EUROPEAN RESEARCH ON CETACEANS - 9

PROCEEDINGS OF THE NINTH ANNUAL CONFERENCE OF THE EUROPEAN CETACEAN SOCIETY, LUGANO, SWITZERLAND

9-11 FEBRUARY 1995

EDITORS: P.G.H. EVANS & H. NICE

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INTRODUCTION

The Ninth Annual Conference of the European Cetacean Society was held in Lugano, Switzerland between 9th and 11th February, 1995. It was attended by 270 persons from 21 countries. The Society is very grateful to Beatrice Jann and her team of assistants for organising such an enjoyable and successful conference, and to the following generous sponsors: Department of Territory of the Canton of Ticino, the Environmental Commission of the Swiss Diving Federation, Worldwide Fund for Nature, CIM (Computer Integrated Manufacturing), Telecom Switzerland, Europe Conservation, Air Canada, and the town of Lugano.

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. No external refereeing has taken place and much of the material presented here it is hoped will eventually be formally published in greater detail in scientific journals.

I have tried to arrange the abstracts broadly by subject, and for this reason, the invited key note lectures are slotted into appropriate spots through the volume. I would like to take this opportunity to give warm thanks to the invited speakers, some of whom came a great distance to address the society: Chris Clark and Bill Watkins from the United States, John Ford from Canada, and David Goodson and Jonathan Gordon from England. The theme that invited speakers were asked to address was "The Acoustic World of Cetaceans".

Finally, I should like to thank Helen Nice for her invaluable assistance with the typing and editing of these proceedings. Unless one has been directly involved with such a job, one does not appreciate the three to four hundred hours that are devoted to this task, and I am very grateful to Helen for the sterling support she has given me.

Peter G.H. Evans

THE APPLICATION OF US NAVY UNDERWATER HYDROPHONE ARRAYS FOR SCIENTIFIC RESEARCH ON WHALES

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INTRODUCTION In 1992, the US Navy initiated the Whales '93 programme which permitted very limited access to acoustic data from the Integrated Undersea Surveillance System (IUSS) for environmental monitoring. This extraordinary programme has provided the opportunity to evaluate the potential use of these acoustic data for basic research on baleen whales that produce loud, low-frequency sounds. Specifically, the focus has been on the application of these facilities for better understanding of seasonal and geographic distributions, estimating relative abundance, deducing acoustic functions for sounds, and evaluating the potential effects of human-made noises (Clark, *et al.*, 1993; Gagnon and Clark, 1993; Clark, 1994, 1995; Mellinger and Clark, in press).

MATERIALS AND METHODS The major source of data comes from the north Atlantic Ocean (>10,000 h) with particular emphasis on the western North Atlantic. Smaller amounts (c. 1,000 h) have been collected from the North Pacific and eastern North Atlantic.

The vast majority of biological signals can be attributed to four species of baleen whale: blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), and minke whales (*Balaenoptera acutorostrata*). A small set of low-frequency biological signals of unknown origin, but with characteristics somewhat similar to those from the identified species, have also been recorded.

The position of a vocalising whale is determined using either time-difference fixing methods or by the intersection of the beams from two or more arrays registering the identical sequences of sounds from the whale.

RESULTS **Blue and Fin Whales** From a seasonal perspective, the results indicate that blue and fin whales are acoustically active throughout the year with the period of absolute peak activity occurring in the winter months. In the northern latitude region (>50° N), the period of peak activity is July-August. In the mid-latitude region (40-50° N), the period of peak activity is October-November. In the southern latitude region (<40° N), the period of peak activity is January-February. Fig. 1 illustrates monthly levels of detections for the northern and southern regions for some of the blue whale data. Here, the term detection does not refer to the detection of a single blue whale sound. Instead, it refers to a series of sounds (>2 h) from a vocalising blue whale whose position in the ocean was determined acoustically. In many cases, the whale was acoustically tracked for many hours or many days. Previous descriptions of seasonal vocal activity for blue and fin whales have been presented by Thompson and Friedl (1982) for the Hawaiian Island region, and by Watkins *et al.* (1987) for the Bermuda Island area.

Blue whales in the Northern Hemisphere produce sounds with generally similar features (Edds, 1982; Thompson and Friedl, 1982). Common sound types include: long, constant frequency (CF) moans; long, frequency-modulated (FM) moans; and long, amplitude-modulated purrs. All such sounds typically have durations of 5-25 s with fundamentals below 25 Hz, although in the Pacific, harmonics are usually emphasised. Occasionally various mid-frequency (30-100 Hz) FM signals occur in coincidence with sequences of blue whale infrasonics, with the resultant overall pattern suggestive of song. Fig. 2 illustrates three geographically distinctive sound types and patterns for blue whales in the Northern Hemisphere.

Fin whales in the Northern Hemisphere also produce sounds with generally similar features (Watkins *et al.*, 1987), but a much greater variety of call structures has been recorded than previously reported. Most sounds are FM down-swept infrasonic pulses below 25 Hz, lasting about one second. However, constant frequency pulses in the 17-19 Hz band and FM up-swept pulses in the 120-150 Hz band are common in the northern region. Most North Atlantic fin whale pulses are in the 19-25 Hz band, whereas North Pacific fin whales often produce pulses in the 15-20 Hz band. For both species, various combinations of these basic sound types occur in deliberate, patterned sequences usually lasting 7-15 minutes, and these sequences are repeated in bouts lasting up to many days.

Minke Whale Sounds from minke whales are detected in the southern region of the North Atlantic during the October - May period (Winn and Perkins, 1976). Peaks of activity change throughout the season as a function of sub-region, with the general pattern that the sub-region of greatest activity moves from south-east to north-west (Clark 1994).

In general, all sounds attributed to minke whales consist of rapid sequences of short (< 200 ms) pulses, with the sequence lasting about a minute, and two types of pulse sequences are most common. In one type, the pulse rate starts fast and ends slow. In the second type, the pulse rate starts slow and ends fast. Pulse sequences occur over a wide frequency range, and there are many variations of the pulse rate. Pulse sequences often occur in pairs with sequence pairs separated by several minutes. Pulse sequences (both paired or unpaired) with nearly identical features are usually repeated regularly every 6-12 minutes.

Since very few simultaneous visual sightings and acoustic recordings of minke whales have been obtained, there is still some question as to whether the source of the pulse sequences, as described above, is really a minke whale. However, these sounds have now also been recorded in parts of the Atlantic and Pacific in areas with known seasonal concentrations of minke whales.

Humpback Whale Humpback song is routinely detected in the southern region of the North Atlantic during the November-April period. It should be noted that these detections all occur in deep water areas. Singing is persistent; song structure appears to be normal; and single animals have been recorded singing continuously for up to 36 hours.

On 15 January, 1995, two singers were recorded in the high latitudes (> 70° N) of the North Atlantic, and the two songs were not the same.

SUMMARY The recent, limited availability of bioacoustical data from existing military hydrophone arrays provides an absolutely exceptional vista into the low-frequency sound environment of the deep ocean. Based on the initial results from the Whales '93 programme, it is clear that the potential gains for basic science, scientific conservation, and environmental monitoring are extraordinary. Every attempt must be made to maintain access to these data, archive the relevant portions, and establish a permanent facility for the collection of the material so that it can be utilised for constructive improvement of the ocean habitat.

Sound Archive and Availability In an effort to promote the distribution of representative samples of baleen whale sounds, the Cornell Bioacoustics Research Programme has established a sound database referred to as Moby. Access is through the internet (Mellinger and Clark 1994; machine: ornith.cornell.edu;place:/pub/moby), and a Bioacoustics group has been established via e-mail (listproc@cornell.edu, subscribe:bioacoustics-1). The U.S. Office of Naval Research has also funded the production of seven compact discs (CDs) containing sounds from all four species. There are two CDs for blue whales, two CDs for fin whales, two CDs for minke whales, and one CD (called "Whales '93 Greatest Hits") containing the clearest examples of all four species. These CDs can be obtained by writing to Dr. Robert Gisiner, Office of the Chief of Naval Research, Code 341, Ballston Center, Tower 1, 800 North Quincy Street, Arlington, VA 22217-5660.

ACKNOWLEDGEMENTS Special access to selected underwater listening devices was provided by the U.S. Navy. Very special thanks go to: Dennis Conlon, Kirk Evans, Chuck Gagnon, John Parrish, Lysa Olsen, and the many other members of the Navy's IUSS community who made this all possible. Significant data collection was assisted by Chuck Gagnon and Clyde Nishimura, while sound analysis and mapping was accomplished by Kathy Brese, Jennifer Colby, and David Mellinger.

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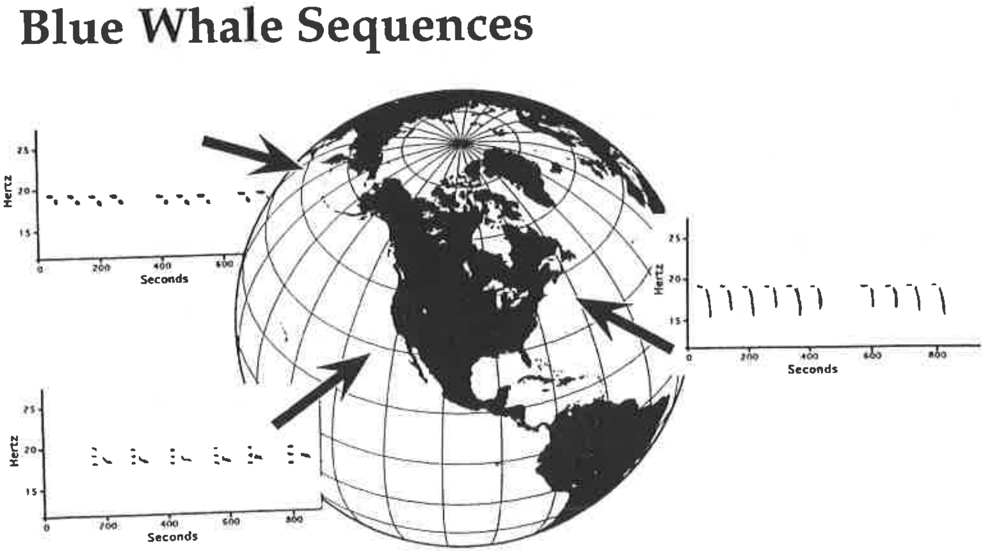

Figure 1. Monthly acoustic detections of blue whales in two different areas of the north Atlantic for the period January 1993 through September 1994 .

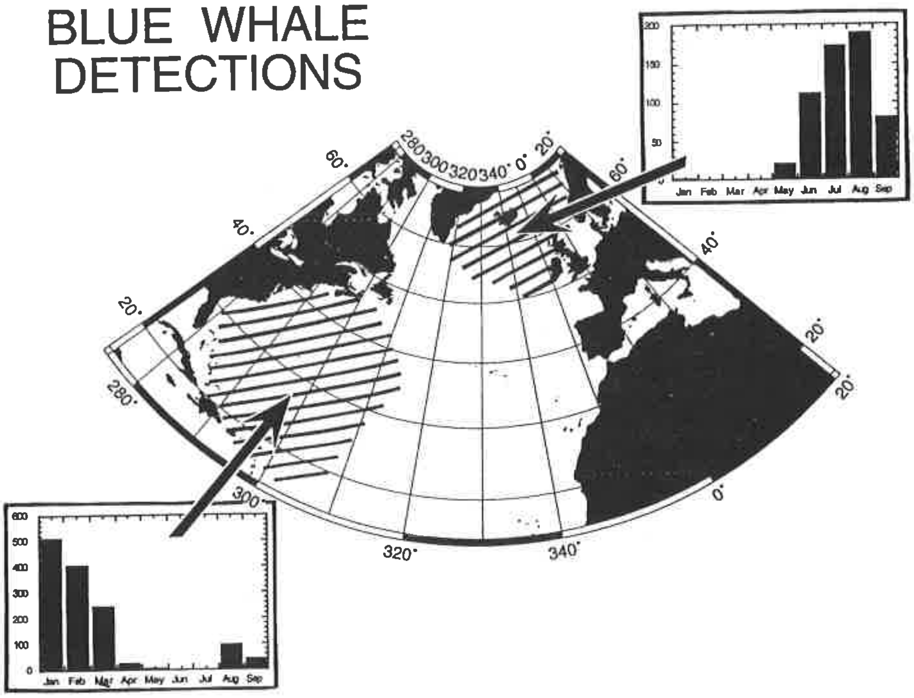

Figure 2. Exemplars of three different structures for blue whale infrasonic sound sequences as recorded in the northern Hemisphere. The three structures are representative of the typical patterns seen in the three general regions, north Atlantic, eastern north Pacific, and western north Pacific.

FIN WHALE SOUNDS

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One of my first research assignments in 1958 dealt with an underwater sound mystery of considerable magnitude. Navy personnel, geophysicists, and oceanographers of several nationalities had discovered underwater sounds that were apparently characterised by precisely repeated sequences at 20 Hz, precise signal duration, precise repetition rates, and uniformly high levels. The sounds were particularly audible on bottom mounted or deep hydrophone systems; they were heard in different locations for periods of hours, days, or even weeks, and their source was a mystery. People were convinced that these were man-made signals being propagated from considerable distances. I was given the job of tracking down the signal. When I suggested that it might be produced by a whale, I was told that the signal was much too precise to be biological. I began listening to the sounds, going to sea in ships and aircraft, and developing special techniques for working with these low-frequency signals.

I found that, with care, the signals could be heard and tracked from surface ships: they were more variable than originally thought, and usually I found that there were fin whales (*Balaenoptera physalus*) nearby. This probably should have been enough to put the controversy to rest, but the physicists and military were not easily convinced, and instead, the search for the source of the 20-Hz signals was made classified and given added importance - making it difficult to publish results, but providing good support for whale studies.

I listened from fixed hydrophone arrays, and we occupied the air space above these installations, for example off Nova Scotia where we spent weeks flying in circles above a marker buoy in an area that was reported to have these sounds only a few days each year. This effort was rewarded finally by the arrival of a small group of fin whales, calling loudly. Also, I worked with tracking arrays in shallow water where I could match the movements of fin whales with their sounds. I followed signal sequences with ship deployed directional systems. I worked with geophysical and military towed systems, sonobuoys and a variety of broadband equipment at the surface and at various depths. All of these consistently led me to vocalising fin whales.

I used bottom-mounted surveillance arrays and a variety of geophysical systems to analyse the occurrence, distribution, and patterns of these sounds in particular regions. We found similar signals in all oceans, from the tropics to the wintertime polar ice-edge. The most complete assessment was our analysis of the sounds from a local area off Bermuda where sounds had been recorded continuously, every day for more than 25 years.

Fin whales produce two categories of vocalisations: (1) the "20 Hz" pulse series, and (2) a wide variety of social sounds. The best known fin whale sounds are the long, repetitive series of "20 Hz" pulses, that appear to be produced seasonally by males, and seem to serve as reproductive acoustic displays, or "songs" (analogous to the song of the humpback whale, or the song of the bearded seal). These long, stereotyped sequences of 20-Hz pulses are heard only from slightly smaller whales separated from others, and spaced a few km from other singing whales, never from the largest (females in this species), and never from whales accompanied by calves. These long, patterned 20-Hz sequences stop when another whale approaches the singer, especially if a female comes by, or when the vocalising whale is disturbed, for example by a passing boat.

The temporal patterns of repetition for the 20-Hz pulses are very similar from all of the vocalising whales in an area, but they vary from year to year, and different areas have different repetition patterns (analogous to the humpback song). For example, a common pattern for the waters off Cape Cod, Massachusetts, is a 7-sec, 11-sec alternating interval between pulses, while the pattern off Bermuda is 12-sec, 12-sec. These pulse sequences are typically produced in long bouts, often in 20-min increments with 2-3 min intervals that often coincide with breathing, and bouts that continue for 30 hrs or more when the whale has no company and is undisturbed.

The distances over which we have noted apparent responses by the whales to these sounds, and the distances that our hydrophones have been able to effectively receive the sounds are limited to about 30 km, at best. Local sound propagation characteristics usually limit ranges to shorter distances than this. There is no evidence for longer range communication. Sound transmission via the deep sound channel, as is often suggested, requires that both sender and receiver are at the sound channel depth (normally below 1,000 m) which does not fit the behaviour of these whales. Although these sounds could also propagate over the 65-km convergence-zones which may occur in the deep ocean, we have found no evidence for whale communication over such distances. Reliable transmission of the sounds appears to be limited to relatively short distances by the effects of local water depth close to shore, and by ambient noise and horizontal propagation in deeper water. These sounds are usually produced within 10 m of the surface: consequently, the effects of near surface sound propagation and multipath may often be noticed.

The "20 Hz" sounds were so named because bandpass filters set at 20 Hz were often used to separate them from other ambient noises. There is considerable variability in these sounds from different whales, ranging from about 17 to 30 Hz, but they are often similar over large geographic areas. A common form in the north-west Atlantic is a 1-sec down-sweep, starting at about 23 Hz and ending at about 18 Hz. The amplitude of the sound rises during the first third, remains high during the middle third, and falls during the final third. In addition, the frequency drops more rapidly during the first half of the sound than during the second half, so that there is most energy at 20 and 19 Hz. Similar, but shorter, series of two to about 20 of the same types of "20 Hz" pulses may also be heard from both males and females, year around, often in apparent communication over longer distances, up to about 30 km.

Social sounds, distinct from the 20-Hz series, are produced by both males and females, often during interactions at close range - 2 km or less. These social sounds may be heard at any time of year, but are most often produced during shared activities, such as feeding. These sounds are of somewhat higher frequency, ranging from about 40 Hz to a little over 100 Hz. They are also shorter, typically lasting about 0.5 sec. Social sounds appear to be distinctive to individuals over periods of a few hours, at least, and they normally are repetitive with two or more sounds produced within 10 sec by each vocalising whale. Since the social sounds are heard more randomly, and they are at a much lower level, they have not been so consistently studied, and their uses by fin whales are less known.

A third, poorly understood category of sound associated with fin whales is that of apparent hydrodynamically generated sound. When close to fin whales, a variety of other low-frequency sounds may be heard which have frequencies mostly below 40 Hz. However, it is evident that these are not vocalisations, but are associated with whale movements, and related to water pressure differences caused by the whale activity. The pressure variations are translated by our hydrophones into equivalent acoustic patterns. Different whale behaviours, such as feeding near the surface on schooled fish, result in sequences of hydrodynamic sound that are distinctive and recognisable.

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DIALECTS AND POPULATION IDENTITY OF KILLER WHALES OFF THE WEST COAST OF NORTH AMERICA

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Killer whales have complex social systems of vocal dialects that can be useful tools for determining population structure and identity. In the waters off the west coast of North America, two distinct forms of killer whales - *residents* and *transients*, have been studied over the past 20 years. These two populations are sympatric but do not mix, are morphologically distinct, and differ in behaviour, social organisation, and, especially, in diet preference. Residents appear to feed exclusively on fish, and transients on mammals. Recently, a third population of killer whales, provisionally named *offshores*, has been identified in this region. Although little is known of this population, offshore killer whales are also morphologically distinct: they typically travel in larger groups than do either residents or transients; and they have not been seen to mix with the other populations.

The 575 resident killer whales off British Columbia and southern Alaska form three separate communities of stable pods, as determined from association patterns. Each community contains one to four clans, which are sets of pods that have related vocal dialects. Each clan is acoustically distinct from any other, and I believe that these represent separate lineages in the matrilineally-structured resident society. Degrees of similarity and differences in dialects appear to reflect the recent ancestry of pods within clans. Dialects provide a very different and probably more accurate indication of the relatedness of different pods than do observed social associations. The 180 transient killer whales identified to date live in smaller, less stable groups than residents. These groups have smaller repertoires of calls than residents, and have very little dialect variation, which probably is a result of their social fluidity. Transients recorded from southern California or northern South-east Alaska all share the same basic dialect, which is distinct from that of any resident pod. A small, apparently isolated population of transients in Prince William Sound, Alaska differs acoustically from other transients. The population of about 200 offshore killer whales has yet another set of distinctive calls, although the details of dialect structure have yet to be determined. Studies to assess the genetic distinctiveness of acoustic groupings within and among populations are currently underway.

WHISTLES AS CLOSE RANGE EMOTIVE SIGNALS IN WILD KILLER WHALES (*ORCINUS ORCA*) OFF VANCOUVER ISLAND, BRITISH COLUMBIA.

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INTRODUCTION Social signals, indicating the emotional state of the signaller, are described as emotive signals (Jakobson, 1960). Their structure is often variable and graded. By contrast, signals used for location and identification of conspecifics are mainly stereotyped and discrete (Marler, 1967). Killer whales (*Orcinus orca*) produce both discrete and graded signals (Ford, 1989). So far research on killer whale acoustic communication has focused mainly on discrete calls (Ford, 1989, 1991). Whistles, characterised as variable pure tones, are poorly investigated, and their function in killer whale communication remains unclear. In this study, we examine the relation between whistles and behaviour.

MATERIALS AND METHODS Simultaneous underwater recordings and surface behavioural observations were made on resident killer whales in the Johnstone Strait, British Columbia from 25 July to 9 September, 1994. Sound recordings conducted by one of us (J. K. B. Ford) from 1978 to 1983 were included in the analysis. Recordings were taken from pods of the A-Clan (northern resident community). Whistles were analysed with the RTS and SIGNAL computer programs for sound analysis. A total of 281 one-minute samples were taken of different behavioural activities and vocalisations of killer whales. The behavioural activities were divided into the following categories: foraging, socialising, travelling, and beach rubbing. The number of sounds per animal per minute and the percent frequency of whistles during each of the behavioural categories were calculated.

RESULTS A total of 4,582 killer whale sounds were counted. 2,906 were discrete calls, 1,180 were whistles and 496 were variable calls. During foraging and travelling, resident killer whales produced mainly discrete calls. Whistles were rarely used (Figs. 1-2). During socialising, killer whales produced mainly whistles and variable calls (Fig. 3). The percent frequency of whistles was higher during socialising (55 ± 31%, n = 89) than during beach rubbing (20 ± 17%, n = 20), foraging (8 ± 14%, n = 99) and travelling (6 ±13, n = 73) (Fig. 4).

CONCLUSIONS During socialising, killer whales form groups in close body contact and engage in a variety of social displays such as breaching, chasing, rolling over each other, and sexual behaviour. We conclude from our study that in this behavioural context, whistles might serve as emotive signals indicating the emotional state of the signaller.

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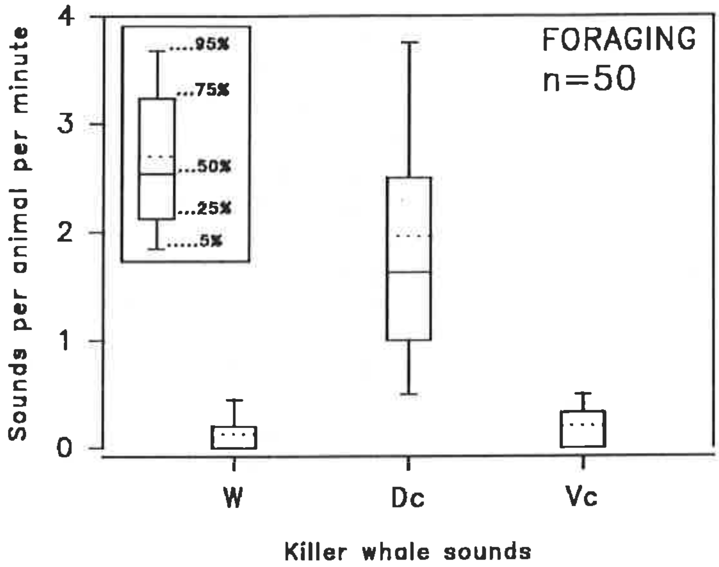

Fig. 1 Number of whistles (W), discrete calls (Dc) and variable calls (Vc) per killer whale from the A-Clan per minute during foraging in 1994. Bars represent interquartiles. Vertical lines represent 95% confidence interval. Dotted horizontal lines represent mean. Solid horizontal lines represent median. N = number of samples analysed.

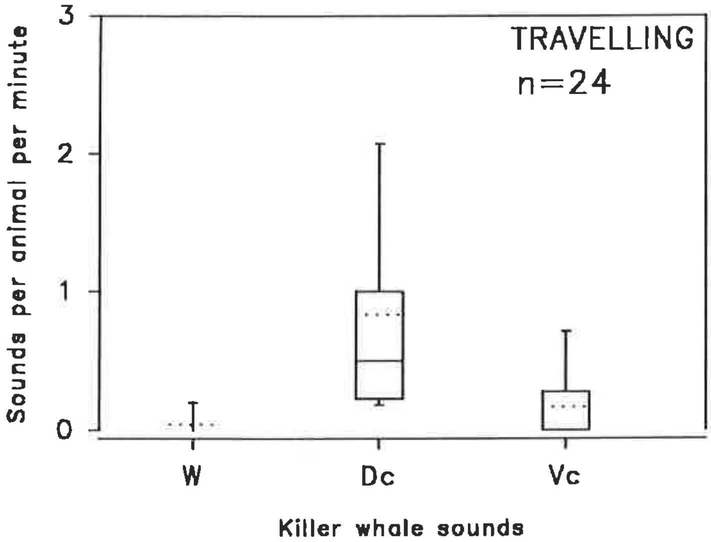

Fig. 2 Number of whistles (W), discrete calls (Dc) and variable calls (Vc) per killer whale from the A-Clan per minute during travelling in 1994.

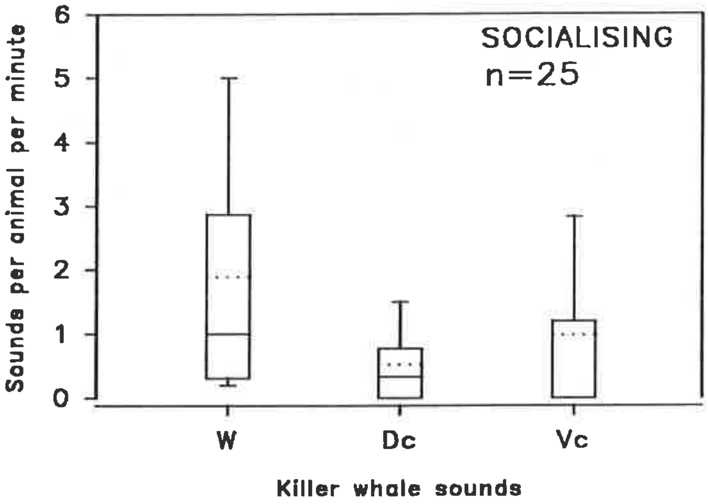

Fig. 3 Number of whistles (W), discrete calls (Dc) and variable calls (Vc) per killer whale from the A-Clan per minute during socialising in 1994.

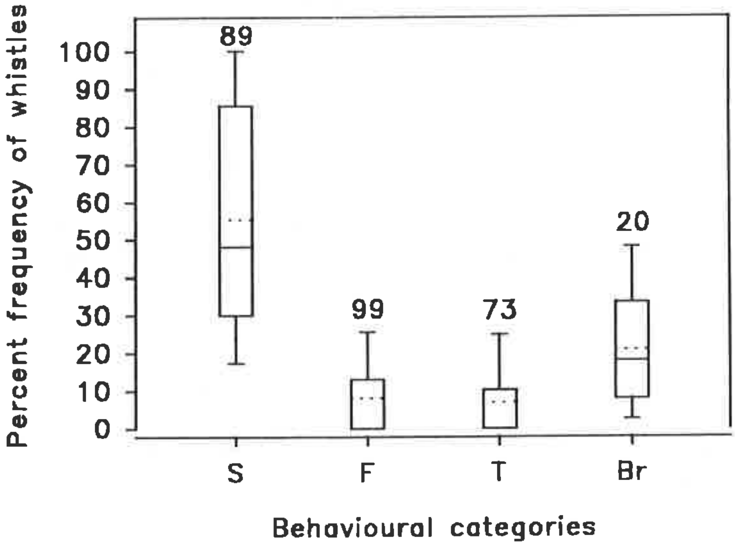

Fig. 4 Percent frequency of whistles of killer whales from the A-Clan during socialising (S), foraging (F), travelling (T) and beach rubbing (Br) between 1978-83 and in 1994. Numbers above bars represent numbers of samples analysed.

SPECTRAL ANALYSIS OF KILLER WHALE CALLS

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INTRODUCTION Using a cluster analysis classification method and spectral analysis, we have attempted to characterise a set of killer whale (*Orcinus orca*) calls, obtained from Johnstone Strait, British Columbia in August 1985. The main goal of this work was to investigate the great variety of calls that killer whales possess, in order to select and to use some of them in a dolphinarium experiment aiming to study the behaviour of dolphins under the effect of different sounds emitted by killer whales.

MATERIALS AND METHODS Our data consist of two recording sessions (lasting a total of 12 minutes) obtained during a cruise carried out in Johnstone Strait, British Columbia in August 1985, containing some clear series of killer whales calls from the A36 subgroup of the A1 pod (Ford, 1988). Killer whales were alone in their subgroup, which usually implies foraging or travelling behaviour, although no behavioural notes were taken at the time. A total of 103 calls were identified, but only 58 signals were used in the subsequent analyses, due to the high level of noise encountered in some parts of the tape, and the subjective choice of parameters we made for the classification analysis, which forced us to consider single calls only. Signals were analysed using the SONO software package, which produced spectra in the frequency domain. The main technical parameters of the SONO system are:

• maximum sampling frequency of input (output) of analog signals	- 250 kHz;
• minimum sampling frequency	- 35 Hz;
• number of time windows of dynamic spectrogram	- 150;
• number of frequency filters of the dynamic spectrogram	- 92

The sampling frequency used was 35 kHz. One kHz filter was used in order to eliminate most of the noise, which was mainly below this level, while few of the orca signals were in that range. Each signal was enumerated in temporal order and stored in data files in the form of successive samples (16 bit integer with sign).

In order to classify the resulting spectrograms, we identified a total of 26 parameters, ranging from duration of the signal to amplitude of the main tones (Fig. 1). A cluster analysis was performed on these calls, using a percentage similarity index and Ward's minimum variance method as agglomeration strategy.

RESULTS Cluster analysis revealed four main groups of signals, displayed by means of a dendrogram (Fig.2). The most discriminating parameters were the number of main tones (thereafter also named components) present in each signal and the appearance of "valleys" after each main tone peak (Δf_i). The first bifurcation in the dendrogram approximately divides calls with a high number of components (7-8, cluster 3) from signals with a lower one (mainly less than 6). Signals contained in cluster 3 (10 signals) are also characterised by a marked presence of peaks before the stationary part of the spectrogram, i.e. with a high Δf_i, increasing with frequency. This characteristic is also present in cluster 2 signals, but with a minor number of components involved. At a lower level of dissimilarity, we found clusters 1 and 4, which are marked by a nearly total absence of valleys after the main tone peaks. The main differences between these two groups may be found in the duration (shorter in cluster 4) and in the number of components (higher in cluster 1). The main detected characteristics of the four groups of signals may be summarised as follows:

a) Cluster 1 (20 signals): total absence of valleys after the main tone peaks - quite high number of main tones (5-7); long duration (average 1,172 ms) and Δt;

b) Cluster 2 (14 signals): marked presence of peaks before the stationary part of the spectrogram, increasing with frequency; quite low number of components (4-5) after the principal frequency;

c) Cluster 3 (10 signals): marked presence of peaks before the stationary part of the spectrogram, increasing with frequency; very high number of components (7-8); high duration;

d) Cluster 4 (14 signals): nearly total absence of valleys after the main tone peaks; low number of main tones (3-4); short duration;

Typical members of each cluster are displayed in Figs. 3-6.

CONCLUSIONS Our classification of the acoustic signals emitted by killer whales aimed to select some of them for experiments studying the escaping behaviour of dolphins under the effect of different sounds. Furthermore, we found that the great variety present in our data seems to confirm that the killer whale possesses a very complex and precise system of communication. Finally, our analysis may be used as a startpoint for additional investigations on the mechanism of the acoustic apparatus of killer whales.

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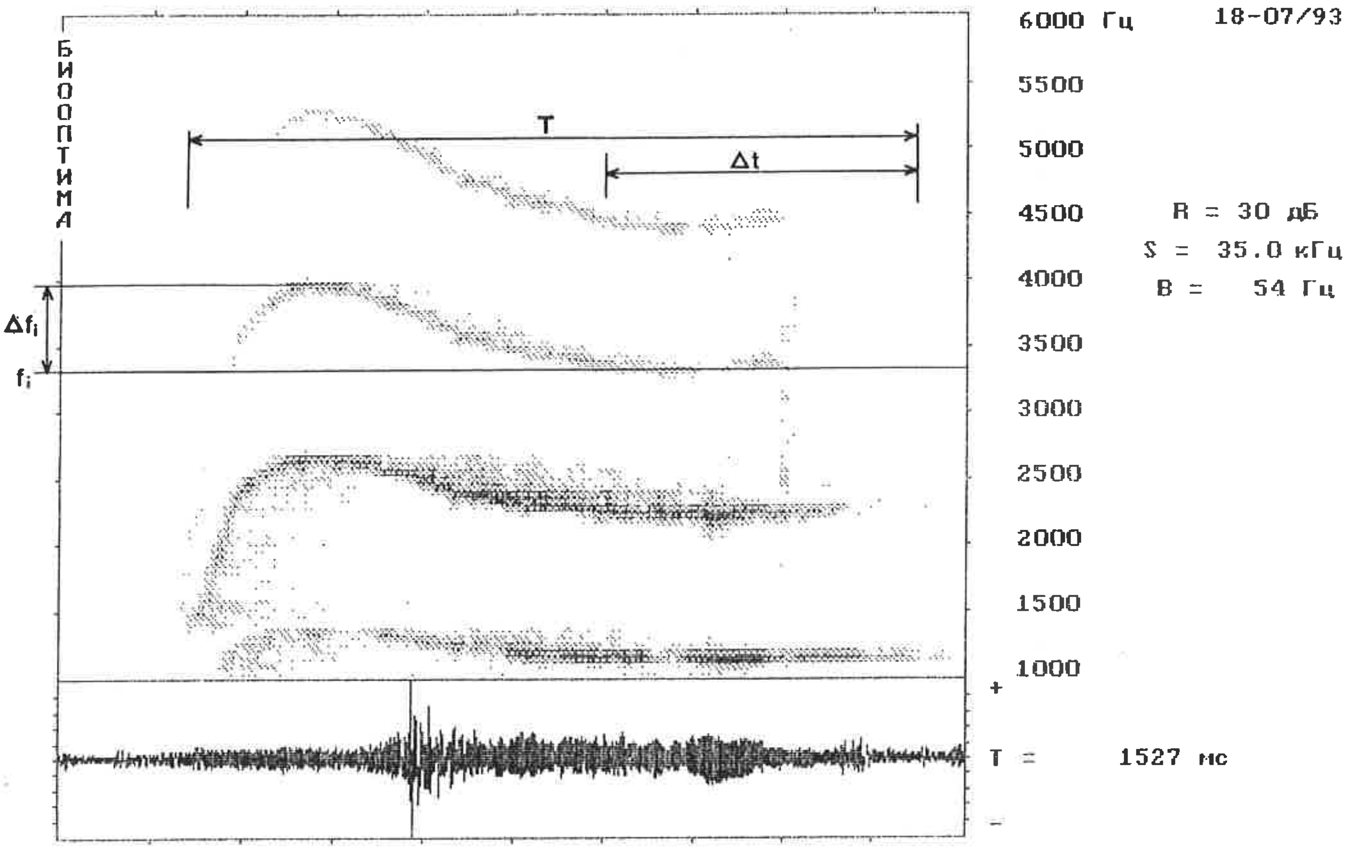

Fig. 1. The chosen parameterization of spectrograms

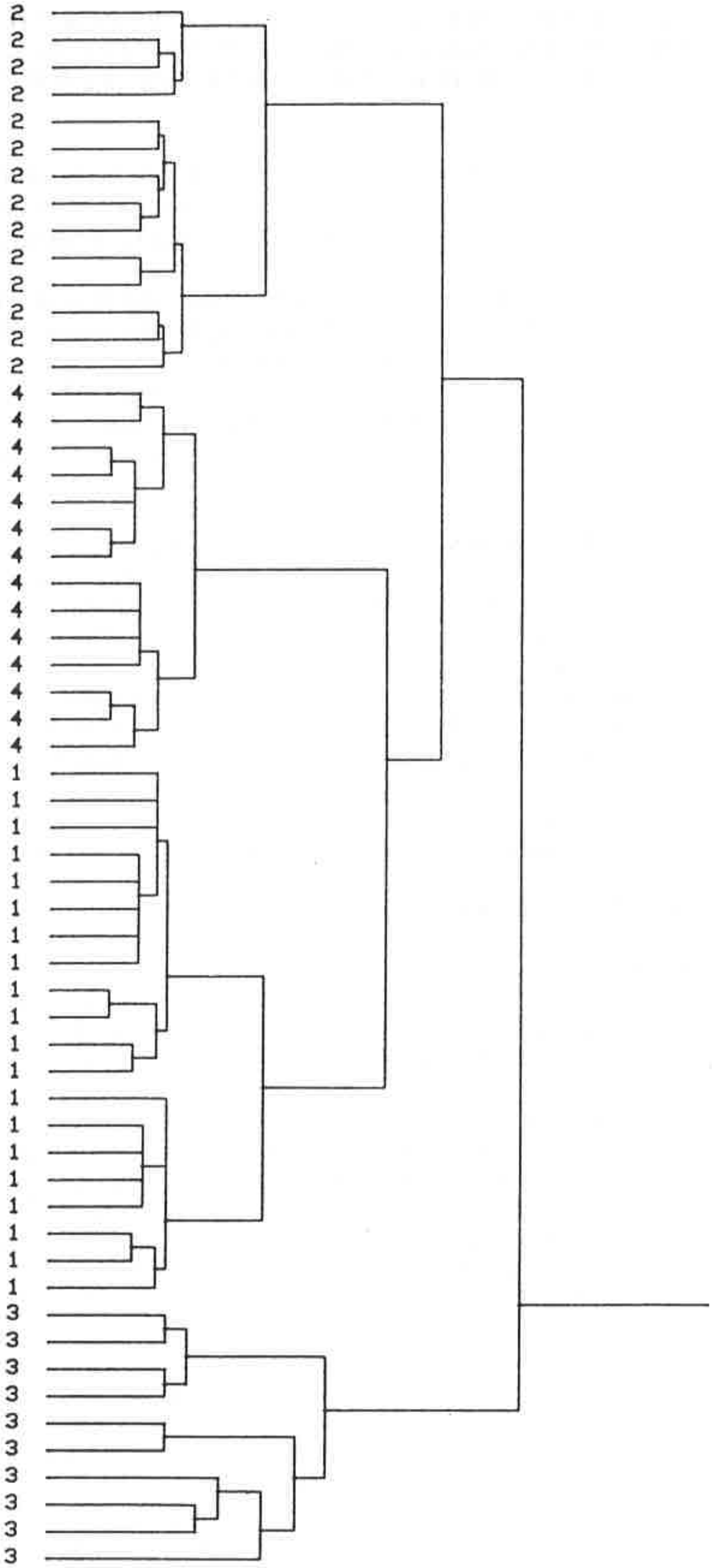

Fig. 2. Dendrogram resulted from Cluster Analysis.

PRELIMINARY RESULTS OF AN EXPERIMENT ON THE EFFECTS OF KILLER WHALE (*ORCINUS ORCA*) CALLS ON THE BEHAVIOUR OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

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INTRODUCTION The needs of the Mediterranean small pelagic fishermen do not seem to be compatible with the needs of the conservation of marine mammals (particularly dolphins). The small pelagic fishermen maintain that high numbers of dolphins in particular sea areas, have a negative effect on the abundance of pelagic fishes (sardines, anchovies, etc.), and simultaneously cause heavy damage to their purse seine nets, which are very expensive. From the other point of view, dolphins are killed by the fishermen both accidentally as by-catches and intentionally with shotguns. In this study, we present the preliminary results of an experiment from a more general project on the study of the interaction between dolphins and Sicilian fishery activities and on the acoustic-based possibility of repelling dolphins from particular areas. In the experiment, we used emitted sounds of killer whales together with some other control signals.

MATERIALS AND METHODS The experiments took place in the Moscow Dolphinarium of the Severtsov' Institute of Evolutional Morphology and Ecology of Animals, of the Russian Academy of Sciences, from 3-20 October, 1994. Sounds with intensities of up to 15 Pa/m were emitted using a tape recorder UHER Report L, amplifier Bruel and Kjaer (B&K) type 2650, and spherical piezo ceramic antenna with sensitivity 0.3 Pa/V/m in the frequency range 1-20 kHz.

The behavioural reaction of the dolphin was recorded by three independent observers who have great experience of behavioural study of dolphins. During the experiments, many factors were taken into account including such subjective behaviours as "saturation", "lassitude" and so on. The duration of the emission was usually from 6 seconds to three minutes; intervals between samples of one series were usually from 7-15 minutes; and between series during the day, from 1-4 hours. The sound intensity of emission had the following values: 1, 2.5, 5, 10, 25, and 40 Pa/m.

RESULTS The changes in behaviour of the study animal were observed in almost all samples; sometimes the behaviour changed after the sound was emitted. Stable, definite positive or negative reactions of the dolphin were not noted. The following behavioural reactions of the dolphin were defined during the experiments and marked with the following numbers:

1 Changing of the track of movement (usually the dolphin moved counter-clockwise):
  a) doesn't change (0);
  b) movement away from the transducer (1), towards the transducer (2);
  c) decreasing (5) or increasing (6) of the diameter of the track;
  d) changing the depth of swimming: near bottom (7), near the surface (8), or in the middle (9).

2 Reaction to the transducer:
a) pays no attention (0);
b) looking far from the transducer (2), looking near the transducer (4);
c) scanning in the direction of the transducer (6);
d) going towards the transducer (8).

3 Other behavioural reactions:
a) the speed of moving did not change (0), increased (1), decreased (2);
b) noisy behaviour: clicking via blowhole (3); snorting via blowhole (4); beating with the tail (5);
c) stopping near (6) or far (7) from the transducer;
d) rapid increase of the depth near (8) or far (9) from the transducer.

In some cases, both positive and negative reactions have been marked during emission of the same signal. Thus for determination of the signals most likely to affect behaviour, the methods of determinational and dispersional analyses have been used during the processing of the results. For qualitative and quantitative evaluation of the results of experiments, the behavioural reaction of the dolphin was determined as repulsion (or negative) - moving away from the transducer, or attraction (positive) - moving towards the transducer, and evaluation of the reactions in balls has been implemented. Processing of the results has been conducted separately for positive and negative reactions, and jointly using the signs "plus" and "minus". The main results remained the same but errors in the data and reliability of the results in some cases changed. Processed results of experiments are summarised in Table 1.

DISCUSSION AND CONCLUSIONS Determinational analysis of the results showed that more frequently negative reactions were demonstrated when signals No 3, 5, 7, 8, 9 were emitted, with the intensity corresponding to the sound pressure of 10 and 5 Pa/m. Positive reactions were demonstrated more often when signals 2, 5, and 7 were emitted. Dispersional analysis of the results demonstrated that the most consistent negative reaction of dolphins occurred during emission of signal No. 8. This signal consists of 6-sec recordings of sounds of some killer whales, two individuals are vocalising simultaneously with some echolocating clicks. The sonogram of this signal is shown in Fig. 1.

The following factors should be taken into account when evaluating the results of experiments: 1) The experiments have been conducted in a large, but shallow pool with concrete walls, without any sound attenuation; 2) The ability of the animal to demonstrate true reactions in the closed space of the pool is mainly lost; 3) The sounds of killer whales which are the stimulus of danger to natural prey such as bottlenose dolphins, could be unknown sounds to the individual caught in the Black Sea where killer whales have not been observed.

Considering the above, further experiments should be conducted that give the dolphins more scope to show their reactions to acoustic stimuli.

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Table 1 Results of experiments with varying factors of intensity and number of signals (in marks)

TYPES OF SIGNAL (see legend)

Intens. Pa/m	No. of signals	1	2	3	4	5	6	7	8	9	TOTAL
2.5	3 (+)	8	5	13	7	0	4	0	2	11	50
	3 (-)	3	0	0	9	5	8	0	3	0	28
2.5	6	0	0	2	1	1	7	2	2	2	17
	(+)	2	0	8	3	0	0	10	4	10	37
2.5	9	3	5	3	4	12	7	1	2	0	37
	(+)	1	0	0	0	1	0	9	3	0	14
5	3	0	4	0	2	8	4	3	2	9	32
	(+)	2	0	0	9	3	9	2	10	3	38
5	6	1	11	3	6	5	6	1	1	2	36
	(+)	9	0	0	0	8	0	8	3	8	28
5	9	6	11	1	4	7	4	2	10	9	54
	(+)	0	8	8	0	2	1	8	4	0	26
10	3	7	9	3	0	6	1	9	2	1	38
	(+)	0	10	8	3	0	1	0	9	3	34
10	6	5	10	2	8	13	2	2	6	2	50
	(+)	0	0	3	3	9	8	8	5	8	44
10	9	2	7	8	2	3	2	3	4	2	33
	(+)	8	0	3	8	0	8	5	9	9	50
Total	(+)	32	62	35	34	55	37	23	31	38	347
	(-)	25	13	30	35	20	35	50	50	41	299
	(+) + (-)	7	49	5	-1	35	2	-27	-19	-3	48
Means	(+)	3.6	6.9	3.9	3.8	6.1	4.1	2.6	3.4	4.2	4.3
	(-)	2.8	1.4	3.3	3.9	2.2	3.9	5.6	5.6	4.6	3.7
	(+) + (-)	0.8	5.5	0.6	-0.1	3.9	0.2	-3.0	-2.2	-0.4	0.6

Notes

1) Sound intensity varied as follows: 1-2.5 Pa /m; 2-5 Pa/m; 3-10 Pa/m.

2) Number of signals repeated during emissions were the following: 1-3 signals; 2-6 signals; 3-9 signals.

3) Types of emitted signals were the following: 1 - orca No. 76; 2 - orca No. 33; 3 - sturgeon No. 2; 4 - pure tone 2.4 kHz; 5 - indiv. *Tursiops truncatus*; 6 - orca No. 31; 7 - own signal of the "Grandfather"; 8 - orca No. 36; 9 - beating of two metal pieces.

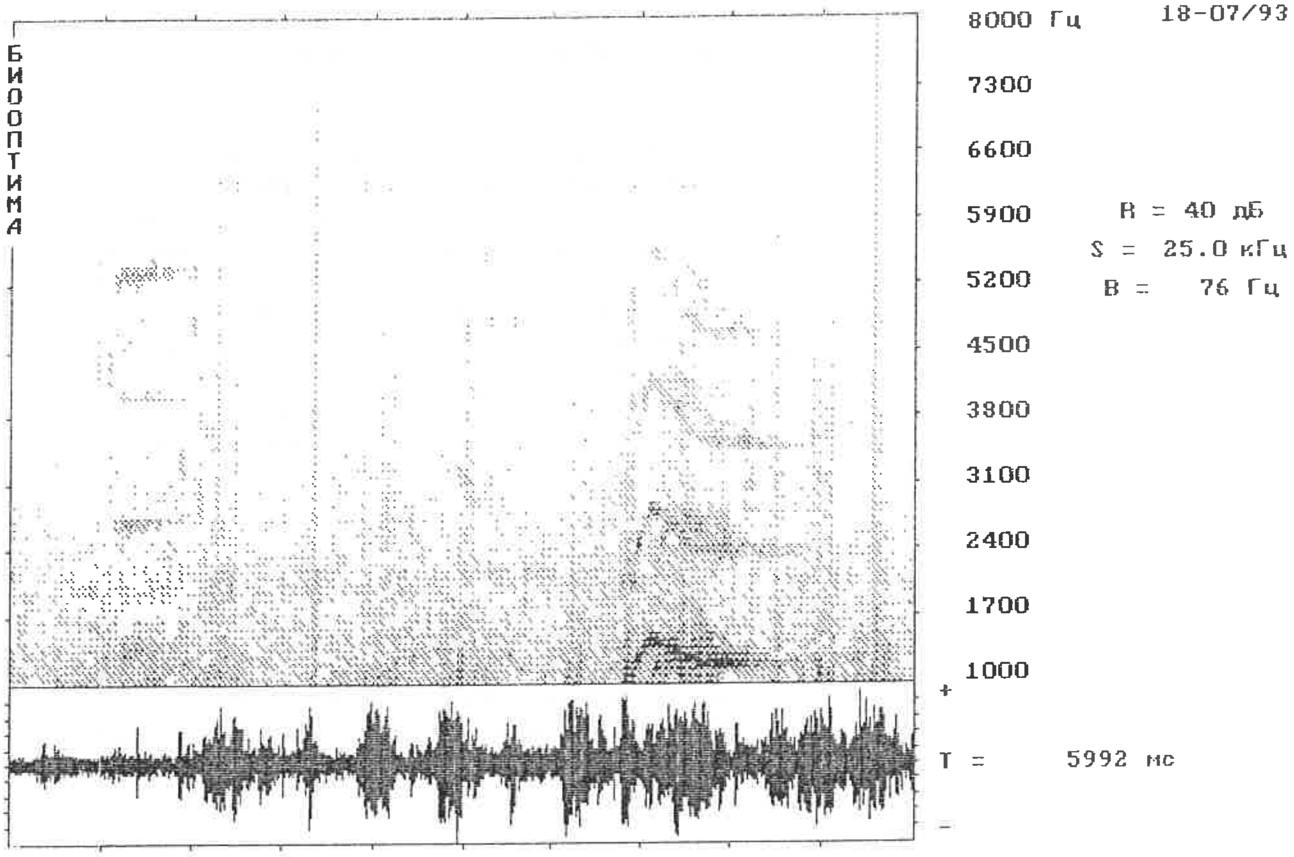

Fig. 1. Sonogram of the signal N. 8 - orc36

A COMPARISON OF KILLER WHALE CALLS FROM NORWAY, BRITISH COLUMBIA AND ICELAND

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INTRODUCTION Killer whale (*Orcinus orca*) pods have distinctive vocal repertoires composed of discrete calls (Ford, 1991; Strager, 1995). The repertoire of discrete calls produced by a whale does not seem to be genetically transmitted. However, the degree of call-sharing does seem to indicate genetic relationships since calls are transmitted by learning, primarily from mother to calf (Bowles *et. al.*, 1988). Different vocal repertoires are thought to be created gradually as pods grow bigger and sub-groups within the pod spend less and less time together (Ford, 1991). Differences in the vocalisations due to mistakes or innovations get fixed in the call repertoires and the repertoires drift apart. For these reasons, Ford (1991) suggests a direct relationship between the common ancestry of different pods and the degree of similarity of their vocal repertoires: the more distant the common ancestry between pods, the fewer calls will be shared in their repertoires.

Ford's hypothesis concerns the development of vocal repertoires of killer whale pods. We suggest that a similar hypothesis can be applied at the level of populations as well. Most of the work on killer whale vocalisations so far has concentrated on the vocal repertoires of groups within a geographical area. In this study, we searched for geographical variation in vocalisations among killer whales from different parts of the world. The hypothesis tested was that common ancestry between killer whale groups will be reflected not only in the amount of calls shared between them, but also in the degree of similarity in the structure of their vocalisations.

It is known that northern and southern resident whales from British Columbia are genetically very closely related to each other, and very distantly related to Icelandic whales (Hoelzel and Dover, 1991). Nothing has yet been published about the genetic relationship of Norwegian killer whales. However, one might expect Icelandic and Norwegian killer whales to be closely related because Iceland and Norway are quite close to one another, and killer whales from both areas feed on the North-east Atlantic stock of herring that sometimes migrates between Norway and Iceland. Furthermore, one killer whale photo-identified in Iceland in 1987 was re-sighted in Norway in 1988 (Similä, pers. comm.).

METHODS Call catalogues of killer whales from British Columbia, Iceland, and Norway were compared to correlate acoustic and genetic relationships. The comparisons of calls were made at two levels: 1) call matches were searched among the different catalogues; and 2) statistical analyses were performed on three acoustical characteristics of the calls (total duration, number of call components, and the presence or absence of an overlapping tone). The statistical tests used were a t-test (for total duration of calls and number of call components) and a chi-square test (for presence or absence of overlapping tone). The description of the Norwegian calls that were used in this comparison was taken from Hanne Strager's catalogue of killer whale calls (1993). The information on calls from resident whales from British Columbia was taken from John Ford's catalogue (1987); calls from northern and southern resident whales were pooled. Measurements on calls from Iceland were taken from Moore *et. al.* (1988). The database consisted of 89 call types from British Columbia, 33 call types from Norway, and 31 call types from Iceland. Each call type is described as the average of measurements made on several different recordings of the same call.

RESULTS AND DISCUSSION The average of the mean duration of calls was 0.79 s (SE = 0.03) for British Columbia, 1.20 s (SE = 0.06) for Norway, and 1.17

s (SE = 0.08) for Iceland. The Canadian calls were significantly ($p < 0.001$) shorter than both the Icelandic and the Norwegian calls, while the Norwegian calls and the Icelandic calls were not significantly different from each other. The average number of call components was 2.54 (SE = 0.1) for British Columbia, 1.97 (SE = 0.15) for Iceland and 1.81 (SE = 0.14) for Norway. Canadian calls had significantly ($p < 0.01$) more components than both Icelandic and Norwegian calls, while the Norwegian and Icelandic calls were not significantly different from each other. The percentage of calls with an overlapping tone was 45 (SE = 11) for British Columbia, 33 (SE = 8) for Iceland and 40 (SE = 7) for Norway. There were no significant differences found for the percentage of calls with overlapping tones among any of the three geographical areas.

All except two calls were area-specific. One call was shared between British Columbia and Norway. This call has a relatively simple structure and the most likely explanation for its occurrence in two geographically isolated areas is that it has evolved independently in the two populations. One call was shared between Norway and Iceland. The structure of this call is quite complex, thus suggesting that killer whales from Iceland and Norway are or have been in contact, since it is less likely that very complex identical calls evolve independently.

In summary, discrete calls produced by Icelandic and Norwegian killer whales are similar to each other and different to the ones produced by killer whales from British Columbia, at least with respect to the chosen acoustical parameters used in this study. We conclude that acoustical comparisons can be a useful tool to study population identity. Our results support the hypothesis that not only calls, but also different features of the calls, such as duration and number of components may be used to reveal relationships among populations.

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ACOUSTIC COMMUNICATION OF NORWEGIAN KILLER WHALES, *ORCINUS ORCA*, DURING COMPETITIVE GROUP INTERACTIONS

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The acoustic communication of killer whales is likely to have various functions for the social relationships within each group of whales. In accordance with other species of social mammals, such as wolves and mangabeys, acoustic signals might also be of importance for interactions between groups. The possible influence of acoustic repertoires upon competitive behaviour between Norwegian killer whale groups has been analysed, and it was hypothesised that tolerance would be expressed between whales that normally share the same home range, thereby familiar with each other's vocalisation, and that competitive events would arise if acoustic "strangers" had entered the area.

Acoustic recordings were obtained in the wintering fjords of herring in northern Norway where approximately 500 killer whales regularly reside from October to the end of January. Different groups of killer whales are usually observed to feed independently of each other within close range. Two group interactions contrasted this usual tolerance. These were termed "feeding patch take-over" and "forced retreat". The acoustic signals produced by the whales during these interactions were compared with the ones produced by killer whales repeatedly photo-identified along the Norwegian coast. Signals were thereby considered as either known as typical for the local population, or not.

Only signals classified as "discrete calls" were subject to analyses on a Kay Elemetric DSP Sona-Graph, and 1,471 calls were considered to belong to any of 29 different versions of discrete calls. Since three out of four groups involved in the two interactions had local variants of calls in their repertoires, such inter-group competition does not seem to require "intruding" whales with an unfamiliar vocalisation as was defined in these analyses.

Definitions of competitive behaviour and population-specific calls are discussed further, as well as the recent alteration of the winter migration of herring into one concentrated area along the Norwegian coast.

SPERM WHALE ACOUSTIC BEHAVIOUR

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INTRODUCTION Sperm whales live in a medium that transmits light rather poorly, and feed at depths to which little or no sunlight penetrates. By contrast, seawater transmits sound very well; indeed sound propagates through water more efficiently than any other form of radiated energy (Urick, 1975). It is not surprising, therefore, that sperm whales are amongst the most acoustically oriented of animals, making vocalisations of one form or another for most of their lives. They probably use these sounds to find their prey, to navigate underwater, and to communicate.

TYPES OF VOCALISATIONS On first acquaintance, sperm whale vocalisations are disappointingly monotonous. They only make impulsive "click vocalisations" (Watkins, 1980), but these can vary qualitatively and can be made in a number of distinct patterns. Analysis of sperm whale vocalisations can also provide clues to the type of whales vocalising, and to their behaviour. Sperm whale vocalisations can be considered in the following categories:

Regular Clicks During their deep feeding dives, sperm whales emit long sequences of loud clicks at fairly regular rates, typically at between one and two clicks per second. Bouts of regular clicking are broken by short silences and "creak" vocalisations (described later).

"Regular" clicks have frequencies ranging from less than 100 Hz to over 30 kHz, and within this range there are certain emphasised frequencies. Emphasised frequencies can vary from whale to whale, and even between clicks in a sequence. Sperm whale regular clicks seem to be rather poorly directional. Higher frequencies are attenuated more by sea water than lower ones. Thus, Watkins (1980) reported that, in recordings from whales at close range, higher frequencies (10-16 kHz) were emphasised, while, in recordings of more distant whales, the emphasised frequencies were around 4 kHz. Source levels measured for sperm whale "regular clicks" have ranged as high as 180 dB re 1m Pa @ 1m (Watkins, 1980). Sperm whale regular clicks can typically be heard at ranges of about 5 miles using fairly simple acoustic equipment (Leaper *et al.*, 1992).

Backus and Schevill (1966) noted that often individual sperm whale clicks were made up of several regularly spaced pulses that decreased in amplitude. They suggested that this burst-pulsed structure could serve to give sperm whale clicks a distinctive "acoustic signature", making their echoes easier to distinguish from other sources of background noise, including the clicks of other whales. Norris and Harvey (1972), on the other hand, suggested that the summation effect of several pulses would increase the size of the response elicited in the whale's auditory system, thus increasing sensitivity. (Clicks making up codas also have a pulsed structure. In fact some of the most pronounced examples of clicks with multiple pulses have come from whales at the surface.)

After a whale has fluked, both the whale's clicks, and their echoes returning from the sea bottom (1,000 or more metres away) can often be clearly heard on surface hydrophones. In these cases it can be determined that sperm whales click soon after the arrival of an echo from the bottom. In deep water, the whale may in fact be clicking after the echo of the click two clicks previously. This can be simply confirmed by hearing two echoes returning after a whale pauses and stops clicking. This would seem to be a strategy for increasing the rate at which information can be gathered using echolocation while still avoiding interference between echoes from small close objects and large distant ones.

Often a sperm whale's rate of clicking increases at a regular rate during the initial phase of a dive. Many echolocators are known to vocalise at roughly twice the travel time for sound between them and their targets. Thus, they increase their click rates as they approach an object. The increase in click rates during the initial part of sperm whale dives when they are diving vertically towards the bottom, are consistent with their known dive speeds (Gordon *et al.*, 1992), suggesting that, like other echolocators, they are increasing their click rate as they approach a major target.

During the middle section of dives, rates of clicking typically fluctuate in a regular way although occasional sudden doubling of click rates has also observed (Gordon *et al.*, 1992).

Creaks "Creaks" are rapid sequences of clicks, produced at rates of up to 220 per sec, and lasting for 10-25 s. Click rate usually increases during creaks. Creaks are typically made during long sequences of regular clicks (Gordon, 1987). Creaks generally sound much quieter than regular clicks. This may be because they are more directional and are not projected towards the surface.

The pattern of click rate during a creak is similar to that during echolocation runs made by bats and dolphins as they close on targets (Griffin, 1958). It has been proposed by Gordon (1987), and others, that they are made by sperm whales investigating targets at close range and may indicate feeding attempts. Gordon (1987) presented some observations that support this proposal. He showed that when sperm whales were being tracked with an echo-sounder they often showed a distinct change in dive rate while creaking. This could be interpreted as the whale diverting to investigate an object. The rates at which clicks were made during creaks, and the rates at which click rate increased were shown to be appropriate for an echolocating sperm whale closing with a target. Observations made by Ohlsohn (1991) during a detailed study of the vocal output of individual whales, can also be parsimoniously interpreted if creaks are assumed to be echolocation runs associated with feeding. She found that the rate of regular clicking increased before creaks (as though the whale was approaching an object of interest). Creak rates were higher in the last 3/4 of a dive and were higher during longer dives. Feeding activity might be expected to be less during the initial travelling part of a sperm whale's dive, and longer dives (which are likely to be physiologically expensive) might only be expected to occur when feeding conditions were good.

Thus, the nature of creak vocalisations suggests that they are echolocation runs, and various other observations are consistent with this. If creaks are indicative of feeding attempts, then creak rates could be used as an index of feeding activity in this species.

Rapid Clicks Sequences of rapid clicks, at rates of up to 80 per sec., are sometimes heard from sperm whales at the surface, often when whales seem to be investigating an object, such as a boat or swimmer (Norris and Harvey, 1972; Gordon, 1987). Gordon (loc. cit.) found evidence that these clicks were projected directionally and the emphasised frequency within successive clicks changed in a regular way. They too would seem to be a form of echolocation.

Clangs Clangs are very loud resonant clicks with a more limited range of frequency emphasis. They are typically heard in sequences, with low but precise repetition rates (eg once every 7 s). Clangs are the same vocalisations as the "slow clicks" reported by Weilgart and Whitehead (1988). They reported that hearing "slow clicks" usually correlated with the appearance of large males in the social groups of females and young sperm whales. However, clangs were first reported from Sri Lanka by Gordon (1987) and here they were often heard during the spring months when no mature males were ever sighted. In the Azores (Gordon, pers. obs.), clangs have only ever been attributed to large males at or near the surface. Ohlsohn (1991) reported that short sequences of clangs were often heard from single male sperm whales just before they came to the surface, while Gordon *et al.* (1992) regularly heard clangs from one particular male just before it surfaced. Mullins, *et al.* (1988) heard "slow clicks" from a single large male at the surface. Several observations suggest that sperm whales can only produce clangs when they are at shallow depths. It could be the case that a substantial volume of air is needed to fill the air spaces within the head to make such a resonant noise.

Codas Codas are distinctive stereotyped patterns of clicks. They were first reported as occurring at the end of long sequences of regular clicks by Watkins and Schevill (1977). However, they are most often heard from larger groups of socialising whales at the surface (Watkins *et al.*, 1985; Gordon, 1987; Weilgart, 1990). The function of codas is not known. They do not seem to act as individual identifiers as Watkins and Schevill (1977) originally proposed, but they may have some other role in acoustic communication.. Weilgart (1993) classified over 1,000 codas recorded from sperm whales in the Galapagos, and elucidated some rules underlying the structure of codas and their patterns of use. She distinguished 23 types of codas that were either "regular codas" (all click intervals equal in length) or "irregular" (usually with one or two delayed final clicks). When codas overlapped, some types were more likely to lead than others, and some codas appeared to initiate bouts of coda production.

If codas are a form of communication then the information they convey is probably coded in the pattern and rhythm of the clicks that make them up. This is unusual in animal communication where frequency modulation is more typically important. This unusual form of communication may have evolved because it is an efficient means of transmitting information through the marine environment or it could be that the sperm whale vocal system is constrained to only be able to produce clicks.

Trumpets A trumpeting type of vocalisation is occasionally heard, usually just after a whale has dived and before it starts clicking. The vocalisation has no obvious function and may merely be made as the vocal system is prepared for use - the sperm whale equivalent of clearing the throat.

FUNCTION It is likely that the function of most of the sperm whale's vocal production is echolocation. It seems that they have two different echolocatory modes. Typical, loud, poorly directional, regular clicks represent a low-acuity, broad-beamed system useful for locating major features such as the bottom, the surface, and perhaps large concentrations of prey. Creaks and rapid clicks represent a narrower-beamed, high-acuity system more typical of that found in other odontocetes, and used to investigate objects at short range.

Regular clicks may also have a role in communication, serving as contact calls to keep widely dispersed foraging groups together. In an earlier section, the interpretation of vocalisation patterns in terms of feeding and foraging behaviour was discussed. If this is correct, then it is likely that whales can achieve the same thing and, as a result, they will be sharing information on local feeding conditions with other animals over a very substantial area. One consequence of this would be to favour the development of co-operative foraging strategies. With simple equipment at the surface, whales can be typically heard at ranges of about 5 miles; on occasion we have heard them at tens of miles. Sperm whales are the only species that we know to be vocally active at the depth of the deep sound channel for long periods of time. Although their calls are not of a sufficiently low frequency to fully exploit the long-range propagation potential of the deep sound channel, Hiby and Lovell (1989) have calculated that, in the deep sound channel, sperm whales should be able to hear each other at ranges of 39 km. Some sounds, such as clangs, are probably much louder than regular clicks. The realisation that communication may be taking place at these sorts of ranges should lead us to revise our concept of what constitutes a group in a species like this.

Some vocalisations, such as codas, seem to be used principally for communication. As the "message" is probably coded in the patterns of the clicks within codas, this seems an intriguingly simple system to study. However, we are still a long way from any real understanding of how coda communication works.

SOUND PRODUCTION Norris and Harvey (1972) investigated the anatomy of the sperm whale's head, and proposed a mechanism for the production of sound that also explains the pulsed nature of some sperm whale clicks. The hugely developed head of the sperm whale is one of its most striking features. In mature males, the head may account for as much as 1/3 of the overall body length. If (as seems likely) the structure is dedicated to sound production, it represents the largest natural sound production organ on the planet. Inside the head are various fat-filled bodies and air passages including the spermaceti sac. This is a long bag of oil (spermaceti), bounded by a thick layer of tendons and stretching from the distal air sac (right at the front of the animal) to the frontal air sac (just in front of the skull). Norris and Harvey (loc. cit.) proposed that impulsive sounds are produced as air is forced through the museau de singe, a thick pair of lips surrounding an air passage and opposed to the front end of the spermaceti sac. Some of this sound would pass directly out into the water to form the first pulse; some would pass backwards to reflect forward from the large flattened frontal sac. When this second pulse reaches the front of the spermaceti sac, a proportion would pass out into the water as the second pulse, while some would reflect from the distal sac, pass back to the frontal sac, and form a third pulse, etc. In this way, a click containing several regularly spaced pulses could be produced. Norris and Harvey (1972) realised that the spacing between pulses would be equal to twice the travel time for sound between these two sound mirrors. This has been confirmed by Gordon (1991) analysing recordings from whales whose lengths were measured photographically.

Below the spermaceti organ lies the junk, so called because it was of less value to the whalers than the spermaceti. This is made up of a series of vertically oriented lens-shaped fatty bodies in a well-vascularised connective tissue matrix. Its potential role in sound production has not been investigated in spite of its intriguing anatomical structure.

ACOUSTIC TOOLS FOR FIELD RESEARCH Acoustic techniques have also proved to be very useful for studying sperm whales in the open ocean. For example, acoustic techniques have been used for finding and following sperm whales (Whitehead and Gordon, 1986), for assessing the size of populations (Leaper *et al.*, 1992), and for measuring the length of sperm whales (Mohl *et al.*, 1981; Gordon, 1991). Gordon *et al.* (1992) monitored sperm whale vocal behaviour to assess disruption of their underwater behaviur by whale-watching vessels. As our understanding of sperm whale acoustic behaviour develops, it will become possible to make stronger inferences about their behaviour during periods when they cannot be seen (when it is dark or they are underwater) by listening to their vocalisations.

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INTER-CALIBRATION OF BODY LENGTH ESTIMATES OF SPERM WHALES

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INTRODUCTION There is a good correlation between sperm whale (*Physeter macrocephalus*) length and age (Best *et al.*, 1984). Knowing the length distribution could be important in both wild population ecology and behavioural studies, since the social structure of many wild animal species is dependent on the size and age of the individuals. This is the case for several species of pinnipeds and for terrestrial mammals (review by Boness, 1991; Wartzok, 1991).

It is now possible to carry out routine estimates of sperm whale length by: (1) photos of a whale at the surface taken from the mast (Gordon, 1990; Waters and Whitehead, 1990); and (2) measurements of the IPI (inter-pulse interval) of the click sounds (Møhl and Amundin, 1991; Gordon, 1991). These two methods are also relatively simple and cheap. In addition, hi-tech instruments useful for marine research are becoming both cheaper and more simple to use. Therefore, we have also tested and evaluated two of them: (1) laser rangefinders, and (2) a multi-beam sonar, as tools for making length estimates.

MATERIALS AND METHODS Two sloops of approximately 11 m length were used as research platforms. They were equipped with instruments for Decca and GPS positioning. We used SLR cameras with 300 mm focal length for individual identification and length estimates, and 85 mm for length estimation from the mast. The whales were photographed with black-and-white as well as colour slide film. Two different laser rangefinders were used: Leica Geovid laser binoculars (resolution 2 m up to 1,000 m range), and Riegl Laser Tape (resolution 5 m up to 3,500 m range). Sounds were recorded preferentially on a two channel towed hydrophone (Leaper *et al.*, 1992) or a one-channel regular hydrophone. The recording equipment was a DAT recorder. A Reson Systems 6012 Sea-Bat multi-beam sonar of 455 kHz with a range of about 200 m delivered a real-time video image.

The study area is situated at the continental shelf between 15-72 km off Andøya Island, in Vesterålen community, Norway. The study was carried out from 18 August to 19 September. The crew of 5-6 persons made three separate 3-day long trips, with the sonar mounted for one trip. Four different length measuring methods were used: (1) *Mast94*; photographs taken at a known height from the mast with known focal length on a whale parallel to the horizon showing the blowhole and the dorsal fin. (2) *Laser90*; photographs taken as previously described, but on deck with a simultaneous distance estimate with a laser rangefinder. (3) *IPI94*; click sounds were recorded, where IPI was estimated for calculating the body length (Norris and Harvey, 1972; Gordon, 1991). (4) *Sonar94*; multi-beam sonar from which the length of the animal was estimated on the monitor with calipers and a ruler. Only encounters of identified whales were used in the analysis.

The different methods were compared applying linear regressions (Abacus: StatView 4.01 and SuperANOVA 1.11) to the data. For the acoustical analysis, five clicks from each recording were selected randomly from a click series starting within 60 s after fluke-up. The measurements from every method were assumed to be normally distributed. If sample sizes were not equal, samples were randomly selected for the test. This study was also compared with data from 1990 (*Mast90*), where photographs were taken from the mast. The lengths of 17 individuals were estimated in the *Mast90* study (Lettevall, 1993).

RESULTS From a total of 55 encounters, linear regressions of mean values from known individuals were carried out. For *Laser94–IPI94* (df=5, r=0.37), *Mast94–IPI94* (df=2, r=0.29) and *Sonar94–Laser94* (df=3, r=0.76), the linear regression did not fit well. The strongest correlation was surprisingly negative for *Sonar94–IPI94* (df=10, r=-0.67), where the ANOVA-test shows that the slope is significantly different from zero ($p<0.05$) (Fig. 1). A Mann–Whitney U-test showed that the means of the size distributions for the different methods were not significantly different ($p>0.20$) for *Mast90–IPI94* (df=29; Wahlberg *et al.*, 1995, this volume), *Mast94–Laser94* (df=8) and *Mast90–Mast94* (df=20).

CONCLUSIONS Because of the limited sample sizes, we were not able to make any intercalibration between the different methods. However, from the data we are able to make a qualified evaluation of the convenience of applying different benign methods for estimating the body length of the sperm whales (Table 1). Previous work using sonar or laser rangefinders for these purposes are unknown to the authors. All methods have different advantages and disadvantages. Present-day laser binoculars are hard to use for making an accurate distance fix from a moving vessel to the back of a moving sperm whale located at the sea surface. More accurate evaluation of the use of sonar for determining the body's terminating points is needed. Disturbances from water movements around the body make these points vague. Taking pictures from the mast is the method recommended since it is both cheap and reliable. The acoustical method has proven cheap, reliable and it requires the least field effort. However, the stability of the IPI from an individual has to be further investigated.

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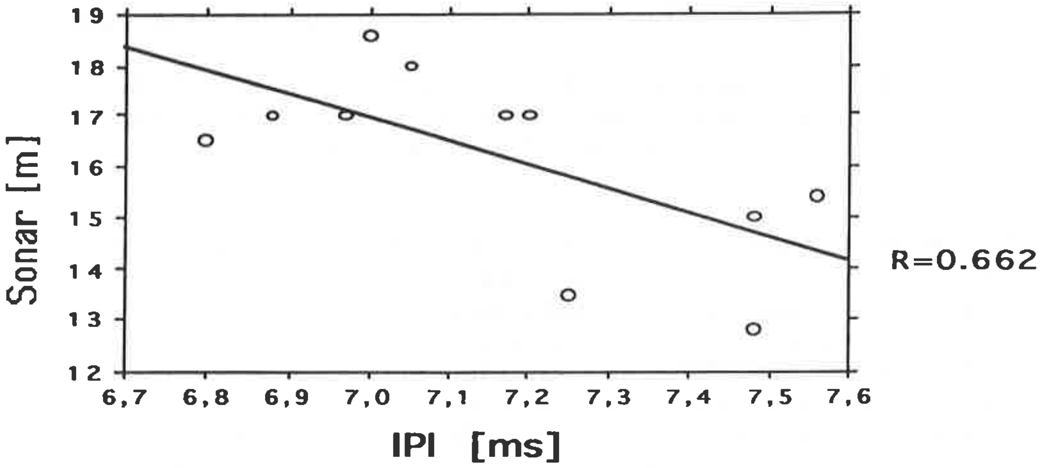

Fig. 1 Linear regression between *Sonar94* and *IPI94* estimated from 11 identified individuals. Formula: [m] = 49,585 - 4,663 * IPI [ms].

	MAST	LASER	IPI	SONAR
Precision Coeff. of variance (%)	7	9	8	15
Critical	Distance est. (variation of height)	Distance est. (target)	Individual variation Whale´s orientation	Whale´s orientation
Costs ($ per Encounter) Additional costs ($)	5 Camera 1000	5 Camera 1000 Laser binoc. 5000	10 Rec. equip. 2000	? Sonar >50,000
Field Effort Crew Effort	1 Busy	2 On deck	1 Relaxed	2 to 3 Very busy
Analyze effort	Big	Big	Small	Medium
Combine with	ID Sightings Density estimates Range estimates	ID Range estimates	Acoustic behaviour Size distribution Acoustic sighting	Diving behaviour Under water behaviour Scattering layers

Table 1. Advantages and disadvantages of using different benign field methods for estimating the body length of large whales.

ESTIMATING THE LENGTH OF SPERM WHALES FROM INTERPULSE INTERVALS IN THEIR CLICKS

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INTRODUCTION According to the most recognised theory of sperm whale (*Physeter macrocephalus*) sound production, the body length of these whales can be estimated by measuring the inter-pulse interval (IPI) in their clicks (Norris and Harvey, 1972). This method has been used by several researchers (Norris and Harvey, 1972; Alder-Fenchel, 1980; Møhl and Amundin, 1991; Gordon, 1991). However, further investigations are needed to assess the reliability of the method. In this study, we used sound recordings from photo-identified individuals in northern Norway and compared the data with that from a 1990 photographic length estimation study conducted on whales in the same area (Lettevall, 1993). This was made part of a project comparing different length-measuring techniques (Lettevall *et al.*, this volume).

MATERIALS AND METHODS The fieldwork was carried out in the waters at the continental slope off Andøya, Norway (69° N; Fig. 1) during August and September, 1994. A single hydrophone-preamplifier-DAT-recorder system was used to obtain sound recordings of photographically identified whales diving within a few hundred metres from the boat. In the laboratory, the clicks were examined on a digital storage oscilloscope. Each click consisted of several pulses P_1, P_2 and P_3 (Fig 2), believed to be caused by reflections between the frontal and distal air sacs in the spermaceti organ (Norris and Harvey, 1972). The pulses were recognised as having an almost constant IPI through the series (Fig. 2). Additional pulses with a varying interval to P_1 were most likely caused by surface reflections.

The criteria for selecting clicks for analysis were: 1) Loud clicks with S/N >1,000, measured with the DAT's peak meter. Only click series starting within one minute after the dive were analysed; 2) Well-defined click pulses P_1 and P_2 with S/N > 2, measured with the oscilloscope; 3) Only click series with more than 40 clicks were used. Five clicks were randomly selected from a series. IPI measurements were made between P_1 and P_2. The IPI of the click series was estimated as the mean of the five measurements. Gordon's (1991) formula (Total length = $4.833+1.453*IPI-0.001*IPI^2$), obtained from intercalibration of photographic length estimates (Gordon, 1990) and IPI measurements, were used to estimate the size of the measured whales. Statistical tests were performed with the software program SuperANOVA 1.11.

RESULTS IPI from 14 photo-identified whales were successfully measured. IPI ranged from 6.6 to 7.7 ms (mean = 7.2 ms, $s^2 = 0.12$; Fig. 3). Gordon's formula (1991) gave reasonable length estimates for the measured whales. The lengths ranged from 14.4 to 16.0 m (mean = 15.2 m, $s^2 = 0.25$; Fig. 3). The length distribution was compared with an investigation made in the same area in 1990, using a photographic technique (Gordon, 1990) on 17 photo-identified whales (mean = 15.0 m, $s^2 = 4.4$; from Lettevall (1993); Fig. 4). The variances were significantly different (F-test: $p<0.01$), but the means were similar (Mann-Whitney U-test: $p>0.20$).

CONCLUSIONS The differences in variances of the length estimations from the photographic and acoustical studies could be due to random variations caused by small sample sizes. Another explanation may be found if we assume that there are groups of even-sized individuals within the study area. The result may thus be explained by differences in the way data were collected. The data for photographic length estimation were collected during three months, while the data for the acoustical analysis were collected during two weeks. Also, in 1994 the fieldwork period was shorter, but the encounter time before returning to harbour was longer than in 1990. This may have decreased the probability of encountering whales from different groups in 1994. This hypothesis can be tested by investigations of associations and distribution patterns for the whales in the area.

Several researchers (e.g. Watkins, pers. comm.) have raised serious criticism against the theory behind sperm whale sound production as described by Norris and Harvey (1972). This accuracy of using IPI for estimating the length of sperm whales is therefore open to question. Further studies of sperm whale acoustics, where the effect on IPI of different oceanographic conditions and whale–hydrophone orientations are needed to settle this matter.

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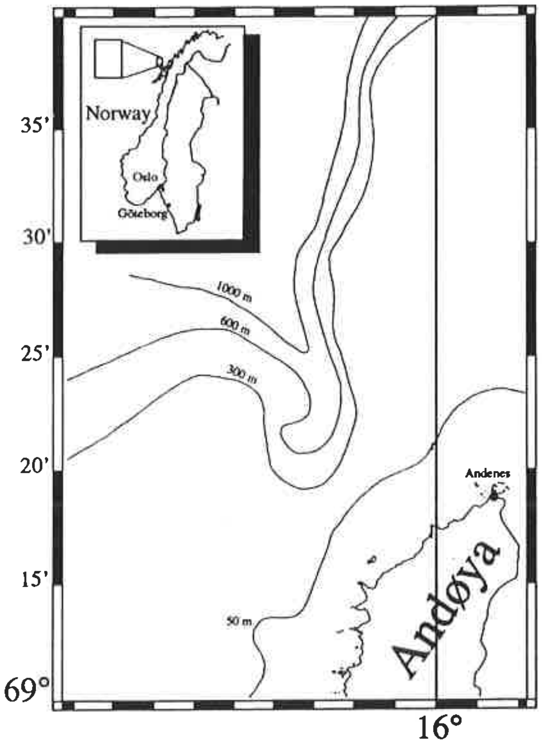


Figure 1. The study area at the continental slope off Andøya island, Norway.

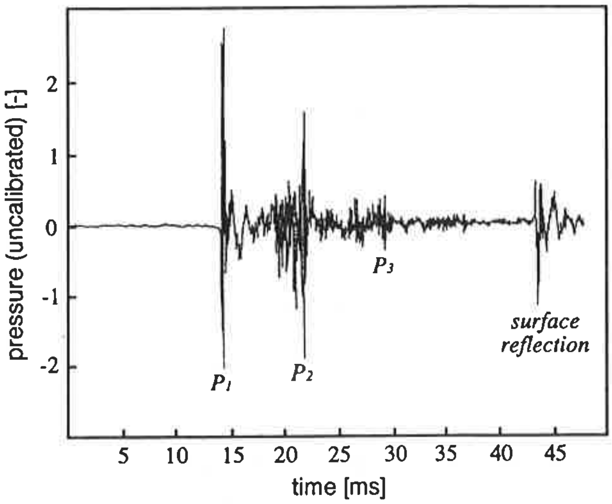


Figure 2. Oscillogram of a sperm whale click with four evenly spaced pulses and a surface reflection. Sampling frequency 48 kHz.

Figure 3. Distribution of IPI's and corresponding body lengths of 14 sperm whales obtained in this study. The lower scale is calculated from Gordon (1991).

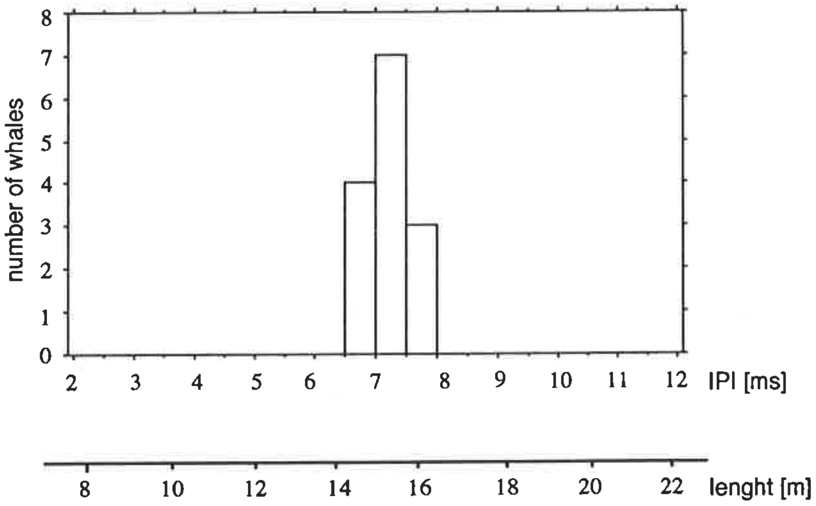
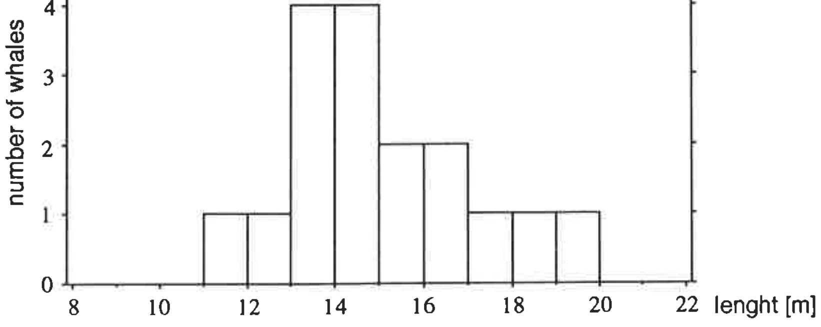


Figure 4. Distribution of body lengths of 17 sperm whales from the same area obtained with a photographical technique in 1990. From Lettevall (1993).



