in the liver, kidney, stomach, intestine and blubber of these six animals was determined by atomic absorption spectrophotometry.

The levels of the examined metals were higher in the liver than in other tissues, except the concentration of iron in the kidneys, which was higher than the levels noted in the liver.

The results suggest that the western Algerian coast is less contaminated with heavy metals when compared with some coastal regions of industrialised countries such as France and Japan.

BIOACCUMULATION OF SELECTED TRACE METALS IN LUNG NEMATODES (*PSEUDALIS INFLEXUS*) OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) IN THE POLISH ZONE OF THE BALTIC SEA

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Parasites of marine mammals are expected to be a very sensitive biomonitor for metallic toxic chemicals in the marine environment. Harbour porpoise (*Phocoena phocoena*), although still an extremely rare species in the Polish zone of the Baltic Sea, has been observed rather more frequently over the last fifteen years, especially in the Gulf of Gdansk. Four species of nematode have been identified in the lungs of harbour porpoises from the Baltic Sea, namely *Pseudalius inflexus*, *Torynurus convolutus*, *Halocercus invaginatus* and *Stenurus minor.*

Eight specimens of harbour porpoise were caught incidentally in salmon gill nets in a coastal region of the Polish zone of the Baltic Sea between March 1993 and October 1995. Concentrations of Cd, Cu, Zn, Pb, Ag, Cr, Co, Ni, Mn and Fe were determined by the AAS method. The quality of the method used was checked and confirmed in a separate comparative study of metals in a standard reference material.

Concentrations of Zn, Cu and Mn in lung samples analysed in the present studies are very similar to those reported earlier for twelve specimens of harbour porpoise collected from the same area between March 1989 and February 1993. Lung tissue of the eight specimens presently studied contained on average 0.03 mg Cd g^{-1} and 0.30 mg Pb g^{-1} dry weight; lung concentrations of both metals in the specimens analysed previously were below the detection of the method used. There are significant differences in concentrations of selected metals such as Cd, Cu, Zn, Cr, Ni, Co, Mn and Fe in the lung nematode *P. inflexus* and its host lung.

It is well-documented that concentrations of Cu, Cr, Ni, Pb, Fe and especially Zn are significantly greater than those in a host lung. Concentration of Co in all cases and Ni in some cases in both the nematode and lung samples were below the detection limit of the method used. Concentrations of Zn, Cu, Mn and Cr in *P. inflexus* were respectively one order and two orders of magnitude greater than in tongue.

Inter-specimen differences in metal concentrations were also observed, mainly concerning parasite levels of Pb, Cd, Cu, Cr, Ni, Mn and Fe. In order to estimate this more quantitatively, concentration factors (CF), discrimination factors (DF), and correlation coefficients (r) were computed. It is evident that selected metals are mostly bio-accumulated in nematodes in respect to the host lung, showing inter-specimen variations.

TRACE ELEMENTS IN BLACK SEA DOLPHINS AND POSSIBLE ROLE OF GLUTATHIONE AS A DETOXIFICATION MECHANISM

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Preliminary analysis on a wide range of tissues of two common dolphins *Delphinus delphis* stranded on the Black Sea coast were analysed for trace metals and organochlorine compounds. Concentrations of Cd, Zn, Cu, Ni, Fe, Cr and Pb, total and organic Hg were 'normal' when compared with common dolphins from the North Atlantic (for Hg after standardisation for length/age) but low when compared with values found for *Stenella* from the neighbouring Mediterranean Sea. The age-linked accumulation pattern for inorganic Hg in liver, resulting from a demethylation process involving selenium (review in Cuvin-Aralar & Furness, 1991; Palmisano *et al.*, 1995) entirely fits into the North Atlantic *Delphinus* population pattern (Fig. 1).

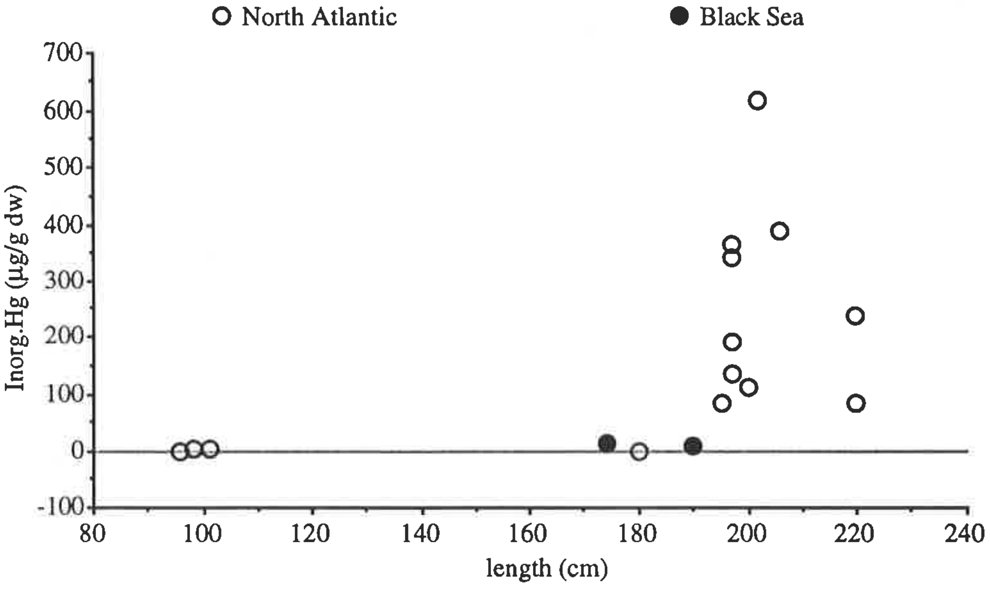

Figure 1 Inorganic mercury in Black Sea common dolphin liver tissue compared to concs. found in the North Atlantic population (Holsbeek *et al.*, in prep); Hg (µg/g dw) as a function of length (relation age/length only up to 190-95 cm = 7-8 years old).

Relatively low levels of heavy metals might be influenced by the anoxic character of the lower Black Sea water masses resulting in high concentrations of suspended trace metals (Haraldsson & Westerlund, 1988). At a population ecology level, such low levels of trace metals in Black Sea common dolphins would indicate that no seasonal migration through the Bosphorus is taken place.

Total PCB concentrations were low when compared with concentrations found in the Mediterranean. However, extremely high levels of op'DEE were detected (up to 600 µg/g dw) compared with dolphins from the North-East Atlantic, and to a lesser extent even from the Mediterranean. The concentration of ppDDT was below detection limit (3 µg/g dw) in all tissues, indicating that the high levels do not result from a recent input. These results are in good agreement with elevated data on ΣEDDTs in Black Sea fish (up to 5 µg/g on a fw basis) as described by Serbanescu *et al.* (1980).

Table 1 Heavy metals and organochlorines (µg/ g dw) in Black Sea common dolphin liver tissue compared to concentrations found in Mediterranean and North-East Atlantic dolphins: 1. André et al., 1991; 2. Alzieu & Duguy, 1978; 3. Holsbeek *et al.*, submitted; 4 unpubl. data laboratory Ecotoxicology VUB.

	Black Sea ***D.delphis***	**Mediterranean** ***S.coeruleoalba***	**North Atlantic** ***D.delphis***
ΣHg	10	40 to 4500 (1)	10 to 600 (3)
Total PCB	10	10 to 450 (2)	< 5 (4)
ΣDDT	max. 600	4 to 470 (2)	< 2 (4)

Glutathione and detoxification Preliminary tests were conducted to investigate whether or not glutathione (GSH) is a likely candidate in the mechanisms of detoxification of heavy metals in marine mammals. The Ellmann method (Elskens *et al.*, 1991) used to determine GSH in liver, kidney and muscle of dolphins was proven to be highly reproducible. For all tissues, increasing levels of 'free' GSH were found to be linked to an increase of non-essential metals. No relation was found with concentrations of essential metals. This finding indicates that increasing levels of non-essential metals would trigger the production of GSH in all tissues as a step towards detoxification.

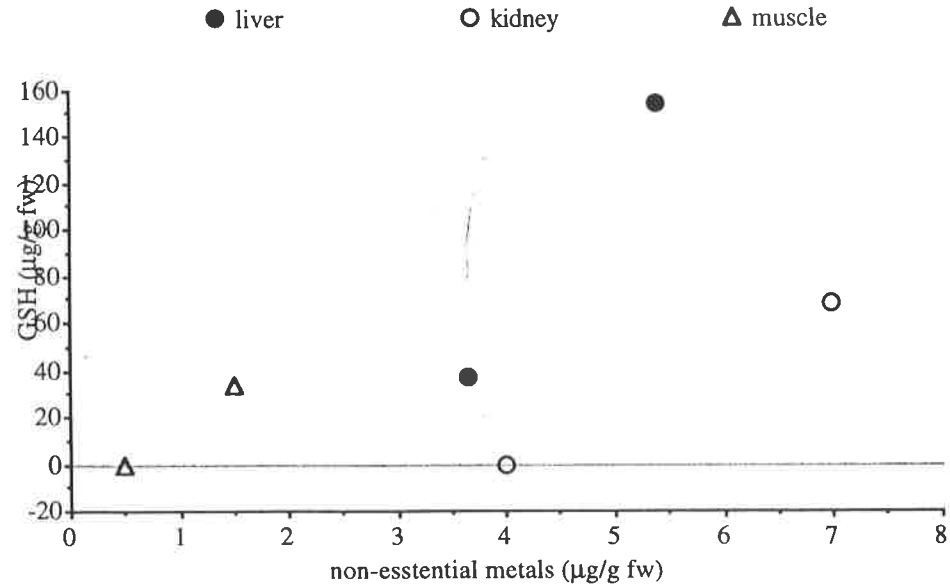

Figure 2 Glutathione levels (5g/ g fw) in liver, kidney and muscle as a function of total non-essential metal concentrations (5g/ g fw)

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ACCUMULATION OF ORGANOCHLORINE COMPOUNDS IN TISSUES OF COMMON DOLPHIN (*DELPHINUS DELPHIS*) IN ALGERIAN WATERS

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Pollution by organochloric compounds has not been evaluated in Algerian waters. Very few studies have been conducted in this field using marine invertebrate organisms. Cetaceans, as top predators, represent a good indicator of marine pollution, particularly by bioaccumulating pollutants.

This is the first study in Algeria using marine mammals as biological indicators of pollution by organochloric compounds. The study was carried out on four stranded common dolphins and two animals captured in fishing nets off the western Algerian coast.

Concentrations of total DDT, total HCH and PCBs have been determined in the tissues of different organs (blubber, liver, muscle, kidney and stomach) of the six animals studied. Analysis was done using a gas chromatograph equipped with an electron capture detector and capillary column.

Common dolphins biologically accumulated PCBs and DDT more than HCH. Immature animals showed higher levels of the organochloric compounds than adults. The average concentration of DDT, PCBs and HCH approached its highest levels in the tissues of striped dolphin and common dolphin on the northern shores of the Mediterranean Sea.

The results show the degree of marine pollution by these pollutants and their expected detrimental impact on the marine ecosystem and, consequently, upon the main exploiter - mankind.

CHLORINATED CONTAMINANTS IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE GERMAN NORTH AND BALTIC SEAS AND OFF THE WEST COAST OF GREENLAND

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INTRODUCTION Harbour porpoises are the most common cetaceans in the German North and Baltic Sea. Their population size has declined during the last decades. Besides the accidental catch, depletion of food sources and disturbance by marine traffic, organic contaminants are discussed as a possible reason for their decreasing numbers (Reijnders, 1992). Organochlorines such as CB and members of the DDT family are ubiquitous anthropogenic environmental contaminants. Due to their lipophilicity and persistence, they accumulate in the fatty tissues of marine mammals. These contaminants are supposed to be partly responsible for reproductive and immunological abnormalities in marine mammal populations (Helle, 1976; de Swart *et al.*, 1994).

The harbour porpoise populations from the North and Baltic Seas are assumed to be two separate stocks. Results on morphometric skull analysis by Kinze (1990) and mitochondrial DNA sequence pattern by Tiedemann and co-workers (1996) support this theory. Data about contaminant levels and compositions can also be helpful for locating marine mammal populations.

One aim of our work was to obtain an actual data set of toxicologically important contaminants in harbour porpoises from the German North and Baltic Seas and off the west coast of Greenland. Another aim was to check whether the North and Baltic Sea populations could be distinguished as separate stocks on the basis of contaminant levels and patterns.

MATERIALS AND METHODS 48 chlorobiphenyls and the chlorinated pesticides HCB, p,p´-DDE, -DDD, -DDT, α- and γ-HCH have been analysed in blubber samples of harbour porpoises from the German North (n = 12) and Baltic Seas (n = 19) and off the west coast of Greenland (n = 6) (different ages and sex). Data (on a lipid weight basis) were derived by extraction of the samples with n-hexane, clean-up with alumina and HPLC and measurements by single and multidimensional GC-ECD.

RESULTS AND DISCUSSION The $\sum$CB, HCB, α- and γ-HCH levels are similar in subadult harbour porpoises from the North (n = 11) and Baltic Seas (n = 18), whereas the p,p´-DDE and -DDD levels are significantly higher in the latter animals (Table 1). The subadult porpoises from West Greenland (n = 4) have lower $\sum$CB and γ-HCH, similar HCB, p,p´-DDE and-DDD contents than the North Sea animals and the highest a-HCH of all animals investigated. p,p´-DDT could only be detected in the arctic samples.

The CB patterns differ significantly between the three areas (Fig. 1): The Greenland harbour porpoises possess for example higher mol.% values of lower chlorinated CB like CB 52, 95, 66, 92, 101 than the North Sea and Baltic Sea animals. Clear differences between the Baltic and North Sea animals are visible concerning, for example, CB 74, 177, 180 and 187. The major contributors in all regions are CB 153, 138, 149.

The obvious differences between arctic animals on the one side and Baltic and North Sea animals on the other could be explained by various factors:

Table 1 $\sum$CB and pesticide levels in blubber samples of subadult harbour porpoises from the North Sea, Baltic Sea and off the west coast of Greenland (pmol/g lipid)

	North Sea			Baltic Sea			Greenland		
	n	median	min - max	n	median	min - max	n	median	min - max
$\sum$CB	11	47615	12710-108457	18	41846	15754-108504	4	3736	2520-4390
HCB	11	672	340-1867	17	1161	483-3246	4	465	233-626
DDE	11	4459	1860-8995	18	14946	5368-37401	4	2448	1687-2843
DDD	10	1210	19-5192	14	6056	12-18428	4	887	673-1406
DDT	10	< 5.25		14	< 5.25		4	870	543-1070
α- HCH	10	< 0.76	< 0.76-67	14	1	< 0.76-221	4	151	70-473
γ- HCH	10	1333	385-4608	14	1966	385-6562	4	51	34-188
$\sum$DDT/$\sum$CB	10	0.12	0.07-0.43	14	0.52	0.29-0.73	4	1.17	1.00-1.32

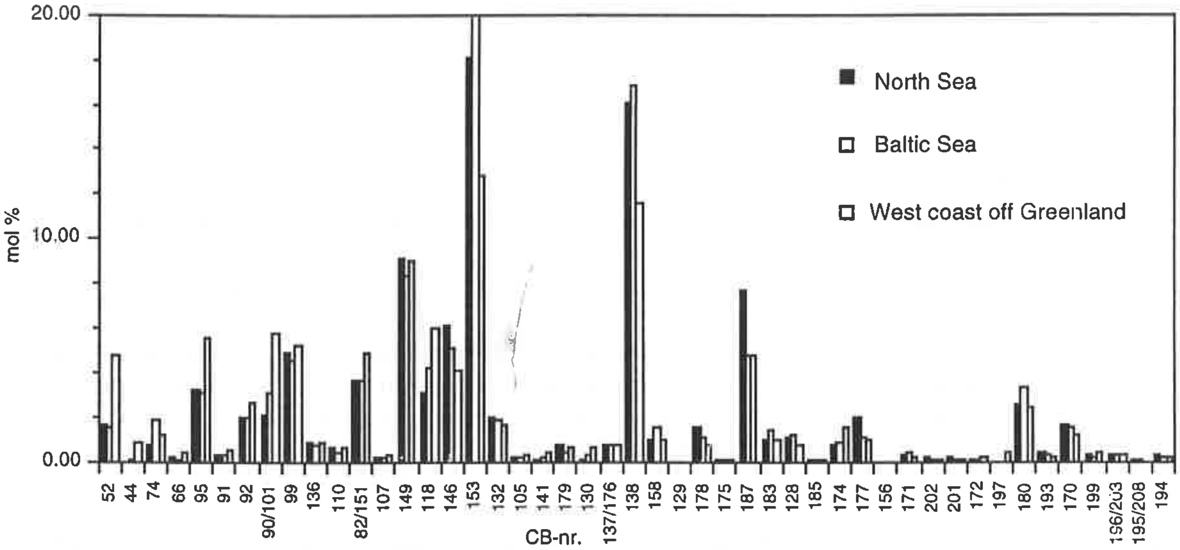

Fig. 1: CB pattern (median of the mol%) in blubber samples of subadult (male and female) and adult (male) harbour porpoises of the North Sea, Baltic Sea and off the west coast of Greenland.

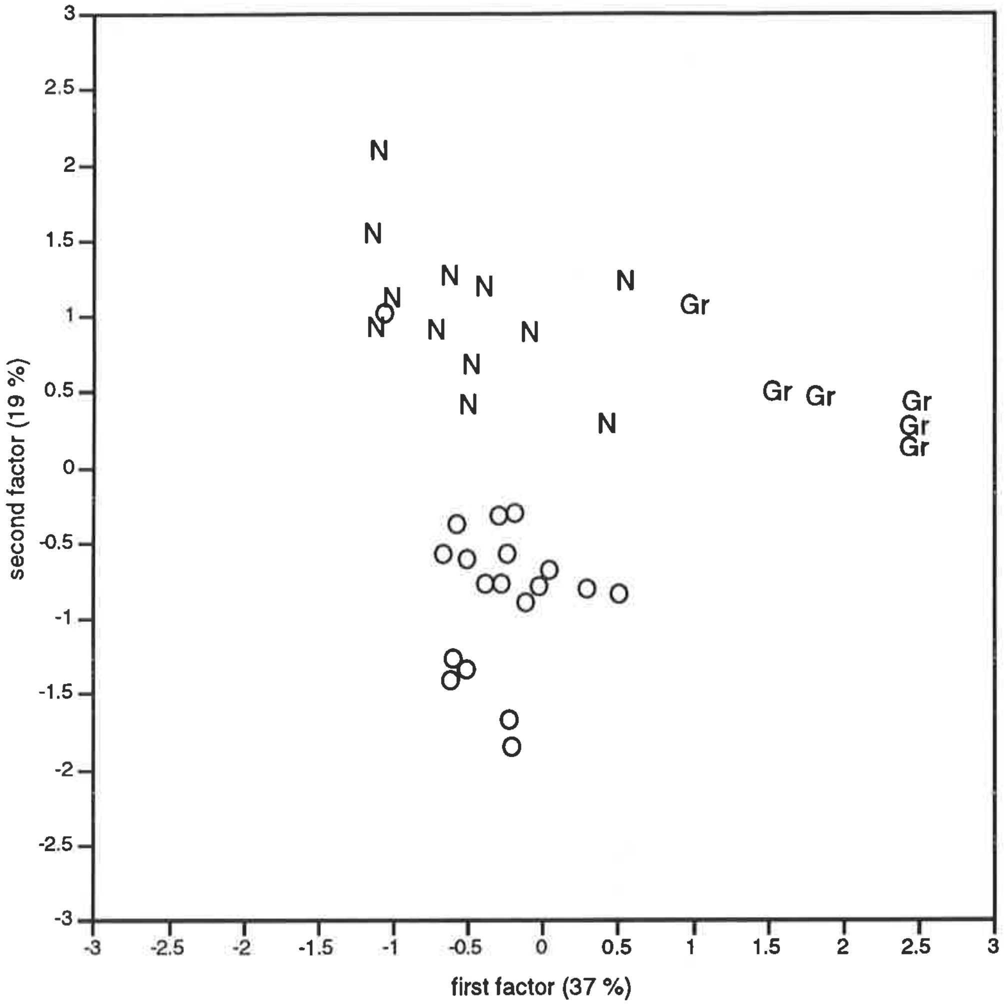

Fig. 2 Results of a principal component analysis (scores) of significantly different CB-mol% values in blubber samples of subadult (male and female) and adult (male) harbour porpoises of the North Sea (N), Baltic Sea (B) and of the west coast of Greenland (Gr).

The mol.% values were tested by analysis of variance (Kruskal-Wallis test). On average, 30 congeners differ significantly between the regions. To elucidate the variations, a principal components analysis was performed with these statistically different congeners. The results are presented as a plot of the scores (the samples). As shown in Fig. 2, the three regions can be distinguished as separate groups. One exception is noticeable: a Baltic animal, an old male with high contaminant burdens, lies within the North Sea group. The CB pattern of this animal was possibly affected by an increased CB metabolism due to a concentration-dependent mechanism. Furthermore, the $\Sigma DDT/\Sigma CB$ values are significantly different between the regions (Table 1). These results confirm the previous assumption that the North and Baltic Sea populations are indeed separate.

ACKNOWLEDGEMENTS The work has been undertaken within the framework of the project "Investigations on small cetaceans as a basis of a monitoring program" (03F0139A) financed by the federal Ministry of Education, Science, Research and Technology. Thanks to the co-workers of the small cetacean project especially to Ursula Siebert and Ralph Tiedemann. Mads-Peter Heide-Jørgensen and Jette Jensen of the Greenland Institute of National Resources, Copenhagen, are kindly acknowledged for the samples of the arctic harbour porpoises.

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A COMPARISON OF EPIDERMAL DISEASE IN EIGHT POPULATIONS OF BOTTLENOSE DOLPHINS

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Bottlenose dolphins (*Tursiops truncatus*) resident in the Moray Firth, NE Scotland, display a variety of skin lesions which appear to be signs of disease, the cause of which is unknown. To investigate whether these features are unusual in bottlenose dolphins, the appearance, prevalence, and severity of lesions in seven other geographically separated populations were compared.

Samples of photo-identification pictures were drawn from studies of populations off Croatia, England, France, Portugal, Scotland, Wales, and the United States. Pictures were examined, the presence or absence of lesions scored, and the area of the dorsal fin that was covered by lesions measured by digitising the projected image.

Lesions occurred in all populations, but took a variety of forms. Some types were universal whilst others were localised, only occurring in one or two adjacent populations. Overall, those animals using the Moray Firth had the highest percentage of skin covered by lesions (median level of 5%) whilst those living in the Gulf of Mexico had the lowest (0.3%).

This work was funded by the UK's Ministry of Agriculture, Fisheries and Food and the Department of the Environment. Financial assistance with travel between sites was provided by The Royal Society, London.

EPIDERMAL LESIONS ON FREE-RANGING BOTTLENOSE DOLPHINS IN THE KVARNERIC (NORTHERN ADRIATIC SEA)

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INTRODUCTION Coastal cetaceans are exposed to a variety of anthropogenic activities (including pollution). By reducing immune function, it is feared that these factors may lead to elevated levels of natural disease. In 1992, Thompson and Hammond suggested that photo-identification pictures might be used to study epidermal disease in free-ranging cetaceans. In this investigation, data from a long term photo-identification study (1987-96) were used to document the appearance and prevalence of epidermal lesions, injuries, and deformities in a population of bottlenose dolphins (*Tursiops truncatus*) from the Kvarnenic (Northern Adriatic Sea).

METHODS AND RESULTS Colour transparency photo-identification pictures of approximately 130 dolphins from all years of the study were used to describe epidermal lesions, injury and deformity types present in the population. A representative sub-sample of pictures (June and July 1993) was used to calculate the prevalence and, where applicable, area of skin covered by each lesion, injury and deformation type in the population. Only high quality photographs were used. For lesions and injuries, only the skin of the dorsal fin was considered.

Lesions were common. Fourteen types were defined of which one or more occurred on 74% of individuals. The most frequent type ("pale lesions") covered up to 32% of a dolphin's skin and occurred on 58% of individuals. For all lesions together, the median level of skin coverage was 0.6%, whilst the skin of the most affected individual had 37% coverage. Injuries were also common. Fin nicks occurred on 85% of animals and rakes on 89%. Deformities were rare, being seen occasionally in the population and were absent from the sample taken.

Results from this study provide base-line information on epidermal condition in a population of Adriatic dolphins. These data also permit comparison with other populations, and may help indicate links between environmental variables and epidermal disease.

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THE SEASONAL DYNAMICS OF ALGAL VEGETATION IN KARADAG DOLPHINARIUM

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INTRODUCTION Microphytic algal vegetation can be an important factor in the formation of artificial ecosystems. A number of specific features relating to dolphinaria (such as limited water scope, frequent sanitary treatments, temperature and lighting levels, etc) create the characteristic algocenosis composition. This biological system includes some typical species and food web interactions with other microalgae, seaweeds, invertebrates, and cetaceans. The integrated investigations were conducted in Karadag dolphinarium (Eastern Crimea) over a period of several years. They elucidated the distinctions between the composition of different ecological groups and typical features of dolphinaria algal vegetation (Gol'din, 1996a), anthropogenic influences (Gol'din, 1994), microalgal skin growths upon bottlenose dolphins and their ecological role (Gol'din and Plebansky, 1992; Gol'din, 1996b), specific features of skin-settling algae, and their differences with the common fouling species in pools (Gol'din, 1995). However, we have never discussed any aspects of seasonal dynamics in dolphinaria algocenosis, and yet this is one of the most essential components of this particular ecosystem. This contribution presents some results in this particular subject area.