DESCRIPTION OF CODA PRODUCTION BY SPERM WHALES OFF THE AZORES, PORTUGAL, 1988, 1989 AND 1991

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Codas are temporally stereotyped click sequences produced by sperm whales, probably as communication signals. These click sequences are most often heard from groups of sperm whales involved in socialising activities close to the sea surface.

The purpose of this project was to describe and characterise sperm whale codas recorded off the Azores in three different years. Codas were analysed using a sound digitiser and specially written software (by Russell Leaper).

Inter-click intervals were measured to define coda patterns. The most common coda heard was established. In total, 1,005 codas were analysed from the summer seasons in 1988, 1989 and 1991. Attempts were made to look for monthly and yearly variations in coda production. Codas heard on each encounter were very different, possibly because they were produced by different groups of sperm whales.

Some preliminary results are presented and the method used is discussed, together with the problems that have occurred.

A TOOL FOR THE STUDY OF SPERM WHALE UNDERWATER BEHAVIOUR

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INTRODUCTION The acoustic tracking of isolated single sperm whales has proven to be relatively efficient using classic oscilloscope analysis. However, when used in the presence of several whales all clicking simultaneously, the discrimination of the signals belonging to a specific whale becomes more difficult as the number of whales increases. This presentation describes the use of a computer program, developed in order to study the vocalisations of individual sperm whales, even when those signals are sharing the recorded tape with the clicks of many other whales. The interest of this technique lies in the possibility "to isolate" the acoustic behaviour of a specific whale in a recorded sequence, study its components, and associate it with a social context.

MATERIALS AND METHODS A thirteen metre motor boat, "Monachus", carried all the research equipment and four to six crew members. The acoustic equipment used in the project which allows the sperm whale clicks to be detected, located and recorded on board "Monachus" consists of a recording system (Leaper *et al.*, 1992) and an independent directional hydrophone. A towed hydrophone includes two AQ-4 Benthos elements each connected to a preamplifier two metres apart. This system is towed 100 metres behind the boat and connected to a DAT recorder Sony TCD II Pro. The equipment to analyse the recorded sequences includes the commercial tools available for the digitising and analysing of the sounds (IBM ACPA sound card, etc.). The program has been installed on a portable IBM PS/2 model P70 386. The language used for the programming was the IBM APL2.

The program was basically developed on sequences recorded when several whales were clicking, and where at least one of them had begun a deep dive. Clicks from whales swimming downwards have the advantage of being very loud and only slightly distorted to begin with; but the disadvantage is that they undergo rapid changes in wave form, frequency content and existence of secondary pulses. The deeper the whale travels, the more distorted and the less characteristic the clicks become. A further factor affecting the clicks is the change of the sound made by the whale, at the sound source. These modifications make recognition of clicks from single intervals difficult when many whales are vocalising simultaneously. Since these distortions in the click characteristic cannot be ignored, it has been necessary to find a method that takes these modifications into account.

Selection of one whale clicks Once the sequence has been digitised, the sound file is reduced to a data matrix - DM1 - consisting of X rows and Y columns. The rows represent the clicks while the columns show the time of click occurrence and click amplitude values. This matrix is made from the digitised sound sequence SQ1 by a routine set to trigger on every amplitude value above a certain level, which is assumed to be the first big peak in a click. From this value, the 30 preceding amplitude values (to be sure to get the beginning of the click), and the following 256 or 512 values are selected and transferred to the data matrix DM1. In this way, all the signal free periods are removed, and only the clicks are left. The visual output on the screen are separate clicks, as seen in Fig. 1. The selection procedure is a combination of:

- comparing the wave forms, and manually picking out some clicks from a specific individual; and

- looking for the rest automatically by using a routine check of the click spectra.

The first step is to find four clicks from an individual. This is done by plotting together two or more clicks in the data matrix DM1 and visually comparing the wave forms (when present the Inter Pulse Interval is an important feature), amplitude, and the Inter Click Interval. Every click can be compared with one or more of the others regardless of their temporal occurrence in DM1. The comparison is illustrated in Fig. 2. Then all the clicks in the data matrix DM1 are converted into spectra, data matrix F1, using Fast-Fourier transformation resulting in 128 or 256 frequency values (half the number of amplitude values). The four spectra of the clicks from the whale in focus are combined into one average click called "Runfourier". Runfourier acts as a reference for the clicks from this animal. By comparing the spectra of Runfourier with the spectra of the remaining clicks in F1, it is possible to find those made by this whale. This is carried out one click at a time in the temporal order of their occurrence. Due to the modifications of the clicks (see above), it is necessary to make the following empirically derived modification of Runfourier: each time a matching click is encountered, its frequency spectra are incorporated into Runfourier and given 1/4 importance in the 'new' Runfourier, which thereafter continues the search for the next match.

The amplitude values of the clicks found are copied to a separate data matrix DM2 to use for further analysis on inter-click-interval, waterfall plot, inter-pulse-interval etc. The clicks can be transferred to a sound file SQ2, either separately, or in selected combinations to be played back alone or with other whale vocalisations. The selected clicks can be removed from the sound sequence SQ1, which makes listening to the remaining click sequences easier.

CONCLUSIONS Sperm whales have become of special interest in the Canary Islands after several collisions with speed ferries of Jetfoil type. The Department of Biology at the University of Las Palmas de Gran Canaria, through the funding of Trasmediterránea, a private shipping company, has undertaken a long term study of the movements and behaviour of the whales around the islands in 1992. As a result of the peculiar diving behaviour of the sperm whale, and the critical moment of its surfacing regarding collision risks, it is of primary importance for the crew of the Jetfoil to know and understand the mechanism and rhythm of these dives. This programme is the first step to understanding this.

In the near future, the authors believe that it will be possible not only to estimate precisely the number of whales in the vicinity, but also to follow the dive of every clicking individual within a group and estimate the probability of their encounter with a Jetfoil or any other ferry in sufficient time to avoid collision.

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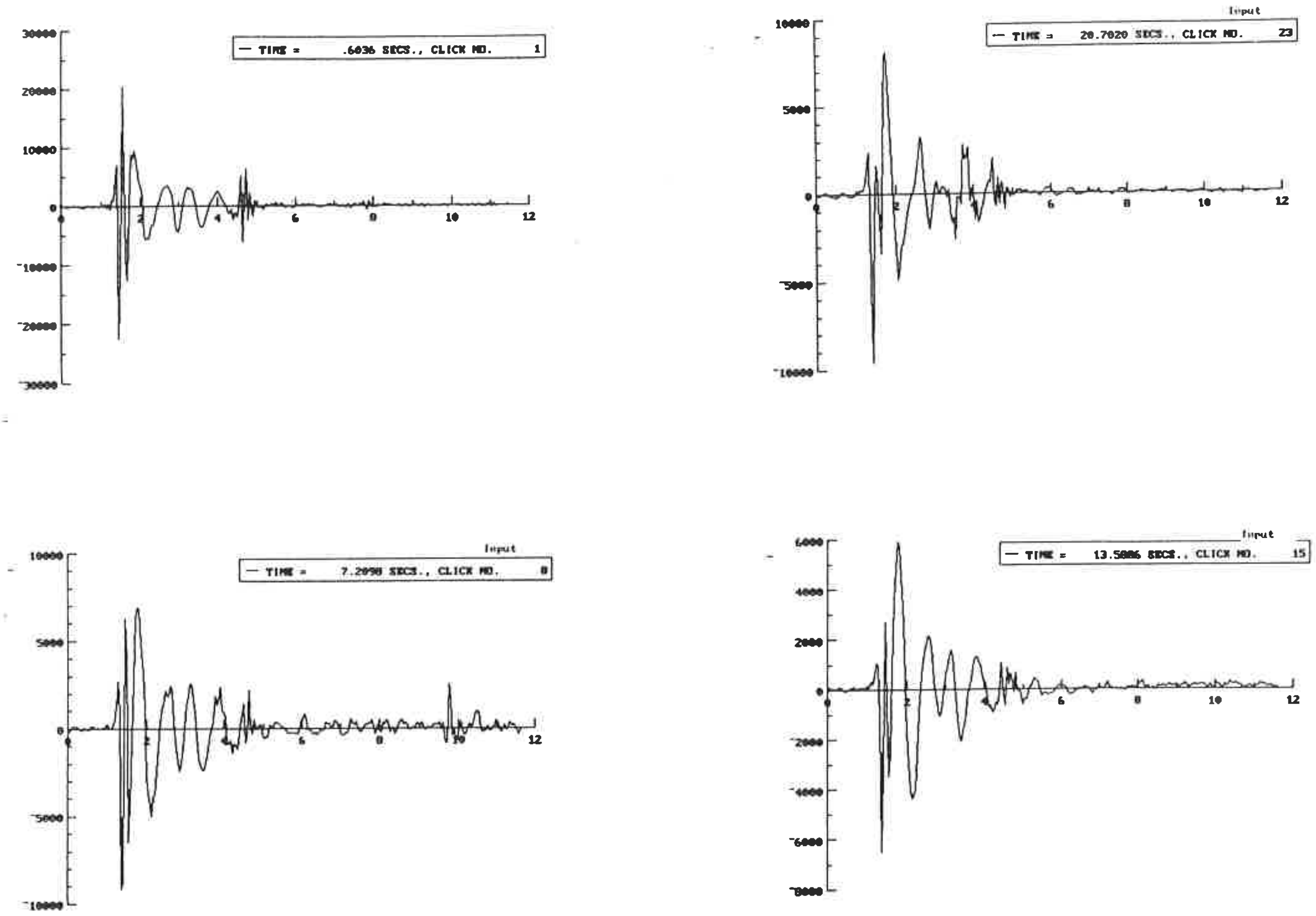
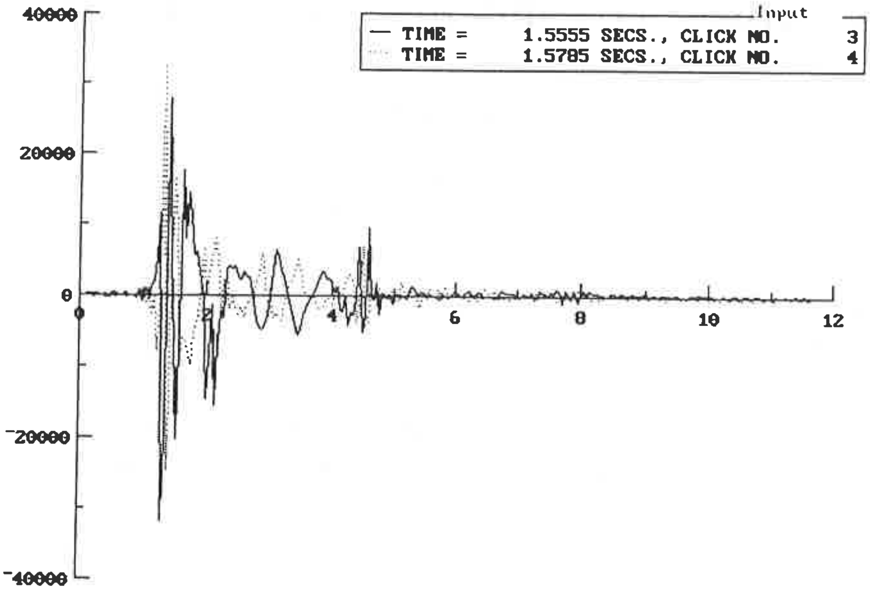
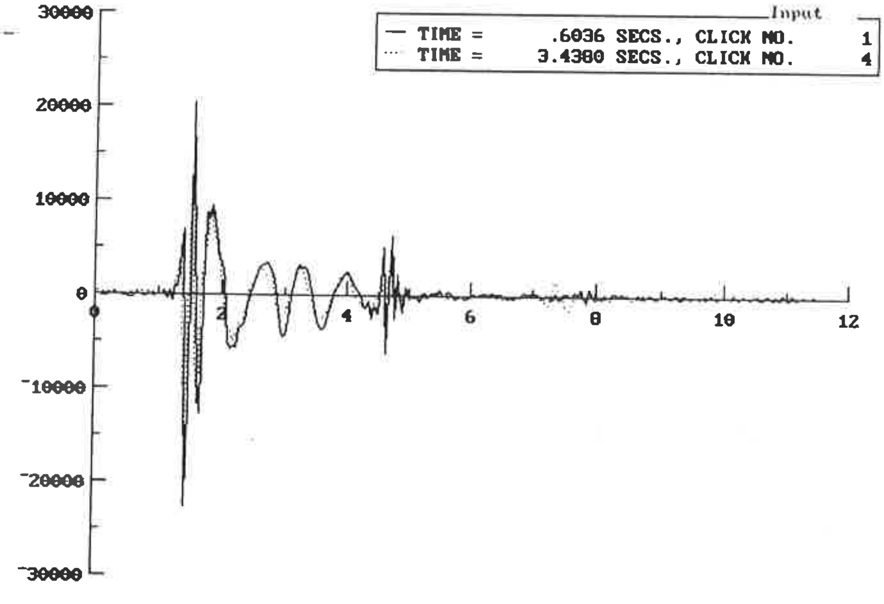


Fig. 1 An illustration of the changes in the wave form seen in a sequence from a whale just after it has been fluking.

The four clicks selected from this individual show how fast the signals get distorted, and underline the difficulty of recognising them when they are mixed with other clicks belonging to different whales.

These clicks have occurred after 0.6, 7.2, 13.6 and 20.7 sec. The time of the click occurrence is written on the graphical output.





The first example shows two signals belonging to two different whales.

The second example is characteristic of two signals belonging to the same whale. Note the match between the two spectra.

This process is first achieved in order to find four clicks fram the same individual, and combine them in an average click. This average click acts then as a reference to look for the rest of the clicks from this specific individual in the same recorded individual.

A SIMPLE HYDROPHONE MONITOR FOR CETACEAN ACOUSTICS

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INTRODUCTION Piezo ceramic materials based on Lead Zirconate Titanate (PZT4) convert applied pressure into a voltage charge between opposing silvered surface electrodes. Alternating pressures, i.e. sound waves, can be detected and converted to electrical signals which accurately replicate the amplitude and waveform of the sound. Provided that the pressure changes carried through the water from a cetacean's vocalisations are efficiently coupled to the ceramic, the result is a hydrophone which with suitable amplification can be monitored on headphones or recorded on a tape recorder (or camcorder). The simple 'bender' device described is cheap to make and sensitive, and whilst it is not recommended for frequency analysis work, it is very suitable for listening to cetacean whistles and clicks. The design is presented in the hope that it will provide a useful stepping stone for researchers concerned to understand the underwater acoustic behaviour of these animals but who are deterred by the high cost of professional acoustic equipment.

BASIC HYDROPHONE DESIGN For use as a hydrophone, sound pressure variations must be coupled to create a bending or compressive stress in the piezo material. In a high quality hydrophone this is usually achieved by forming a hollow sphere of the piezo ceramic (usually as two matching hemispheres) and making an electrical connection to the inner and outer silvered surfaces. The assembled sphere is then moulded in chloroprene rubber to insulate and waterproof the assembly. Such 'ball' hydrophones, whilst expensive, have a very flat wideband frequency response and are equally sensitive to sound waves arriving from any direction (omni-directional response). Cylindrical sensing elements are also commonly used, although for high frequency work these may have directional sensitivity patterns which must be appreciated. 'Bender' hydrophones are constructed from very thin ceramic disks supported as a diaphragm and, whilst these are both sensitive and cheap to manufacture, they suffer directional sensitivity patterns and may have deep dips and peaks in their frequency response. These disadvantages make them less suitable for analysis work, although military sonobuoys frequently employ hydrophones of this type.

MATERIALS AND CONSTRUCTION One pre-mounted piezo ceramic disk (a 20mm diameter ceramic on a 28mm brass disk is preferred); two small disks (or squares) of polycarbonate sheet 4 to 6 mm thickness and about 60 mm square; a neoprene 'o' ring seal 4mm thick and about 39mm diameter; 3 to 4 m of thin coaxial cable (Suhner 50 ohm, 3mm diameter or similar); Quick setting epoxy adhesive; 3.5mm jack plug (to suit the tape recorder). Note - suitable Piezo ceramic disks (Fig. 1), ready mounted on a brass diaphragm, are available from hobby electronic sources at very low cost and very similar devices can be salvaged from musical greeting cards. The assembly is completed with 6 (nylon) 4mm screws and nuts which are fitted outside the sealing ring.

There are a number of ways in which the piezo ceramic could be mounted but the simple sandwich construction illustrated in Fig. 2 has been found to be quite effective and requires little in the way of tools or workshop skills to make. Construction dimensions are not critical, although the volume of air enclosed and the thickness and stiffness of the plastic selected will alter the resonant frequencies a little. Polycarbonate is the preferred construction material as it is acoustically well matched to sea water.

If the coaxial cable is kept fairly short (< 5m) it can be connected directly to the input of a tape recorder (or camcorder) but much better results will be achieved using a suitable preamplifier designed to filter out low frequency sea-state and boat noise below 2 kHz. To drive (600 ohm) headphones, a preamplifier with a gain of between 40 and 50 dB is necessary.

RESULTS AND DISCUSSION The frequency response and sensitivity obtained from a typical device are shown in Fig. 3. (Note - the apparent ripples in the sensitivity are an artifact produced by multipath interference in the 2m deep measurement tank. In free-field conditions, the response will be much smoother but will still be dominated by the resonances at 4 kHz and at 16 kHz). Typical sensitivity is usually better than 205 dB re 1V/Pa, which compares well with many commercial hydrophones. The electro-mechanical resonances are also shown in the conductance response (Fig. 4), which is included to indicate how the source impedance varies with frequency. The unmodified frequency response and sensitivity is adequate for listening to a variety of underwater sounds including dolphin whistles and clicks (wideband dolphin clicks extend from the audible spectrum to over 100 kHz and, although the ultrasonic part will not be heard, the inter-click intervals are detectable and can be used to interpret underwater behaviour - Goodson *et al.*, 1988, Goodson & Datta, 1992; Goodson *et al.*, 1994). Since sea state and shipping noise becomes very significant below 2 kHz, and as most dolphin whistles are between 2 and 22 kHz, the response to signals outside this band can usefully be filtered out. By setting a single high pass CR filter pole at 7 kHz, a 6 dB/octave response below this can be obtained that will flatten the 4.25 kHz resonance peak and minimise interference from sea-state noise. The resonance peak at 16 kHz is usefully placed to compensate for the falling high frequency response of most cassette recorders.

Other filter break points can be calculated: Freq(-3dB) = 1/(2**C*R) where C is in Farads and R in ohms. The preamplifier input impedance should be high, and a suitable circuit using a dual bi-fet operational amplifier is shown in Fig. 5.

CONCLUSION The high cost of hydrophone equipment is frequently cited as a reason for not attempting to listen to cetaceans underwater. Since acoustic behaviour is especially important and few alternative non-intrusive methods of study are available, it is hoped that researchers wishing to study these animals in the wild will not be deterred from trying this economic starting point. Adding underwater sounds to a video recording is a particularly useful technique. Some notes to aid construction have been prepared for both the hydrophone and for a matching preamplifier, and these can be accessed electronically via the internet:

http://info.lut.ac.uk/departments/el/research/bioacoustics/index.html

It is intended that these technical notes will remain accessible and may be updated during 1995, but no other support will be provided.

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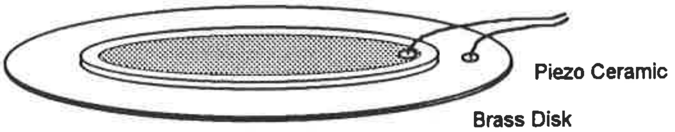


Figure 1.

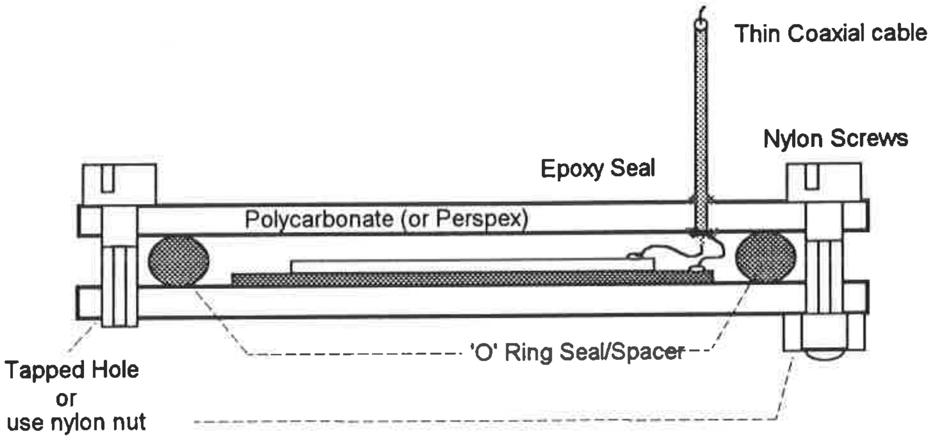


Figure 2. Laminated construction bender hydrophone

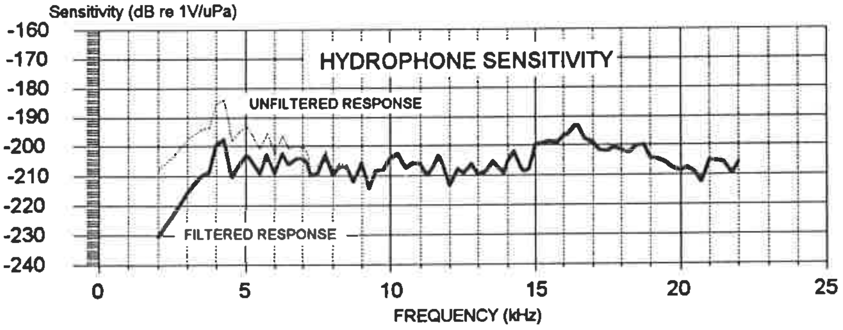


Figure 3. Frequency response (in a reverberant tank)

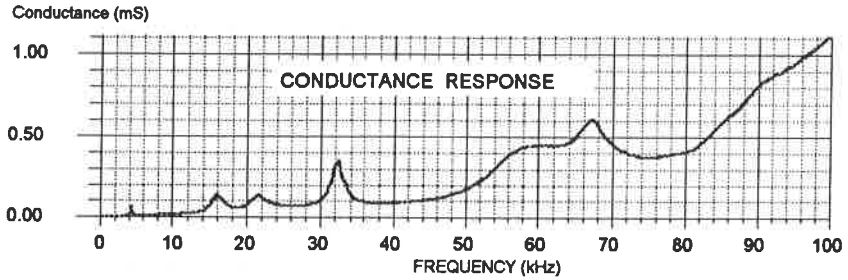
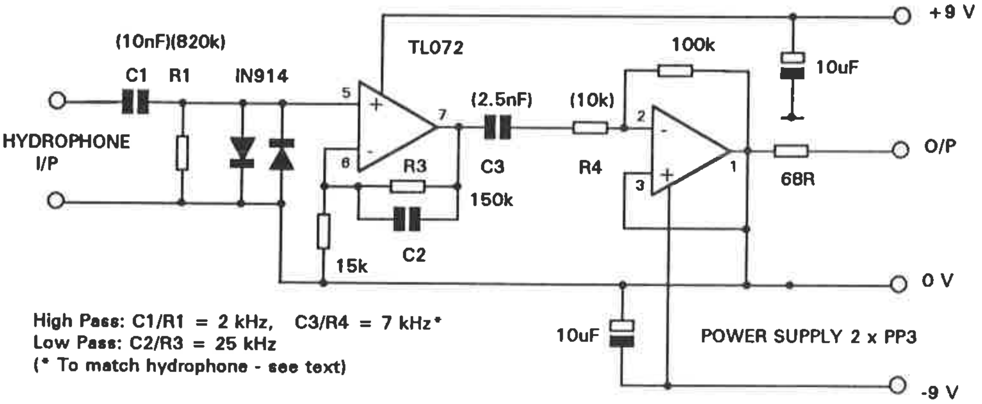


Figure 4. Electrical conductance plot of the hydrophone in water



High Pass: C1/R1 = 2 kHz, C3/R4 = 7 kHz*
Low Pass: C2/R3 = 25 kHz
(* To match hydrophone - see text)

Figure 5. Circuit diagram of a Bi-fet preamplifier with values for +40 dB gain

TRACKING CETACEANS BY SONAR CLICK DETECTION

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INTRODUCTION The system described provides a means of passively tracking one or more echolocating cetaceans in three dimensions. This arrangement will allow the behaviour of dolphins to be passively observed in the wild, especially in the vicinity of fishing equipment, enabling their reaction to underwater obstacles to be monitored. In particular, this system will allow the effectiveness of deterrents intended to prevent the by-catch of dolphins in trawling nets to be evaluated more accurately.

METHOD The operation of the system is based on the principle that when a dolphin produces an echolocation click, it will be detected by one or more hydrophones in an array. Since the distance between the source and each element of the array is different, the radiating acoustic wave will be incident at each of the hydrophones at different times, as indicated in Fig. 1.

In order to track the acoustic source (i.e. the dolphin) in three dimensions, the echolocation clicks must be received by an array of four hydrophones (H_1-H_4). The tracking software can then produce a unique solution provided that the hydrophones are not all placed in the same plane, and no three hydrophones lie in the same line.

The arrival times (t_1-t_4) of a given echolocation click at the hydrophones are measured and passed to the tracking software which can produce an estimate of the position of the acoustic source. However, a modern computer is required to perform the detailed mathematical manipulation in real time and, as such, it is not possible to compute the tracking equations underwater.

As a result, the timing data is transmitted to the surface and the tracking software implemented aboard the fishing vessel. The resulting (X,Y, Z) co-ordinates produced are displayed on a computer display indicating the path of the dolphin against time. The option to produce hard-copy plots of the dolphin tracks is also available. Fig. 2 illustrates the functionality of the system.

Since the system is intended to track dolphins in the vicinity of trawler nets, it is necessary to locate the hydrophone array such that it maintains a fixed orientation and position relative to the net. Two systems are currently being considered, either locating the hydrophones on the net itself, or alternatively, to tow the array behind the fishing vessel independently.

Attaching the hydrophones to the mouth of a fishing net provides us with a large framework in one plane around the area of interest on which to attach the hydrophones. However, since one of the hydrophones must be placed off this plane, it would be necessary to attach it to one of the tow lines or another frame protruding forward. Since the position of the hydrophones relative to each other must be constant whilst tracking, both of these techniques are hampered by the movement of the structure whilst being towed through the water. Further problems arise when deploying and retrieving the net as the hydrophones and cabling could become tangled in the lifting gear.

Towing a fixed frame with the hydrophone array attached eliminates the relative movement of the hydrophones, but measures must be taken to ensure that the frame does not spin and vibrate wildly whilst under tow. The advantage of using the remotely operated vehicle (ROV) arrangement as shown in Fig. 3 is that it allows the array to be steered into position such that the area of observation can be varied as required. The camera on board the ROV can visually confirm that the tracking system is stable and behaving correctly. Furthermore, the ability to deploy the ROV and array completely separately from the fishing net will save time and reduce the chance of damaging equipment due to tangling with the lifting gears.

In addition to ensuring that the hydrophone array is stable, a suitable method of transmitting the timing data back to the vessel must be considered. The problem is complicated by the use of a high data rate (e.g. 1.2 Mbit/s) combined with a long transmission path (up to 500 m).

Having transmitted the timing data to the surface, the first step in tracking the acoustic source is to acquire its starting position. In order to produce a valid estimate for this position, the tracking software must determine arrival times on the four hydrophone channels which correspond to the same click produced by the dolphin. It can be shown that the maximum spread of these arrival times is dependent only on the positioning of the hydrophones and the speed of sound in water. Hence, the tracking process does not begin until such time that only one click arrival occurs on each of the four channels in this maximum spread time-window. Tracking of the dolphin cannot begin until its position has been unambiguously acquired, as shown in Fig. 4. Having acquired the position of the acoustic source, the tracking software can then maintain the alignment of subsequent clicks received on the four channels. In this way, the software can compute the time differences (Δt_{12}, Δt_{32}, Δt_{42}) between the arrival of a given click on each hydrophone channel.

These time differences (Δt_{12}, Δt_{32}, Δt_{42}) are used as the input variables for a set of tracking equations developed by Hardman & Woodward (1994). It is assumed that the speed of sound in water is a constant and that acoustic propagation occurs with negligible refraction and distortion. This software produces two estimates for the position of the acoustic source corresponding to the roots of a quadratic equation. One of these estimates will be the true location of the dolphin, the other being discounted by observing that the timing data that such a position would yield, does not match that observed. A further test is performed to ensure that the estimated position is attainable by the dolphin, given its maximum possible velocity and previous position. If this is not the case, then there remain two possibilities: either the new position is due to some inaccuracy within the system, or a new acoustic source has been detected. In the latter case, the possibility of a second dolphin being present in the area is explored, thus producing two traces simultaneously.

In order to display the results of the tracking software in three dimensions, it is intended to use a split display arrangement, with an (X,Y) plan view of the local area, and separate (diving depth, time) view. It is believed this arrangement conveys the location of the dolphin relative to local objects in the most intuitive manner. Fig. 5 illustrates the display layout.

In order to ensure that the tracking system provides a realistic estimation to the path of the dolphin, care must be taken that the tracking software retains reasonable accuracy in the presence of errors introduced into the system. In practice, the system is required to estimate the position of the acoustic source to within a specified resolution, for example to within 5m in the X,Y, and Z co-ordinates over the area of interest. This specification determines the accuracy required by the electronic timing circuits, and the minimum base-line of the hydrophone array. Decreasing the base-line in order to ease the deployment considerations discussed earlier, dictates that the electronic timers must have a higher resolution, thus increasing the data rate on the transmission channel. It can be seen, therefore, that a compromise must be made between these three specifications.

RESULTS AND DISCUSSION The theoretical development of the dolphin tracking system has been completed and computer simulations performed to ensure that the tracking software will successfully acquire and track a moving acoustic source. Work is currently in progress to solve some of the practical problems of deployment and stability of the hydrophone array whilst being towed. Alternative methods of transmission from the hydrophone array to the fishing vessel are being investigated. A sea trial of the system is expected to go ahead in March 1995.

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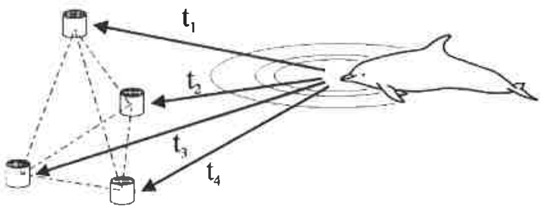

Fig 1 - Radiation of sound wave

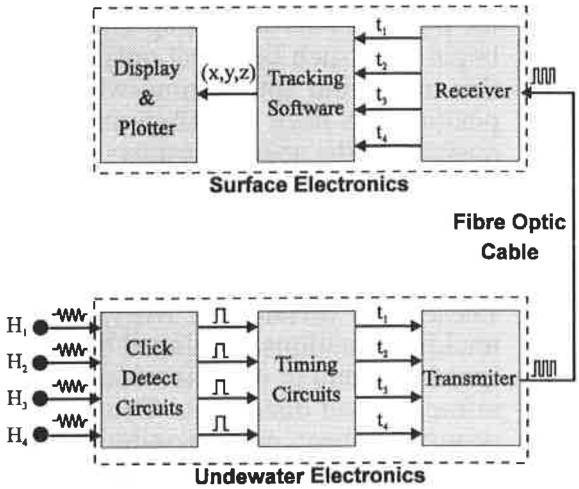

Fig 2 - Block diagram of tracking system

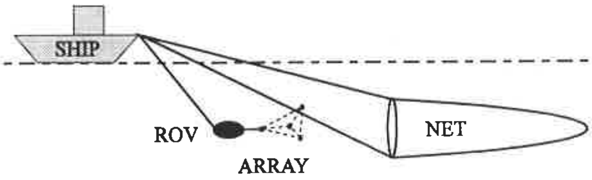

Fig 3 - Independent towing of the array

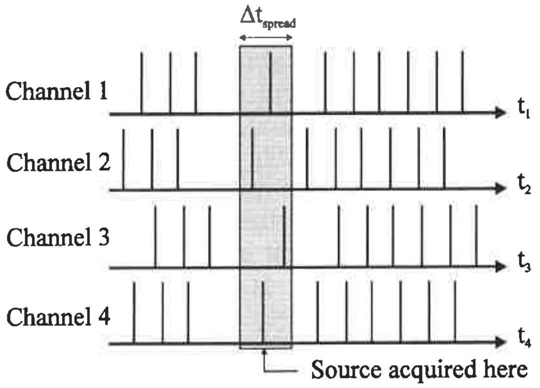

Fig 4 - Acquisition of dolphin position

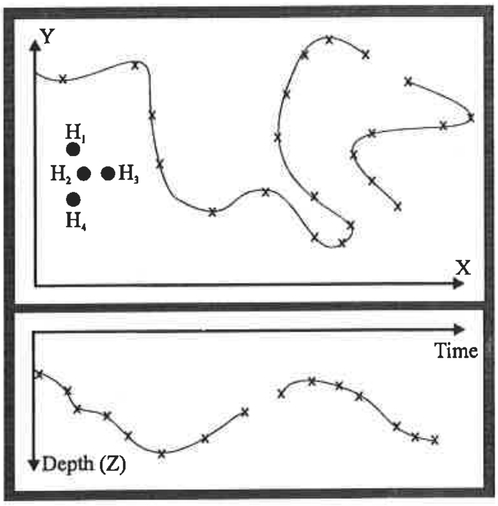

Fig 5 - Tracking display

THE ENHANCEMENT AND IDENTIFICATION OF WHISTLES AND OTHER TONAL SOUNDS FROM MARINE MAMMALS AMONG BACKGROUND NOISE

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INTRODUCTION Passive acoustic reflectors are being developed to reduce the number of small cetaceans which become entangled in fishing nets (Goodson *et al.*, 1994). During trials of grids of these reflectors with wild bottlenose dolphins (*Tursiops truncatus*) in the Moray Firth, Scotland, different dolphin groups showed avoidance using echolocation at ranges from 50 m to 170 m. Beyond this, it was thought that avoidances were due to previous knowledge of the reflector grid's location, although group identities were needed to verify this.

Traditionally, photographic identification techniques have been used to distinguish individual bottlenose dolphins, but the distances to the animals (often over 500 m) made this very difficult. It was proposed that the whistles made by the dolphins would be analysed for identification of groups, as this phenomenon has been studied for many years with bottlenose dolphins (Caldwell and Caldwell, 1965). However, these 'signature' whistles may vary depending on the state of excitement of the animal, and animals have been known to mimic the whistle of a companion (Tyack, 1986). Signature whistle identification was believed to be a useful method for identification of groups if the composition did not change over the period of the trial (less than two weeks). Clearly, mimicry within groups would not disrupt the results of the analysis.

Before any pattern recognition routines could be applied, the whistles' contours first had to be isolated. The initial problem of identifying the contour was largely determined by the background noise. Echolocation clicks, sea-state noise, and overloading of the recording system may all contribute to the problem. Computerised techniques have been developed to reduce these effects, and allow the extraction of the whistle contour from the filtered signal to be relatively easy. Additionally, these techniques have been extended to develop software capable of detecting the presence of dolphin-like whistles (and other tonal components) in periods of long absences. This allows the many hours of raw data to be automatically pre-processed to identify just those areas of interest.

THE FOURIER TRANSFORMATION The signal returned from a hydrophone contains the amplitude of the received sound at different times, but this is often difficult to relate to sounds as we perceive them. A more intuitive form is to display the energy in different frequencies at different times, commonly displayed as a spectrogram (Fig. 1) with different colours or a grey scale representing the different energy for a frequency at a particular time. The method of transforming the amplitude/time data to frequency/time can be achieved by a Fourier transformation. The mathematics behind the Fourier transformation is well described in many signal processing books (e.g. Press *et al.*, 1986) and will only briefly be described here.

The output from the hydrophone (or a recording made from the hydrophone) is sampled at a sampling rate f_s, so that values are stored every $1/f_s$ seconds. The Fourier transformation then takes a number of these samples, say N, and computes a further N values for the energy at each frequency within those N samples. Fast routines exist for calculating the transformation when N is a power of 2 (i.e. when $N = 2^k$, and k is an integer). However, for a sample rate of f_s, only frequencies up to $f_s/2$ can be determined, and the upper $N/2$ values from the Fourier transformation are the mirror (actually complex conjugate) of the lower values. Thus, if we sample at a rate of 44 kHz, only frequencies up to 22 kHz are resolvable.

The number of samples N taken for each transformation calculation (termed here the 'time partition') determines the number of frequencies that can be distinguished. For instance, if the time partition is 128 samples wide, only 64 frequency energy values will be returned. At a sample rate of 44 kHz, each value would represent a range of frequencies 344 Hz wide (22 kHz/64 = 343.75 Hz), and each time partition would be 2.9 msec (128/44 kHz ≈ 2.9 msec). If a larger N was used, the 'frequency bins' would become narrower (enabling better frequency resolution), but the time partition would become wider (reducing time resolution).

BACKGROUND NOISE REDUCTION Inspection of the Fourier transformation of whistles suggested that echolocation clicks tended to mask the shape of the whistle contour. Echolocation clicks generally have a spectrum which changes only slowly with frequencies below 22 kHz, so an initial method was devised for removal of these clicks whereby the average energy between time partitions was normalised. The average energy was calculated for each time partition and then all values were scaled up or down accordingly. This calculation is described mathematically in Equation 1:

$$\overline{E}(t) = \frac{1}{N}\sum_{k=0}^{N-1}|f(k,t)|^2 \qquad (1)$$

where $\overline{E}(t)$ represents the average energy in time partition t, and $|f(k,t)|^2$ the energy in frequency bin k for time partition t. The normalised energy value E_n was set to some value which could easily be seen on the display, and the new filtered transformation $f'(k,t)$ was calculated from Equation 2.

$$f'(k,t) = \sqrt{\frac{E_n}{\overline{E}(t)}}\,f(k,t) \qquad \text{(2}$$

However, some remnant of the echolocation click was often present in the filtered transformation, as the click spectrum was rarely uniform, especially if the dolphin was not pointing directly at the hydrophone. This prompted a modified algorithm, where the average energy was calculated only from the values of the m surrounding frequency bins, where m could be specified by the user (Equation 3):

$$\overline{E}(k,t) = \frac{1}{2m+1}\sum_{l=k-m}^{k+m}|f(l,t)|^2 \qquad \text{(3}$$

This new average, now dependent on the frequency bin, was used in the calculation of the filtered transformation (Equation 4):

$$f'(k,t) = \sqrt{\frac{E_n}{\overline{E}(k,t)}}\,f(k,t) \qquad \text{(4}$$

This filtering produced a noise 'trough' around the whistle, as the high energies contained in the whistle frequencies would have a large effect on the average energy calculation for surrounding frequencies. It was then relatively easy to use a maximum value following routine to extract the whistle contour from the filtered transformation.

DETECTION OF THE PRESENCE OF A WHISTLE A whistle detection routine was developed based on the filtering routines shown in Equations 3 and 4. Data were read in through a sound card in real time, passed through the Fourier transformation, and filtered. Calculations were then made for the background noise and the current signal using a running average with an exponential decay. The exponential decay was made long for the background noise, and short for the current signal, which helped to emphasise tonal components.

The background noise spectrum was removed from the current signal values, and energy peaks in the resulting spectrum noted. A frequency was considered to be a 'peak' if its value was above a certain number of standard deviations from the mean spectral energy, and if neither of the two adjacent frequency bins contained higher values. The peaks from the previous time partition were then compared, and the 'time of existence' of those in the same frequency bin or adjacent bins to the current peaks was incremented. After a peak had been in existence for a user-defined number of time partitions, it was flagged as a possible dolphin whistle, and its start and end times recorded in a log.

The whistle log could then be used with recorded data to trigger sampling of the whistles into the computer for further analysis. When using data from an interaction between a seal and a dolphin, it was found that the routines detected the tonal components of both seal and dolphin vocalisations.

CONCLUSIONS It has been possible to automate whistle contour extraction from background noise, and to quantify the whistle for further pattern recognition. The routines have concentrated on enhancement of the tonal components and reduction of impulsive sounds, which allowed a much simpler routine to trace the whistle contour from the filtered data than would otherwise have been possible. The resulting contours are now available for computerised classification to determine the likely vocalising animal.

Based on this work, a whistle detection algorithm has been developed which is able in real-time to indicate the likely presence of a whistle from data taken directly from a hydrophone or recording. This software thus greatly reduces the raw data to just those areas containing possible whistles. It has been found that the routines may be used for the detection of seal vocalisations, as the tonal components contained therein are also detected.

ACKNOWLEDGEMENTS The funding for this work provided by the U.K. Ministry of Agriculture Fisheries and Foods and the Department of the Environment is gratefully acknowledged. Thanks must also go to Mr A.D. Goodson and Dr. B. Woodward of Loughborough University, and Dr M. Klinowska of Cambridge University for their help and support in this project.

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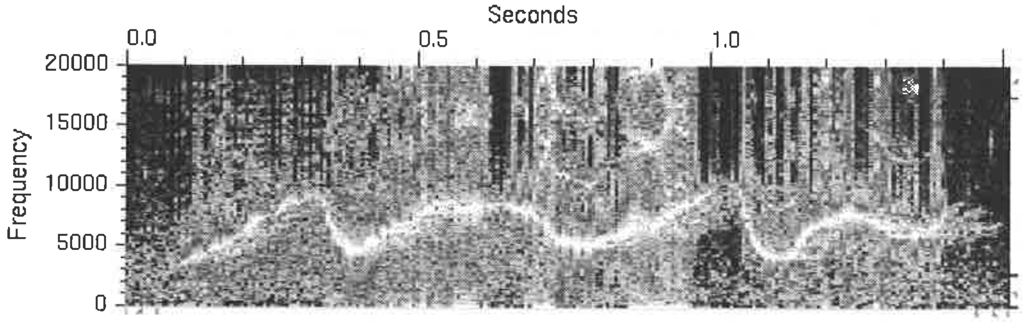

Fig. 1 The Fourier transform of a typical dolphin signature whistle in noise

STUDYING THE ACOUSTIC SIGNALS OF THE HARBOUR PORPOISE

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INTRODUCTION Recent data from fishery observer programmes in Denmark (Lowry & Teilman, 1994), and current studies in the UK and Eire suggest that, whilst surface set gillnets rarely catch harbour porpoises, *Phocoena phocoena*, a much higher mortality of this species occurs in European bottom set gillnet fisheries than had been appreciated. Confirmation that these victims were foraging on the bottom at the time of death has been provided by stomach contents. The traditional view of *P. phocoena* inhabiting a coastal or estuary animal habitat is also called into question as these animals may be caught in gillnets set on the continental shelf, well offshore, in water depths occasionally greater than 100m. The European data seem to indicate a situation similar to that of the north-east seaboard of the USA and Canada where harbour porpoise mortality is particularly high in ground net fisheries, (Jefferson & Curry, 1994). Mitigation methods, such as enhancing gillnet acoustic detectability, developed for other cetacean interactions, have been proposed, but the re-design of such devices, whether active or passive, is based on very limited knowledge of this species' sensory abilities. This paper seeks to present some new acoustic data and describes methods being developed to refine our knowledge. Precision measurements of juvenile porpoise signals and preliminary data from a short study of harbour porpoises in the wild are included.

METHODS The echolocation spectra and Source Levels (SL) of two, rescued and rehabilitated, juvenile harbour porpoise, were measured at the Zeedierenpark Harderwijk. These animals were accustomed to handling, from the bottle feeding, and were co-operative when held at set distances from the hydrophone. The attention of the animals was gained by moving a plastic target directly behind the hydrophone. The click trains recorded peaking sharply in intensity as the animal's head movements, aimed at the moving target, intercepted the hydrophone position. Recordings were made at high tape speed on a Racal Store 4DS instrumentation recorder (frequency response 300 Hz to 300 kHz). Small ball hydrophones (HS120) were selected for their omnidirectional characteristics at high frequency and were carefully re-calibrated in the laboratory after these tests. Video recordings determined that the animals remained accurately positioned. The recorded signals made at three different ranges by two different animals were then analysed for their peak intensity, and the maximum amplitude pulses analysed spectrally to determine the power distribution in the pulse (Goodson *et al.*, 1995).

Since sonar beam-width data were not easy to determine in this study the opportunity to derive those data from similar sized animals was obtained during a porpoise pathology workshop held at the Sea Mammal Research Unit, Cambridge.

In September 1994, echolocation signals were recorded in the wild from harbour porpoises observed from an inactive oil-rig moored in the Cromarty Firth, Scotland. Individual animals foraging at the surface were tracked by theodolite and camera whilst being monitored on a hydrophone system. The acoustic monitoring included signal processing to extract the ultrasonic clicks and make these audible to the observers and recordable on the cameras and on a Sony TCD-D7 digital (R-DAT) recorder. The method employed split the received hydrophone signals into two frequency bands with low frequencies between 2 kHz and 22 kHz sent to one recording channel of the R-DAT. Frequencies between 40 kHz and 160 kHz were processed with a precision rectifier and the click 'envelope' extracted and, after filtering, recorded on the second channel of this recorder.

RESULTS AND DISCUSSION The SL's of the juvenile harbour porpoises measured ranged between 140 and 160 dB re 1Pa at 1m (the average for each animal was 150 dB) with the spectral power peak centred around 145 kHz and a -3 dB bandwidth of 13 kHz, (Fig. 1). Very little acoustic energy was emitted below 120 kHz. The figures obtained match those for juveniles studied by Kamminga (1994), and were rather higher in frequency than those reported for adult porpoises by Mohl and Andersen (1973) and by Akamatsu *et al.*, (1994). Akamatsu's data also suggest that in less reverberant conditions, SL's tended to increase by about 10 dB. These data would appear to indicate that the centre frequency of the sound generating mechanism is body size dependent.

Direct measurement of the sonar beamwidth is difficult and requires a high frequency multi-hydrophone data capture system. In the absence of such measurements, physical acoustics can be used to predict limits using the maximum width and height dimensions of the porpoise melon. Given a spectral peak around 145 kHz, the number of wavelengths defining this acoustic aperture can be used to calculate the minimum possible beamwidth that can be formed. For the animals studied this appeared to be 8° (azimuth) and 12° (elevation). Since the signal is very 'monochromatic', aperture spectral spreading effects are small, and detection of signals outside this narrow sonar beam is difficult. Energy levels outside the beam are generally some 50 dB below those at the beam centre. It is worth noting that in adult animals, a lower peak frequency (longer wavelength) may compensate for the increased melon dimensions, and hence sonar beamwidths may be expected to remain similar throughout life.

In the Cromarty Firth field study, whilst weather conditions severely restricted the observation periods, some 700 surfacing positions were plotted using electronic theodolites, from which individual swimming speeds and breathing rates have been extracted (Mayo *et al.*, 1995). The TCD-D7 digital recorder continuously records time and date in the digital signal sub-code permitting acoustic events to be accurately related to both video and theodolite tracking data. Falling cooling water from the oil rig generated a masking sound which tended to obscure much of the low frequency data channel. However, this effect did not extend into the high frequency band, and the 'click detector' circuitry worked well to extract the harbour porpoise ultrasonic clicks. In sea-state zero, sonar clicks from individual animals were occasionally detected from a maximum range of 350 m, rather better than expected. It was very evident that these echolocation signals were narrow in beamwidth and could only be sensed when the animal orientated directly towards the hydrophone. From the repetition rate of the clicks received, the animal appeared to be searching out to a maximum range some 27 m ahead of itself, (Fig. 2). Variations in the signal intensity also indicate head scanning movements searching a relatively small sector. The swimming patterns observed suggest that at the time these animals were foraging for, and chasing, fish which were close to the water surface.

CONCLUSIONS These data suggest that harbour porpoises possess a relatively low power, narrow band, narrow beam sonar which is optimised to detect small (ingestible size) fish targets at maximum ranges of around 300 m. The lack of energy outside the sonar beam will aid foraging very close to the surface or bottom, and, as the detection range of the sonar is seen to be short, porpoises may exploit these boundaries to improve their search efficiency. It seems quite likely that in bottom set fishing net interactions, the porpoise sonar beam may not ensonify the otherwise detectable net features such as the headline if these are deployed much more than a metre above the seabed.

ACKNOWLEDGEMENTS Special thanks are due to Dr Ron Kastelein and the staff of the Harderwijk rehabilitation centre in the Netherlands and to the two rescued porpoises Marco & Frank; to Dolphin Ecosse in Cromarty and to the SONAT oil company for providing access to the rig 'John Shaw'; to the SMRU pathology workshop participants and particularly to the colleagues and students who took part in the field studies. Support for this work was provided by the Commission of the European Community DG XIV, and by the UK Ministry of Agriculture, Fisheries and Food and the Department of the Environment.

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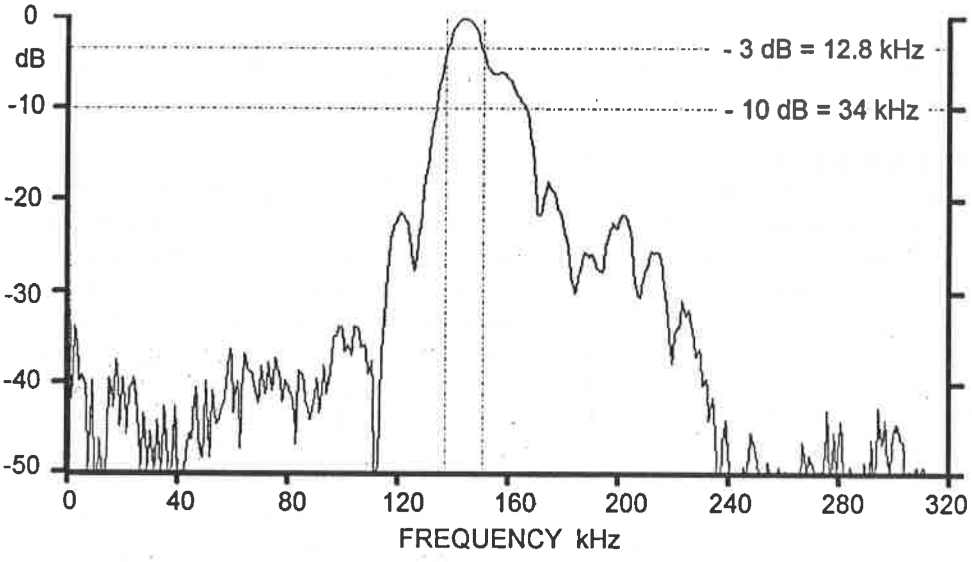
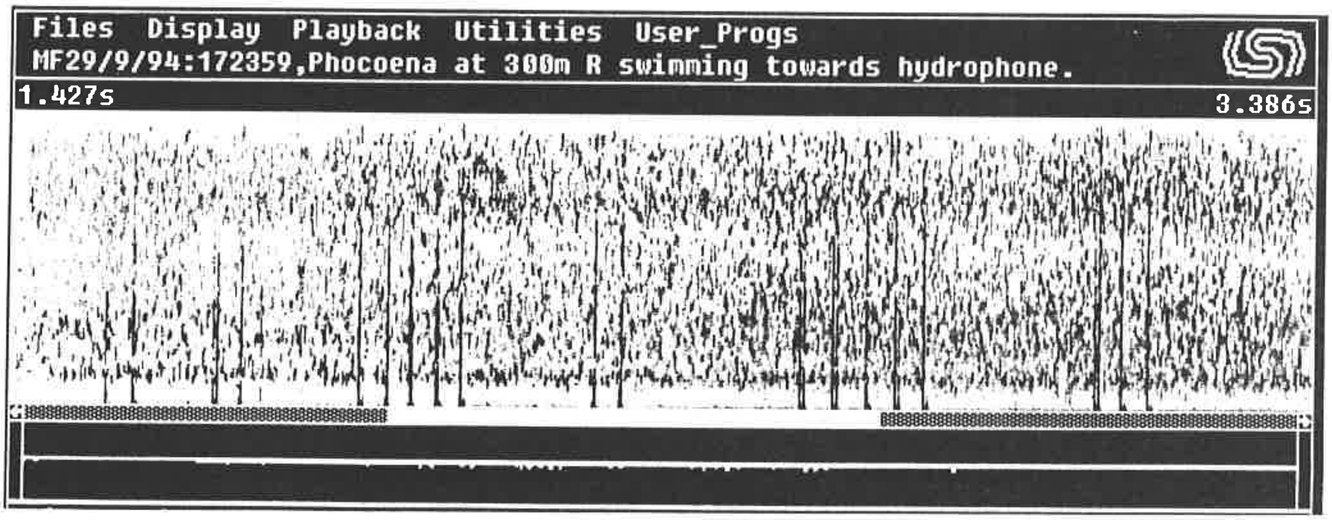


Fig. 1 Spectrum from a juvenile harbour porpoise click recorded on axis at 4 m range. SL 160 dB re 1Pa at 1m, Centre frequency 145 kHz, -3 dB bandwidth 13 kHz, Dynamic range 60 dB.



MF29/9/94:172359,Phocoena at 300m R swimming towards hydrophone.

Fig. 2 Foraging clicks detected and recorded from a wild harbour porpoise orientated directly towards the hydrophone at 300 m range. Inter-click interval 0.036s implies a maximum searched range of 27m.

AN ETHOGRAM OF UNDERWATER BEHAVIORS OF THE ATLANTIC SPOTTED DOLPHIN, *STENELLA FRONTALIS*

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INTRODUCTION Categories of behaviour most common to us in the field are those observed of bottlenose dolphins from the surface (Shane, 1990). General categories usually include travelling, resting, feeding, socialising, and milling. Aerial behaviours have been described for a few species including spinner dolphins (Norris et al., 1994), and dusky dolphins (Würsig and Würsig, 1977). Intraspecific social behaviors have been described for the pantropical spotted dolphin (Pryor and Kang, 1980), and recently for Hector's dolphin (Slooten, 1994). Behavioral descriptions have not shared the ability to be distributed as widely in publications as spectrograms of vocalisations and so their definitions often remain vague.

Ethograms are often specific to a species or field site, but there are some basic categories of adaptive behaviour that are in need of consistent operational definitions. These include: locomotion, thermoregulation, ingestion, elimination, body maintenance, avoidance of predators, parental care, epimeletic (care-taking), explorative, protection/shelter seeking, rest, play, social, sexual, and agonistic behaviour.

Most ethograms are either structural (postural/spatial) or functional (by consequence of the behaviour). Do we start with general categories either intuitively functional to us or of adaptive significance (feeding, mating) and then describe behavioural units found within these categories? Or do we start with units of behaviour, such as ventral to ventral posture, copulation, and later put them in the functional categories? By zooming in and out between structural and functional behavioural categories, we can perhaps provide accurate measures of behaviour, supported by good data, that can serve as indices of functional acts.

METHODS Since 1985, a community of free-ranging Atlantic spotted dolphins have been observed underwater in the Bahamas. The clarity of water and accessibility of the dolphins have allowed extensive video documentation of underwater dolphin behavior in the wild. Various video recorders were used, including an 8 mm and Hi 8 mm camcorder with direct hydrophone input for simultaneous sound recordings during behavioural activity.

RESULTS One hundred and eleven structural units have been observed and used to record an ethogram of underwater behaviours. Behaviours were catalogued according to physical activity including:

1) **Group movement** - 5 types (e.g. rest, milling)
2) **Foraging** - 5 types (e.g. surface/underwater)
3) **Feeding** - 6 types (e.g. bottom, schooling fish)
4) **Physiological/Bodily** - 9 types (e.g. defecation, regurgitation)
5) **Postures/Intradolphin Spatial** - 32 types (e.g. head to head, open mouth)
6) **Bubble Displays** - 4 types (e.g. bubble rings, trails)
7) **Aerial** - 12 types (e.g. breaches, leaps)
8) **Spatial Mid-water Column** - 6 types (e.g. vertical sinks, rafts)
9) **Spatial Bottom Behaviors** - 4 types (e.g. laying on bottom)
10) **Contact Behaviors** - 26 types (e.g. pec rubs, beak to genital)
11) **Play** - 2 types (e.g. object and non-object)

In addition, twenty vocalisations were categorised into five types, including:

1) **Frequency modulated whistles** - 6 types (e.g. signature whistles, chirps)
2) **Burst-pulsed vocalisations** - 3 types (e.g. squawks)
3) **Echolocation trains** - 3 types (e.g. echo trains)
4) **In Air** - 2 types (e.g. chuff, raspberry)
5) **Bodily/Interface/Misc.** - 6 types (e.g. tail hit, aerial)

Ten functional categories, both intra- and interspecifically (with bottlenose dolphins) into which signals, vocal and non-vocal, were observed, include:

1) Foraging and Feeding
2) Group movement
3) Parental
4) Alloparental care
5) Aggressive or agonistic
6) Sexual play
7) Non-sexual social
8) Distress or excitement
9) Disciplinary activity
10) Courtship and mating

Suggested ways of further analysing behaviour include: 1) the use of supplemental information such as acoustic cues with surface behaviour 2) slow-motion analysis; 3) analysis of synchronised and sequential activity; 4) co-ordinating surface and underwater behaviour; and 5) knowing individual life histories to understand developmental aspects of behaviour.

CONCLUSIONS The definition and use of context is the meaning that is derived from the overall activity of the behaviour and audience providing possible multiple meanings for the same signal. The danger with context is to presume/assume the function of a signal and to prematurely label it. This can also occur with labels for vocalisations, like the signature whistle which may have other functions in real life, or a distress call which describes a function (i.e. the animal flees or seeks protection) instead of describing the spectral components. Research often suffers as a result of inconsistent terminology in the literature and between researchers. Developing consistent terminology for behavioural and vocalisation repertoires is critical for comparative work. Categorising behaviours in the wild is needed to help supplement our current understanding of dolphin behaviour, to monitor human interactions with dolphins, and to answer questions about their health, stress levels, and normal behaviour.

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THE ACOUSTIC WORLD OF THE BOTTLENOSE DOLPHINS IN THE SADO ESTUARY

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INTRODUCTION Groups of bottlenose dolphins (*Tursiops truncatus*) belonging to a resident population of approximately 50 animals spend a major portion of their time in the Sado estuary or in adjacent waters on the central west coast of Portugal (for a more complete description, see dos Santos and Lacerda, 1987). They may be observed carrying out different activities inside the estuary, predominantly foraging. Mullets are captured at or near the surface, often in characteristic episodes of aroused group feeding. The animals also spend many hours moving erratically, with long dives, often quite spread out, in what appear to be searches for bottom prey like eels, sandeels, toadfish, flounders, or other benthic species known to exist in these areas. However, the dolphins must accommodate to the costs of using a habitat bordered by a city, a growing harbour, and a large industrial area.

Preliminary measurements of underwater noise levels and frequency spectra were obtained throughout the study area (approx. 100 sq. km), and an overview of the time spent by the animals in the different zones was calculated. The purposes were to obtain some information on the levels and characteristics of the noise that the dolphins are exposed to, and to see whether they tend to avoid the noisiest areas of the estuary.

METHODS Measurements were made with a B&K 8101 hydrophone, calibrated to yield amplitude levels, and a Sony DAT recorder. Our measurements were limited by the DAT to the range between 20 Hz and 20 kHz. A net of 42 points was established, where two 20-minute samples of underwater sound were recorded on different dates, during the daytime, with and without visually identifiable sources of noise. Level and frequency analysis of these recordings was made with a Norwegian Real Time Analyser 830, which computed averaged noise levels and 1/3 octave spectra.

Dolphin movement data from 1988 to 1992 were analysed, covering 40 sightings (selected for their long duration), with a total of 136 hours of observation, in all months of the year. The study area was divided into a number of zones, just according to size and convenience for localisation using landmarks. The number of minutes that dolphin groups stayed in each zone was calculated.

RESULTS The overall ambient noise levels varied between a minimum of 122 dB re 1 μPa and a maximum of 151 dB (harbour area). Fig. 1 was obtained from the averages of all measurements, and gives a general idea of the noise levels throughout the estuary. Fig. 2 shows the average spectrum levels from all measurements, as converted from 1/3-octave analysis. The emphasis at maxima was in the range of around 100 Hz, corresponding especially to boat and machinery noise.

As far as the use of this area by the dolphins is concerned, data from different years do not vary significantly, and the overall percentages of "dolphin time" in the different zones may be seen in Fig. 3.

DISCUSSION AND CONCLUSIONS Although the noise measurements were not made at the same time as the dolphin observations, the animals clearly spent much time in areas where noise levels were high. It is possible that these zones are richer in food because they are the least polluted of the estuary, and for this reason, perhaps the animals cannot afford to shift their occupation habits to quieter zones.

The frequency range of the highest noise levels is not the range of best hearing for the dolphins, and most of the energy in their communication and echolocation emissions is at higher frequencies. The sounds typically produced by fish, however, are well within the frequency range of the high levels generated by traffic and industry, and here we might have a serious effect of noise on the dolphins. They often forage in silence, even in muddy waters, taking advantage of their detailed knowledge of the estuary and possibly using sounds made by fish as a way to detect them, as has been argued by Barros (1993). The ambient noise we measured at these frequencies might not be high enough to stress a dolphin, but it may be enough to mask fish sounds and decrease their detection distance, therefore reducing the probability of capture, at least when they forage in the silent mode. Underwater noise adds to the the other forms of habitat degradation, possibly affecting the animals even in zones where other pollution factors are not so prominent.

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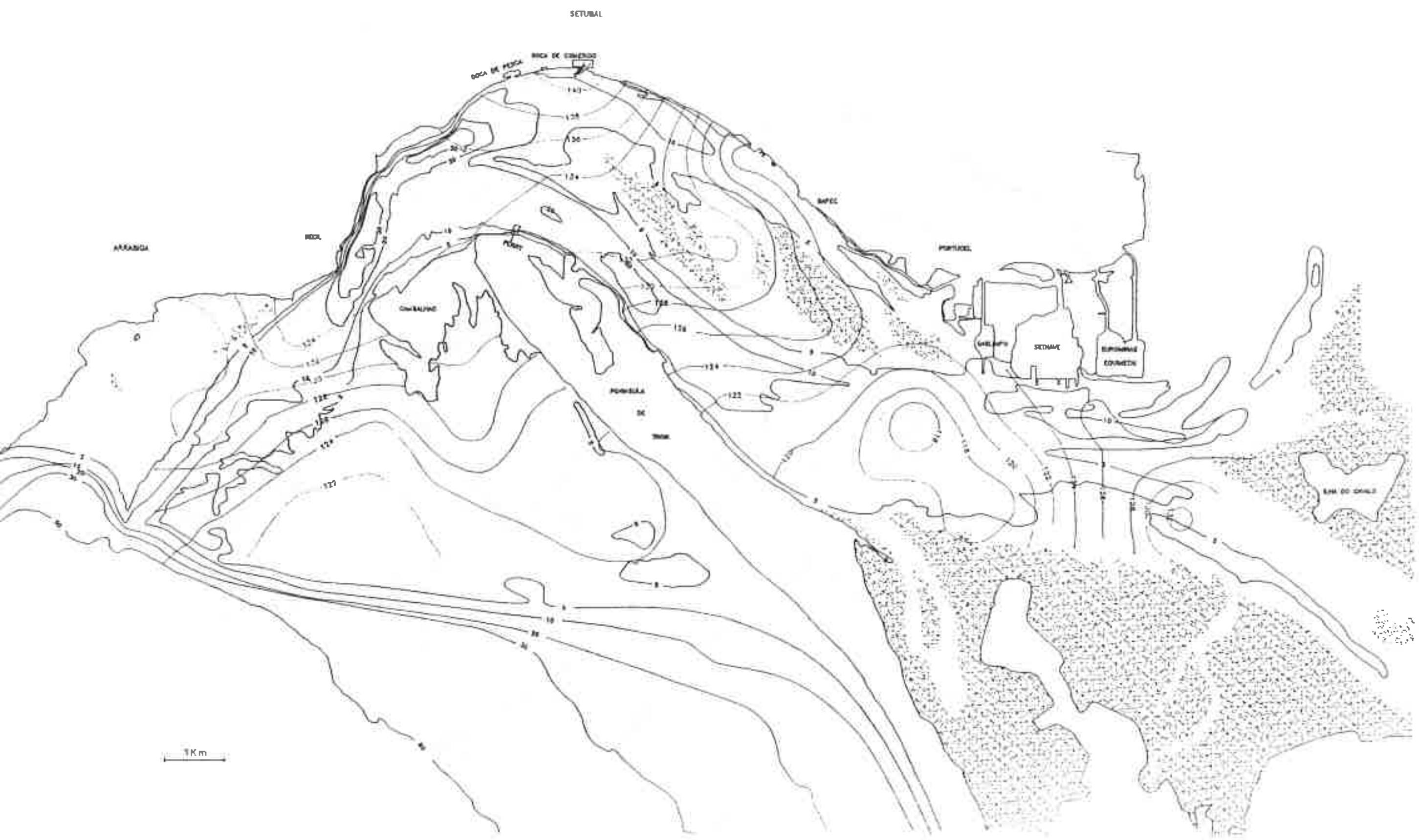

Fig. 1 Noise levels measured throughout the estuary, in dB re 1 μPa

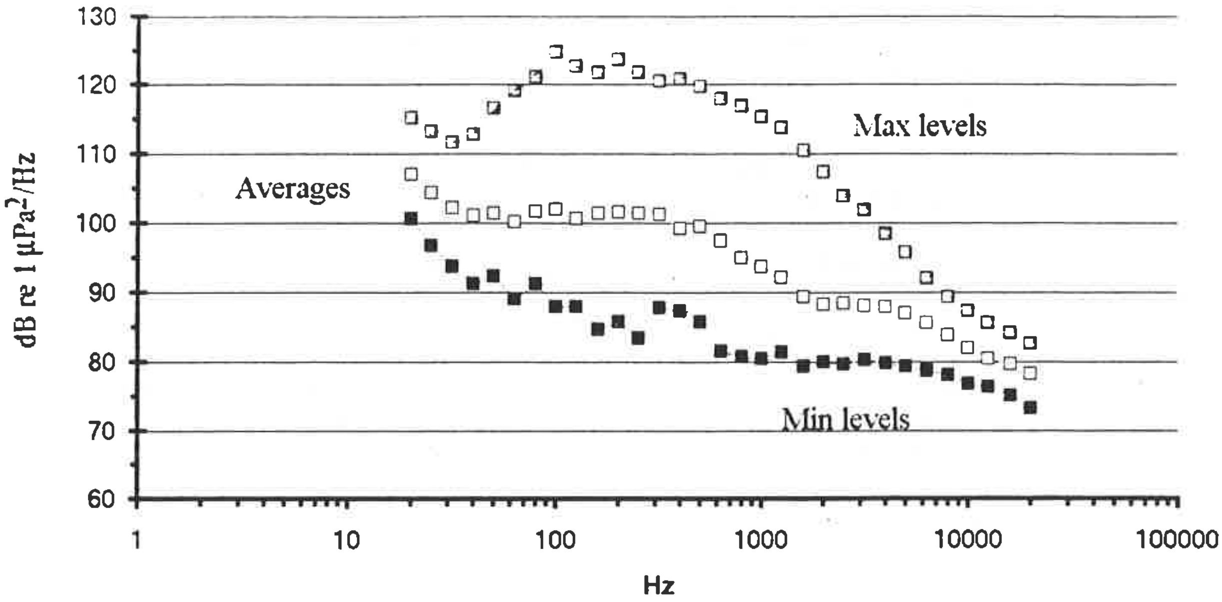

Fig. 2 Spectral characteristics of ambient noise in the Sado estuary

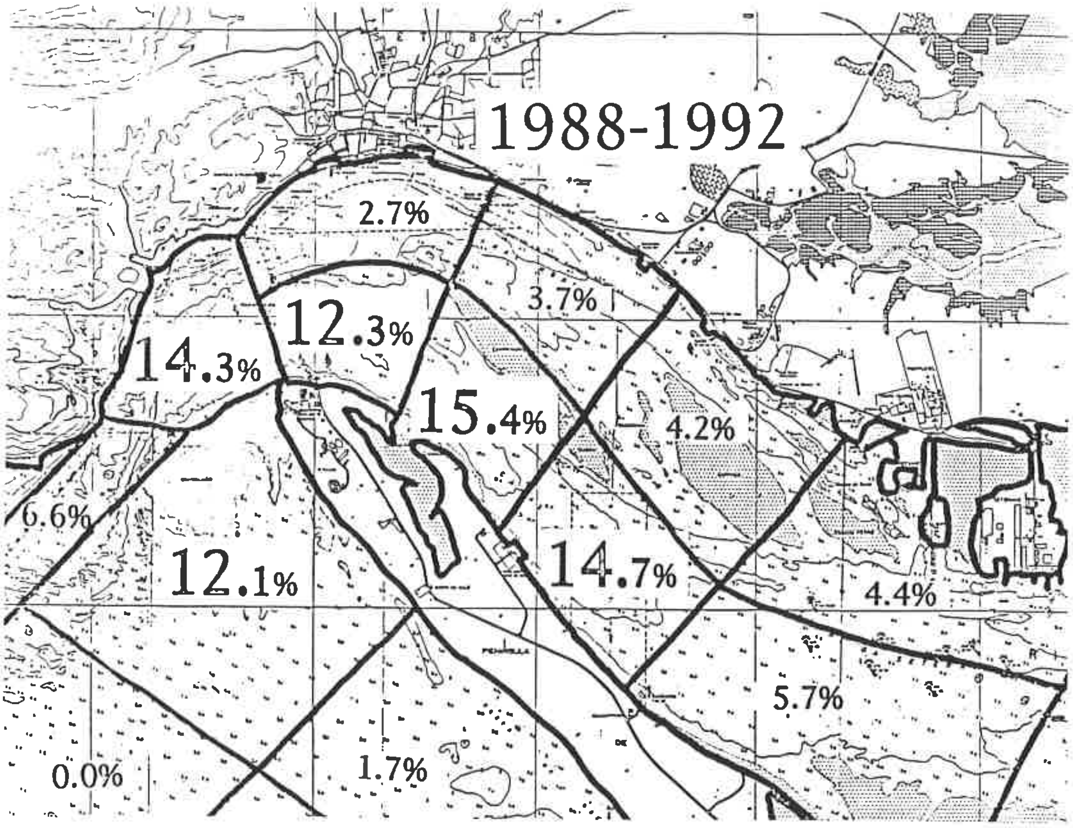

Fig. 3 Percentages of time spent by the dolphin groups in different areas of the estuary, as observed during sightings greater than two hours, from 1988 to 1992

ACOUSTIC BEHAVIOUR OF A CAPTIVE NEWBORN BOTTLENOSE DOLPHIN

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INTRODUCTION On 5th September, 1994, Bonnie, a 20-year old bottlenose dolphin (*Tursiops truncatus*), delivered a healthy female calf named Cleo. The birth took place at 1:00 pm, after more than one hour of labour. Bonnie and her calf are housed at the Acquario di Genova, together with an approximately 10-year old male named Micha. They belong to the Aquatic World Cattolica (Rimini, Italy). The research was carried out during the calf's first year, divided into two six-month periods.

The method of data collection was basically the same throughout the year, except that the frequency of recordings decreased during the second period.

The aims of the project were: to study the ontogeny of vocal and gestural behaviours. That is, to correlate gestural and vocal behaviours together, and in certain contexts, particularly looking at the mother-calf relationship, and relationships between the calf and other individuals inside the pool. The vocal and gestural behaviours were also examined when the calf approached objects. The calf's vocalisations were compared with those coming from adults. This investigation was an attempt to study some of the behaviours related to the development of echolocation; and to contribute to a detailed ethogram of this species.

MATERIALS AND METHODS Recordings in the pool were made by means of a spherical hydrophone (ITC-1089C, 1 Hz - 350 kHz) provided by Alenia-ELSAG Sistemi Navali (Genova), connected to both a S-VHS Hi-Fi video recorder and a DAT recorder (SONY DTC-690). The video recorder was connected to a S-VHS movie camera (Fig. 1). Recordings were made in the frequency range from 100 Hz to 22 kHz. Recordings were then analysed with the real-time Digital Signal Processing Workstation developed by Pavan (Pavan, 1992, 1994) at the University of Pavia, to correlate observed behaviours with sounds. Selected video recordings were analysed, and the real-time spectrographic analysis of sounds was incorporated in the video to allow an intuitive correlation of the observed behaviours with sounds.

Observations were carried out on every Monday, Wednesday and Friday from 9:00 am to 6:00 pm, together with video and audio recordings for both quantitative and qualitative analyses.

Quantitative analysis: recordings took place on Monday and Wednesday during four 15-min periods, starting at 9:00 am, 11:00 am, 2:00 pm and 5:00 pm The main intention was to provide data for statistical analyses regarding early variations in the calf's activity, and to find sequential correlations between different behaviours. The same recordings were also taken into account when carrying out qualitative analyses.

Qualitative analysis: recordings took place on Monday, Wednesday and Friday to collect new behaviours and to follow their development.

RESULTS AND DISCUSSION A previous analysis allowed us to identify a probable favoured whistle from each adult (Caldwell and Caldwell, 1971). Bonnie showed the same whistle during labour and for a few hours after delivery (Fig. 2) as well as during some interactions with Cleo (Fig. 4). The calf's first vocalisations were heard three days after birth, and at least for the first month were always associated with bubble streams from the blowhole. Her first whistles seemed to be tremulous and irregular, but whistle contour apparently changed with time and became more consistent, at least within a certain period of time (Fig. 3). Some vocal interactions between Bonnie and Cleo may suggest the calf's possible mimicry towards her mother's favourite whistle (Fig. 4). The Calf's sonar clicks have been recorded, according to our frequency range (100 Hz-22 KHz) (Fig. 5), since she was two months old.

CONCLUSIONS We are not able to add anything to the previous considerations as yet. Further conclusions will require a detailed analysis of the huge amount of data collected.

ACKNOWLEDGEMENTS Thanks to Alenia-ELSAG Sistemi Navali for technical support and FONDAZIONE CETACEA for references. Special thanks to Prof. Diana Reiss from Columbia University for her helpful collaboration.

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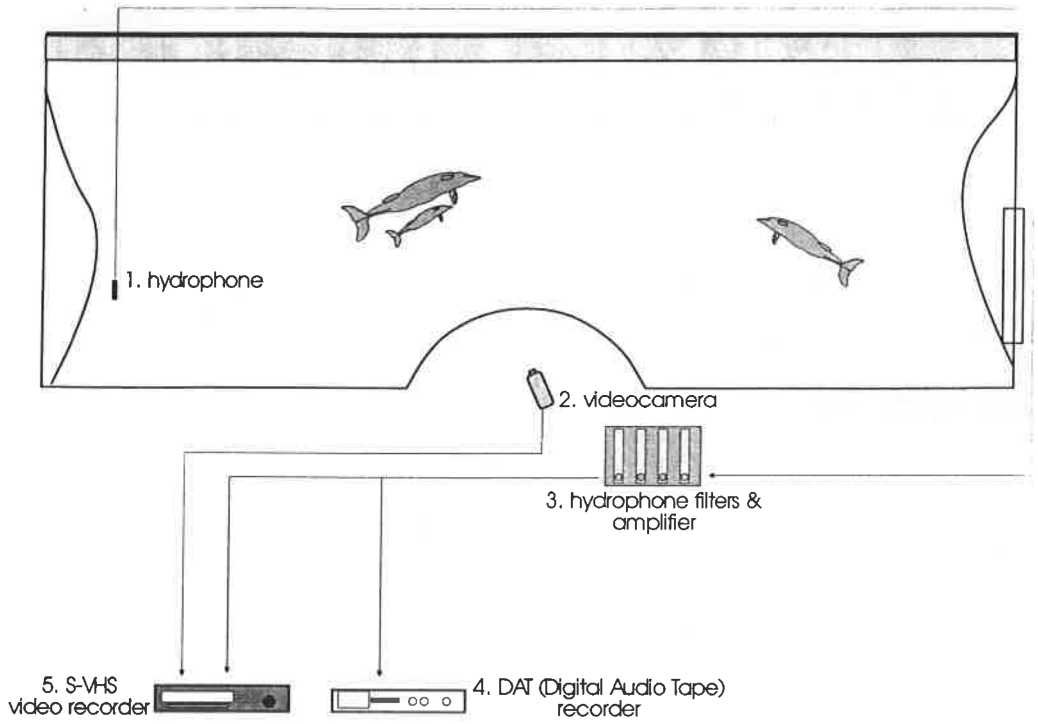

Fig. 1 The data collection system: 1-Spherical hydrophone ITC-1089C, 1 Hz-350 KHz; 2-Movie Camera S-VHS, Panasonic Hi-Fi Stereo NV-MS4 HQ; 3-Amplifier EG e G, Model 113 pre-amp; 4-DAT Digital Audio Tape Deck, Sony DTC 690; 5-Video recorder, Panasonic Hi-Fi Stereo NV-FS200 HQ S-VHS.

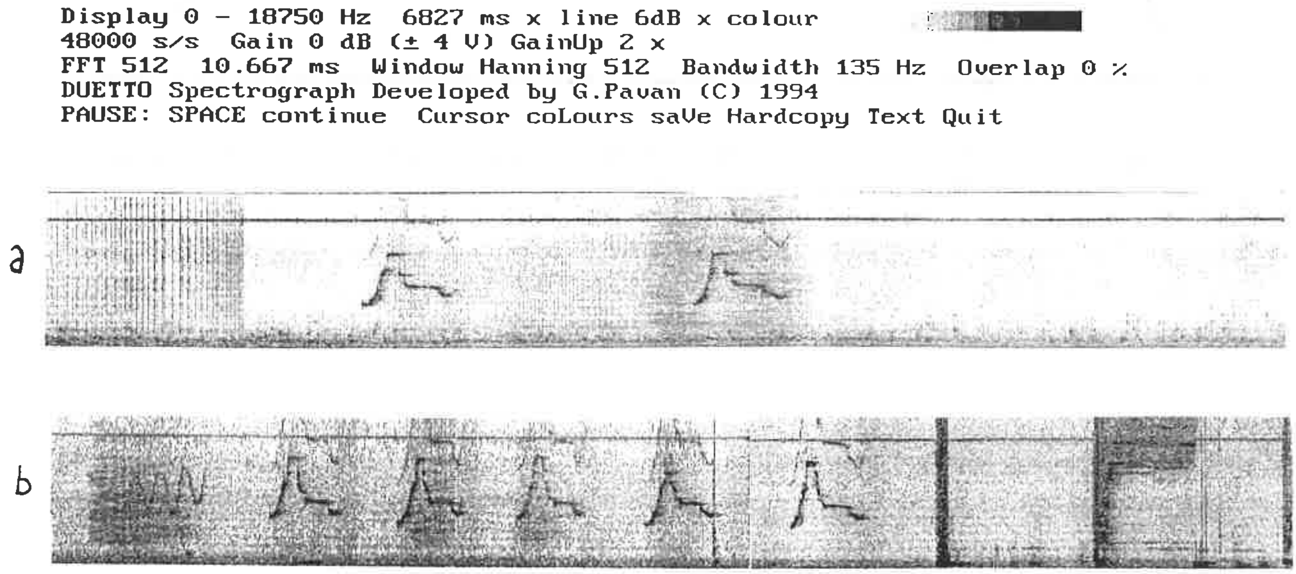

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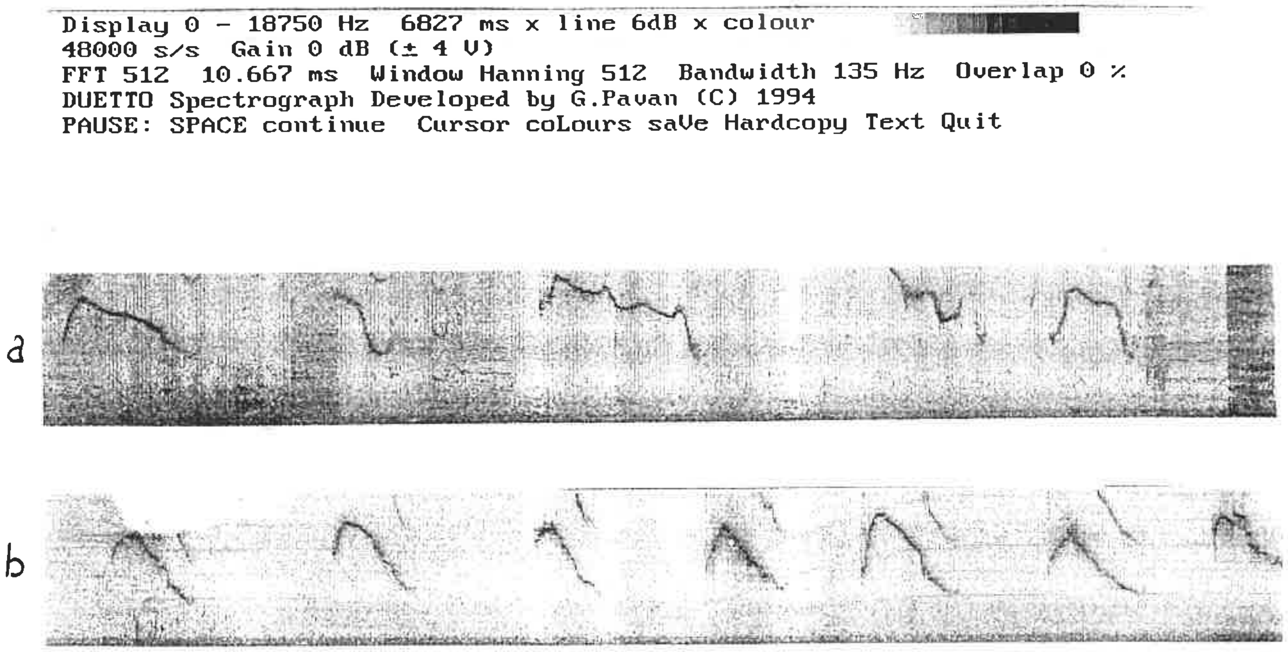
Fig. 2 Bonnie's favourite whistle recorded in two different contexts: a) before parturition, 20/05/94; b) during delivery, 5/09/94.



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FFT 512  10.667 ms  Window Hanning 512  Bandwidth 135 Hz  Overlap 0 %
DUETTO Spectrograph Developed by G.Pavan (C) 1994
PAUSE: SPACE continue  Cursor coLours saVe Hardcopy Text Quit
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Fig. 3 Cleo's whistles recorded during the same contexts in two different periods: a) tremulous and irregular whistles, 30/09/94; b) more consistent whistles, 12/10/94.