MATERIALS AND METHODS In the course of inspections, 330 algal samples were collected from water (86), dolphin skin (89), pool walls, metal and wood constructions (130) and the adjoining sea area (22). This material was fixed with 70% ethanol or weak formalin solution, or in Gol'dberg medium. It was then sown, identified, and analysed. The rates of occurrence (%) were calculated in the following way. The ratio of the number of samples containing a particular species to the number inspected was taken to represent the frequency of occurrence rate (FOR). The temporary frequency of occurrence rate (TFOR) is the ratio of the species detected in certain time periods to the sample as a whole. This method allows one to compare and analyse our data with those from other authors (for example, Kustenko, 1991).

RESULTS 62 species of algae have been isolated from planktonic and benthic samples and specimens scraped from the skin of dolphins. They belonged to Bacillariophyta (53), Dinophyta (2), Chlorophyta (4) and Cyanophyta (3) groups (Table 1). The diatom genera *Nitzschia*, *Amphora*, *Licmophora*, *Navicula*, *Synedra*, *Cocconeis*, *Achnantes*, etc, have the greatest diversity among pool inhabitants.

The distribution of algal species is very heterogeneous during the calendar year and depends upon the season. We have therefore observed the higher specific diversity in spring months: March (24), April (30) and May (27). It declines to some extent in summer: June (18) and July (18), but the lowest rates were in October (6) and December (8). After that, a rise in the species number occurred in January (15). Among diatoms, *Nitzschia hybrida f. hyalina* dominated throughout the year, and was the most abundant and wide-ranging species. Others had more limited distributions.

During spring and summer, various *Licmophora* species, *Amphora terroris*, and some *Nitzschia* - *N. delicatissima*, *N. rupestris*, etc, could be found together. In April, *Licmophora flabellata*, *Licmophora* sp. and *Cymbella* sp., as well as *Nitzschia tenuirostris*, *N. longissima*, *Pleurosigma elongatum*, *Navicula halophila*, *Navicula* sp., *Amphora* sp., *Achnanthes longipes*, and *Ulothrix* sp. had a mass propagation period. There were a lot of *Nitzschia seriata* cells in May and almost as many *Striatella unipunctata* and *Grammatophora marina*, with rather fewer *Licmophora Ehrenbergii*, *Navicula* sp., *Amphora* sp. and *Melosira moniliformis*. The mass propagation of

Table 1 Microphytic algae in Karadag dolphinarium

SPECIES OF ALGAE	**LOCALISATION & PHENOLOGY**
BACILLARIOPHYTA	
Achnanthes brevipes Ag.	pw,12
A. longipes Ag.	pw,3,4,12.
Achnanthes sp.	pw,1,3,4,7.
Amphora angusta Greg.	pw,6.
A. coffeiformis Ag.	pw,4,5,6.
A. hyalina Kutz.	pla,7.
A. ocellata Donk.	pw,1.
A. terroris Ehr.	pw,3*.
A. turgida Greg.	fl,3.
Amphora sp.	pw,1,4,5*,6*,7*.
Bacillaria paradoxa Gmel.	pw,4.
Berkeleya rutilans (Trentep.) Cl.	fl,4;pw,4.
Climacosphenia sp.	pw,4.
Cocconeis kamtschatkuensis Mann.	pw,1.
C. scutellum Ehr.	pw,1.
Cocconeis sp.	pw,1,5,12; sh,3,5; pla,5.
Cyclotella sp.	pw,5,6.
Cylindrotheca closterium	= Nitzschia closterium
Cymbella sp.	pw,4*,5,12˘2.
Diatomella sp.	pla,3.
Donkinia recta Donk.	pw,4.
Entomoneis (Amphiprora) paludosa W.Sm.	pw,4.
Fragilaria tabulata	= Synedra tabulata
Grammatophora angulosa Ehr.	pw,sh,3,4,5.
G. marina (Lyngb.) Kutz.	fl,7; pw,4,5*,7*; sh,3,4,5*.
Licmophora abbreviata Ag.	fl,tr,lp,3,4; pw,4; pla,4.
L. dalmatica (Kutz.) Grun.	sh,3,4;pw,5,6.
L. Ehrenbergii (Kutz.) Grun.	df,ab,lp,1,7;pw,4,7*.
L. flabellata Ag.	pw,4*,5,6.
Licmophora sp.	pw,4*,5*,6*; pla,7.
Melosira moniliformis (O. Mull.)	pla,3;pw,5.
Melosira sp.	pw,5,6.
Navicula grevillei W. Sm.	pw,3,12.
N. halophila var. convergens (Grun.) Cl.	pw,4.
N. pennata var. pontica Mer.	df,fp (l),fl,pw,sh,3*,4,7.
Navicula sp.	ab,lp,3; pw,1,4,5,6,10,12; pla,5.
Nitzschia (Cylindrotheca) closterium (Ehr.) W. Sm.	pw,plb,pla,1,3,10.
N. delicatissima Cl.	pw,4,5*,6*,7*; pla,plb,7*.
N. hybrida f. hyalina Pr.-Lavr.	pw,1*,3*,4*,5*,6*,7*,12*; sh,pla,5*;plb,7*.
N. longissima (Breb.) Ralfs	pw,4,5,7*.
N. rupestris Pr.-Lavr.	pw,5*,6*,7*; plb,7*.
N. seriata Cl.	fl,7;pw,7*;plb,1.
N. tenuirostris Mer.	pw,plb,1,3,4,5*,6*,7*.
Nitzschia sp.	lp,3; pw,3,4,7; sh,3;
Pleurosigma elongatum W.Sm.	pw,4,5,10.
P. formosum W.Sm.	pw,5; pla,5.
Rhizosolenia calcar-avis Schulze	plb,10*.
Rhoicosphenia marina (W.Sm.) M.Schmidt	pw,1*,12;pla,3.
Stauroneis constricta (Ehr.) Cl.	pw,5*,6*,7; pla,plb,7.
Striatella delicatula (Kutz.) Grun.	pw,4.
S. unipunctata (Lyngb.) Ag.	pw,5*,6*.
Synedra curvata Pr.-Lavr.	pw,7.
Synedra (Fragilaria) tabulata (Ag.) Kutz.	pla,3*,4;pw,5*,6*.
Thalassionema nitzschioides Grun.	pw,7; pla,plb,1.
Trachyneis aspera (Ehr.) Cl.	pw,1.

Table 1 (cont.) Microphytic algae in Karadag dolphinarium

SPECIES OF ALGAE	LOCALISATION & PHENOLOGY
CHLOROPHYTA	
Cladophora sp.	pw,5.
Scenedesmus obliquus Kutz.	pw,5.
Ulothrix sp.	lp,fp (l),3.
Chlorophyta (non-identified)	pw,3*.
CYANOPHYTA	
Anabaena sp.	df,3; plb,11.
Oscillatoria sp.	pw,4.
Cyanophyta (non-identified)	pw,3,5,6; pla,plb,7*.
DINOPHYTA	
Ceratium sp.	pla,10.
Prorocentrum cordata (Ostf.) Dodge	pw,10.

CONVENTIONAL DESIGNATIONS

df	dorsal fin
ab	abdomen
fl	flukes
fp (l)} fp (r)}	left and right flippers
tr	trunk
drs	dorsal part of dolphin's body
lp	lateral parts of dolphin's body
pw	pools walls
sh	shingle in littoral zone
pla	plankton in littoral zone
plb	plankton in pools
1-12	time of discovery and isolation (month)
*	mass propagation period

Nitzschia delicatissima, *N. rupestris*, *N. tenuirostris*, *Stauroneis constricta*, *Striatella unipunctata*, *Fragilaria* (*Synedra*) *tabulata*, *Licmophora* sp. and *Amphora* sp. could be observed in May - June: also some new species appeared. In July, *L. Ehrenbergii*, *N. longissima*, *N. delicatissima*, *N. rupestris*, *N. seriata*, *G. marina*, *Amphora* sp. and some Cyanophyta were revealed in most samples, especially in benthic or fouling ones.

Amphora sp., *Pleurosigma elongatum*, *Rhoicosphenia marina*, *Rhizosolenia calcar-avis* and *Navicula* sp. occurred in algocenosis during autumn and winter period. In October, *Rh. calcar-avis*, *Navicula* sp., *P. elongatum*, *N. closterium* and *Dinophyta* species were most prevalent in pool fouling complex and in the water. December samples contained many cells of *Achnanthes brevipes*, *A. longipes*, *Rh. marina*, *Navicula grevillei* and *Cocconeis* sp. Only *N. hybrida f. hyalina* exceeded their number significantly and dominated there. The same pattern occurred in January but second position belonged to *Rh. marina* and then *N. closterium*, *Cocconeis* sp., *Achnanthes* sp., *Amphora ocellata* and *Navicula* sp. follow. In March, specific and numerical abundance of diatoms was observed. There were *S. tabulata*, *Licmophora dalmatica*, *G. marina*, *N. seriata*, *N. closterium*, *N. tenuirostris*, *Rh. marina*, *Amphora hyalina* and *Achnanthes* sp. among them; this situation was very similar to the winter water bloom. By the end of this month *Grammatophora angulosa*, different *Amphora* species and *Navicula pennata* var. *pontica* have appeared in the dolphinarium pools.

During some years, overgrowing vegetation changed its composition: *L. Ehrenbergii* cells were dominant, and combined with *G. marina* in upper conventional horizons and with *N. seriata* in middle ones.

The most typical and important feature of microphytic algal benthos is the increase in species diversity during such periods because the species number is very low in microphytic plankton during water blooms and mass propagation of some algae (Bodeanu, 1979).

Analysis of algal occurrence revealed the most typical species. The higher FOR indices in dolphin skin growths included *Licmophora abbreviata* (10.0%), followed by *N. tenuirostris, L. Ehrenbergii, N. pennata* var. *pontica* (4.0%), and then *Amphora turgida, Berkeleya rutilans, G. marina, Navicula* sp., *Nitzschia seriata* and *Anabaena* sp. (2.0%). In benthic algocenosis, the most common species was *N. hybrida f. hyalina* (21.4%). Other species - *Navicula* sp. (12.8%), *N. longissima* and *P. elongatum* (7.7%), *N. tenuirostris* (6.8%), *G. marina* and Cyanophyta (6.0%) - were less frequent in the pools. In planktonic samples, those with higher indices included *L. Ehrenbergii* and *N. closterium* (13.6%) and *N. delicatissima, N. seriata, S. tabulata, G. marina, L. dalmatica, P. elongatum* (9.1%). From the FOR index, we can single out the most common algae in the dolphinarium as *N. hybrida f. hyalina* (10.6%), *Navicula* sp. (6,8%), *L. Ehrenbergii* (5.6%), *N. tenuirostris* (5.3%), *P. elongatum* (4.2%), *G. marina* (3.4%), *N. seriata* (3.0%) and *L. abbreviata* (2.7%).

We can identify four groups based on the TFOR index:

1. 87.5%. *N.* hybrida *f. hyalina* and *Navicula* sp.

2. 62.5%. *Amphora* sp.

3. 50%. *G. marina, N. tenuirostris, N. delicatissima, S. tabulata, Licmophora* sp., *Cymbella* sp., *Cocconeis* sp. and Cyanophyta.

4. 37.5%. *L. Ehrenbergii, L. dalmatica, L. flabellata, Rh. marina, N. pennata* var. *pontica, N. longissima, S. constricta* and *P. elongatum.*

During the different periods of the century (from 1932) a number of authors (Stroikina, 1940, 1950; Koshevoy, 1959; Roschin, Chepurnov, 1987; Kustenko, 1991) registered other algal species dominating in plankton and benthos of the Karadag coastal region. This provides evidence that the algocenosis is constantly changing and highlights its present imbalance and the necessity for a dedicated monitoring organization in the Karadag zone, especially in the dolphinarium.

CONCLUSIONS In Karadag dolphinarium, 62 algal species were isolated and identified. Most of them were diatoms. The distribution of algae is very heterogeneous during the calendar year, and depends on the season. There are two (in some years, three) periods of algal mass propagation. The higher species diversity occurs in the spring months. This is reduced to a certain extent in summer, but the lower indices occur in October and December. The next increase in species number takes place in January. Among diatoms, *Nitzschia* hybrida *f. hyalina* dominated all year round, and were the most abundant and widespread species. Others had a more limited distribution. During some years, overgrowing algocenosis changes its composition: *L. Ehrenbergii* cells dominate; they occur together with *G. marina* in upper conventional horizons and with *N. seriata* in middle ones. There is a need for a dedicated monitoring organization in the Karadag zone, especially in the dolphinarium.

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SUDDEN ICE FORMATION - A CAUSE OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) MASS MORTALITIES IN THE SEA OF AZOV

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INTRODUCTION Cetacean mass mortality as a result of unfavourable hydrometeorological conditions is a rare phenomenon in the Black and Azov Seas. There is only one known cause for these events: an extraordinarily rapid formation of ice in the Azov Sea preventing harbour porpoises from migrating into the warmer waters of the Black Sea through the Kerch Strait. Mass mortalities as a result of this were noted in 1941, 1944-45 (Kleinenberg, 1956), and in 1950 (reports from local inhabitants). The most recent harbour porpoise mass mortality due to ice probably occurred in the south-western part of the Azov Sea at the end of 1993.

METHODS AND RESULTS In April 1994, during an annual expedition to the Azov Sea, an active search for cetacean strandings was undertaken along the Arabat Spit. Twenty dead harbour porpoises (*Phocoena phocoena*) were discovered on a sandy beach of about 50-60 km in length. That year, winter was unusually cold and prolonged, so the Azov Sea was covered by ice until mid-March, and the spring migration of harbour porpoises from the Black Sea into the Sea of Azov was delayed: cetaceans were not observed in coastal waters by researchers, and fishermen did not meet porpoises in the open sea.

According to reports from locals, most carcasses discovered (17) were stranded in March and April, just after the ice melted; three other carcasses had stranded earlier, before the cold season. The distinct signs of post-mortem decomposition indicated that the 17 most recently stranded harbour porpoises had died about five months previous, in November 1993. Thus, their carcasses had been stored in, or under, the sea ice for the entire winter.

DISCUSSION It is known that harbour porpoises spend only the warm part of the year in the Sea of Azov where they find conditions optimal for breeding, calving and foraging (Kleinenberg, 1956; Tomilin, 1957; Geptner *et al.*, 1976). Annually, porpoises leave the Azov Sea in October - November and return in March - April. The month of October sees the instigation and culmination of harbour porpoise migration out of the Azov Sea (Fig. 1, left). Animals move from shallow waters in the north to the coasts of the Crimea and Taman peninsula, and then through the Kerch Strait to the Black Sea. They follow their main prey - anchovies - in accordance with seasonal fish stock concentration and movement towards the south. The gradual decrease in water temperature (more significant in the northern part of the sea) is an initial signal for the migration of both fish and, hence, cetaceans. The final stage of the cetacean's autumn migration usually takes place in November, when the last porpoises (and the last of their prey) leave the Azov Sea. Even the extensive formation of large ice-fields (quite an uncommon event for November) does not obstruct this process, because animals accumulating in the ice-free area (the most deepest and saltiest waters of the Azov Sea) have an unimpeded exit into the Black Sea.

In 1993, Azov's "Indian summer" was unusually warm (up to +18°C) and prolonged. There was no significant decrease in water temperature during October. During this period anchovies remained disseminated, they did not form large compact shoals in front of the Kerch Strait and they did not start their mass migration into the Black Sea. The autumnal migration of cetaceans was delayed (Fig. 1, right), probably due to the abnormal behaviour of their prey species. Harbour porpoises were widely distributed in the sea, including its south-western corner. During first few days of November 1993, a sudden sharp frost (down to -20°C) and strong, perpetual, north-east winds caused the rapid formation of sea ice and the "capture" of harbour porpoises. Ice-fields primarily formed in shallow bays of low salinity and were then transported by wind to other areas. Some cetaceans (the majority?) were pushed through the Kerch Strait, due to climatic pressures, of weather, but others perished in the ice traps.

CONCLUSIONS In autumn 1993, weather conditions had distinctive peculiarities, which influenced the seasonal distribution and movements of Azov's marine fauna, including porpoises. As a result, some cetaceans were caught in the ice and died. It is highly probable that the total number of victims was a few hundred, only in the south-western part of the Azov Sea.

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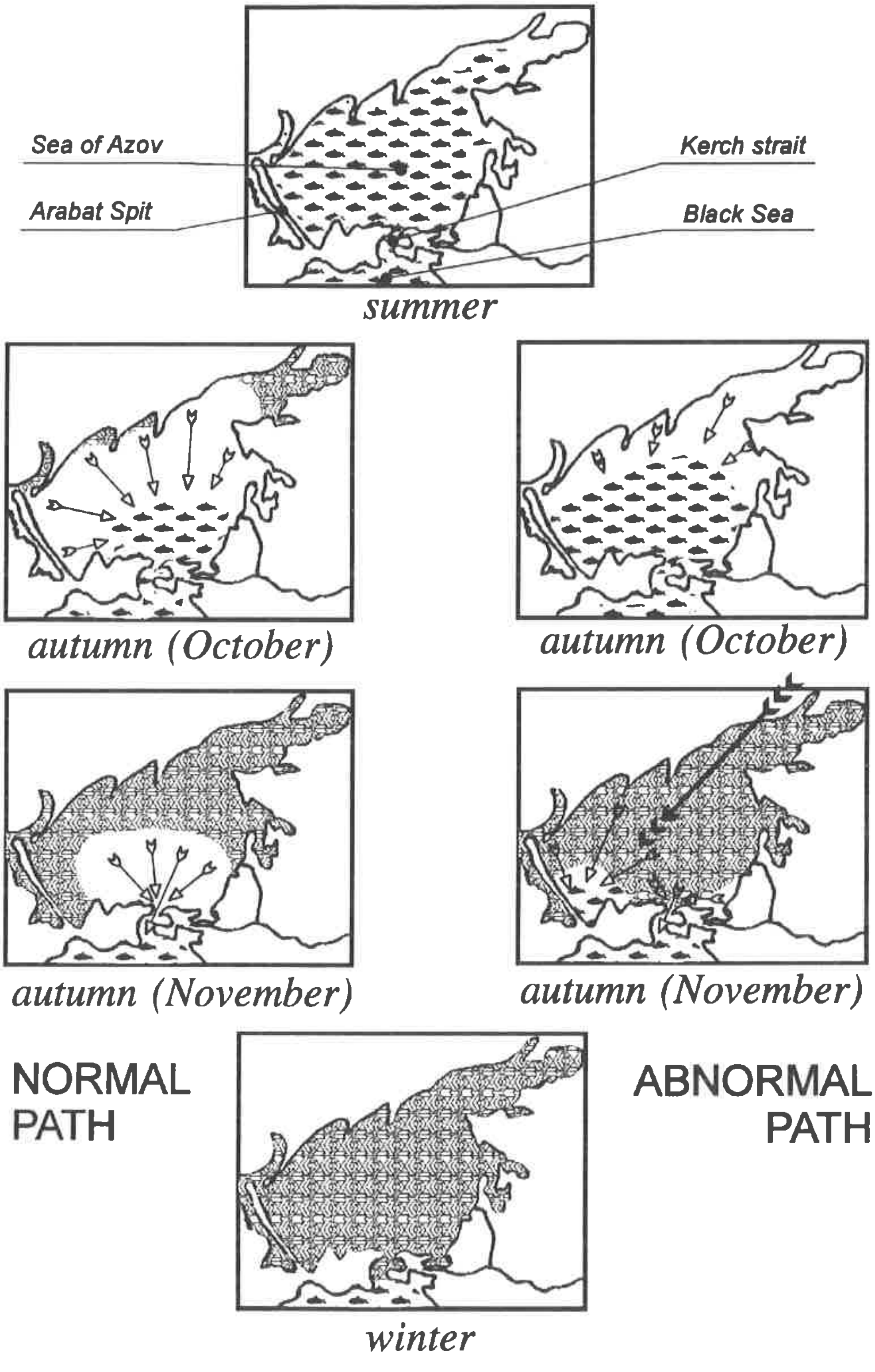

Fig.1. Distribution and movements of harbour porpoises in the Sea of Azov during the year

TECHNIQUES

APPLICATION OF A SIMPLE METHOD FOR THE CORRECTION OF SAMPLING HETEROGENEITIES IN THE ANALYSIS OF CETACEAN DISTRIBUTION IN RELATION TO BOTTOM DEPTH

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INTRODUCTION When conducting analyses of time- or space-related variables, the researcher often faces biases inherent in the sampling scheme. When sampling effort is unequally distributed across different strata, uncorrected data will lead to meaningless results. In the case of the distribution of cetaceans in relation to bottom depth, we propose here a simple method to correct the analysis: an unbiased indicator, called "bathymetric affinity".

MATERIALS AND METHODS Our analysis starts from a well-known definition of population density (Buckland *et al.*,1993):

$$D = (n / L) \times (1 / 2.\underline{esw}) \times \underline{S}$$

where n is the number of sightings for a given species, $\underline{S}$ is the estimated mean school size, L is the survey effort and esw is the estimated effective search half-width.

This relationship can be re-written for the stratum i:

$$Di = (1/2.\underline{esw}) \times (N_T/L_T) \times (f_i / e_i)$$

if we enter the frequency f_i and the relative sampling effort e_i :

$fi = N_i / N_T$ is the ratio of the number of individuals seen in the stratum i to the total number of individuals observed;

$e_i = L_i / L_T$ is the ratio of the effort in stratum i to total effective effort.

If we assume that $(1/2.\underline{esw})$ is not dependent on a particular stratum, we can express the relative density of one stratum i to another stratum j:

$$D_i / D_j = (f_i / f_j) \times (e_j / e_i)$$

Now, instead of choosing a particular stratum for reference, we can express this relative density as the ratio of the density Di to the sum of the densities for all strata, Ds:

$$D_i / D_S = D_i / \sum D_i$$

This descriptor is, hereafter, given the term "bathymetric affinity". Its meaning is fairly simple: if the total population was to be shared between k bathymetric strata of equal surface, each stratum would shelter a fraction of the population equal to its bathymetric affinity. The sum across strata of bathymetric affinities is equal to unity.

The data analysed in this study were obtained during summer surveys of the central Liguro-Provençal basin, carried out between 1988 and 1994. A total of 4,314 miles (7,980 km) were surveyed over this seven-year period. The surveys were conducted from a 10 m motorised yacht, at an average speed of five knots, with a sea state of less than Beaufort 3. The sampling regime was not homogeneous, i.e. surveys were carried out randomly within the study area.

The position of the survey vessel and environmental information were recorded every half hour or when cetaceans were detected. Detection and approach procedures have been detailed elsewhere (Gannier, 1995). Sightings of 7,221 cetaceans were considered in this study. For the purpose of this paper, we stratified the depth range of the Liguro-Provençal basin (0 to 2,700 metres) into four strata: the area in the depth range 0-500 m was called the "near-shelf" stratum; the area with a depth range of 500-1,000m is called the "upper slope"; the area with a water depth of 1,000-2,000 m was called "deep slope"; and waters with a depth over 2,000 m depth were designated "open sea" (Fig. 1).

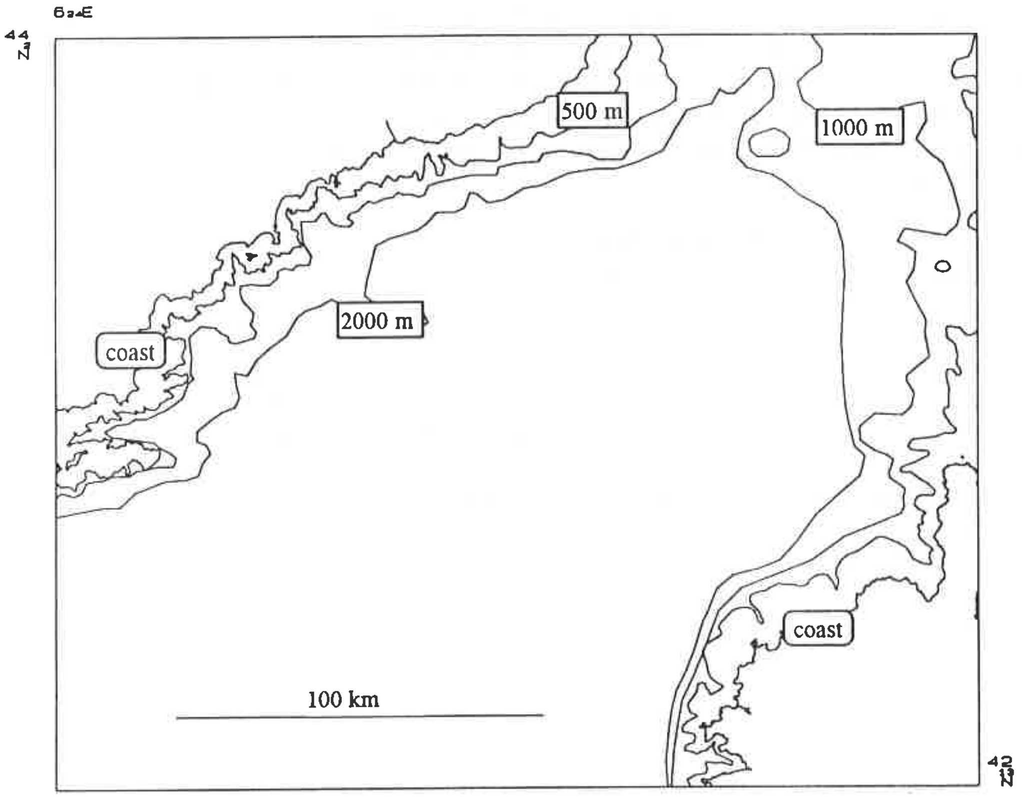

Fig. 1 Map of the study area displaying the four bottom depth strata utilised in this study

The data were analysed with the geographical software "Oedipe-Karto" (Massé & Cadiou, 1993; courtesy of the Sète IFREMER station), which enabled the user to make the geographical stratification directly from the computer screen (following the isobath lines), and to cross-reference with survey data (for example effective search effort and number of cetaceans of different species).