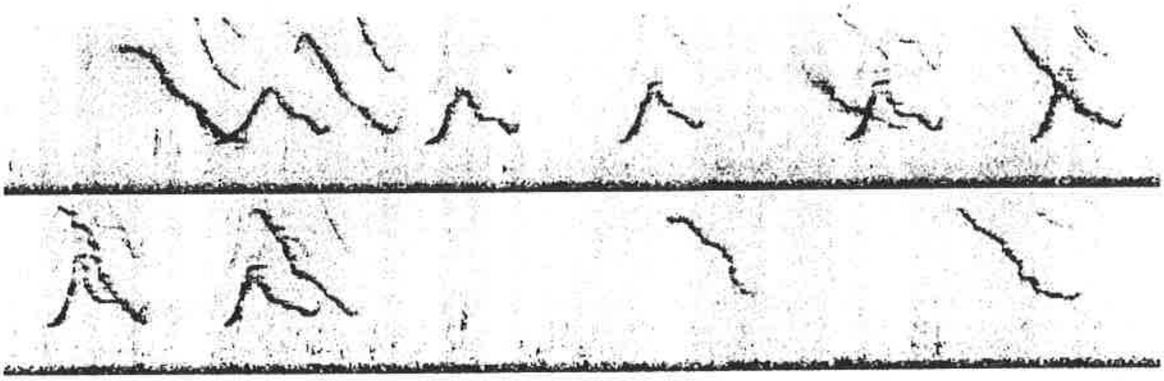

Fig. 4 Vocal interactions between Bonnie and Cleo. Is Cleo trying to imitate Bonnie's favourite whistle?

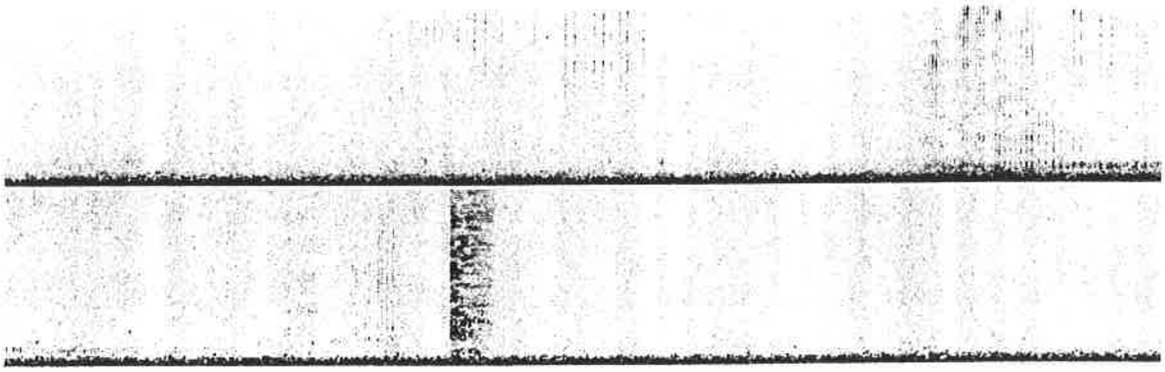

Fig. 5 Calf's first recorded sonar clicks, 16/11/94.

DEPLOYMENT OF A SEA-BED MOUNTED HYDROPHONE FOR CETACEAN MONITORING

E. Harland*, R. Plowman** and M.Turnbull**

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Durlston Country Park, located on the south-west coast of England at 50° 35.5'N, 1° 57'W (Fig. 1), has conducted a visual watch for cetaceans since 1988. The results suggested that there was regular cetacean activity during the spring and autumn, with a decline in activity during the summer months (Fig. 2). With the increased use of the waters off the Dorset coast for commercial and pleasure activities and with the prospect of a high level of oil exploration in the future, it was decided in 1992 to increase the scope and coverage of cetacean activity by deploying a hydrophone on the sea-bed (Fig. 3) off Durlston to monitor the cetacean acoustic activity on an extended basis. This project was incorporated in the Durlston Coastwatch project as part of the Voluntary Marine Nature Reserve scheme and was sponsored by English Nature.

Species identified by the visual watch were common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*) and pilot whales (*Globicephalus melas*). Strandings records for the area suggested that striped dolphins (*Stenella coeruleoalba*) and harbour porpoise (*Phocoena phocoena*) might also be expected in the area. This suggested that the hydrophone would need a bandwidth extending up to 200 kHz. However, in order to get the system operational with the funds available at the time, a 40 mm ball hydrophone was chosen even though it had a bandwidth limited to 50 kHz. A preamplifier with a gain of 26 dB was constructed and encapsulated in 40 mm UPVC water pipe using polyurethane. A sensor to measure the water temperature was also included. Underwater-mateable connectors were used to allow the unit to be serviced by divers, thus avoiding the need to recover the unit. The hydrophone and preamplifier were mounted on a substantial tripod so that the hydrophone would be approximately 1.5 metres above the sea-bed. The tripod was designed to be heavy enough to anchor itself even in the most extreme sea conditions likely to be encountered, and was robust enough to withstand incidental damage by fishing operations.

The signals were brought ashore using 500 metres of quad-core screened cable from Jacques Cable Systems (part no CAF9001) (Fig 4). This was unarmoured, but sheathed in thick polyurethane and has the advantage of being cheap. The cable was weighted to keep it anchored to the sea-bed. The signals were buffered and then driven up a further 750 metres of cable to the visitor centre where the audio processing equipment is located.

This system was deployed in October 1993, with the assistance of local fishermen, but suffered a series of problems associated with the use of thin cable. The decision was made to replace the cable with a more substantial cable. Cable and Wireless Marine Ltd were approached and they agreed to donate a suitable heavily-armoured quad cable (Fig 5) and also to loan the necessary equipment to deploy it. The Royal Marines Landing Craft Training Wing, based at Poole, were also approached and they agreed to provide a landing craft to carry the deployment equipment. This new cable was successfully deployed in July 1994.

However, when tested, it was found that the short stub cable at the shore end had been damaged as it was manoeuvred into position part way up the cliff. Further testing of the preamplifier and hydrophone using a lightweight temporary tripod led to a new design using a 20 mm ball hydrophone with a bandwidth of 150 kHz and an integral preamplifier with a gain of 52 dB. Repairs to the shore cable were carried out and the preamplifer/hydrophone changed in late August and the system then became operational.

The audio processing system was installed in early September and immediately, cetacean acoustic activity was heard.

For those contemplating such a project, it is important to remember that the water has to be shared with other activities such as fishing and pleasure boating. If these people are on your side and involved, your equipment is likely to last much longer! Their assistance can potentially save money, by also providing some of the resources needed to deploy such a system. Later, such volunteers can act as eyes and ears keeping a watch over the installation and also recording visual sightings.

When designing the system, bear in mind that the sea-bed is only slightly less inaccessible than outer space when it comes to repairing equipment! It is better to over-engineer the system, particularly the cable. Money saved in purchasing a lighter cable will be more than outweighed by the cost of replacing the cable later. The preamplifiers must be designed and constructed for high reliability and remote testing. One should also be aware of tests that can be carried out using simple test equipment to check the integrity of the underwater system.

Once the system is deployed, do not forget it is there to collect and analyse data. Regular visual inspections of the shore equipment, and diver inspection and cleaning of the underwater system, will give early warning of impending failure and keep the system operating at the peak of its performance. Keep monitoring the electrical performance of the system as it is very easy for system performance to degrade with time without the operator noticing.

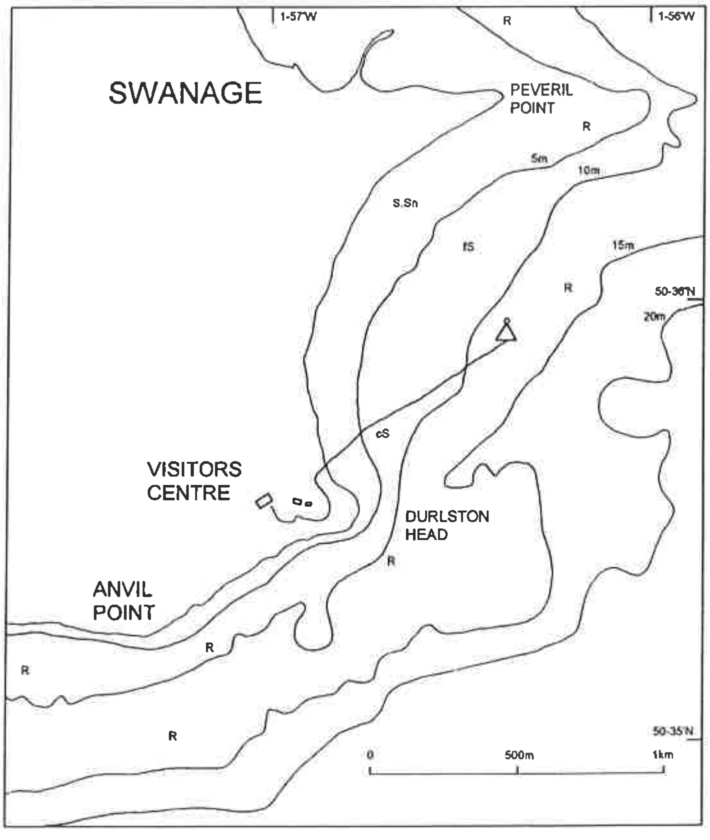

Fig 1. Location of hydrophone

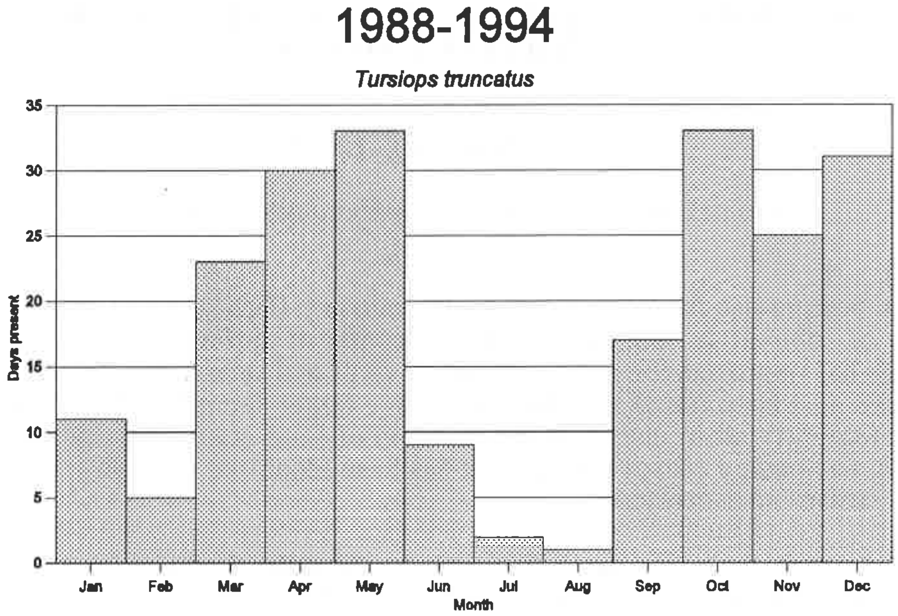

Fig 2. Data from visual watch.

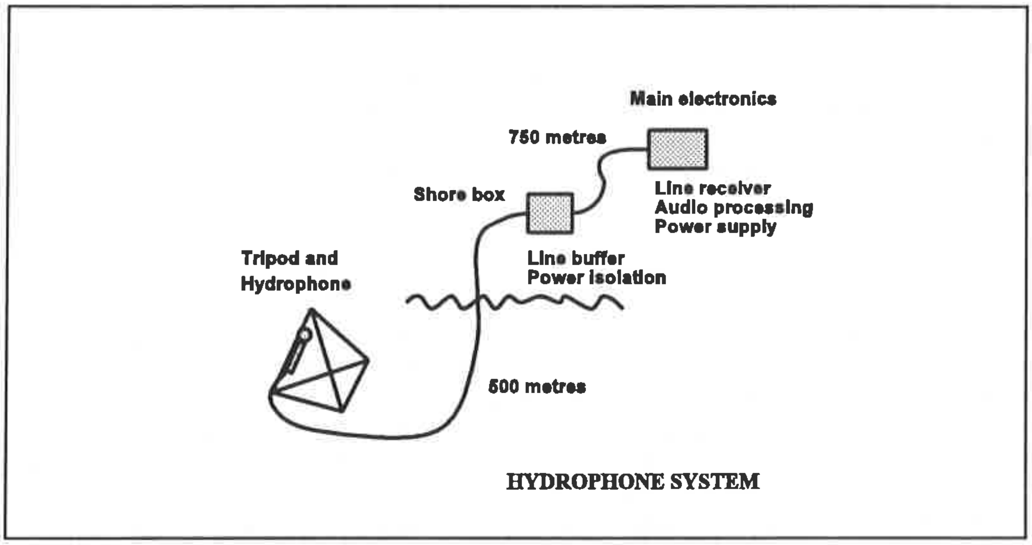

Fig 3. Hydrophone Installation

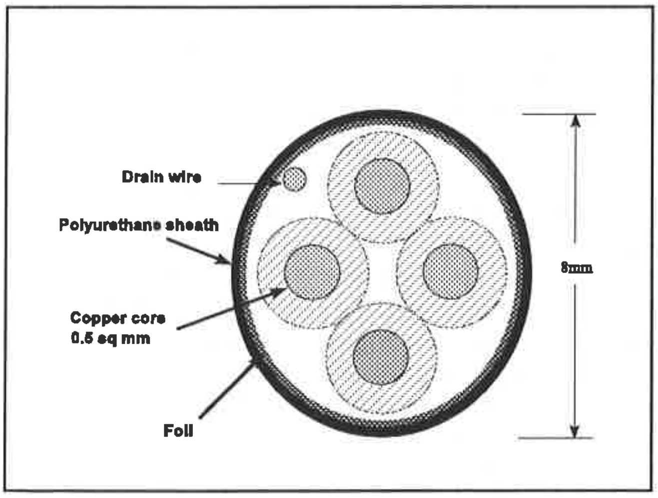

Fig 4. Thin cable

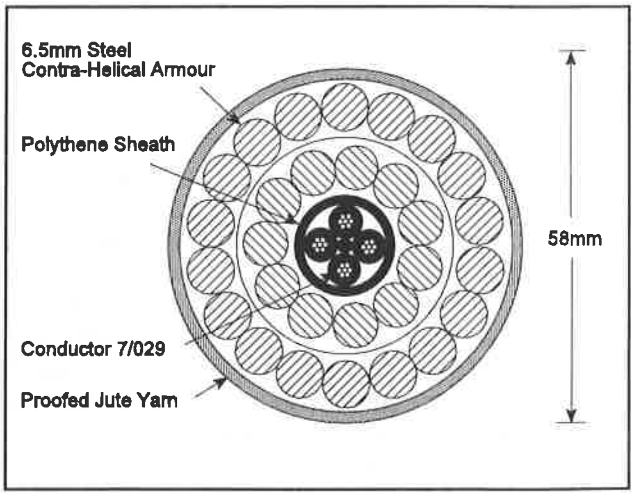

Fig 5. Thick cable

MINIMISING CETACEAN-INDUCED FALSE ALARMS IN MILITARY SONARS

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Sonar has been in use for many years by the military (Urick, 1975), not only for the detection of submarines, but also for the detection of surface ships and mines. As technology has improved, the noise radiated by ships and submarines has decreased and means have also been found to reduce the active target strength. As the targets have become more difficult to detect, so the problem of false alarms has increased. False alarms can have many causes but one that has been identified for many years is due to various cetacean-induced effects.

For passive sonars, the noises made by cetaceans can cause effects which are difficult for untrained operators to comprehend. A typical example is the sound of the fin whale (*Balaenoptera physalus*) which shows on passive sonars as a strong signal around 20 Hz (Fig. 1). It is also possible for the sounds to be attributed to the wrong cause. Sperm whales (*Physeter macrocephalus*) are often referred to as carpenter fish because of the distinctive sound they make. Seals are another problem with some operators being convinced that their sounds originate from an artificial source.

For active sonars, the problem is more complex (Fig 2). The sounds made by cetaceans can interfere directly with the operation of the receiver but a greater problem is that of false targets caused by echoes from the larger animals or groups of smaller animals. It is also possible for target masking to be caused by large groups of animals and by the sounds that they make.

The UK Defence Research Agency, as part of its sonar research programme, has been asked to look at ways of minimising these cetacean-induced false alarms. At the start of the work it became clear that there was very little factual data on cetaceans available to the operators, and even less acoustic data. In order to rectify this situation we have embarked on a programme of work to assemble a database which is easy to use and optimised to aid the sonar operator. The Sea Animal Noises Database (SAND) will provide a system for the storage and retrieval of information about marine animals (Fig 3). Text, sounds, photographs, and movie information from a number of sources will be stored. Retrieval will be made on a variety of selection criteria. The flow of data during the preparation of the database is illustrated in Fig. 4. The current preferred computer platform is the Apple Macintosh, but it should be possible to migrate to other platforms such as the Power PC.

The main source of acoustic data is currently the archives of the Woods Hole Oceanographic Institute. Margaret Klinowska of Cambridge University has been providing the textual information. The sound data are being supplemented with data gathered within the DRA and by external sources, including Jonathan Gordon of the Wildlife Conservation Research Unit at Oxford University. The acoustic and image data used will need to have accompanying data defining how, when, and where it was collected. We are always looking for more data, both acoustic and visual. If you have any data we may use, please contact either of the authors. The database will be issued as a CD-ROM and user guide to naval sonar operators and training establishments. It will also be available to scientists within the DRA and to contractors engaged in developing new sonar systems. The package will include a simulator for in-service sonars so that the user can choose to hear or see the data as they would from the sonar set. The sounds in the database can also be used during the development of sonar systems to evaluate their response to marine mammal sounds. It may be possible in future systems to train the sonar set itself to recognise and reject cetacean-induced false-alarms.

It is hoped that the database will be released into the civil research community and perhaps, at a later stage, to put it on general release to the public. Within the civil research community, the database should be a useful source of information for those involved in conservation issues, and also for those who only infrequently come into contact with some of the animals described. It could also be used in university courses and for other educational purposes.

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THE PASSIVE SONAR PROBLEM

Passive sonar operating band: 10Hz to 10KHz
Many cetaceans make noises in this band

Example of Fin Whale ticks on Time/Frequency Display

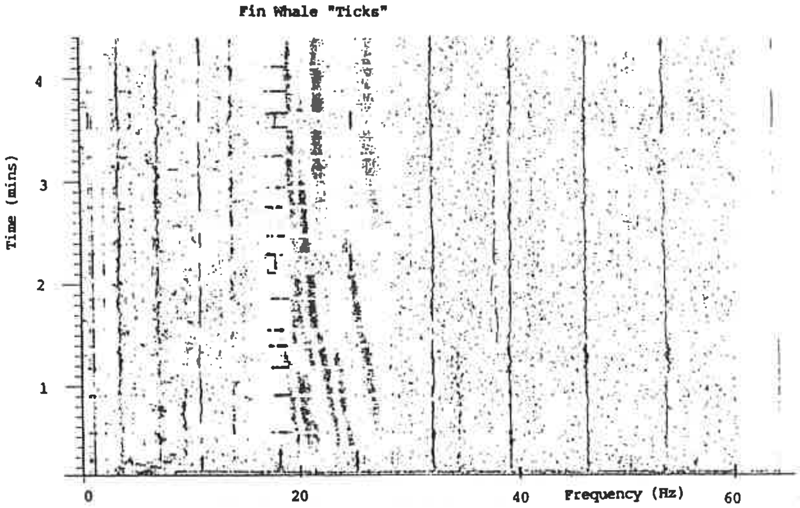


Fig 1. The passive sonar problem.

THE ACTIVE SONAR PROBLEM

Active sonar operating band: 2 KHz to 12 KHz

Submarine Target Strengths: +5 to +20dB
(depending on size and structure)

Whale Target Strengths: -5 to +10dB
(depending on size)

Note: False alarms also caused by vocalisations in the reception band of the active sonar.
Also target masking can be caused by high reverberation levels from pods of animals in the active sonar beam.

Fig 2. The active sonar problem.

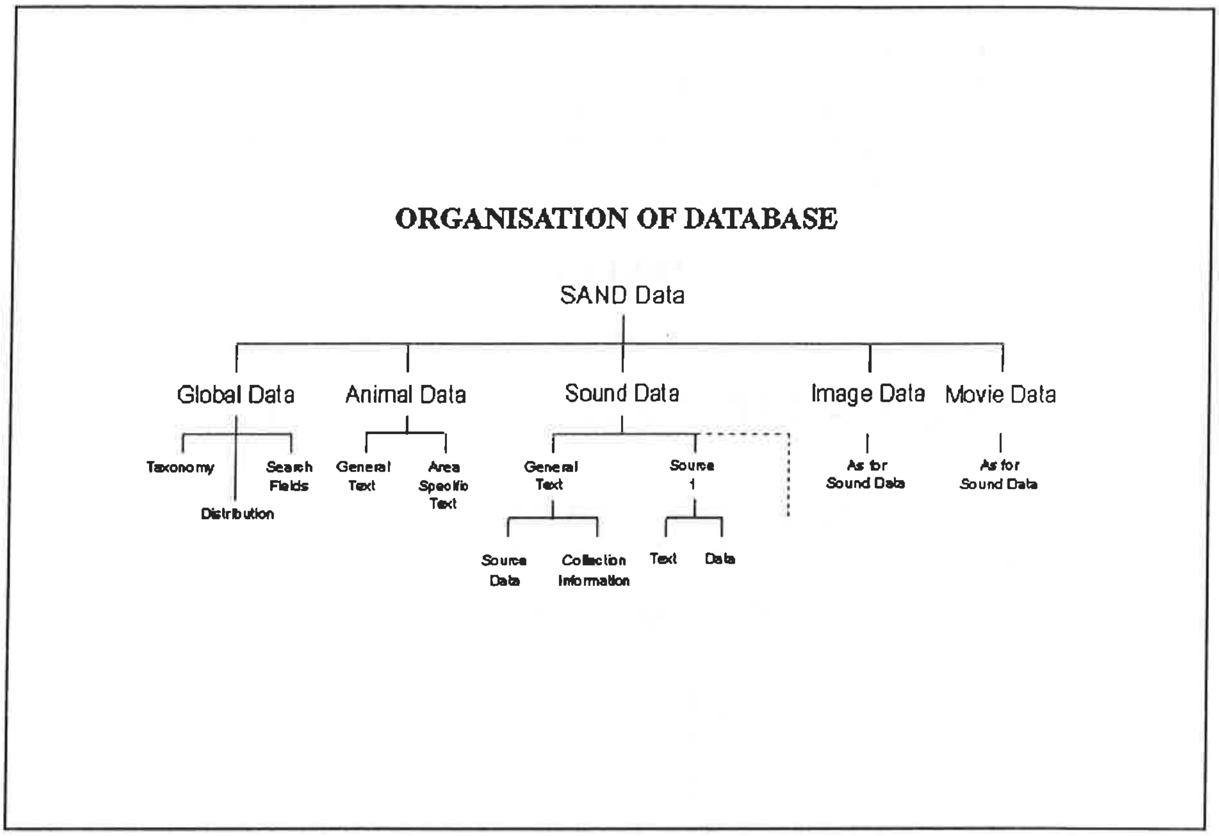
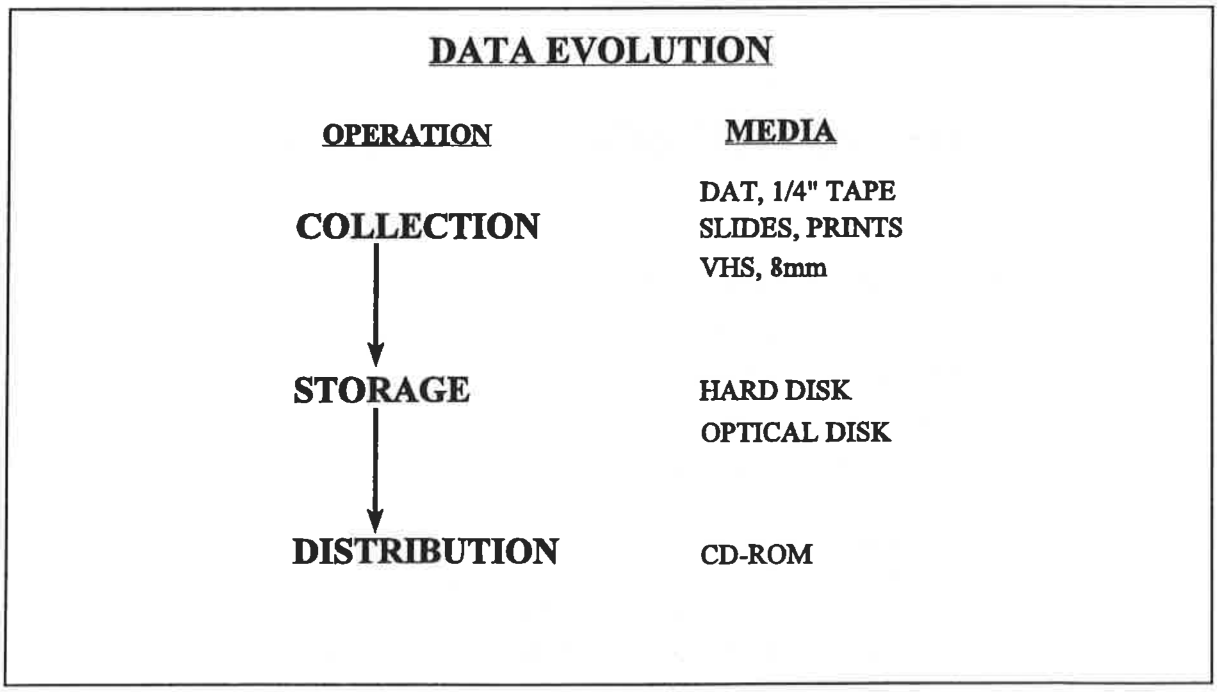


Fig 3. Organisation of the SAND database



DATA EVOLUTION

OPERATION — **MEDIA**

COLLECTION — **DAT, 1/4" TAPE**
SLIDES, PRINTS
VHS, 8mm

STORAGE — **HARD DISK**
OPTICAL DISK

DISTRIBUTION — **CD-ROM**

Fig 4. Data flow and storage media.

DEVELOPMENT OF AN AUTOMATED HARBOUR PORPOISE CLICK DETECTOR

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Harbour porpoises are notoriously difficult to observe and become almost impossible to see in moderate or rough sea conditions. Acoustics provide complementary study methods to those based on visual observation which are less weather dependent and can be carried out 24 hours a day.

Recordings of free ranging harbour porpoise vocalisations indicate that they emit narrow band ultrasonic clicks with the centre frequency between 115 and 145 kHz. IFAW has been developing a system since 1992, to monitor these vocalisations in the field. The current system records the frequency structure and intensity of all the clicks detected on a computer. The data are then processed to allow porpoise vocalisations to be distinguished from other sources of noise. The ultrasonic clicks are converted to an audible form using envelope tracing circuitry. Recording the data directly to a computer allows the system to be deployed from platforms of opportunity by small survey teams, and eliminates the problems of inter-observer bias.

The equipment has been used during the SCANS project, and during surveys by the British JNCC Sea Birds at Sea team, the Dyfed Wildlife trust, Dr Harald Benke (Kiel University), and Dr Peter Evans (Oxford University).

Results from these studies have been encouraging and the system has detected vocalisations from five dolphin species, and has successfully discriminated these from harbour porpoise vocalisations. Preliminary results comparing visual and acoustic detections are presented.

INTRODUCTION A decline in harbour porpoise numbers has been observed in several parts of the North Atlantic in recent years. Bycatch (mortality due to interactions with fishing gear) is a cause of particular concern in many areas. (Smith *et al.*, 1991).

Harbour porpoises are difficult to observe and become almost impossible to see in moderate or rough sea conditions. Techniques for monitoring harbour porpoise vocalisations promise to provide a complementary study method to visual observations with several potential advantages. Acoustic range is more predictable and less affected by meteorological conditions than visual range and can be superior to visual range, especially when small research vessels are used. Acoustic methods allow automated data collection, eliminating human error and inter-observer bias. In addition, acoustic studies can continue 24 hours a day.

The International Fund for Animal Welfare (IFAW) commissioned the development of a system to monitor harbour porpoise vocalisations automatically in 1992.

METHODS

Vocalisations of harbour porpoises Measurements of the vocal behaviour of harbour porpoises and of potential noise sources were made at five locations around the British Isles during the summer of 1992 and 1993. Narrow band clicks with centre frequencies between 115 and 145 kHz were the only vocalisations recorded from harbour porpoises.

Equipment The automated equipment is simple and compact, will run from 12V batteries, and can be deployed by one person. A hydrophone is towed at a depth of 5-10m, between 50-200m behind the vessel at speeds of up to 12 knots.

The system is composed of several different units, as shown in Figure 1. The output from the towable hydrophone is monitored by an analog circuit which detects impulsive click type sounds and measures their frequency composition. These data are passed in digital form to an IBM compatible laptop computer to be stored for analysis.

Click detection and aural monitoring circuitry The input from the hydrophone is initially filtered into three bands, one centred at 50 kHz, the second centred at 72 kHz, and the third flat between 115 and 145 kHz.

The envelope of the click in each frequency band is traced, the wave thus formed falls into the human audible range, and at this stage, the signal can be monitored aurally or recorded on normal audio tape or DAT.

The amplitudes of the click envelopes in each of the three frequency bands are measured, together with simultaneous measurements of relative background noise. All data are stored on the hard disk of the computer.

One program is used on the vessel to collect, store and display data in real time. A second program analyses the data off-line. Both programs use the frequency structure, pattern and volume of the clicks collected to differentiate narrow band porpoise clicks from broader band 'noise clicks' such as propeller cavitation, clicking shrimps, collisions of the hydrophone with debris in the water, various types of sonar and depth sounding equipment, and vocalisations from other cetacean species.

Vessels used in the Small Cetacean Assessment in the North Sea (SCANS) survey were made available as platforms of opportunity. This allowed the collection of acoustic data in conjunction with high quality visual sightings data from large parts of the North Sea, Baltic, and the Celtic Shelf (Hammond *et al.*, 1995).

Analysis Links between acoustic and visual encounters were classified as being definite, likely, possible, or absent, based on the range to the sighting and the time elapsed between the visual sighting and the acoustic detection.

One useful way to explore these data is to consider visual and acoustic encounters as independent means of detecting porpoises, and to then investigate how various factors affect the probability of "hearing" porpoise groups which have been spotted, and conversely the probability that porpoises that were detected acoustically were also seen. Porpoises were considered as having been detected both visually and acoustically when encounters were linked.

RESULTS

Automatic Detection in Conjunction with Visual Surveys During the main SCANS survey in July 1994, the equipment was deployed from six vessels. 355 hours of usable acoustic data were collected. In this time, a total of 690 individual porpoises were detected visually, while there were 265 acoustic encounters with groups. Many acoustic encounters may have involved more than one individual, however. The acoustic and visual encounters are summarised in Table 1. This shows the variation of detection rates with sea-state. While the rate of visual detections fell off rapidly with sea-state, as would be expected, the rate of acoustic encounters remained remarkably stable. The proportion of acoustic detections linked to visual sightings also fell off dramatically at sea-states above one, a further indication that in these conditions, only a small proportion of porpoises within acoustic range were being sighted.

To investigate linked encounters further, only those porpoises sighted within an area 200 m ahead of the boat and 500 m on each beam were considered. 296 porpoises were sighted within this area while on acoustic effort, and of these, 33% were detected acoustically.

Figure 2 uses all linked visual and acoustic detections to show the total number of visual sightings and acoustic detections that were made in each range category. The range scale is perpendicular range from the trackline calculated from the estimated range and bearing of the visual sighting.

Figure 3 shows that the percentage of visual sightings detected acoustically does tend to decrease moderately with sea-state but the frequency of acoustic detection of sighted porpoises is not significantly affected by sea-state (Chi Square test; sig. 0.2, df 12).

By comparison, 30% of all acoustic encounters were linked with a visual sighting. (This could be taken as an indication of the proportion of porpoises within acoustic range which were detected visually). Figure 4 shows that, as might be expected, the proportion of visual detections falls off markedly with sea-state. Frequency of visual detection of acoustically detected porpoises was significantly affected by sea-state (Chi Square test, sig. 0.0001, df 12).

Vocalisations from other cetacean species The system has also detected vocalisations from bottlenose dolphins (*Tursiops truncatus*), pilot whales (*Globicephala melas*), killer whales (*Orcinus orca*), white-sided dolphins (*Lagenorhynchus acutus*), common dolphins (*Delphinus delphis*), Risso's dolphins (*Grampus griseus*) and white-beaked dolphins (*Lagenorhynchus albirostris*), and was able to distinguish these from harbour porpoise vocalisations.

DISCUSSION Results of the field trials reported here indicate that the automated system can detect harbour porpoises at ranges and rates which allow it to be a useful survey tool. Acoustic detection was less affected by sea-state than visual sightings, and the overall acoustic detection rate exceeded the visual detection rate at sea-states of three and above. This represents the majority of conditions in many exposed areas of the North Atlantic outside the summer months.

In an acoustic survey, the factors likely to affect the probability of detection include levels of background noise, from sources such as sea-state, precipitation, and vessel noise, and behavioural changes in the rate at which acoustic signals are made. As the results of the SCANS survey show, increases in background noise due to sea-state had little effect on detection rate.

In its present stage of development, the automated equipment is a simple and efficient means of collecting data which can be used to estimate a relative index of abundance. Such indices of abundance could potentially be obtained with relatively low coefficients of variation because large amounts of data can be obtained at little cost. Further work is needed, however, to allow acoustic methods to yield absolute abundance measures.

There are many situations (during the winter months in temperate waters, for example) where the number of calm days suitable for conducting visual surveys for harbour porpoises is so limited as to make visual methods impracticable. In these situations, acoustic methods may be the only way to examine seasonal trends in abundance and distribution. Further, in view of the other advantages of acoustic techniques outlined in the introduction, there is a useful role for such methods, even in situations where they do not provide a greater range or probability of detection than other methods.

Other uses for the equipment The equipment monitors its own performance and collects data automatically, enabling it to be left for many days without attention, so that, for example, fixed hydrophones could be deployed in locations frequented by porpoises, and used to monitor movements over long periods. In particular the equipment could be used to investigate factors which affect entanglement of porpoises in fishing gear.

Future developments and applications We are currently developing a directional version of the equipment using linear multi-element arrays to provide bearings to, and positions of, vocalising animals. This will enhance the technique in a number of ways, such as improved noise rejection, and provide better information on the number of animals in a group, avoidance reactions, range verses detectability, and behaviour.

Application to other species The equipment, or modified versions of it, are also likely to be suitable for surveying and studying other species known to make similar vocalisations. The vaquita (*Phocoena sinus*) and *Cephalorhynchus* spp. which make similar sounds to harbour porpoises, and suffer heavy human impact, are particularly appropriate candidates.

ACKNOWLEDGEMENTS This work is funded by the International Fund for Animal Welfare. We are grateful to the organisers of the SCANS survey for permitting us to place acoustic equipment on their vessels, and for allowing us access to visual data for comparative purposes.

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Data collected on the SCANS survey

Sea state	**0**	**1**	**2**	**3**	**4**
Hours of data collected	13	60	107	113	62
Number of sightings of harbour porpoise groups or individuals	139	312	132	80	26
Number of acoustic encounters with groups	15	40	74	83	47
Mean number of visual detections per hour (number of sightings/hours of data)	10.69	5.2	1.23	0.71	0.42
Mean number of acoustic detections per hour (number of encounters/hours of data)	1.15	0.67	0.69	0.73	0.76
Proportion of acoustic encounters linked to visual encounters	0.86	0.60	0.25	0.31	0.21

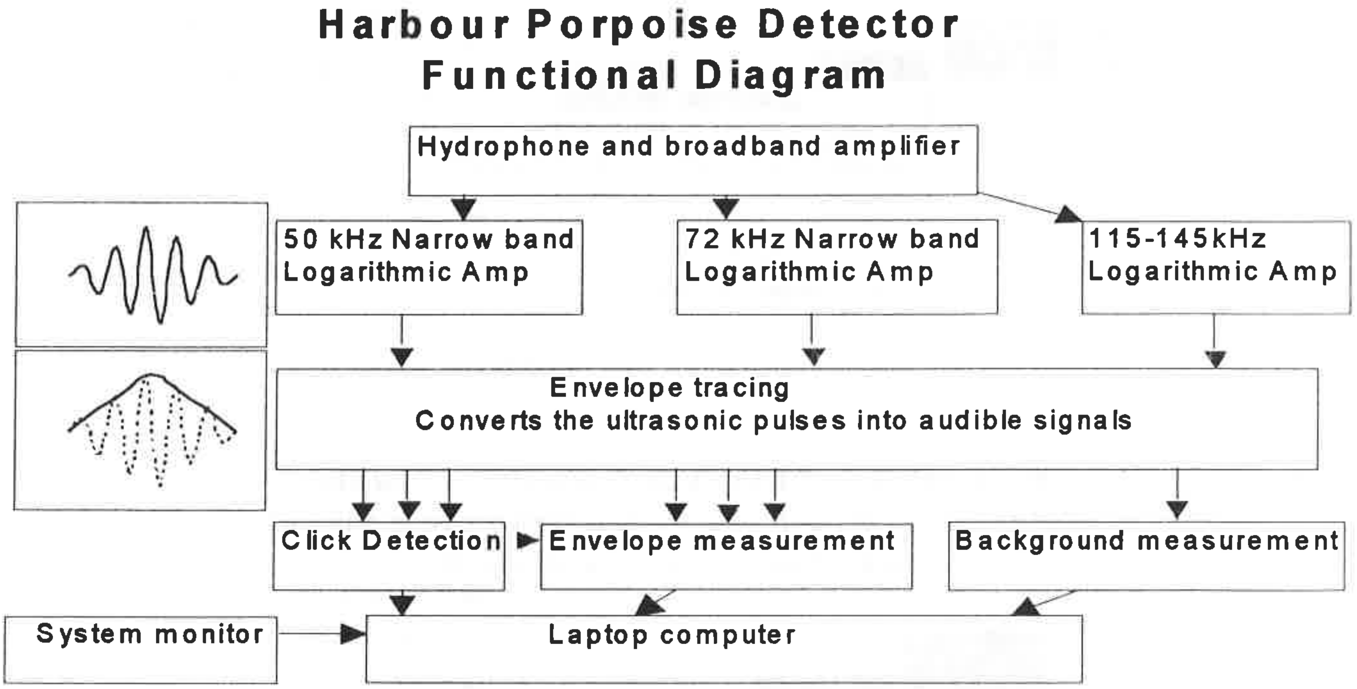

Figure 1

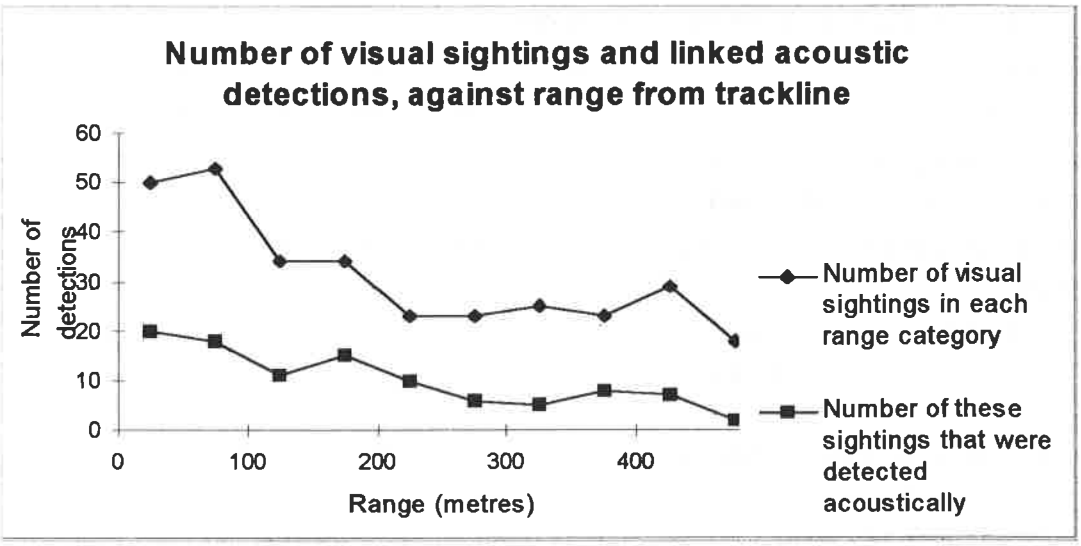

Figure2

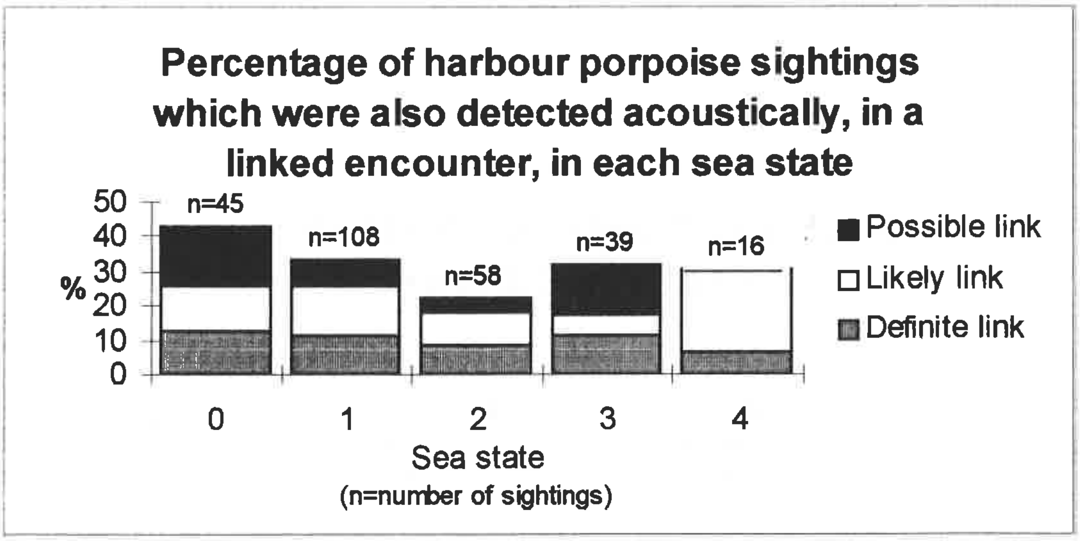

Figure3

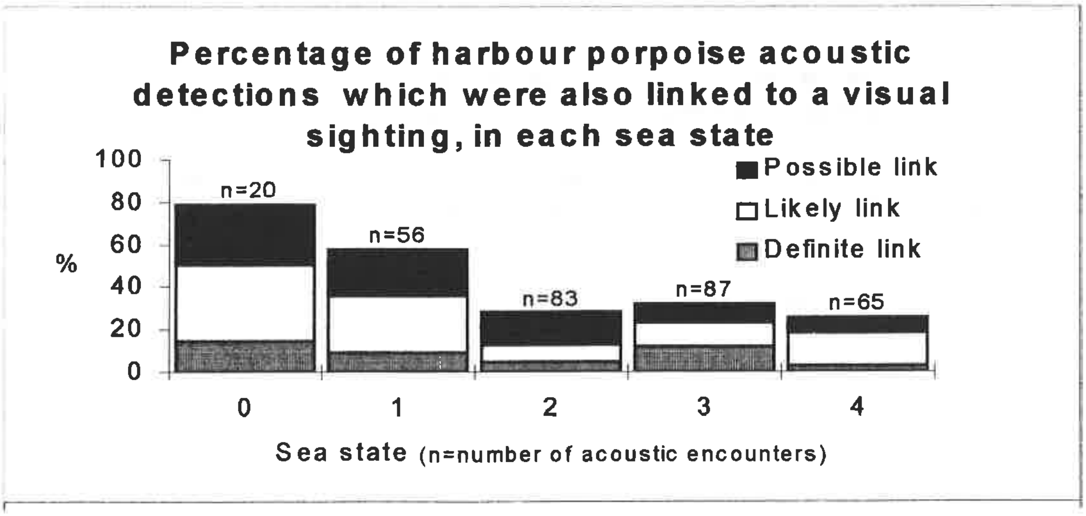

Figure 4

INTERACTIVE DIGITAL SOUND LIBRARY ON CETACEANS OF THE MEDITERRANEAN SEA

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INTRODUCTION Since bioacoustic research is basically carried out through the detection, the systematic classification, and the analysis of animal acoustic emissions, zoological sound libraries are of primary importance. Sound Libraries are national and international institutions, somewhat similar to museums, whose main task is to collect, file, and preserve the recordings of animal voices and make them available to the scientific community as well as to educational activities.

The Cetacean Sound Library created at the Centro holds recordings made during research cruises organised by our laboratory, the Tethys Research Institute, and Europe Conservation Italy to study the acoustic behaviour, distribution and biology of cetaceans in the Tyrrhenian Sea. From 1987 to the present, 67 hours of recordings from six odontocetes (*Physeter macrocephalus*, *Tursiops truncatus*, *Grampus griseus*, *Globicephala melas*, *Stenella coeruleoalba* and *Delphinus delphis*) and one mysticete (*Balaenoptera physalus*) were collected, analysed, catalogued and organised in a Cetacean Sound Library which can be considered the most important of its kind in Europe.

The Sound Library consists at present of 34 analog tapes and 46 DAT digital audio tapes for a total of 67 hours of effective recordings. Absolute duration in minutes and percentage distribution of available recordings per species are listed in Table 1. Aims of this Sound Library include: providing detailed information about the acoustic capabilities of cetaceans of the Mediterranean, such as their species-specific sound characteristics, and creating the basic knowledge needed to develop useful techniques and instrumentation for cetacean research as well as to allow comparison with other recordings made in different areas to determine the consistency of the theory about the existence of dialects or geographical variations. A catalogue based on a widely used database format (dBase III) was created in order to allow an easy and reliable access to the collected recordings. It contains the most significant information about the species recorded, the technical details of the recordings, their location in the library, including links to sound clips, spectrograms and images digitally stored on the Interactive Digital Sound Library. Each record of the database refers to a single continuous recording (Table 2).

The Library provides flexible and specific access to sound information for research and other purposes such as environmental monitoring, species identification, censusing activities, and educational applications. Also, it provides information highly relevant to the conservation of cetaceans in the Mediterranean Sea and should be used to support future research on the impact of underwater noise on the marine life, especially in protected areas. The detailed knowledge of acoustics of marine animals would allow one to carry out studies on the impact of underwater noise of anthropogenic origin, such as that produced by commercial, tourist or sporting sea traffic, as well as military, scientific and industrial activities, thus establishing parameters for the evaluation of possible disturbance or damage caused to the animals. For these reasons, recordings of noises and sounds due to the environment and to artificial sources, mainly ships and sonars, should be made and included in the Sound Library.

Based on the Digital Signal Processing Workstation (DSPW) developed at the Centro, an Interactive Digital Sound Library (IDSL) was created in order to widen the access to the Sound Library and to experiment new technologies in the management and distribution of sounds. Selected recordings were stored in digital format to allow direct access from PCs in a networked computing environment. Specific software was developed to perform spectrographic analyses in real-time, allowing one to select a stored recording and to listen to the sounds with the synchronous and continuous visualisation of their spectrographic features. Moreover, text and images (photos, graphs, or samples of spectrograms) can be linked to each recording to increase the amount of information given to the user.

MATERIALS AND METHODS The transformation of signals in the digital domain allows a new approach in the management of the data, thus facilitating the operations of filing and analysis in connection with both the listening and the real-time display of the signals. DAT recordings (16 bit, 48k s/s) were digitally transferred to the IDSL, thus preserving their full quality, while analog tape recordings were acquired sampling them (16 bit linear format) according to their frequency contents (8 k, 16k, 32k or 48k s/s achieving frequency upper limits from 3.5 kHz to 22 kHz). Digital transfer was achieved by an Audiologic AudioBoard Plus equipped with digital I/O modules, while sampling of analog tapes was made with the Audiologic Duetto board.

The Audiologic Duetto is a 16 bit ISA board which is characterised by a high sound quality: two channels, simultaneous sampling, 16 bit resolution, line input with selectable gain (0, 3, 6, 9 dB), S/N ratio 90 dB, sampling rate selectable among 8000, 9600, 11025, 16000, 22050, 32000, 44100, 48000 s/s, on board high-precision anti-aliasing filters (64x oversampling with digital filtering). It allows hard-disk recording in mono or stereo, in full 16 bit linear format or with two selectable compression algorithms (compression ratios 2:1 and 4:1) to save disk space. In full 16 bit linear format, this board allows direct acquisition, hard disk recording and playback of audio signals with CD or DAT quality. The IDSL is actually stored on a set of WORM (Write Once Read Many) optical disks but can be more conveniently and rapidly operated by a high-speed hard-disk or Syquest removable cartridge. A 270 Mbyte Syquest cartridge can hold about 70 minutes of single channel recordings sampled at 32k s/s (14 kHz freq. range) or 48 minutes at 48k s/s (22 kHz freq. range).

As far as the implications for future development are concerned, we have to think of the possible storage of the entire Sound Library on CD-ROMs to make the long-term storage safe and to make all the recordings easily accessible through the IDSL in a networked environment.

ACKNOWLEDGEMENTS The Cetacean Sound Library was created by the Laboratory of Marine Bioacoustics, which was conceived by the Centro Interdisciplinare di Bioacustica of the University of Pavia and financed by the Italian Ministry of the Environment.

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Table 1 Duration of available recordings per species

	minutes	%
Physeter macrocephalus	2432	61
Stenella coeruleoalba	717	18
Tursiops truncatus	428	11
Grampus griseus	244	6
Globicephala melas	46	1
Delphinus delphis	25	1
Balaenoptera physalus	105 *	2

* Recordings made in the presence of fin whales to be analysed

Table 2 Explanation of the record structure of the Sound Library catalogue

TAPE_CODE	tape identification code
TYPE	recording type (open reel, compact cassette, DAT, video tapes)
SIDE	tape side (analog recording)
TRACK	tape track(s) or channel(s)
SPEED	tape speed (analog tapes) or sampling frequency (DAT tapes)
RECORDER	recorder type, model and settings
NR	noise reduction (if used)
CUE	tape counter
PRG_NUM	program number(s) (if available)
TIME	absolute tape time (if available)
DURATION	duration of the recording
SUBJECT	subject(s) of the recording
SPECIES	species recorded
SP_CODE	species code(s) *
ID	photo-identification code(s)
QUALITY	quality of the recording (0-3)
RECDATE	date of the recording
RECTIME	daytime of the recording
LOCALITY	locality of the recording and geographical co-ordinates (if avail.)
AREA_CODE	area code *
OPERATOR	recording operator
INSTITUTE	institute
ARCHIVE	institute were the orginal recording is stored
BACKUP	code, date and location of the backup copy
REFERENCE	reference to the related cruise log
DISTANCE	recording distance or sighting distance
TRANSDUCER	transducer(s) used (type, model, settings)
AMPLIFIER	amplifier used (type, model, settings)
FILTERS	filter(s) used (type, model, settings)
WATER_TEMP	water temperature
AIR_TEMP	air temperature
WEATHER	weather conditions
BEHAVIOUR	observed behaviour(s)
BEHAV_CODE	observed behaviour code(s) *
N_INDIVID	number of recorded animals and/or number of observed animals
NOTE	general information (photo-id, other research, associated species)
IDSL-FILE	name of the digital signal file in the IDSL
IDSL-TIME	time location of the cuts transferred in the IDSL file
IDSL-CLIP	name of a representative digital signal file in the IDSL
IDSL-SPEC	reference(s) to representative spectrogram(s)
IDSL-PICT	reference(s) to representative picture(s)
IDSL-HELP	reference to a multimedial help file

* Species, behaviour and area codes were used according to Watkins *et al.*, 1988

ACOUSTIC RESEARCH CRUISES IN THE MEDITERRANEAN - 1994

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INTRODUCTION The Centro di Bioacustica has organised two dedicated acoustic research cruises in early and late summer 1994 respectively for the purpose of improving our knowledge about the present distribution and acoustic behaviour of the sperm whale (*Physeter macrocephalus*) in the northern Tyrrhenian Sea (Fig. 1). Acoustic and Digital Signal Processing techniques for the detection and counting of common cetaceans in our waters, are also tested.

MATERIALS AND METHODS A dipole-array of hydrophones was towed at speeds up to 14 km/h, from a 15m auxiliary Marconi-cutter. Listening stations were held on a 24h schedule for at least 5 min every half an hour. The detection and identification of vocalising animals was supported by a real-time DSP-Workstation developed at this Centre. Sound recordings, photographs, and video-sequences were taken when necessary. The entire instrumentation, which included two DAT recorders, was powered by batteries and photovoltaic panels, thus allowing a complete autonomy from the host vessel and good rejection of interfering noise.

Towed Array of Hydrophones It is well known that the most critical link in gathering acoustic data is the sensor itself. A towed "dipole" array of hydrophones was developed by Alenia Elsag Sistemi Navali (Genova, Napoli) and USEA (La Spezia) to meet the specific requirements of our research, such as reliability associated with a high acoustic quality (Table 1). The designed array is comparatively easy to deploy, and can be operated from non-specifically equipped vessels. However this operation requires at least four persons.

The towed array consists of an oil-filled (isopar oil) acoustically transparent hose which is 12 metres long, 6 cm in diameter, and holds two groups (mini-arrays) of acoustic transducers, their preamplifiers, and a pressure transducer. The two mini-arrays, made of three acceleration cancelling transducers each, are positioned 8 metres apart. The mini-arrays can be operated with the three transducers in parallel, in order to achieve a directional receiving pattern and to attenuate longitudinal noise above 2 kHz, or selecting only the central transducer of each array to get an omnidirectional sensitivity pattern. The submerged structure is stabilised by a 25-metre terminating tail.

The towing cable, which holds the electrical conductors, is 160 metres long with a cable grip in kevlar, positioned 150 metres away from the array. The operating depth of the array is related to the towing speed and to the position of the cable grip (Table 2). An optional weight can be mounted to modify the diving profile. A dedicated electronic controlling unit provides power to the array, amplification and filtering of the received signals. The amplifier is characterised by a flat frequency response from 5 Hz to 270 kHz (-3 dB), two channels, selectable gain (0 - 70 dB), selectable 12 dB/oct high-pass filters (5 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz), switchable 48 dB/oct low-pass filter at 42 kHz (-3dB), transducer selection (one or three transducers active for each channel). A programmable peak display prevents overloading of the amplifier and connected recording instruments, while a calibration input allows one to check for the calibration of the entire electro-acoustic chain. A depth-meter, connected to the pressure transducer in the array, displays the effective operating depth in real-time so that it is possible to evaluate the timing of surface reflected echoes.

RESULTS Three odontocete and one mysticete species were identified among the 37.total sightings While at sea for 22 days, 393 listening stations were held and 20 h of DAT sound recordings collected. The most common species was the striped dolphin (*Stenella coeruleoalba*) sighted 24 times, followed by fin whale (*Balaenoptera physalus*) with ten sightings, the sperm whale with two sightings and Risso's dolphin (*Grampus griseus*) with one sighting.

Sperm whales, the target species of these cruises, were sighted twice and tracked acoustically. Both were tracked for several hours and the longest continuous track lasting 12 h. Both were subadult males and produced one and the same coda pattern. It was intriguing to discover that this coda pattern matched with all codas recorded in previous years from different animals and different locations within the Tyrrhenian Sea. Distinctive codas, term adopted according to Watkins *et al.* (1977), were heard 32 times during five recording sessions in 1991 at Filicudi, in 1992 and 1994 at Cap Corse and in 1994 off the island of Asinara, Sardinia. All belonged to the /// / - pattern, thus corroborating the hypothesis that codas might be a geographical marker. The question whether they are occasional visitors in the Mediterranean or if they belong to a discrete population remains unanswered, and further investigations are required to assess status and trends of the Mediterranean population.

Thanks to applied technologies, the continuous recording of sperm whale acoustic behaviour across several diving cycles allowed an accurate mapping and quantification of the different signals they emit. The longest uninterrupted recording we collected lasted 12 hours, covering 14 diving cycles of a single individual over a distance of approximately 27 nautical miles. As far as the implications for future research are concerned, we look forward to the cooperative research programme which has been recently set up by the Italian Navy within the frame of the ENCY 95 (European Nature Conservation Year) programme. This project will possibly lead to a severe improvement in underwater acoustic research and in providing information relevant to the conservation of cetaceans in the Mediterranean.

ACKNOWLEDGEMENTS The cruises were organised within the frame of the ENCY 95 (European Nature Conservation Year). Financial support for the research and development of the instrumentation was provided by the Italian Ministero dell'Ambiente - Ispettorato Centrale Difesa Mare - and Ministero dell'Università e della Ricerca Scientifica e Tecnologica - progetto nazionale Etologia 40%. Thanks are due to the skipper Antonio Molinari, to the entire staff of the Institute of Entomology, to Alenia Elsag Sistemi Navali of Genova, to USEA of La Spezia, and to Claudio Cavolla for their precious technical assistance.

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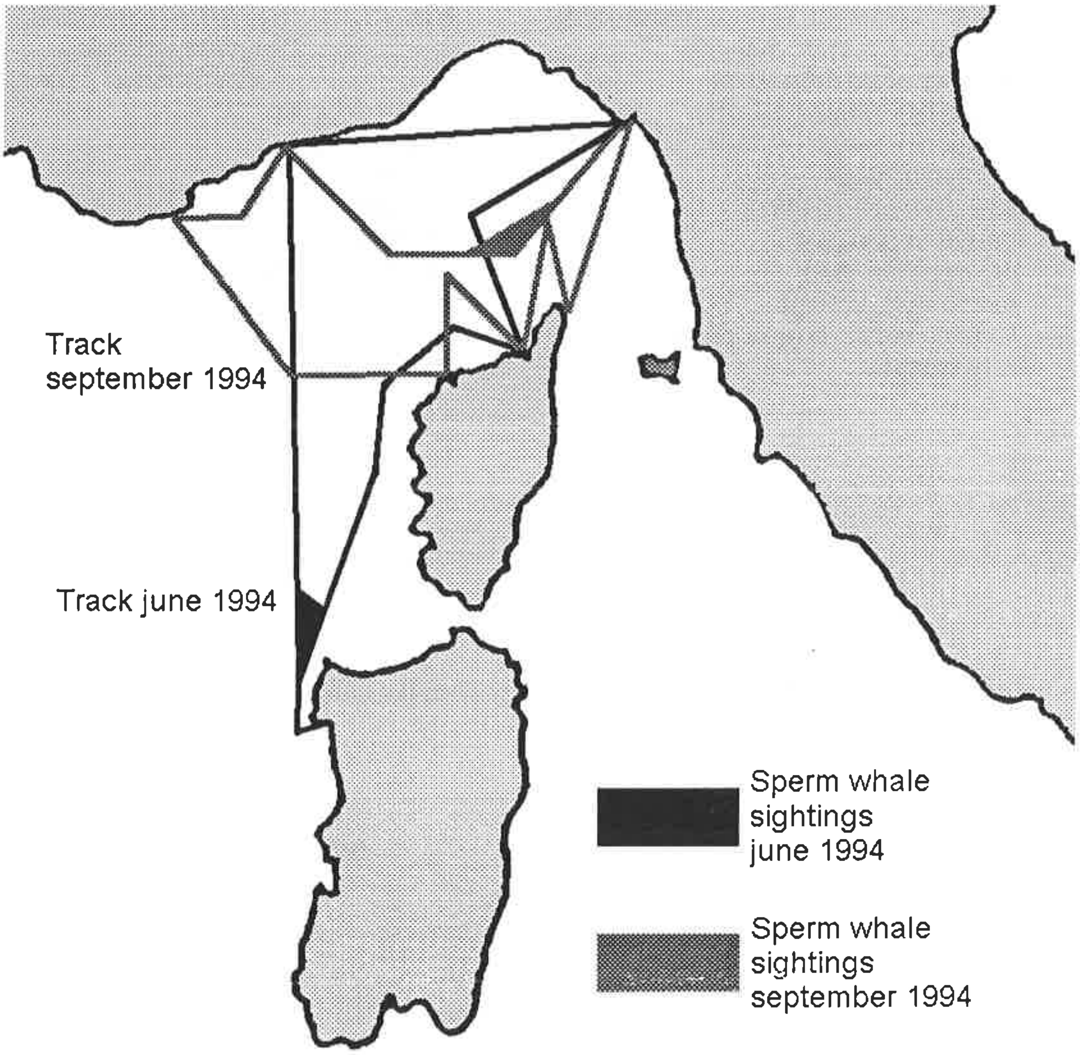
Table 1 Technical specifications of the ALENIA array

number of receivers	2 mini-arrays, 3 transducers each
distance between central transducers	8 m
number of output channels	2
number of preamplifiers	2
frequency range (±2 dB)	1 Hz - 35 kHz
frequency range (±5 dB)	1 Hz - 70 kHz
resonance peak	42 kHz (+5 dB)
sensitivity at 10 kHz	-173 dB //V/µPa
output impedance	47 Ohm
preamplifier gain	28 dB ±0.5 dB
max output voltage	3 Veff
balance between mini-arrays	±1.5 dB (at 10 kHz).
cable length	160 m, grip set at 150 m

Table 2 Operating depth of the array with the cable grip set at 150m.

speed		**drag**	**depth**
m/s	knots	kg	m
1	2	7	45
2	4	15	22
3	6	32	14
4	8	57	10
5	10	90	7

Fig. 1 Research area



THE DURLSTON CETACEAN MONITORING PROJECT

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Durlston Country Park is located on the south-west coast of England at 50° 35.5'N, 1° 57'W (Fig. 1) and is operated by Dorset Country Council as part of their Countryside Service. In recent years, it has encouraged a number of innovative marine research projects which now have independant status under the title of Durlston Coastwatch. The immediate sea around the park has been designated a voluntary Marine Nature Reserve, recognised and part funded by English Nature. A cetacean watch has operated since 1988 and this has revealed the presence of ceatceans throughout most of the year (Fig. 2).

With the increased use of the waters off the Dorset coast for commercial and pleasure activities and the possibility of a high level of oil prospecting activities in the future, it was decided to try to increase the scope of the cetacean monitoring programme. The main aim was to increase the coverage of the monitoring programme in time and area to obtain a more precise picture of the animals present, the use they make of the area, and any long-term changes in this pattern due to the influence of other users of the waters.

After considering various ideas, it was decided that the best method to achieve this increased coverage was to deploy a fixed hydrophone at Durlston, with an option to deploy a second hydrophone several miles to the west at Chapman's Pool, combined with portable hydrophone systems deployed from small boats and an increased visual watch. The visual watch would include photo-identification to try and establish the identity of resident animals and to compare our library with those maintained by adjacent research groups. Additional aims of the acoustic project include monitoring the long and short term levels of ambient noise and identifying the causes of this noise, both man-made and biological.

The coastline is mainly limestone but has a number of clay outcrops. The sea-bed is sand with rocky outcrops and extensive kelp beds in the shallower inshore waters. The water depth is generally 10-15 metres and the area is bounded to the east by a rock ledge and associated tidal race. The cliffs rise to 100 metres and make a good vantage point for the visual watch, but make the transportation of hydrophone cables ashore very difficult. After a careful survey of the area it was decided the only satisfactory solution was to place a hydrophone in the middle of Durlston Bay so that it was sheltered from the prevailing south-westerly winds and to bring the cable ashore in the lea of Durlston Head where the cliffs were less steep and a rocky outcrop provided some shelter for the point where the cable crossed the shoreline.

This hydrophone system has now been installed (Harland *et al.*, this vol.) (Fig. 3) with the help of Cable and Wireless Marine, the military, local fishermen, and divers. Planning is well advanced for the second hydrophone at Chapman's Pool. The visual watch has now identified seven bottlenose dolphin (*Tursiops truncatus*) individuals, and work is continuing to expand this library. The acoustic watch has yielded a number of interesting sounds, not all of which are cetacean-related. One outcome has been that during the autumn of 1994, almost continuous cetacean acoustic activity has been heard, but visual contact has been acheived on comparatively few occasions. It is believed that much of this activity may be caused by species other than *Tursiops* and the immediate aim of the project is to identify these species and their location. Work is also in hand to try and understand the sources of biological background noise and to geographically map acoustic coverage.

Acoustic techniques being investigated as part of this project include the use of click detectors so that operators can monitor the ultrasonic part of the spectrum with simple equipment, long-life, moored sonobuoys for temporary deployments to extend the acoustic coverage and pocket-portable listening systems for use from very small boats. The click detector built into the permanent hydrophone system has proved invaluable for monitoring cetacean activity and a similar design is now being incorporated into the portable listening equipment. Means of deploying hydrophones from small boats which minimise the effect of cable noise and boat self-noise have been investigated and a system devised which allows hydrophones to be deployed from very small boats right up to large research ships.

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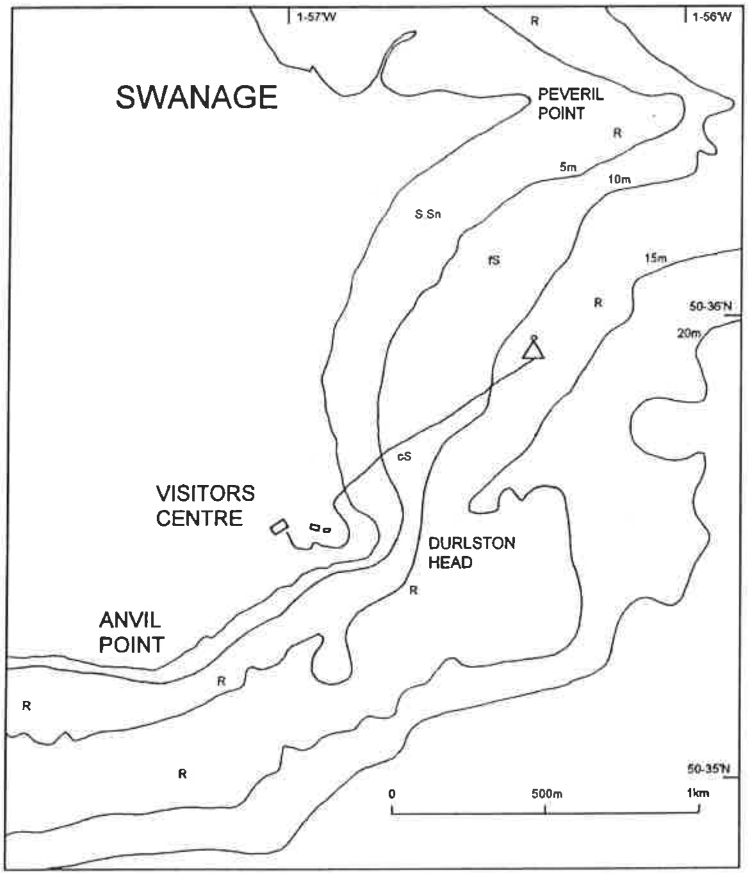

Fig 1. Location of site.

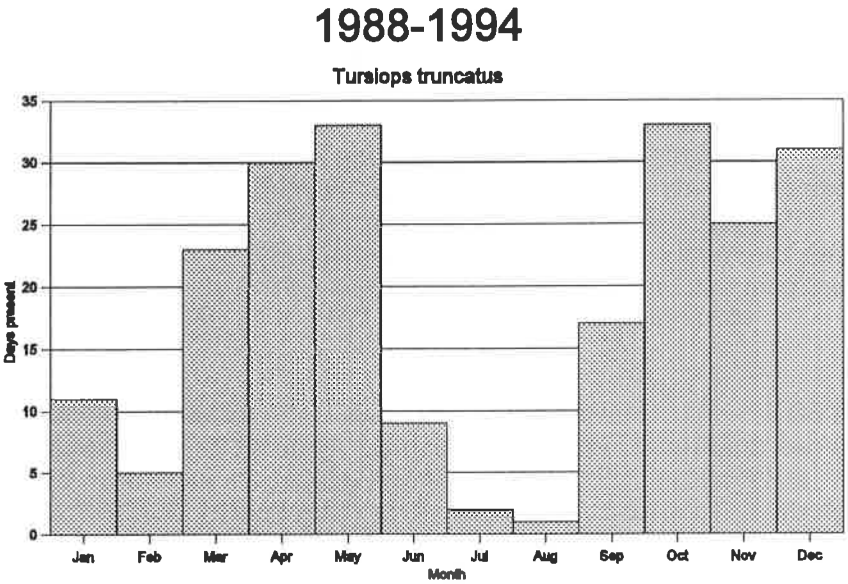

Fig 2. Visual survey results

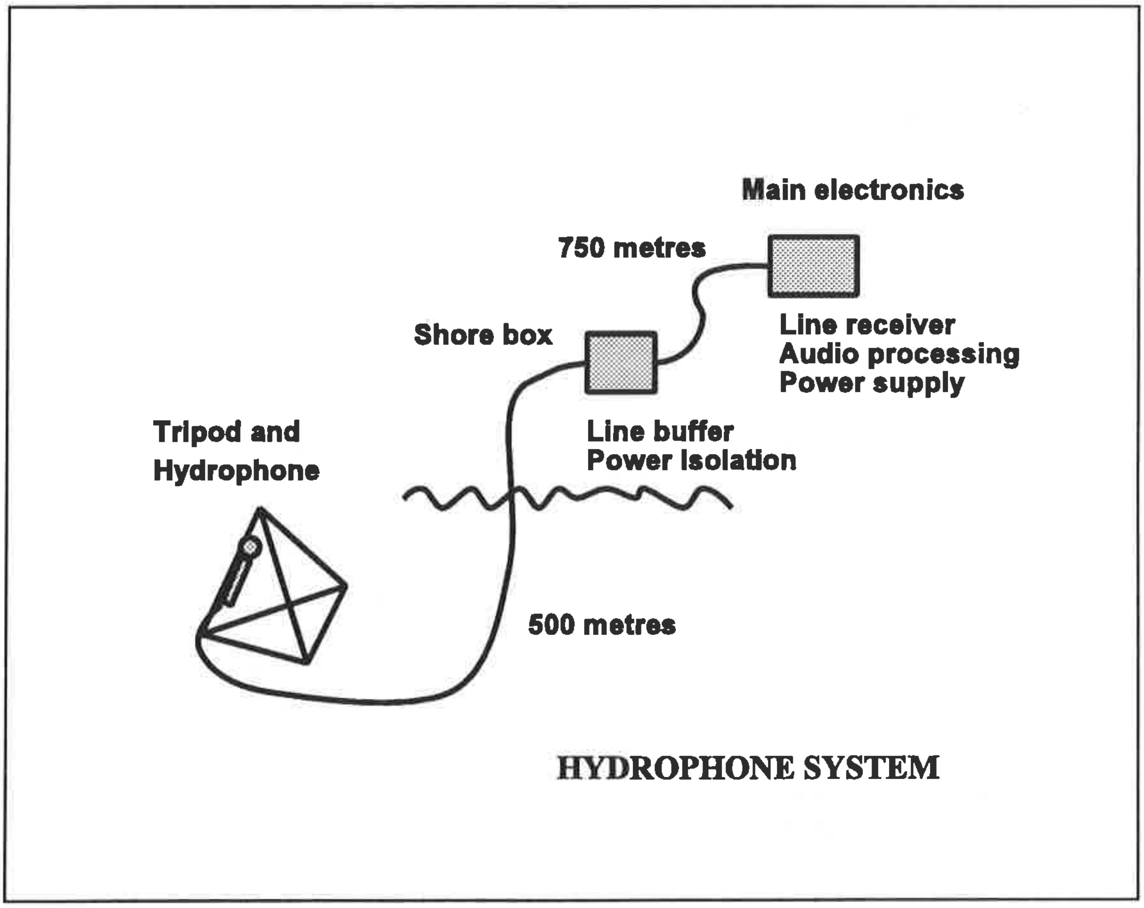

Fig 3. Hydrophone equipment

THE USE OF DRILLING RIGS IN TRACKING THE HARBOUR PORPOISE, *PHOCOENA PHOCOENA*

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INTRODUCTION During 1991, 1992 and 1993, techniques were developed to track bottlenose dolphins *(Tursiops truncatus)* resident in the Moray Firth, NE Scotland (Mayo & Goodson 1992, 1993). These techniques have now been used to track harbour porpoise *(Phocoena phocoena)* in the adjacent Cromarty Firth. The Cromarty Firth affords deep water anchorages to oil drilling rigs between contracts, and these drilling rigs have been used as observation platforms. The observation positions can be 35 metres above sea level and porpoises have been tracked to within 75 metres of the base of the rig before the view was obscured by the rig deck.

THE SITE The Cromarty Firth can have up to 12 rigs moored at any one time, spaced out between Nigg and Invergordon. In September 1993, the rig "Dan Princess", and in September 1994 the rig "John Shaw", were selected as being in the area where harbour porpoise had been most frequently observed. ("John Shaw" was moored at Ordnance Survey reference NH 761682). Electronic theodolites were set up on an observation deck in each case, from where an arc of nearly 250° could be observed. The nearest shoreline was some 1,800 m away at the extreme edge of the observation arc and 2,500 m in the centre; the occasional boat traffic was restricted to relatively small vessels.

MONITORING PROCEDURE The observations taken in 1993 were an investigation into whether watching from a drilling rig was feasible. Although a full observation team was not used, results indicated that useful data could be generated in this way. In 1994, a team of five observers was used, equipped with one total station, one electronic theodolite (Sokkia DT4), four video cameras, and underwater sound monitoring facilities. The video cameras were necessary to verify observed surfacings as such, and to make corrections for rig movement, as will be discussed below.

Observers took shifts monitoring the observation area until animals were sighted, at which time all observers operated equipment on the observation deck. Sound recording equipment was installed in a cabin adjacent to the observation deck, underwater sounds made by animals during any tracking being recorded for later analysis. Porpoises were only sighted in calm conditions, though there is no reason to suppose that they were not in the area when the sea state was rougher. In September, the area around the Cromarty Firth can be subject to extremely rough weather interspersed with periods of absolute flat calm. In 1994, observation was maintained from Sunday 25th September to Friday 30th September. Porpoises were seen on the Sunday afternoon on four occasions totalling 19 minutes and on Thursday afternoon continuously for just under two hours.

ANIMAL BEHAVIOUR Under calm surface conditions, and with a relatively steep observation angle in elevation, it is possible to see animals below the surface and to track them there. On a number of occasions animals were observed creating a V-shaped wake as they swam just below the surface; it was for this reason that tracking was videoed so that if an estimate of surfacing intervals were made only true surfacings would be included. Animals were also observed twisting and turning just below the surface, presumably as they foraged for fish swimming there. Fig. 1 shows tracks observed on the Thursday afternoon, and Fig. 2 shows the last track that day.

TRACKING The sighting technique requires an accurate measurement of the height of the deck above sea level This was done by using one of the surveying instruments (Sokkia SET5 total station) in distance measuring mode with a prism held at the rig pontoon or in a support vessel.

The observations were made from a semi-submersible drilling rig, which is a floating vessel. As a result, the theodolites were moving in space as the rig underwent pitch, roll, yaw and heave, although heave was deemed to be minimal. An attempt to apply corrections for yaw, pitch, and roll was made as follows: video cameras were set up and locked off, pointing along the centreline of the rig and perpendicular to it, and a voice commentary that included sighting times was recorded by each camera. Fixed points (the shoreline and a church steeple) were sighted at known times so that when the video tape was replayed, an estimate of the instantaneous displacement in pitch, roll and yaw could be made. It was found that, with the rig moored head to sea, roll was minimal. The cycle times for pitch and yaw were not regular but of the order:- pitch - 8 seconds, yaw - 50 seconds. The maximum values of the displacements were:- pitch +/-1.5 minutes of arc, yaw +/-32 minutes, representing maximum errors in distance from observer of 3.1 m at 500 m in the direction of pitch and lateral displacement 4.7 m at the same range. It should be noted, however, that it is difficult to zero yaw readings at the centre of swing, as this tends to process. Actual errors may therefore be up to double those quoted above.

The two surveying instruments were used by observers using different techniques. The majority of sightings were made using the instrument telescope. Some were made using the instrument external optical sights. This latter technique introduces additional errors which can be corrected using standard surveying packages to calculate standard and systematic errors (Mayo & Twigg 1994, Twigg & Mayo in press). The track shown in Fig. 2 was observed using both observational methods, the maximum deviation being 25 m at 450 m range. The optical sight version is shown here as the longer continuous sequence of observations.

ANALYSIS OF DATA Full analysis of the data has not yet been completed, but Fig. 3 shows histograms of surfacing intervals, distance between surfacings, and speed between surfacings for the track shown in Fig. 2. (It should be noted that the speed is the minimum "land" speed since it is computed from the straight-line distance between surfacings and is not corrected for tide flow).

UNDERWATER ACOUSTICS Two ball hydrophones were deployed a short distance from the rig and connected by cable to a digital tape recorder in a cabin near to the observation deck. An acoustic filter was employed to eliminate most of the rig self noise, since the object was to record the echolocating clicks of porpoises, which are at about 140 kHz. This was successfully done. Unfortunately water discharged from the rig approximately 25 m above sea level fell near the hydrophone and produced considerable high-frequency noise.

ACKNOWLEDGEMENTS The funds for this work were provided by the UK Department of the Environment and Ministry of Agriculture, Fisheries and Food whose support is gratefully acknowledged. Thanks are also due to Lauritzen Offshore and Sonat Offshore for facilities and hospitality aboard "Dan Princess" and "John Shaw" respectively. Finally thanks are due to Billy and Victoria Fraser of Dolphin Ecosse for accommodation ashore and boat services.

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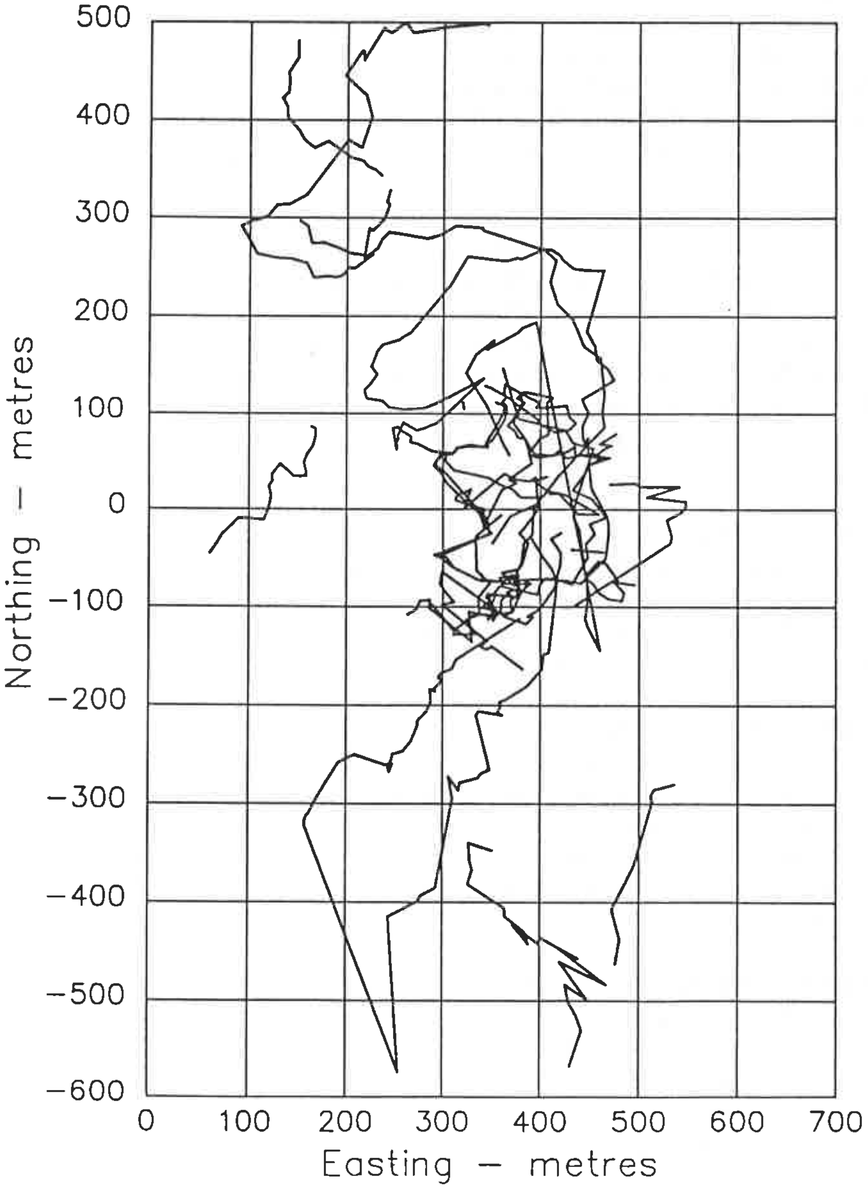

Fig. 1 Porpoise tracks observed on Thursday 29 September 1994

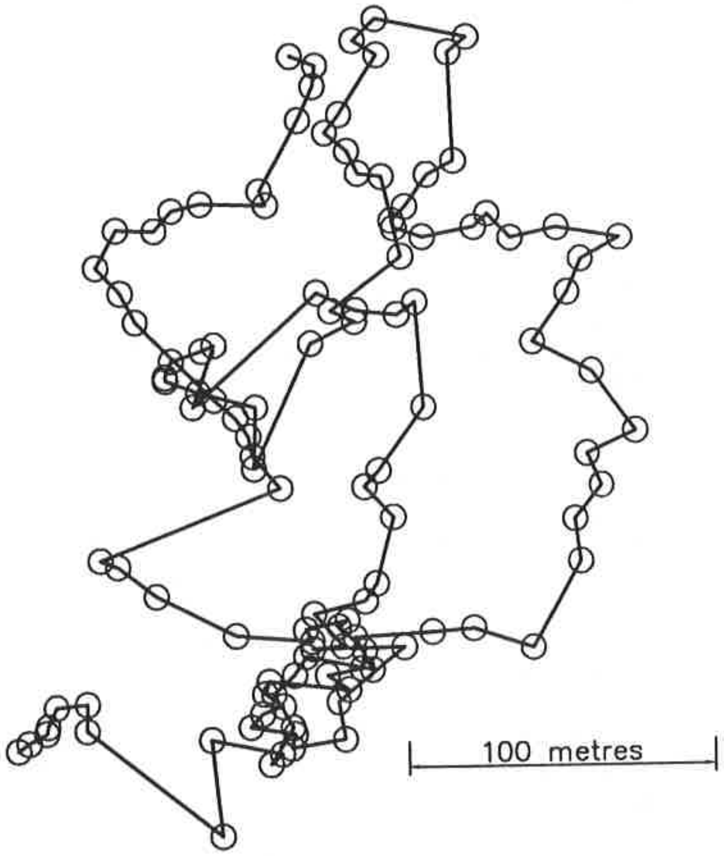

Fig. 2 Porpoise track 29/19.