Table 1 Summer sighting frequencies of four cetacean species in the Liguro-Provençal basin, in four bathymetric strata

SPECIES/STRATUM	0 - 500 m	500 - 1000	1000 - 2000	over 2000 m
Stenella coeruleoalba	5.3	6.0	19.9	68.8
Grampus griseus	0	42.9	55.7	1.4
Globicephala melas	0.4	0	11.9	87.7
Balaenoptera physalus	0.4	2.4	11.7	85.5

RESULTS AND DISCUSSION The sighting data for the four most common species in the Liguro-Provençal basin is summarised in Table 1 and the calculated bathymetric affinities are summarised in Table 2.

Table 2 Summer bathymetric affinities for four cetacean species in the Liguro-Provençal basin

SPECIES/STRATUM	0 - 500 m	500 - 1000	1000 - 2000	over 2000 m
Stenella coeruleoalba	9.7	22.4	28.4	39.3
Grampus griseus	0	66.6	33.0	0.4
Globicephala melas	1.1	0	24.9	73.9
Balaenoptera physalus	1.0	11.9	22.1	65.0

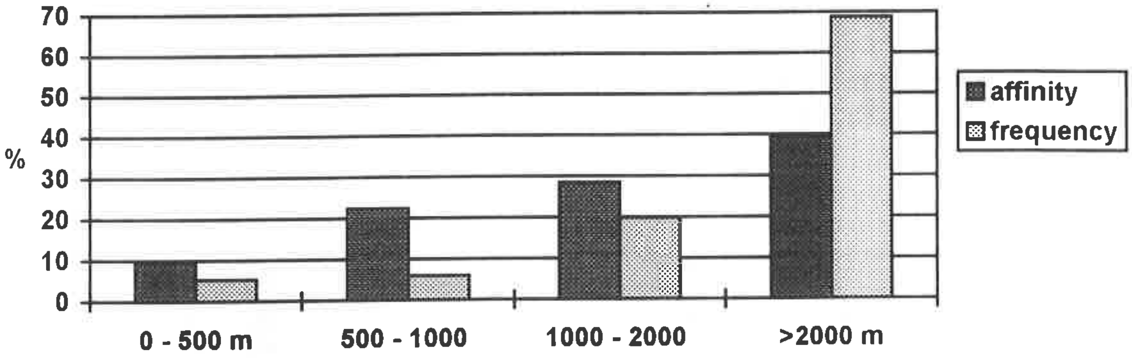

Fig. 2 A comparison of uncorrected analysis (frequency) and corrected (affinity) sightings data for the striped dolphin

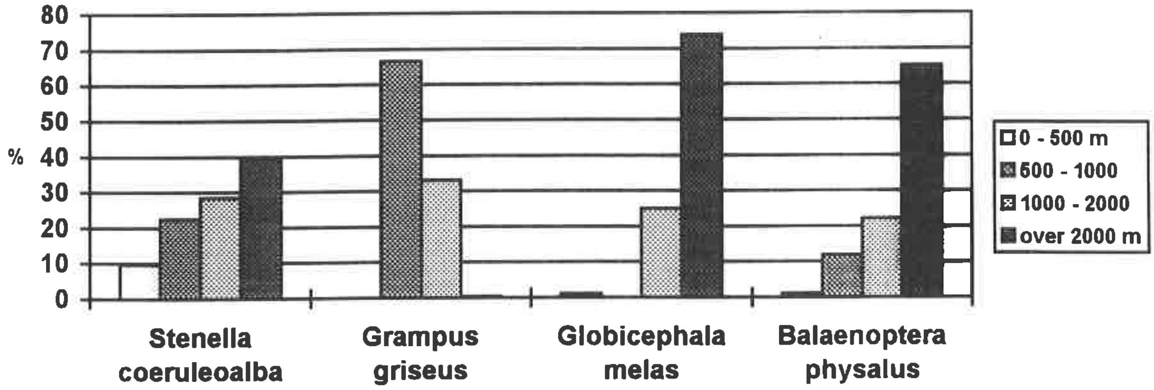

Fig. 3 A comparison of the bathymetric affinities of the four commonest species in Liguro-Provençal basin

The results differ greatly when comparing the data which were analysed directly with those which were corrected (Fig. 2). When analysed directly, the density of sightings for water depths of 0-500 m differs from densities in depth of over 2,000 m by a factor of thirteen. However, if the data are calculated as bathymetric affinities, the difference is not so great: the density differs by a ratio of only four. The greatest discrepancy between directly corrected and uncorrected data is for the upper slope, where bathymetric affinity is over three times higher than the uncorrected frequency. The latter was clearly biased downwards due to a reduced relative effort.

Figure 3 displays a bathymetric spectrum for the different species. Density of striped dolphins increased with bottom depth, but they were found in all four bathymetric strata. Risso's dolphins were found, almost exclusively, above the upper and deep slope, with a marked preference (66.6%) for the latter. By contrast, pilot whales and fin whales shared a preference for the open sea (73.9% and 65% respectively), although the latter is also frequently found on the slopes.

Figure 4 compares the drawing power of each stratum for the different species, although it should be noted that this figure is not an indicator of abundance. The near-shelf stratum mainly attracts striped dolphins. The upper slope is very attractive for Risso's dolphins, and to a lesser extent for striped dolphins and fin whales. The deep slope is remarkable in that it is almost equally favoured by all four species. The open sea is a domain from which Risso's dolphins are nearly excluded, and where a high proportion of fin whales and, above all, pilot whales are found (sperm whales, not detailed here, had a 100% affinity for this stratum).

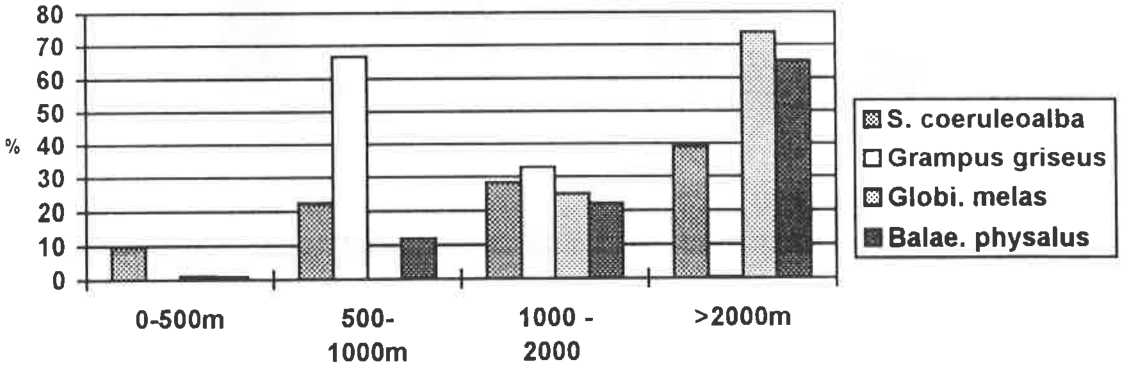

Fig. 4 A stratum by stratum comparison of the bathymetric affinities of the four most common cetacean species in the Liguro-Provençal basin

CONCLUSIONS This method is one means of analysing data where stratification occurs. An alternative approach would be to consider the relative density as a random variable and to statistically analyses the data within each separate stratum. Unfortunately, it is often impossible to stratify sampling during field studies into cetacean ecology, as environmental variables are multiple or *a priori* unknown (sea surface temperature).

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WHICH HOME RANGE ESTIMATION METHOD SHOULD WE USE?

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The study of space utilisation in mammals, whether marine or terrestrial, consists of the determination of their home range, defined as "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young". Variation in home range utilisation describes the relative importance to which different units of space are used by an animal over a period of time.

Descriptive parameters of home range include size, shape, and distribution of activity, and reflect significance for biologists in terms of territory, behaviour, and population characteristics. In Brittany, coastal groups of bottlenose dolphins were studied with the aim of describing their home range and pattern of space utilisation. Field observations collected were plotted as a series of locations on a grid map. A variety of methods are proposed to transform these points into an area: the minimum convex polygon, the Fourier transform method, the bivariate normal distribution, the non-parametric method, and the uniform distribution - corresponding with various probability models. No real agreement exists concerning these methods, and their use results in different estimates of the size and shape of the home range. Therefore, inter-study comparisons are nearly impossible because the resulting home range depends upon the original data and the assumptions of the method.

Another technique which can be used to measure habitat space and quantify animal movement patterns is the fractal method. This analysis implies that the home range is not only a bounded space within which an individual may be found, but also takes into account the intensity of use.

The choice of a method for the analysis of home range data depends on many parameters and results obtained are very different according to the analytical method used. Consequently, comparing home range size and shape between different coastal groups may be impossible if one does not have any information about the data themselves and the analytical method used.

THE EFFECTIVE UTILISATION OF SCIENTISTS AND NON-SCIENTISTS IN AN INTEGRATED STUDY ON FREE-RANGING BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) AT DURLSTON COUNTRY PARK, DORSET, UK

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INTRODUCTION The deployment of non-scientists in cetacean research is increasing. In some quarters, results obtained from non-scientist centred studies are perceived as of lesser value than studies conducted exclusively by scientists. However, the effective use of non-scientists within a rigorously designed research programme will enhance rather than detract from the value of the study.

The Durlston Dolphin Research Programme, based at Durlston Country Park in southern England, is studying a discrete group of free-ranging bottlenose dolphins (*Tursiops truncatus*). Since 1988, park staff and local residents have collected sightings data. Whilst being effective in recording the frequency of dolphin activity in the study area, a lack of long-term planning and scientific guidance has restricted the development of the project. Likewise the deficiency of quality assurance, feedback and ongoing training has meant that some of the data are not amenable to rigorous analysis. The project has now embarked on a directed long-term study, deploying non-scientists and scientists in appropriate elements of the program. By taking an integrated approach, it has been possible to utilise the skills brought to the study by all of its members, be they scientist or non-scientist. In this way, the program maintains scientific rigour, while benefiting from the dedication and enthusiasm of those in the local community who first recognised the importance of studying the dolphin group.

ADVANTAGES AND DISADVANTAGES OF NON-SCIENTIST INVOLVEMENT IN CETACEAN RESEARCH Numerous cetacean research projects around the world utilise non-scientist volunteers to gather data, and there appears to be an upward trend both in the number of such projects and the number of participants. Although the value of non-scientist volunteers in cetacean research has been discussed by other authors (Evans, 1980; Evans *et al.*, 1985; Evans *et al.*, 1992), there is still a tendency amongst researchers (and volunteers themselves) to denigrate the quality of data derived from these studies.

Problems frequently associated with the involvement of non-scientist volunteers in research programs include the limitation of the scope of the research (due to the need to simplify methodology), and inconsistency of data (due to variation in the skill, experience, and perception of the volunteers, and a lack of quality control). Cetacean watch programs, particularly those in areas where sightings are infrequent, often suffer from a high turnover of volunteers, which compounds these factors. Overall, there may be a tendency towards a loss of scientific rigour, even to the extent that the data collected are redundant for the purposes of statistical analysis.

On the other hand, volunteer involvement presents a number of opportunities and advantages which are generally unavailable to research teams. The research effort can be greatly increased at little extra cost, enhancing the rate and volume of data collection and, of course, the cost-effectiveness of the program. There may be unrivalled opportunities for long-term systematic research, and the interests and skills of the team members may present new avenues of research. Last, but by no means least, the opening of cetacean research to non-scientists will lead to the promotion of the public understanding and perception of science and is likely to result in enhanced local support for cetacean research and conservation initiatives.

It is clearly desirable to design a research programme so as to maximise the advantages of non-scientist participation while minimising the disadvantages. Such a program might feature the following:

1) interdisciplinary approach, structured so as to promote different levels of participation according to ability and interest, and to utilise the diversity of skills available;
2) regular training and evaluation to reduce inconsistency and broaden the scope of the research;
3) a mentor system, enabling new recruits to benefit from the experience of long-term participants;
4) regular meetings and feedback to maintain the momentum of participants, reinforce the value of the research and promote problem-solving;
5) visits to related projects, to put own research into context and promote group cohesion.