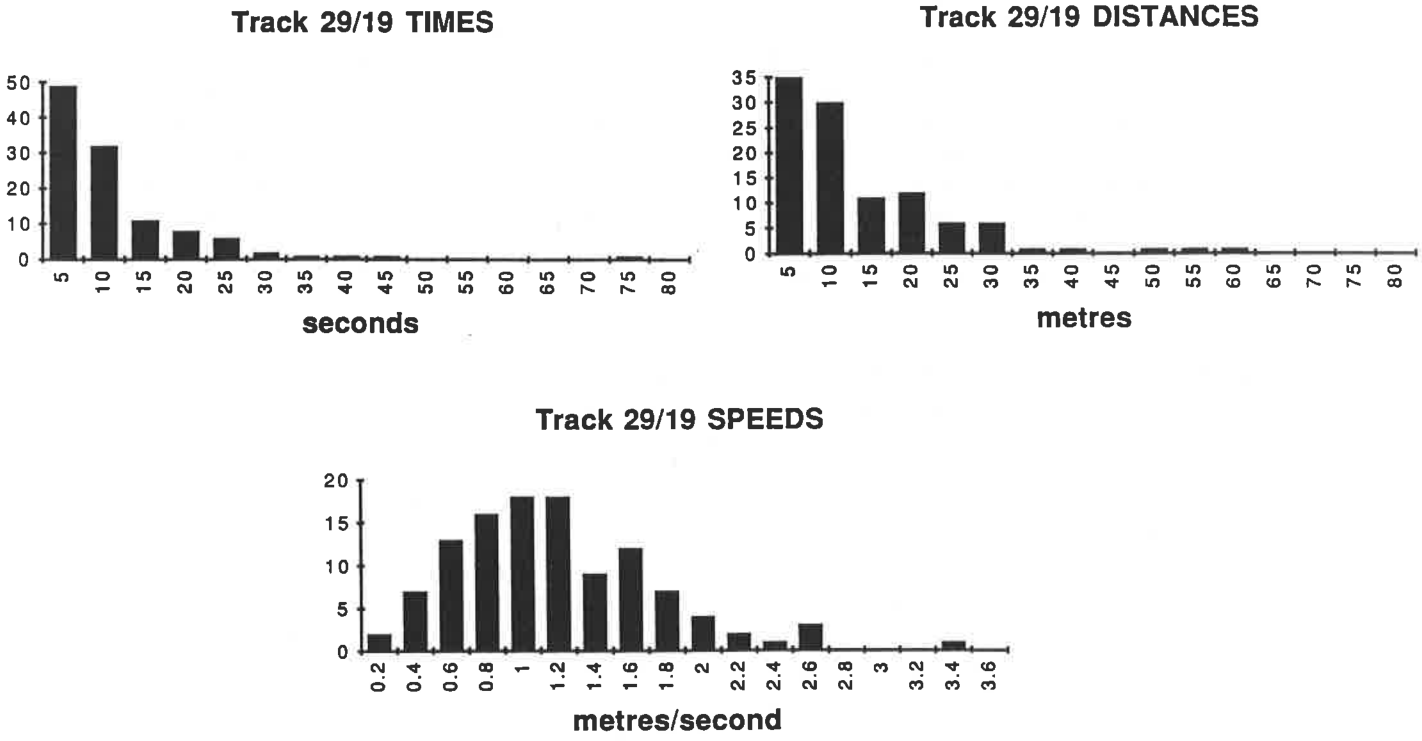

Fig. 3 Surfacing intervals, distances and swimming speeds for track 29/19.

MARINE MAMMALS INVENTORY OF TURKEY

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INTRODUCTION Turkey has a 8,353 km coastal zone and is surrounded by four seas of different oceanographic characters. However, the general knowledge about the marine mammals, especially cetaceans, in these waters is rather poor. A research programme for data collection and field observation of the marine mammals has been conducted under the Marine Mammal Project since 1987. The preliminary study has confirmed that the Black Sea and Marmara Sea still have a single pinniped species, the Mediterranean monk seal, *Monachus monachus*. There are also three Odontoceti species existing in these seas: the common dolphin *Delphinus delphis*, the bottlenose dolphin *Tursiops truncatus*, and the harbour porpoise *Phocoena phocoena*. In the Aegean Sea, there are five Odontoceti species: the common dolphin, the bottlenose dolphin, the striped dolphin *Stenella coeruleoalba*, the sperm whale *Physeter macrocephalus* and Cuvier's beaked whale *Ziphius cavirostris*. The fin whale *Balaenoptera physalus* is the only Mysticeti species which lives in the Aegean Sea. Besides these cetaceans, *M. monachus* also exists in the Agean.

In the Mediterranean coastal waters of Turkey, there are seven odontocetes, one mysticete and one pinniped species. The odontocetes being the common dolphin, the bottlenose dolphin, the striped dolphin, the pilot whale *Globicephala melaena*, Risso's dolphin *Grampus griseus*, the sperm whale and Cuvier's beaked whale. The only mysticete member is the fin whale. Again, the Mediterranean monk seal has a viable population in this area.

MATERIALS AND METHODS In order to analyse all information and sightings, the seas surrounding Turkey were divided into four regions (Fig. 1): Black Sea, Marmara Sea, Aegean Sea and Mediterranean Sea. Study cruises could not be programmed to sample homogeneously within each region. Most of the observations were conducted from sailing vessels ranging in length between 10 and 20 m. Oppurtunistic observations were also recorded. Observations were mostly conducted in calm weather. The presence of animals was assessed visually. Where possible, school size was determined by approaching the animals. Binoculars,video cameras and still cameras were used for identification of species. In addition to these field observations, recording sheets were distributed among sailors, divers, fishermen, etc. in all coastal areas of Turkey.

RESULTS AND DISCUSSION There are three odontocete species in the Black Sea (common and bottlenose dolphins, and harbour porpoise) (Slastenenko, 1955; Tomilin, 1967; Çelikkale *et al.*, 1989) The common dolphin is an open sea species feeding mainly on anchovy, sprat, mackerel and other pelagic fishes. It migrates from west to east from November to January. Bottlenose dolphins and harbour porpoises exist as resident populations in the western part of the Turkish Black Sea . The bottlenose dolphin is a coastal species and feeds mainly on fishes such as goby, turbot, and sole. Migration takes place from December to March from Y∂neada to Sinop, and often extending to the Hopa region. The harbour porpoise is also a coastal species and feeds mainly on anchovy, sprat and cod. The most abundant of these species is the common dolphin, followed by the harbour porpoise and then bottlenose dolphin (Çelikkale *et. al.*,1989). Two individuals of the only pinniped species, the Mediterranean monk seal, were observed on the Turkish side, between Karadeniz Ere∂li-Ayancyk. In the Marmara Sea, three dolphin species were observed. These were again, the common dolphin, harbour porpoise and bottlenose dolphin. The dolphins in this sea may be considered as two different types of populations. One is resident and the other comprises immigrants. Resident populations include common and bottlenose dolphins located around the Marmara Islands. A resident population of harbour porpoises has not yet been determined in the Marmara Sea. Authors have mentioned in the past that Black Sea and Marmara Sea populations are unique, and that there is a regular migration route following that of pelagic fish (Devedjyan, 1926; Slastenenko 1955).

So far as the Aegean Sea is concerned, there are resident populations of both common and bottlenose dolphins in the north. However, Berkes (1977) mentioned that the Mediterranean bottlenose dolphin has a spring migration through the Marmara Sea and the Istanbul Strait into the Black Sea and out again in the autumn. However, the Çanakkale and Istanbul Straits actually act as barriers against marine mammals because of the amount of international sea traffic. In addition to this, all resident populations of common and bottlenose dolphins in Çanakkale and Istanbul Strait no longer exist.

In the Aegean Sea, Gökova Bay, Sygacyk, Güllük and Gökçeada regions between April and May during 1990, five observations of sperm whale were made. The most common species in this sea is striped dolphin and this species often causes damage to fishing nets. Cuvier's beaked whale) and Fin whale were also observed during the study period.

The Mediterranean monk seal lives mainly in the northern Aegean Sea, including Foça, Syðacyk and the surrounding area, and around the Bodrum Peninsula. A total of 16 individuals have been recorded in these areas. In the Mediterranean, the monk seal still has a viable population in the area between Antalya and Tasucu. During the study, eight individuals were identified in this area.

CONCLUSIONS This work represents the first attempt at determining the distribution of the most common cetacean species in different regons of the seas surrounding Turkey. However, because the data presented here were not the product of a rigorously planned sampling scheme, the results should be considered with some cauton. There are about 20 species living in the whole Mediterranean sea (UNEP, 1991). Nine cetacean and one pinniped species exist in Turkish coastal waters.(Marchessaux, 1980). Twelve odontocetes and two mysticetes occur in the eastern Mediterranean Sea (not including long-finned pilot whale, *Globicephala melas*, and Risso's dolphin), rough-toothed dolphin (*Steno bradenensis*) and false killer whale (*Pseudorca crassidens*) were also not recorded in this study.

It should be realised that more data and long term studies are needed to understand better, the abundance and migration of each species, and to define their distribution more accurately in Turkish waters.

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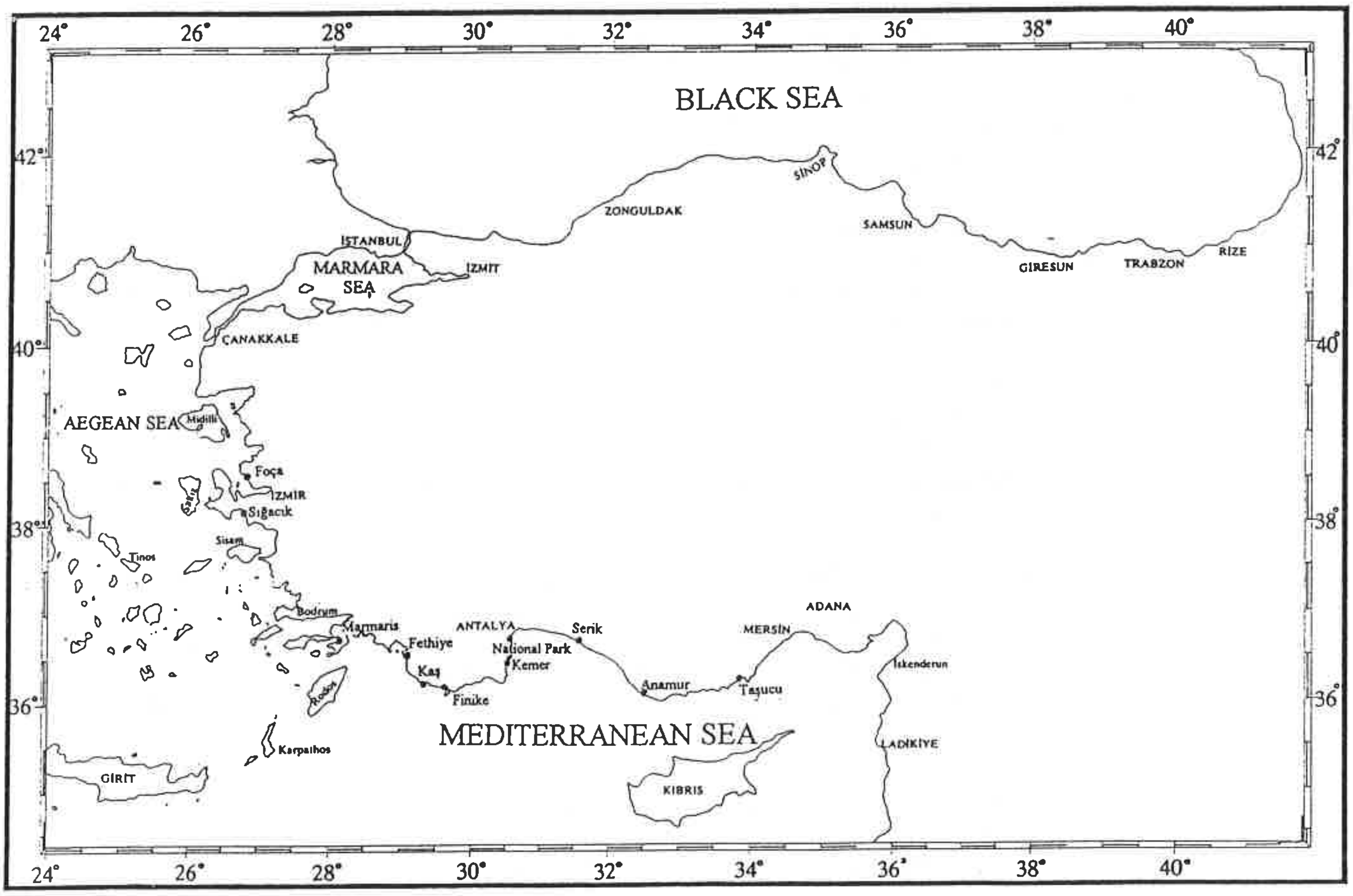

Fig. 1 Study Area

PRESENCE AND DISTRIBUTION OF THE CETOLOGICAL FAUNA OF THE AEGEAN SEA: PRELIMINARY RESULTS

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Until now, our knowledge of the cetological fauna of the Aegean Sea, has been limited. It relies mainly on reports made by unskilled people, or, most of all, on the analysis of strandings (Marchessaux, 1980, Marchessaux and Duguy, 1979). The small amount of data that does exist often contains many errors (Cebrian and Papacostantinou, 1992).

In 1993 and 1994, a series of cruises were conducted in the Aegean Sea, to obtain a wider and more accurate knowledge of the ecology, biology and relative abundance of marine mammals. We carried out research aboard commercial ferries, fishermen's boats and the ship belonging to the Institute of Marine Biology of Crete (I.M.B.C), which was also conducting researches on fishery resources. During the period of the research, 119 trips were carried out along 50 different routes, mainly among the Cyclades, Sporades and Dodecanese Islands, with a total sighting effort of 514 hours. In the central and southern area of the Aegean Sea, 77 sightings were recorded. Those sightings were of the following species: *Balaenoptera* sp., sperm whale, *Physeter macrocephalus*, Cuvier's beaked whale, *Ziphius cavirostris*, bottlenose dolphin, *Tursiops truncatus*, common dolphin, *Delphinus delphis,* striped dolphin, *Stenella coeruleoalba*, and Risso's dolphin, *Grampus griseus* (Fig. 1).

Bottlenose dolphins and striped dolphins were the most common species (Fig. 2). Bottlenose dolphins were observed throughout the Aegean Sea, especially along the coasts of the north and central islands, while striped dolphins were recorded mainly southwards around Santorini Island. In particular, we must stress the presence of Risso's dolphins in the core area of the Sea, and the simultaneous presence of common dolphin in the same areas as bottleniose dolphin (in the eastern area of the basin). Sightings of sperm whale, *Balaenoptera* sp., and Cuvier;'s beaked whale were reported as rare.

The interaction of dolphins with small scale fisheries has been recorded, especially in the eastern islands. Fishermen claim heavy damage to their nets. We observed nets that have holes very similar to the ones that have been observed in north-eastern Sardinia (Italy), in areas where bottlenose dolphins are present (Marini *et al.*, this volume).

ACKNOWLEDGEMENTS We wish to thank all the people who have helped us in these surveys. In particular, we thank the University of Crete, the Institute of Marine Biology (Prof. A. Eleftheriou and Dr. A. Kallianiotis), the crews of "Phylia" and "I. Rossos" and Dr. B. Catalano from the University of Rome "La Sapienza".

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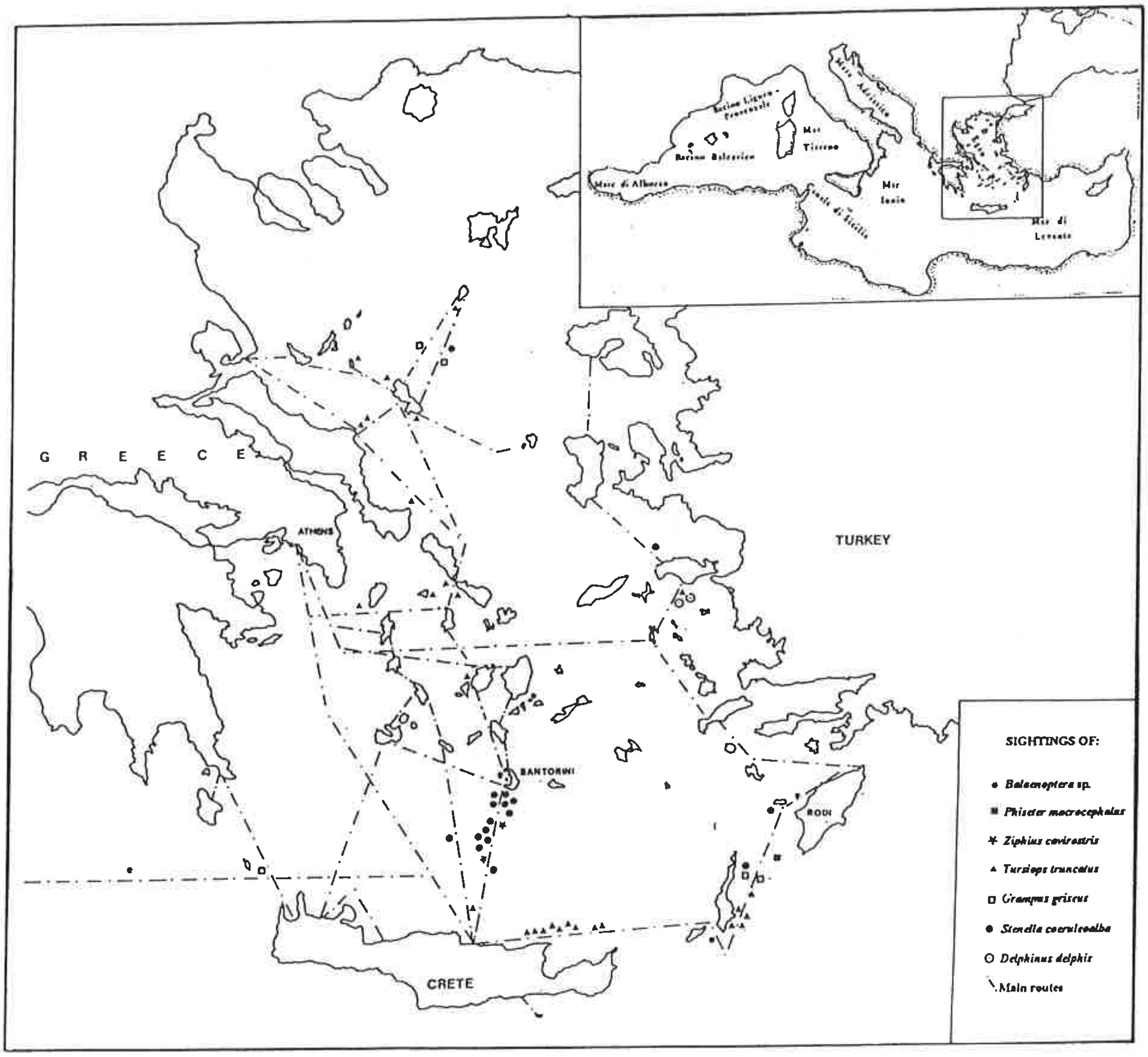

Fig. 1 Map of Study Area

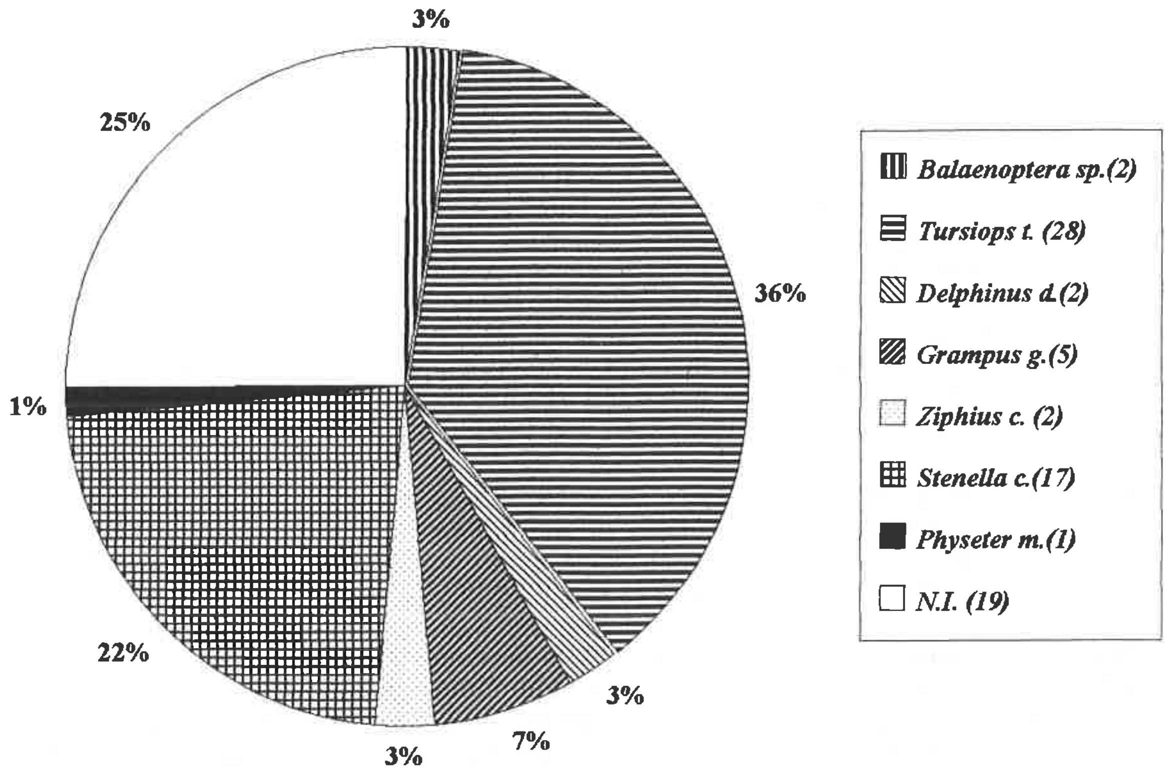

Fig.2. Sightings per species

A CETACEAN SURVEY IN TARANTO GULF: WORK IN PROGRESS

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INTRODUCTION The first data on the presence of cetaceans in Taranto Gulf were recorded in the summer of 1991. During 1992 and 1993, further data were obtained, but owing to a lack of stable parameters, we have decided not to use them in our study. In the summer of 1994, Hydrosphera Association obtained new data about the cetaceans in a particular study area with the intention of starting a long term study. Cetological studies have never been performed accurately in the Taranto Gulf and the little information available about this area is that documented by Centro Studi Cetacei (1987, 1988, 1989, 1990) on the strandings which have occurred. This work considers the differences in encounters between 1991 and 1994.

MATERIALS AND METHODS The survey was carried out in the Taranto Gulf (Northern Ionian Sea) in the body of water between Policoro (Matera), Campo Marino (Taranto) and Gallipoli (Lecce). The Circolo Velico Lucano of Policoro (Matera - Basilicata) contributed two sailing vessels of length 42 feet, for the duration of the survey. Each cruise lasted six days and followed a pre-established course in order to obtain comparison data with that of 1991. Both the behaviour of the cetaceans observed and the composition of the groups were recorded. Photo-identification techniques were also applied to *Grampus griseus* and *Tursiops truncatus*. For this purpose, Minolta and Canon cameras with 70-210 mm zooms were used in addition to a video camera 8 HI band.

RESULTS AND DISCUSSION During the summer of 1991, the following schools of cetaceans were observed: two striped dolphins, *Stenella coeruleoalba*, three bottlenose dolphins,*Tursiops truncatus* and four Risso's dolphins,*Grampus griseus.* During the summer of 1994: six striped dolphins, six bottlenose dolphins, two Risso's dolphins, and one fin whale, *Balaenoptera physalus*. During 1994, these schools contained many young specimens. Particular attention has been given to Risso's dolphin which seems to be observed very frequently in the area studied, and also to bottlenose dolphin which has been sighted particularly in the areas in front of Policoro and Gallipoli. The evidence suggests that these schools are resident in these areas.

The results of this survey confirm the importance of the cetacean fauna in the area studied. Hydrosphera plan to continue the survey next summer, paying particular attention to Risso's dolphin and bottlenose dolphin in an attempt to learn more of their ecology and behaviour.

ACKNOWLEDGEMENTS We would like to thank Mr. Sigismondo Mangialardi of Circolo Velico Lucano who supplied the sailing vessels and the whole logistic structure, the Commune of Policoro, the military authority (Capitaneria di Porto of Taranto), the Presidents of the Lega Navale of Campo Marino and of Gallipoli, and Ms Lisa Yardley, for their help towards this work. We also give special thanks to all participants of the cruises.

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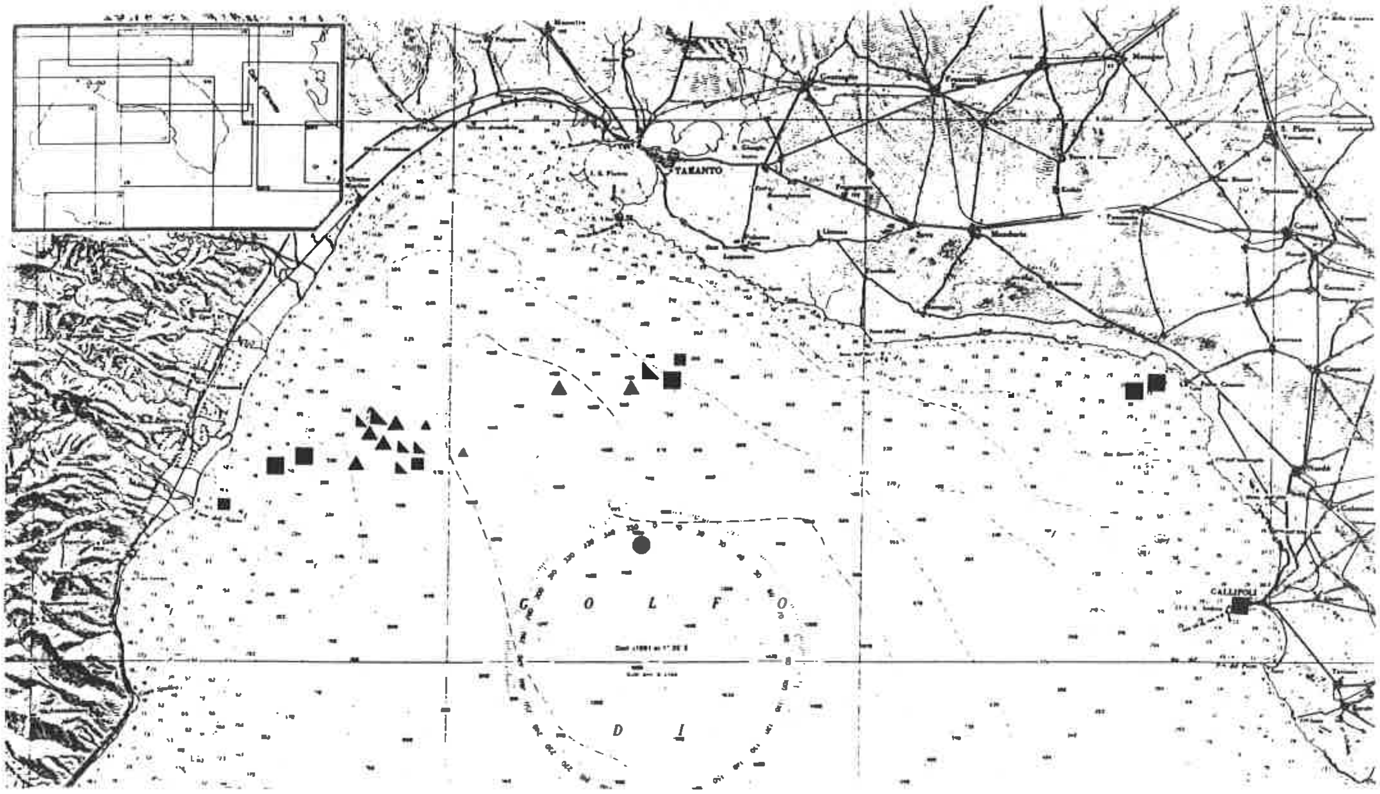

Distribution of sightings:

Balaenoptera physal	1991	● 1994	*Stenella coeruleoalba*	▲ 1991	▲ 1994
Tursiops truncatus	■ 1991	■ 1994	*Grampus griseus*	◣ 1991	◣ 1994

Fig. 1 Map of Study Area with distribution of cetacean sightings

THE DISTRIBUTION OF CETACEANS OFF NORTHWESTERN SARDINIA

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INTRODUCTION The waters off northwestern Sardinia include the southern portion of the Mediterranean International Sanctuary for cetaceans, one of the most productive pelagic regions of the Mediterranean Sea (Jacques, 1990), which harbours a rich fauna (Notarbartolo di Sciara *et al.*, 1993). In order to increase our knowledge of the cetaceans inhabiting northwestern Sardinia, a series of dedicated cruises were organised in the waters adjacent to the Island of Asinara.

MATERIALS AND METHODS Research cruises were conducted aboard a 13m long sailing vessel from 14 July to 2 September, 1994. The study area (Fig. 1) included offshore and inshore waters adjacent to the Island of Asinara. For the purpose of calculating sighting frequencies, we considered only the time spent looking for cetaceans with good weather conditions (wind force equal or below Beaufort 3). Each sighting was plotted on a nautical chart in order to assess water depth at the location of the sighting and the distance from the nearest land.

RESULTS During 122.6 hours of observation in good weather conditions, 28 cetacean groups were encountered; three of these were unidentified. Eight sightings made with negative weather conditions were considered only for analysis of the relationship with depth and distance from the nearest land. Five cetacean species were observed, including, in order of decreasing sighting frequency: striped dolphin (*Stenella coeruleoalba*) (7.33 sightings/100 h), bottlenose dolphin (*Tursiops truncatus*) (6.52 sightings/100 h), fin whale (*Balaenoptera physalus*) (3.26 sightings/100 h), common dolphin (*Delphinus delphis*) (1.63 sightings/100 h) and Risso's dolphin (*Grampus griseus*) (1.63 sightings/100 h).

The descriptive statistics of distance from the nearest land and of water depth at the location of sighting are shown in Tables 1 and 2 respectively. Only bottlenose dolphins were observed both inside and outside the Gulf of Asinara, in shallow waters and between 0.5 and 16.4 km from the nearest coast. All other species were found offshore, at distances from land greater than nine kilometres, and in waters deeper than 700 m. Striped dolphins and Risso's dolphins were found both north and west of Asinara, while common dolphins and fin whales were seen only to the west.

DISCUSSION This research represents a preliminary attempt to increase our knowledge of the cetaceans inhabiting the waters off northwestern Sardinia. Distribution data of the cetacean species encountered reflect their well-known habitat preferences (Notarbartolo di Sciara and Demma, 1994). Distribution of bottlenose dolphins in the Gulf of Asinara appears to be affected more by depth than by distance from land. In fact, bottlenose dolphins were regularly seen in a wide range of distances from land (0.5-16.5 km) but always in waters shallower than 100m. By contrast, striped dolphins and fin whales were exclusively pelagic.

ACKNOWLEDGEMENTS This research was funded by Europe Conservation, the harbour of Nettuno (Rome) and Balloon. We wish to thank all the paying volunteers who participated in the cruises, the staff of Europe Conservation, Rome, and Valeria Fano for their help.

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Table 1- Descriptive statistic of distance from the nearest coast for five cetacean species

Species	**n**	**x**	**sd**	**se**	**Range**
Tursiops truncatus	11	8.07	4.96	1.50	0.55-16.48
Stenella coeruleoalba	9	16.40	5.27	1.76	10.55-27.78
Delphinus delphis	2	13.70	1.05	0.74	12.96-14.44
Grampus griseus	2	12.49	4.57	3.23	9.26-15.72
Balaenoptera physalus	9	17.28	4.77	1.59	10.92-22.22

n = total number of group sighted for each species; x = mean distance from the nearest coast (km);

sd = standard deviation; se = standard error.

Table 2- Descriptive statistic of water depth at sighting location for five cetacean species

Species	**n**	**x**	**sd**	**se**	**Range**
Tursiops truncatus	11	54.73	14.35	4.33	20- 70
Stenella coeruleoalba	9	1388.89	586.39	195.39	700-2400
Delphinus delphis	2	1150.00	353.55	250.00	900-1400
Grampus griseus	2	1100.00	424.26	300.00	800-1400
Balaenoptera physalus	9	1627.78	540.32	180.11	700-2200

n = total number of group sighted for each species; x = mean water depth (m); sd = standard deviation; se = standard error.

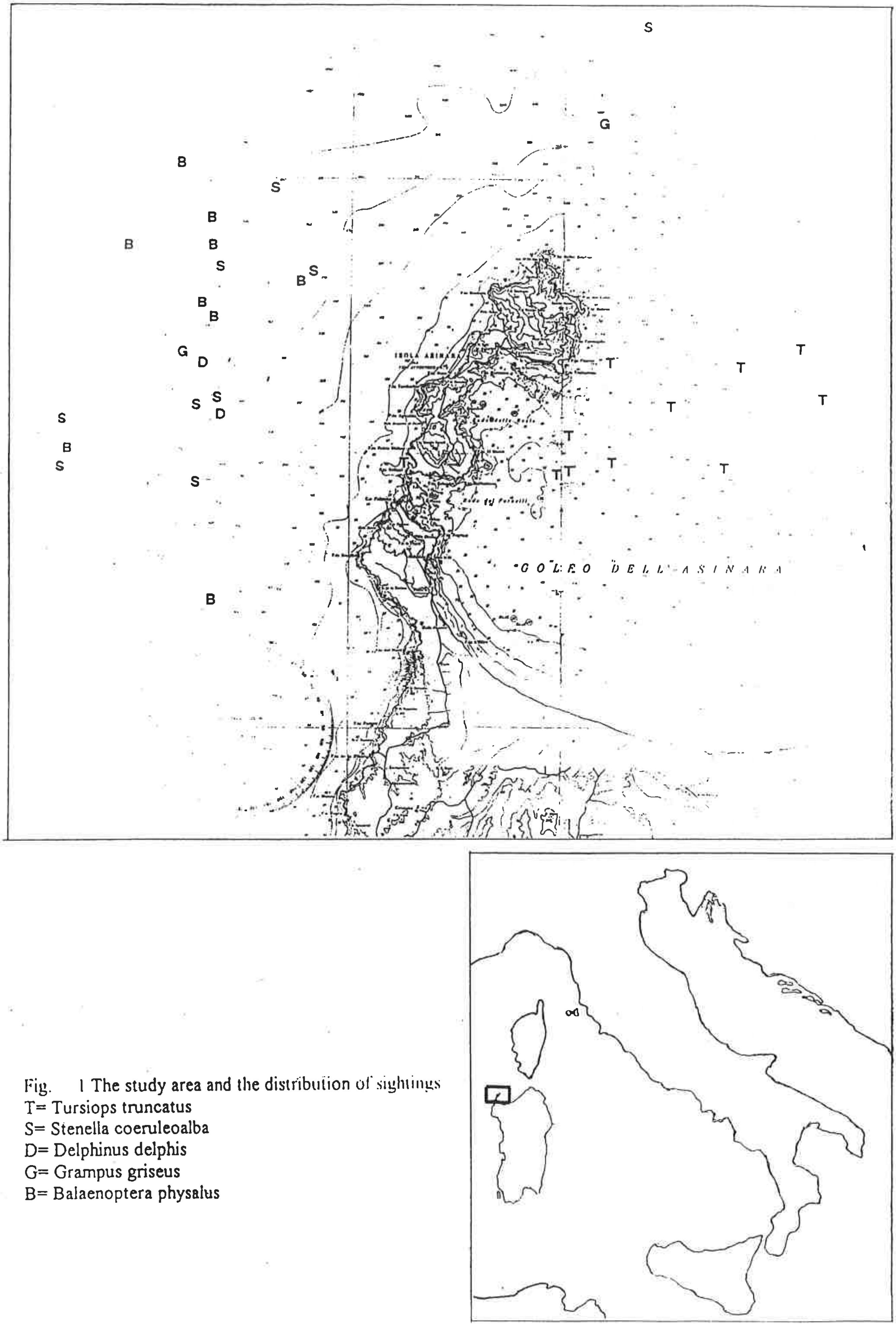

Fig. 1 The study area and the distribution of sightings
T= Tursiops truncatus
S= Stenella coeruleoalba
D= Delphinus delphis
G= Grampus griseus
B= Balaenoptera physalus

A PRELIMINARY STUDY PRESENTING DATA COLLECTED DURING A WWF RESEARCH CAMPAIGN IN THE LIGURIAN SEA (SUMMER 1994)

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INTRODUCTION This preliminary study presents data collected during summer 1994 for the nautical campaign organised by WWF in Liguria. The aim of the research was to observe, study, and census the cetaceans living in the Ligurian Sea.

MATERIALS AND METHODS The research campaign started on 10th July and finished on 12th August, 1994. It was divided into five one-week periods. The monitored area included the Ligurian Sea from Bordighera (IM) to Lerici (SP). The two vessels used were 14m long sloops. Fifty-one members of WWF were involved in this campaign and were co-ordinated by seven WWF researchers (biologists and naturalists). A triangular area was covered between two ports, enabling the vessels to sail out some distance from the coast. Shifts were organised so that observations were continuous throughout the sailing time.

RESULTS During the five-week campaign, observation time totalled 268 hours and 1,017 miles were travelled. In total, 24 sightings were recorded and three species were identified: bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*) and Risso's dolphin (*Grampus griseus*), and one sighting of a *Balenoptera* sp.. On five occasions, it was not possible to recognise the species. Table 1 shows the mileage covered, the number of sailing hours and the cetacean sightings for each day. Fig. 1 shows the percent sightings for each species. Graphs 2 and 3 show the number of bottlenose dolphins and striped dolphins forming a single group. The two groups of Risso's dolphins sighted comprised seven and eight individuals respectively.

OBSERVATIONS Common dolphins were not sighted during the investigation, thus confirming the decline in numbers of this species observed in the last twenty years. Large groups of bottlenose dolphins (up to 50 individuals) were observed, often consisting of sub-groups. This contrasts with the observation of Cagnolaro *et. al.* (1983), that near the coastline the maximum number of bottlenose dolphins observed at any one time was ten individuals. It was also noted that the behaviour of striped dolphins appeared to be friendlier than that of bottlenose dolphins.

ACKNOWLEDGEMENTS We wish to thank Dr. Lilia Capocaccia, Director of Museo di Storia Naturale di Genova, and Dr. Maurizio Würtz, Istituto di Anatomia Comparata dell'Università di Genova.

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Table 1: sightings carried out during the research campaign

date	hours miles	cetaceans sighted	date	hours miles	cetaceans sighted	date	hours miles	cetaceans sighted	date	hours miles	cetaceans sighted	date	hours miles	cetaceans sighted
July 9th			**July 16th**	8h 35mil		**July 23rd**	4h 9.2mil		**July 30th**	4h 9.2mil		**Aug. 6th**	2h 13mil	
July 10th	9h 34mil	*Grampus g.* *Stenella c.*	**July 17th**	9h30' 30.3mil	*Stenella c.*	**July 24th**	11h 36.3mil		**July 31st**	11h 36.3mil	*Stenella c.*	**Aug. 7th**	9h 32.7mil	cetaceans n.i.
July 11st	9h 46.6mil		**July 18th**	11h 39mil	*Stenella c.*	**July 25th**	10h 43mil	*Balaenoptera* sp,	**Aug. 1st**	10h 43mil		**Aug. 8th**	9h 25.5mil	Tuesiops t. (3sightings) cetaceans n.i.
July 12nd	9h 51.8mil		**July 19th**	6h 29mil		**July 26th**	10h 46.4mil	*Tursiops t.* (3 sightings)	**Aug. 2nd**	10h 46.4mil		**Aug. 9th**	9h 22.7mil	
July 13rd	7h15' 31mil		**July 20th**	7h 20.6mil		**July 27th**	10h 25mil	cetaceans n. i.	**Aug. 3rd**	10h 25mil		**Aug. 10th**	2h30' 6mil	
July 14th	13h 80mil	*Stenella c.* *Grampus g.*	**July 21th**	6h 21.1mil		**July 28th**	12h 46.7mil	*Tursiops t.*	**Aug. 4th**	12h 46.7mil		**Aug. 11st**	5h 11mil	
July 15th	7h15' 29mil		**July 22nd**	7h 27.7mil	*Tursiops t.*	**July 29th**	8h 28.6mil		**Aug. 5th**	8h 28.6mil	*Stenella c.* (3 sightings) cetaceans n. i. (2 sightings)	**Aug. 12nd**	4h 6.5mil	

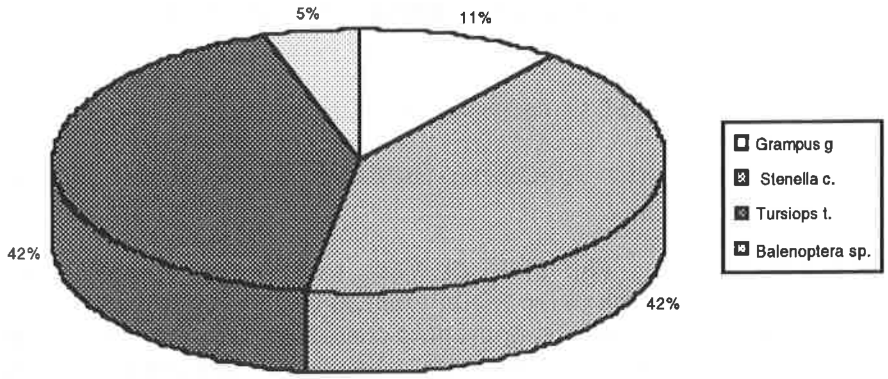

Fig. 1 Percentage of sightings per species

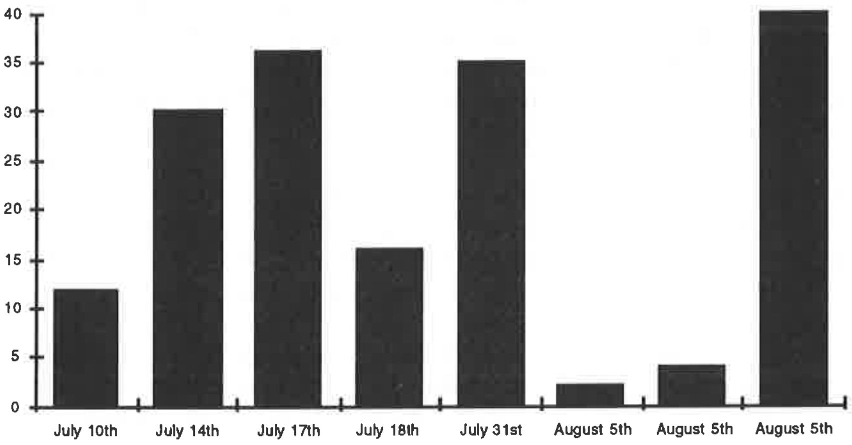

Fig. 2 No of striped dolphins sighted per group

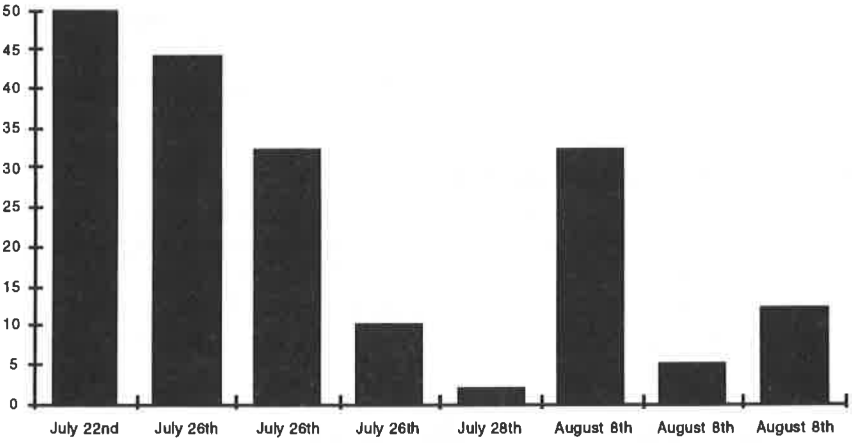

Fig. 3 No.of bottlenose dolphins sighted per group

A LONG-TERM SURVEY ON DISTRIBUTION AND DYNAMICS OF CETACEANS ALONG THE SOUTHEASTERN COAST OF SPAIN: PRELIMINARY RESULTS 1992-94

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INTRODUCTION The Gulf of Vera (South-east Spain) is particularly interesting for cetacean research in the Mediterranean due to its geographic position at the edge of the Alborán sea, and its oceanographic characteristics: narrow continental shelf with deep canyons relatively close to the coast. The aim of this study is to determine the present situation of the cetaceans in the area, establishing which species are resident and which enter the region during their migrations. In this study we are trying to establish the possible relations between the distribution and dynamics of the different groups, with oceanographic and meteorological factors, taking into account also analysis of social structure and behaviour.

METHODS Sighting cruises have been carried out on board the 60 ft. gaff rigged ketch "Toftevaag" during the months of April, June, July, August and September 1992, 1993, and 1994. Navigational, oceanographic and meteorological data were recorded during sailings. When sightings occur, data are also recorded on species, number of individuals, social structure, behaviour, etc. These data are complemented with photo-identification.

For the purpose of detailed analyses, the research area has been divided into three. These three areas have been further divided according to depth ranges and 5 x 5 nm. quadrats. Up to now, the research project has totalled 6,007.7 nm. of effort in 196 days (1,334.64 hours) with an average of 1.68 sightings per day.

RESULTS During these first three campaigns, 330 cetacean observations have been made comprising 12,176 individuals of seven different species (see Table 1). A total of 263 hours have been spent with cetacean groups. The distribution of the five most frequently observed cetacean species is shown by area in Fig. 1, and by depth range in Fig. 2 and Table 3. Group sizes are summarised in Table 2.

Striped dolphin (*Stenella coeruleoalba*)

This was the most frequently observed cetacean, with a total of 118 sightings (35.8% of the total sightings). This was the most pelagic of small cetaceans observed in the region with an increasing number of sightings per unit effort as depth range increased (mean = 1,064 m.; SD = 456.66). Most sightings were of groups of 20 to 60 individuals (mean = 50.31). The maximum number of sightings was obtained during September in all three years.

Common dolphin (*Delphinus delphis*)

The second most frequently observed, being more abundant in the southern area, with 78 sightings (23.5% of the total sightings). It is slightly less pelagic than the striped dolphin, occurring at a mean depth of 917.4 m. (SD = 474.22), and more often seen in shallow continental shelf waters than the striped dolphin. Most sightings are of groups of 12 to 60 individuals (mean = 50.3). On 19 occasions, mixed groups of striped and common dolphins were observed.

Long-finned pilot whale (*Globicephala melas*)

This species does not appear to be permanently resident in the area with 31 sightings (9.4% of the total sightings) were made, all between 350 and 1,800 m. of depth (mean = 945.5 m, SD = 368.71). Most sightings made were of large groups of up to 300 pilot whales (mean = 76.2; SD = 78.74) subdivided into smaller groups of 8 to 15 individuals which at times were highly dispersed.

Risso's dolphin (*Grampus griseus*)
This was a non-resident species. However, different groups were seen each season entering the research region, with 15 sightings made (4.6% of the total sightings). 66.7% of the sightings were made in areas where the water depth was between 700 and 1,100 m (mean = 871.9 m, SD = 313.03). Groups found were relatively small, numbering between 5 to 25 individuals (mean = 12.13; SD = 6.74).

Bottlenose dolphin (*Tursiops truncatus*)
A total of 23 sightings (7.0% of the total sightings) were made. At least 25 individuals of a resident group have been identified. These are generally observed in the Bay of Mazarrón, but several members of this group have been observed further south in front of Aguilas and Garrucha. On both the northern and southern borders of the research region, other groups have regularly been observed. Several sightings of individuals seen on passage near Cabo de Palos could indicate some contact between these groups. The group at Mazarrón is usually found inside the continental shelf although some sightings have been made where the water reaches depths of 400 m (mean = 123.6; SD = 114.87).

Sperm whale (*Physeter macrocephalus*) and Fin whale (*Balaenoptera physalus*)
The sperm whale was seen less frequently than expected with only five sightings (1.52% of the total sightings) each of a single individual. With all sightings, long periods of submergence were recorded. There were only two sightings (0.61% of the total sightings) of fin whale, both at the end of August 1994. One of three individuals, and one lone individual (followed for 18 nautical miles), all heading southwest at approximately five knots.

DISCUSSION The most abundant species of cetaceans found were the striped dolphin and common dolphin, followed by the long-finned pilot whale. Less abundant were the bottlenose dolphin and the Risso's dolphin; the sperm whale and fin whale appeared to be very scarce.

The species which appeared to be resident in the area were the bottlenose dolphin, common and striped dolphins. The long-finned pilot whales have only been observed during the summer months confirming the information obtained from local fishermen. An outstanding event which has been observed during the three campaigns is the sudden gathering in September and moving south of the groups present in the area during the summer. Different groups of Risso's dolphins occasionally enter the region, probably to feed along a section of coastline for a few weeks before moving on to a new region. The same can be said about the sperm whale, although in this case the number of sightings has been very low. As for the fin whale, the only two sightings of this species have been of migrations towards the Alborán Sea in late August.

ACKNOWLEDGMENTS The authors would like to thank more than 300 volunteers who have contributed with the look-out watches on board the "Toftevaag" and with the financial support of the research. Special thanks are due also to Pedro Garcìa (A.N.S.E. Cartagena), Julio Màs (Oceanographic Institute of Mar Menor), the local office of the government of Murcia, the Environment Agency (AMA) of Almería, and the Customs and Guardia Civil of the region, for their support.

Table 1. Summary of sightings during 1992, 1993 and 1994.

Species	1992	%1992	1993	%1993	1994	%1994	TOTAL	% TOTAL
Stenella coeruleoalba	21	32.31	36	27.27	61	45.86	118	35.75
Delphinus delphis	18	27.69	34	25.76	26	19.55	78	23.54
Globicephala melas	4	6.15	13	9.85	14	10.53	31	9.39
Grampus griseus	6	9.23	4	3.03	5	3.76	15	4.55
Tursiops truncatus	4	6.15	16	12.12	3	2.26	23	6.97
Physeter catodon			1	0.76	4	3.01	5	1.52
Balaenoptera phisalus					2	1.50	2	0.61
Unidentified small c.	12	18.46	28	21.21	18	13.53	58	17.58
TOTAL	66		132		133		330	

Table 2. Descriptive statistics for group sizes of the five most frequently seen species.

Group size	n	X	Mode	SD	Min.	Max.
Stenella coeruleoalba	118	50.4831	50	55.4265	1	350
Delphinus delphis	77	50.3377	60	54.0669	1	300
Globicephala melas	31	76.2258	30	78.7408	5	300
Grampus griseus	16	12.1250	9	6.7417	2	25
Tursiops truncatus	23	7.1739	1	7.4690	1	25

Table 3. Descriptive statistics for distribution per depth of the five most frequently seen species

Depth	n	X	Mode	SD	Min.	Max.
Stenella coeruleoalba	118	1064.0	600	456.659	120	2100
Delphinus delphis	78	917.4	1100	474.216	60	2050
Globicephala melas	31	945.5	1100	368.708	350	1800
Grampus griseus	16	871.9	950	313.033	400	1700
Tursiops truncatus	23	123.6	20	114.870	8	400

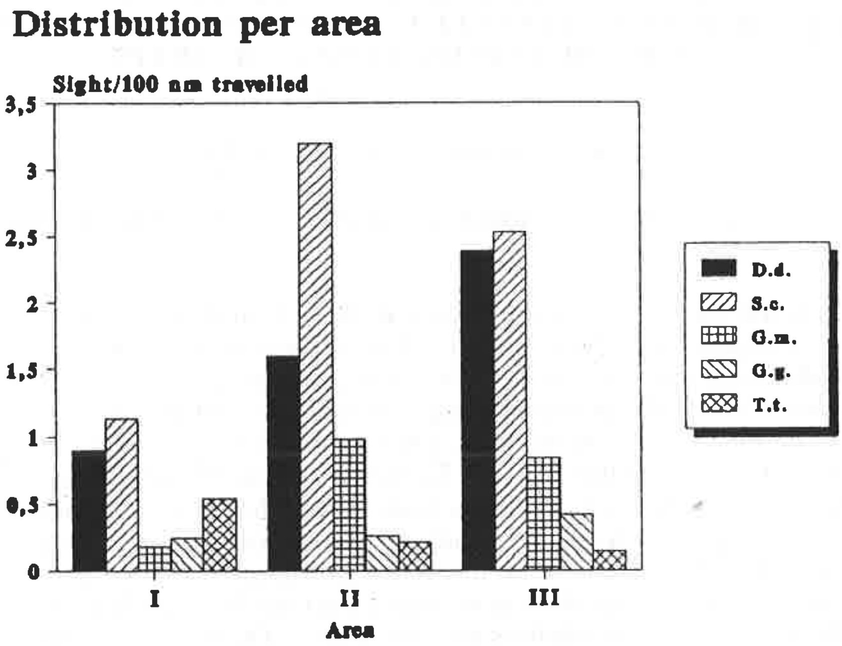

Fig. 1. Distribution per area of the five most frequently seen species in this region.

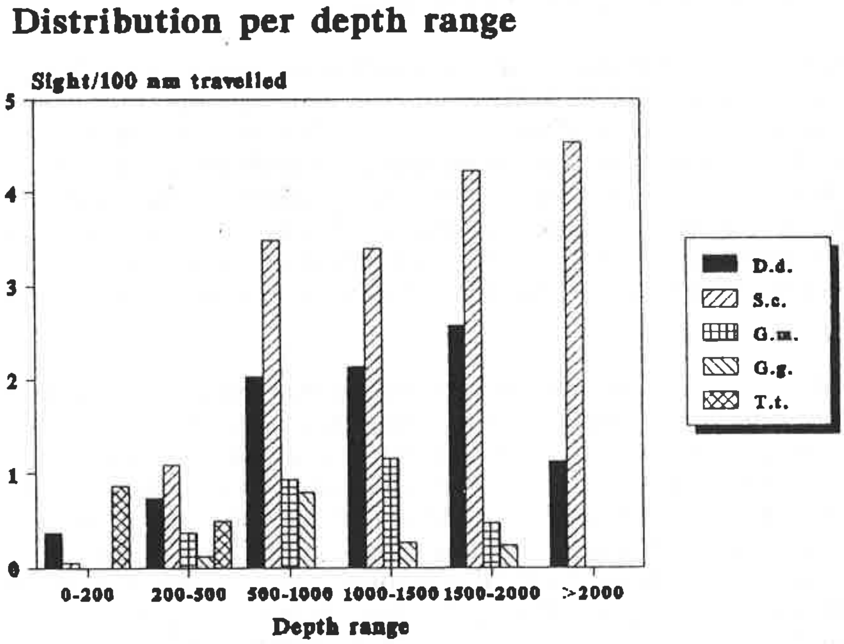

Fig.2. Distribution per depth range of the five most frequently seen species in this region.

STUDYING A POSSIBLE COMPETITION FOR ECOLOGICAL NICHE BETWEEN THE COMMON DOLPHIN, *DELPHINUS DELPHIS*, AND STRIPED DOLPHIN, *STENELLA COERULEOALBA*, ALONG THE SOUTHEASTERN COAST OF SPAIN

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INTRODUCTION From historical data on strandings and research on bone collections, it appears that the common dolphin (*Delphinus delphis*) population in the western Mediterranean basin was probably substantially larger than at present (Casinos, 1974; Silvani, 1992). On the other hand, the striped dolphin (*Stenella coeruleoalba*) appeared to be more scarce in the past, whereas it is now definitely the most common and widespread species in this region. The region between Cabo de Gata and Cabo de Palos in South-east Spain, where the Alnitak Project has been undertaking this survey since 1992, is of great interest for studying the interaction and competition of both species. Cabo de Palos seems to be the actual northern limit for the common dolphin which is found in greater numbers as we move into the Alborán Sea. North of Cabo de Palos, sightings of common dolphins are very scarce (Duguy *et al.*., 1983; Evans, 1987) and in most cases amount to just a few individuals apparently associated with groups of striped dolphins, or swimming alone or in pairs (Fabbri *et al.*., 1992).

The aim of this research is to monitor this possible competition by studying the dynamics and distribution of both species over a longterm period, and to determine to what extent these two species share the same ecological niche in the research region, in order to establish which factors may be provoking this substitution. The research sailing ship "Toftevaag" has carried out sighting cruises from April to September of 1992, 1993 and 1994 covering 6,007 nautical miles in 196 days.

METHODS Navigational, oceanographic and meteorological data were recorded on the hour and at every course or weather alteration. When sightings occurred, data were recorded on species, number of individuals, social structure, behaviour, etc. These data were complemented with photo-identification. For the analysis, the research area has been divided firstly into three main areas for determining any possible variations in relation to latitude. These areas have been further divided according to depth ranges, and in 5 by 5 nm. quadrats for detailed unit effort analysis. The results presented here consist of a preliminary analysis of part of the information collected.

RESULTS Distribution of both species was calculated by unit effort for ocean depth ranges, 5 by 5 nm. quadrats, and for the three larger areas of decreasing latitude. The latter calculation is represented here in one map for each species (Figs. 1 and 2). These include 118 sightings of striped dolphin and 78 sightings of common dolphin. This analysis includes all sightings recorded in conditions of sea state 3 or under. The maps include under each circle, the total amount of miles of effort per area. Several group movements have been observed indicating some possible seasonal migrations for striped dolphin in this region. During the three field seasons, a significant increase in striped dolphin sightings was recorded in September (Fig. 3). Observations of pigmentation differences suggest that several groups of striped dolphins move into the area at the end of summer whereas the groups observed during the spring and summer move away. For the common dolphin, Fig. 4 shows a more even distribution throughout the season. The common dolphin has been seen more readily entering the continental shelf waters whereas, previously, it was seldom seen in waters of over 2,000 m in depth. The striped dolphin was very rarely seen within the continental shelf waters and observed with increasing frequency as ocean depth increased. Group sizes showed no significant difference between both species, with a mean of 50.31 and SD of 55.43

for the striped dolphin and mean of 50.34 and SD of 54.07 for the common dolphin (Cañadas and Sagarminaga, this volume). There were 19 sightings of mixed groups in the quadrats (Fig. 5). From the groups encountered, those of common dolphins appeared more willing to approach the ship, whereas many groups of striped dolphins showed indifference. Data on behaviour towards man were especially important in this area, since some intentional catches of dolphins are still carried out on a local level (Silvani, 1992).

DISCUSSION From the results analysed so far, it seems clear that as in the rest of the Mediterranean Sea, in the study area the striped dolphin and common dolphin seem to share the same niche to a great extent. It remains unclear which biological or ecological characteristics are responsible for the apparent decline of the common dolphin to the advantage of the striped dolphin. By monitoring the populations of both species in this region on a long term basis, we hope to be able to obtain a clearer picture of the situation establishing whether the common dolphin population is undergoing a recovery and how both species are competing.

ACKNOWLEDGMENTS The authors would like to thank more than 300 volunteers who have contributed to the watches on board the "Toftevaag" and the financial support of the research. Special thanks are due also to Pedro García (A.N.S.E. Cartagena), Julio Más (Oceanographic Institute of Mar Menor), the local office of the government of Murcia, the Environment Agency (AMA) of Almería, and the Customs and Guardia Civil of the region, for their support.

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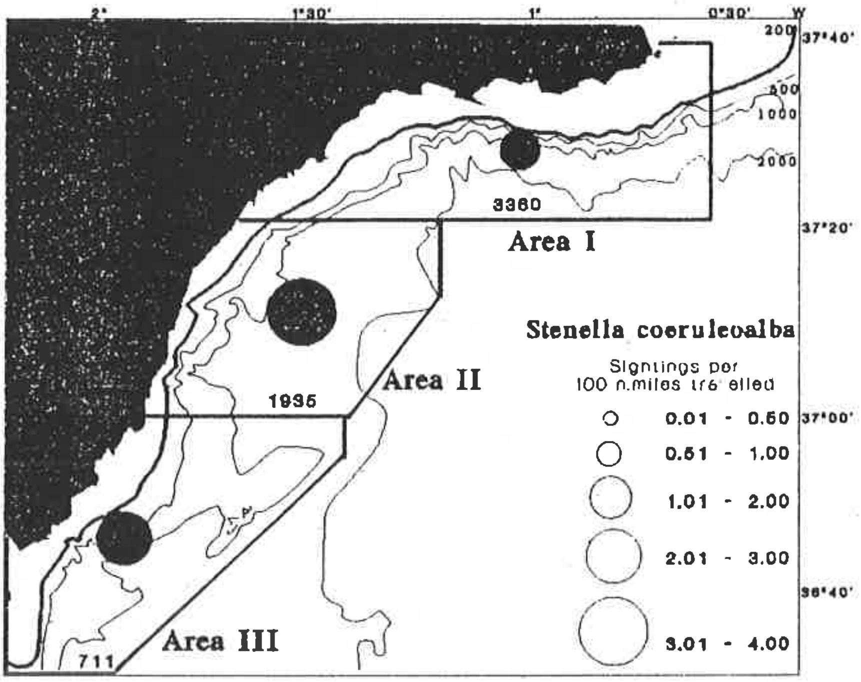

Fig. 1 Distribution by effort unit of striped dolphin for the three areas of the research region.

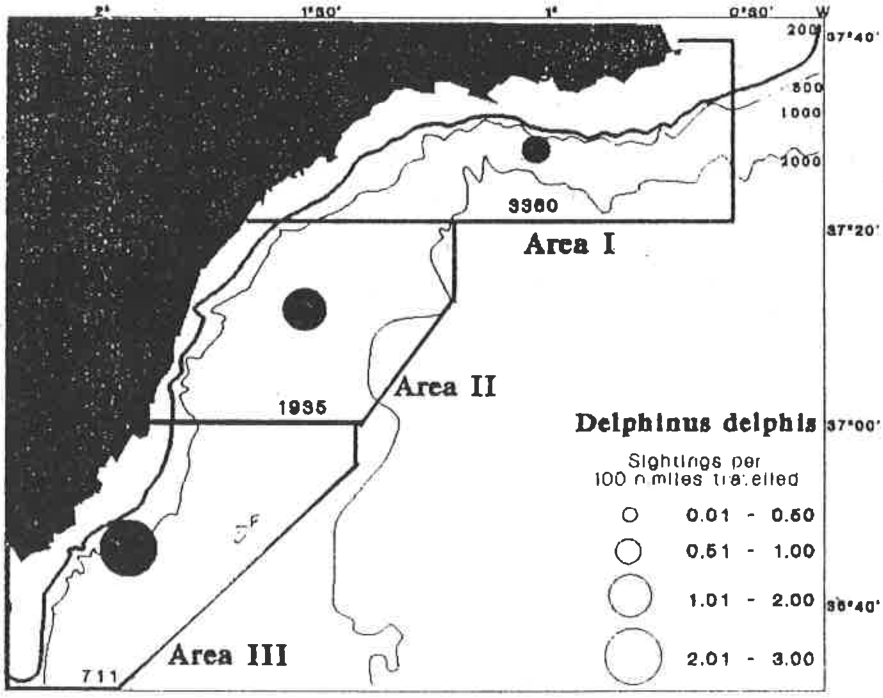

Fig. 2 Distribution by effort unit of common dolphin for the three areas of the research region

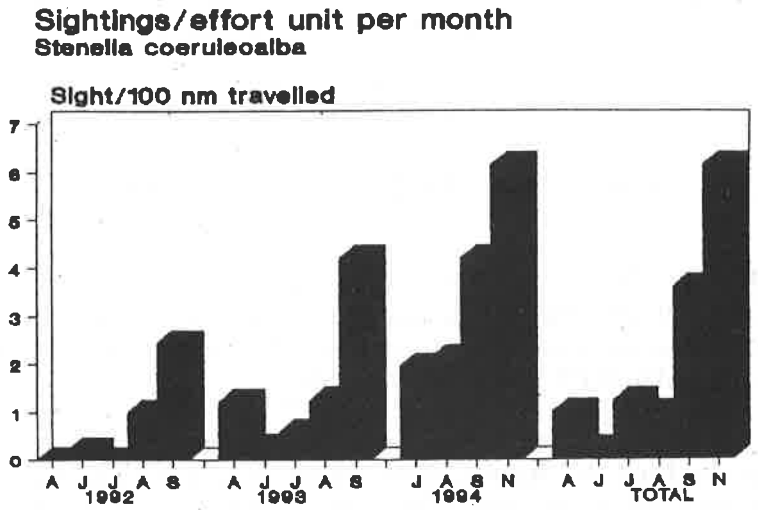

Fig. 3 Distribution of sightings of striped dolphin per month

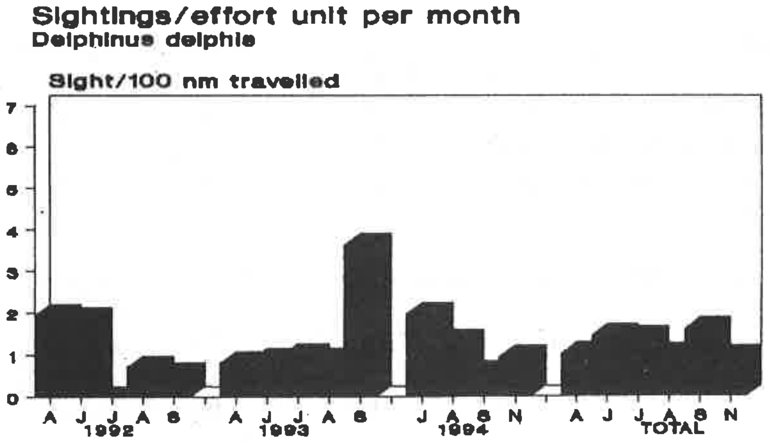

Fig. 4 Distribution of sightings of common dolphin per month

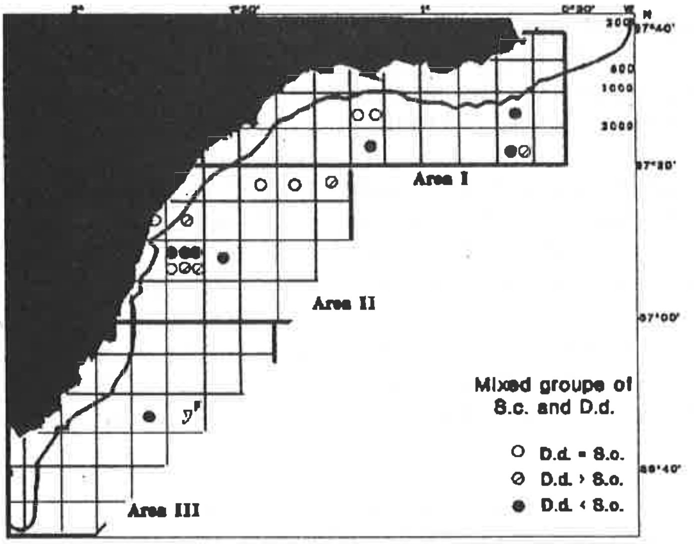

Fig. 5 Mixed groups of striped dolphin and common dolphin sighted

CETACEAN SURVEY IN THE ENGLISH CHANNEL AND BAY OF BISCAY

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INTRODUCTION The seasonal distribution of cetacean species in the English Channel and Bay of Biscay was investigated. This involved performing monthly cetacean surveys on the ferry from Plymouth to Santander (Northern Spain), over the period March 1993 to December 1994.

One of the main aims of the survey was to look at the seasonal distribution of common dolphins in the English Channel. This information was particularly relevant after 107 animals were washed up dead on Britain's south-west shores in 1992 (Kuiken *et al* 1994). The survey aimed to find out if this species was resident in the Channel all year round or just in the winter months when the majority of strandings occurred. In the Bay of Biscay, the survey aimed to provide additional information about cetacean distribution in the early spring and late autumn.

METHODS During the crossing, two observers performed timed watches from either side of the ferry (MV Val de Loire) and noted details of all cetacean sightings. To keep in contact across the boat, observers used two-way radios. All watches were made from the upper deck of the boat and this gave a height of eye of 25 metres and a clear 180° scan. Only sightings recorded in conditions below sea state 4 were used in effort-based analysis.

To analyse the sightings data the route taken by the ferry was stratified into 9 x 50 nm. zones (Fig. 1).

Zones 1 - 2	English Channel
Zones 3 - 5	Brittany coastline
Zones 6 - 9	Bay of Biscay

RESULTS A total of 19 trips were made over the two-year period, surveying 8,027 km over the nine zones. Observers logged a total of 138 separate sightings of cetaceans, and not surprisingly, sea state 0 was found to be the most productive time for watches.

Common dolphin groups were seen 58 times, accounting for 42% of all sightings. The highest sightings rate occurred in zone 5 with 20.5 sightings/per 1,000km travelled (Table 1). Sightings were low in the Channel, with the majority of sightings occurring along the Brittany coastline and in the Bay of Biscay.

Group size varied from one individual to over 50 animals, and the estimated total number of dolphins seen was 574. Juveniles were seen with 19% of common dolphin sightings, and they were seen all the year round. Common dolphins were the only species to frequently approach the ferry, and bow-ride for short periods.

There were 17 sightings of pilot whales, accounting for 12.3% of all sightings. Group size varied from one to eight animals accounting for an estimated total of 69 individuals. Sightings of pilot whales took place almost entirely in zones 8 and 9, during the months March to December.

Bottlenose dolphins were seen on ten occasions, accounting for 7% of sightings. They were seen in groups of one to 15 animals, giving an estimated total of 54 animals. The majority of bottlenose dolphin sightings (70%) took place in the neritic zone.

Harbour porpoises were only seen on two trips, with one sighting in the Channel in June 1994, and eleven sightings along the Brittany coastline in July 1994. The sightings along the Brittany coastline took place in unusually calm conditions of sea state 0, and an estimated 39 individuals were seen in groups of one to nine animals.

Fin whales were the most common balaenopterid species seen, accounting for five sightings of single or pairs of animals. They were seen all year round, in zones 7 and 8, from March to November.

Other species included a blue whale (March), minke whales (September), beaked whales (December), northern bottlenose whales (July) and sperm whales (April and July).

Seabird and cetacean associations were most frequently seen between northern gannets (*Morus bassanus*) and common dolphins. In zone 3, gannets accompanied all common dolphin sightings.

CONCLUSIONS Common dolphin sightings in the English Channel were very low with only two sightings and a large amount of negative data, showing that this species was not present along the ferry route across the channel for the majority of the 19 trips. However, there were frequent sightings of this species along the Brittany coastline in zones 3, 4 and 5, indicating that they were present here for most of the year. In autumn, large groups of over 50 animals were seen in these zones compared with the usual group size of 5-10 animals during the rest of the year. Mackerel (*Scomber scombris*) are in this area during the autumn, prior to moving into the Channel to spawn. It is possible that the larger common dolphin group size observed in the autumn was due to the increased food availability. When mackerel move into the Channel, it is probable that these dolphins follow them, as noted by Evans (1980), then coming into conflict with fisheries intent on capturing the mackerel.

Another aim of the survey was to look at the distribution of fin whales throughout the year in the Bay of Biscay. This species was seen from April to November, indicating that they are present in the Bay for the majority of the year.

One further aim of the survey was to assess the suitability of the ferry for observing cetaceans. The result of 138 sightings obviously shows that the ferry was a fairly good platform to use. However, problems were encountered due to the 20-knot speed at which the boat travelled. Besides the limited time this allowed for identification of cetaceans, it is also possible that many of the larger species were missed as we passed while they were submerged. Overall, the survey was successful producing some very interesting results, and it will continue until the end of 1995.

ACKNOWLEDGEMENTS Thanks are due to Brittany Ferries, including Maria Hammett, Jessica White, Captain Selous and the crew of the MV Val de Loire. Special thanks go to to all the observers who participated in the survey including Kathryn Morris, Dave Curtis and Margaret Lloyd-Davies. Thanks also to the Sea Watch Foundation, West Country Television, and English Nature for providing funding for the survey.

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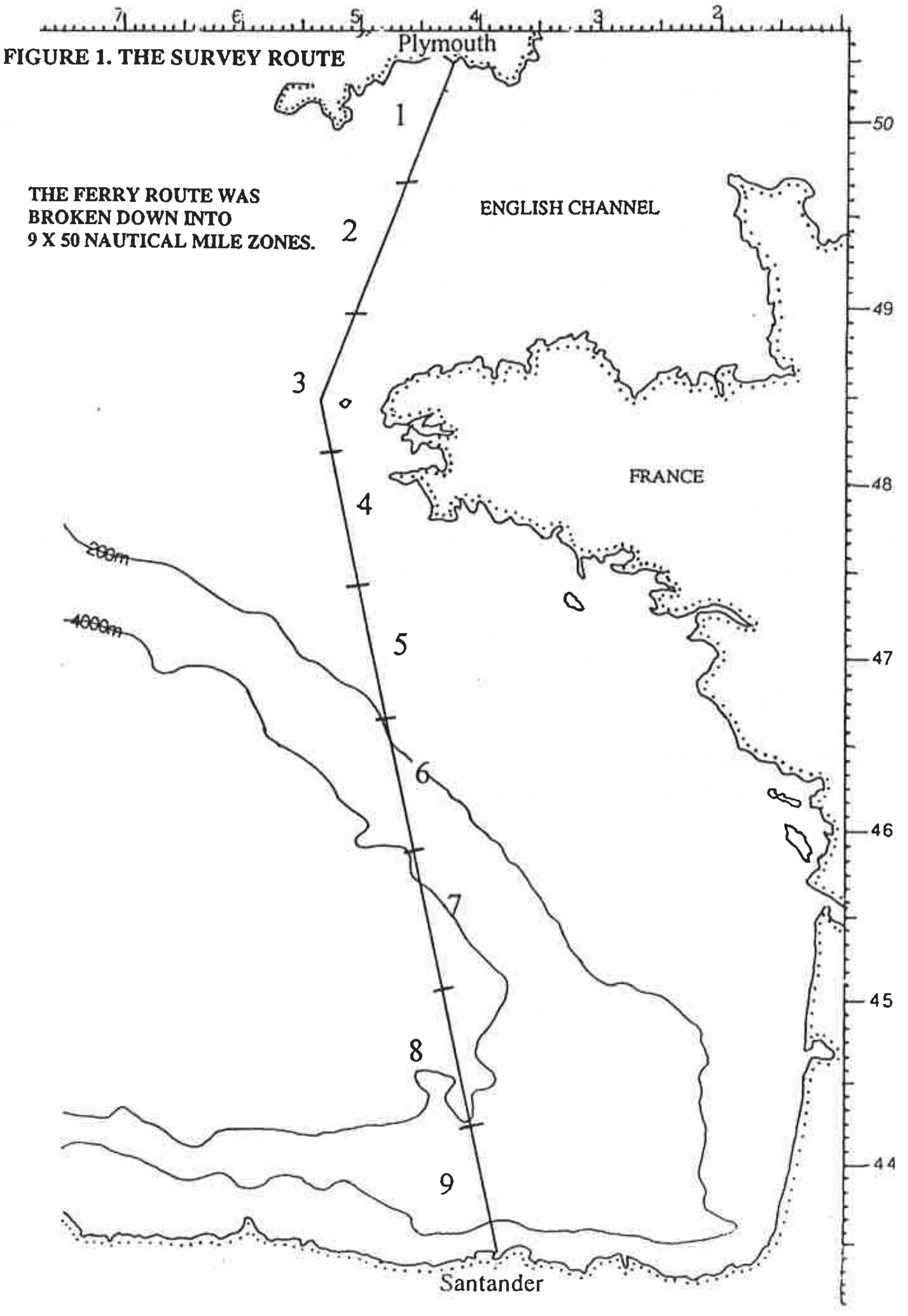
Table 1 Cetacean sightings per 1000km surveyed in the 9 zones

SPECIES	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
Common dolphin		1.6	9.7	9.3	20.5	10	3.3	6	12.8
Pilot whale			0.7					7.2	5
Bottlenose dolphin			1.4	2.7		10.4	3.3		2.2
***Balaenoptera* sp.**							13.2	7.3	2.2

FIGURE 1. THE SURVEY ROUTE



THE FERRY ROUTE WAS BROKEN DOWN INTO 9 X 50 NAUTICAL MILE ZONES.

THE DISTRIBUTION AND ABUNDANCE OF HARBOUR PORPOISES AND OTHER SMALL CETACEANS IN THE NORTH SEA AND ADJACENT WATERS

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To provide accurate and precise estimates of abundance for harbour porpoises and other small cetaceans throughout the North Sea and adjacent waters, an intensive shipboard and aerial sightings survey was conducted in July 1994 as part of project SCANS - Small Cetacean Abundance in the North Sea.

New methods of data collection and analysis were developed as part of the project. These methods included estimating g(0) for the aerial survey using data collected from two aircraft flying in tandem (one behind the other).

The survey area included the North Sea (including waters north to 62°N), Skagerrak, Kattegat, western Baltic Sea, Channel and Celtic Shelf. Good weather enabled most of the area to receive excellent survey coverage, but too few data for analysis were collected in the Western Baltic.

The three most commonly sighted species were harbour porpoises, white-beaked dolphins and minke whales. Harbour porpoises were distributed throughout most of the North Sea, Skagerrak, Kattegat and Celtic Shelf. None were seen in the southern tip of the North Sea or the Channel. White-beaked dolphins were concentrated between 55° and 60° N, particularly in the western North Sea, and on the Celtic Shelf. Common dolphins were seen almost exclusively on the Celtic Shelf. Other small cetacean species encountered in small numbers included white-sided dolphins, bottlenose dolphins, striped dolphins, Risso's dolphins, killer whales and pilot whales. Estimates of abundance for the entire survey area using the new methodology are 352,523 (CV = 0.14) [95% CI: 267,000-465,000] harbour porpoises, 7,856 (CV = 0.30) [95% CI: 4,000-13,300] white-beaked dolphins, and 8,445 (CV = 0.24) [95% CI: 5,000-13,500] minke whales.

INFLUENCE OF SEASTATE ON ABUNDANCE ESTIMATES OF HARBOUR PORPOISES

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INTRODUCTION The harbour porpoise (*Phocoena phocoena*) is widely distributed in the northern hemisphere. Much attention has lately been given to this species. This is mainly because of its poorly known status and the considerable bycatch. In the management of harbour porpoise populations, it is crucial to obtain reliable abundance estimates as well as estimates of the bycatch in fishing gear. This study presents abundance data from the experimental part of the international SCANS survey (Small Cetacean Abundance in the North Sea) which took place during 7-20 April 1994 in the Great Belt, Denmark.

MATERIALS AND METHODS The oil spill fighter 'Gunnar Seidenfaden' from the Danish Ministry of Environment was chosen as the survey vessel because of its height, speed and accommodation facilities. The ship is 56 m long, 12 m wide and weighs 1,660 tons (868 BRT), with a maximum cruise speed of 12 knots. Three sighting platforms at 10 m (primary platform), 12 m (recorder and tracker platforms) and 16 m (secondary platforms) above sea level were used. Two people on the recorder platform recorded effort (speed, position, weather, sea-state, glare, observer positions) and porpoise information on a computer linked to a GPS. This team also recorded all sightings of porpoises via VHF radios from the other platforms. Two people on the tracker platform searched ahead of the vessel. They tracked the animals from before they were expected to react to the vessel, until they had passed abeam. Three people on the primary platform and two people on the secondary platform observed independently in the 180° arc in front of the vessel. All sightings were reported as they were made to the recorder via VHF radios.

When counting cetaceans, several difficulties generally arise. Factors like visibility (sea-state, glare, fog), distribution of the animals, migration, diving patterns, and responsive movement may affect abundance estimates. In this study, all data were stratified by sea-state to quantify the influence of sea-state on the abundance estimate. The data collection and analysis followed the line transect method described by Buckland *et al.* (1993), with modifications by Borchers & Buckland (1994). The computer program 'Distance' (Laake *et al.*, 1994) was used in the analysis. Due to difficulties in determining g(0) (the proportion of animals present on the trackline but not seen), only relative abundance (not absolute abundance) was estimated from the sightings collected by the primary team. Pod sizes were estimated from all sightings made from the primary platform and from pods sighted three or more times from the tracker platform.

RESULTS 670 km of transects were surveyed and approximately 400 distinct observations of harbour porpoise groups were made from the primary platform during 14 days. Data were collected during sea-states 0, 1, 2 and 3, with effort amounts of 212 km, 181 km, 145 km and 132 km, and total observations of 306, 138, 27 and 12, respectively. Nearly all days involved more than one sea-state, so the combined effort for each sea-state was spread over the entire survey period.

An area of 326.2 km^2 was used for extrapolation. Abundance estimates were calculated by using the average pod size from each sea-state (1.1-1.5), and also by using the independent pod size obtained from the tracker platform (2.3, Table 1). Calculations of abundance with the independent pod size gave point estimate of 1,466 harbour porpoises in sea-state 0; 975 in sea-state 1; 309 in sea-state 2; and 170 in sea-state 3 (Table 1). A comparison of the four sea-states revealed a tendency towards higher abundance estimates in lower sea-states. Surveys conducted in sea-states 0 and 1 were not significantly different. There was also no significant difference found between sea-states 2 and 3. However, the difference between these two intervals was significant (Fig. 1). A correction factor for surveys conducted in sea-states higher than 0 was calculated by regression of the relative abundance point estimates. This showed that estimates should be multiplied by 2.1, 4.7 and 10.9 for sea-states 1, 2 and 3 respectively.

DISCUSSION A minimum estimate of 1,466 harbour porpoises (density = 4.5 per km^2) were present in a small part of the northern Great Belt during April 1994. Even though no correction was applied for g(0), this is the highest density of harbour porpoise ever reported in Europe. Aerial surveys in 1991 and 1992 revealed a density of only 0.25 harbour porpoises/km^2 in the Great Belt (Heide-Jørgensen *et al.*., 1992, 1993). The much higher density found in April 1994 could be explained by the southward spring migration through Danish waters, where harbour porpoises pass through the narrow Danish straits to the Baltic proper. It is not known whether the high density is a local phenomenon due for example to spawning of herring in this area, or representative of a larger area. The Great Belt is in any event more important to harbour porpoises in the spring than was previous believed.

The data stratified by sea-state reveal that sea-states greater than 1 have a significant effect on abundance estimates. The correction factor was calculated very primitively but it at least provides an idea of the magnitude of the effect that sea-state has on estimates of relative abundance. The results show that estimates of relative abundance from ship-based surveys of harbour porpoises will be downward biased if any effort in sea-states greater than 1 is included, unless some kind of correction factor is applied.

CONCLUSIONS Ship-based surveys were conducted in the Great Belt during 7-20 April 1994 covering an area of 670 linear kilometres. A total of 483 sightings were collected from which a minimum number of 1,500 harbour porpoises was estimated within the surveyed area. A comparison of relative abundance estimates stratified by sea-state, revealed no significant difference in the abundance between sea-state 0 and 1 and no significant difference was found between sea-state 2 and 3. However, between these two intervals a significant difference was obtained. This suggests that, unless corrected, ship based surveys of harbour porpoises abundance will be negatively biased when effort in sea-states above 1 is included.

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Table 1. Data collected from primary platform for sea-states 0, 1, 2 and 3. The mean pod size from the primary platform as well as an independent pod size is used

Seastate	0	1	2	3
Area (km2)	326,2	326,2	326,2	326,2
Effort (L, km)	212,1	181,4	144,8	131,9
No. of transects	29	28	19	16
Truncation (m)	550	400	300	300
No. of sightings (n)	258	101	18	9
Sighting rate (n/L)	1,2164	0,5569	0,1243	0,0681
Coefficient of variation (CV)	0,1175	0,1928	0,3067	0,3504
ESW (1/f(0), m)	309,45	213,01	150	150
Coefficient of variation (CV)	0.052	0.0814	0.0605	0.0856
Mean pod size (E(S))	1,5116	1,493	1,1111	1,3333
Coefficient of variation (CV)	0,0313	0,0428	0,0686	0,1768
Density of pods (DS, pods/km2)	1,9654	1,3073	0,4143	0,2273
Coefficient of variation (CV)	0,1285	0,2093	0,3127	0,3607
Density (D, porpoises/km2)	2,971	1,9518	0,4604	0,3031
Confidence interval (CL)	2,2788-3,8734	1,2736-2,9913	0,2404-0,8816	0,1362-0,6748
Abundance estimate (N)	969	637	150	99
Confidence interval (CL)	743-1263	415-976	78-288	44-220
Coefficient of variation (CV)	0,1323	0,2136	0,3201	0,4017
Independent pod size				
Mean pod size (E(S))	2,286	2,286	2,286	2,286
Coefficient of variation (CV)	0,0709	0,0709	0,0709	0,0709
Density (D, porpoises/km2)	4,4931	2,9885	0,9472	0,5197
Confidence interval (CL)	3,3747-5,9819	1,9479-4,5849	0,5132-1,7483	0,2586-1,0442
Abundance estimate	1466	975	309	170
Confidence interval (CL)	1101-1951	635-1496	167-570	84-341
Coefficient of variation (CV)	0,1468	0,221	0,3205	0,3676

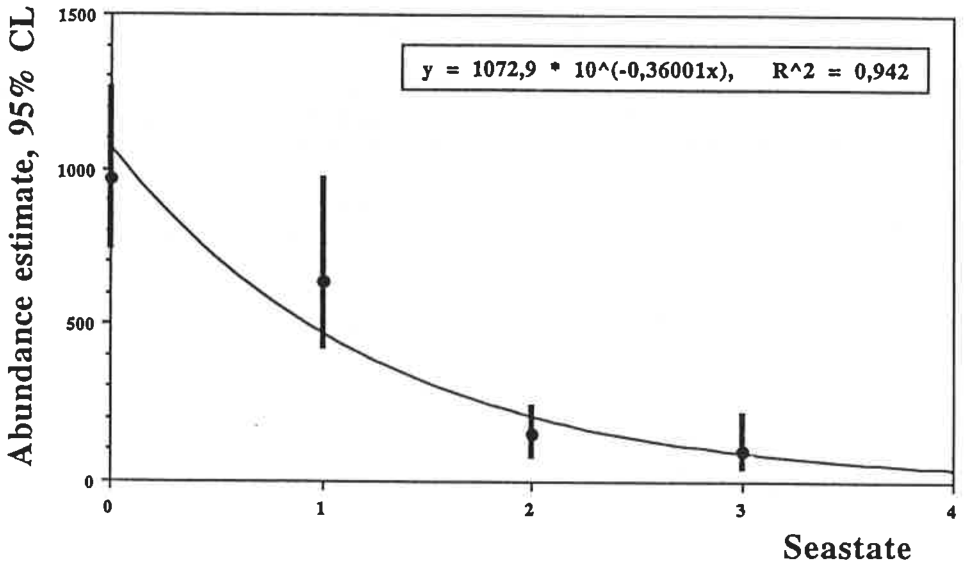

Fig. 1. Abundance estimates for each sea-state with 95% confidence intervals. An exponential curve is fitted to the point estimates

BACKGROUND AND RECENT ACHIEVEMENTS OF SEA LIFE SURVEYS AND THE CREATION OF THE HEBRIDEAN WHALE AND DOLPHIN TRUST

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Sea Life Surveys (SLS) is a commercial whalewatching business which operates off the west coast of Scotland. Set up in 1990, SLS aims to combine scientific research with education by involving the general public in sensitive, practical ecotourism.

This poster reviews the following:

- History and background to Sea Life Surveys
- List of current research programmes
- Results and main achievements to date
- Future prospects for the scientific research
- The creation of the charity - The Hebridean Whale and Dolphin Trust, and ways of supporting the work.

WINTERING AREAS OF FIN WHALES (*BALAENOPTERA PHYSALUS*) IN THE MEDITERRANEAN SEA: A PRELIMINARY SURVEY

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The fin whale (*Balaenoptera physalus*) is the most common mysticete species present in the Mediterranean Sea. Its summer presence is well known and many authors have reported on its feeding grounds in the Ligurian Sea. Some colleagues have observed fin whales in the Ionian Sea and we have also recorded some sightings in the Aegean Sea.

The presence of fin whales in the Mediterranean Sea during winter has been a subject of debate for a long while. The lack of winter observations made some authors think that the fin whales spent the feeding season in the Ligurian Sea and the breeding season somewhere in the Atlantic Ocean. One of the hypotheses considered two populations exchanging their "possession" of the Mediterranean in the different seasons (Viale, 1981). However, there seems to be no reasonable evidence to confirm this hypothesis.

On the basis of sightings during autumn and winter showing the lack of fin whales in the Gibraltar area (Hashmi and Adloff, 1991) and taking into account the winter strandings of this species along the North African and Israeli coasts, our group has formulated the hypothesis that the Mediterranean population (or "stock", *sensu* IWC) consists of a group that is isolated from those fin whales living in the Atlantic Ocean. The oligotrophic waters of the Mediterranean Sea could support a population of fin whales with a particular migratory pattern. The trophic conditions cannot sustain a large number of animals, but water and air temperatures are favourable all year round permitting the whales not to expend a large energy budget in a migration to the Atlantic Ocean. Instead, they stay in the main feeding ground in the north-western basin and only move away when the weather is rough, the water and the air temperatures are low, and the resources become too scarce. There has been evidence of strandings in the Ligurian Sea during winter months. There have also been calves stranded in the northern Tyrrhenian Sea during autumn and winter.

As we observed during our study in the Tyrrhenian Sea, two main peaks in the presence of fin whales have been recorded in autumn and spring: they seem to represent the southward and the northward migrations from and to the Ligurian Sea respectively. We do not rule out the possibility that some exchanges occur with the Atlantic populations, since we believe that the Strait of Gibraltar is not an obstacle to whales, as confirmed by the presence of some humpback whales (*Megaptera novaeangliae*) that sporadically enter the basin.

If a large proportion of the population does not spend the winter in the Ligurian Sea, where do they spend it? We assumed that these animals remained in the southern part of the Mediterranean, perhaps in the Gulf of the Sirte (north of the Libyan coasts). North African waters may represent an appropriate breeding ground and would rule out the need for long migrations to the Atlantic Ocean. From North African waters in spring, they would spread to the other areas, mainly to the Ligurian Sea, but also towards the Ionian Sea and the Eastern basin. However, due to the political situation in that area, this hypothesis has been difficult to verify because of the impossibility of carrying out research in those waters.

Last winter, we received information on the presence of fin whale close to the coast of the Island of Lampedusa, a small Italian island situated on the African continental shelf, quite close to the Tunisian coasts (Fig. 1). The island is only ten kilometres long and no more than two kilometres wide. The cliffs are very high, particularly along the northern coasts, and therefore present a good vantage point for observations. A preliminary survey was carried out in the second half of March when we observed a very high density of animals of this species all around the island. We had sightings of females with calves (one of them was probably lactating) and a relatively high number of animals demonstrating feeding behavior. On some occasions, the group consisted of ten individuals. Some of these individuals remained at this location for the entire survey period.

In February, the crews of trawlers operating offshore, reported sightings of a fin whale more than one hundred miles south of Lampedusa. Local fishermen report that every year, from late March until early April, there are high numbers of fin whales around Lampedusa. Last December, a group of approximately twenty whales was reported in the waters around the island of Linosa, not far north of Lampedusa. These observations seem to confirm the presence of fin whales in North African waters during winter, thus supporting our model.

Chlorophyll concentration is not a good index of the productivity of the sea, because it is rapidly consumed by "grazers". The study of zooplankton abundance in the Sicily Channel suggests that the total number of individuals per square metre is the same as has been reported by several offshore stations in the Gulf of Lions in the northwestern Mediterranean. In this area, bottlenose dolphins have been observed in addition to tuna and great numbers of seabirds. This situation suggests that the Sicily Channel constitutes a secondary feeding area for fin whales in late winter - early spring, before their northward migration. This would represent a main difference to the Atlantic population, which probably only has very low consumption of food in the breeding grounds.

The North Atlantic populations are assumed to breed in autumn (September - November). The strandings of calves in the Ligurian Sea and in the northern Tyrrhenian Sea in the same season suggest that the breeding and the calving periods are similar in both the seas. A network for the recording of strandings, similar to the ones working in Italy and France, is lacking along the North African coasts. This makes it difficult to draw comparisons between the two areas. It should be noted that only dead calves have been recorded in the northern part of the basin. This suggests that there are unfavourable conditions for the calves in that area.

One problem is that fin whales have not been observed during the late autumn and early winter months, during their southward migration. A likely reason is that they swim some distance from the southern Sicilian coast, exploiting a southward current. During their spring migration to the Tyrrhenian Sea, they avoid this countercurrent passing along the North African coast, at the same time taking advantage of some local northward currents. We have recently begun surveys from ferry boats between Sicily and Lampedusa to verify this hypothesis.

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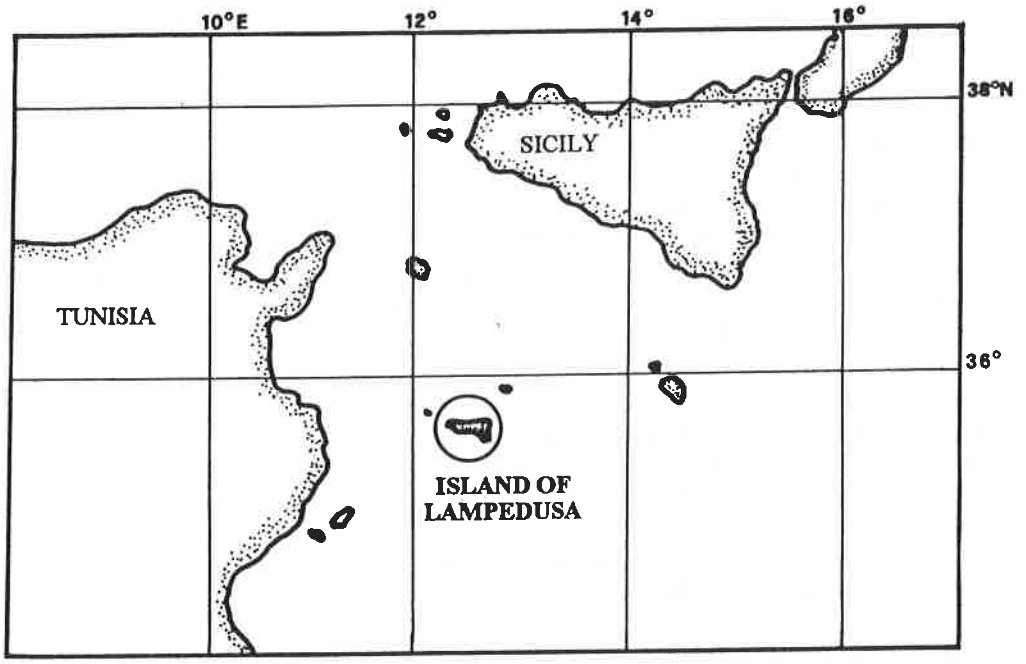

Fig.1 - The Sicily Channel

PHOTO-IDENTIFICATION OF THE MINKE WHALE *BALAENOPTERA ACUTOROSTRATA* OFF THE ISLE OF MULL, SCOTLAND, UK

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ABSTRACT Sea Life Surveys, set up by Richard Fairbairns in 1990, conducts research and whale-watching trips in the waters around the Isle of Mull on the west coast of Scotland. The main focus of this research is the minke whale *Balaenoptera acutorostrata* and, since 1990, a photographic database has been collected, containing photographs and sightings information. This database was analysed to evaluate the potential of using photo-identification to identify individual minke whales. Twenty-eight minke whales have been identified using distinguishing features such as dorsal fin notches, scars to the body, and lateral body pigmentation. Fifteen whales have been seen at least twice, eleven of which have been sighted in more than one year. This suggests that some minke whales show site fidelity in returning to the area in successive years. Ten of the identified whales have been sighted at least twice within one year, with eight of these sighted in at least two different months of that year. This suggests that some minke whales are seasonally resident in the waters around Mull. There appears to be no evidence of any exclusive ranges as shown by minke whales in the eastern North Pacific (Dorsey, 1983). However, the data suggest that the whales tend to move progressively northwards throughout the season. This could be explained by spatial changes in prey abundance or temporal changes in the whales' selection of diet.

INTRODUCTION The waters to the north and west of Mull in Scotland contain an ecologically diverse marine life. Regularly sighted cetaceans include the minke whale, harbour porpoise (*Phocoena phocoena*), Risso's dolphin (*Grampus griseus*), common dolphin (*Delphinus delphis*), and occasional sightings of the killer whale (*Orcinus orca*). "Sea Life Surveys" was set up in 1990 by Richard Fairbairns, conducting research and whalewatching trips covering the waters between Mull, the Scottish mainland (Ardnamurchan Point), Coll, Tiree, Eigg, Muck, Rum and the Treshnish Isles. The main focus of this research is the minke whale; and data collected on these trips include details of location, photographs, behavioural observations and details of environmental conditions. The aim of this study was to evaluate the potential for identifying individual minke whales using photographic techniques, and to use this photo-identification as a tool to answer various questions about the ecology of the minke whale in the coastal waters around Mull. In particular, the aim was to investigate whether individual whales are returning to the study area in successive years, whether they are seasonally resident or transient, and to determine the ranges of individual whales in the survey area.

MATERIALS AND METHODS The photographic catalogue consisted of photographs taken during whale-watching seasons from May to October in 1990-94, and were taken by Richard Fairbairns. The survey trips were conducted aboard the 10.5 metre M.V. Alpha Beta, equipped with a flying bridge and a Global Positioning System (GPS). Photographs were taken with a Canon EOS10 35mm SLR camera equipped with a 300 mm f2.8 lens and a motor drive. Shutter speed was set at 1/1000 s. The film used was Fujicolor 200 ASA print film and photographs were processed at a commercial photographic laboratory. Black and white prints were sometimes produced from the colour negatives to highlight certain features to aid individual identification, for example, by varying the contrast of the prints, scars and pigmentation of the whale were enhanced. All the photographs were examined and initially sorted by selecting those photographs which were of sufficient quality for identification purposes. A photograph was considered to be of good quality if the major axis of the whale in the photograph was perpendicular to the photographer and the image was large enough to show various distinguishing features such as fin shape, lateral body pigmentation (three distinct swaths of lighter pigmentation on each side of the minke's body), and body scars. These were then studied for various features in order to distinguish between individual whales and to match re-sightings. A catalogue of identified whales was established, containing all the photographs from the identified sightings and any subsequent re-sightings. The locations of all the sightings for each identified whale were plotted to investigate the possibility of exclusive ranges and intra-seasonal movements.

RESULTS Twenty-eight whales were identified from a total of 671 sightings. The whales identified by year (1990-94), the number of identified sightings per year, and the total number of sightings per identified whale are shown in Table 1. Whale no. 11 had a calf with her in 1992, and they were seen together throughout this season. Of the 28 individually identified whales, 16 were identified by dorsal fin characteristics, seven identified by scarring, and five identified from a combination of lateral body pigmentation patterns, fin shape, and small white scars. Fifteen of the identified whales have been sighted at least twice. The greatest number of re-sightings for one whale was 11. Eleven of these whales have been sighted in more than one year, and this illustrates that whales are returning to the same area in successive years, showing temporal site fidelity. Ten of the identified whales have been sighted at least twice within one or more years, nine of which were sighted in at least two different months in any one year. This suggests that these whales may be resident at least seasonally in the waters surrounding Mull. The locations of the identified whales reveal that there is considerable overlap in the ranges of these whales, so there appears to be no evidence of any exclusive ranges, as shown by minke whales in the eastern North Pacific (Dorsey, 1983). However, the data suggest that some whales tend to move progressively northwards throughout the season.

DISCUSSION This study has shown that photo-identification is a feasible technique for the individual recognition of minke whales in the coastal waters around Mull. The data reveal that from using such techniques, some important aspects of life-history patterns can be understood. The individuals recognised in this study were mainly identified from dorsal fin characteristics such as notches or unusual fin shapes. Dorsey *et. al.* (1990), studying minke whales in the eastern North Pacific, identified 40% of these whales from dorsal fin features compared with 57% of identified individuals in this study. Dorsey *et. al.* (1990), in their study, used a smaller boat with greater manoeuvrability than the boat used in our study. The higher percentage of whales thus identified from dorsal fin characteristics in this study may reflect the greater difficulty in obtaining the optimal position for taking photographs that will highlight other features such as lateral body pigmentation and body scarring. In the eastern North Pacific, Dorsey *et. al.* (1990) report that the minke whales have numerous oval scars, thought to be of biological origin. These scars proved to be very useful for identifying individuals in this eastern north Pacific population, but were less useful in this study as very few of the whales photographed in our survey area have these scars. Despite this, several re-sightings have been achieved, allowing some aspects of the life history of the minke whale to be determined. It is very important that this photo-identification work is continued to maintain the photographic database and with further re-sightings, our knowledge of the life history of the minke whales will be enhanced.

The possibility that minke whales show site fidelity may have important implications for the identification of stocks and for the setting of catch quotas because, if whaling is resumed, it could have a severe effect on local populations. The results from this study imply that a small population of minke whales are resident during the summer around Mull and some of these return year after year. There is a possibility that some of these whales may remain all year round and these whales will probably have different feeding strategies to those of migratory whales. Residency of such a large mobile predator would have important implications in terms of energy, material flow, and material cycling in the local ecosystem. The distribution of minke whales throughout the survey area over the season is likely to be in relation to their prey species. The northward progression of the minke whales throughout the season could be explained by a shift in the abundance of prey species or temporal changes in the whales' selection of diet.

ACKNOWLEDGEMENTS Thank you to the International Fund for Animal Welfare (IFAW) who helped to fund this project.

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ID No.	1990	1991	1992	1993	1994	TOTAL No.
1	1	3	2	4	1	11
2			3	2	3	8
3			1			1
4			1			1
5			1		3	4
6		3	1	1		5
7	1	1	1			3
8		1		3		4
9				1		1
10		1				1
11		1	4			5
12		1		1	1	3
13		2				2
14			1		1	2
15				1		1
16			1	1		2
17					1	1
18					2	2
19					1	1
20			1	1	1	3
21				2		2
22		1				1
23		1				1
24				1		1
25		1				1
26					2	2
27					1	1
28					1	1
TOTAL ID/YR *	2	11	11	11	12	

* Total number of individually identified whales in that year

Table 1 Whales identified by year, showing the year of sighting and the total number for each whale

PHOTO-IDENTIFICATION-BASED SHORT-TERM TRACKING OF BOTTLENOSE DOLPHINS RESIDENT IN THE KVARNERIC, NORTHERN ADRIATIC SEA

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INTRODUCTION Individual variation in movement patterns, range and habitat choice is an important element of the social ecology of free-ranging cetaceans, and provides insight on the spatial needs of individual dolphins, relevant to the understanding of the living conditions offered by captive situations. However, information on individual free-ranging dolphin movements is rarely available, unless acquired through the use of invasive techniques such as radio-tagging. In this study, performed during a long-term investigation of the socio-ecology of a coastal bottlenose dolphin (*Tursiops truncatus*) community found in Croatia, we describe the movements of selected individual dolphins followed continuously from a small boat for several hours, to outline their movement patterns and assess mean speed of travel and area coverage.

MATERIALS AND METHODS The study area, roughly 900 km wide, includes the sheltered, coastal waters between the eastern shore of the islands of Losinj and Cres, and the west coast of Pag, encompassing a variety of different marine habitats (e.g. rocky coastline and bottom, submerged reefs, seagrass flats, and a mud sea bed with a mean depth of approximately 70 m).

Surveys have been conducted since 1987 from inflatable boats with fibreglass keels, equipped with 25 to 45 HP outboard engines. In 1991-94, a total of 326 days were spent at sea during the study, totalling more than 1,600 hours. Over 650 hours were spent observing and photographing 715 dolphin schools. The position of the boat, determined by GPS (Magellan Nav 1000 Plus), was recorded at regular intervals of 15 min (3 min in 1994) during uninterrupted observations. The dolphins' position (always within 50 m from the boat) was then approximated to the boat's position. For mapping dolphin movements, GPS data where plotted on a digitised map of the study area by using VMAP 2.1. Photo-identification was performed, following Würsig and Jefferson (1990). Over 13,800 slides were included in the catalogue for the identification of individual dolphins, resulting in 106 animals identified by natural permanent marks on their dorsal fins. Individual sexing was opportunistically performed from photographs of the genital area during aerial behavior; furthermore, adult individuals constantly accompanied by a calf over several months, were considered females.

Group size and composition changed frequently during the observations, and movements were related to particular individuals, only if photo-identification data documented their presence throughout the sighting. To better represent movement patterns in the analysis, we arbitrarily considered only trackings exceeding 180 min, involving 36 identified individuals. Fourteen individuals, chosen among those showing a high level of residency in the study area (Fig. 1), were selected for plotting: six females, five males, and three dolphins of unknown sex. Available data for males and females were analysed (disregarding the duration of the trackings) to compare movement patterns between sexes. Three parameters were adopted to describe movement patterns: "geographic movement", "geographic speed", and "area covered" (Fig. 2).

RESULTS The movement patterns of four selected dolphins in the study area are shown in Figs. 3-6. Despite remarkable individual differences, most individuals often frequented a few particular areas. Some of these areas have particular bottom features such as slopes, rocky shallows, or submarine mountains, although a large percentage of movements occurred on merely flat, muddy bottoms. Movement patterns within frequently visited areas were without apparent direction, while routes outside these areas were somewhat more linear and subject to fewer random changes. Observations often showed that dolphin movements roughly corresponded to the 50m-isobath. Movement plotting indicated that the selected individuals, although showing a high level of residency in the study area, often moved out of it.

The mean duration of trackings considered for the analysis was 276 min (SD = 85.3, SE = 11.4, n = 56, range = 180-552). Descriptive statistics for geographic movement (GM), geographic speed (GS), and area covered (AC) is given below:

	mean	**SD**	**SE**	**n**	**range**
GM (km)	8.8	5.05	0.67	56	0.3 - 20.0
GS (km/h)	2.0	1.16	0.16	56	0.08 - 4.7
AC (km^2)	64.3	55.69	7.44	56	0.72 - 207.1

A positive correlation was found between duration of a tracking and geographic movement (F = 6.4, df = 1, $p<0.05$, r = 0.325; Fig. 7). Tracking duration was also positively correlated with the area covered by the dolphins (F = 35.58, df = 1, $p<0.001$, r = 0.63; Fig. 8). Finally, geographic movement and area covered showed a positive correlation (F = 93.74, df = 1, $p<0.001$, r = 0.797; Fig. 9).

A Kruskall-Wallis test showed no significant differences in the mean area covered by males and females (H = 2.79, df = 2, $p>0.05$). Similarly, there were no differences between sexes for both geographic movement (H = 3.86, df = 2, $p>0.05$), and geographic speed (H = 0.153, df = 2, $p>0.05$).

The correlation between area covered and duration of tracking was strong for both males and females, but a linear regression showed a significantly higher slope coefficient for males (Fig. 10) than for females (Fig. 11; t = 4.5, df = 138, $p<0.001$).

DISCUSSION Dolphins in the study area engage in several different activities, characterised by a different speed and movement pattern. Most time (77%) is devoted to activities including long dives with sequences of ventilations (with or without directional movement), while travelling near the surface covers only a small percentage of the behavioural budget (Bearzi *et al.* 1993). Given the low occurrence of steady directional movement, and the irregular shaping of the routes, geographic speed is slow (mean = 2 km/h) compared with the typical speed during travelling (6.5 km/h; G. Bearzi, unpublished data). Movement patterns of the dolphins in the study area seem to reflect their unceasing search for food, perpetually moving from one feeding area to another while looking for occasional, scattered prey.

Despite these intricate movement patterns, local dolphins cover relatively wide areas per unit time. Although the short duration of the tracks (mean = 276 min, range = 180-552 min) prevents further insight, a rough estimate of the daily geographic range can be obtained by projecting the same correlation between movement and time over 24 hours. The "average" dolphin would show a geographic movement of about 31 km per day (based on equation $y = 0.019\ x + 3.479$; Fig. 7), covering an area of 543 km^2 ($y = 0.411\ x - 48.45$; Fig. 8). Given the low regression coefficient between the variables, these data should be carefully considered, while waiting for more detailed studies to be performed.

The actual situation is obviously more complex, and the study itself highlights wide individual differences in movement patterns and habitat use. Moreover, since most data relate to regular visitors of the study area, other patterns of movement may be under-represented, as for "homeless" dolphins covering large areas with little preference for any particular location.

Although differences in area covered, geographic movement, and geographic speed were not statistically significant between sexes, females seem to cover comparatively smaller areas than males during a given period of time. Further investigations may confirm that this result reflects a higher mobility of males - and possibly a female's preference for core areas - as found for other bottlenose dolphin communities (Wells *et al.*, 1980).

ACKNOWLEDGEMENTS We are grateful to Laura Bonomi, Caterina Fortuna, Giancarlo Lauriano, and Brigitte Sifaoui for their help in the field and during data analysis. This research was largely funded by Europe Conservation. Additional funds were given by Centro Interdisciplinare di Bioacustica, University of Pavia. The main inflatable boat used for this research was sponsored by Novamarine.

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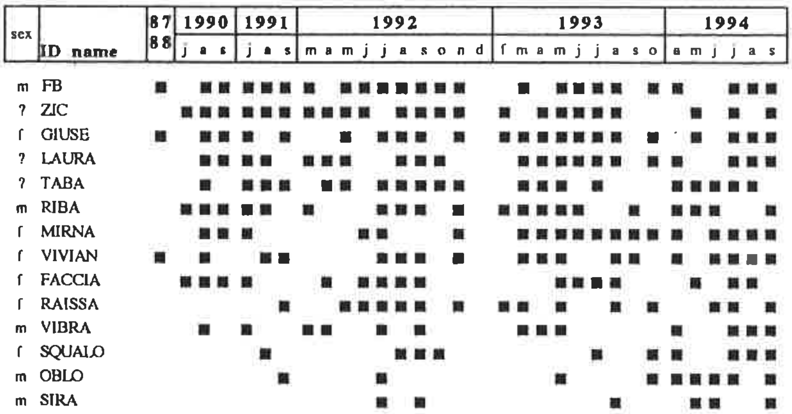
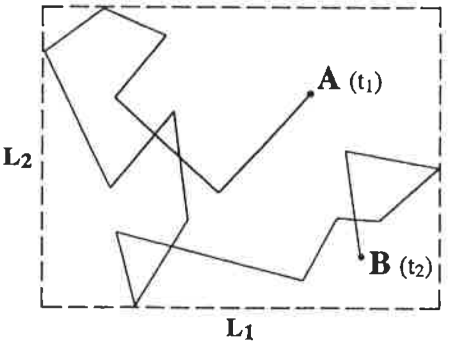


Fig. 1 Residency of 14 selected dolphins in the study area.



A = position at the beginning of the sighting

B = position at the end of the sighting

t = $t_2 - t_1$, duration of the sighting (min)

Geographic Movement = A-B (km)

Geographic Speed = A-B / 60 t (km/h)

Area Covering = $L_1 \times L_2$ (km^2)

Fig. 2 Parameters adopted to describe movement patterns.

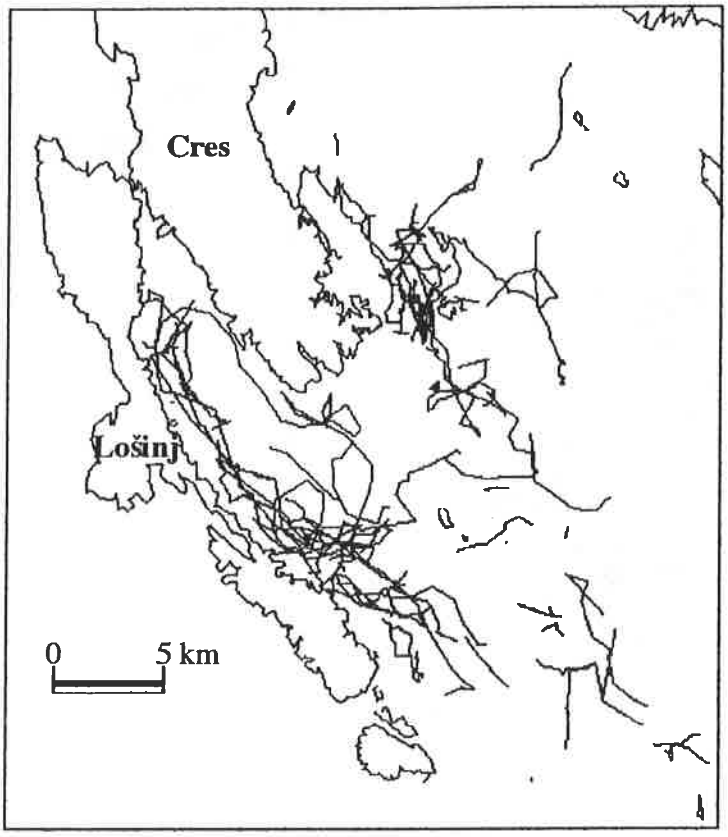


Fig. 3
name: "FB"
sex: MALE

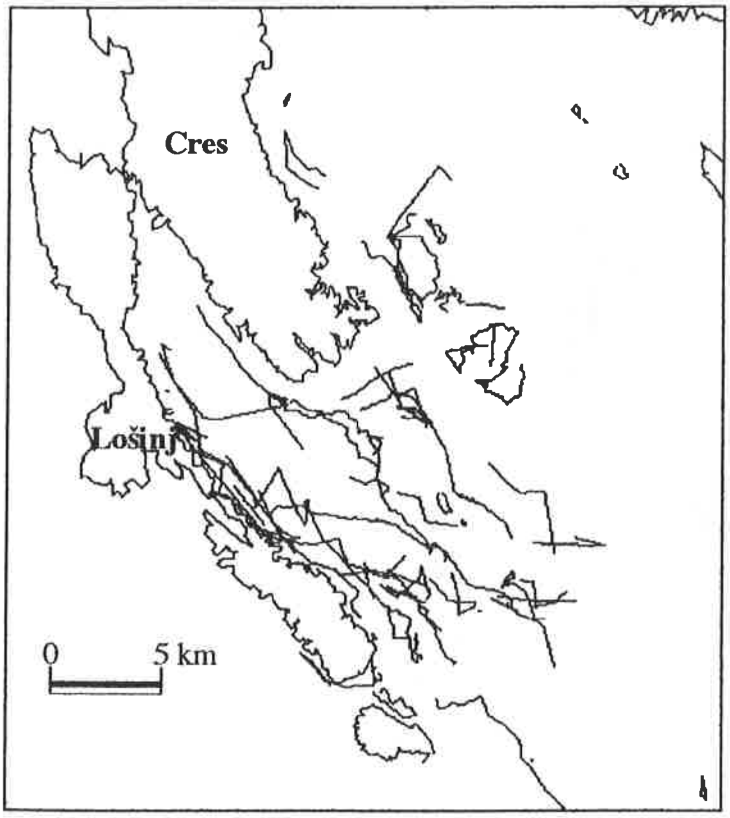


Fig. 4
name: "GIUSE"
sex: FEMALE

Figs. 3-4 Movement patterns of selected dolphins in the study area.

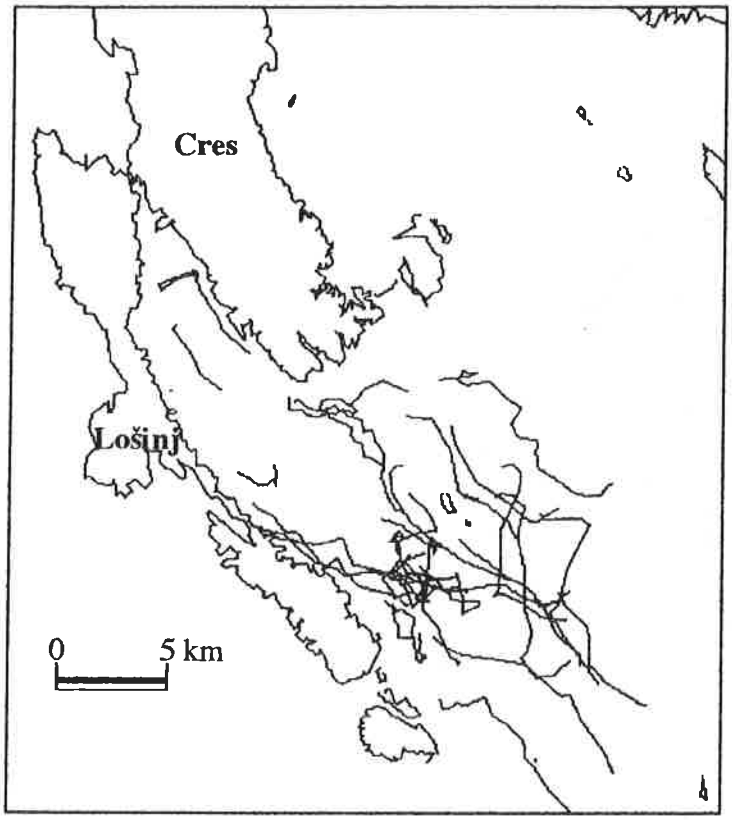


Fig. 5
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sex: FEMALE

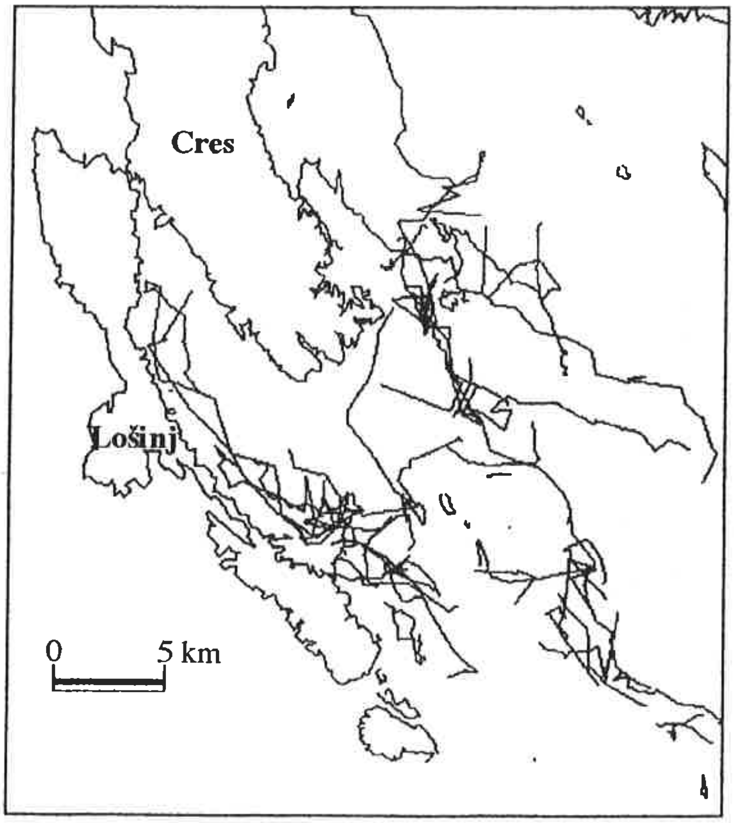

Fig. 6
name: "LAURA"
sex: unknown

Figs. 5-6 Movement patterns of selected dolphins in the study area.

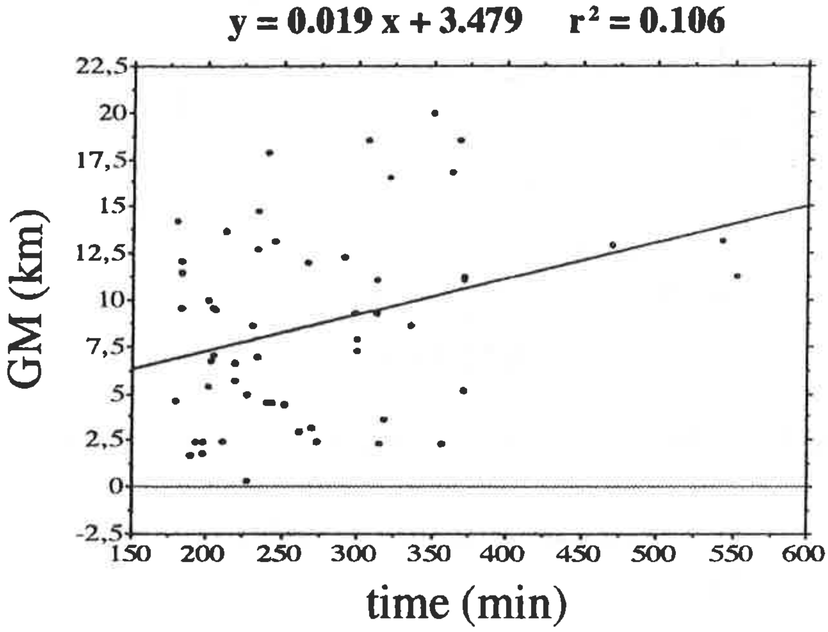
y = 0.019 x + 3.479 r² = 0.106

Fig. 7 Correlation between geographic movement and time.

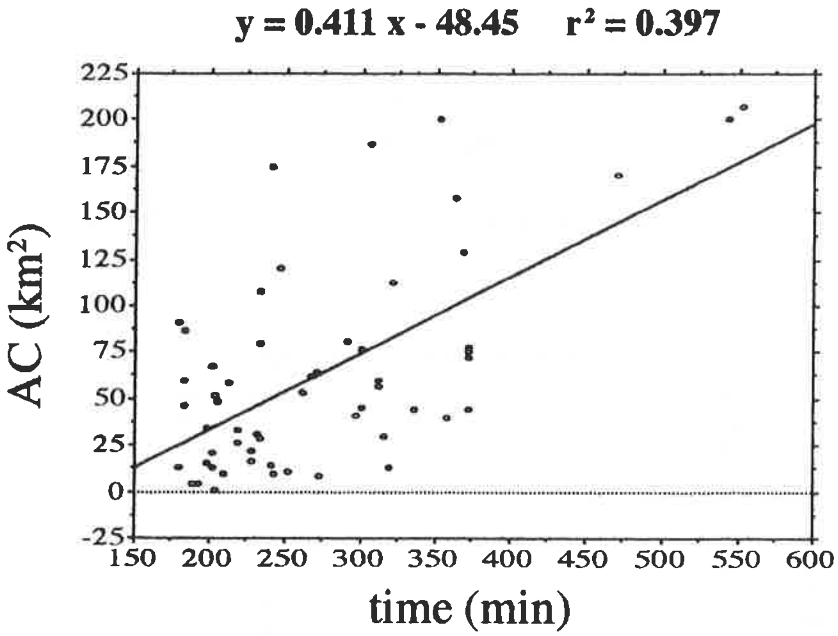
y = 0.411 x - 48.45 r² = 0.397

Fig. 8 Correlation between area covering and time.

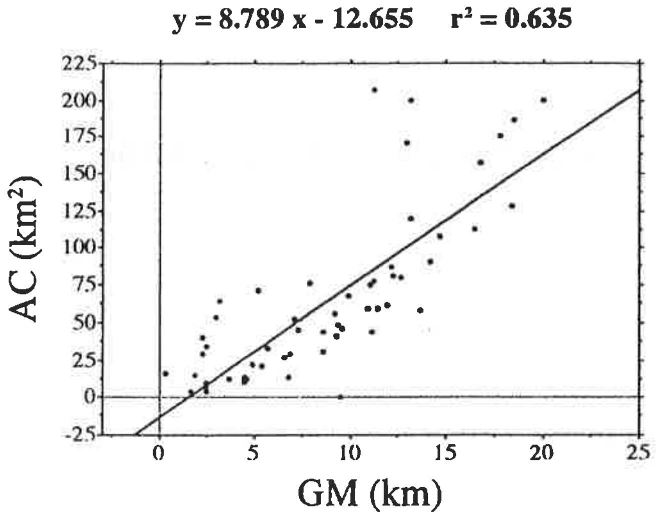

Fig. 9 Correlation between area covering and geographic movement.

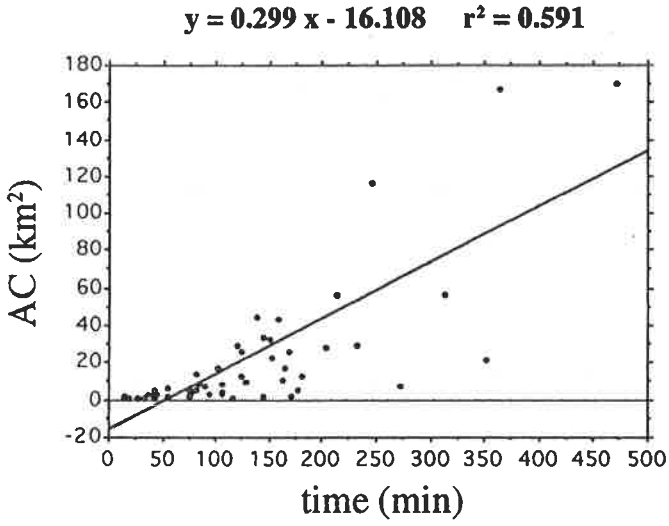

Fig. 10 Correlation between area covering and time: MALES.

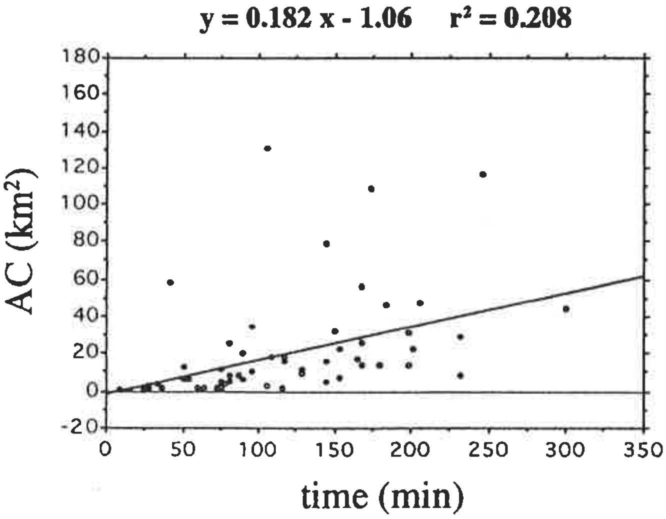

Fig. 11 Correlation between area covering and time: FEMALES.

SOCIO-ECOLOGY OF BOTTLENOSE DOLPHINS, *TURSIOPS TRUNCATUS*, ALONG THE NORTH-EASTERN COAST OF SARDINIA (ITALY): PRELIMINARY RESULTS

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Since 1991, throughout all the seasons, a study has been carried out on the ecology and the behaviour of bottlenose dolphins *Tursiops tuncatus* along the north-eastern coast of Sardinia (Fig. 1). Sightings have been recorded from land-based vantage points, from inflatable vessels, and from trawlers. The research area is approximately 150 square km wide and contains a large range of habitats and depths including extensive Gulfs and relatively sheltered lagoons. Human activities in the area are very intense, especially during the tourist season.

During more than 1,200 hours of observation, 99 systematic sightings were recorded, in addition to some opportunistic ones. School size was observed to be quite small (mean = 2.58, SD = 1.88, SE x 1.96 = ± 0.37, range = 1-10) (Fig. 2), and the use of different habitats and diurnal rhythms appeared to be somewhat complex. A possible model could imply that the dolphins come close to the coast (up to a few metres from the shore) in the evening and stay there until dawn. When this occurred, the dolphins tended to be either alone or in very small groups, feeding around gillnets and on benthic prey. During daylight hours, the dolphins tended to remain offshore, often following trawlers in waters up to 100 metres deep. The school sizes remained small except during social interactions which appeared to be more frequent during spring and autumn. The dolphins were never observed partipating in co-operative hunting activities. The scattered structure of the benthic prey seemed to support small schools, but females with calves were sighted swimming alone. Predators such as sharks and killer whales are absent from the area, so there is no need for dolphins to exist in large schools for defence purposes.

The dolphins were usually very cautious of humans and vessels, and were therefore difficult to approach. As a result, photo-ID techniques were very difficult to carry out. In addition, very few animals carry clear scars or notches. However, a particular individual has been identified in a photograph dated 1986 and was also photographed again in 1993. The home range and the dimension of the population remain unknown.

Feeding around gillnets can greatly reduce the search and hunting effort for these animals as the nets are often operating in the same places and the fishes are easier to catch in the vicinity of these nets. In the Black Sea, Bel'kovich (1991) observed bottlenose dolphins pushing prey against a net, using it as a "wall" to reduce movement of the prey. This could be the first step in the evolution of a new feeding strategy. This behaviour seems to be widespread throughout the Mediterranean Sea (Turkey, Greece, Italy, Spain, Corsica and North African coasts). It should be noted that the nets employed in the basin are quite different from those used in other part of the world.

Trawlers' crews claim the "thieving" of cephalopods by the dolphins. Bottlenose dolphins were often observed following the trawlers and diving for 3-5 minutes over the net. They swim away as soon as the nets are recovered and they have never been seen actually feeding on organisms that have been discarded by the fishermen. We suspect that the cephalopods become more visible to the dolphins when they are alarmed by the nets passing along the seabed, and in an attempt to escape, project upward from the bottom. If this is the case, the dolphins are not only exploiting pelagic prey but those resources in deep waters too. Gillnet fishermen use small petards to scare the dolphins but, usually, they have very short term results. Sometimes dolphins become entangled in the nets and are killed by the fishermen. Trawlers are occasionally reported to shoot the dolphins though, in realistic terms, killing rates are probably low. However, they could still represent an important percentage of the total mortality of the population which we think is quite small.

ACKNOWLEDGEMENTS CTS Dept. for Environment supported this research. The National Railway Board helped us in transportation to and from the Sardinia.

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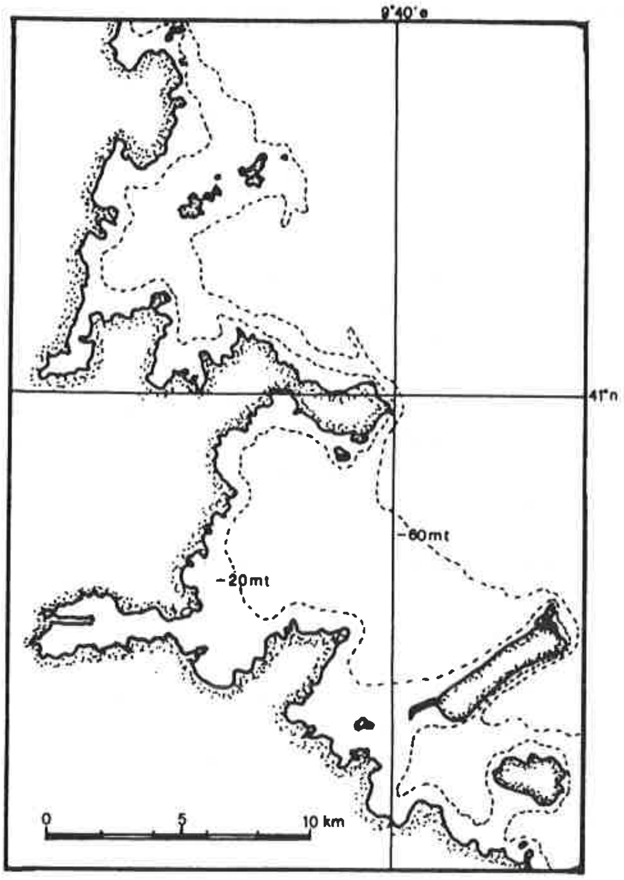

Fig. 1 Map of Study Area - North-east Sardinia

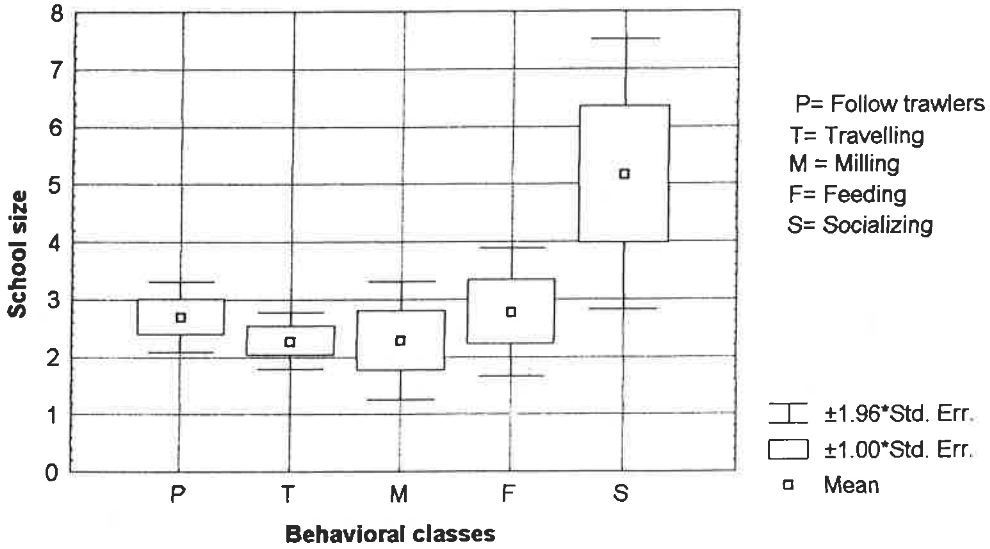

Fig. 2 School sizes of bottlenose dolphins in relation to different behaviours

AN EXAMINATION OF THE OCCURRENCE PATTERN OF BOTTLENOSE DOLPHINS IN THE SADO ESTUARY REGION

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INTRODUCTION For the past two decades coastal resident populations of bottlenose dolphins (*Tursiops truncatus*) have been regarded as natural laboratories where long term studies have been developing. At the same time there has been an increasing concern for their conservation due to the polluted and stressful environment in which they live. The Sado estuary region is one of the few places in Europe where a resident group of bottlenose dolphins exists. In order to create a continuous monitoring programme to assess the conservation status of that group, a preliminary study was designed to define the approaches to be followed. I present here some of the findings.

MATERIAL AND METHODS Five boat surveys during February 1994 preceded the main sampling period which was March to June 1994. This period was designed to survey both the area most visited by the group, (our main study area), the interior of the estuary and contiguous sea areas (Fig. 1). Overall, forty boat surveys were carried out: thirty in the main study area, and five in each of the other two areas (A & C in Fig. 1). Individuals were both visually and photo-identified. Presence within the calves' school (see definition below), movements, position and the dolphins' group dynamics were noted during each survey.

Calves' school Typically each day, dolphins were observed joining in one school. This always happened near the estuary mouth when they were leaving or entering the estuary or, occasionally, when moving inside the estuary. The dimension and composition of this school varied during the day and between days. The presence of calves in the school was always observed. Thus, we have chosen them for its core and the school for the sampling unit. An individual was part of this school - "calves' school" - if its general movement coincided with that of the school, and if its position was no more than 100 m away from the median position of the two existing calves.

Association Index The Jaccard association index was used to measure the association level between a certain individual and the calves' school. The following formula was used:

$$\frac{\textit{No. days individual A observed in calves' school}}{\begin{array}{c}\textit{No. days indiv. A observed} \\ \textit{in calves' school}\end{array} + \begin{array}{c}\textit{No. days indiv. B observed} \\ \textit{out of calves' school}\end{array} + \begin{array}{c}\textit{No. days calves' school observed} \\ \textit{without individual A}\end{array}}$$

RESULTS Thirty-six individuals were photo-identified: two calves (#1 and #2), 4 juveniles (#3 - #6) and 28 adults (#7 - #36) (Fig. 2). At least two further apparently unknown adult individuals were seen. A conservative estimate for the total number of dolphins that were present in the study area produced a value of 36-38 individuals. Although the discovery curve suggests that photo-identification procedures were incomplete (Fig. 2), most of the individuals were photo-identified before the sampling period had started. The majority of these visited the study area more frequently (Fig. 3). The association pattern of individuals within the calves' school (Fig. 4) reveals:

1) The existence of an assemblage of individuals with high association indices (> 0.90) with the calves' school. These were never observed outside the school and were present in 92% or more of the school's observations. This assemblage, besides the two calves

two further individuals eventually identified as females. These individuals were also those who visited the study area more frequently (Fig. 3).

2) The existence of a group with a decreasing level of associations with the calves' school. This applies to the individuals seldomly observed in the school and also found outside the school, namely in the interior area of the estuary.

3) The existence of an assemblage of individuals which were never, or only once, observed in the calves' school. They were seen at the entrance and in the interior area of the estuary. Individuals seen only once, actually in the school, were observed in the nearby sea.

DISCUSSION The occurrence and association pattern analysis reveals the existence of a group that regularly visits the main study area - the calves' school. Although with variable composition, there is an assemblage of individuals always present which constitutes the nucleus of the school. The presence of mother and calf pairs and the observation of baby-sitting and epimeletic behaviours may explain the high association indices observed, although we do not know much about the association levels between individuals that constitute this assemblage. Stable bands were also reported in Sarasota, USA (Scott *et al.*, 1990) and Shark Bay, Australia (Smolker *et al.*, 1992) coastal bottlenose dolphin communities.

Individuals with labile or null associations with the school have a different pattern of movement in the study area which may be reflected in their home ranges. The interior area of the estuary and/or the contiguous sea area may be used more often by some of these individuals. The contiguous sea area may be visited by other coastal bottlenose dolphins potentially providing an opportunity for genetic exchange.

The monitoring over the years of this group is focused on the calves' school which will allow inferences about its composition and the association level between individuals to be made. It will also allow observation of its demographic tendencies which may help us to conclude its conservation status. Surveys in the interior area of the estuary and in the sea will search for other individuals and other groups with calves, contributing to the knowledge of the demographic position of the calves' school in the coastal population.

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Smolker, R., Richards; A.F., Connor, R.C. and. Pepper, J.W. 1992. Sex differences in patterns of association among Indian Ocean bottlenose dolphins. Behaviour, 123(1-2): 38-69.

14-Feb	16-Feb	17-Feb	18-Feb	20-Feb	28-Mar	2-May	5-Jun
#1, #2, #4 and #7-22	#5 and #6	#2 and #23-26	#27-29	#30	#31	#32	#33-36

Table 1 First moment of photo-identification.

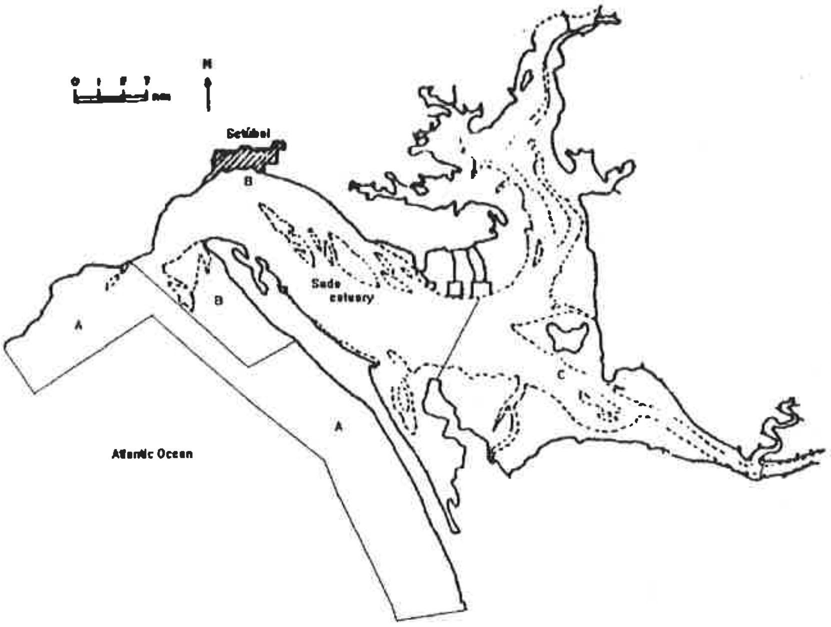

Fig. 1 Study area and survey zones. A- marine zone; B- main study area; C- interior of Sado estuary.

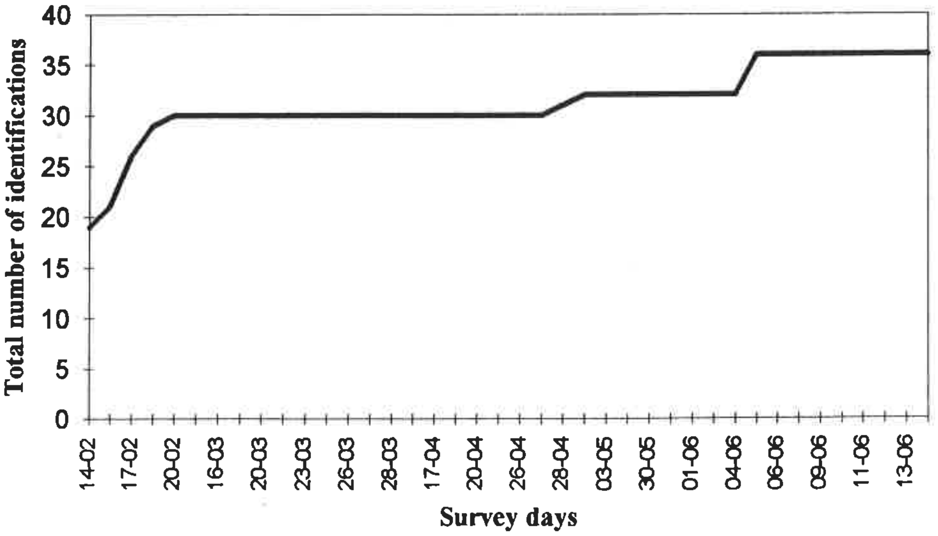

Fig. 2 Discovery curve for individually identified dolphins

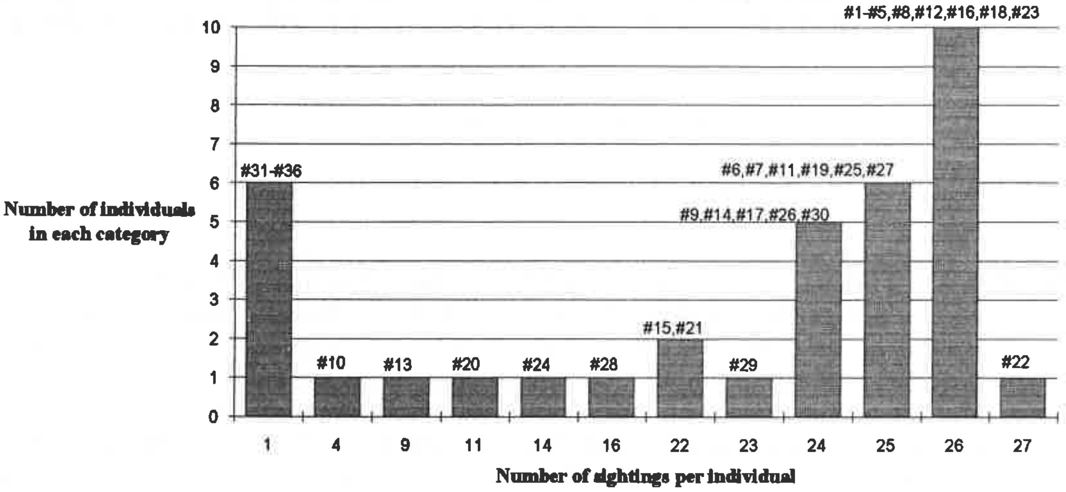

Fig. 3 Frequency of sightings of each identified individual. The total number of individuals = 36 and the number of surveys = 31 (only sampling period was considered excepting days 20-03 and 09-06, in wich dolphins weren't observed).

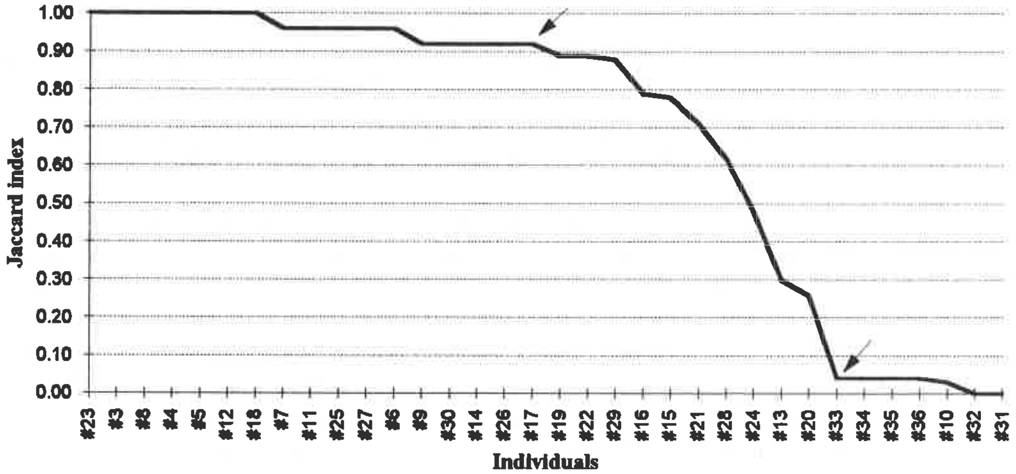

Fig. 4 Association pattern of individuals with calves' school using Jaccard index. Arrows separate the three defined assembladges of individuals.

SEASONAL VARIATIONS IN HABITAT AND ACTIVITY BUDGET BY RESIDENT BOTTLENOSE DOLPHINS AT ILE DE SEIN, FRANCE

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INTRODUCTION A group of 14 bottlenose dolphins (*Tursiops truncatus*), is resident year round in the vicinity of Ile de Sein, Brittany, France. These dolphins dwell in a restricted home range less than 3 km^2. The accessibility of this pod and the predictability of its observation within a small radius from the island constitute a unique opportunity for investigations on habitat and resource utilisation by resident bottlenose dolphins. We have started a three-year study of habitat use strategy by these bottlenose dolphins in which we aim to investigate the relationships between environmental parameters and the dolphin activities at different time and space scales. This paper shows preliminary results (the first year cycle is not totally completed) on seasonal variations in home range and activity budget.

MATERIALS AND METHODS Field sessions took place once every two months from May 1994 onwards. The data collected during each field session include a quantitative mapping of the home range and habitat use for selected categories of activity (mostly resting, travelling and foraging) and a survey of various environmental parameters such as seaweed coverage and growth, relative fish abundance, boat traffic and weather/sea conditions.

The home range has been mapped on a 200 m cell-sized grid of the area. Data were collected by tracking the animals from a rubber boat at a distance allowing observations with minimum disturbance, dolphin location, group size and activity being recorded every five minutes. During the summer season (May, July and September) at least 500 such data were collected, whereas during winter sessions, sample sizes were only half of this, due to difficult sea conditions. In January, very strong storms precluded any data collection during the whole month. Broad categories of activity were determined from surface observations of pod structure, orientation, swimming speed, and surface events.

Seaweed coverage was assessed visually by a diver at selected spots included in the dolphins' home range, and corresponding to different benthic habitats. Seaweed growth was obtained by measuring about 30 fronds of each dominant kelp species (*Laminaria hyperborea* and *Saccorhiza bulbosa*) at every selected spot and field session. Fish abundance was assessed by counting fishes along standardised underwater transects, discriminating three major water layers : the kelp bed (between sea bottom and upper surface of kelp bed), the interface (one or two metres above the upper surface of kelp bed, or above the sea-bottom in the case of bare rocks and sand banks) and the pelagic layer (from the interface up to the sea surface).

RESULTS AND DISCUSSION

Seasonal variations in habitat use and activity budget The intensity of space utilisation is shown as peaks on the maps of the study area (Fig. 1). For each field session, a presence of dolphins in relation to observation effort is given and indicates that the home range mapped at any season is used by the dolphins during c. 90% of the time (only daylight hours have been sampled). Within their home range, the dolphins concentrate their activity in a limited number of very restricted spots, each one being only a few hundred metres across (generally less than ten cells of our gridded map of the area). Three of these spots are located in the western part of their range and are predominantly used in May and November. Although weather and sea conditions did not allow us to map the January habitat use, the few observations made from land at this period were also located to the west of the island. Data obtained in March 1995 (not shown here) gave an almost identical map of habitat use as in May and November.

Consequently we believe that this home range can be generalised throughout winter from November to May. By contrast, the maps obtained in July and September show a very sharp peak of habitat use intensity in the north-eastern part of the area at the entrance of the harbour. This summer home range is established in July and lasts until the spring tides of September, generally associated with a period of unstable weather and sea conditions.

Paralleling this seasonal shift in habitat use, activity budget also shows well-defined seasonal variations (Fig. 2). Foraging is by far the dominant activity in May (70% of daylight hours, i.e. about 10 hours per day), dropping to a very low level in July and September (20%, or about 3 hours per day) and slightly increasing again in November (45%, or about 4 hours per day). It must be noted here that we have no idea of their nocturnal activity and, furthermore, partial evidence suggests that, at least in summer, activity budget and home range can be different during the night than during daylight hours.

Seasonal variations in seaweed growth and fish availability For clarity, one can split the annual home range into two distinct areas: the western home range, located westwards to the island and the eastern home range, located around the island, mostly in the vicinity of the harbour. A summary of seasonal shifts in the use of these two areas is given in Fig. 3a and compared with seasonal trends in seaweed coverage and growth as well as in fish availability in the same zones (Figs. 3b and 3c).

It appears that none of these environmental parameters display seasonal trends that could match the variations observed in activity and habitat use by the dolphins. Indeed, seaweed parameters behave identically in both areas and fish availability is only weakly seasonal in either zone; fish availability being lower all the year round in the harbour than in the western home range. Furthermore, the only microhabitat found to display strong seasonal variations in fish availability is a sandbank where sandeels (and pollack, a predator of sandeel) were nearly ten times as abundant in July and September as they were in May and November. This sandbank is located in the eastern range at less than one kilometre from the entrance of the harbour where the dolphins spend most of their time in summer. Although fish were abundant there and this site lies very close to the dolphin summer daylight home range, we have never seen them feeding on this resource.

The lack of clear-cut relationships between the seasonal shift in habitat use and several parameters connected with the foraging conditions suggests that the change in daylight home range observed in summer might not be dictated by food requirements. Some non-trophic environmental parameters should be investigated which could match better the changes of space utilisation by the dolphins. One such parameter is space utilisation by man which is strongly seasonal, with a peak in July and August mostly affecting the eastern home range of the dolphins. The number of ferry trips is higher in summer than in other seasons. The number of working days for local fishermen is also higher in summer due to the sea-state, and the number and activity of sailing boats and various other leisure boats are also greatly enhanced in summer. These activities are concentrated in the vicinity of the harbour where the dolphins commonly dwell in summer; however the existence of a functional connection between these parameters and the dolphins' space utilisation strategy is totally unknown at present.

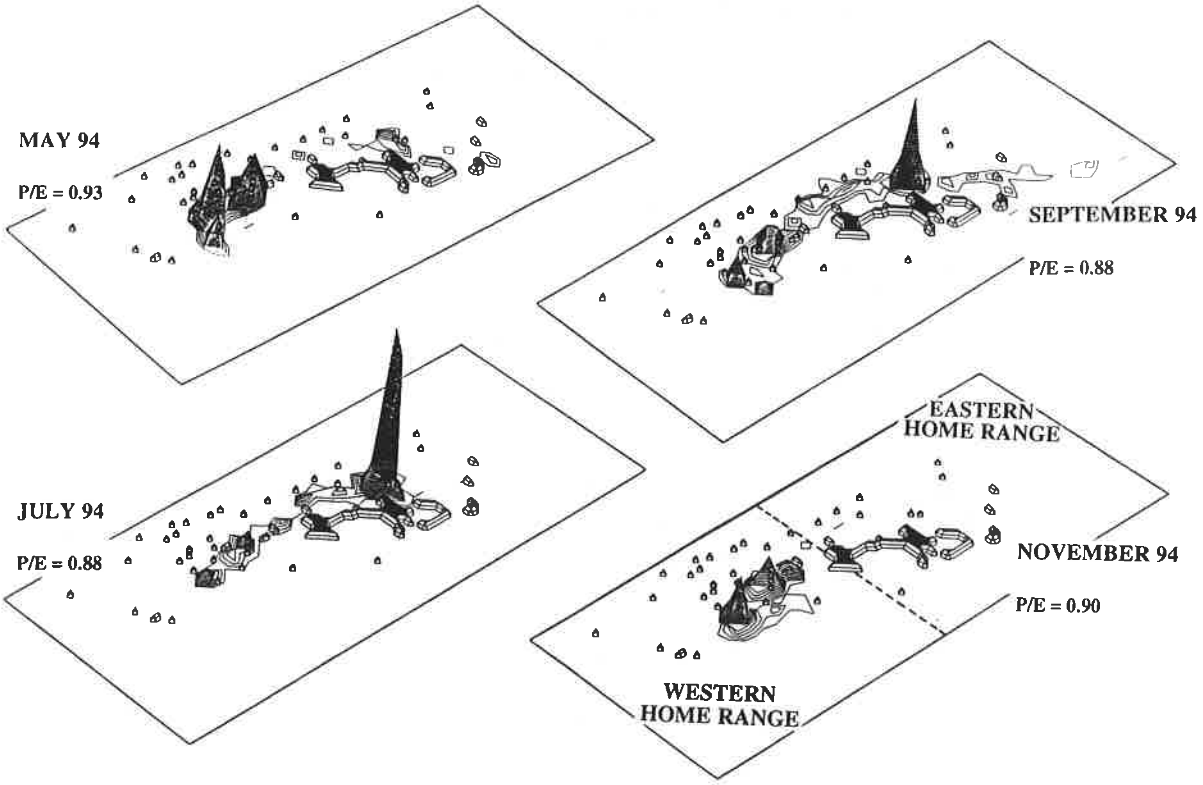

Figure 1 - Seasonal variations in habitat use.

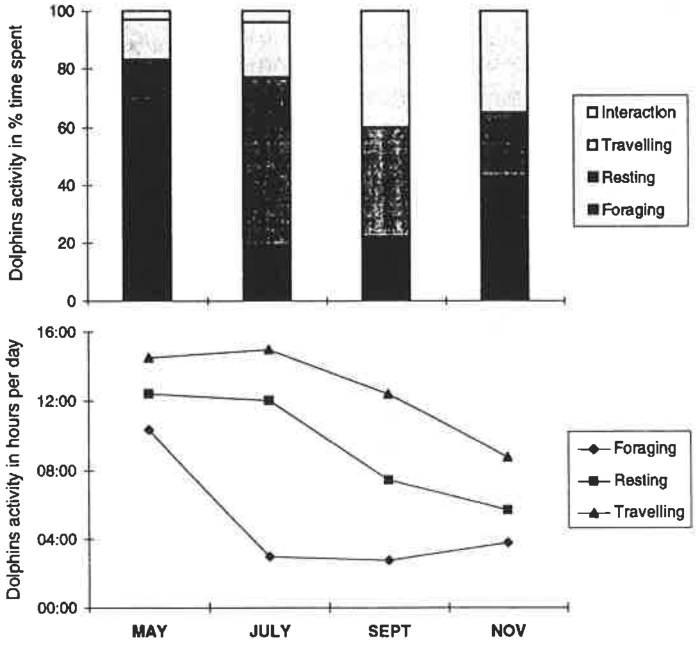

Figure 2 - Seasonal variations in diurnal activity budget.

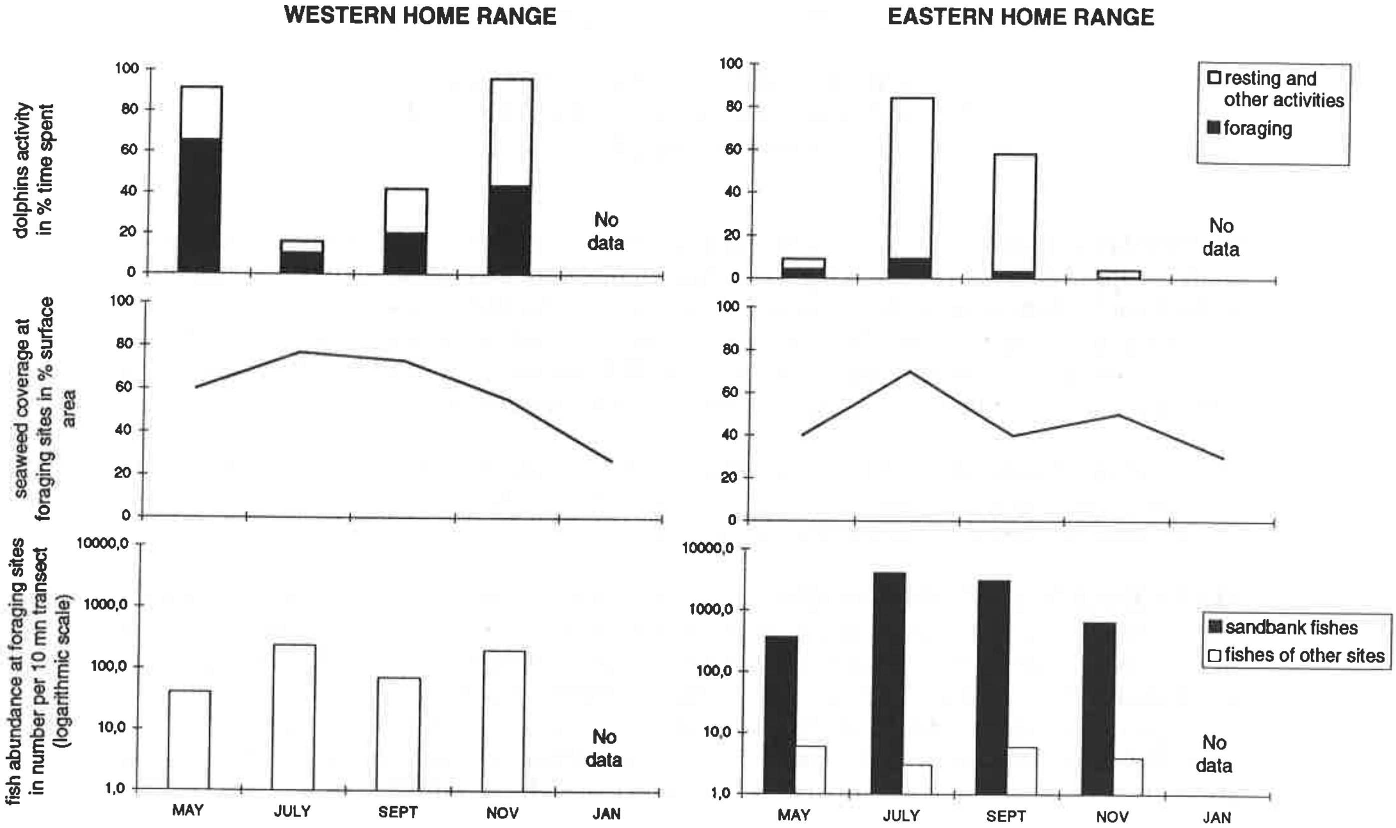

Figure 3 - Seasonal variations in activity budget, seaweed coverage and fish availability in western versus eastern home range.

APPLICATION OF MULTIVARIATE STATISTICAL TECHNIQUES ON A COMMUNITY OF COMMON DOLPHINS *DELPHINUS DELPHIS* IN THE IONIAN ISLANDS OF GREECE

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INTRODUCTION This work describes the results of multivariate statistical analysis applied to data concerning the common dolphin, *Delphinus delphis*, community sighted in the Ionian Islands of Greece. The aim of research cruises was to perform an eco-ethological study (work in progress), to obtain reliable information to confirm the present hypotheses. In this paper, data on the behaviour of common dolphins was not considered, because the statistical techniques used need numerical values only.

Multivariate statistical techniques were used, in this case to verify the hypothesis that there are differences among the observations made during two years' research (1993-94), comparing the different months of each year.

MATERIALS AND METHODS Research cruises were conducted aboard a 16m sailing vessel, and took place in 1993 from June to September, and in 1994 from July to September. When each sighting was made, data were recorded using forms divided into three-minute sections, containing information concerning the size, formation and type of the school, the breathing rates, speed, position of the school in relation to the boat, the route followed, and general behaviour. Photo-identification of all common dolphins was carried out, and many specimens were sighted in both years.

Seven variables were considered for the statistical analysis: number of specimens sighted, number of young dolphins, number of newborn dolphins, number of boats present in the area at the time of sighting, approach visibility, distance from the coast and depth of the water. It was decided not to include the sea temperature with every sighting because it proved insignificant for our purpose.

Principal Components Analysis (PCA) and Cluster Analysis (CA) were performed by chemometric software "BEG" (Farina *et. al.*, 1991). Linear regression was performed by home-made software.

RESULTS PCA (Table 1) showed that there was no significant correlation among the original variables because five Principal Components were necessary to explain 90% of the total variance. In addition, the scores of PCA were not discriminated so far as the two different years are concerned, because the evidence of CA (Fig. 1) showed the random distribution of the observations under consideration. The general hypothesis that all sightings come from the same distribution was also tested, but it was not confirmed on the basis of the loadings values (Fig. 2). As the values of all variables in the loadings were too variable, a non-homogeneity of the sightings resulted.

A significant correlation at 95 % probability between the number of common dolphins and the presence of other boats in the area was observed (correlation coefficient = 0.602). The frequency of sightings of common dolphins in the area is 0.031, and the population density was calculated at 0.396 per km^2.

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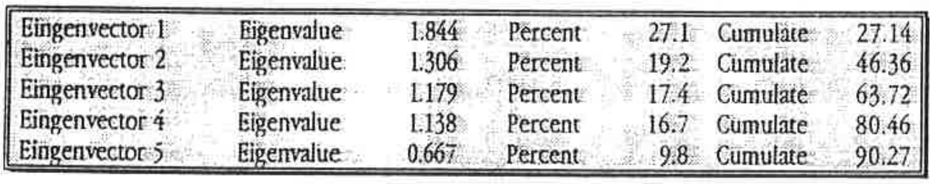
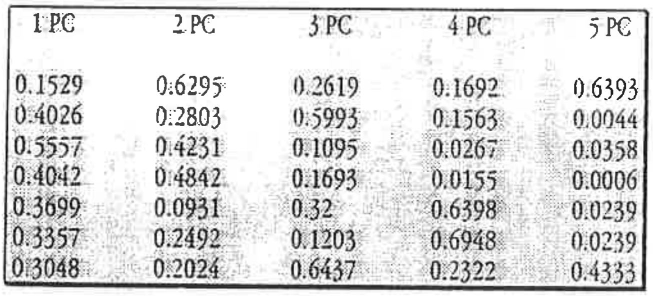
Table 1 Summary Statistics on Principal Components Analysis



Eingenvector 1	Eigenvalue	1.844	Percent	27.1	Cumulate	27.14
Eingenvector 2	Eigenvalue	1.306	Percent	19.2	Cumulate	46.36
Eingenvector 3	Eigenvalue	1.179	Percent	17.4	Cumulate	63.72
Eingenvector 4	Eigenvalue	1.138	Percent	16.7	Cumulate	80.46
Eingenvector 5	Eigenvalue	0.667	Percent	9.8	Cumulate	90.27



1 PC	2 PC	3 PC	4 PC	5 PC
0.1529	0.6295	0.2619	0.1692	0.6393
0.4026	0.2803	0.5993	0.1563	0.0044
0.5557	0.4231	0.1095	0.0267	0.0358
0.4042	0.4842	0.1693	0.0155	0.0006
0.3699	0.0931	0.32	0.6398	0.0239
0.3357	0.2492	0.1203	0.6948	0.0239
0.3048	0.2024	0.6437	0.2322	0.4333

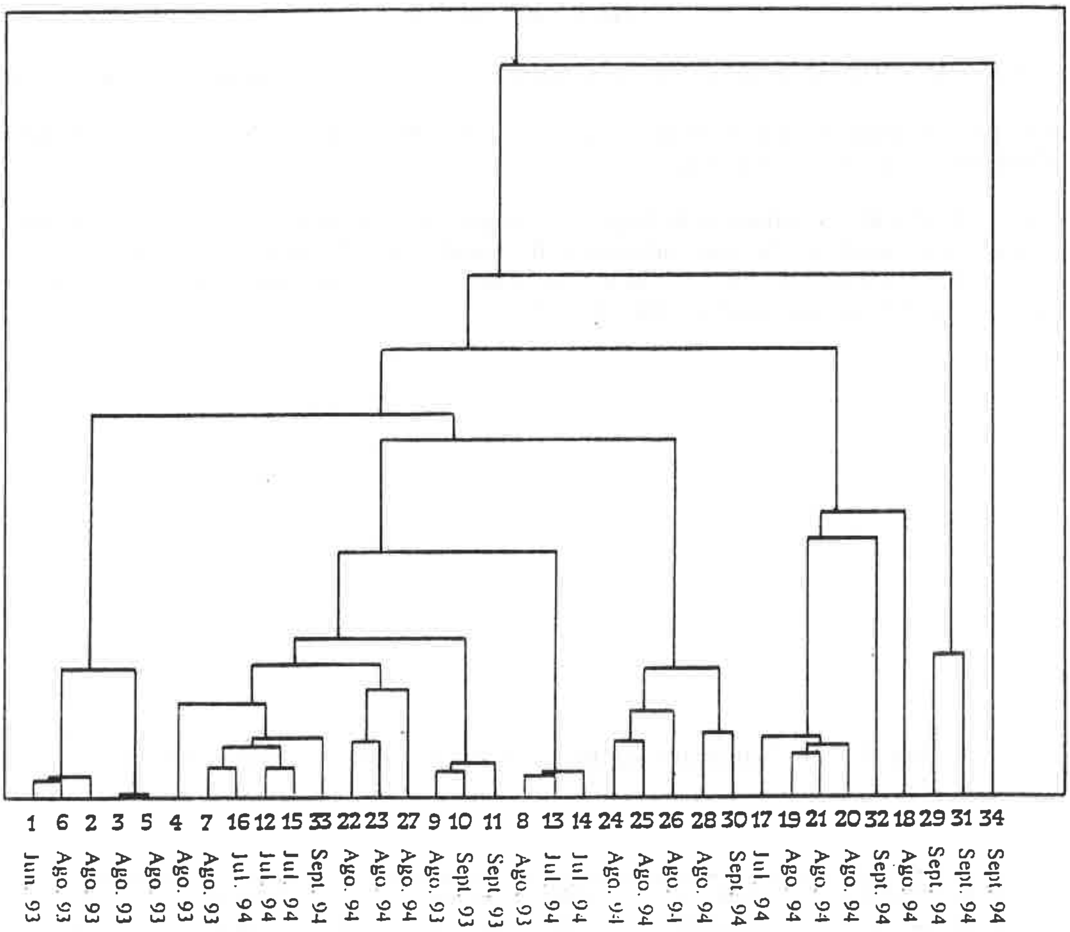


Fig. 1 Dendrogram of CA of the considered data, showing the random distribution of observations

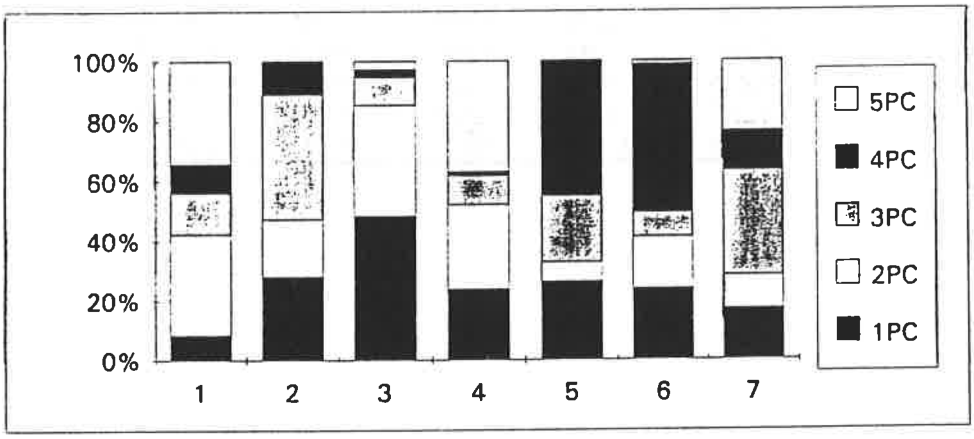


Fig. 2 Results of PCA on the considered data set

ABUNDANCE OF COMMON AND STRIPED DOLPHINS IN THE SOUTHWESTERN MEDITERRANEAN

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INTRODUCTION In the past twenty years, the western Mediterranean population of common dolphins appears to have shown a decrease in its original distribution range. Museum collections and stranding records show that this species was common in the northern basin up to the early 1970s, but has become extremely rare since then. On the contrary, the striped dolphin is still abundant in the entire basin, although during 1990-92, it suffered the effects of a large-scale epizootic that resulted in the death of thousands of individuals, thus reducing its total population by a significant factor. Both species are subject to various problems of conservation, including pollution, by-catches, direct killing and overexploitation of their food resources. As a result, their current status is a matter of concern. The study of the distribution and abundance of these two species of dolphins is paramount to determine their conservation status and to assess changes in their population through the years.