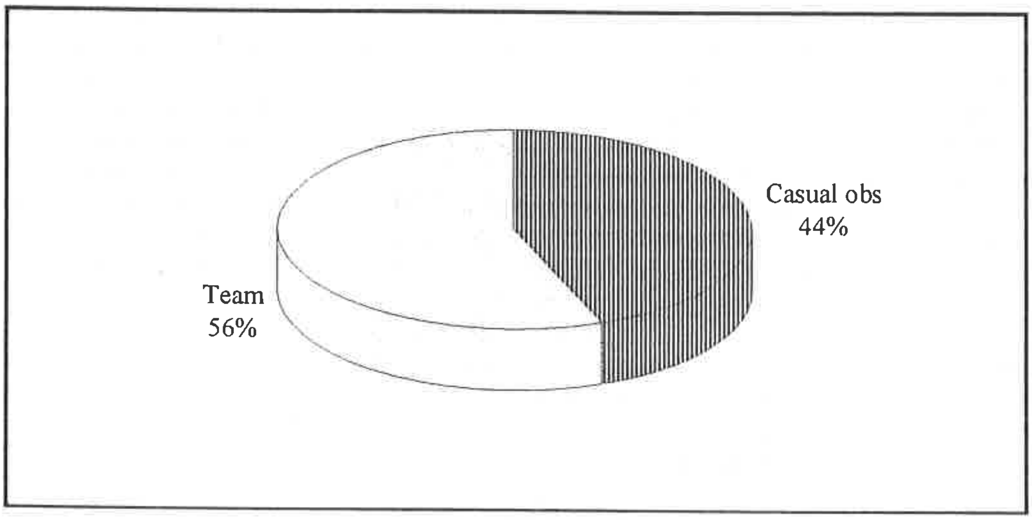

Fig. 1. The proportion of bottlenose dolphin sightings within the Durlston Marine Research Area recorded by dolphin watch team members and casual observers in 1996 (n=155).

CASE STUDY - DURLSTON DOLPHIN RESEARCH PROGRAMME

Since 1988, a team of local volunteers, mostly non-scientists, has been conducting a systematic watch (approximately 30 hours per week) from Durlston Country Park, recording details of all cetacean sightings. The team succeeded in confirming the existence of a semi-resident group of bottlenose dolphins, and inspired the designation of a voluntary marine nature reserve and the development of a multi-faceted marine research program (Harland *et al.*, 1996a,b; Harland & Williams, 1997; Williams *et al.*, 1997), including dolphin photo-identification, bioacoustics and sublittoral habitat surveys. Amongst the great strengths of the program were the high level of volunteer involvement in many facets of the work, from hydrophone installation to data analysis, and the tremendous commitment and enthusiasm of the volunteer team, resulting in extensive local interest in and support for the project. Although the team's efforts more than doubled the number of dolphin sightings recorded (Fig. 1) the actual sightings data were highly variable in quality and tended to be of a qualitative rather than quantitative nature. While these data yielded interesting seasonal sightings trends (Fig. 2), the collation of records from team members with those from casual observers hindered the correction of this analysis for research effort, and the subjectivity and variability of environmental (weather, sea state, etc) and dolphin data thwarted attempts to correlate sighting patterns with environmental factors. As such, the level of information gleaned from nine years' data is severely limited.

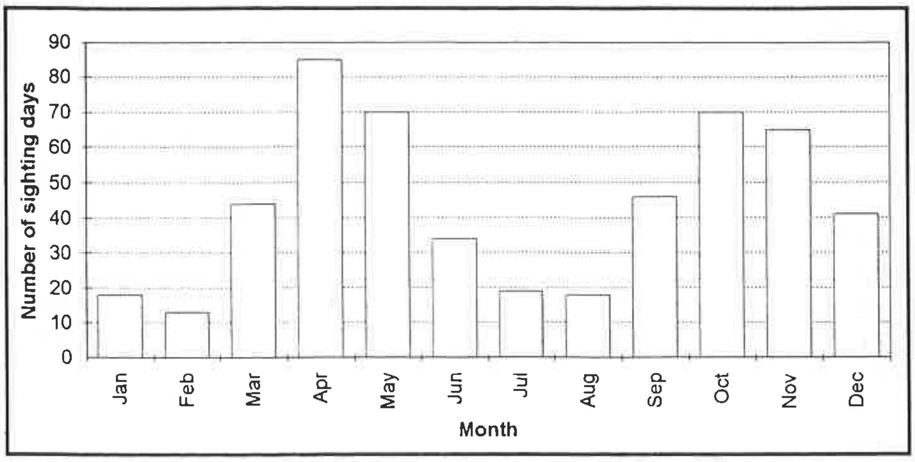

Fig. 2. The total number of days per month on which dolphin sightings were recorded within the Durlston Marine Research Area from 1988-1996.

In late 1996, the dolphin watch entered a new phase. The methodology and recording forms were adapted so as to increase the number of parameters recorded (including detailed behavioural and environmental records, as well as boat traffic information) while eliminating reliance on descriptive and imprecise terminology. Intensive training was provided, together with opportunities for feedback and discussion. The mentor system was formalised in order to facilitate integration of new recruits. The result of these changes will be to enable rigorous analysis of sightings, behavioural and environmental data: 'proper science'. In turn, this will enable the pulling together of the other elements of the program - of sub-littoral habitat maps with dolphin activity patterns, of observed behaviour with acoustic recordings, of boat traffic and noise with dolphin behaviour and movements - the possibilities are diverse and exciting!

CONCLUSIONS Non-scientist participation in cetacean research programs tends to be viewed with scepticism, taken for granted or, at worst, dismissed. We contend that it is an undervalued resource which, with forethought, commitment, and care can significantly enhance the status of research.

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THE DEVELOPMENT OF A TECHNIQUE FOR MAKING LAND-BASED OBSERVATION OF CETACEANS

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The objectives of this study were to investigate the effects of potential boat disturbance on killer whale group behaviour in terms of pod geometry and inter-individual spacing; develop techniques for land-based studies of cetaceans, and to introduce whalewatching guidelines to the community of Tysfjord, north Norway in order to encourage responsible whaslewatching in an area of booming tourism.

Land-based observations of killer whale group behaviour were made from a small island in Tysfjord for the months of October and November 1996. A team of two persons monitored behavioural sequences in the presence and absence of boats using a manual theodolite and video camera with a high power zoom. The analysis of the material involves digitising the video images and subsequent positioning of all objects in each frame.

The combination of theodolite and video appears to be a valuable and interesting technique for monitoring cetacean behaviour from land vantage points. However, there is still scope for refinement and improvement of the method.

APPROACH METHODS FOR THE STUDY OF THE CETACEANS LIVING IN THE NORTHERN ADRIATIC SEA (GULF OF TRIESTE - LAGOON OF VENICE): INTERVENTION PROTOCOL FOR HEALTHY AND DISTRESSED ANIMALS

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The aim of this paper is to define in detail an intervention protocol for studying the cetaceans living in the northern Adriatic Sea (Gulf of Trieste - Lagoon of Venice). This protocol has been drafted based upon to studies conducted by its authors, the results the of a literature search and research undertaken by scientists operating in the Mediterranean Sea (especially in the northern Adriatic). It accounts for the different ways in which cetaceans in a variety of states (healthy, in distress or stranded) can be approached, even in a lagoon area.

The work underlies the use of biomedical techniques (veterinary examination with possible therapies to be adopted for animals in distress; post-mortem examination and laboratory tests for stranded animals) that give a more precise indication of the condition of the cetacean. When used in conjunction with demographic and eco-ethological data on the population (for example social behaviour and breathing frequency), it could help to assess the present and future health of the population.

SEALS & OTHER MARINE ANIMALS

POPULATION STRUCTURE OF SOME GREY SEAL BREEDING COLONIES AROUND THE UK AND NORWAY

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INTRODUCTION About 40% of the total world, and most of the European, population of grey seals (*Halichoerus grypus*) inhabit the seas around the UK. Between September and December, the seals gather at onshore breeding sites where the females give birth, suckle their young for 2-3 weeks and to mate. Studies with marked seals and the use of satellite telemetry have shown that seals can and do travel considerable distances. Thus, they could easily travel between breeding sites suggesting that there could be considerable interchange of individuals leading to genetic homogeneity. However observations over several years at two Scottish breeding sites of marked adult animals indicate that most seals have a high fidelity to a given breeding site (Pomeroy *et al.*, 1994). In addition, there are indications that some pups, when they themselves become mature, also return to the sites where they were born in order to breed (Pomeroy *pers. comm.*).

If faithfulness to a particular breeding site (philopatry) was extensive, then there would be little interchange of breeding individuals, and the process of genetic drift would be expected to give rise to genetic differentiation between sites. To assess the degree to which grey seals in the NE Atlantic are philopatric we are analysing variations in a 350 base sequence of the mitochondrial DNA control region obtained from seals at a number of breeding sites. This report describes the results from five of those sites.

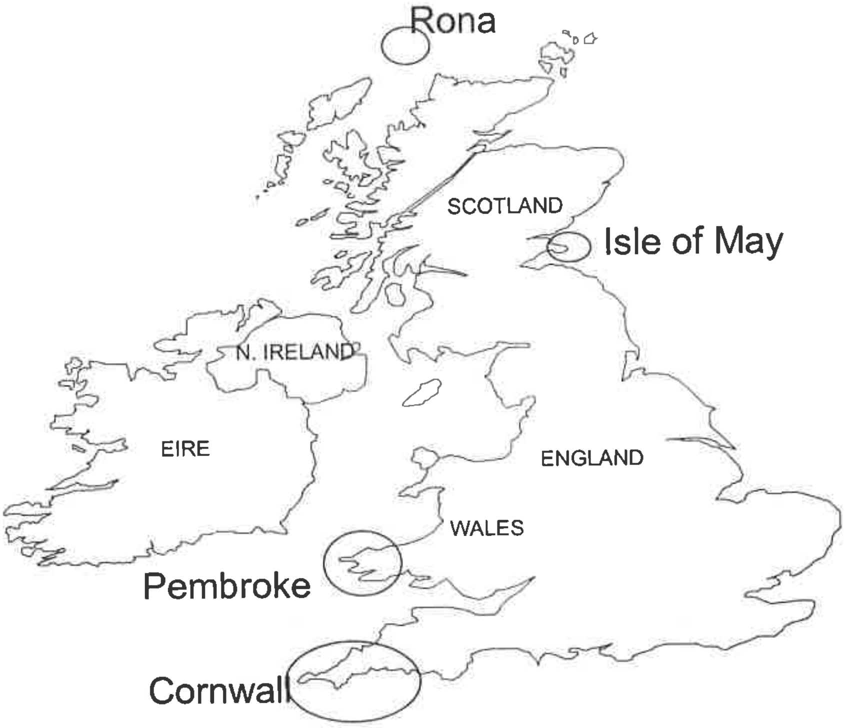

Fig.1 UK Breeding sites sampled

MATERIALS AND METHODS

Samples: Blood samples or skin biopsies were obtained from 117 pups or female seals from five breeding sites namely: Cornwall, England (n = 29); Pembroke, Wales (16); Rona, Scotland (27); Isle of May, Scotland (29); and Trondheim area , Norway (16). The UK sites are indicated on Figure 1. Total genomic DNA was extracted by standard procedures following tissue digestion with Proteinase K.

PCR Amplification and sequencing of control region: The mit DNA control region was amplified by PCR using the primers ThrL (5'-cccggtcttgtaaacc) or ProL (5'-caccaccaacacccaaagct) and H189 (5'-ctatgtcccgctaccattgac) using the extracted DNA as template. The double-stranded product was sequenced for 350 bases in all samples using the internal primers DLH (5'-cctgaagtaggaaccagatg), H34 (5'-ccaaatgcatgacaccacag), H16539 (5'-caaccattccatgtacatgc) and ProL. For any unique haplotypes found, the PCR and sequencing processes were repeated to check on the sequence. The methods are described in more detail in Walton (1997).

Data analysis: The degree of population geographical substructure was tested using the programs AMOVA (Analysis of Molecular Variance, Excoffier *et al.*, 1992) and ARLEQUIN (Schneider *et al.*, 1996).

Table 1 Grey seal haplotype distribution

HAPLOTYPE	CORNWALL	RONA	PEMBROKE	MAY	NORWAY	TOTAL
A	4	5	4	6	2	21
B	0	5	0	7	0	12
C	3	2	4	0	0	9
D	3	2	0	4	0	9
E	4	0	2	2	0	8
F	6	0	0	0	0	6
G	0	4	0	2	0	6
H	1	0	0	0	5	6
I	0	1	1	3	0	5
J	2	1	0	0	0	3
K	2	1	0	0	0	3
L	0	0	0	0	3	3
M	0	0	1	0	2	3
N	2	0	0	1	0	3
O	0	0	2	0	1	3
P	0	2	0	0	0	2
Q	0	0	2	0	0	2
R	0	0	0	2	0	2
S	0	1	0	1	0	2
T	0	0	0	0	1	1
U	1	0	0	0	0	1
V	0	0	0	1	0	1
W	0	0	0	0	1	1
X	0	0	0	0	1	1
Y	0	1	0	0	0	1
Z	0	1	0	0	0	1
AA	1	0	0	0	0	1
AB	0	1	0	0	0	1
TOTAL	29	27	16	29	16	117

RESULTS AND DISCUSSION

Within the 350 bases sequenced in all animals, 30 variable sites were found of which 29 were transitions (20 G/A and 9 T/C) and one insertion (a C); there were no tranversions. This gave rise to the 28 different haplotypes (not shown) whose distribution patterns are shown in Table 1. Type A, the most common, was found at all five breeding sites, whereas others had a more restricted distribution e.g. the next most common type B was only found at two sites and type F was only found in Cornwall. This suggests a degree of population substructuring.