Line transect data from sightings surveys carried out in the western Mediterranean and the Alboran Sea during 1991 and 1992 were analysed to produce estimates of abundance of common and striped dolphins in the southern part of the basin, where common dolphins are still relatively abundant.

METHODS Abundance of striped dolphins was estimated for each of the two southern geographic strata considered in the survey of 1991 (Fig. 1), and these estimates were combined to produce an overall estimate for the southwestern Mediterranean, assuming a common value of $f(0)$ (probability density function of perpendicular distance data) (Fig. 2). Sample size considerations and the large variability in school size and encounter rate (number of sightings/track on effort) precluded a reliable estimate of abundance of common and striped dolphins in the Alboran Sea. In order to reduce variability in school size, abundance estimates for that area were combined across years, using a weighted average and assuming common values of $f(0)$. This was done if there were no significant differences in these variables among years. Bias in school size was reduced by size-bias regression methods (Buckland *et al.* 1993). Abundance estimates were computed using the software package DISTANCE V.2.1. (Laake *et al.*, 1994).

RESULTS AND DISCUSSION Abundance of striped dolphins in the area between the South of the Balearic Islands and Sardinia was estimated at 18,810 individuals (%CV: 34.17; 95% CI: 8,825-35,940). In the southwestern Mediterranean it was estimated at 39,963 individuals (%CV: 38.19; 95% CI: 18,206-87,721). The large variability in encounter rate and school size found in the Alboran Sea stratum considered in 1991 prevented a reliable estimate of striped dolphin abundance. However, an average estimate of abundance across years was produced for the area considered in 1992 (Fig. 2). Abundance of striped dolphins in the Alboran Sea was estimated at 17,728 individuals (%CV: 32.61; 95% CI: 9,507-33,059).

During the survey conducted in 1991, common dolphins were only present in the southern geographic strata, with the exception of two schools sighted in the waters of Corsica. In the south, common dolphins were found to be abundant in the Alboran Sea, especially in waters close to the Straits of Gibraltar, and only three sightings were made in the south-eastern geographic stratum. Therefore, abundance was estimated only for the Alboran Sea (south-western stratum). Combining estimates across years in the same way as has been done for striped dolphins, the abundance for common dolphins was estimated at 14,736 individuals (CV%: 40.02; 95% CI: 6,923-31,366).

ACKNOWLEDGEMENTS Thanks are due to Xavier Pastor and Ricardo Aguilar from Greenpeace Spain, who made the cruises possible with their support. Special thanks are due to the observers and the crews of the Greenpeace M/V Sirius for their co-operation during the surveys. Alex Aguilar and Phil Hammond provided helpful advice and assistance in the preparation and achievement of the surveys. Màrius Tresànchez helped in the preparation of additional software routines. The Spanish Institute of Nature Conservation (ICONA) funded this project.

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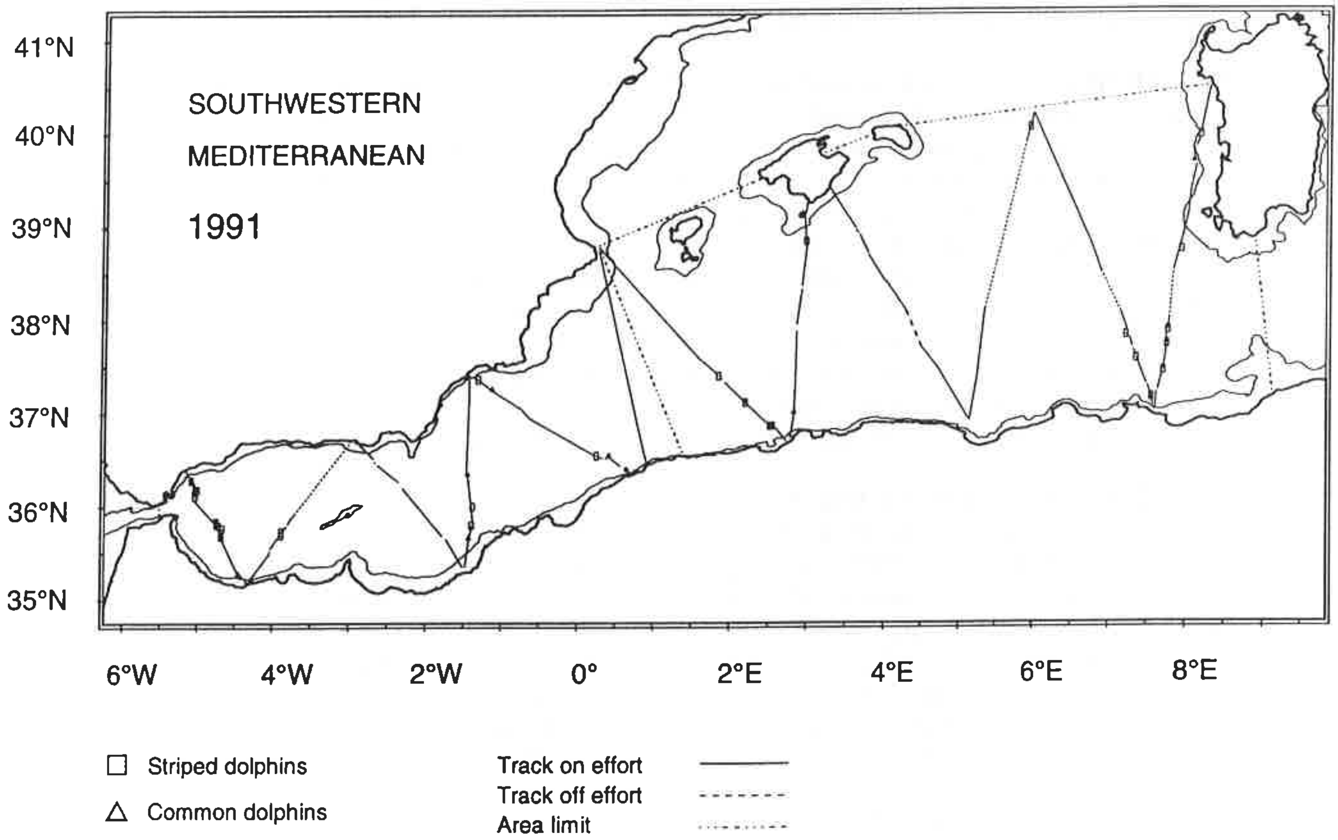
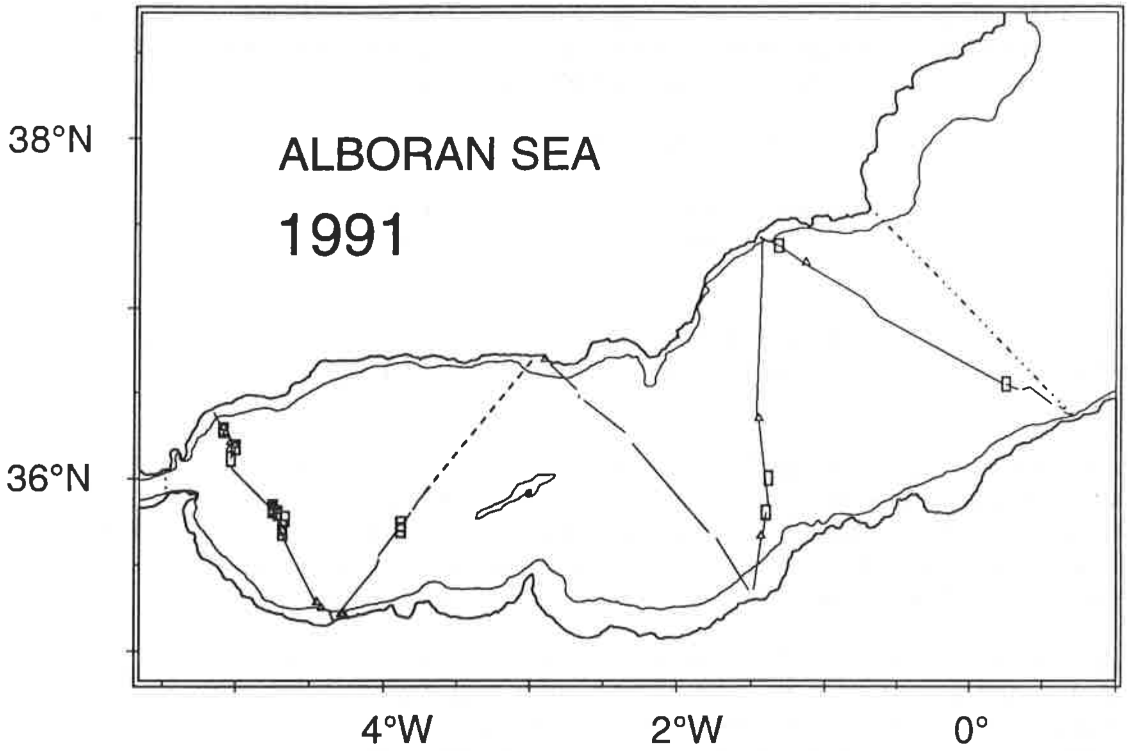


Figure 1 Southwestern Mediterranean with cruise tracks and sightings of striped and common dolphins during 1991



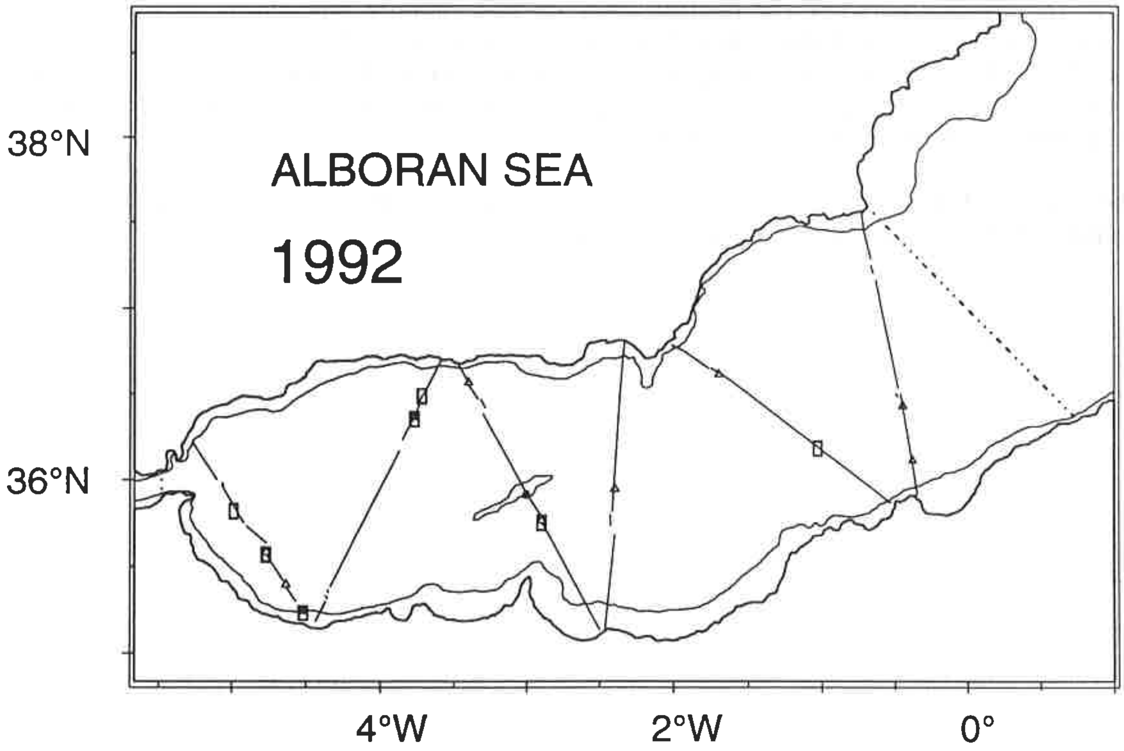


Figure 2. Alboran Sea with cruise tracks and schools of striped and common dolphins sighted during the surveys of 1991 and 1992.

THE FIRST RISSO'S DOLPHIN (*GRAMPUS GRISEUS*) MASS STRANDING DESCRIBED ON THE MEDITERRANEAN COAST OF THE IBERIAN PENINSULA

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There are no reports of Risso's dolphin mass strandings on the north-east coast of Spain in the literature. A case which happened in the spring of 1994 in the delta of the river Ebro is described.

On the afternoon of 17th April, five Risso's dolphin*Grampus griseus* specimens were found stranded alive in shallow waters protected by the isthmus of the delta, El Trabucador. The coastguard services immediately returned the animals to the open sea. Twenty-four hours later, four of them stranded again in the same area of beach. The group consisted of one adult, two sub-adults, and one juvenile, all female.

After an examination by the C.R.A.M.C. veterinarian staff, the adult female was removed and placed apart because of its serious health problems resulting from large wounds in both sides of the body and acute respiratory deficiency. The rest of the group, even though seemingly in the same respiratory condition as the adult, were carried through the isthmus by means of stretchers. This was carried out in order to break the contact between the healthy animals and the sick one, by using the natural barrier offered by the isthmus. In a short time, the animals were out of sight in the open sea. The dolphins were not seen again, even during a week of intensive survey. In spite of our efforts, the sick Risso's dolphin died four hours later as we were driving her with a dolphin transporter van to the C.R.A.M.C.

The healthy members of the group demonstrated the herd instinct shown with the mass stranding which was broken by physical separation.

A MASS STRANDING OF WHITE-SIDED DOLPHINS *LAGENORHYNCHUS ACUTUS* (GRAY) IN KILLALA BAY, CO. MAYO, IRELAND

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INTRODUCTION Nineteen Atlantic white-sided dolphins, *Lagenorhynchus acutus* (Gray), live-stranded on a beach known locally as Ross Strand in Killala Bay (grid reference G2234) on the north-west coast of Ireland, on 19th September 1994. Eye-witnesses reported that the stranding occurred over a number of hours with 11 animals stranding first, followed by a second group of eight animals stranding approximately 20 m further along the beach. No attempt was made to rescue the animals, and all the animals died. Mass strandings of white-sided dolphins in Ireland are rare events, with only one previous record, of five animals in Co. Kerry in 1967 (Greeson, 1968). In the United States, two large multiple strandings of white-sided dolphins occurred in 1973 and 1974, with 20 and c. 150 animals stranding respectively (Sergeant *et al.*, 1980). Of those 150 animals stranded, only 53 were retrieved for post-mortem examination (Geraci *et al.*, 1978).

MATERIALS AND METHODS Post-mortem examinations were carried out on all nineteen animals *in situ*, following a standard protocol (Kuiken and Baker, 1993). Samples were taken for contaminant analysis, genetics, diet, ageing, reproductive status, and parasitology, following standard guidelines.

RESULTS AND DISCUSSION Ten of the animals stranded were male and nine female with 15 adults and four juveniles present. Two of the juveniles were female and two male. Lengths ranged from 158 to 240 cm for females and 170 to 274 cm for males. Ages determined from the GLGs in the dentine ranged from less than one to 17 (Fig. 1). Growth was found to increase exponentially for both sexes, with males being slightly larger than females of a given age. Animals aged between 2 and 7 (or between 185 and 220 cm) were absent from the group. This has also been found by Sergeant *et al.*, 1974 who noted a lack of animals between the ages of 3 and 6 in their study, and concluded that immature white-sided dolphis of both sexes, on reaching the age of weaning, tend to leave or be driven from the reproductive herd. In addition, Sergeant *et al.* (1974) noted a biased sex ratio in the stranded herds of 46 females:10 males, and this led them to postulate that not all males returned to the reproductive group but formed a "bachelor herd". Instead, in this study, there was no difference in the sex ratio among the adults (7 females:8 males). Differences between the two studies may be due to differences in sample size or bias in sub-sampling in the US study.

Of the females examined, seven were mature, showing evidence of either corpora lutea or corpora albicantia. These ranged from 218 to 240 cm in length. Six of these animals were lactating and two were pregnant, each with a small foetus measuring 40 mm and 32 mm respectively, suggesting that mating took place in late August/early September. A previous stranding on the Irish coastline of a pregnant female white-sided dolphin with a near-term foetus occurred in July (Smiddy, 1992), suggesting a gestation period of 11 months.

Of the males examined, two animals were small (170 and 185 cm in length) and immature, with a combined testes weight of 8 and 10 g respectively (Figure 2). The remaining animals were sexually mature, with combined testes weight ranging between 350 and 700 g, corresponding to a body length of ≥ 249cm. These results are similar to those obtained by Sergeant *et al.* (1974), who suggested a length at sexual maturity of ≥ 240 cm (approximately 6-8 years), and by Addink *et al.*, (this volume).

All animals were in good nutritive condition (assessed by the thickness of the blubber layer and the dorsal musculature). However, none of the animals showed signs of recent feeding and no chyle was seen within the lacteals of the intestinal mesentery. Food remains were found in 17 of the 19 animals. These consisted of well-worn otoliths, eyeballs, and a squid beak. Most of the otoliths were very well-worn and could only be identified as gadoid spp., but included *Trispoterus* sp., herring, scad, and one argentine.

The nematode *Stenurus globicephalae* was found in the cranial sinuses of 18 of the 19 animals. Total numbers of nematodes found in the sinuses of these animals ranged from 103 to just under 3,000 individuals, with the smaller, younger animals having between 103 - 189 individuals (Keane, *pers. comm.*). These nematodes were also located in the lungs of thirteen of the nineteen animals at very low concentrations. There was no apparent pathology associated with these parasites at either location. Gross pathological lesions associated with trematode parasites within the walls of the fundic and pyloric stomachs were present in 15 of the animals. They appeared as small nodular lesions on the mucosal surface and often showed extensive submucosal fibrosis when sectioned. These lesions are identical to the lesions associated with the trematode *Pholeter gastrophilus* in other cetacean species. In contrast to these findings, the postmortem reports of the mass stranding of Atlantic white-sided dolphins in 1974 in the United States did not report any gross pathological lesions in these locations. However, trematodes were seen on histological examination of the pyloric stomach wall in two out of seven specimens, and a single trematode identified as *Pholeter gastrophilus* was isolated from a duodenal cyst (Geraci *et al.*, 1978). In twelve of the animals, white plerocercoid cysts, probably *Phyllobothrium delphini*, were found mainly within the blubber of the abdominal region. Larger plerocercoid cysts, *Monorygma grimaldii*, were found sub- or retroperitoneally or associated with the abdominal mesentries adjacent to the testes or uterus. One animal had a plerocercoid cyst within the testicular tunic. In the subcutaneous tissue, 11 of the animals had long, coiled nematodes, probably *Crassicauda* sp. Five animals had *Crassicauda* sp. nematodes within the ducts of the mammary glands but of these only one animal showed minimal pathological changes possibly associated with these parasites. This again contrasts with the findings of the investigation into the mass stranding of Atlantic white-sided dolphins in 1974 in the U.S. which reported extensive pathology in the mammary glands associated with *Crassicauda grampicola* infection (Geraci *et al.*, 1978). Very small numbers of nematodes, probably *Anasakis* sp., were found in five cardiac stomachs.

Overall, the animals had a small number of pathological lesions (Table 2). Three of the adult males had penile lesions typical of genital herpes on both gross and histological examination, and three of the larger animals had arthritic erosions of the cartilage of the head of the humerus. Three of the animals had damaged fins, a few had missing teeth, and one had a deformed jaw. Subcutaneous abscesses were found in the abdominal area of two animals. Interestingly, two of the animals had intestinal leiomyomas which are benign tumours of the smooth muscle of the intestine. Leiomyomas were also reported in the post-mortem reports from the mass strandings of white-sided dolphins in the United States at a 12 percent prevalence (Geraci *et al.*, 1978). Another interesting (although harmless) lesion was found in one animal where the intestine had herniated through a tear in the intestinal mesentery.

The most interesting findings were found in the oldest and largest animal (male) in the group. On post-mortem examination, the heart was found to be abnormal. Both left and right ventricles were markedly dilated with particularly thin walls giving the heart a flaccid enlarged appearance. The cranial aortic valve cusp was also markedly dilated with a single rupture slightly above the centre of the cusp measuring 6 mm at the widest part. Interestingly, histological examination of the ruptured valve revealed an area of fibrin around the margin of the tear, suggesting that the lesion had initially been larger than it appeared grossly, and had undergone a period of incomplete chronic repair. It is therefore proposed that the rupture of the aortic valve lead to aortic valvular dysfunction and left-sided ventricular volume overload followed by dilation of the left ventricle and left-sided failure. Concomitant right-sided heart failure would then subsequently develop, thus accounting for the grossly dilated right ventricle, again a result of volume overload. Therefore, the evidence of congestive heart failure found in this animal is considered to be cardiogenic in origin, caused directly by the inability of the heart to compensate for the valvular dysfunction caused by a damaged aortic valve.

There have been many theories put forward as to why mass strandings occur. These range from topographical and geographical features to heavy parasite burden, confused sonar or disease. Klinowska (1986) examined geomagnetic features associated with areas where mass strandings were recorded in the UK and suggested that mass strandings occur in areas where lines of equal magnetic intensity run parallel to the shore and suddenly turn to become perpendicular to the shore. Killala Bay is such an area.

CONCLUSIONS Post-mortem examination revealed that all animals were in good nutritive condition and that, for eighteen animals, death was associated with live stranding. The remaining animal died from a combination of live stranding and congestive heart failure. It is speculated that the significantly diseased animal stranded and that the other animals in the group followed him in, and subsequently died. Whether any significance can be attached to the fact that the sick animal in this case was the largest and oldest animal in the group and therefore of some importance in social hierarchy can only be speculative. Little is known about social structure in cetaceans, in general. However, it may be that if any sick or dying animal live strands then the others within the group (due to the highly social structure characteristic of all cetacean species), would remain with this animal, irrespective of age or "status". It is also noteworthy that this particular region is an area where geomagnetic lines of equal intensity run perpendicular to the coastline and therefore, concords with the theory that these geomagnetic features may influence the location of mass strandings of some cetacean species.

ACKNOWLEDGEMENTS We would like to thank the National Parks and Wildlife Service for part-funding the post-mortem examinations and the UK Department of the Environment (London) for financial support for Paul Jepson. We are also grateful to Michael Sweeney and Tom Durkan (NP&WS) for provision of transport and help on site.

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Table 1 Parasitic lesions found in Atlantic white-sided dolphins (*Lagenorhynchus acutus*) mass stranding at Ross Strand, Co. Mayo, September 1994

LESION	NUMBER	%
Stenurus globicephalae in ear sinuses	18	95
Trematode damage to stomach wall	15	79
Cestodes in blubber	12	63
Crassicauda in subcutaneous tissue	11	58
Monorygma grimaldii infection	8	42
Crassicauda in mammary gland	5	26
Nematodes in gastric lumen	5	26
Parasitic nodule in lung	1	5

Table 2 Lesions found in Atlantic white-sided dolphins (*Lagenorhynchus acutus*) mass stranding at Ross Strand, Co. Mayo, September 1994

LESION	NUMBER	%
Genital herpes	3	16
Arthritic lesions to shoulder	3	16
Trauma to fin	3	16
Missing teeth	3	16
Subcutaneous abscesses	2	10
Intestinal leiomyomas	2	10
Intestine herniated through tear in mesentery	1	5
Tear in aortic valve	1	5

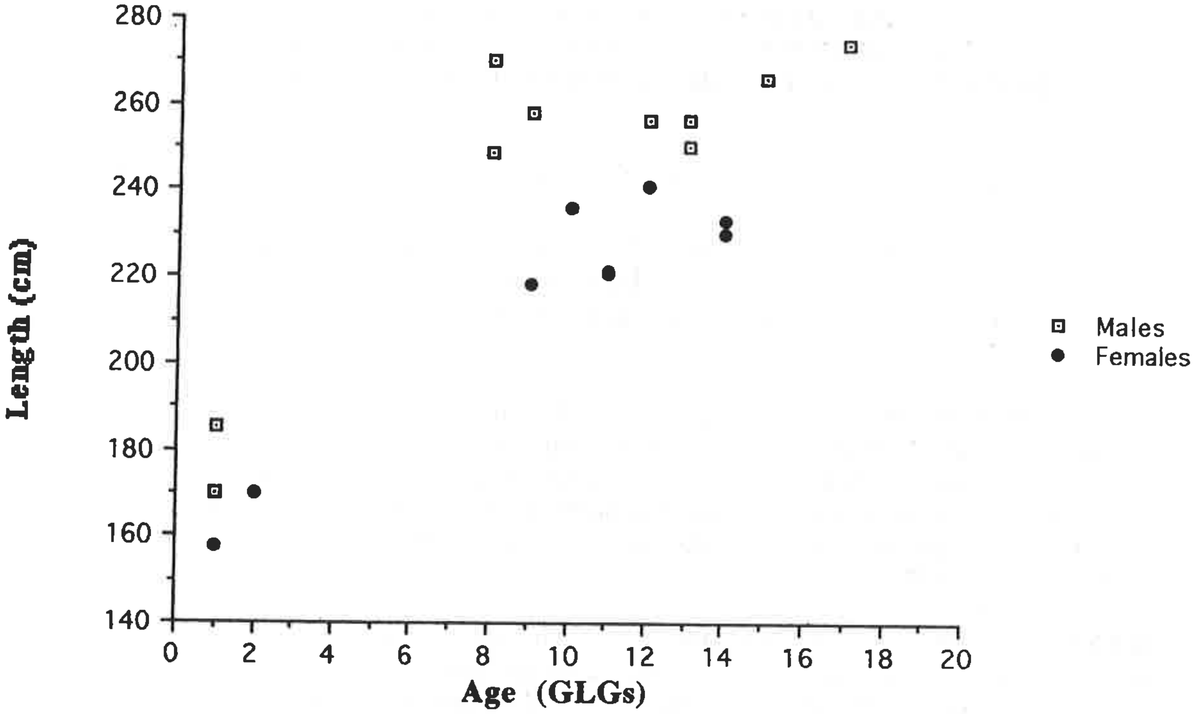

Figure 1 Relationship between growth in body length and age (in dentinal GLGs)

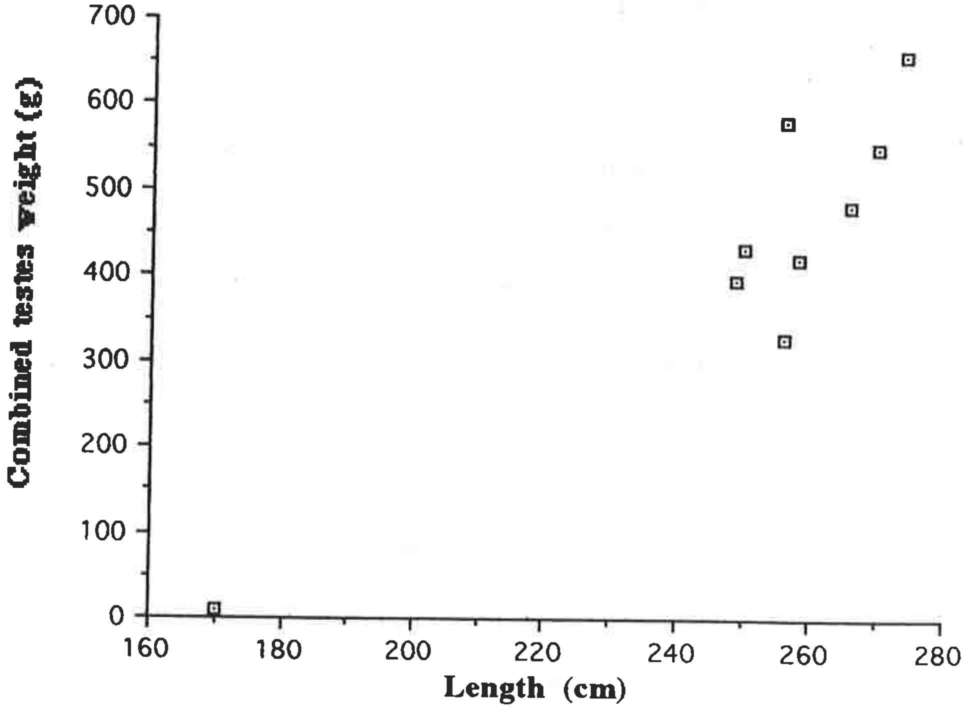

Figure 2 Relationship between total length of animal and combined weight of testes

CASE REPORT ON TWO LARGE WHALES (*MEGAPTERA NOVAEANGLIAE* AND *PHYSETER MACROCEPHALUS* IN THE GERMAN PART OF THE NORTH SEA

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INTRODUCTION As part of a German government funded project, a humpback whale *Megaptera novaeangliae* and a sperm whale *Physeter macrocephalus* found dead in the German part of the North Sea, were investigated. Both species occur very rarely in German waters. Humpback whales have been recorded in three cases on the German coast and sperm whales in nine cases (Table. 1; Schultz, 1970; Goethe, 1983; Meyer, 1994).

RESULTS AND DISCUSSION The dead humpback whale was found drifting almost 50 km west of the island of Helgoland on 12th October 1994, and was dissected on board of the oil defence ship "SCHAHÖRN". The female whale was subadult and measured about 10 m in length. The upper jaw, cranium and the fluke were missing. The blubber thickness ranged between 2.0 cm and 7.5 cm, indicating the poor nutrient condition of the animal. The stomach was empty. Because of advanced decomposition of the carcass, no detailed post-mortem examination was possible. Ectoparasites were determined as *Cyamus boopis, Conchoderma auritum* and *Coronula diadema.* No endoparasites were found. The skeleton was transferred to the Marine Museum of Stralsund.

The sperm whale was first observed still alive, by fishermen near the island of Baltrum in Lower Saxony on 3rd November, 1994. The animal stranded on a sand bank in front of this island, where it died the next day. The male sperm whale measured 13.8 m in length and weighed 39 t. The animal was in a good nutritive condition, with a blubber thickness of 10 - 27 cm. According to the length-age relationship, the animal was aged at about 10-15 years. However, a more accurate age determination by reading dental growth layers is necessary and still in progress.

In the stomach and intestine, cephalopod beaks were found and analysed. Three species of cephalopods were identified. Counting the lower beaks, 186 *Gonatus fabricii,* one *Histioteuthis bonnellii* and five *Alloposus mollis* were found. Measurements of the lower beaks revealed a mantle length for *G. fabricii* of 17.4-27.5 cm (mean 22.1 cm) and a weight of 116 to 413 g (mean 228 g). The weight of *A. mollis* ranged between 334 and 703 g (mean 574 g). The total weight of the stomach contents calculated by the beaks was 42.3 kg for *Gonatus fabricii* and 2.9 kg for *Alliposus mollis* (total 45.2 kg). The length of the intestine measured 160 m and contained cephalopod beaks and small pieces of faeces. Ambergris was not present.

Parasitological examination revealed a few whale lice (*Cyamus catodontis*) on the body surface and tape worm larvae (*Phyllobothrium* sp.) in the blubber layer.

The skeleton was collected for the Nationalparkzentrum Wilhelmshaven.

To our knowledge, 21 sperm whales were recorded on European coasts in the period of November 1994 to February 1995 (Belgium 4, Denmark 1, Germany 1, Netherlands 4, Scotland 11). This unusually high number indicates a disorientation or disorder of the animals.

Squid beaks in the stomach of the examined sperm whale show an unusually high percentage of Gonatidae in the food composition. Usually, Histiotheutidae represent about 70% of found squid individuals and about 30% of food by wet weight in the waters of Iceland and Spain (Clarke, 1974, 1976). *Gonatus fabricii* is an arctic deep sea species which extends south in the eastern North Atlantic to about 60°N. Cephalopod beaks may remain for up to five days in the stomach (Clarke, 1974). This indicates that the sperm whale had not fed in the North Sea and had come from the north probably on its southward migration.

ACKNOWLEDGEMENTS We thank Dr. U. Piatkowski (Institut für Meereskunde an der Universität Kiel) for his help in identifying the cephalopod beaks.

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Table 1 Coastal records of *Megaptera novaeangliae* and *Physeter macrocephalus* in the German part of the North Sea (after Schultz, 1970; Goethe 1983; Meyer, 1994).

Year	Place	Number of Individuals	Body Length (m)	Weight (t)
Physeter macrocephalus				
1575	Tondern	1	-	-
1604	Pellworm	2	-	-
1721	Wischhafen/Elbe	1	18-21	-
1723	Neuwerk	5	11.2-15.3	36.4
1738	St. Peter	-	14.6	-
1751	Minser Oog	1	16.3	-
1762	Borkum	1	-	-
1762	Neuwerk	2	-	-
1984	Weser Aestuary	1	17.5	65
1994	Baltrum	1	13.8	39
Megaptera novaeangliae				
-	Großvogelsand/Elbe	-	-	-
1824	Elbe Aesturay	-	-	-
1991	Jade/Tonne 46	1	6.9	-
1994	50 km west of Helgoland	1	ca. 10	-

OBSERVATION OF HARBOUR PORPOISES FROM THE FERRY BETWEEN THE ISLANDS RØMØ (DENMARK) AND SYLT (GERMANY), SUMMER 1994

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The island Sylt is in the north of the German part of the North Sea. The Danish island, Rømø, is found to the north of Sylt. Both islands are connected to the mainland by a dyke. It is only through the "Lister Deep" that ebb and flood get into the Wadden Sea that is between the islands and the mainland. Harbour porpoises (*Phocoena phocoena*) very often appear in the area and can be observed clearly.

MATERIALS AND METHODS Between 18 July and 20 August, observers from the "Seevogelrettungs- und Naturforschungsstation Sylt e. V." observed this area from two routes taken by the Rømø-Sylt ferry. Details of the ferries are given below:

	M/V "WESTERLAND" and	M/V "VIKINGLAND"
year of construction	1971	1974
length	58.37 m	68,27 m
speed	12.4 knots	12 knots
position of the observers above sea:	10.50 m	10.50 m

The area observed lies between 55° 00.5'N to 55° 05.5'N and 08° 26'E to 08° 36'E, and surrounds the northern parts of Sylt and the southern parts of Rømø. The main ferry traffic is on a diagonal between the harbours: List/Sylt (55° 01.0'N, 08° 26.5'E) and Havneby/Rømø (55° 05.25'N, 08° 34.0'E). In the summer, the M/V "WESTERLAND" drives to a sand bank where seals often lie, that is on the Danish side of the "Lister Tief" (55° 04.3'N, 08° 26.0'E) twice a day (13:30 and 16:00, starting off at Havneby). Opposite this seal bank, other observers watch the area from the beach of Sylt (probably fewer animals were observed here because of smaller observation intensity from the ferry).

Their task was to look out for harbour porpoises and seals (harbour seals,*Phoca vitulina*) as well as grey seals (*Halichoerus grypus*) in this area and to write down the co-ordinates of the sightings. Furthermore, they were asked to observe how near the animals approached water-craft, such as the ferry, and how they reacted to them. With the help of the captains, the co-ordinates were determined by GPS (Global Positioning System) and entered on a naval map. The observers were trained with video-tapes and preparations.

Underwater, harbour porpoises can swim very quickly back and forth for a distance of 100m or more. Therefore it might be possible that more animals were counted than those which are actually there. This was especially the case if tourists, locals or lifeguards happen to see harbour porpoises and count them for scientific purpose as was done for Kremer *et al.*, 1991, 1992, and 1994. Here for example, a lifeguard "saw" one mother with three calves and then two large groups of harbour porpoises within three and a half hours, but we only observed one mother/calf-group in the same time.

In order to determine the size of the group of harbour porpoises, our observers only counted the animals that surfaced at the same time.

RESULTS During the course of 314 journeys, harbour porpoises were seen 206 times. The result of an addition of all group sizes is 274 animals. But the greatest number of individual harbour porpoises that were seen on one journey was nine.

In most cases, the harbour porpoises swam over underwater slopes but avoided a sand-spit that went far out in the sea, as well as the shallow areas in the east. During the observation period, the concentration of the animals changed from the German to the Danish coast, probably due to the fact that the fish upon which they fed had to be followed.

As for many other observations, most harbour porpoises could be seen at flood tide (Fig. 1). Surprisingly, there is a decrease in sighting frequency when the tide is reaching high tide. But then the sightings increase when water is still ebbing, continuing to halfway to the flood tide.

The question remains where the animals go to when the tide ebbs. The observers placed on the beach at least did not see them swim out of the area observed, but the animals might also have swum north along the coast of Rømø.

It is interesting to note that harbour porpoises were often seen over or under a ton at 55° 04.4'N, 08° 35.7'E depending on flood tide or ebb tide, a place where sewage is introduced into the sea. We do not know the quality of water (sewage from private households and/or from a mussel cannery) that is introduced and how often this is done. Probably fish feed on the sewage, and harbour porpoises are attracted to feed upon these fish. However, as these data have only been obtained by visual observations from a moving ferry, we cannot be certain whether the animals were really feeding there or appeared for other reasons.

Sightings	**flood tide**	**ebb tide**
North of the sewage opening	18	7
East of the sewage opening	5	0
South of the sewage opening	10	8
Total	33	15

The numbers of harbour porpoises which are thought to swim in the sewage outfall are shown in the above table. The animals north and south of the ton which are swimming in the possible outfall are 68.4% of the total number of sightings moving north and south in the area.

Fig. 2a shows the sightings for every passage; fig. 2b shows the number of animals sighted for one trip. On 34.4% of the trips, the observers did not see any porpoises; on 65.6% of trips, they had between one and seven sightings comprising one to nine animals. The daily record when adding all the sightings from one ferry was 22 animals in sightings from 6 trips (22 July, 1994) and 23 animals in sightings from eight trips (30 July, 1994). The highest number of individual harbour porpoises from one trip was nine animals (30 July, 1994, five singles, and two mother/calf-groups).

Figs. 3a-c show the distances of harbour porpoises to the ferries. The beams explain the sightings, the squares the combined totals of animals. Therefore, 77 sightings (37.4%) with 102 animals (37.2%) were observed at a distance of up to 50 m to the ferry, and an additional 82 sightings (39.8%) of 114 animals (41.6%) were observed at a distance of 51-100 m.

Ten mother/calf groups (45%) within 50 m distance of the ferry as well as ten additional sightings (45%) between 50 and 100 m also show, that it becomes increasingly difficult to identify mother/calf groups definitely from a moving ferry.

Are harbour porpoises disturbed by the ferries? To give a fair answer, some assumptions should be fulfilled: it is necessary to observe harbour porpoises for a period of time to study their behaviour without influence of the ship before and after the nearest contact. Furthermore, it is also important to note that not every change in behaviour near the ship is a negative disturbance.

The observers have to decide subjectively whether or not the harbour porpoise is disturbed by the ferry. Therefore, they have to explain the situation in their own words. 135 sightings (65.5%) including 16 mother/child groups (66.7%) are without any comment; 54 sightings (26.25%) including five mother/child groups (20.8%) stated that there was no disturbance. Only 17 sightings (8.25%) including three mother/child groups (12.5%) noted the possibility of a "disturbance". Included in these descriptions of a "disturbance", were some situations where the observer saw a harbour porpoise "diving quickly" near the ferry, and was unable to observe it any more.

However, the ferries cannot be an important disturbance factor because 37.4% of the sightings (37.2% of animals) were at a distance of less than one length of a ferry, and 77.2% of the sightings (78.8% of animals) were at distances less than twice the length of a ferry.

A reliable ferry drives the same route with the same speed. So harbour porpoises should be able to calculate course and speed. By contrast, most motor-vessels as well as jet-skis, and perhaps also surfers and fast sailing boats (such as small catamarans) that often drive at high speeds, often change direction and do not produce enough noise to alert a harbour porpoise to their presence.

During the observations, some harbour porpoises swam towards the ferry and dived just in front of it, often surfacing just behind in the wake. Maybe the swirl produced by the engine helps in finding food or provides something for the porpoises to play in.

OBSERVER EFFICIENCY Individual differences characterised the sightings made by our observers. Some of them, who were in a shift that sometimes started when the animals had just disappeared, were unlucky. In certain other cases, the animals surfaced only shortly after the end of a shift, and the observers were already gone. Others, however, were lucky to see harbour porpoises almost every day.

Sometimes, in a group of two observers, only one saw the animals and the other could not find them, however hard he or she tried. This either was the result of decreasing attention or just bad luck - the more so if the conditions for sightings were bad (with waves). The same thing also occurred to the authors from time to time, one sees a harbour porpoise, and the other has to look for the animal for a long time before he sees it.

ACKNOWLEDGEMENTS Special thanks go to our observers Miriam Blank, Constanze Blödner, Sindy Frackowiak, Karina Heljen, Melanie Hilmes, Carla Janning, Ivonne Krull, Ricarda Lewien, Sandra Osthoff, Silvia Schmidt, Manja Seifert, Susan Süße, Verena Willms and Holger Zeck. By working tirelessly, these young people made this project possible. Also we have to thank the Rømø-Sylt Linie GmbH, her managing director Mrs. Bodil Glistrup, as well as the captains and the crew. The results contribute considerably to European cetacean research. They are an example of a friendly and excellent co-operation between Danes and Germans. We hope to be able to repeat the project in 1995. We would like to find more young observers and to have the opportunity to do the observations from the ferries again. Finally, we thank Andrea Schmidt, who helped us translate the text very quickly.

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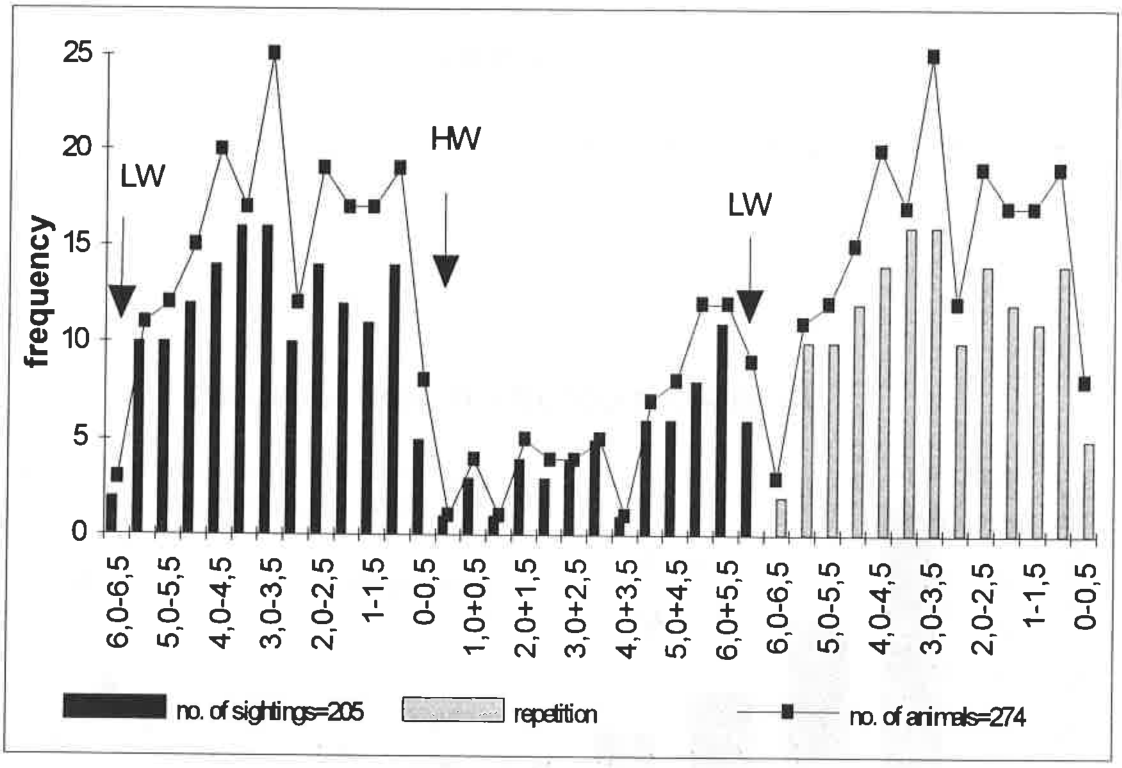

Fig. 1: Distribution of sightings dependent on the tides, divided into half hours before and after high tide.

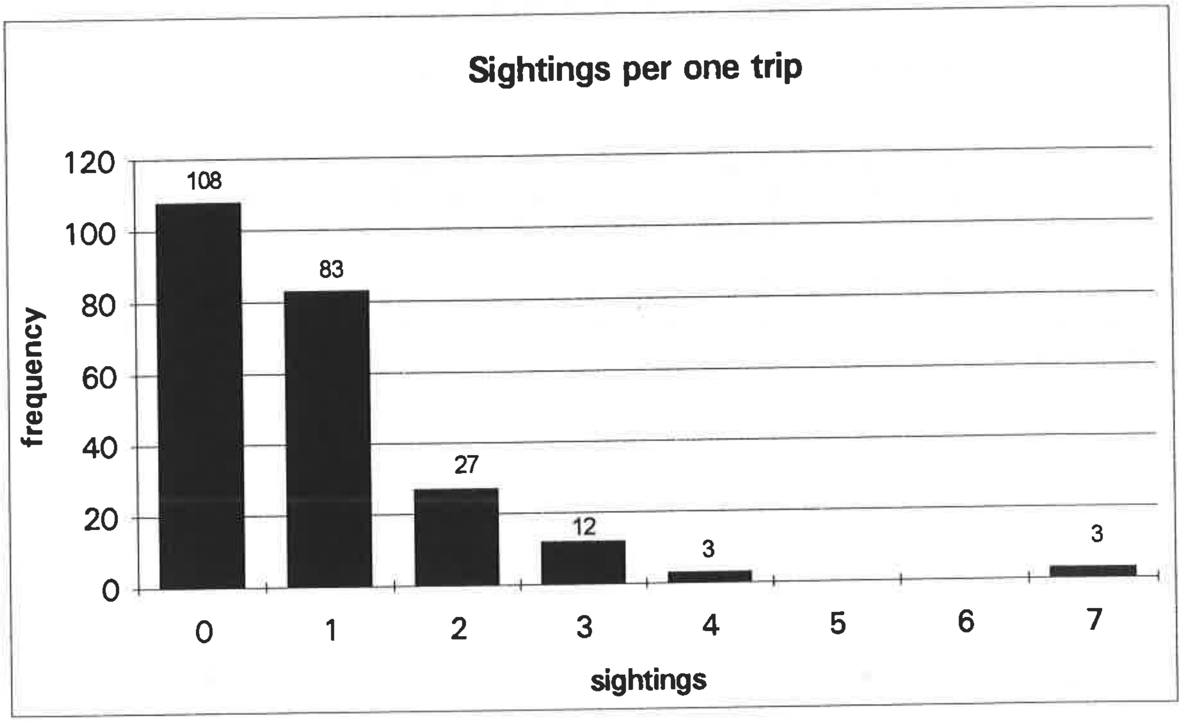

Fig. 2a: Distribution of sightings of one crossing

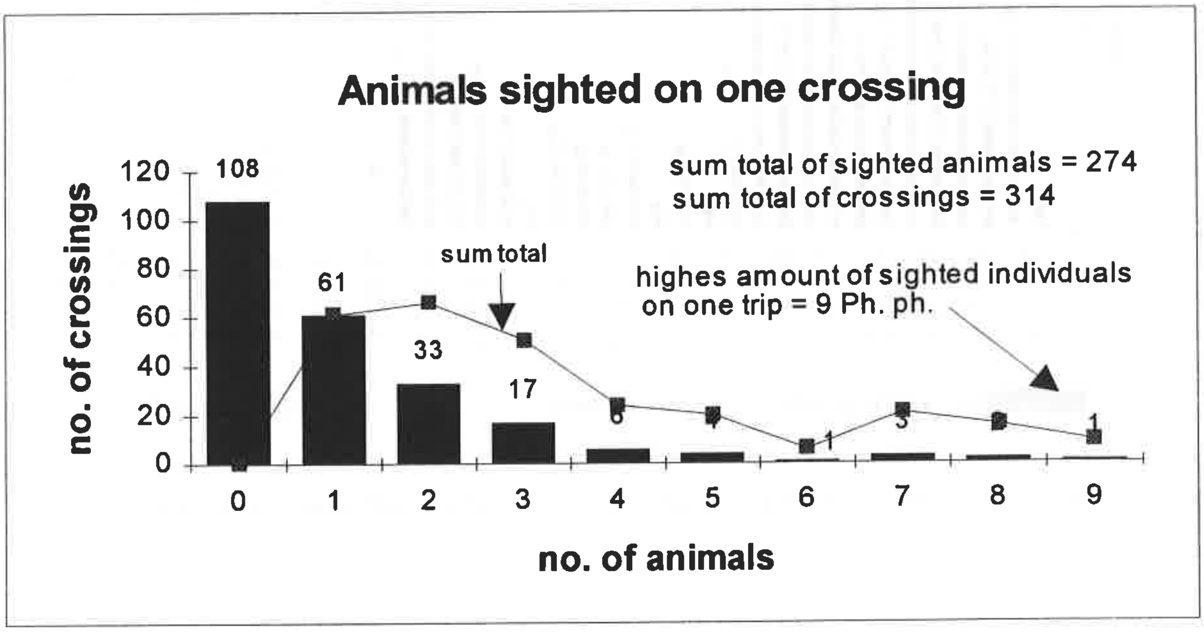

Fig. 2b: Distribution of animals sighted on one crossing

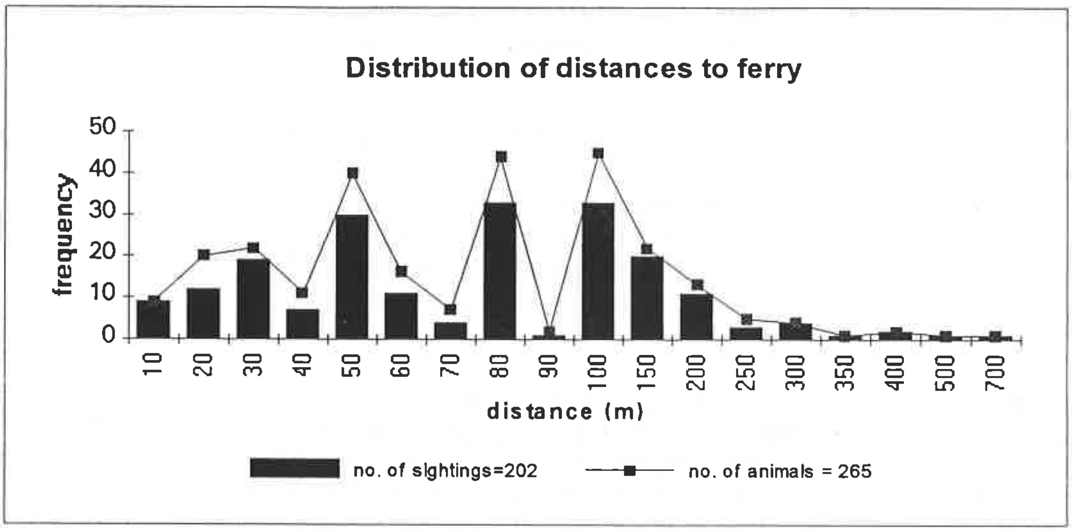

Fig. 3a: Distribution of distances of *Phocoena phocoena* to ferry

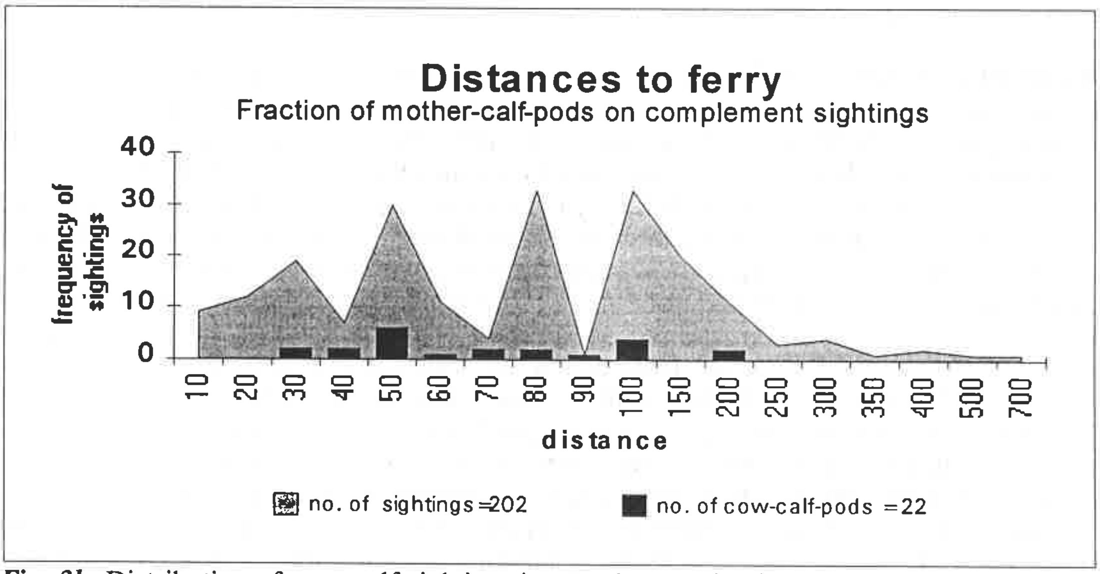

Fig. 3b: Distribution of cow-calf-sightings in complement sightings

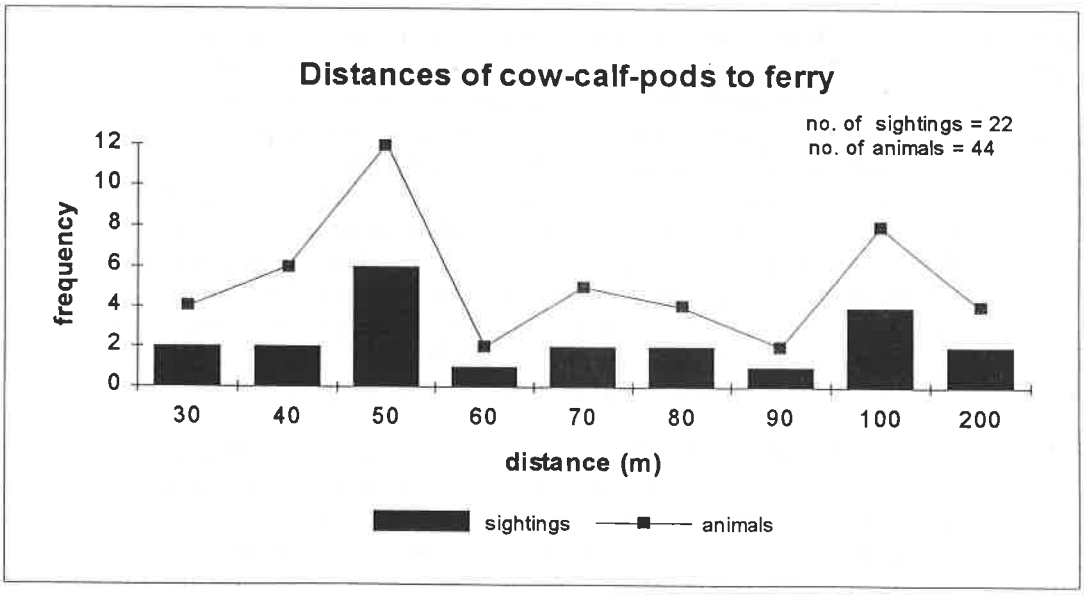

Fig. 3c: Distribution of distances to ferry of cow-calf-pods

SIGHTINGS OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN THE GERMAN BIGHT

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INTRODUCTION As part of a national research project on the abundance, health status, and migration of small cetacean populations in German waters (funded by the Federal Ministry of Environment), incidental sightings of harbour porpoises in the German Bight were collected by the University of Kiel. The Society for the Protection of the Waddensea (Schutzstation Wattenmeer) collected incidental sightings data of small cetaceans recorded by tourists and locals on the island of Sylt, which is located in the northern part of the German Bight. In this work, both sets of data are combined and present an overview on the distribution of harbour porpoise sightings in the German Bight from 1988 to 1994.

MATERIALS AND METHODS The information on harbour porpoise sightings has been collected using a standardised data form supplied by the Wadden Sea project of the World Wide Fund for Nature (WWF). This data form was combined with information on the biology of harbour porpoises and has been distributed to potential observers. (e.g. to local conservationists, tourists, the crew members of governmental and tourist vessels and ferries) by the University of Kiel, the authorities of the National Park Schleswig-Holstein Wadden Sea and by non-governmental conservation-groups, namely the Schutzstation Wattenmeer. The following information was retrieved: date and position of observation, number of animals, occurrence and number of calves, behaviour of the animal(s), place from which the observation was made, and distance to the observed animal(s). If the sighting was ship-based: type of propulsion and meteorological information (e.g. sea-state, cloud coverage, etc.) was also recorded. It cannot be ruled out that some of the observers may have misidentified some of the species, but due to the fact that other cetacean species in the area of investigation are comparatively rare (Benke & Siebert, 1994) mis-identifications are infrequent. Only reports from the German Bight of sighting position and the exact, or highest and lowest number of animals were used for further analysis. For the calculation of the group size characteristics, only sightings with the exact number of animals reported were used.

RESULTS Between November 1988 and July 1994, a total of 1,461 sightings were recorded. Eighty-five percent of the analysed records were from land-based watches (15% ship-based). Most of the sightings were gathered from the northern part of the German Bight, particularly from waters west of Sylt (Fig. 1). It is obvious that the animals enter the inner Wadden Sea waters east of the barrier islands. In contrast to descriptions from earlier literature (Verwey, 1975), harbour porpoises have been sighted close to the coast throughout the year. Most animals were sighted as single individuals (44%) or in pairs (35%), as shown in Fig. 2. The mean group size was 1.9. Ten percent of the analysed sightings include at least one calf. Nearly all calves (99%) were sighted in waters close to the island Sylt. The largest group comprising 40 to 50 animals was sighted in April 1993 in the inner Wadden Sea waters. Most of the sightings (69%) occurred in summer and autumn (1 June to 30 November; see Fig. 3).

DISCUSSION AND CONCLUSIONS It is not possible to correct the data for observer effort, so no trend in abundance could be estimated from these recordings of incidental sightings. However, the spatial distribution of harbour porpoise sightings seems to be independent of the spatial distribution of potential observers, as indicated by the numbers of stays overnight of tourists in the study area. The information presented here can be used to support other findings on the distribution of harbour porpoises in German waters. Both the data of this study and from aerial surveys (Heide-Jørgensen *et al.*, 1993) and the high number of strandings at the coast of the island Sylt (56% of all strandings in the German Bight from 1990 to 1993 - Bohlken *et al.*, 1994) strongly suggest a "high density breeding and nursing area" of harbour porpoises west of this northernmost situated German island.

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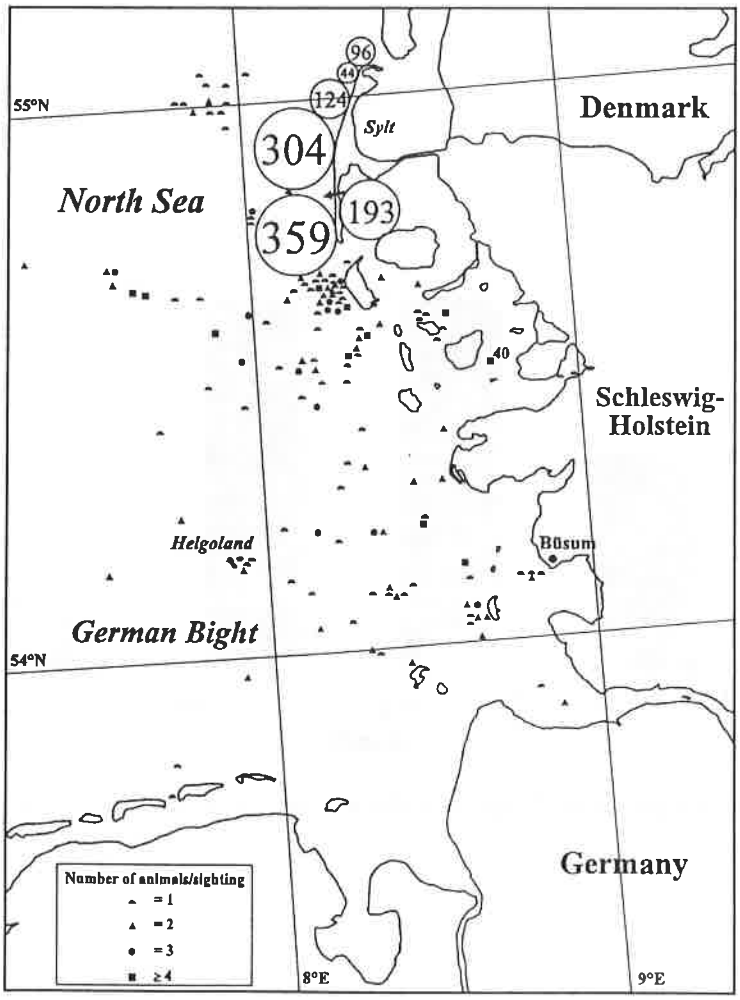

Fig.1: Distribution of sightings of harbour porpoises in the German Bight (1988 to 1994).

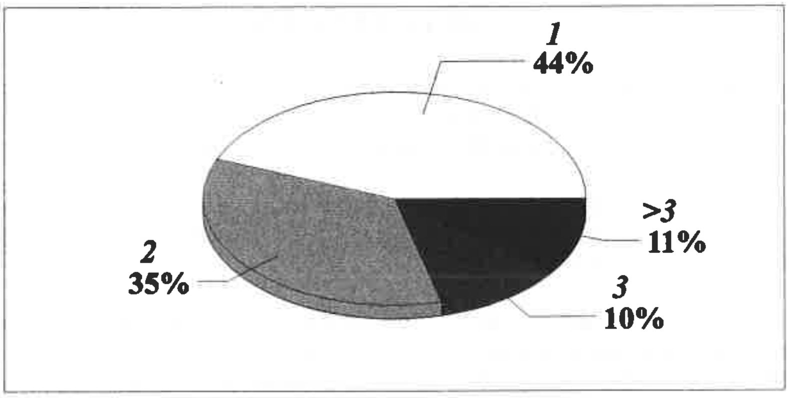

Fig. 2: Group size of harbour porpoise sightings.

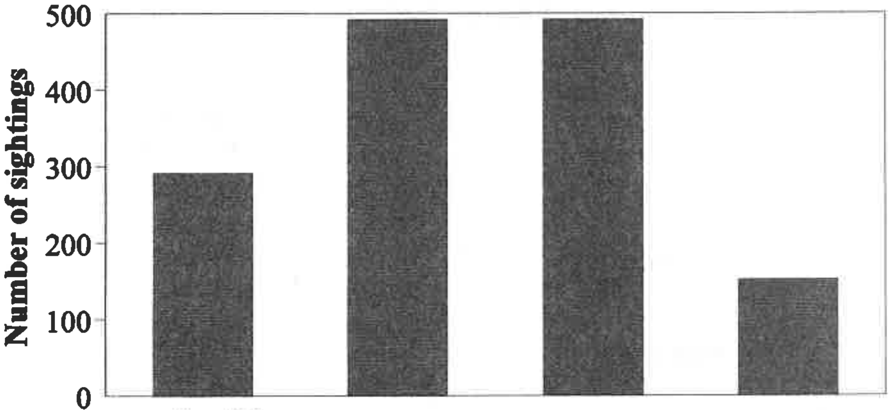

Fig. 3: Number of reported sightings of harbour porpoises in the study area (1988 to 1994).

ASSOCIATIONS BETWEEN PORPOISES, SEABIRDS, AND THEIR PREY IN SOUTH-EAST SHETLAND, N. SCOTLAND

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INTRODUCTION The harbour porpoise *Phocoena phocoena* is the commonest of all cetaceans in Shetland waters. Standardised boat transects over a number of years between mid-August and mid-September 1977-93 have indicated declines in harbour porpoises at three separate areas in Shetland, particularly between 1982 and 1990 (Evans and Gilbert, 1991; Evans *et al.*, 1993). The observed declines coincided with a period when several seabird species underwent widespread repeated breeding failure due to food shortage (Heubeck, 1989). In order to better understand the main factors influencing geographical and temporal variations in porpoise numbers in Shetland coastal waters, a study was undertaken between May and October of 1992-94, funded by WWF-UK, Shetland Amenity Trust, and Scottish Natural Heritage.

METHODS & RESULTS

Diurnal and Seasonal Patterns of Occurrence Systematic land-based watches were conducted regularly at two areas in South Shetland with known porpoise concentration - Mousa Sound and Noss Sound, throughout the periods May - October, 1992-94. In Mousa Sound, porpoise numbers were highest during early morning (mainly from June to mid-August), and in the evening (mainly from mid-August to October). However, as the season progressed, numbers were more inclined to remain in the area throughout the day, as exemplified by a significant increase during the middle of the day between mid-August and October. In the northern part of Noss Sound, porpoise numbers showed an evening peak, particularly associated with social activity, although generally during the day, the area was used mainly by transiting animals. As at Mousa Sound, feeding occurred primarily in early morning, but also during evening hours.

Porpoises occur in all months of the year in Shetland waters, although peak numbers are found between July and October when it appears that numbers of adults enter coastal waters with newborn calves (Evans *et al.*, 1993). Young are first observed during April and May, but their frequency rises sharply during July and early August. The timing of seasonal variation in numbers of porpoises in coastal waters varied slightly between years, with peaks occurring in September (1992), August (1993), and August (1994).

Associations between Porpoises and Potential Fish Prey Dedicated boat surveys of inshore waters of SE Shetland were conducted along pre-determined routes between June and October 1992-94 (see Fig. 1). The main aim was to determine spatial and temporal variation in abundance of harbour porpoise, various species of seabird, and various potential fish prey species. All porpoise sightings were recorded (and selected seabird species in a 100 m belt transect), whilst a Simrad EY200 echosounder with colour printer was used to collect oceanographic and fish data. Environmental conditions were recorded every five minutes on a cruise log sheet, along with vessel position, bearing and speed. Data were collected by a minimum of two observers at any one time, and transects were only started in relatively calm sea conditions (sea state two or less).

The operational settings of the echosounder corresponded to those used by SOAFD Fisheries Laboratory, Aberdeen, to provide comparable echosound traces. Since trawl samples of selected traces could not be taken to determine fish densities, and without the use of calibrated echosound integration equipment, the acoustic data can provide only a semi-quantitative indication of prey abundance at a pre-determined colour threshold. Fish species were identified by the characteristic colour (reflecting target strength) and shape of their echo-traces, except for gadoids (saithe, whiting, and Norway pout) which could not easily be distinguished from one another and so were combined. All fish traces were identified and scored separately by at least two people, with a sample examined independently by a SOAFD fisheries biologist. On a number of occasions, some experimental fishing was also conducted in the vicinity of fish shoals to elucidate the identity of prey species. Shoal area was calculated by measuring the vertical height and the length of echo-traces (see Wright & Bailey, 1993) and organised for analysis into six size classes, referred to as echo-integral values. These provided estimates of shoal size for sand-eel; gadoid, herring, and mackerel shoal sizes were compared in relative terms only (for further details, see Borges, 1995).

There was little seasonal correlation between numbers of porpoises and four species groups of fish (sand-eel, gadoids, herring, and mackerel). However, significant spatial correlations existed between porpoise abundance and sand-eels in both 1992 and 1993 (data for 1994 not yet analysed), which did not exist for any of the other fish species examined (Table 1). The spatial relationships are indicated in Fig. 3. The two localities along the south-east coast with porpoise concentrations (i.e. the southern entrance to Noss Sound between the islands of Noss and Bressay, and between Helliness and No Ness encompassing Mousa Sound) possessed important sand-eel spawning grounds, and other fish species (particularly gadoids such as saithe and whiting) were in greatest abundance there. These were also the areas where shags were concentrated, whilst kittiwakes occurred primarily around Helliness, and arctic terns in Mousa Sound. Gannets were in greatest abundance close to a breeding colony on the island of Noss. Only small numbers of guillemot, razorbill, or puffin were seen, mainly in the immediate vicinity of breeding colonies (for example at Noss, No Ness, and Sumburgh Head), and black guillemots were only found in numbers in Mousa Sound. Although porpoises were noted associating with a number of seabird species, shags showed the highest frequency of association in all three years (Fig. 4), ranging from 38-71%. Most shag-porpoise associations involved large groups of shags (mean 36, max. 205 indivs.). Shags are well-known to feed on sand-eels, and on a few occasions, echosounder traces showed them diving into sand-eel shoals, with porpoises also close by. Wright & Bailey (1993) also found a significant relationship between shag group size and sand-eel shoal size in the coastal waters of S. Shetland. In the region, kittiwakes and arctic terns also appear to be dependant upon sand-eels (Martin, in Heubeck, 1989), although they are restricted to skim-feeding at the surface; the other seabird species have more catholic diets, taking a range of fish including sprats, various gadoids such as whiting, and small herring.

A further analysis of porpoise-prey associations was made at a finer spatial scale by scoring the percentage of occasions when fish shoals of different species were present within 200 m of a porpoise close encounter (i.e. 100 m from the vessel). A range of 200 m was chosen, given the echosounder beam width of 100 m. On some occasions porpoises were not associated with any prey. This result is not surprising considering the fact that porpoises were often encountered either in transit or engaged in social activity. The species most frequently encountered in close proximity to porpoises was sand-eel, followed by gadoids (Fig. 2). Both mackerel and herring were only rarely observed within 200 m of porpoises, although it should be noted that both of these fish were scarce in the study area during the survey period.

Porpoise spatial distribution in relation to tidal stream flow Porpoise activity at Mousa and Noss Sounds differed markedly. At Mousa Sound, 93% of all observations involved foraging activity, whereas in northern Noss Sound, 61% involved transiting and only 30% foraging. This highlights the importance of the region around Mousa as a feeding area. Although feeding occurs close to the island of Noss (as revealed from boat transects), the main area is slightly to the south of the Sound.

Porpoise activity in Mousa Sound was affected by the tidal cycle, and by the occurrence of spring or neap tides (which determine the tidal range). Significantly more movements of porpoises within the Sound were in a northerly direction ($t=2.34$, $p<0.05$), the although the direction of movement varied according to tidal state, facing predominantly northwards when the current was moving south, and southwards when the current moved north. The presence of porpoises in Mousa Sound tended to coincide with states approaching a turn of tide, i.e. 2-3 h before and 3-5 h after high water, when current strength had reached a maximum and was beginning to decline once more. This pattern was clearest during spring tides when tidal flow was strongest. Numbers of porpoises were greatest at the northern end of the Sound and in mid-channel where the sea sloped down from a depth of 20 to 40 m. During flood spring tides, porpoises also concentrated, but to a lesser extent, in mid-channel at the southern end of the Sound. Preference for these areas is probably due to their proximity to topographical changes which provide local upwellings and thus favourable conditions for fish. The relatively strong current which flows through the centre of the Sound aids transport of potential prey and helps replenish nutrients. Porpoise activity in the bay north of Mousa Sound was particularly noticeable around three hours after high water when the tidal flow was in a westerly direction, progressively moving south-west with the ebb tide.

DISCUSSION AND CONCLUSIONS The observed decline during the 1980's in numbers of harbour porpoise in Shetland coastal waters during summer coincided with successive years of poor recruitment of young sand-eels into the adult population, and widespread breeding failure in a number of seabird species known to be dependant upon sand-eels (Heubeck, 1989). The possibility that changes in porpoise numbers in the region were related in some way to fish population changes clearly needed investigation.

Land-based surveys of porpoises in August around Shetland highlighted the importance of the central- and south-east coasts for the species. Areas with concentrations of porpoises coincided with known sand-eel fishing grounds, with two localities (Mousa Sound to Helliness, and south Noss Sound) being particularly important. However, sand-eels form a fundamental part of an extensive food chain supporting many other fish species, several of which are much better known as prey of the harbour porpoise. These include young stages of herring and mackerel, and a wide range of gadoid fish such as cod, saithe, pollack, and whiting. Thus any general association between porpoises and sandeels might not reflect a primarily predator-prey relationship, but could be the result of incidental associations caused by predation by porpoises upon other fish which in turn are preying upon sand-eels. This hypothesis was examined by echo-sounder surveys, and the following lines of evidence indicated that porpoises indeed were associating with sand-eels rather than other potential prey species: (1) porpoise distribution showed significant spatial association with sand-eels but no other fish prey examined, in both 1992 and 1993; (2) the frequency of close association (i.e. up to 200 m from porpoises) was greater with sand-eel than any other prey; and (3) direct records (from echotraces) were frequently obtained of porpoises diving over sand-eel shoals.

Most porpoise activity in Mousa Sound involved foraging or feeding, although later in the summer social behaviour became more common, particularly in the evening. By contrast, in the northern part of Noss Sound, porpoises were mainly observed transiting, the main feeding area being at the southern end of the Sound out of sight of the observation point. Temporal variation in porpoise activity may be related to the diurnal behaviour of fish prey. Sandeels, for example, emerge into the water column in response to increased light intensity (Wright & Bailey, 1993), whilst herring come to the surface at dawn and dusk (Helfman, 1986), forming shoals during the day which disperse at night (Harden Jones, 1962).

In Mousa Sound, porpoises were observed to forage against the tidal flow, positioning themselves mainly at the northern end in mid-channel at the head of a basin into which currents bring potential prey. These sheltered areas have a sandy substrate with water depths ranging from 20-30 m, which may be favoured in energetics terms by diving porpoises, particularly if accompanied by calves. Feeding occurred at states approaching a turn of tide, i.e. 2-3 h before and 3-5 h after high water, when current strength had reached a maximum and was beginning to decline again. Porpoise activity at this time was much more pronounced during spring tides compared with neap tides, presumably reflecting their stronger tidal flows. Most coastal areas in Shetland with concentrations of porpoises are characterised by being semi-enclosed, sheltered areas with strong tidal streams, and an unneven undersea topography likely to favour fish aggregations. Land-based observations at both Mousa and Noss Sounds, and boat transects in SE Shetland coastal waters all indicated an increase in numbers of porpoises between June and October. The sharpest increase occurred during August, with some evidence of a decline by late September (although poor weather conditions may have contributed to this).

A detailed comparison of porpoise and prey distribution indicates closest associations between porpoises and sand-eels. The lack of any strong seasonal correlation between porpoise abundance and any prey, including sand-eel, may be because those fish are at their most abundant during the summer months, resulting in porpoises having no need in energetics terms to be strongly selective or to concentrate only in areas of high prey abundance. On the other hand, sand-eel and gadoid abundance were generally highest during early summer, declining sharply in July/August, in contrast to porpoise abundance which increased sharply during August. For this reason, it seems likely that porpoises may move into inshore waters of Shetland for reasons other than high prey abundance. Numbers increase markedly during August at the end of the breeding season, alongside an increase in the percentage of calves present and an increase in time spent engaged in social activities. It may be necessary for adults to bring their calves into shallow waters so that they can start to feed independently of their parents and not have to dive too deep to capture food, particularly if it is demersal. The presence of energy rich fish (such as sand-eel, young herring and mackerel) could mean that total abundance need not be so very high, whilst also providing useful free time for social activities.

ACKNOWLEDGEMENTS Grants in support of this project were kindly provided by the WWF UK, the Shetland Amenity Trust, and Scottish Natural Heritage. Warm thanks also go to many persons who have helped on the project, particularly Paula Barnett, Lisa Borges, Quentin Carson, Paul Fisher, Dorien Hoogerheide, Rachael Limer, Ian Rees, and Julie Wainwright; the staff of the SNH office in Lerwick, Martin Heubeck (SOTEAG) and Ronnie Gallagher (Sullom Voe terminal); Peter Wright, Martin Bailey, and Phil MacLachlan of SOAFD; and the boat skippers Robbie Leask and Jimmy Birnie.

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Table 1 Spearman rank order correlation coefficients for total abundance of porpoises vs. fish prey per cell for 1992 & 1993 (n = 20, 23)

VARIABLES	Rs_{92}	p_{92}	Rs_{93}	p_{93}
Sandeels	0.81	0.001	0.67	0.002
Mackerel	0.40	0.08	0.47	0.03
Gadoids	0.38	0.10	0.43	0.04
Herring	0.33	0.16	0.27	0.22

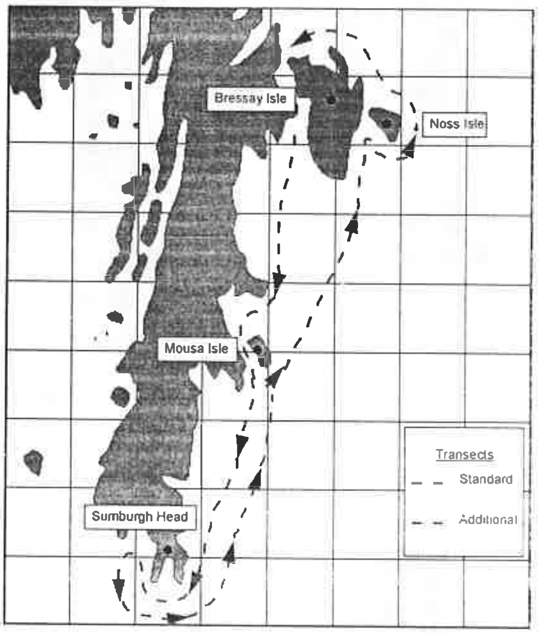

Fig. 1 Map of regular transect route conducted in South-east Shetland

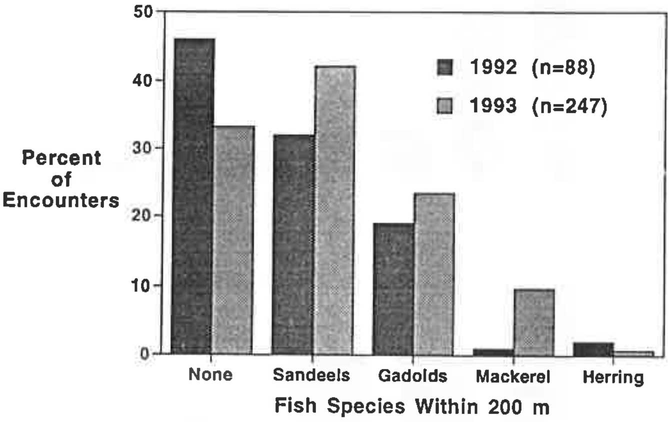

Fig. 2 Associations of harbour porpoises with various fish species (percent encounters within 200 m of fish shoals)

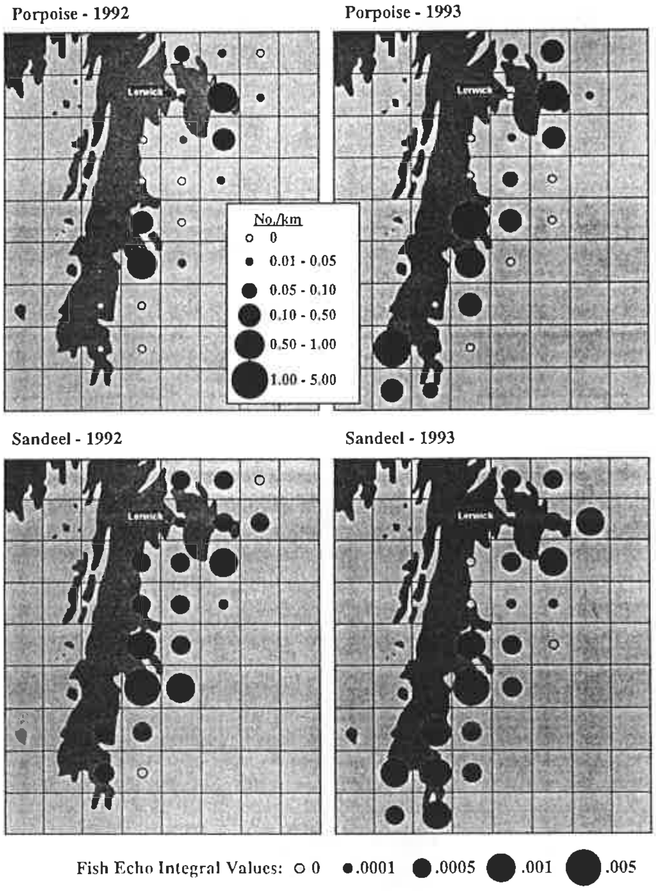

Fig. 3 Comparison of porpoise and sand-eel distribution in South-east Shetland

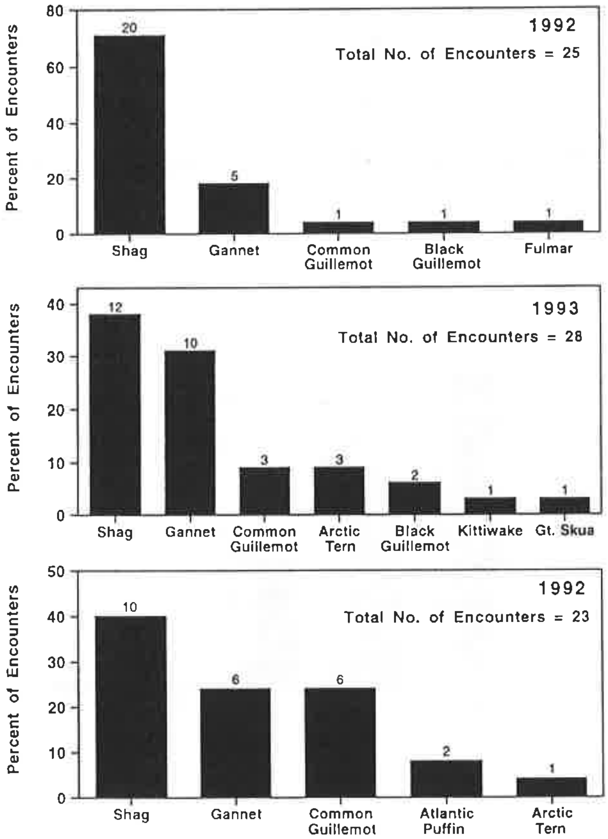

Fig. 4 Frequency of associations between harbour porpoises and various seabird species in Shetland, 1992-94 (sample sizes = no. of encounters for each species)

STOMACH CONTENTS OF HARBOUR PORPOISES AND DOLPHINS IN IRISH WATERS

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INTRODUCTION The distribution and abundance of cetaceans in Irish waters has been correlated with the distribution of their preferred prey species (Evans, 1990), but there is no published work on the diet of small cetaceans in Irish waters. However, some studies have been published on the diet of harbour porpoises in British waters (Rae, 1965; 1973) and dolphins in the North-east Atlantic (González *et al.*, 1994; Pascoe, 1986; Santos *et al.*, 1994; Wurtz and Marrale, 1993). The present study provides the first published data on the diet of harbour porpoises and dolphins in Irish waters.

METHODS The stomach contents of 26 harbour porpoises (*Phocoena phocoena*), 27 common dolphins (*Delphinus delphis*), seven striped dolphins (*Stenella coeruleoalba*), four white-sided dolphins, (*Lagenorhynchus acutus*) and one white-beaked dolphin (*L. albirostris*)were examined. Ten of the harbour porpoises and ten common dolphins were incidentally caught in fishing nets and landed intact, while all other animals were stranded on the Irish coast.

Prey items were identified, ranging from fish otoliths and bones to cephalopod beaks. Each otolith was identified to species level wherever possible, categorised as left or right, and measured. The prey items in each individual stomach were quantified by determining the maximum number of left or right otoliths, and matching left and right otoliths of a similar size (± 1 e.p.u.). The minimum, maximum and best estimates were then determined for each individual. Cephalopods were quantified from the number of lower rostrums present. The diet is presented as the frequency of occurrence, and as the proportion of the total number of prey items recovered from each species.

RESULTS Prey remains were found in 19 harbour porpoises, 26 common dolphins, and all the other dolphins examined. Gadidae occurred in 64% and Clupeidae in 21% of the harbour porpoise stomachs examined (Table 1). However, the most frequent prey types were *Trisopterus* spp. (30%), whiting, *Merlangius merlangus* (5%) and sprat, *Sprattus sprattus* (5%). Gadidae (85%) and Clupeidae (27%) were also among the main food items occurring in the stomachs of the common dolphins examined, and cephalopod remains were found in 52% of stomachs examined. As with the harbour porpoises *Trisopterus* spp. (23%), clupeoid species (7%) and whiting (8%) accounted for most of the prey items recovered. In the striped dolphins examined, 57% of the stomachs contained gadoids, 14% clupeoids, and all seven had cephalopod remains. The fish species recorded consisted mostly of *Trisopterus* spp. The most frequently occurring species in the diet of the white-sided dolphins examined were mackerel, *Scomber scombrus* (10%) and silvery pout, *Gadiculus argenteus thori* (41%).

Cephalopod remains were found mainly in common and striped dolphins (Table 2). Common dolphins fed primarily on *Gonatus*, *Histioteuthis* spp. *Toderopsis*, *Loligo forbesi* and the common octopus *Eledone cirrhosa*. *Gonatus*, *Histioteuthis* and *Ilex* sp. were recovered from the stomachs of striped dolphins. The main prey items in the diet of stranded and by-caught harbour porpoises and common dolphins are comparable within each species although more prey species were recorded from the by-caught harbour porpoises. In common dolphins, more prey species were reported from stranded dolphins. Two myctophid species, *Diaphus sp.* and *Notoscopelus kroeyerii*, and a greater number of squid were recovered from by-caught dolphins, reflecting their origin of capture as these animals were mainly caught >250km from the coast.

The harbour porpoises landed in the present study were mainly caught in the bottom set gill-net fishery operating in the Celtic Sea, where the main target species is hake *Merluccius merluccius*. The common dolphins were caught in drift-nets by Irish tuna boats targeting albacore tuna *Thunnus alalunga*. It is clear that the harbour porpoise and common dolphins caught by these fisheries were not feeding on the target species of the fishery, but most likely a common food fish.

DISCUSSION The present study shows that small cetaceans in Irish waters feed on a variety of pelagic and demersal fish species and cephalopods. The diet of harbour porpoises and common dolphins is similar, with pelagic species such as herring, *Clupea harengus*, and sprat, and demersal whitefish such as whiting frequently being eaten. White-sided dolphins seem to feed mainly on pelagic species. Cephalopods are more frequently consumed by striped dolphins. These results are similar to other dietary studies in the North-east Atlantic but one striking result is the importance of *Trisopterus* spp., namely poor cod *T. minutus* and Norway pout *T. esmarkii* in the diet of both harbour porpoises and common dolphins.

The abundance of *Trisopterus* spp. has also been reported for other marine top predators in Ireland such as cephalopods (Collins *et al.*, 1994) and gulls Laridae (Creme, unpubl. data). *Trisopterus* spp. are not fished commercially in Ireland, and they may have increased in relative abundance in recent decades through competitive release. This suggests that where fish stocks have been reduced through overfishing, cetaceans may switch to more abundant, non-commercial prey species. These species are calorifically less suitable as a food for marine mammals compared with the energy rich Clupeidae. The implications for cetacean energetics can only be speculated upon!

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Table 1. Diet of harbour porpoises and dolphins from Irish waters.

Prey species	Harbour porpoise (n = 19)		Common dolphin (n = 26)		Striped dolphin (n = 7)		White-sided dolphin (n = 4)	
	% freq	% Nos	% freq	% Nos	% freq	% Nos	% freq	% Nos
Clupea harengus	15.8	0.6	14.8	1.3	-	-	25.0	0.6
Sprattus sprattus	5.3	4.7	11.1	1.8	14.3	6.2	-	-
Clupeidae	**21.0**	**10.6**	**26.9**	**7.0**	**14.3**	**12.6**	**25.0**	**1.2**
Argentina sphtraena	-	-	11.1	0.8	-	-	25.0	1.9
Merluccius merluccius	-	-	26.9	0.6	-	-	-	-
Unident. Gadoid	36.8	38.3	17.2	4.6	28.6	45.4	25.0	42.2
Merlangius merlangus	42.1	4.5	30.7	8.2	28.6	0.45	-	-
Malananogrammus aeglefinus	5.3	0.1	-	-	-	-	-	-
Gadus morhua	5.3	0.1	-	-	-	-	-	-
Trispoterus spp.	42.1	30.1	40.7	22.6	57.1	34.4	25.0	1.3
T. minutus	21.1	10.3	14.8	5.4	-	-	25.0	1.3
T. esmarkii	-	-	17.2	4.0	-	-	-	-
Gadiculus argenteus thori	5.3	1.3	6.9	0.6	-	-	50.0	41.1
Mircomesistius poutassou	-	-	3.4	0.4	-	-	-	-
Gadidae	**63.6**	**84.6**	**85.1**	**37.6**	**57.1**	**80.2**	**25.0**	**85.9**
Maurolicius muelleri	-	-	6.9	0.8	-	-	-	-
Trachurus trachurus	5.3	0.7	24.1	0.9	-	-	-	-
Gobidae spp.	5.3	0.1	11.1	4.5	14.3	0.45	-	-
Aphis minuta	-	-	3.4	4.4	-	-	-	-
Scomber scombrus	-	-	6.9	0.4	-	-	75.0	10.1
Diaphus sp.	-	-	10.3	2.4	-	-	-	-
Notoscopelus kroyerii	-	-	6.9	0.3	-	-	-	-
Unidentified fish	26.3	2.8	20.7	0.2	28.6	1.4	-	-
Cephalopods	**5.3**	**1.4**	**51.7**	**4.5**	**100**	**5.2**	**25.0**	**0.6**

The stomach of a white-beaked dolphin contained 2 unidentified Gadoid and 6 scad *Trachurus trachurus*.

Table 2. Cephalopods recorded in the diet of harbour porpoises and dolphins from Irish waters.

Prey species	Common dolphin (n = 15)		Striped dolphin (n = 7)	
	% freq	% Nos [1]	% freq	% Nos [2]
Gonatus sp.	40	51	57	7.8
Histioteuthis sp.	40	46	57	7.8
Bracioteuthis sp.	7	3.9	-	-
Chiroteuthis sp.7	7	2.6	-	-
Ilex fubei	-		57	57.7
Loligo forbesi	27	4.6	-	-
Todarodes sp.	7	1.3	-	-
Toderopsis sp.	13	4.6	-	-
Unident. squid	17	5.3	14	19.2
Eledone cirrhosa	33	4.6	-	-

A single *Loligo forbesi* and 11 unidentified squid were found in a harbour porpoise and a single Loligo sp. was found in a white-sided dolphin. [1] n = 151, [2] = 26

FOOD OF THE COMMON DOLPHIN (*DELPHINUS DELPHIS*, L) IN ALGERIAN WATERS

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Food habits of cetaceans have been reported over the last 30 years. However, there are many gaps in our knowledge of their diet. In this work we have identified the prey species of the common dolphin (*Delphinis delphis* L.) present in Algerian waters and determined the relative proportions of each.

The stomach contents of ten specimens of common dolphin stranded on Algerian coasts have been used to study their diets. Data showed that the food of common dolphins was composed mainly (93.6%) of pelagic fishes (*Sardina pilchardus, Sardinella aurita* and *Engraulis enorasicholous*), and to a small extent (6.4%) of cephalopods. Most (85%) of these prey species are of low commercial value.

We identified seven species of fish belonging to five families. One family, Clupeidae, including different sardine species, was the most commonly found (45.8%) in the ten stomachs studied. Another family, Engraulidae, represented 38.65% of the prey found in the stomach contents. The remaining three families (Scombridae, Carangidae and Sparidae) accounted for about 5% of the prey found in the stomach of common dolphins.

It can be concluded that common dolphins are opportunistic in their diet and consume almost all types amongst the fish and cephalopod fauna of Algerian waters.

DOES THE LONG-FINNED PILOT WHALE FEED ON TUNA? - A MISTAKE IN THE MEDITERRANEAN LITERATURE

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The feeding habits of long-finned pilot whales have been extensively studied in the Faroe Islands (North Atlantic), where the traditional "harvest" of more than 1,800 individuals per year, with a bycatch of 100 dolphins (Bloch *et. al.*, 1993) make it possible to study redundant material. Out of more than 7,000 observed prey items, 93% were cephalopods and 7% fish (Desportes and Mouritsen, 1993), the latter consisting of mainly benthic species. Corresponding results have also been obtained in Eastern Canadian waters (Sergeant, 1962).

Less is known about the feeding of pilot whales at lower latitudes and in the Mediterranean, where only a few stomach contents have been studied. A particularly intriguing question is whether pilot whales feed on pelagic fish, especially on large pelagics such as tuna.

There is an old reference in the literature on the Mediterranean pilot whales pursuing large bluefins:

> Scordia, C. 1939. Intorno alle incursioni del *Globicephalus melas* (Traill) nello Stretto di Messina, e ai danni che ne vengono apportati alla pesca del tonno. (Incursion of *Globicephalus melas* (Traill) into the Straits of Messina and the damage caused to tuna fishing). Memorie di Biología Marina e di Oceanografia, 6(2): 1-7.

"In a 1934 publication I reported briefly on the incursion into the Straits of Messina of a school of about thirty individuals of *Globicephalus melas*. This occurred in February 1933 when tuna fishing using hooks was still being practised in the upper part of the Straits. As I reported, these cetaceans started to attack the tuna, ripping off strips of flesh, and killing and devouring them. Two specimens were caught off Ganzirri using the usual harpoon (I have referred to this technique, also used in the fishing of tuna, on a previous occasion [1932]) after a fierce fight with the fishermen who were intent on catching the tuna using fishing lines. Of the two specimens, the male weighed about 1,000 kg and was about six metres long. After being caught it was transported to Messina and exhibited to the public in a shop. Thanks to the courteous permission of Dr Trischitta, this Institute was given possession of the head, which was already in a bad state because, as we have said, the specimen had already been on show to the public for several days. It was then carefully prepared in the Veterinary Anatomy laboratory of the University. Its cranium forms part of our Institute's collection. The other was a female weighing about 600 kg and measuring about four metres in length. It was kept at Ganzirri by the fishermen who were able to obtain a substantial quantity of oil.

The pilot whales' unexpected attack against the tuna, many of which were killed and devoured, put their ranks to flight and for several days none of these large fish were seen. But then they returned to their usual feeding grounds in the Straits, and indeed that February proved most profitable, with the capture of a total of 121 individuals, of a mean weight of 72.01 kg (as against 74.62 for the month of January), and with an average daily number of 6.72 (as against 4.90 for the previous month, and 5.30 for the month after). Fishing continued until 12 April......"

This text includes a photo with the following caption: "Skull of the male *Globicephalus melas* about 6 m long and 100 kg in weight, caught at Ganzirri in February 1933."

The morphology of the skull, the length-weight relationship, and the hunting behaviour of the pod all indicate that this was in fact false killer whale *Pseudorca crassidens*.

One of us, L. Cagnolaro, was able to find in the Aquarium of Messina the skull which was published by Scordia as *G. melas*. It can definitely be assigned to *P. crassidens* and has the following measurements:

Pre-maxilla - conyle length	64.6 cm
Skull width at squamous bone	38.5 cm
Rostral basis width	20.6 cm
Rostral length	31.5 cm
Teeth formula	8 - 8
	9 - 9
Teeth height	3 - 3.4 cm
Teeth diameter	1.9 cm
Right mandibular branch straight length	53.2 cm

In conclusion, the "incursion" which in February 1933 damaged the tuna fishery in the Straits of Messina was made by a pod of false killer whales. Probably these cetaceans were also involved in the second incursion (1939) described by the same author.

Sightings of false killer whales, one of which was captured, had already been registered in 1925 near the Calabrian coast, and in the period 1978-82, two specimens were caught in drifting long lines not far from the Straits (Di Natale and Mangano, 1983).

False killer whales are considered rare in the Mediterranean. The long-finned pilot whale, which used to be more common at least in the past, as far as these areas are concerned, have never disturbed large tuna fisheries.

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SPATIAL OCCUPATION AND SOCIAL ORGANISATION IN CAPTIVE BELUGA WHALES (*DELPHINAPTERUS LEUCAS*)

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INTRODUCTION Cetaceans are regarded as having a highly developed social life and are greatly influenced by the distribution of resources (Amundin and Amundin, 1973). In such a framework, social and spatial organisation is a dynamic process between the animals and their environment, and is highly influenced by their ontogeny. So we thought it would be interesting to test whether social organisation arises among unfamiliar animals under captive conditions. We studied beluga whales (*Delphinapterus leucas*) and, in particular, how they occupy their habitat and organise their group in an aquarium. We observed the spatial occurrence of the activities in order to answer the questions: "how do these animals interact?" "where do these interactions occur?" and "towards which individual are certain behaviours aimed?"

MATERIALS AND METHODS

Animals and habitat Five beluga whales from Hudson Bay, were studied: three females (22, 10 and 5 years old), and two males (10 and 5 years old). The animals were kept in two heterogeneous tanks connected by a gate. We divided the pools into 18 imaginary areas according to physical criteria and three depth levels : a1, a2, a3, b1, b2, b3, c1, c2, c3, d1, d2, d3, e1, e2, e3, f, g1, g2 (with f being the shallow area and g the medical pool).

Data collection and analysis From March to June 1993, the whales were observed from the underwater viewing gallery that surrounded the main pool. We collected ethological and spatial data (by 5-minute focal animal sampling) each day from 08:30 to 10:30, from 12:00 to 14:00, and from 16:30 to 18:30 hrs. We compiled a non-exhaustive list of 78 behaviour items, which we gathered into two categories : (1) "non-interactive behaviour" including travelling, playing, resting, actions directed towards the environment and other activities; and (2) "interactive behaviour" including aggression (with physical contact), intimidation (without physical contact), submissive, sexual, affiliative and synchronised behaviours. Spatial distribution was also considered. We pooled all the data together, and calculated the frequency of each item per animal and per area. Sociograms were then constructed describing the organisation of the interactive behaviour.

RESULTS The youngest females were the most active. All the animals displayed most of the non-interactive behaviour in the upper levels of the pools (Fig. 1). The oldest female (F22) remained mainly in the centre of the pool (area a in Fig. 1), and partly above the underwater viewing gallery (c1). F10 also remained in area c1. F5 frequented the upper level of the medical pool (g1), the shallow area (f) and the deep level d3. M10 remained in the peripheral area b (b1 and b3); and M5 remained in the upper level of d. The oldest beluga whales (the biggest ones) never entered the shallow area. The animals were distributed in the peripheral zones while the central area (a) was occupied by F22. During non-interactive behaviour, spatial occupation of the basins can be summarised by "one animal to one part of the pool".

In the interaction field, the beluga whales displayed affiliative behaviour more frequently than aggressive behaviour (Fig. 2). We noticed that F10 and M5 were very affiliative towards F22 but the F22 interacted more frequently with F10 than with M5. F5 interacted with her young conspecifics but not with the oldest ones. The aggressive interactions were mainly displayed by the two males: M10 directed his interactions towards the youngest male (M5), and vice versa. F22 did not display aggressive behaviour. The males were more aggressive than the females, and the females were more affiliative between themselves than the males.

CONCLUSION This ethological study demonstrates that captive beluga whales, as previously observed in bottlenose dolphins (*Tursiops truncatus*) by Ballance (1992), displayed a heterogeneous distribution, each animal remaining mainly in one (or two) area(s) of the pool. Moreover, each animal developed preferences to interact with one, or several, social partner(s). These results are consistent with the data of Johnson and Norris (1986), and Wells (1991) from bottlenose dolphins. So we can assume that the beluga whales at the Vancouver Aquarium constitute a social group.

ACKNOWLEDGEMENTS We are grateful to the Vancouver Public Aquarium for providing help and support. Special thanks to Dr. J. K. B. Ford.

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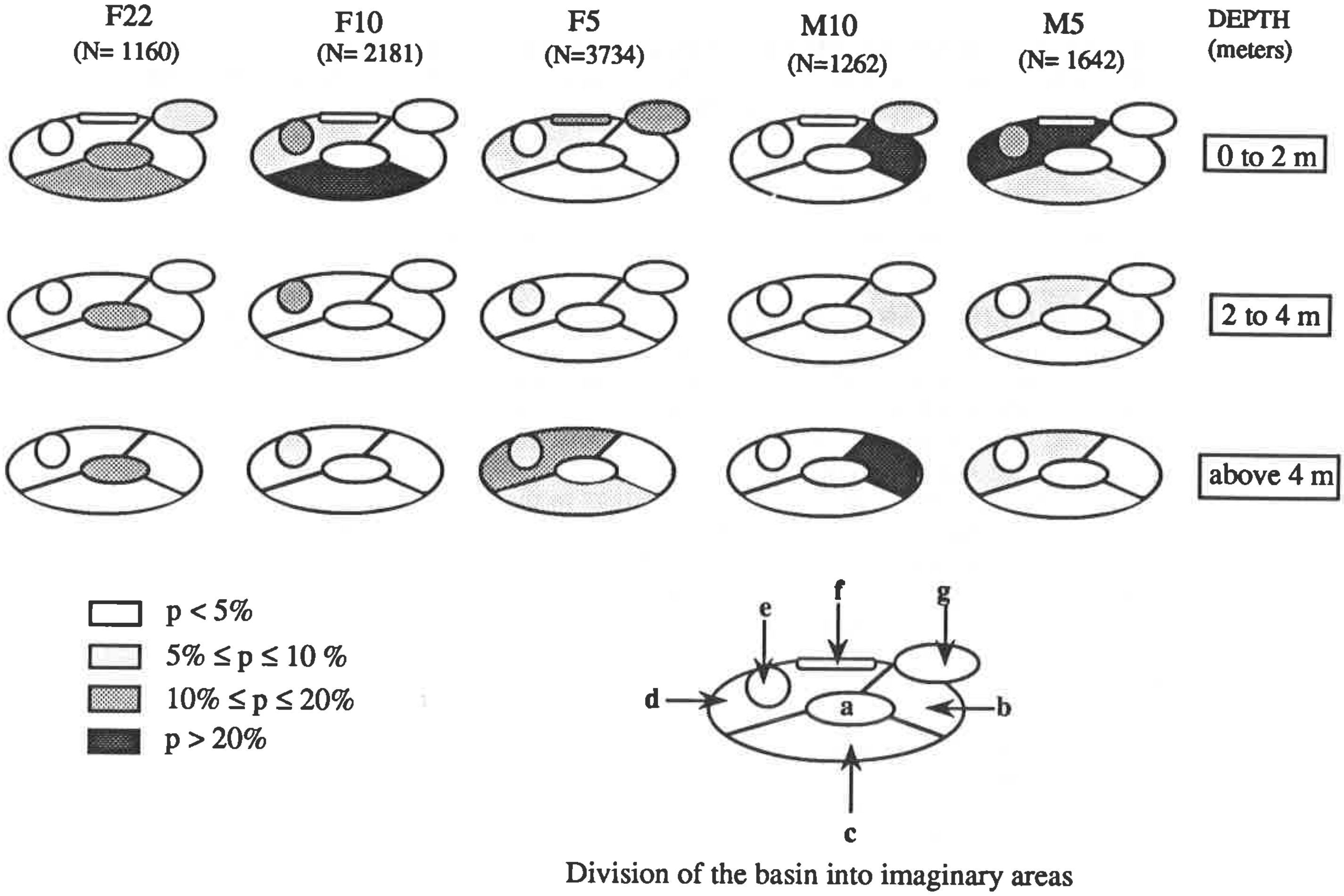

Fig. 1 : Spatial occupation of the pools by the five beluga whales of the Vancouver Public Aquarium during non-interactive behaviour (F: female; M: male; 5, 10, 22: whales' ages; N: number of items; p: percentage of items developed in an area (number of non-interactive items in one zone / sum of all non-interactive items in the whole pool) x 100).

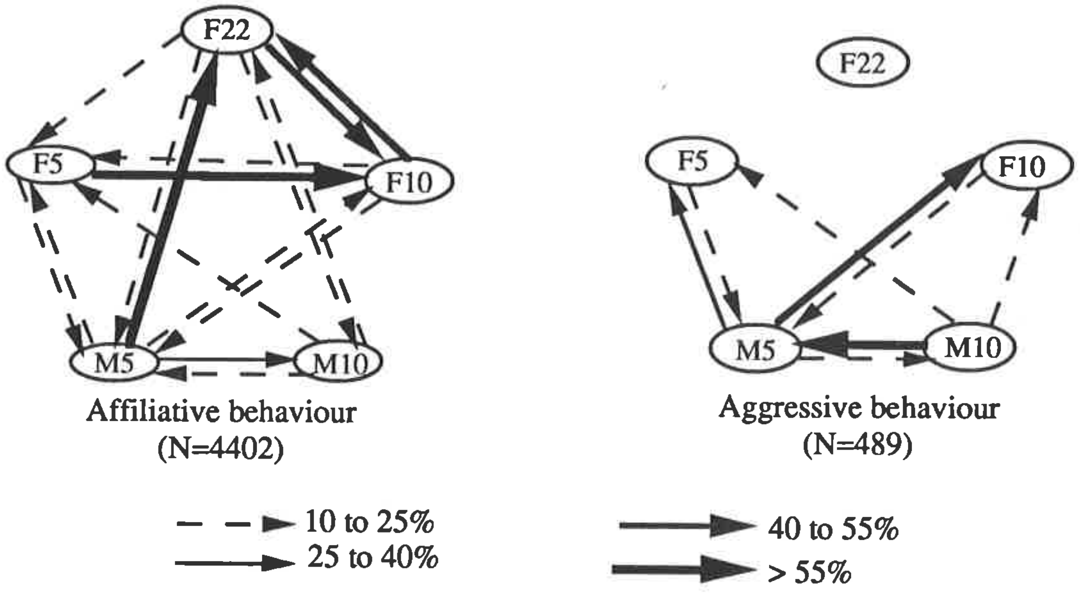

Fig. 2 : Sociograms of the main interactions between the five beluga whales (F: female; M: male; 5, 10, 22: whales' ages; N: total number of interactions (number of interactions developed by each animal / sum of all interactions) x 100).

RELATIONSHIPS BETWEEN SPERM WHALE DISTRIBUTION AND PRIMARY PRODUCTIVITY OVER LARGE SPATIAL SCALES IN THE PACIFIC OCEAN

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INTRODUCTION AND OBJECTIVES As sperm whales (*Physeter macrocephalus*) are pelagic, deep diving species, feeding on meso- and bathypelagic squid, very little is known about the factors influencing their distribution. Unlike most species of baleen whales, it is impossible to relate sperm whale distribution to the distribution of its main prey item, since nothing is known about the ecology of these deep sea-living squid (Clarke, 1966, 1980, 1987). One potential way around this problem is to study the distribution of other links in the food chain, and to try to relate them to sperm whale distribution. It has often been suggested that sperm whales occur in areas of upwelling and high primary productivity (Townsend, 1935; Gulland, 1974); therefore, chlorophyll concentration may be a good indicator of sperm whale distribution. However, spatial and temporal lags are likely to occur between a peak in chlorophyll concentration and a peak in sperm whale density, making it necessary to take into account a wide range of spatial and temporal scales.

The present study investigates sperm whale distribution over broad spatial and temporal scales (the smaller scales will be considered in a separate study). The goals are:

- To examine whether time-averaged sperm whale distribution is correlated with time-averaged chlorophyll concentration over spatial scales ranging from 120 to 960 square miles.
- To determine if breeding and calving requirements influence sperm whale distribution regardless of food resources.

MATERIALS AND METHODS Over such large spatial and temporal scales, sperm whale distribution seems to be best described by the American whaling data (Best, 1983; Shuster, 1983). A large amount of data has already been extracted from logbooks, and charts of sperm whale distribution have been compiled by Maury (1852) and Townsend (1935). Townsend's charts (1935) record the position of 36,908 sperm whales killed between 1761 and 1920, and were used for the present study.
Over broad spatial scales, chlorophyll concentration is well described by satellite imagery. The Coastal Zone Color Scanner recorded images between 1978 and 1986, providing chlorophyll concentration for the majority of the ocean during most calendar months (Lewis, 1989).

The study area (the Pacific Ocean between 40°S and 40°N, and the meridian 140°E and the coast of America) was divided into squares of 2° by 2° (120 nautical miles by 120 nautical miles). The total number of whales killed in each two-month period and the mean chlorophyll concentration for each two-month period were calculated for each square. A Spearman correlation coefficient was calculated for whale kills and chlorophyll concentration. To increase the spatial scale, four squares were pooled to form, successively, 4°/4°, 8°/8° and 16°/16° squares, and similar analyses were carried out.

To investigate the influence of breeding and/or calving requirements on sperm whale distribution, sperm whale kills were first divided into two categories: the whales belonging to the northern reproductive schedule (sperm whales killed between 40°N and 10°N), and the whales belonging to the southern reproductive schedule (sperm whales killed between 40°S and 10°S). Then, for each category and for each two-month period, a Spearman correlation coefficient was calculated between sperm whale kills and chlorophyll concentration.

RESULTS AND DISCUSSION The Spearman correlation coefficients between sperm whale kills and chlorophyll concentration show substantial positive correlations over every spatial scale (2°/2°, 4°/4°, 8°/8° and 16°/16° squares). The coefficient of correlation increases with increasing spatial scale up to 8°/8° and then decreases slightly, suggesting that the best correlation between sperm whale density and chlorophyll concentration occurs at a spatial scale of approximately 500 nautical miles (nm.) by 500 nm. (Fig. 1). These results can be related to previous analyses carried out on sperm whale distribution and spatial organisation using survey data (Jaquet and Whitehead, 1994). In this work, it was demonstrated that, at any given time, sperm whales formed concentrations about 300 nm. across, in areas where food resources were higher than in adjacent water. Using data averaged over large temporal scales, the present study suggests that these concentrations of sperm whales move over time following changes in chlorophyll concentration, over areas roughly 500 nm. across (Fig. 2).

If sperm whales changed their distribution to satisfy breeding and/or calving requirements, regardless of food resources, one would expect that, during the peak of the breeding and/or calving season, the whales will be less closely associated with chlorophyll concentration than at other times of the year. Fig. 3 shows the Spearman correlation coefficient (*r*) for each two-month period and for each reproductive schedule. In the Southern Hemisphere, contrary to what might have been expected, *r* is slightly higher for the two-month period corresponding to the peak of the calving season, than for all the other two-month periods. In the Northern Hemisphere, *r* is low for every two-month period, and where *r* is slightly lower for the period corresponding to the peak of the breeding season, this difference is not significant. Therefore, there seems to be no relationship between a low correlation coefficient during a two-month period and the peak of the calving and/or breeding season, suggesting that these factors do not influence sperm whale distribution in the way they do for most species of baleen whales.

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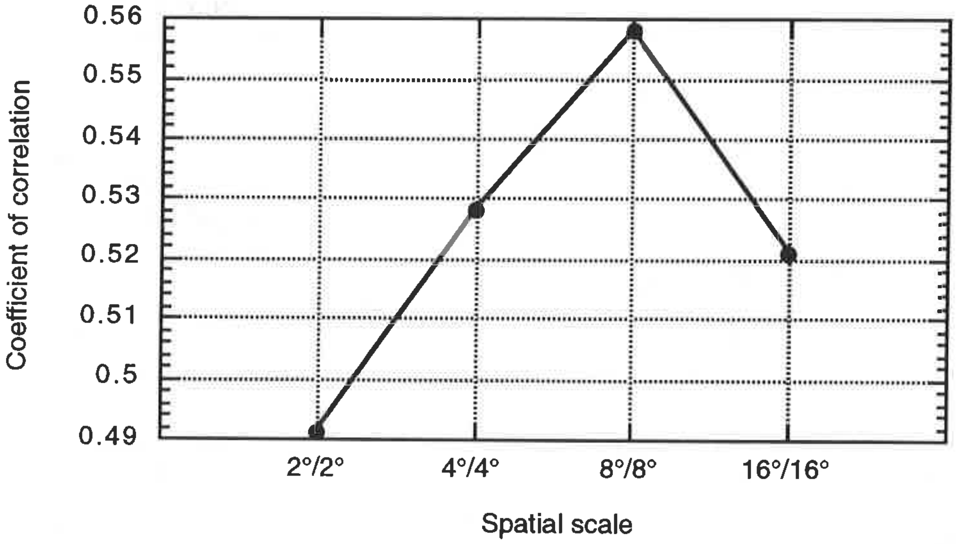
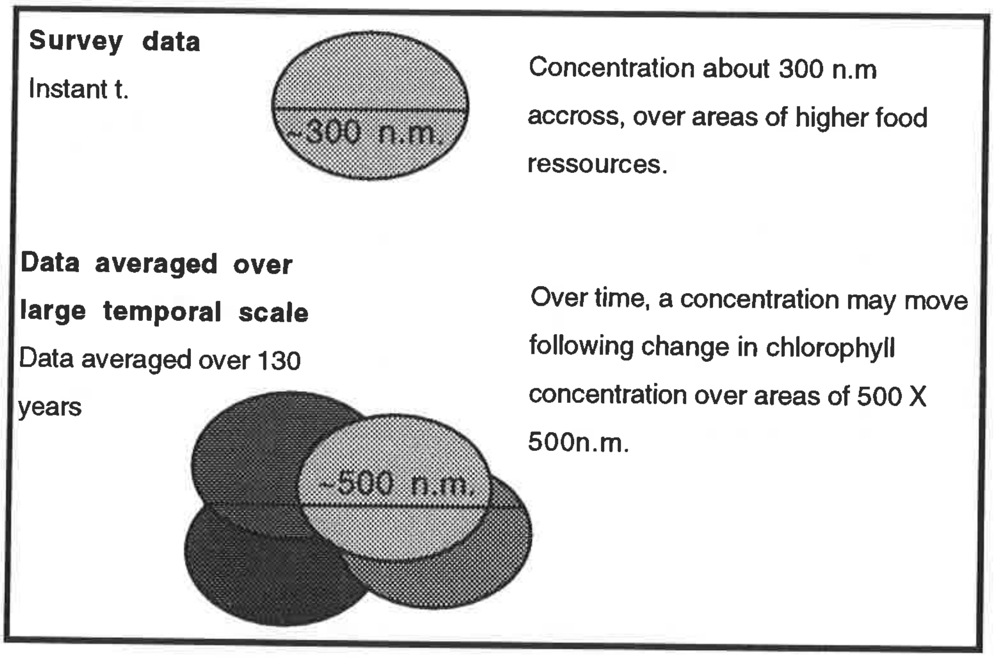


Fig. 1 Spearman correlation coefficient between sperm whale kills and mean chlorophyll concentration



Concentration about 300 n.m accross, over areas of higher food ressources.

Over time, a concentration may move following change in chlorophyll concentration over areas of 500 X 500n.m.

Fig. 2 Sperm whale spatial organisation: a punctual situation and a situation averaged over time

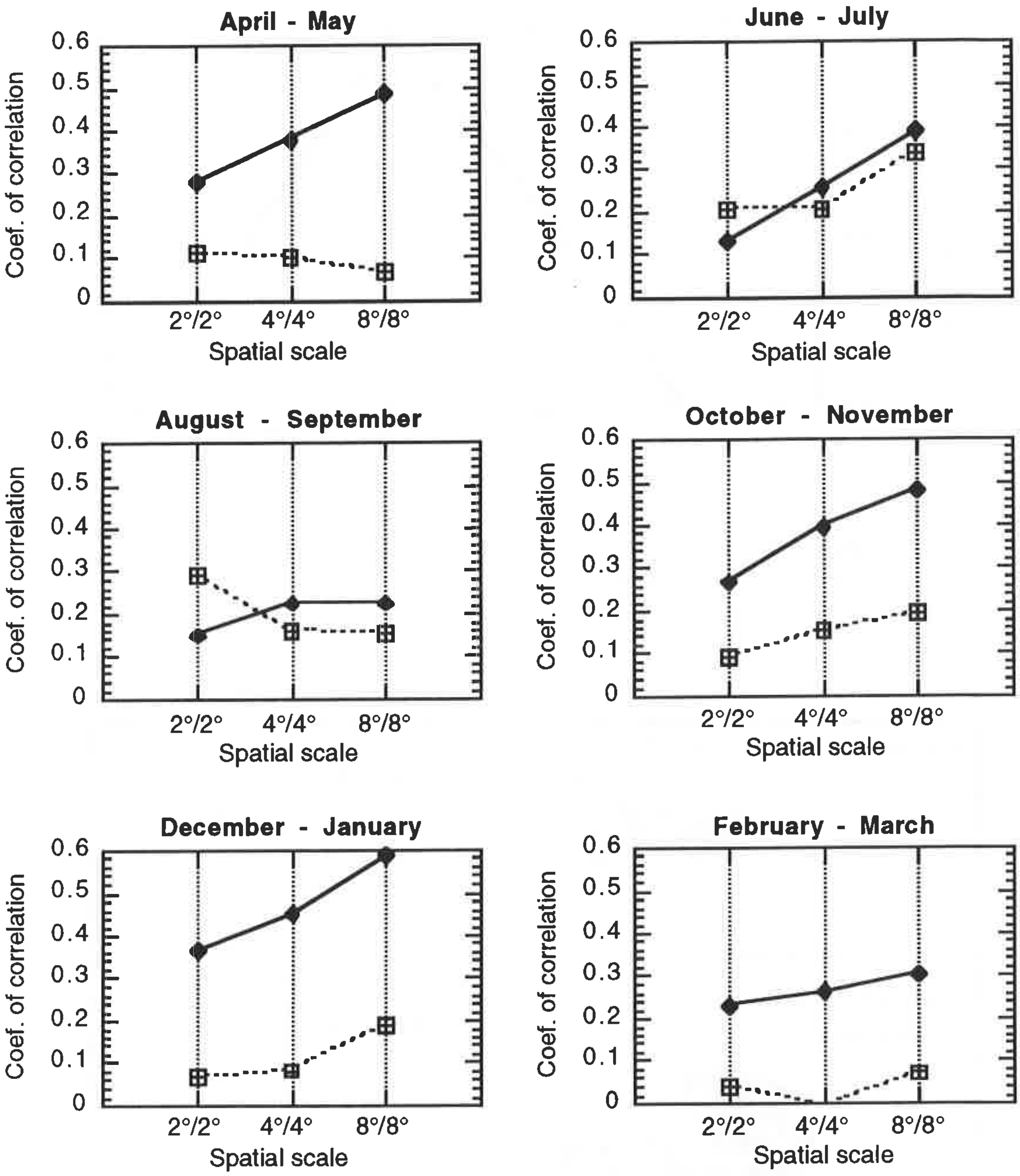


Fig. 3 Spearman coefficient of correlation between whale kills and chlorophyll concentration for each 2-month period and for both hemispheres.

The solid line (——) represent the whale kills between 10°S and 40°S, and the dashed line (- - - -) the whale kills between 10°N and 40°N.

In the Northern Hemisphere, the peak of the breeding season occurs in Feb-March, and the peak of the calving season in April-May; in the southern hemisphere, the peak of the breeding season is in Oct-Nov, and the peak of the calving season in Dec-Jan (Caldwell *et al.*, 1966; Rice, 1989).

SUCKLING AND WEANING BEHAVIOUR OF TWO CALVES OF BOTTLENOSE DOLPHINS*TURSIOPS TRUNCATUS*

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The aim of the present study was to compare suckling behaviour and weaning of two captive male bottlenose dolphin calves during their first year. Calves, Tabo and Golia were born at Cattolica's Dolphinarium in 1993, three weeks apart, and were kept in a pool with their mothers. Data were collected from birth to 52 weeks of age according to the following plan: (a) 1st week: 20 hrs/day; (b) 2nd-8th weeks: 20 hrs/week; (c) 9th-16th weeks: 20 hrs/2 weeks; and (d) 17th-52nd weeks: 20 hrs/3 weeks. Frequency and duration of attempted and successful bouts of suckling were recorded.

Attempted suckles, which were more frequent than successful ones on the first day, almost disappeared by the fifth day and then settled down at a very low frequency. On the other hand, frequency of successful suckles was high for the first month, and then decreased and maintained a constant level. After the 35th week, suckling frequency increased again until the 52nd week for Tabo, whereas Golia reduced suckling after the 47th week with no increase again. The duration of successful suckles was higher during the first period and then decreased, reaching constant values. Except for the initial and final values for suckling, the two babies seemed to be quite similar in these behaviours. The youngest calf started weaning spontaneously at six months of age, while the oldest started at nine months. In conclusion, our data partly agree with other observations, although both suckling and weaning seemed to be highly variable, and possibly due to different biological and environmental conditions.

MOTHER-CALF SPATIAL RELATIONSHIPS IN TWO CAPTIVE BORN BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

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The aim of the present study was to investigate spatial relationships between two captive male bottlenose dolphin calves and their mothers, and how these relationships may change through time, reflecting the development of their independence. Calves (Golia and Tabo) were born at Cattolica's Dolphinarium in 1993, three weeks apart, and were kept in a pool with their mothers. Data were collected from birth to 52 weeks of age, according to the following observation plan: (a) 1st week: 20 hrs/day; (b) 2nd-8th weeks: 20 hrs/week; (c) 9th-16th weeks: 20 hrs/2 weeks; and (d) 17th-52nd weeks: 20 hrs/3 weeks.

The frequency and duration of separations were recorded and classified into four categories, depending on the relative roles of the mother and calf in separating and regaining physical proximity. Initially the calves were responsible for separation from their mothers whereas the mothers were inclined to maintain physical proximity to their young. Since the age of two weeks for Tabo and seven weeks for Golia, mothers began to promote separations and the calves attempted in most cases to regain contact with them, although most separations continued to be mainly promoted by the calves. Thereafter, and until the 52nd week of age, both separations and reunions were mainly the decision of the calves.

In conclusion, the two mother-calf pairs showed a similar ontogenic profile in spatial behaviour, although we observed some significant variations in the frequency, duration and modality of separation. It seems likely that such differences could be partly due to the dominance of Golia's mother, who showed less tolerance to the calf's separations.

MOTHER-CALF-RELATIONSHIP AND BEHAVIOURAL DEVELOPMENT OF TWO NEWBORN BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

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INTRODUCTION Analyses of mother-offspring relationships have been made for several species of mammals, especially for various species of primate. For cetaceans, very little data exist. In the wild behavioural investigations of mother-calf-pairs of dolphins are very difficult to study. Although the breeding success of captive bottlenose dolphins is increasing (77 bottlenose dolphin births in Sea World since 1978) the mother-calf-relationship and the behavioural development of calves have hardly been studied.

In November 1993, two bottlenose dolphin calves were born at the dolphinarium of Nuremberg. The breeding facility in Nuremberg provides very good conditions for the observation of the animals. The calves were one of each sex and their mothers differed in age and experience. The initial signs of these influences on the mother-calf relationship shall hopefully be concluded from this study.

METHODS Observations of both females were started four months before the births in order to establish a behavioural base-line and to record behavioural changes in the last months of the gestation period. Each female was observed for one hour per day using focal-animal sampling (Altmann, 1974) and a continuous record (Martin and Bateson, 1993). After the births, this type of observation was continued, adding new behavioural categories. During the observation interval, video and audio information were simultaneously recorded. Thus, acoustic communication between mother and calf and the correlation of certain behaviours and sounds could be analysed. A second type of behavioural sampling, in which the behaviour of each mother-calf pair was recorded every hour for twenty minutes, was conducted in order to obtain a precise idea of behavioural changes over a 24 hour period.

RESULTS The results presented here are taken from the 24-hour-recordings. Both calves exhibited a very high frequency of suckling bouts during the first days of their lives. Noah (son of Eva) showed a rate of 11 to 20 suckling bouts per hour during his first 10 days (Fig. 1). The rate dropped to 4.5 bouts per hour during days 11 to 28 (n=18, s=1.8). During the following five months, a mean rate of 2.4 suckling bouts per hour (n=17, s=0.6) was recorded. In her first half year Neike (daughter of Emy) showed a slightly higher suckling rate than Noah. During her first week, the number of suckling bouts per hour was as high as Noah's, ranging from 9 to 20 bouts per hour (Fig. 1). During the next three weeks, the mean suckling frequency diminished to 5.3 bouts per hour (n=21, s=1.6), and further to 3.2 bouts per hour (n=18, s=0.9) during weeks 5 to 25.

During the first month, both mother-calf-pairs swam close to each other almost the entire time. With Neike and Emy, the amount of time spent with synchronous swimming diminished slowly and evenly, from 85.9 % in week 7 to 53.9 % in week 24. Noah and Eva exhibited a more irregular pattern for this behaviour: in week 8, they spent 51.8 % of the total observation time in synchronous swimming. In week 15, this behaviour reached a peak with 75.4%, ranging from 52.2% to 61.1% during the weeks 16 to 24. The amount of time spent with synchronous swimming was 53.9% at the end of the first six months, equalling the proportion of the time budget taken for this behaviour by Neike and Emy at the same point of development.

Parallel to the decrease in synchronous swimming, the amount of time the calves spent separated from their mothers increased. The behavioural category "calf alone" comprises all sorts of activities, where mother and calf separate and pay no attention to each other. The calf may swim or jump around in the tank, play with an object, or explore the tank. The development of the two calves concerning this category shows some differences. As with synchronous swimming, Neike exhibited a more regular increase than Noah did (Fig. 2). The amount of time that Neike spent on her own increased from 2% in week 6 to 31.2% in week 24. She spent a large amount of time alone during weeks 18 to 24, when the percentages ranged from 30 to 40%. From week 8 to 24, the average rate of being alone was 26.7% (n = 17) with a high variation (s = 9.3). Noah separated from his mother at an earlier stage of his life. Already, in week 6, he spent 10.1% of the observation time on his own. Throughout weeks 8 to 21, the amount of time spent alone ranged from 19.1% to 32.8%. The first time that Neike spent more than 20% of the time separated from her mother, was recorded in week 11. With Noah spending on average 26.2% of time alone during weeks 8 to 21, this nearly equalled Neike's average time spent alone (but the standard deviation was much less: s = 4.4, n = 14).

DISCUSSION The preliminary results presented here concern only very few behavioural categories, but they already show similarities and differences in the development of the two mother-calf-pairs. The suckling behaviour and the quality of the most prominent behaviours exhibited in the first six months are very similar in both pairs. On the other hand, the development of independence, that can be measured by the amount of time that mother and calf spend separated from one another, takes place at different ages of the calves with Noah gaining independence some weeks ahead of Neike. This is probably due to the different ages and experiences of the mothers. Eva being older and more experienced than Emy, allows Noah to leave her relatively early, whereas Emy is more cautious with her first calf and keeps it at her side for a longer period of time. The complete evaluation of the data will give us much more information and a detailed picture of the mother-calf-relationship of the bottlenose dolphin.

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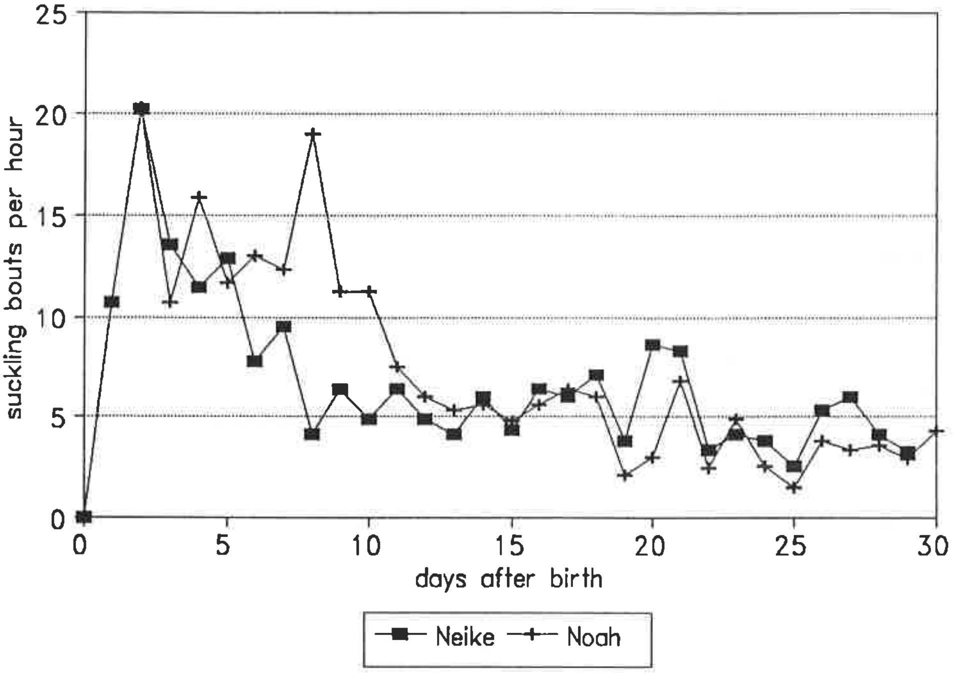

Fig. 1 Suckling behaviour

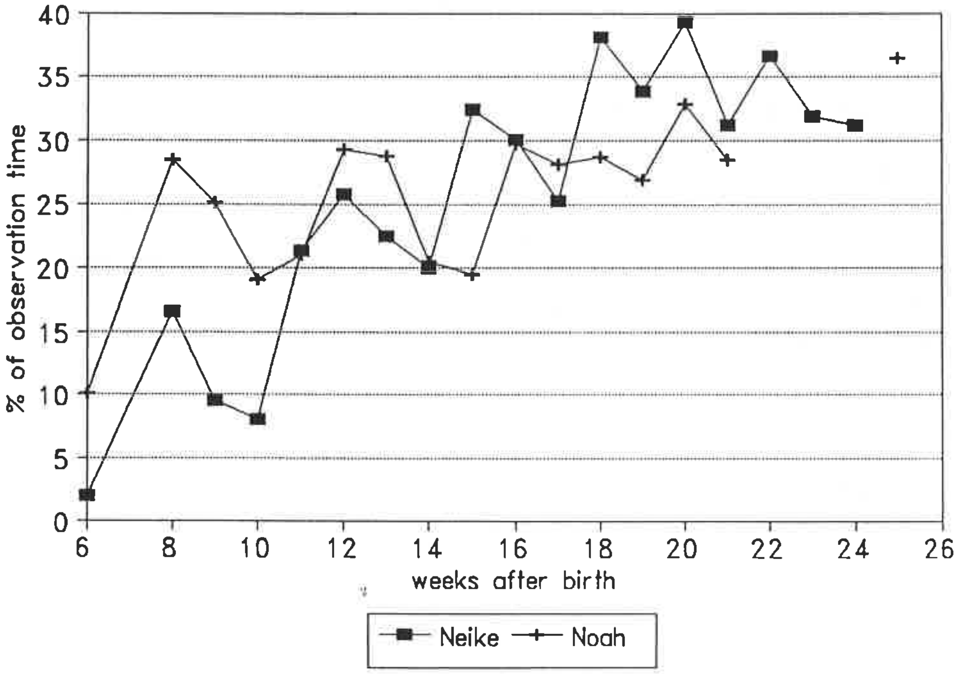

Fig. 2 Calf alone

PLAY BEHAVIOUR IN THE BOTTLENOSE DOLPHIN
(*TURSIOPS TRUNCATUS*)

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INTRODUCTION Within the behavioural repertoire of many mammal species, play behaviour comprises a significant proportion of time. Play is defined as any activity which is carried out by an organism entirely for its own sake in a non-functional context. It includes behaviours such as searching, fighting, courtship, hunting, and copulation. Fagen (1981) views play as a behavioural tactic available to mature and immature animals, and is expressed with strategies dictated by natural selection.

Particularly in confined conditions, bottlenose dolphins are said to spend a significant time participating in playful behaviours (Bel'kovich, 1978). The main goal of this presentation was to describe the play behaviours in bottlenose dolphins and to measure the relative contribution of play behaviour to behaviour in general. A second aim of the study was to evaluate the influence of enrichment activities on the behaviour of the dolphins by presenting them with different types of objects.

METHODS During the study, five dolphins (two subadult males and three adult females) were observed. The behaviour of each animal was recorded using the focal sampling and continuous recording methods (Martin and Bateson, 1993). In order to evaluate the influence of objects on the behaviour of the dolphins, a total of 28 different types of object were presented to the animals. The behaviour in the absence and presence of these objects was analysed using the software package Observer 3.0 (Noldus, 1991). Duration, frequency, and the relative contribution of each behavioural category to total behaviour were recorded and calculated. Twenty sampling units (each of 45 min. duration) were carried out.

RESULTS A detailed description of 44 behavioural categories observed during this study is shown in Table 1. Behavioural categories are divided into two major groups: object play behaviour, and social behaviour. Fig. 1 shows the relative contribution of each primary behavioural class to total behaviour, under the condition where objects are present. The percentage was calculated for one animal on the basis of ten sessions, during which at least ten different types of objects were placed in the tank. Fig. 2 shows the relative contribution of the most frequent object-play behavioural categories that occurred in 7.9% of the observed time (label "op" in Fig. 1). The social behaviour class (label "sb" in Fig. 1) included social play behaviour (label "pb" in Fig. 1), and other behaviour categories like resting or normal swimming (see Table 1). Further social behaviour categories classified as non-play behaviours (not marked with * in Table 1) occurred in 58.1% of the observed time, whereas play categories occurred in 34.5%. There was a slight overlap (0.5%) in the occurrence of object play and social behaviour. A detailed analysis of the relative contribution of social play categories is shown in Fig. 3.

A detailed analysis showing the relative contribution of each behaviour category during control sessions (without objects in the tank) is presented in Fig. 4. Social play categories occurred during 37.7% of the observed time, the remaining social behaviour categories comprised 62.3% of the observed time. A detailed analysis of the relative occurrence of play behaviour categories is shown in Fig. 5.

DISCUSSION Even when only a few sessions were analysed, there was a tendency among the dolphins to show increased rest behaviour during control sessions. The presence of objects in the tank induced play behaviour and decreased the occurence of resting behaviour. During the total observation time, the relative contribution of aggressive behaviour was not significant. The results obtained demonstrate a high percentage of play behaviour (42.4% op+pb, 37.7% pb under the control condition) which is clearly higher than the occurrence of play behaviours (3%) observed in other mammal species including primates and carnivores (Fagen, 1981).

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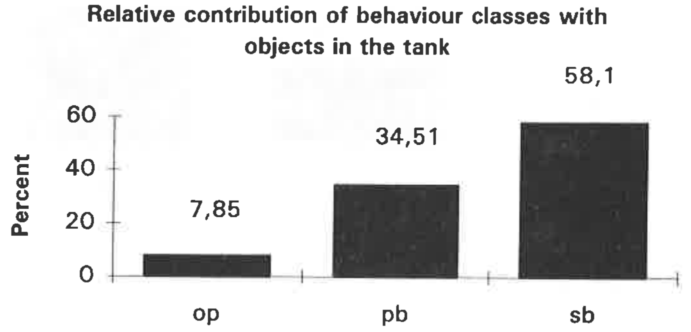

Figure 1: Relative contribution of behaviour classes with objects in the tank.
op: objectplay; *pb*: play behaviour; *sb*: social behaviour

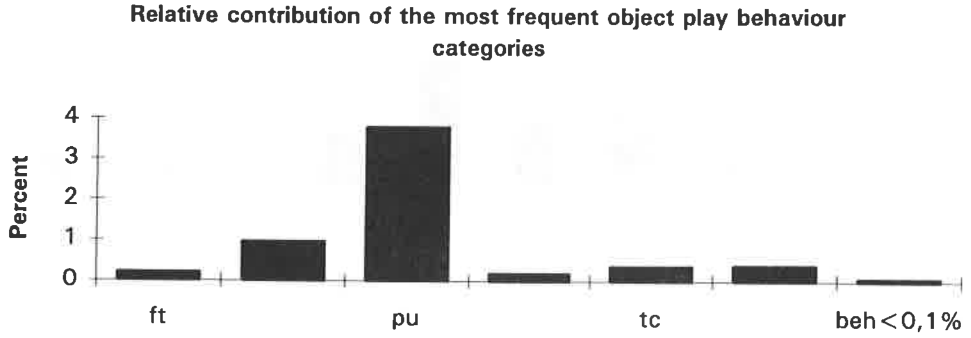

Figure 2: Relative contribution of the most frequent object play behaviour categories
tr: transporting; *pr*: pressing; *pu*: pushing; *so*: swimming with an object in the beak; *tc*: throw and catch; *beh.<0,1%:* behaviours that occur in less than one percent of the observed time

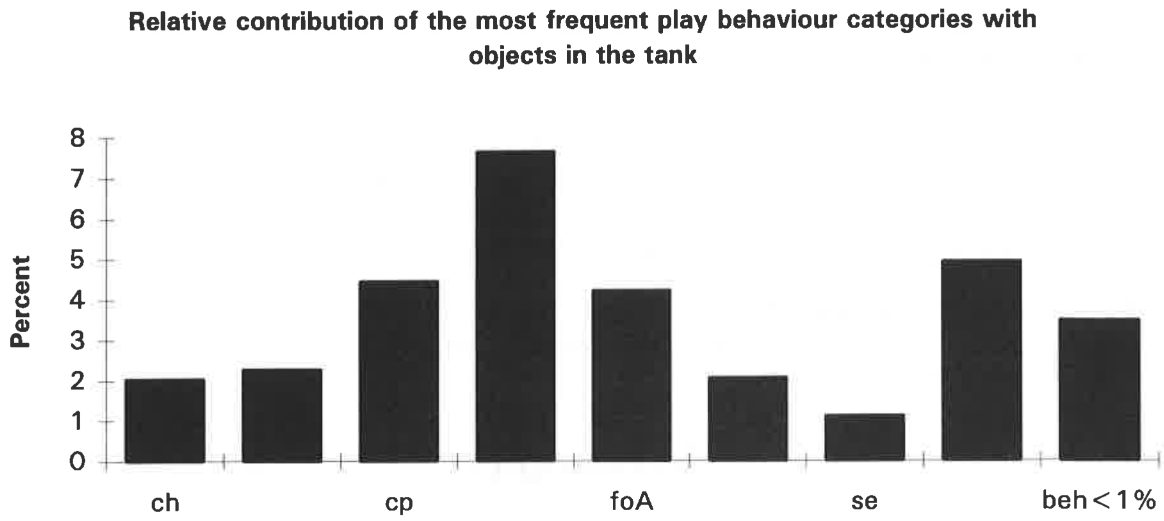

Figure 3: Relative contribution of the most frequent play behaviour categories without objects in the tank. *ch*: chasing; *ci*: circling; *cp*: contact play; *fo*: being followed; *foA*: following active; *ob*: observing; *se*: sexual play; *ta*: tailcatching; *beh.<1%*: behaviours that occured in less than one percent of the observed time

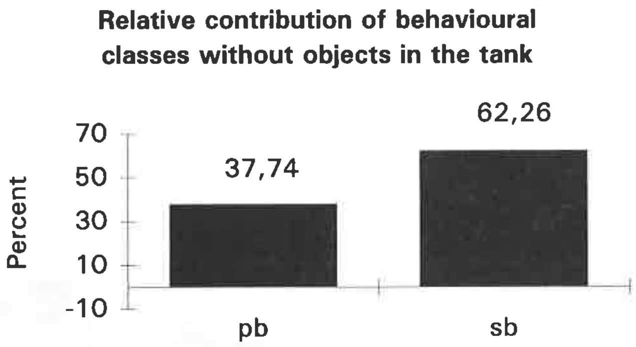

Figure 4: Relative contribution of behavioural classes without objects in the tank. *pb*: play behaviour; *sb*: social behaviour

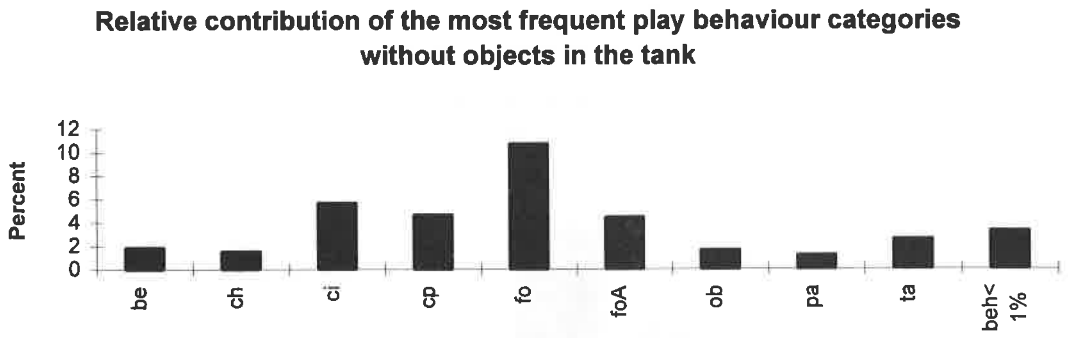

Figure 5: Relative contribution of the most frequent play behaviour categories without objects in the tank. *be*: beaching; *ch*: chasig; *ci*: circling; *cp*: contact play; *fo*: being followed; *foA*: following active; *ob*: observing; *pa*: passing; *ta*: talcatching; *beh<1%:* behaviours that occur in less than one percent of the observed time.

Table 1 Behavioural categories for the analysis of play behaviour in the Dolphinarium of Nuremberg

1. playing with objects

Category	Code	Definition
balancing	ba	balancing an object on the beak
catching	ca	catching an object with the beak
dribbling	db	dribbling an object with the beak
passing	po	passing and slightly touching an object
pressing	pr	pressing an object under water with the beak or other parts of the body
pushing	pu	pushing or pulling an object with the beak
rolling	ro	rolling an object on the ground by using the beak or other parts of the body
swimming with an object	so	holding an object in the beak while swimming
throwing and catching	tc	throwing and catching an object with the beak
transporting	tr	transporting an object by using the outside o the beak, the melon or other parts of the body
under the platform	up	stationing an object under the platform
following with object	ft	following another animal with an object in the beak
chasing with object	ct	chasing another animal with an object in the beak
observing with object	ot	observing with an object in the beak
tailcatching with object	to	tailcatching another animal with an object in the beak

2. social behaviours

attacking *	at	swimming towards another animal at high speed
beaching *	be	gliding out of the tank with the entire body
blocking *	bl	obstructing other animals
breaching *	br	jumping and landing on the back, the belly or on the side
chasing *	ch	chasing other animals
circling *	ci	swimming around other animals or objects
contact play *	cp	behaviour that includes short tactile, chasing and tailcatching interactions
cross swimming *	cs	zizagging in front of other animals
drifting	dr	swimming smoothly
following *	fo	pursuing other animals
frontal *	fr	standing or swimming in front of other animals
moving an animal *	mi	pushing an animal at its tail, the pushed animal is immobile
observing	ob	watching other animals or objects
pressing an animal *	pi	pressing other animals down by using the beak or other parts of the body
pushing an animal *	ip	shortly pushing other animals
pushing away *	py	pushing away other animals from someone or something
ramming *	ra	ramming other animals with the melon
resting position	rp	the dolphin lays inactive in the water
rubbing	ru	the dolphin rubs its body at other animals or objects
sexual behaviour *	se	any tactile interaction in/ with the genital region
jumping *	ju	the dolphin leaves ther water entirely
speedy swimming *	ss	swimming at high speed
tail catching *	ta	pursuing other animals with open beak and trying to catch their fluke or peduncle
tailslapping *	ts	slapping other animals or on the water surface with the fluke
waving *	wa	slapping one flipper on the water surface while swimming at the side
in the channel	ic	the animal is in the channel and out of sight
beak to beak *	bt	two animals are rubbing their beaks against each other

* activities that might appear in a playful context

BEHAVIOURS ACCOMPANYING A CHANGE IN THE DOMINANCE HIERARCHY OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) WITH RESPECT TO ADULT MALES

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INTRODUCTION A dominance hierarchy is both a consequence of interactions among group members and also a rule-system that, after establishment, can regulate social conflicts. However, in a number of species, this rule system may not persist, because subdominant individuals attempt to increase their rank position. In marine mammals such as the bottlenose dolphin (*Tursiops truncatus*), social relationships are particularly dynamic between adult males, and this can cause severe problems if individuals do not have enough space (Saayman *et al.*, 1973; Bateson, 1974; Wells *et al.*, 1980; Östman, 1991).

In this paper, we present our first results of a study on changes in the dominance hierarchy of bottlenose dolphins. In particular, we document behaviours of individuals, that accompanied an increase in the rank position of an adult male. The study has been conducted in the semi-free confinement of the Dolphin Reef, Eilat, Israel. Details of the site and further projects running there are given in Todt & Hultsch (this volume).

METHODS Data presented here were collected during 87 days from 3 June through 20 September, 1994. Minimum observation time per day was eight hours during daylight. Additional observations and recordings were conducted until the end of January 1995. Recordings were made by two hydrophones with preamplifiers (all B&K) and video cameras (Sony, CCD series). Observations were conducted both from underwater and from the observation tower, 10 m above sea level. Besides two adult males (Dicky and Cindy, approximately 8 and 20 years old, respectively), three adult females inhabit the confinement and one female calf (born in 1992) in addition to two male calves, both born on June 27, 1994.

To describe the changes in the relationship between the two males, we divided the examined period into three developmental phases, lasting 39, 27 and 21 days, respectively. Phase distinction was based on both the space in which the subjects were mainly seen swimming and by their social partners. We concentrated on two behavioural categories: 'chase' and 'rough-and-tumble-interaction', both involving at least two dolphins.

Chase Following another dolphin at high speed. Actor and recipient are not changing their roles. Chases often include attacks (bites or strong tail thrusts) by the actor which can result in visible wounds or scratches. The swimming is highly directional, i.e. with a straight course.

'Rough-and-Tumble-Interaction' (RTI) A versatile behavioural pattern characterised by a rather stationary episode including a lot of physical contact between the participants such as pushing and poking each other, head-butting, biting different parts of the body, or jumping onto each other. This period can be preceded and/or followed by more locomotory behaviour like parallel swimming (both fast and slow), parallel jumps, or one dolphin following the other. The swimming is not directional. During slow parallel swimming, the dolphins may touch each other either with the pectoral fins or the tail. The roles may change within one interaction. The duration of a RTI is highly variable, i.e. ranging from one minute to half an hour.

RESULTS AND CONCLUSIONS **Phase 1** This was characterised by very few interactions between Cindy and Dicky. Both spent most of their time in different subgroups, and, after the birth of the two calves, Dicky, the younger male, could typically be seen swimming alone. Although the relative frequency of RTI during phase 1 was low (see Fig. 1), the majority of interactions between Cindy and Dicky, besides the chases by Cindy, consisted of this behaviour.

Phase 2 This showed a similar proportion of chases by Cindy on Dicky and vice versa (see Fig. 2). In addition, Dicky could still be seen swimming alone in the flat areas of the enclosure while the remainder of the dolphins were resting in the preferred deeper areas. Nevertheless, he spent much more time with his conspecifics than before. Relative frequency of RTI with Cindy increased to about three times as compared to phase 1.

Phase 3 This was characterised by the greatest changes, with Dicky now joining the other dolphins regularly. Neither of the two males could be assigned as dominant over the other, as was clear before. Cindy was still chasing Dicky often, but now Dicky did so as well. Comparing the relative frequencies of his chases towards Cindy yielded a frequency almost ten times higher than was observed in phase 2. The amount of RTI increased again and reached its maximum value here.

Not only did the frequency of RTI's increase during the course of the study, but also the type of behaviour itself was subject to modifications. In phase 1, the two males could be observed interacting in this way exclusively. In phase 2, Cindy showed this behaviour several times (Dicky once) with always the same adult female. In phase 3, three individuals participated simultaneously in an RTI, both males and the already mentioned female, for the first time. RTI's involving more than two animals consisted only of the tumble phases of the behaviour. A characteristic of the RTI's between the males was that they often occurred at predictable times, and in phase 3, in predictable areas. During RTI, the vocal signalling behaviour showed special features. The sounds produced were highly variable, both in single parameters and in types. Besides highly vocal episodes during RTI, we regularly found longer periods (>1 min) where no sound at all was produced up to a range of 50 kHz (the upper frequency limit of our recording system). Such 'silent' episodes occurred both during the more locomotory and the tumble-like interactions.

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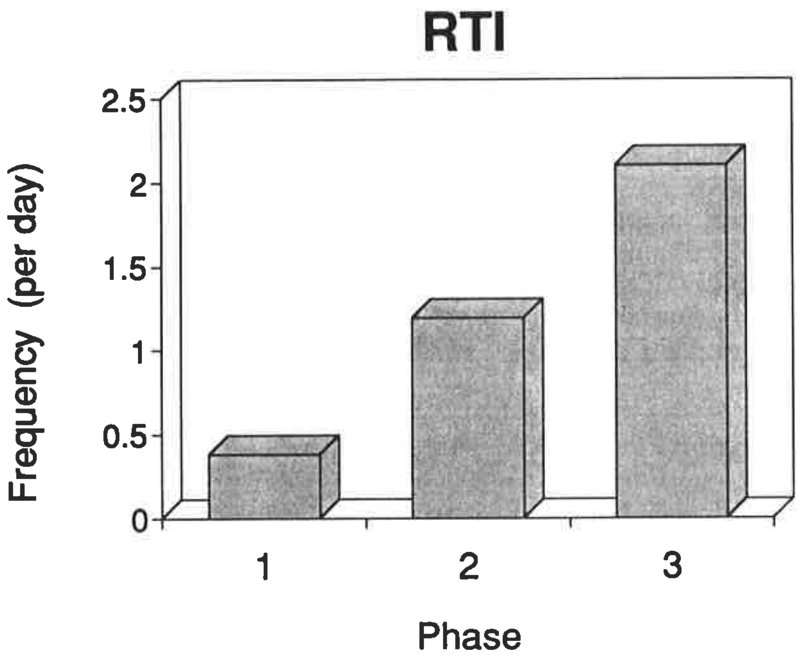

Fig. 1 Frequency (Mean) of 'rough-and-tumble-interactions' (RTI) performed by Cindy and Dicky during the developmental phases 1; 2; 3 (see text). Standard deviations (phase 1; 2; 3) were: 0.78, 0.79, 1.67.

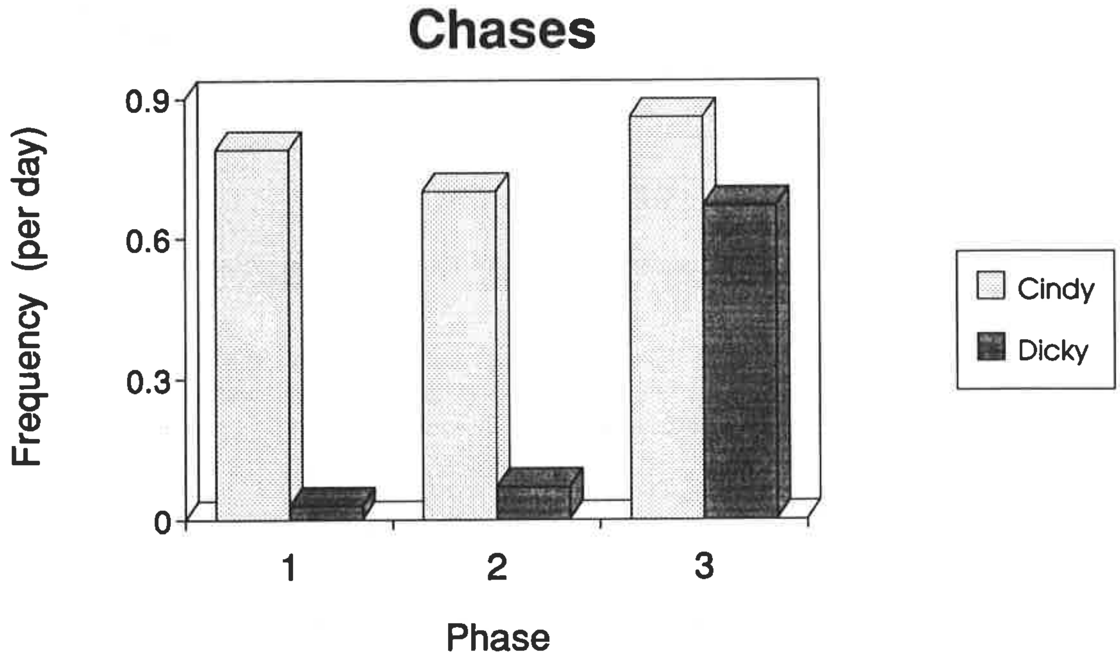

Fig. 2 Frequency (Mean) of chasing episodes during the developmental phases 1, 2, 3. Light = Cindy chasing Dicky. Dark = Dicky chasing Cindy. Standard deviation (phase 1; 2; 3) for Cindy : 1.0, 1.17, 0.79, for Dicky: 0.17, 0.26, 0.73.

ON THE ASSESSMENT OF STEREOTYPED BEHAVIOUR IN CAPTIVE DOLPHINS

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INTRODUCTION Stereotyped behaviour patterns are seen as indicators of a lack of space and structure in housing conditions, and a lack of social interactions in captive animals (Ridley and Baker, 1982; Mason, 1991). Thus they are important in assessing the quality of the housing conditions of animals. In this abstract, a list of phenomena is presented that describes possible indicators for stereotyped behaviour patterns in dolphins. A second list provides other factors which may imply that the observed behaviour patterns are not stereotyped.

The two lists are condensed from the general definitions of stereotyped behaviour patterns by Mason (1991), and the specific observations of bottlenose dolphins (*Tursiops truncatus*) by Greenwood (1977), Gygax (1993), and Sobel *et al.* (1994).

Indicators of stereotyped behaviour patterns

- Single behaviour pattern (e.g. head-pressing) shown repeatedly, often at a specific location (Greenwood, 1977).
- Behaviour pattern shown consistently in a specific location in space, e.g. skewed swimming (Gygax, 1993).
- Swimming in circles with stereotyped direction of circling which can only be disturbed by social interactions and not by physical changes in the environment (Sobel *et al.*, 1994).
- Spatial movement on stereotyped routes, e.g. swimming in circles (Gygax, 1993).
- Increased circling (rate of circles, speed) prior to a feeding session (Mertens, 1977, Gygax, 1993).
- Decrease in diversity of behaviour prior to a feeding session (Mertens, 1977; Gygax, 1993).
- Increase of stereotyped behaviour patterns with length in captivity (Gygax, 1993).

Indicators of non-stereotyped behaviour patterns

- Turning, breathing and leaping occurring in less restricted areas of the tank than in various species of seals (Lorenz, 1969).
- Swimming in circles without following very strict routes (varying by about 1 m on either side).
- All animals show similar patterns, though stereotyped patterns are known to be individualistic (Mason, 1991).
- An alternative explanation for swimming in circles is that fast swimming can only be shown in circles and that swimming in the same direction as their poolmates could allow the dolphins to avoid disturbance of their swimming paths, caused by collisions with each other.

DISCUSSION The behaviours under consideration could not reveal any clear presence or absence of stereotyped patterns in the captive dolphins. This implies that an assessment of stereotyped behaviour patterns in captive dolphins can only be done, if at all, with a broad investigation considering many different factors. A specific difficulty in assessing stereotyped behaviour patterns in dolphins is the fact that the dolphin's habitat and behaviour are perceived as very unusual by human observers, and interpretation of behaviour cannot be done in an intuitive way. In other words, the decrease of familiarity with a species from a terrestrial mammal to seals and dolphins might be reflected in the declining ease of assessment of stereotyped behaviour patterns.

It is crucial to gain more knowledge on how to interpret cetacean behaviour in the wild if one is ever to judge certain spatial behaviour as sterotyped, in captivity. For example, it might be possible to compare the restriction of swimming routes and locations of turning, breathing, and leaping to the patterns found in the wild.

ACKNOWLEDGEMENTS I thank many members of the Department of Ethology at the Universtiy of Zurich for useful dicussions, and KNIE's Children's Zoo for the opportunity to collect data. Special thanks to A. Griffin who often pointed out contradictions in my arguments and patiently corrected my English.

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A WILD DOLPHIN FEEDING PROGRAMME AT TANGALOOMA, AUSTRALIA

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To date, the only reported long term, regular interaction, where tourists hand-feed wild dolphins has been at Monkey Mia, Western Australia. There are no data which detail the beginnings of this interaction as scientific research commenced there in the mid 1980s, nearly two decades after the feeding began.

In early 1992, a similar human-dolphin interaction (*Tursiops* sp.) began at Tangalooma, on the shores of Moreton Island, 35 km east of the city of Brisbane, Australia. This interaction has been closely monitored with regular and systematic observation, backed up by video and hydrophone records. It provides the first detailed account of how these kinds of interactions begin and develop.

This paper reports on the specific conditions which existed within the local dolphin pod before the hand-feeding began. It traces the behaviour of dolphins as they started to take fish from humans in 1992, and it details the increasing confidence of the dolphins during these interactions over subsequent years. Furthermore, the paper outlines some of the potential risks associated wth these kinds of interactions, both for the dophins and for the tourists, and it suggests strategies which may be successful in alleviating them.

BEHAVIOURAL ECOLOGY OF THE DOLPHINS *INIA GEOFFRENSIS* AND *SOTALIA FLUVIATILIS* IN THE UPPER REGION OF THE AMAZON, PERU

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INTRODUCTION The behavioural ecology of the dolphins *Inia geoffrensis* and *Sotalia fluviatilis* was studied between October 1994 and September 1995 in the Río Samiria, Río Pacaya, and Río Tapiche - black water rivers of the Peruvian Amazon. All these rivers are several hundred kilometres long and up to 200 m wide. The Río Samiria and Río Pacaya are relatively clean and are part of the Pacaya-Samiria National Reserve. This reserve has an area of 20,800 km^2 and is the second largest nature reserve in the whole Amazon region (Bayley *et al.*, 1992). The Río Tapiche is inhabited by 25,000 people living in 13 villages and the town of Requena.

METHODS Our main observation platform was the 18 m wooden houseboat "Miron Lento" powered by a 24 horsepower inboard diesel engine. For smaller tributaries and lakes, we used the 6.5 metre aluminium boat "Miron de Bufeo" powered by a 65 horsepower outboard engine. Between October and December 1994, which includes part of the dry season and part of the season when the water is rising, we surveyed all three rivers from the mouth to 350 km upriver. Three observers were always present on the top deck of the large boat (3.4 m above the water level). During surveys with the smaller boat, two people were located on the observation platform (2.0 m above the water level).

Photo-identification and focal animal observation (14 hours) were used to study abundance, distribution, site fidelity, movement patterns, foraging strategies, and the social system of *Inia* and *Sotalia.* Natural marks including pigmentation pattern were used for identification (Leatherwood *et al.*, 1991). Due to their surfacing behaviour, photo-identification of *Inia* turned out to be quite difficult. It was almost impossible to predict where and when they would next surface. In addition, *Inia* may also surface for hours in a manner that reveals only a few centimetres of the body above the water surface. A change of colour or intensity of colour, as described by Trujillo (1994), has never been observed. Photographing *Sotalia* was even more difficult. *Sotalia* has a large fleeing distance - almost too large to allow good pictures of these small cetaceans to be taken. *Sotalia* also often "run" through the water creating much splashing, so that no clear view of the body is possible.

RESULTS The results of our first surveys (October to December 1994) are presented here: *Inia* were found in all three rivers from the mouth all the way up-river, and *Sotalia* were only seen in the first 250 km where the rivers were wider, deeper, and had less current. The total numbers of each species sighted indicate that these rivers were inhabited by more *Inia* than *Sotalia.* The ratio in all three rivers was between 2:1 and 3:2.

The abundance of *Inia* in the Río Pacaya and the Río Samiria was very high - approximately one *Inia* per two kilometres of river, and was even higher in the Río Tapiche, with about one *Inia* per kilometre of river.

The dolphins were mainly seen in pairs or small groups of three or four animals. Only 2% of all *Inia* and *Sotalia* were sighted singly. In general, calves were seen further up-river, especially in the Samiria. Nine of the 16 calves seen in the Samiria were in the last 80 km of river in the 350 km survey; and of twelve sightings of *Inia* in that area, nine were seen with calves. Fig. 1 shows the group size distribution and the calf sightings in relation to the group size of both species. *Inia* calves were mainly found in groups of three and four animals, as were *Sotalia* calves, but the latter were also often just with the mother. The groups of three animals consist mainly of the mother, her calf, and a large animal, which by its size, appearance and behaviour was apparently a male. In a group of four animals, there would typically be a mother, calf, male, and a juvenile - most probably the offspring of the previous year.

DISCUSSION The numbers of our calf observations are small, but there may be indications of a system in which *Inia* in particular, moves inside the tributaries of the large rivers (e.g. Amazon, Marañon, Ucayali) during the calving season. From there, they move further upstream.

Inia does not, as presumed for other areas (Best and da Silva, 1989), live solitarily. The high abundance of the top predators, *Inia* and *Sotalia*, in all three rivers suggests that dolphins play an important role in the Amazonian riverine ecosystem. Further surveys will show if the results we found vary with season and water level.

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

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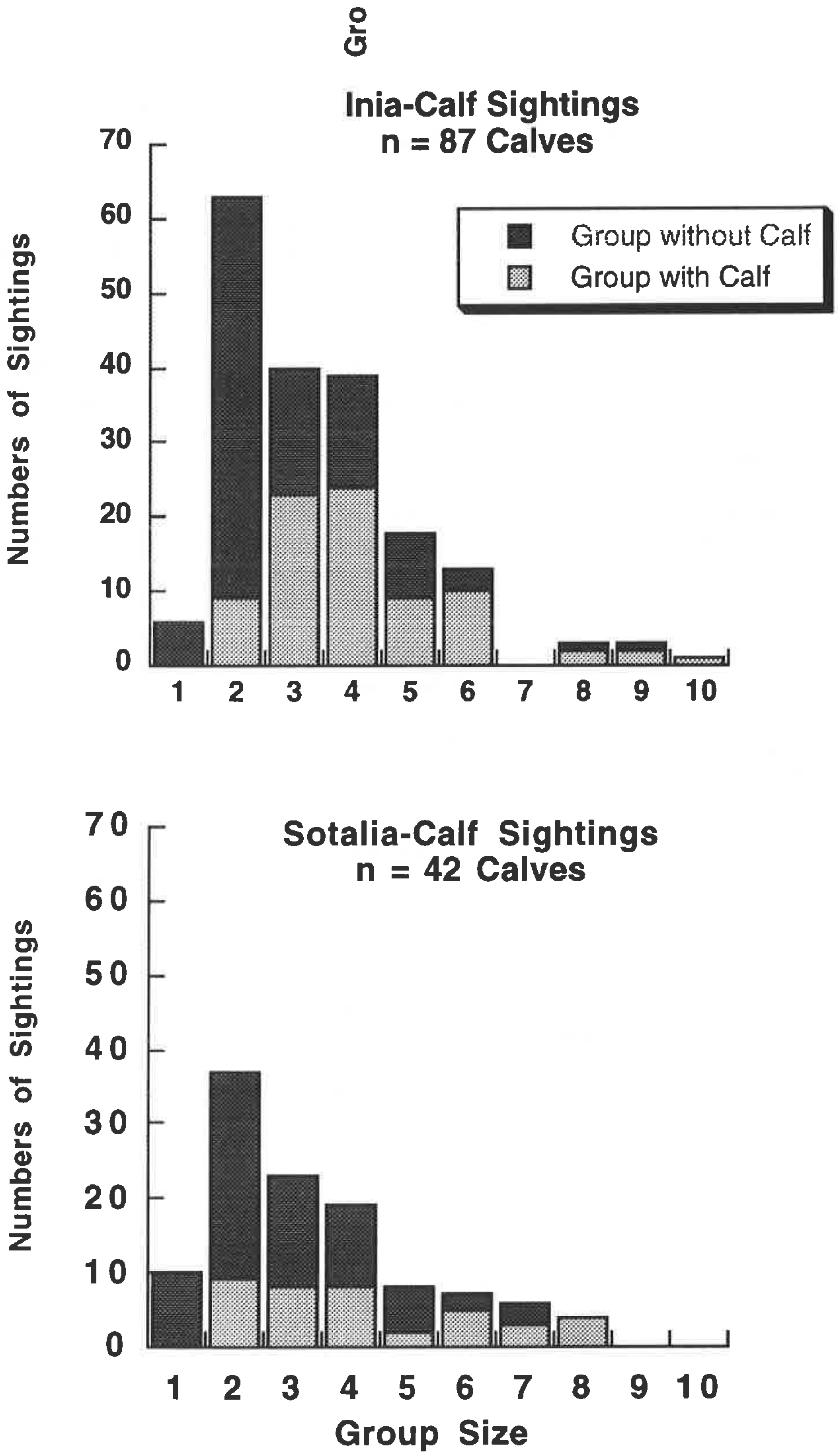

Fig. 1 Group size distribution and calf sightings in relation to group size of *Inia geoffrensis* and *Sotalia fluviatilis* (Oct.-Dec. 1994 in three rivers of the Peruvian Amazon).