Use was made of two freeware computer programs AMOVA and ARLEQUIN to describe the data at the population level. AMOVA makes use of information from both haplotype frequency distribution and the diversity between pairs of haplotypes to form a distance matrix from which it calculates a measure (Phi$_{ST}$) of genetic distance between pairs of populations. ARLEQUIN has a facility to perform conventional F$_{ST}$ measurements which use only haplotype frequency distributions. In both cases, the statistical significances of the inter-population distances were evaluated by Monte Carlo re-sampling with replacement methods. Data were re-sampled 1,000 times.

Table 2 AMOVA Interpopulation PHI$_{ST}$ values

RONA	PEMBROKE	MAY	NORWAY	
0.074*	0.092*	0.060*	0.101*	**CORNWALL**
	0.033	0.005	0.061*	**RONA**
		0.089*	0.118*	**PEMBROKE**
			0.040	**MAY**

* significantly different ($p<0.05$)

Using AMOVA (Table 2), the ten possible inter-population distances ranged from 0.005 to 0.118, of which all but Rona / Pembroke, Rona / Isle of May, and Norway / Isle of May were significantly different. Using ARLEQUIN (Table 3), conventional F$_{ST}$ measures inter-population distances ranged from 0 to 0.098, of which all but Cornwall / Pembroke and Rona / Isle of May were significantly different. Hence there is evidence for significant genetic differentiation between many of the sites tested. However, there are discrepancies between these two methods on whether or not the differences between Cornwall / Pembroke, Pembroke / Rona, and Isle of May / Norway are significant. The reasons for this are unclear but it may be that when the genetic distances between pairs of populations are low then much larger sample sizes may be needed to clearly indicate significant differences.

Table 3 ARLEQUIN Interpopulation F$_{ST}$ values

RONA	PEMBROKE	MAY	NORWAY	
0.042*	0.024	0.052*	0.080*	**CORNWALL**
	0.043*	-0.009	0.082*	**RONA**
		0.063*	0.097*	**PEMBROKE**
			0.098*	**MAY**

* significantly different ($p<0.05$)

Allen *et al.* (1995) studied seals from Rona and the Isle of May using eight microsatellite loci, and found an interpopulation distance of 0.006. This value is low but highly significantly different, although this was only apparent with large sample sizes (they analysed a few hundred from each site). In the present study, neither form of analysis showed a significant difference between Rona and the Isle of May; it may be that microsatellites are more sensitive than DNA sequencing to revealing differences in relatively newly separated colonies.

The results from this study show that significant genetic differences do occur between some breeding sites, providing supporting evidence that grey seal populations tend to be philopatric and not panmictic. In some cases, the significance level depends on the analytical procedure followed, and thus more studies are required to clarify the issue.

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IRELAND'S GREY SEAL (*HALICHOERUS GRYPUS*) POPULATION: A CASE OF OLD HABITS AND NEW BEGINNINGS

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Until the early part of this century, the grey seal was actively hunted by some coastal communities in Ireland. Such events have been colourfully recorded in the literature and oral tradition of these areas. Today, the conflict between seal and man continues in Irish coastal areas. On several occasions this has resulted in illegal seal-culling. Furthermore, some fishermen habitually shoot seals, particularly during salmon drift-netting operations in summer. However, the extent of this action or its effects have not been determined to date.

Historical information on Ireland's grey seal population is sparse and often misleading. Recent research at University College Cork investigates the current population status and site fidelity of the grey seal throughout the year at key island colonies. Methods used include conventional counting in addition to photo-identification.

To date, results gathered at study sites suggest that the breeding population size is quite consistent, with estimates derived from previous surveys by the Wildlife Service. However, observed grey seal abundance varies with season and study area, and some of the largest aggregations occurring during the annual winter/spring moult exceed expectations derived from breeding population data. These results are set against a background of increasing grey seal populations elsewhere in the North Atlantic, and they represent an interesting beginning for grey seal research in Irish waters, particularly in the light of fisheries-interaction problems.

THE WHITE VENTRAL PATCH OF MEDITERRANEAN MONK SEAL (*MONACHUS MONACHUS*) PUP, THE PUP'S PASSPORT

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INTRODUCTION Mediterranean monk seal pups, unlike pups of the other two monachinae species, the Caribbean monk seal (*Monachus tropicalis*) and the Hawaiian monk seal (*Monachus schauinslandi*), display an overall black lanugo interrupted by a yellowish white patch on the belly (King 1956). We observed that this white patch varied between individuals and remained unchanged, at least during the pupping stage, making it a potentially non-invasive tool for the individual identification of pups.

METHODS Our study was conducted between 1993-96 in two caves in the "las Cuevecillas" area (21°03'32"N-17°03'82") in the Peninsula of "Cabo Blanco" (Western Sahara) (González *et al.*, 1997a), where the largest colony of this species is found. The size of the colony is currently estimated to be 288-318 individuals (Forcada *pers. comm.*). To examine the validity of the pup identification method, during the period July 1995 - April 1996, we studied the pattern of variation of the ventral coloration of 36 pups. Sex and coloration patterns were established by three means: 1) Direct examination of stranded pups and tagged pups); 2) cliff-top observations of swimming pups with binoculars; and 3) Analysis of images obtained from a video camara installed in the roof at the entrance of the cave.

RESULTS AND DISCUSSION The white patch is squarish in shape and extends laterally from the mid-lateral region. The anterior limit coincides approximately with the centre of the body, and caudally it ends between the umbilical scar and the genital slit. Black spots frequently appear within this patch. Both the differences in the shape of the patch and in the position of the spots confer an individually-specific pattern, which enabled us to recognise and monitor the pups from birth to their first postnatal moult. In some animals, the lateral shape of the white patch remained after the first moult, making it possible to monitor them for at least a further half a year.

We further discovered that pups present a sexual dimorphism in the shape of the patch. In females, the caudal margin of the white patch is close to the tail and is straight; the umbilical slit falls within the patch. In contrast, in males the caudal margin forms an inlet that reaches, or almost reaches, the umbilical slit. The slit of the penis falls outside the ventral patch.

To date, 21 pups (10 females and 11 males) with recognisable white patches have been sexed. In all cases the sex predicted by the pattern of the patch coincided with the actual sex determined by direct observation.

It is concluded that individual recognition througth the white ventral patch constitutes a reliable method of identifying and sexing pups which does not require direct contact or handling of the animals. Therefore, the method is essencially non-invasive, a highly recommended characteristic when working with such an endangered species.

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PHOTO-IDENTIFICATION CATALOGUE OF MEDITERRANEAN MONK SEALS (*MONACHUS MONACHUS*) FROM THE WESTERN SAHARA

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INTRODUCTION Mediterranean monk seals (*Monachus monachus*) can easily be identified by their natural markings because their fur is short and their scarring pattern is clearly visible. The use of natural marks to identify individual animals has successfully been applied to several species of marine mammals and reported in a number of population and behavioural studies (Würsig and Würsig 1977; Katona and Kraus 1979; Bigg 1982; and Hiby and Lovell 1990).

Photographs of Mediterranean monk seals from the western Sahara taken since December 1992 were used to compile a catalogue of each individual of the colony. The catalogue has allowed the monitoring of the seals over time and the assessment of the movements of individuals, population size, behaviour, and life history parameters.

MATERIALS AND METHODS

Field work. Photo-identification surveys were organised in sessions lasting 15-30 days. Intervals between sessions ranged 1-5 months.

Photo-identification sites were established at the top of the main hauling out caves, 15-20 meters above the sea level, and in the other major areas of concentration of seals.

Sets of slides, including all the possible visible parts of the animals while swimming, were collected for each available seal during each session. From these, a sketch with the most prominent markings was made for each individual.

Analysis of photographs. In the first screening process, series corresponding to individuals were selected from each new session and these were matched with the sketches. New individuals and matches with existing individuals of the catalogue were confirmed by three researchers in the second screening process.

Five views of the head and body of the seals were considered as the most appropriate views for individual recognition: frontal, right lateral, left lateral, upper view of the head, and anterior dorsal view of the body. Each new individual included in the catalogue was given a number and, if it had distinctive identifying features, also with a name. In addition, every slide was assigned a code and was graded according to its *photographic quality* and the *recognizability* of the animal. Later, with the best slides of each specimen, the sketch of every available view of the seal was completed.

The details of the slides in the photographic collection were stored on a database. Besides, information on location and date of collection, weather and sea conditions when the photographs were taken, and miscellaneous biological and behavioural data were also included.

RESULTS AND DISCUSSION Ten photo-identification sessions were conducted between May 1993 and April 1996, but opportunistic photographs of seals were available since December 1992. Throughout this time, over 10,000 slides were examined. About 4,100 of these were considered to contain useful marking information and to be of sufficient photographic quality to justify their inclusion in the catalogue.

379 animals have been assigned a number in the catalogue. However, only 224 individuals can be considered unmistakably identified. Examination of scarring pattern over time in selected animals showed that scars and other pigmentation patterns were stable over the study period.

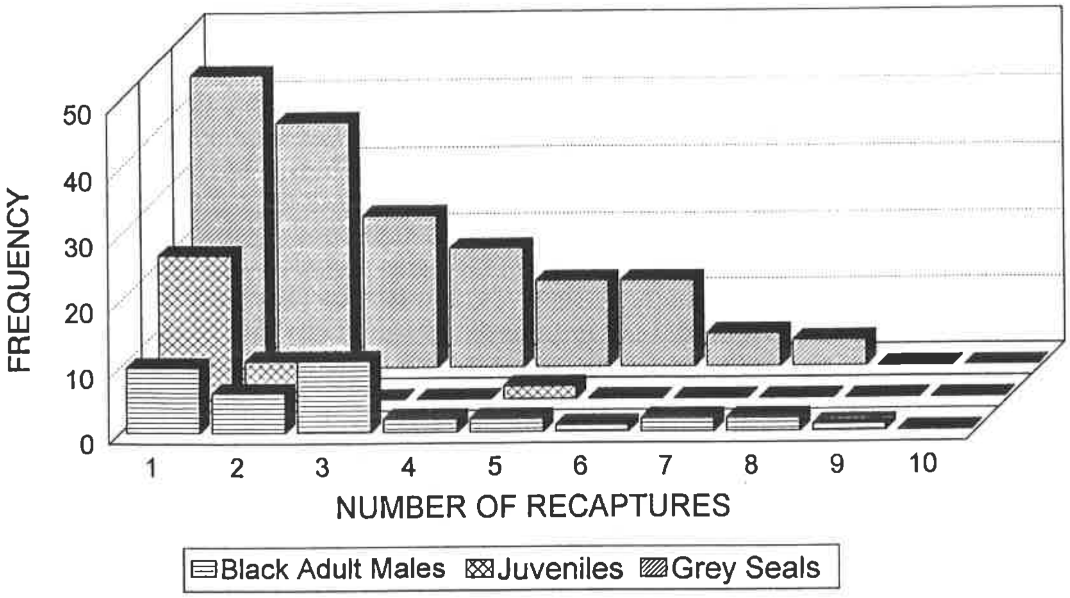

Fig. 1 Frequency of number of recaptures for the different morphological categories

Figure 1 shows the frequency of number of recaptures for the different morphologic categories. Recaptures of adult seals, both grey and black, were more regular than recaptures of juveniles. This is due to the fact that juveniles usually have only a few scars in their skin, and therefore they are difficult to recognise. On the other hand, black adult males and grey individuals behave differently, which produces a lower probability of recapture of the first group. The low recapture frequency of juveniles, altogether with the high proportion of new juvenile seals caught, indicates that photo-identification of this group is likely to be unfeasible. By contrast, adult seals can be photo-identified over time although in black adult males, photographic efficiency is comparatively low.

ACKNOWLEDGEMENTS The European Communities LIFE project (B4-3200/94/741) funded this study.

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DIVING ACTIVITY DATA ON ONE OF THE MOST ENDANGERED DIVERS: AN ADULT MALE MEDITERRANEAN MONK SEAL. HOW TO OBTAIN THE INFORMATION WITHOUT DISTURBING THE DIVER

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The aim of the present study was to obtain, for the first time, reliable data on the diving activity of an adult male Mediterranean monk seal (*Monachus monachus*) using a data logger. Because this is one of the most endangered mammal species world-wide, conventional methods to attach depth-recorders, which require the capture and handling of the individual, were dismissed and a non-invasive methodology to deploy the device was developed. Thus, a Time Depth Recorder (TDR) was mounted on a belt and fastened to the ankle of an adult male from the colony of Cabo Blanco (Western Sahara) while it was hauled out. This operation did not require the physical restraint of the seal, neither for the attachment of the TDR nor for its recovery, and allowed continuous behavioural recording for 51 days (June 18th to August 7th, 1996).

In total, 1,190 hours of activity and 3,590 dives were registered. The seal displayed a daily behavioural pattern, returning each day to shore. The activity budget showed that a large proportion (74.34%) of the total time was spent at the surface in relation to that spent diving (11.39%) or hauled-out (14.26%). Duration and depth of the recorded dives were 136 to 1.65 sec. and 20.3 to 0.28 m, respectively. The maximum duration and depth recorded were 8 min. and 58 m respectively.

Most dives (53%) were shallow, not deeper than 8 m, and only 5% of them exceeded 50 metres. Deep dives took place during daylight hours, whereas haul-out periods occurred between dusk and dawn. Dives in the 40-50 m range were frequent, and were probably associated with foraging since time spent at bottom was proportionally long and most dives were flat bottom squared, a dive profile usually associated with feeding in other phocid species.

ACTIVITY AND ORIENTATION OF SEA TURTLES IN CAPTIVITY DURING THE FIRST 100 HOURS AFTER HATCHING

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INTRODUCTION It is a well known practice in sea turtle conservation programs to excavate natural nests on the beach in order to rebury the eggs in hatcheries for incubation by the sun. After hatching sea turtles are placed into sea water tanks and released some days later. This has been done for many years although it is unknown whether or not the released hatchlings have a chance to survive at sea. Scientific results of the last years (Hewavisenthi and Kotagama, 1990; Wyneken and Salmon, 1992) have led me to the assumption that captivity right after hatching might influence the animal's activity and orientation (Albrecht, 1994).

MATERIALS AND METHODS Experiments were carried out at the Sea Turtle Hatchery in Bentota, Sri Lanka with hatchlings of green turtles (*Chelonia mydas japonica*, THUNBERG 1787) and Olive Ridley turtles (*Lepidochelys olivacea*, ESCHSCHOLTZ 1829). The study included behavioural observations of hatchlings in sea water tanks and release studies after varying periods of captivity within the first 100 hours after hatching.

Behavioural observations: Between March and May 1994, I retained around 80 animals of the same clutch in a tank with a diameter of 130 cm for 100 hours at the most. 24 observations series were made at daytime and 3 at nighttime. At daytime I chose one animal from the group and watched it for 10 min. For each of the 797 study animals, I recorded all periods of swimming activity, all directions of movements, each foraging behaviour and all kinds of aggressive interactions. At night, I counted for sevaral hours the number of swimming animals in the group in intervals of 3 min.

Release studies: Animals were released at sunset and at night on the beach. At sunset, I released 50 hatchlings in total, each one in company with four others. For each study animal I recorded the exact position during the crawl in intervals of 10 sec. At night, I released 102 groups of ten hatchlings. I placed them in the centre of a circle with a radius of r = 3 m. When all animals had left the circle, I measured the angles of the point where the tracks of the turtles intersected the circle line.

RESULTS **Behavioural observations:** Activity decreased significantly after the first or second day. The swimming animals were significantly oriented towards the sea. Seaward orientation was stronger in green turtles than in Olive Ridley turtles. From day to day, the number of oriented animals decreased. The longer the duration of captivity was, the more aggressive became the turtles of both species. Green turtles started looking for food on the fourth and Olive Ridley turtles on the second day. Green turtles reduced their swimming activity significantly after the first, and Olive Ridley turtles after the second night.

Release studies: At sunset, the crawling velocity of Olive Ridley turtles decreased slightly from day to day and animals deviated more from the direct route to the sea. The crawling behaviour of green turtles was not influenced by captivity in this study. At night, animals were significantly oriented towards the sea independent of species and age. Soon after hatching, green turtles clustered more than later and more than Olive Ridley turtles. With increasing time of captivity, green turtles deviated more from the shortest direction to the water. In this study, the direction of crawling Olive Ridley turtles was not influenced by captivity. However, in both release studies, an increasing number of Olive Ridley turtles did not move at all from the second to the fourth day of age.

CONCLUSIONS The data show that hatchlings should be released as soon as possible after hatching. Activity patterns in sea tanks and release data indicate that Olive Ridley turtles are more strongly affected by captivity than green turtles. I suggest that Olive Ridley turtles should be released immediately after hatching and not retained in tanks. Green turtles should not be released later than in the evening of the first day. The hatchlings need to depart from the shore before their activity decreases (Albrecht, 1996; Albrecht, 1997).

ACKNOWLEDGEMENTS I wish to thank the organisations Aktionsgemeinschaft Artenschutz e.V. in Germany and the Turtle Conservation Project in Sri Lanka for their support.

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(2) On previous occasions, a number of figures and tables have required re-drawing. This takes up considerable time for editors, and causes undue delay. So please prepare them in their final form, and provide the originals for camera ready printing. Number every table and figure for cross-reference to the text. Place tables, then figures, in chronological order, and on separate pages to the text. Figure captions should be placed underneath each one and Table captions above, with Fig. 1, Table 1, etc. in bold type, lower case, and the caption itself in ordinary type, lower case and centred.

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(4) Two lines below this should be the text of the abstract. Do not indent the first line but include one line space between paragraphs. Please use double-spacing for the hard copy of the text.

(5) Use common (vernacular) names of species in preference to Latin names, but on the first occasion only, please use both. All Latin names should be in italics and in parentheses. References in the text should be written as follows: (Capelli *et al.*, 1979; Di Sciara, 1982). Note the commmas between name and year.

(6) Sub-headings such as **INTRODUCTION, MATERIALS AND METHODS, RESULTS, CONCLUSIONS,** and **ACKNOWLEDGEMENTS** should be at left hand end of the text, but **REFERENCES** should be centred. There is no need for a summary of the abstract.

(7) Check references carefully to ensure they are complete, with full title and page numbers given. They should be given in plain font, size 10 (except for book and journal titals which go in italics), using the following format:

Aguilar, A. and Jover, L. 1982. DDT and PCB residues in the fin whale, *Balaenoptera physalus*, of the North Atlantic. *Rep. int. Whal. Commn*, 32: 299-301.

Sequeira, M. L. 1990. On the occurrence of Ziphiidae in Portuguese waters. Pp. 91-93. In *European Research on Cetaceans - 4.* Proc. 4th Ann. Conf. ECS, Mallorca, 2-4 March, 1990 (Eds. P.G.H. Evans, A. Aguilar & C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

Stewart, B.S. and Leatherwood, S. 1985. Minke whale *Balaenoptera acutorostrata* Lacépède, 1804. Pp. 91-136. In *Handbook of marine mammals*, vol. 3. (Eds. S.H. Ridgway and R.J. Harrison). Academic Press, London. 430pp.

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TENTH ANNUAL REPORT OF THE EUROPEAN CETACEAN SOCIETY: 1996

Paid-up members of the European Cetacean Society for the year 1996 numbered 382 plus 6 institutional members, from 18 European and 7 non-European countries. The highest representation came from Portugal (85), Germany (58), United Kingdom (52), Italy (46), Spain (33), France (18), the Netherlands (13), and Switzerland (12). Other member countries include Belgium, Croatia, Denmark, Faroe Islands, Greece, Hungary, Iceland, Ireland, Norway, Sweden, Turkey and Ukraine within Europe, and Algeria, Canada, China, Hong Kong, Mexico, South Africa, and the United States elsewhere.

The conference held in Lisbon between 11 and 13 March on the theme "Population Biology in relation to Conservation" was very successful, with 301 participants from 27 different nations. Four invited speakers addressed the society: Scott Kraus from the United States, Tony Martin and Lex Hiby from the United Kingdom, and Michael Milinkovitch from Belgium. The day before the conference, a workshop on sighting techniques was organised by Peter Evans, and one on Pathology was organised by Manuel Garcìa Hartmann after the conference. The abstracts of the meeting are published as Proceedings under the title "European Research on Cetaceans - 10", edited by Peter Evans.

Three Newsletters were produced during the year, reviewing recent research nad 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 Pathology in Bycaught Animals. During the course of the year, Peter Evans received editorial support from Helen Nice, Chris Parsons, and Kirsty Young to whom the society is very grateful.

A course on "Marine Mammals: Biology and Conservation" was held in Valencia from 9-13 September, organised by Antonio Raga. 140 students participated in the course, which consisted of lectures given by 13 different researchers on cetaceans, grouped into three modules, and a round table discussion.

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 Germany in March 1997, were organised adjacent to one another in time, and advertised in the respective newsletters of the two societies.

The organisation of the 1998 Conference in Monaco continued, under the supervision of Anne Collet, in collaboration with the SMM (and the EAAM).

Finally, the European Cetacean Society has continued to provide advice to gevernment departments and non-governmental organisations in European coutries, and specialist information for various public enquiries, with representation at ASCOBANS and ASCOBAMS.

Beatrice Jann
(Hon. Secretary)

FINANCIAL REPORT FOR THE YEAR UP TO 7 MAR 1996

	DM	£
Balance as of 7 March 1996	**8,766.53**	**926.84**

Income	**German account DM**	**British account £**
Transfer of funds to Oxford account		1,000.00
Interest on savings account		15.56
Membership fee for 1996 & profit, Conference in Lisbon	14,594.05	
Membership fee for 1996 to ECS-accounts	5,266.21	477.01
Total Income	**28,626.79**	**2,419.41**

Expenses	**German account DM**	**British account £**
Travel expenses:		
board meetings San Remo, 1995 & Stralsund 1996	4,529.40	208.99
ECS-Newsletters (postage, printing, etc)	6,468.02	69.90
ECS-Proceedings (Lugano, Lisbon), typing & production		300.00
ECS-Proceedings (Lugano, Lisbon), printing	14,007.46	
Abstract Volume (Stralsund) printing	1,693.60	
Editorial expenses (duplication, postage, faxes, etc)		131.84
E-mail subscription		150.00
Bank account expenses	118.87	
Total Expenditure	**26,817.35**	**860.73**

	DM	£		DM
Balance as of 28 February 1997	**1,809.44**	**1,558.68**	=	**5,407.00**

ROLAND LICK
(Hon. Treasurer)

EUROPEAN CETACEAN SOCIETY - 1997

The **European Cetacean Society** was formed in January 1987 at a meeting of eighty cetologists from ten European countries. A need was felt for a society that brought together people from European countries studying cetaceans in the wild, allowing collaborative projects with international funding.

AIMS (1) to promote and co-ordinate the scientific study and conservation of cetaceans;
(2) to gather and disseminate information to members of the society and the general public.

ACTIVITIES The Society set up seven international working groups concerned with the following subject areas: sightings schemes; strandings schemes; cetacean pathology; bycatches of cetaceans in fishing gear; computer data bases that are compatible between countries; the harbour porpoise (a species in apparent decline in Europe, and at present causing serious concern); and a regional agreement for the protection of small cetaceans in Europe (in co-operation with the United Nations Environment Program/Convention on the Conservation of Migratory Species of Wild Animals, Secretariat in Bonn, Germany). Some of these have been disbanded now, having served their purpose, and other groups (such as one covering the Mediterranean Sea) have been established. The names and addresses of contact persons for all working groups are given at the end.

Contact persons have been set up in each European member country, where appropriate, to facilitate the dissemination of ECS material to members, sometimes carrying out translations into the language of that country. Their names & addresses are given below.

A newsletter is produced three times a year for members, reporting current research in Europe, recent publications & abstracts, reports of working groups, conservation issues, legislation & regional agreements, local news, and cetacean news from around the world.

There is an annual conference with talks and posters, and at which the annual general meeting is held. The results are published as annual proceedings, under the title *European Research on Cetaceans*. Besides the present volume, ten others have been published for conferences held in Hirtshals (Denmark) in 1987, Tróia (Portugal) in 1988, La Rochelle (France) in 1989, Palma de Mallorca (Spain) in 1990, Sandefjord (Norway) in 1991; San Remo (Italy) in 1992, Inverness (Scotland) in 1993, Montpellier (France) in 1994; Lugano (Switzerland) in 1995, and Lisbon (Portugal) in 1996. 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). Send cheques together with membership details to: European Cetacean Society, Mrs Ines Westphal, Deutsches Museum für Meereskunde und Fischerei, Katharinenberg 14-20, D-18439 Stralsund, Germany.

Membership fees can also be paid by **credit card** or **transferred directly** to the following ECS-account: Dr Roland Lick, Treasurer, ECS, Postbank Hamburg (FRG), Account No. 789584-205, Bank Code 200 100 20 (giving your name and calendar year for membership fee.) Payment in excess of the membership fee will be gratefully received as a donation to the Society.

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