ASPECTS OF THE BIOLOGY OF THE HARBOUR PORPOISE, *PHOCOENA PHOCOENA*, IN GERMAN WATERS

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As a part of a national research project on the abundance, health status and migration of small cetacean populations in German waters, a total of 449 stranded and bycaught cetaceans from the North Sea and Baltic Sea were examined at the University of Kiel between 1990 and 1993. Gross pathological examinations were performed and measurements and samples for further studies were taken. Sex, total body length, girth, blubber thickness, and body and organ weights were recorded. Reproductive organs and teeth were collected for age determination.

The maximum length and weight of females was 1.63 m and 73 kg respectively. For males - the corresponding values were 1.56 m and 45 kg. The oldest harbour porpoise was an 18-year old male from the North Sea. Yearlings and neonates formed the largest age group of the stranded and bycaught dolphins. Neonates measured 0.78 m in length and weighed 9 kg.

Data for age and length of individuals in relation to sex and location were taken to calculate a growth-curve. Males were seen to grow faster in body-length during their first month. However, during the first years, females were larger than males of the same age. Animals from the Baltic Sea were larger than those from the North Sea of the same age.

PRELIMINARY RESULTS ON REPRODUCTION OF HARBOUR PORPOISES IN GERMAN COASTAL WATERS

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Reproductive rates are essential components in describing the dynamics of populations. In former studies, the results of reproduction of harbour porpoises *Phocoena phocoena* are very different: sexual maturity is attained at between 14 months and 6 years, depending on region and author. Reasons for this dissimilarity may be based on different methods, but formerly it was not possible to generalise from one population to another, because they live in different ecological habitats.

In this Diploma thesis, as a part of a national research project on the abundance, health status and migration of small cetacean populations in German waters, the anatomy and histology of reproductive organs were examined. The main effort has concentrated upon the life history parameters, age at sexual maturity, reproductive seasonality, and pregnancy rates.

Between August 1990 and March 1993, the reproductive organs of 64 out of 268 stranded and bycaught harbour porpoises were examined. The animals originated equally from the North Sea and the Baltic Sea. As the available material was very limited, statistically consolidated results cannot be expected.

For females:

-Evidence of lactation was obtained.
-The uterus was measured and examined for the presence of a foetus.
-After measuring and weighing the ovaries, corpora lutea and albicantia were counted, measured, and histologically analysed.
-The follicular development in the ovaries was recorded and in each case the largest ones were measured.

For males:

Size and weight of testes with and without epididymis and samples for histology were taken. Diameter of seminiferous tubules and phases of spermatogenesis were recorded.

CHANGES IN THE GONADS WITH AGE

Females

Age specific ovary weights of female harbour porpoises from the North Sea

-Up to an age of 3.75 years, the combined ovary weight increased only slightly. These animals were sexually immature.
-At the age of 4 years and older, the sizes and combined ovary weights increase greatly. These females have reached sexual maturity. The weight of mature ovaries varies greatly with reproductive status and ranges here from 4 to 14 g.
-At the age of 12 years and older, the weight of the ovaries is lower. These females were senescent. No follicles can be recorded in their ovaries.

A similar distribution of the data is seen between combined ovary weights and body length of the female harbour porpoises.
-At a body-length of 138 cm and longer, the combined weights of the ovaries increase greatly. These animals were sexually mature or senescent.

The female harbour porpoises of the North Sea generally reach sexual maturity at the age of 4 years and at a body-length of about 140 cm.

Age-specific ovulation rate of harbour porpoises
The number of corpora increases with age. The corpora albicantia seems to persist indefinitely. Young females often ovulate more than once each year. Older females seem to ovulate only once each year. In the female harbour porpoise, only the left ovary becomes active. The right usually remains undeveloped throughout life. However, one sexually mature female from the Baltic Sea seems to be an exception. Her ovaries showed a bilateral activity.

Males

Age-specific testes weights of male harbour porpoises from the North Sea
-Testes weights of male harbour porpoises at two years of age or less show a slight increase with age, from 4 g (in a newborn male) to 21 g (in a 2-year old animal). Immature males have seminiferous tubules ranging in diameter from 40 to 80 µm, but the sizes and weights of testes of the four year and older males are much bigger and heavier. Their combined weights range from 300 to 1,050 g. The histological examination demonstrates that these animals have reached sexual maturity. A significant increase in tubule diameter is found. The wide range of the values is notable. There is no correlation between testes weights and age of mature males.

Generally, and according to the presence of a pre-pubescent male at the age of 2.75 years, one can suppose that male harbour porpoises of the North Sea reach sexual maturity at the age of 3 years and at a body-length of about 125 cm.

REPRODUCTIVE SEASONALITY

Parturition season
All carcasses of neonates were found in the period from late May to mid-July. Accordingly, calving in this population of harbour porpoises occurs from May to July. Most of the neonates were found along the coast of Sylt. In the vicinity of this island, there seems to be an important breeding-area.

Mating season
Mating seasons of harbour porpoises can be inferred from studies of the state of the testes of mature males. Even reasonably good data from such sources may not necessarily allow one to define a mating season with great precision, because here, sampling is limited to a particular time of the year. The heaviest testes with the largest tubule diameters were found in a dying male in July. In the following months, the combined right and left testes weight decreased from 1,050 to 150 g by December. Because of the lack of material from January to June, it is conceivable that mature males may also possess enlarged testes in June.

Conclusive mating seems to take place in the high summer months between June and August.

PREGNANCY RATES

Pregnancy rate was calculated as the proportion of pregnant animals in the sample of mature females. The reported proportion of mature females carrying a detectable foetus is only 0.3. This is surprisingly low for a relatively short-living sea mammal. If sampling occurred prior to implantation, however, the pregnancy rate will be underestimated. Another point to be noted is the often poor condition of the carcasses. In a rotten uterus, it is impossible to detect a small foetus, so it makes sense to use a corpus luteum on the ovary as a criterion for pregnancy. In this case, the preliminary estimated pregnancy rate is 0.8.

CONCLUSIONS

1. These preliminary results indicate that sexual maturity is attained at the age of three years in males, and four years in females.

2. Seasonal changes in testicular size, weight, and the presence of spermatozoa in the seminiferous tubules and in the epididymis suggest that copulation occurs around July.

3. After a period of gestation of 11 months, the calves are born between May and July.

4. The estimated pregnancy rate is 0.8. This high rate is indicative of yearly reproduction in this population.

RECENT HISTORICAL ASPECTS OF REPRODUCTION AND SEASONALITY IN THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) FROM DUTCH WATERS

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As part of an ongoing study of harbour porpoises in Dutch waters, historical (1920-1965) data were investigated for useful reproductive information. Recent dissection findings from harbour porpoises stranded on the Dutch coast between 1990 and 1994 give information on the life history parameters of the present population.

The following observations include both sets of data: near-term foetuses are observed in March and April. Neonates are found from May to the end of August and into September. Thus the reproductive season and birth period in Dutch porpoises appear to be extended by comparison with other populations. A previous study reported an age of sexual maturity (ASM) of six years for Dutch female porpoises, whereas in recent animals, an ASM of four to five years is found.

Information available from recent studies only includes some males with aseasonal sperm activity and, in a species known for its ovarian asymmetry, a high incidence (about 25 %) of females in which both ovaries are functionally developed.

LIFE HISTORY OF NARWHALS IN WEST GREENLAND

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Standard length and total body mass were measured and samples of reproductive organs, embedded teeth, lower jaws and stomach contents were collected from narwhals taken in the Inuit harvest in West Greenland during 1993-1994.

Age estimation was tested utilising both incremental layers in jaws and dentinal and cemental layers in embedded teeth. The largest (58) number of growth layer groups was found in decalcified and stained thin sections of the jaws. It is assumed that 2 growth layer groups are deposited annually. The mean standard length at physical maturity was 490 cm and 410 cm for males and females, respectively. The mean body mass at physical maturity was 1,600 kg and 880 kg for males and females, respectively.

Male narwhals attain sexual maturity at 12-16 years of age at a mean standard length of 450 cm. The testes weight was <100 g and >400 g for immature and mature males respectively. The tusk protrudes at a body length of 260 cm, and it continues to grow throughout the life of the narwhal.

Female narwhals attain sexual maturity at 6-9 years of age at a mean standard length of 380 cm. Gestation lasts at least 14 months, with implantation in early April, and calves are likely to be born in July-August when the females are at their summering grounds.

THE BIOLOGICAL SIGNIFICANCE OF ICE ENTRAPMENTS

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Several species of whales have been reported to have been encountered in ice entrapments. The most frequently entrapped whales are narwhals, *Monodon monoceros*, and belugas, *Delphinapterus leucas*. Certain areas in West Greenland are known to have entrapments of Monodontids at regular intervals of two to three years. In these areas, cold Polar water meets warm water of Atlantic origin, which makes the ice conditions particularly unstable.

When entrapped, the whales often die from lack of air, but in some cases they are discovered by hunters and subjected to severe hunting mortality. The pertinent question is whether these large scale periodic mass die-offs should be incorporated into the population predictions of the whale populations as part of their natural mortality. This assumes that the ice entrapments are density dependent.

Evidence from studies of mitochondrial DNA suggests that narwhals have very low genetic variability. This is probably caused by a historical ‘bottleneck’ in the size of the narwhal population. It is known that ice conditions during certain periods after the last ice age have changed dramatically within a short time in the North Atlantic. A possible hypothesis is that these changes in ice conditions were unfavourable for the narwhals and that this causes them to be reduced to low numbers.

THE ROLE OF THE MEDITERRANEAN IN FIN WHALE ECOLOGY: INSIGHT THROUGH GENETICS

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The fin whale, *Balaenoptera physalus*, is the only regular mysticete in the Mediterranean Sea. The species can be observed during summer mostly in the northwestern portion of the basin, in large feeding concentrations, and, in winter, in much smaller numbers throughout the area. Whether fin whales found in the Mediterranean are North Atlantic trophic seasonal immigrants, or a smaller isolated population permanently residing in this sea, has long been a subject of debate, and a number of alternative and intermediate hypotheses have been proposed (Marini *et al.*, 1992; Notarbartolo di Sciara, 1994; Viale, 1985).

Results of a genetic study have now provided evidence in support of the "residence" hypothesis. The nucleotide sequence in the mitochondrial control region was determined in 30 biopsies collected from free-ranging fin whales in the Ligurian Sea during the 1992 and 1993 summer seasons. A comparison with 221 whales sampled in five other feeding areas in the North Atlantic revealed that whales from the Ligurian Sea constitute a separate population (with respect to mitochondrial DNA), with a level of genetic diversity four times lower than that found in the North Atlantic sample (Berubé *et al.*, 1994).

If fin whales found in the Mediterranean are genetically distinct from their North Atlantic conspecifics, it is unlikely that they migrate during winter into the Atlantic Ocean to breed. The hypothesis of a small, reproductively isolated Mediterranean population is further corroborated by occasional observations in this region of cow-calf pairs in early summer (Tethys Research Institute, unpublished data), and by findings of stranded neonates in late autumn and early winter (Ficalbi, 1919; Paulus, 1966; Cagnolaro *et al.*, 1986). To determine whether Mediterranean fin whales constitute one panmictic population or a number of smaller, ecologically independent subgroups, the biopsy sampling scheme should be expanded to include whales found in areas other than the Ligurian Sea. Finally, to definitely prove the "residence" hypothesis, conclusive evidence of major fin whale breeding activities in the Mediterranean (which are likely to occur in the southern basin) must be provided.

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GENETIC STRUCTURE OF HARBOUR PORPOISES *PHOCOENA PHOCOENA* IN THE SEAS AROUND THE UK, EIRE AND THE NETHERLANDS

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INTRODUCTION The harbour porpoise *Phocoena phocoena* is the smallest and most commonly found cetacean around the shores of the UK. Despite this, remarkably little is known about either the population size or structure of these animals. Also, there are increasing concerns about the vulnerability of this species to being accidentally killed in fishing gear. The IWC and ASCOBANS have proposed that further research be performed to improve knowledge on porpoise numbers, levels of by-catches, and on population structure in the North Atlantic. This present study sets out to investigate porpoise population structure in the waters around the UK, Eire, and the Netherlands by direct sequencing of a portion of the control region of mitochondrial DNA (mit DNA), obtained via the polymerase chain reaction.

METHODS AND MATERIALS DNA was extracted from 155 porpoise tissue samples by standard procedures. The animals were subdivided into seven putative populations based on the proposals by Gaskin (1984). Animals were found stranded, unless otherwise stated, and both sexes were nearly equally represented in each area: Shetland (n=21, 13F & 8M, 19 bycaught); East England (n=33, 16F, & 17M), English Channel (n=4, 2M & 2F), Celtic Shelf (n=13, 2F, 3M, & 8 unknown, 9 bycaught) and the Irish Sea -East (n=40, (22M, 18F, & 1 unknown), Irish Sea-West (n=24, 7M, 12F, & 5 unknown, 8 bycaught) and the Netherlands (n=20, 8M, & 12 F).

The mit DNA control region was amplified using the polymerase chain reaction (PCR). Following the initial use of the primers of Kocher *et al.* (1989), more specific primers were designed for both PCR and sequencing. A 200 base sequence of the 5'-end of the control region was obtained by direct sequencing (McPherson *et al.*, 1993) of the PCR product using a commercial kit (USB Biochemicals, Sequenase 2). Nucleotide diversity of the different haplotypes found in this study was measured using the percent difference in the programme MEGA (Kumar *et al.*, 1993). The degree of population geographical substructure was tested using the programme AMOVA (Analysis of Molecular Variance, Excoffier *et al.*, 1992). This procedure calculates standard variance components and an array of haplotype correlation measures referred to as phi statistics. The significance of the observed variance components was tested using 1,000 Monte-Carlo simulations of the data set.

RESULTS AND DISCUSSION In the 200 bases sequenced, 16 variable sites were identified which defined 19 distinct haplotypes. Fig.1 lists each of these haplotypes and their distribution patterns in each geographical location. The most common haplotype occurred in 103 (>60%) of the samples and was the most commonly found haplotype in all areas. The next most common occurred ten times and nine of these were in samples from the Irish Sea, suggesting some degree of geographical sub-structure.

The results from the AMOVA analysis of between-population comparisons are listed in Table 1. The phi values are generally low, being 0.05 or less, showing that of the variation present, 95% or greater is due to within-population rather than between-population differences. None of the *p* values were statistically significantly different at the 5% level. The differences between the Shetland and East Irish Sea populations with a *p* value of 0.053 were the closest to being statistically significant. So, overall, the AMOVA analysis does not show any statistically significant geographical substructuring of porpoise populations around the UK. However, there are indications that there is some level of substructure which may need larger sample sizes to become more apparent.

A comparison of West and East UK populations by AMOVA is shown in Table 2. This was performed by combining the results of the Irish Sea (west + east) and also the North Sea (East England and the Netherlands). Overall, there is no significant difference between the two areas when all animals are considered ($p = 0.054$) although the value is very close to being significant. However, when the sexes are treated separately, then a very significant difference is seen between the females ($p < 0.01$) but no difference is detected between the males ($p = 0.84$). If there is differential movement of the two sexes then it could lead to differences in haplotype distribution, but since mit DNA is inherited maternally, then the evidence is lost every generation since successive male immigrants would leave no male heirs. Andersen (1993), in her allozyme study, found a surplus of homozygotes in the North Sea which could be explained by a mixing of several sub-populations, or by non-random mating illustrated by males from different areas straying into the North Sea. It is intended that the same samples used in the present study are also tested for a nuclear marker such as microsatellites, to further investigate possible differences in male and female populations.

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Table 1 Between-population comparisons via the AMOVA program.

Values below the diagonal of 0 values are the phi (ϕ) values which are measures of the variation between corrected for the variation within pairs of populations. Values above the diagonals are the measures of significance (p) obtained from 1,000 Monte Carlo simulations of the data set. The samples from the English Channel were omitted because of the small sample size.

	Shetland	**E. England**	**Netherlands**	**Celtic-shelf**	**Irish Sea (E)**	**Irish Sea (W)**
Shetland	0	0.12	0.08	0.42	0.05	0.43
East England	0.03	0	0.89	0.30	0.14	0.54
Netherlands	0.05	-0.03	0	0.12	0.15	0.28
Celtic-shelf	-0.01	0.01	0.05	0	0.27	0.90
Irish Sea (E)	0.04	0.02	0.04	0.01	0	0.34
Irish Sea (W)	-0.01	-0.01	0.02	-0.05	0	0

Table 2 Comparison of West and East UK populations by AMOVA. Va and Vb are the variances among and between populations respectively. 1,000 bootstrap simulations were performed.

	Phi	**p**	**Va**	**Vb**
All	0.30	0.054	2.99	97.01
Males	-0.026	0.838	-2.64	102.64
Females	0.130	0.008	12.99	87.01

Fig 1 . Porpoise haplotypes and their distribution

N	HAPLOTYPE	CODE	REGION							
			1	2	3	4	5	6	7	n
1	aggcacgtcagttcct	A	12	25	3	9	22	16	16	103
2	...t............	B		2			2		1	5
3	g..t............	C		1			8	1		10
4	g..t.t........t.	D	3	1	1	1		1		7
5	..............t.	E	2					1		3
6	g..t.t......c...	H	1					1	1	3
7	...t.t........t.	J		1						1
8	g..t....t.......	K		1						1
9	g..t..........t.	L	1	1			1		1	4
10	g..t.t.......t..	M		1						1
11	ga.t.t..........	O					1			1
12	g..t..a..g......	P					1	1		2
13	g.atg......c....	R	1							1
14	..............tc	S	1							1
15	g..t.t..........	V				3	1	2	1	7
16	...t.t..........	W					1	1		2
17	.......c........	AB					1			1
18	..........a.....	AF					1			1
19	g..t..a.........	AE					1			1
			21	33	4	13	40	24	20	155

Region 1 = Shetland
Region 2 = East England
Region 3 = English Channel
Region 4 = Celtic Shelf
Region 5 = East Irish Sea (Wales & England)
Region 6 = West Irish Sea (Ireland)
Region 7 = Netherlands

OBSERVATIONS ON THE OCCURRENCE OF SKIN LESIONS IN THE RESIDENT GROUP OF BOTTLENOSE DOLPHINS FROM THE SADO ESTUARY REGION, FOLLOWED THROUGH PHOTOGRAPHIC DATA

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INTRODUCTION Skin lesions are among the common dermatological diseases of small cetaceans (Sweeney, 1975), and are observed in both captive and wild dolphins. While captive animals provide a good opportunity to assess the biological cause and the evolution of such infections, much less is known about wild animals. Only recently have coastal populations been regarded as providing an opportunity for monitoring dermal disease, by using photographic methods (Thompson and Hammond, 1992; Wilson *et al.*, 1992).

The Sado estuary region, in Portugal, is one of the places in Europe where a resident group of approximately 40 bottlenose dolphins (*Tursiops truncatus*) exists. During a photo-identification study, we observed the presence of a variety of skin lesions and have been following their evolution. This abstract aims at describing the observed lesions, and preliminary observations concerning their evolution.

MATERIALS AND METHODS Photographic surveys in the study area (Fig. 1) occurred from February to June 1994, and from October 1994 to early January 1995. Slides of the dorsal fin and flanks were taken with a manual focus camera with a 75-300 mm zoom lens. These were analysed using one or two slide projectors. In the first step we scoured the 36 known individuals for the presence of lesions. The individuals that seemed to be free of lesions and those that were photographed inadequately, were rejected from the analysis (n=8). In the second step, in the 28 selected individuals, lesions were categorised taking into account their size, area, shape, and colour. Finally, the development of lesions with time was observed.

RESULTS Four types of lesions were defined (see Table 1).

Minimum estimate of the number of individuals suffering skin lesions

With the exception of one of the two existing calves, all other individuals analysed (the other calf, four juveniles, and all 22 adults) displayed skin lesions, (which corresponds to 94% of the analysed individuals). Some individuals exhibited more than one type of skin lesion, the most common type being Type C (Table 1). One of the juveniles and two of the adults were more affected than the other individuals, a large area of the body being covered with skin lesions. When considering a minimum estimate for the size of the group at 40 individuals, at least 67.5% of the group were affected by skin lesions.

Evolution observed in skin lesions

A coloration change was only possible to observe in six individuals. In five cases, there was clear evidence that Type C lesions, with a darker coloration than the bottlenose dolphin's natural pigmentation had changed to a lighter coloration, or were observed in the process of changing. In another individual, Type A lesions, with a dark outer ring and a light interior, changed to a darker coloration. Changes in the size of lesions were not observed.

DISCUSSION A considerable variability in skin lesions seems to exist. When comparing the observed lesions with others previously described in the literature, we concluded that Type A lesions appear to be similar to "tattoo lesions", resulting from infection of poxvirus (Flom & Houk, 1979). These were also observed by Thompson and Hammond (1992) and Wilson *et al.* (1992) on the bottlenose dolphin population of the Moray Firth, Scotland. We do not know the cause of the other lesions observed.

Our sampling period only showed a window in the evolution of skin lesions. Although a considerable number of dolphins were affected, development was only possible to observe in a small number of individuals, and sampling was carried out only after the initial stage of lesion occurrence, which will most likely have been several years previous.

The Sado estuary and the Moray Firth are polluted and stressful environments. It has been suggested that untreated urban sewage in addition to toxic chemicals could contribute to the contamination of marine animals by pathogenic organisms (Watermann and Kranz, 1992). A better photographic coverage of individuals, such as the ones seldomly observed in the estuary, and those never seen, may provide a useful comparison with those that regularly visit the estuary and have a chronic exposure to estuary pollution. Future work will also look at photographs taken before this study, which may give us more information about the evolution of these lesions. In addition, the continuing photographic monitoring of individuals will aid in assessing the future prevalence and possibly the effects of lesions, at both individual and group levels. Yet, pathological data is necessary for the determination of causes.

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Type of lesions	Description (form, coloration, aprox. lenght)	Incidence (n=28)
A	circular dark ring with light interior or dark circle 1cm to 3 cm	10
B	irregular brown 3 cm to more than 20 cm	3
C	variable (circular, amoeboid or irregular) darker and/or lighter than the normal pigmentation 3 cm to more than 20 cm	24
D	amoeboid orange more than 40 cm	1

Table 1. Types of lesions observed. Description and incidence.

THE DISTRIBUTION OF MICROALGAE OVERGROWING THE SKIN OF CETACEANS IN THE BLACK SEA DOLPHINARIA

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INTRODUCTION Until recently, we had very little information about microalgal inhabitants of the skin surface of the Black Sea dolphins. However, during our investigations in Karadag (Eastern Crimea) and Little Utrish (Caucasian coast near Anapa) dolphinaria, 24 microalgae species, including 22 diatom species, were identified from skin scrapings and smears taken from bottlenose dolphins, *Tursiops truncatus ponticus* (Barabash-Nikiforov, 1940; Gol'din, 1994a). As a result of this work, the most frequently occurring algae were determined (Gol'din, 1994c). In addition, it is thought that there is a relationship between the appearance of algal growths and the poor health status of captive dolphins (Gol'din and Plebansky, 1992). The main purpose of this work is to reveal whether or not there is a relationship between the distribution of different algal species in dolphinaria and their occurrence on the skin of the captive dolphins within these dolpinaria. This comprehensive investigation will contribute to determining the interspecific relations occurring in Black Sea dolphinaria between microalgae and dolphins.

MATERIALS AND METHODS Over a period of several years, more than 150 scrapings were investigated from the walls of the pools, from metal and wooden structures dipped into the water, and from shingle within the dolphinaria, including the adjoining aquaria. The algal growths were collected by means of benthic sample selection, incorporating areas at different depths and receiving different amounts of light. Algal material extracted from these samples, was examined and identified, according to the general methods (Naukova, 1989).

RESULTS AND DISCUSSION From examining the sample material, it has been possible to determine structures of different species of algae and their distribution in the pools in relation to depth, light availability, and seasonal change. In Karadag dolphinarium, 12 diatom species, among the 39 overgrowing algal species identified were able to exist on the dolphin skin surface Among the 16 overgrowing algal species detcted in Little Utrish dolphinarium, six species were identified as dolphin skin inhabitants. The most abundant algae species were identified as: *Nitzschia hybrida f. hyalina*, *Navicula* sp., *Navicula pennata var. pontica*, *Licmophora* sp., *Licmophora Ehrenbergii*, and *Grammatophora marina.*

It should be noted that *Nitzschia* and *Navicula* occurred in all of the samples examined, but there was no correlation between frequency of occurrence of this algae in the environment and on the dolphin skin surface. For example, the main algal diversity of the Karadag pools takes place during May (5-6 species). However, at this time of the year, overgrowing algae were absent in the skin samples from dolphins. It was during March and July that there was the highest diversity of algal species on the dolphin skin and, during these months, algal diversity was low in the pool. In addition, despite the exceptional abundance of *Nitzschia longissima* in the pools, this species was never encountered in a skin sample. An alga typically growing on the skin surface of dolphins in high latitudes is *Coccone* sp.. Although recorded in Karadag during winter, it was surprisingly not detected in the skin samples from the dolphins (Table 1). These data confirm the predictions that specific features of dolphin skin-feeding algae are correlated with the health status of the particular captive animal.

CONCLUSIONS The algae associated with the skin surface of captured bottlenose dolphins have their own specific features, differing from the common algae growing in the pools. These algae, associated with the skin surface of captive bottlenose dolphins, are to some extent reflecting the health status of those dolphins.

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Table 1 THE COMPARATIVE STRUCTURE OF SOME ALGAL OVERGROWINGS IN DEPENDENCE ON THE SEASON AND THEIR SUBSTRATE (+ Karadag, ++ Little Utrish)

The Algae species	Pool walls overgrowings	Dolphins skin surface scrapings
Achnantes brevipes Ag.	+ March	++ June
A. longipes Ag.	+ January + April + December	++ June
Amphora angusta Greg.	++ June	-
A. hyalina Kutz.	-	+ March
Cocconeis sp.	+ January, + December	- -
Grammatophora marina (Lyngb.) Kutz.	+ May, July	+ April, July ++ June, September
Licmophora sp.	+ April-May	++ June, September
L. abbreviata Ag.	-	+ March, April
L. Ehrenbergii (Kutz.) Grun.	+ May, July	+ January, July ++ June
Navicula sp.	+ January + April,May + December	+ March
N. pennata var. pontica Mer	+ March - + April	+ March,April, July ++ June
Nitzschia hybrida f. hyalina Pr.-Lavr.	+ January- -December	-
N. longissima (Breb.) Ralfs	+ April + July	- -
N. seriata Cl.	+ May, July	+ July
N. tenuirostris Mer.	+ March- -April	- -
Rhoicosphenia sp.	+ January + December	- -
Striatella unipunctata (Lyngb.) Ag.	+ May ++ June	++ June
Synedra (Fragilaria) tabulata (Ag.) Kutz.	+ May	++ June

EXAMINATION OF THE DERMO-EPIDERMAL RELATIONSHIP IN THE UPPER RESPIRATORY TRACT OF THE STRIPED DOLPHIN (*STENELLA COERULEOALBA*)

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INTRODUCTION The upper respiratory tract of odontocetes has multiple functions in respiration and sound production. While its anatomy has been studied extensively by gross examination, microscopic analysis has been widely neglected. The use of standard histology and scanning electron microscopy (SEM) for the study of the relation between dermis and epidermis may provide information about the functional strains on the tissue at different locations. Skin is made of dermal ridges with dermal papillae and epidermal ridges with knobs, together forming the dermo-epidermal connection (Giacometti, 1967; Palmer & Weddell, 1964; Stromberg, 1989).

MATERIALS AND METHODS Skin samples of the region of the neck, upper nasal tract, and blowhole were obtained from several heads of striped dolphin (*Stenella coeruleoalba*). The samples were fixed in 10% formalin, embedded in paraffin, and stained with hematoxylin/eosin. For SEM examination, separation between dermis and epidermis was achieved in fresh or frozen samples by a ≥36 h bath in 57°C tap water, obtaining complete epidermal structures. Dermal slides were obtained by means of immersion of the samples for 3 h in 4% NaOH at 37°C. Formalin-fixed material was processed, increasing the time to 24 h. The dermal/epidermal surfaces were then processed for SEM by routine procedures.

RESULTS AND CONCLUSIONS The general alignment of the dermal ridges has its own pattern in the blowhole region, lying perpendicular to the skin surface corrugations (cutaneous ridges) (Shoemaker and Ridgway, 1991). The SEM images reveal a major development of the dermal ridges in the blowhole area when compared with neck epidermis. A decrease in dermal papillae length is noted with decreasing distance from the lips. At some locations they even disappear completely, as for instance in the caudal wall of the main nasal passage. This is probably related to a lack of movement of the structures adjacent to this epithelium.

The dermal ridges can: (1) take a curved position placing the papillae parallel to skin surface; (2) show a compression of the papillae; and at some places (3) become undulating, changing inclination to opposite sides therewith, in the same ridge. These three patterns are found in the lateral walls of the blowhole commissures and in some areas of the main duct. These areas are involved in movements perpendicular to the surface of the epithelium. The dermal papillae adopt a pear shape when becoming shorter, as the tip of the papillae enlarges. This appearance is found in the middle of the anterior lip.

Changes in the arrangement of the dermal structures show the differences between zones in the upper respiratory tract, especially in those subjected to traction forces, i.e. an elongation and curving of the crests establishing parallel to surface, found mainly in the anterior lip, in contrast to the posterior one and most parts of the commissures. Coincident with the special patterns in the dermo-epidermal relationship due to traction forces, the fibre arrangement (mainly muscular, collagenous and elastic) in the dermis becomes directional, parallel to these forces. Despite the apparent independence of movement (i.e. when whistling), an appreciable difference between blowhole sides has not been observed.

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BASIC ANATOMY AND HISTOLOGY OF THE NASAL SAC SYSTEM OF THE STRIPED DOLPHIN (*STENELLA COERULEOALBA*)

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INTRODUCTION The upper respiratory tract in odontocetes between the blowhole and the external bony nares consists of a main nasal passage and a variable number of paired diverticulae called air sacs (Fig. 1). The anatomy of this region has been widely studied (Lawrence and Schevill, 1956; Schenkkan, 1973; Mead, 1975; Cranford, 1988; Heyning, 1989; Curry, 1992). In this paper, a review carried out on the striped dolphin (*Stenella coeruleoalba*) is presented.

ANATOMY OF THE SACS AND MAIN TRACT The nasal sac system in this species is made up of four paired sacs and a main tract. There is an asymmetry between each sac of the right and left side: the right one is larger (Fig. 1). The most external are the broad and dorsoventrally flattened **vestibular sacs**, which are extensible due to a large amount of surrounding elastic tissue. Their large entrance forms part of the main nasal passage that tightens into a transverse slit, opening ventrally to the sacs.

Located deeper in the main tract are the horseshoe shaped, tubular **nasofrontal sacs** with their intrinsic muscles and glandular components. Just rostrolaterally and similar in character lie the small comma-shaped **accessory sacs** Rostrally to the bony nares extend the wide and flat **premaxillary sacs**, intimately lying over the premaxillary bones, and consisting of thin walls of slack connective tissue.

The muscular **nasal plugs** occlude the base of the main tract, covering the bony nares and extending laterally to the opening of accessory and nasofrontal sacs by means of a lateral projection (or liplike extension). Under the nasal plugs, running along the lateral margins of the bony nares to the posterior wall of the tract, the **diagonal membranes** are located: thin tough folds of epithelium with a core of dense connective tissue. By closing the main tract, the nasal plugs create a sinuous space between plugs and blowhole.

ANATOMY OF ADJACENT STRUCTURES The whole sac system lies over the premaxillary, nasal, ethmoid and maxillary bones. It is covered by a dense lamina of fibrous connective tissue which comprises the lower half of the upper tract (excluding the blind ends of nasofrontal and accessory sacs covered by an elastic sheet). We have tentatively called this (to our knowledge, previously undescribed) structure "**laminar fibrous complex** (LFC)". It encloses all structures: sacs, internal muscles and a caudal part of the melon ("inner melon"). The whole fibrous structure (LFC) is continuous, with the exception of a rostral opening filled mainly with fat, which gives a communication with the outer, cranial portion of the melon. The most probable function of the "laminar fibrous complex" seems to be the locking of the air passage at the level of the slitlike opening. Moreover, it subdivides the melon into two distinctive parts. The **blowhole ligament** (a tendinous structure with a cartilage core) forms the back wall of the "laminar fibrous complex", with two additional openings in this laminar complex for the nasofrontal and accessory sac.

Directly underneath the slitlike opening are two pairs of **dorsal bursae** - ovoid masses of adipose tissue found on each side. One is located rostrally to the tract under the "LFC" and one caudally between the blowhole ligament and the back wall of the tract (Amundin and Cranford, 1990).

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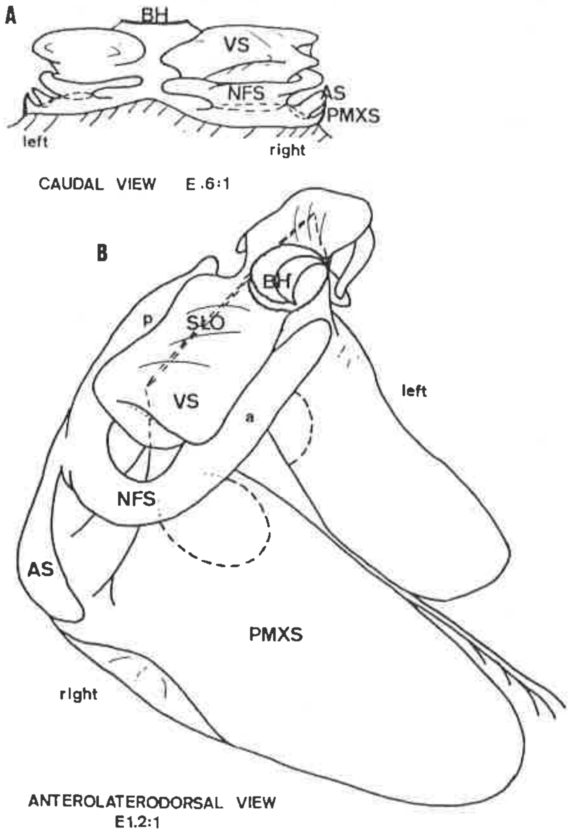

Fig. 1 General drawing of the nasal sac system. Caudal view (A) showing the opening of the nasofrontal sac and accessory sac to the main tract and (B) anterolaterodorsal view. AS- accessory sac, BH- blowhole, NFS- nasofrontal sac, a- anterior, p- posterior, PMXS- premaxillary sac, SLO- slitlike opening, VS- vestibular sac.

SURFACTANT OF CETACEAN LUNGS

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INTRODUCTION Lung surfactant of terrestrial animals is the lipoprotein material lining the pulmonary alveoli. The main function of lung surfactant is its ability to reduce surface tension and hence prevent alveoli collapsing at end-expiration (Birkun *et al.*, 1981). Until now, all information about the cetacean lung surfactant has been limited to the first data on the surfactant parameters (Artov, 1990), and a mention that the surface activity of the pilot whale lung extracts (Olsen *et al.*, 1969) is similar to that of man. The present study was undertaken to obtain more extensive data about cetacean surfactant peculiarities, and to try to consider a possible connection of the surfactant traits with cetacean-specific respiration patterns.

MATERIALS AND METHODS Extracts from the lung parenchyma of Black Sea common and bottlenose dolphins were studied. Surface activity was determined by means of surface tension estimation on the Wilhelmy-Langmuir device with calculation of the Clements stability index. Lipid composition was studied by thin-layer chromatography. To compare data with that of terrestrial animals, the extracts and lavage fluids from laboratory rat lungs were also studied.

RESULTS All the dolphin lung parenchyma extracts reveal presence of the surfactant. The surface activity of surfactants from healthy mature dolphin lungs is similar to that of terrestrial animals (Table 1). The surface activity of common dolphin surfactant is closer to these than bottlenose dolphin surfactant. As a whole, the functional activity parameters of dolphin surfactant are moved slightly to the area of lower surface activity (Fig.1). The surface activity drop of surfactants from diseased and new-born animal lungs is similar to that for terrestrial animal cases.

What is the possible cause of the lower surface activity in dolphins? We suggest the surfactant in dolphin lungs is participating in two opposite processes in connection with two respiratory scenarios. During breathing at the water surface, the surfactant should prevent the alveoli collapsing at end-expiration (like that of terrestrial animal lungs). On the contrary, during deep-diving, the surfactant should not strongly hinder the alveoli from collapsing under pressure. Possibly, the lower surface activity is a result of a compromise between these two functions. Also, during deep-diving the main function of the surfactant apparently changes and acts to prevent alveoli sticking rather than alveoli collapsing.

The following properties differ from the lipid composition of dolphin surfactant: poorer phospholipid spectrum in normal and mature lungs, and higher content of phosphatidylethanolamine (Table 2). The higher content of phosphatidylethanolamine, phospholipid with low surface activity, conforms to the data on the lower functional activity. In addition, an unidentified lipid fraction was detected in samples from the diseased lungs of adult bottlenose dolphins. It is the same lipid fraction that was detected in newborn bottlenose dolphin lungs (Artov, 1990). Apparently, disturbance of the lipid metabolism as a result of disease or the process of surfactant development in newborn animal lungs may be the cause of the appearance of this fraction.

CONCLUSIONS The data obtained confirm the surfactant existing in cetacean lungs. The hypothesis of surfactant participation in two opposite respiratory processes and a change in its functional tasks is suggested. To verify this, model studies should be carried out. Identification of the new lipid fraction may throw light upon the metabolism of the cetacean surfactant lipids.

ACKNOWLEDGEMENTS I am very grateful to Dr. A. A. Birkun, Jr. for assistance on pathomorphological description of the samples and Dr. L. G. Safronova for help in the thin-layer chromatography study.

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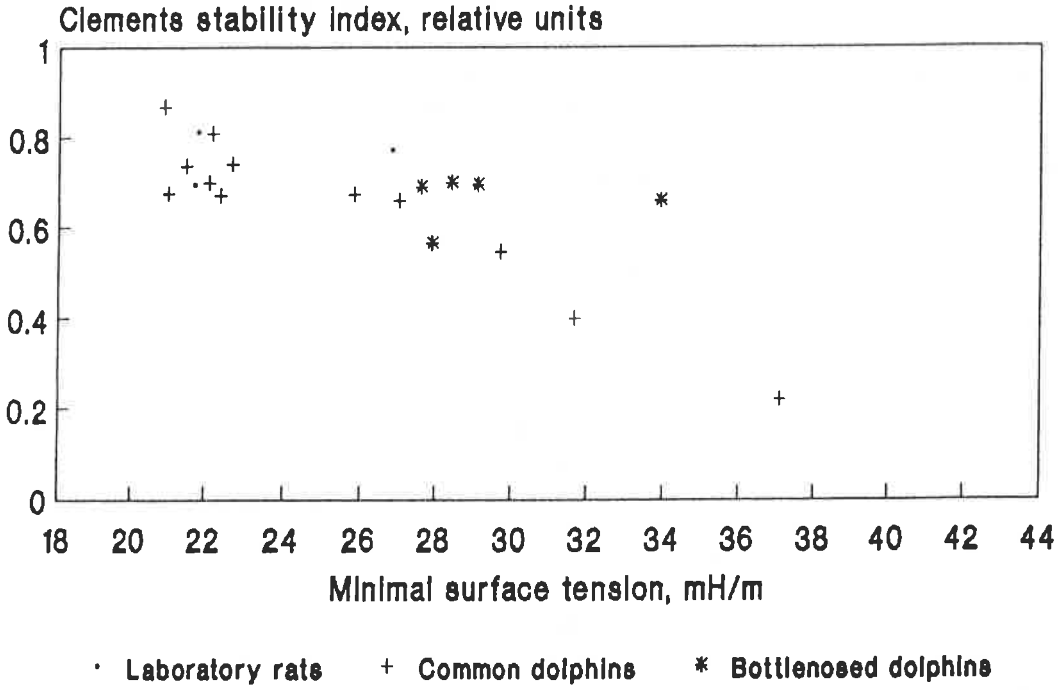

Fig.1 Surface activity parameters of surfactants from laboratory rat and dolphin normal lungs.

Table 1 Parameters of surface activity of the surfactants from dolphin and rat lungs

Animals	Number of samples	Minimal surface tension		Clements index stability	
		average	range	average	range
Bottle-nosed dolphin, adult					
- normal lung	5	29.37±1.60	27.56-33.88	0.662±0.025	0.699-0.567
- diseased lung**	4	37.09±2.24	31.78-40.97	0.303±0.116	0.634-0.202
Bottle-nosed dolphin, new-born	3	34.75±1.12*	33.03-36.85	0.585±0.021*	0.612-0.545
Common dolphin,N1	3	29.45±4.49*	21.53-37.09	0.501±0.151*	0.737-0.220
Common dolphin,N2	5	24.83±2.46	20.93-31.74	0.660±0.075	0.869-0.402
Common dolphin,N3	4	22.91±1.01	21.00-25.76	0.726±0.033	0.811-0.673
Laboratory rats	3	23,45±1,37	21,74-26,80	0,760±0,028	0,813-0,695

* Artov, 1990
** lung with symptoms of bronchitis and peribronchitis

Table 2 Phospholipid composition of the surfactants from dolphin and rat lungs (% from total phospholipids)

Phospholipids	Laboratory rats (three animals)	Common dolphins (two animals)	Bottle-nosed dolphin, adult		Bottle-nosed dolphin, new-born
			normal lung	diseased lung**	
Phosphatidylcholine	40±1	67±7	43±1	38±6	32±4
Phosphatidylethanolamine	31±1	28±5	57±1	27±6	38±1
Phosphatidylinositol	13±1	-	-	16±1	10±1
Sphingomielin	15±2	31;25*	-	20±0,4	15±2
Lisophosphatidylcholine	-	-	-	5±2	-
X - fraction	-	-	-	28±8	27±13
Number of samples	3	10	2	2	4

* in two samples
** lung with symptoms of bronchitis and peribronchitis

ANISAKID NEMATODES OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN DANISH WATERS - PRELIMINARY RESULTS

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INTRODUCTION Marine mammals are definitive hosts of stomach nematodes of the family Anisakidae. The life-cycle of Anisakidae is wholly marine, with crustaceans (especially euphausiids) serving as first intermediate hosts, squid and fish (especially teleosts) as second intermediate hosts, and marine mammals (especially cetaceans) as final hosts. (Smith and Wootten, 1978) (Fig. 1). Little is known of the role of marine mammals in the life cycles of these nematodes. However, these animals are essential for the completion of the nematode life cycles since adult worms develop and mate only in these hosts.

Here, we study anisakid infections in Danish harbour porpoises (*Phocoena phocoena*). This common inshore species occurs at least seasonally in sheltered bays and estuaries, feeding mainly on benthic fish along European coasts. Herring (*Clupea harengus*) and whiting (*Gadus merlangus*) are among the species taken (Klinowska, 1991). In this work, we identify the anisakid nematodes in porpoises and present quantitative information of the anisakid infections in the digestive tract (stomach, duodenal ampulla and oesophagus).

The aim of this preliminary study is to elucidate the role of porpoises in the transmission of anisakid nematodes, and to reveal seasonal or annual variation of the nematode species.

MATERIALS AND METHODS Forty-seven harbour porpoises were collected from strandings or by-catches at various locations in the North and Baltic Seas (Fig. 2) during 1988-89. In 1988, 15 males and 10 females were collected, and in 1989, 15 males and 7 females. The biological parameters, sex, age, length and weight of each animal were recorded. The stomachs were removed after freeze storage and examined for parasites.

Nematodes were cleaned in lactophenol and identified to species level. The specimens were counted and those of *A. simplex* were grouped into several stages: third and fourth larval stage, immature adult males, immature adult females, mature adult males and mature adult females (Table 1). To study annual and seasonal changes in nematode infections, we grouped abundance data from each into three 3-month periods (January - March, April - June, and July - Sept) due to small sample size. The terms prevalence (percentage of porpoises infected) and abundance (mean number of parasites per porpoise, including uninfected porpoises) are used, following Margolis *et al* . (1982).

RESULTS AND DISCUSSION In total, 3,432 nematode specimens belonging to three species (*Anisakis simplex*, *Contracaecum* sp. *and Hysterothylacium* sp.) were recovered. *A. simplex* was by far the dominant species, accounting for 99.57% of the total number of specimens. By contrast, *Contracaecum* sp. and *Hysterothylacium* sp. represented only 0.17% and 0.26% of the total respectively. *A. simplex* was the most abundant species both in 1988 and 1989. However, its abundance and prevalence dropped in 1989 (from 73% in 1988 to 22% in 1989). *Hysterothylacium* sp. and *Contracaecum* sp. showed very low abundances (Fig. 3) and, contrary to *A. simplex*, their prevalence increased in 1989.

Figs. 4 and 5 show a peak in abundance for all maturity stages of *A. simplex* during spring in both years. In this study, *A. simplex* is the most common anisakid species in the porpoises. This agrees with previous results indicating that the species is frequently found in harbour porpoises in the North Atlantic (Smith, 1989) and in Danish waters (Clausen and Andersen, 1988). According to Lick (1991), the harbour porpoise is the main definitive host for *A. simplex* in this area.

There might be different explanations for the decline in prevalence and abundance of *A. simplex* in 1989:

- abiotic factors
- fluctuations in the abundance of larval stages in the intermediate hosts
- changes in feeding habits of the porpoises
- changes in local densities of the porpoises

These possibilities will be investigated in further studies. We observed a conservative pattern in the variation of the abundance of *A. simplex* in both years. This is apparently related to a seasonal cycle: the development stages increased in spring and declined in summer. These fluctuations seem synchronic for all the development stages. This may indicate that the porpoises are constantly reinfected during the annual cycle.

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Table 1 Criteria for identification of the different development stages for *Anisakis simplex*

DEVELOPMENT STAGES	CHARACTERS	REFERENCES
L3	Booring tooth + Mucron +	Grabda, 1976
L4	Lips + Genital ducts. -	Grabda, 1976
IMMATURE FEMALE	Lips + No eggs in Uterus	Gibson, 1970
MATURE FEMALE	Lips + Fully developed eggs in Uterus	Gibson, 1970
IMMATURE MALE	Lips + Papillae, spicules not well developed	Berland, pers. comm.
MATURE MALE	Lips + Papillae, spicules well developed	Gibson, 1970

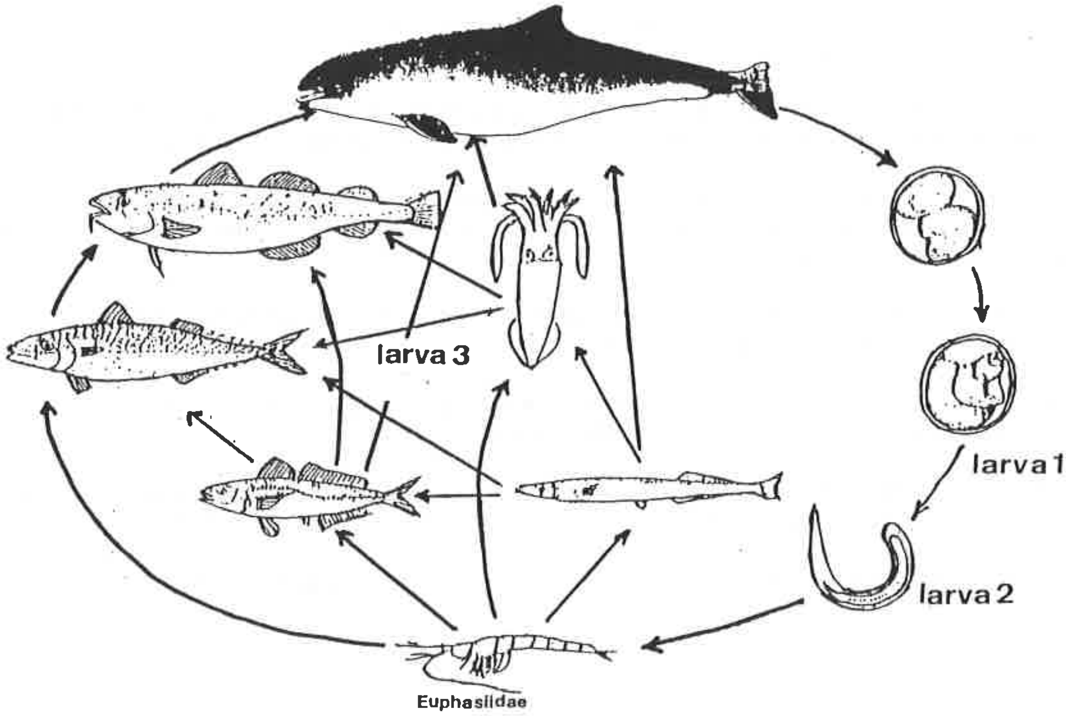


Fig.1 Life-cycle of *Anisakis simplex*

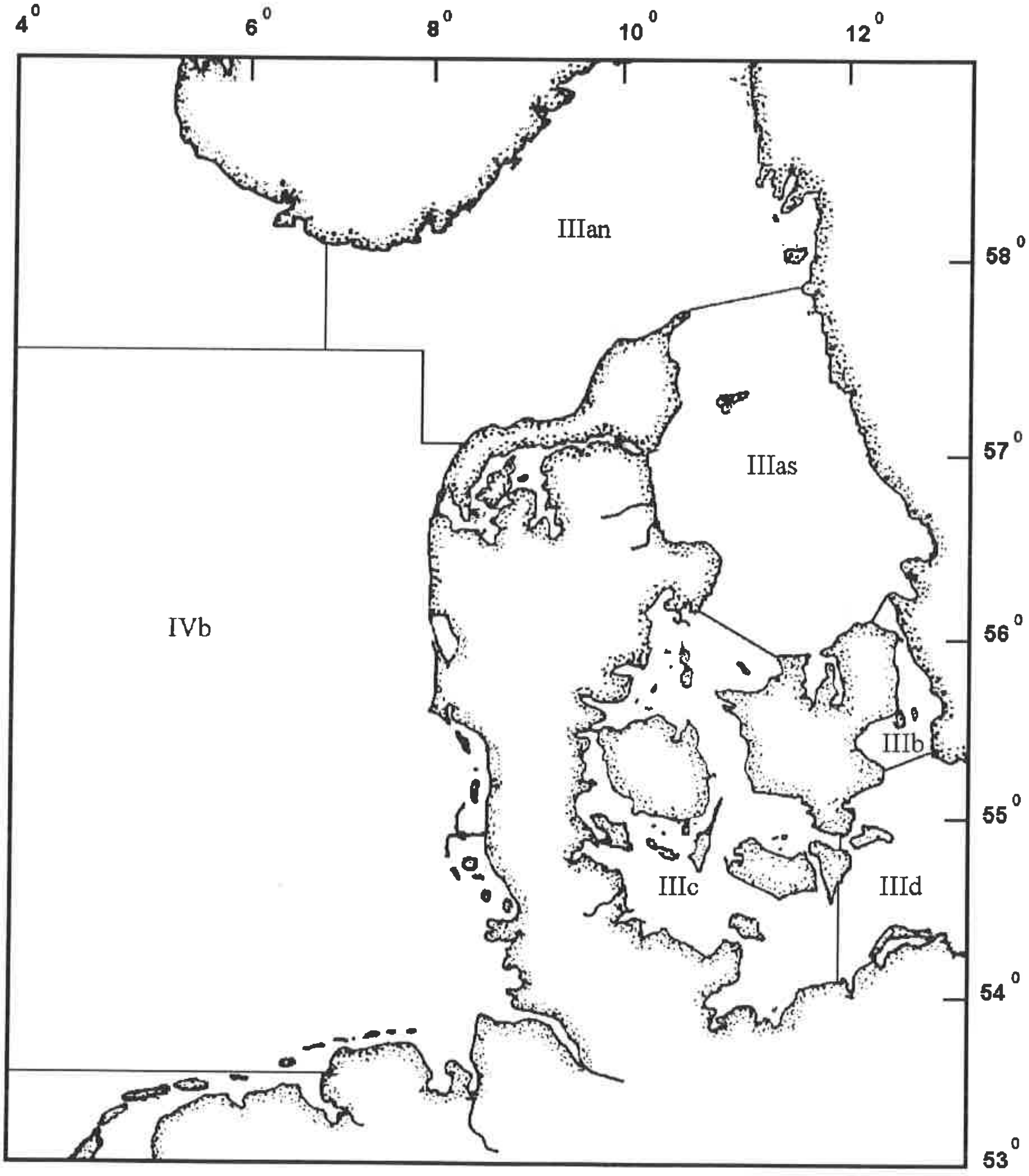


Fig. 2 ICES Areas of Danish fisheries
IVb: Nordsöen; IIIan: Skaggerak; IIIas: Kattegat; IIIb: Øresund, IIIc: Indre farvande; IIId: Vestlige Ostersø

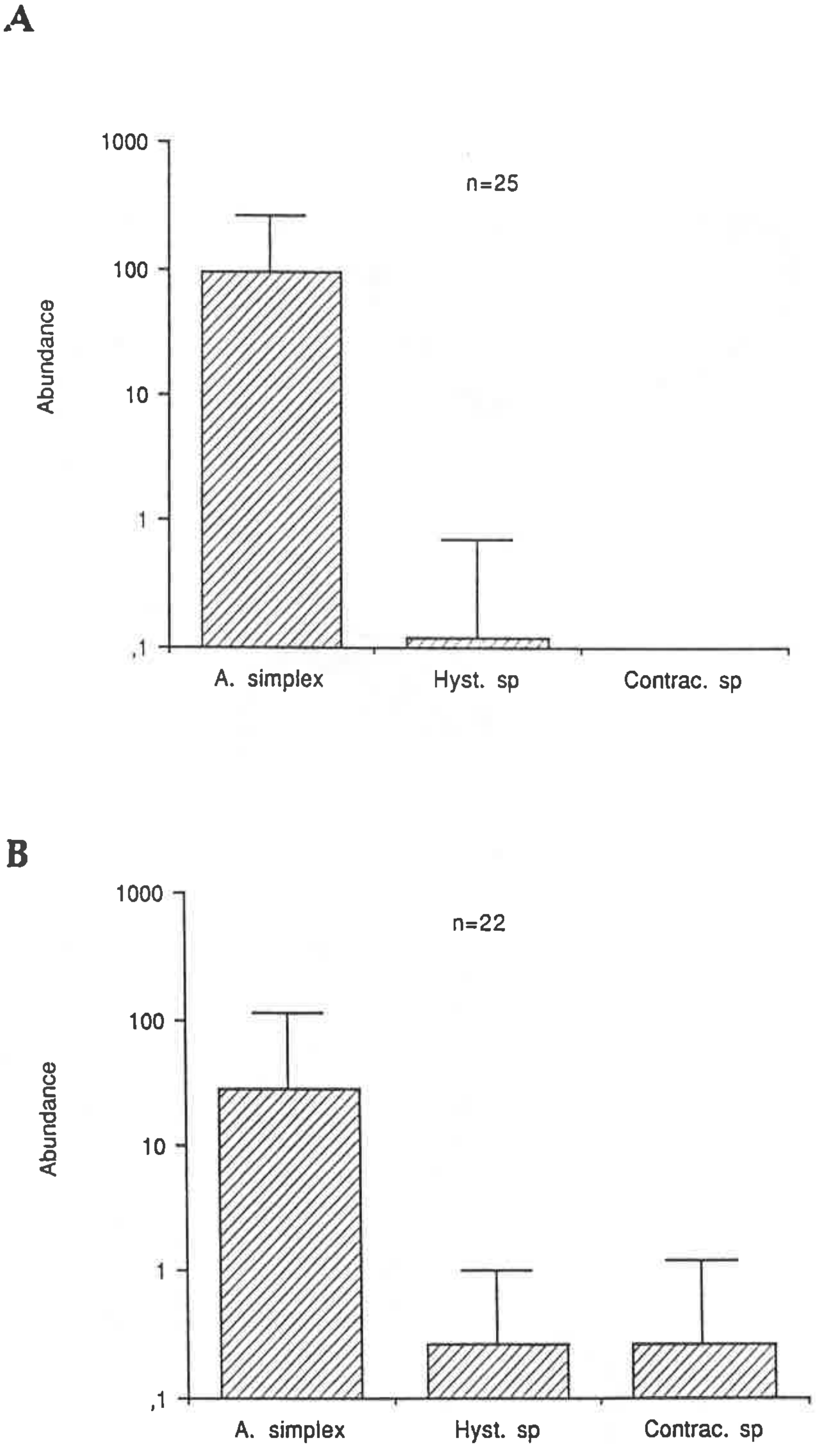


Fig. 3 Mean abundance (± 1 SD) of the three nematodes species found in Danish harbour porpoises in (a) 1988 and (b) 1989

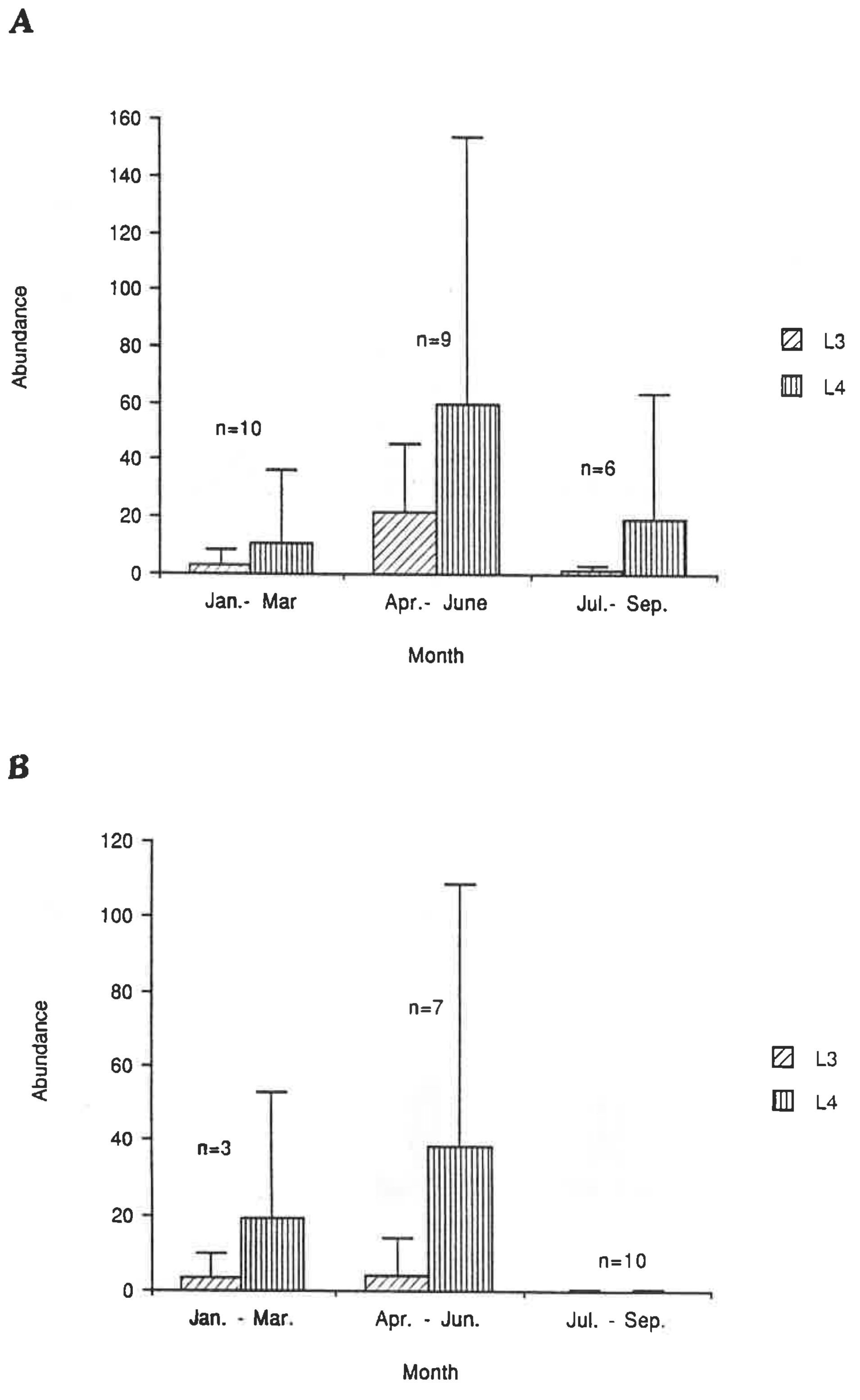
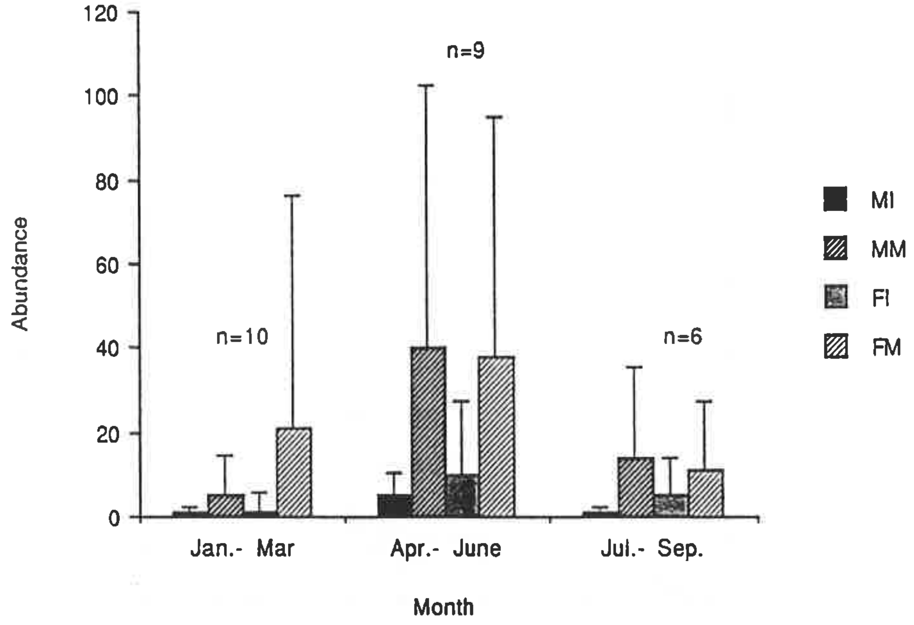


Fig. 4 Seasonal patterns in the abundance of third and fourth larval stages (L3 and L4) of *A. simplex* in Danish porpoises of (a) 1988 and (b) 1989

A



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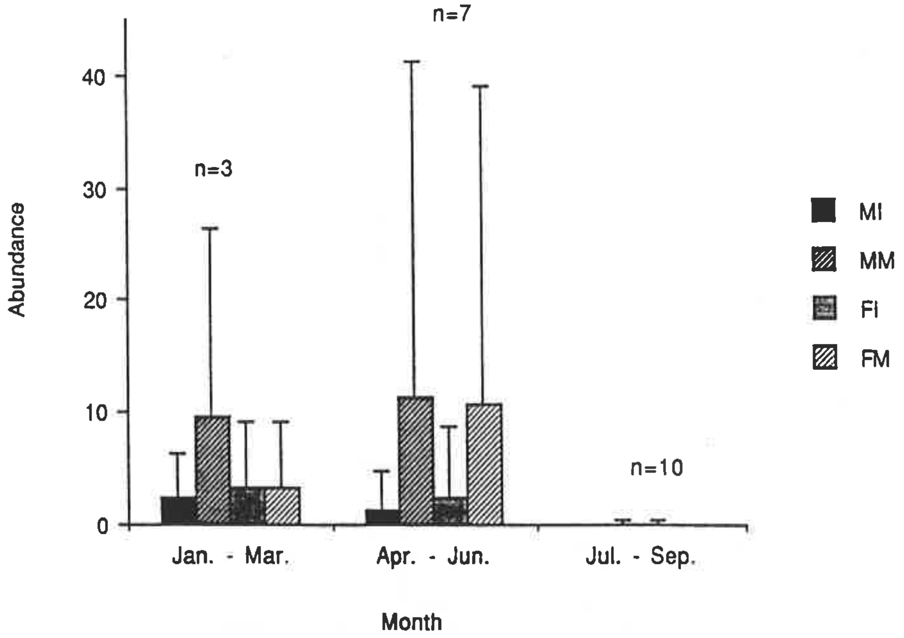

Fig. 5 Seasonal patterns in the abundance of adult stages of *A. simplex* in Danish porpoises of (a) 1988 and (b) 1989.
MI: Immature male, MM: Mature male, FI: Immature female, and FM: Mature female

STOMACH PARASITISM IN DOLPHINS INCIDENTALLY CAUGHT BY THE FRENCH TUNA FISHERY

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INTRODUCTION During the North-eastern Atlantic tuna fishery 1992 and 1993 campaigns, the stomachs of dolphins incidentally caught were sampled for their contents and parasites.

MATERIALS AND METHODS The stomachs of 79 striped dolphins (*Stenella coeruleoalba*) and 33 common dolphins (*Delphinus delphis*) were available for the present study. The parasites were preserved in 70% ethanol, and identified under transmitted light or scanning microscope. Pathological tissues found were analysed (histological sections stained with hemalun-erythrosin). The age of each dolphin was determined from the number of dentinal growth layer groups. Reproductive status was determined from histological sections in the gonads and genital tracts.

RESULTS The two main stomach parasites found were the trematode, *Pholeter gastrophilus,* in cysts of the stomach wall; and the nematode, *Anisakis simplex*, (Balbuena, 1991; Cocheton *et. al.*, 1991). Larval stages of *A. simplex* were fixed in the wall, and adult stages were free-living in the stomach. The prevalence of these parasites is very high for both species of dolphin (Fig. 1). No significant differences were noticed for the infestation prevalences between the two host species, irrespective of their sex and bycatch location. Young animals were less parasitised than older ones (Figs. 2-7).

DISCUSSION Until now, most parasitological impact studies have been carried out on stranded dolphins. The present study provides information on presumably healthy dolphins. However, the host samples do not represent the whole population as 80% of the dolphins caught were less than three years old (Goujon *et. al.*, 1993).

The high prevalence of the nematode, *A. simplex*, a very widespread species, in marine fish (sometimes up to 100%, Huang and Bussieras, 1988), may explain the fact that a large majority of dolphins are parasitised (Oshima, 1987; Sakanaki, 1990). A similar explanation could be possible for the trematode, *P. gastrophilus* (Raga *et. al.,* 1985)

Pathological impact on host populations is very low. However, two obstructions of pyloric stomach due to *P. gastrophilus*, and five large ulcers due to *A simplex*, were noticed. Every pregnant or lactating female (n = 2) had ulcers with many *Anisakis* individuals. This may imply that pregnancy and lactation could decrease the immunity level of females and thus *Anisakis* larvae would more easily become embedded in the stomach wall and form ulcers (Babin *et. al.*, 1994).

ACKNOWLEDGEMENTS Thanks are due to the observers on board the tuna fishing vessels, who collected the samples, and to the staff of the Musée Océanographique of La Rochelle, for their assistance throughout the present study, in particular to Nathalie Mérour who prepared the dolphin teeth and genital tracts for histological examinations. Special thanks are due to the Prof. J. A. Raga (University of Valencia) who confirmed the identifications of parasites, and to the Prof. J. P. Trilles (University of Montpellier) who supervises my thesis.

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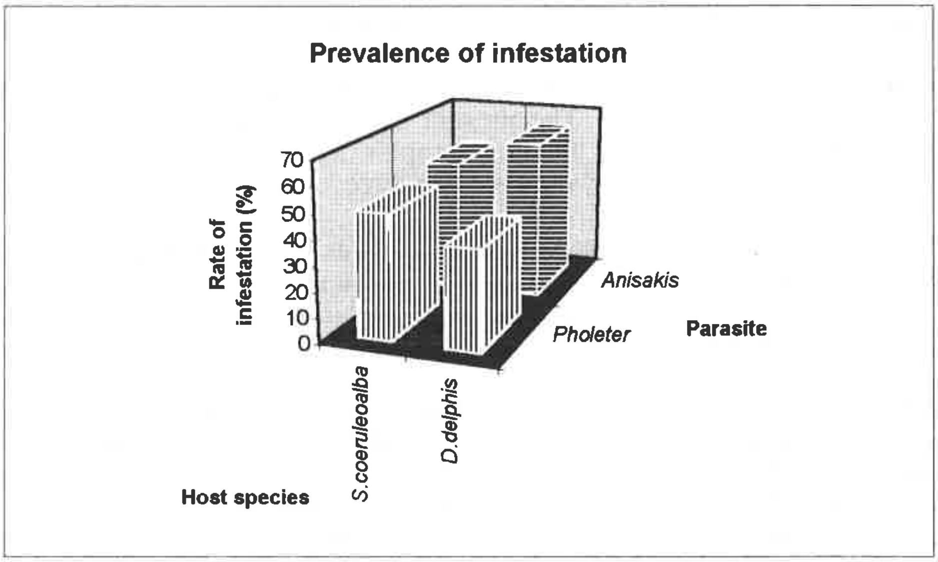
Figure 1



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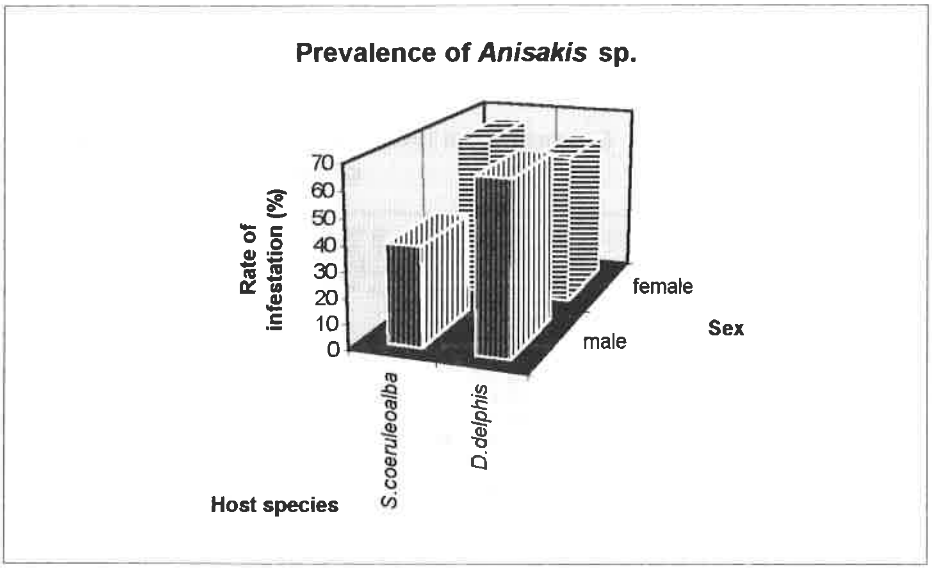

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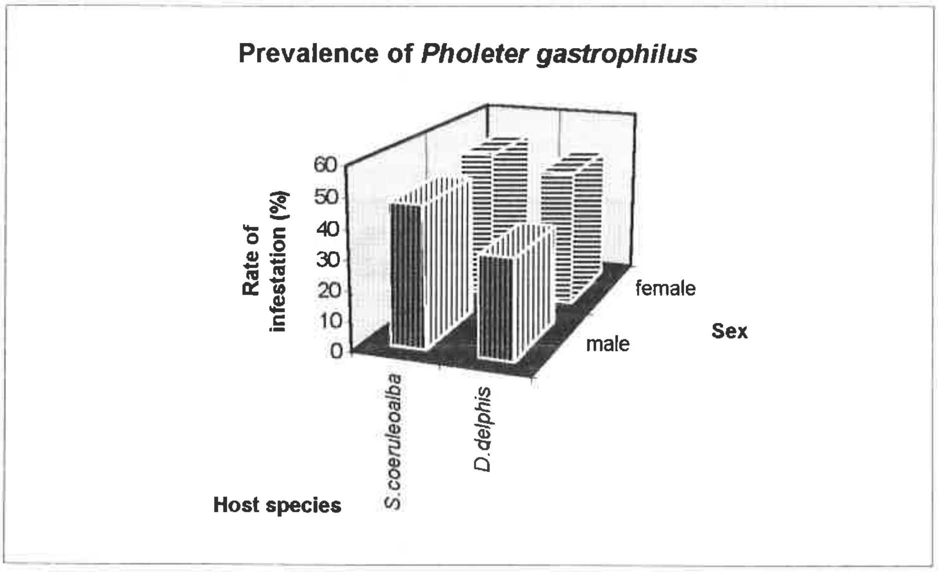

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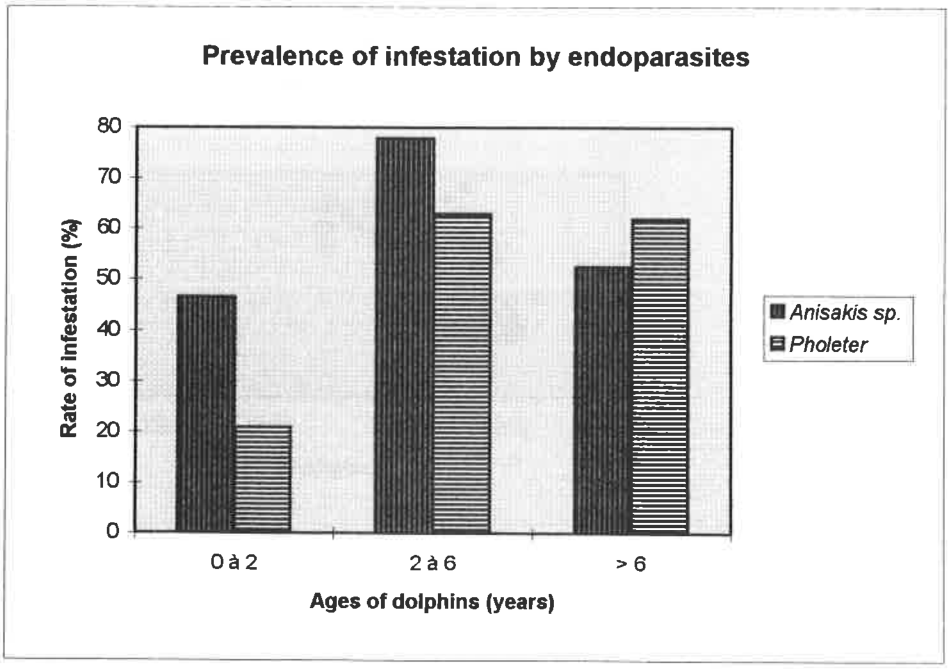

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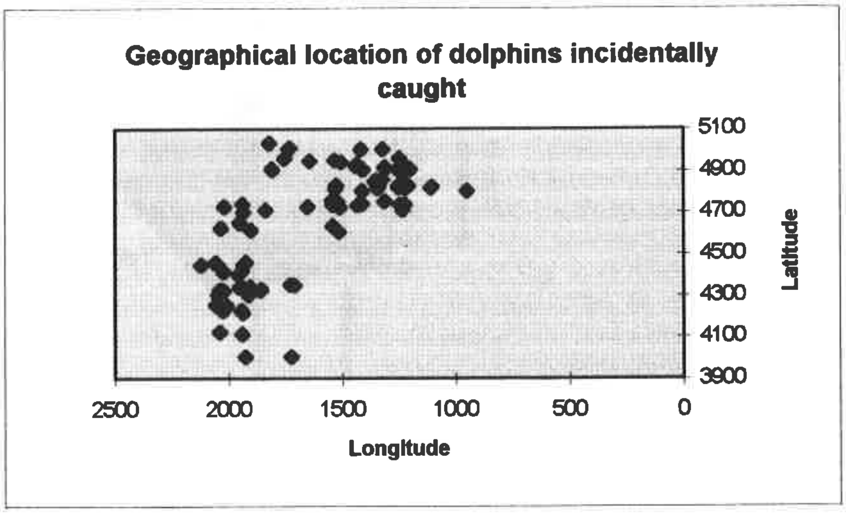

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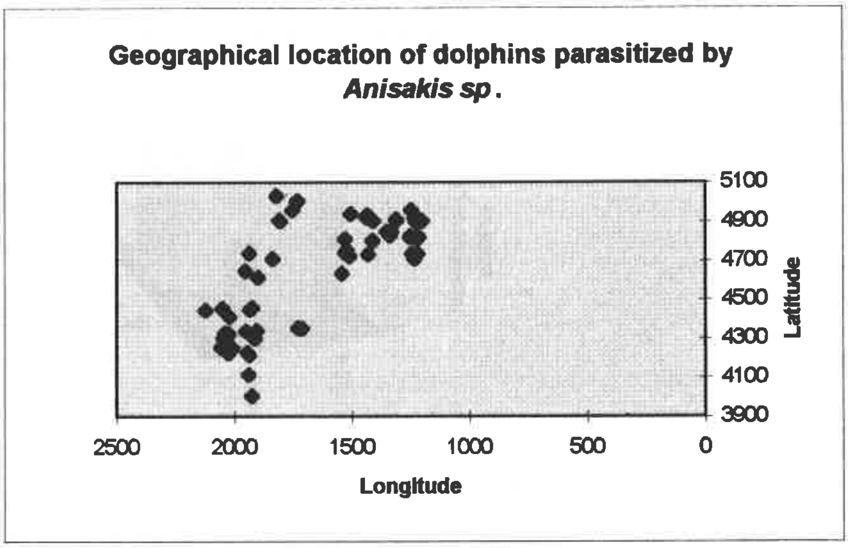

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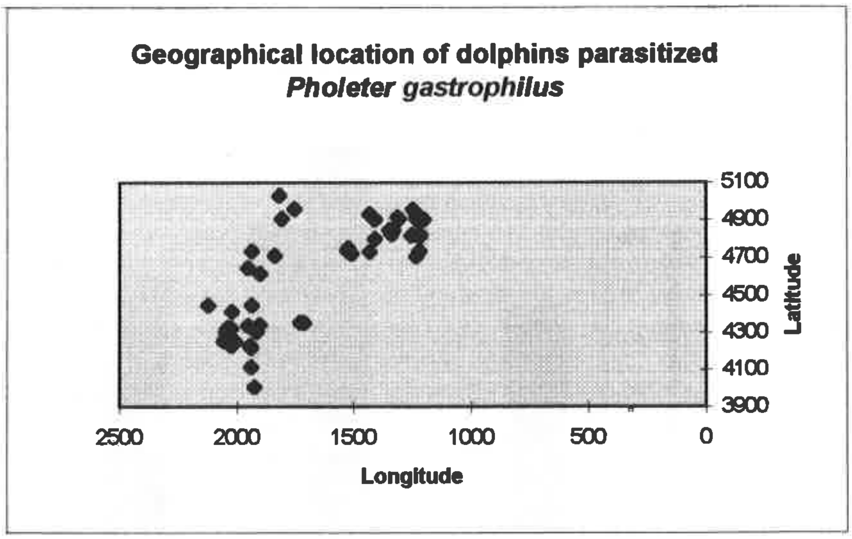

BACTERIOLOGICAL FINDINGS IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) STRANDED ON THE DUTCH COAST, 1990-1994

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Bacteriological information on free-ranging cetaceans is difficult to gather and the scarce literature on the subject mainly refers to (single) case studies. Basic information on normal bacterial flora and on facultative and obligate pathogens is currently unavailable for most cetaceans.

From cetaceans found stranded on the Dutch coast between 1990 and 1994, samples for bacteriological examination were taken whenever the freshness of the material was considered suitable. Such samples were collected from lesions as well as from seemingly healthy organ systems (with special emphasis on those which would be available to the clinician). To a limited extent, material which had been frozen was sampled for comparison.

The results include the isolation of rare *Salmonella* sp., *Pasteurella* sp. and different *Vibrio* spp., together with a range of post-mortem invaders and potential pathogens. Clostridial infection and erysipeloids were not found during this study.

PATHOLOGICAL CASE STUDIES OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) STRANDED ON THE DUTCH COAST, 1990-1994

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From 1990 to 1994, harbour porpoises stranded on the Dutch coast were examined according to an expanded version of the ECS cetacean dissection protocol. In this presentation, a synopsis of the most interesting findings, with cases of known as well as unknown etiology, is given, including stomach foreign bodies, functional impairment caused by abscesses in uncommon locations, pneumonia and others.

A RARE CONGENITAL HEART DEFECT IN A HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) CALF FROM CARDIGAN BAY, WALES

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A female harbour porpoise (*Phocoena phocoena*) calf stranded live at Arthog Beach, Barmouth, Gwynedd, Wales on 24th August 1994. She was held overnight in a small inflatable pool before being transported by air the next day to the RSPCA Wildlife Hospital, King's Lynn, Norfolk for clinical investigations and treatment. The facilities at the rehabilitation centre included an 8 m diameter soft sided round pool of maximum depth 1.6 m. Mains water with added salt, to salinity 2% (S.G. 1.016), was circulated through a sanitising and filtration unit based on ozone, protein skimming, pressure sand filtration, and U.V. light. This system is in use at the hospital for seal rehabilitation.

CLINICAL FINDINGS The principal clinical sign on initial examination of the porpoise was a loud pansystolic heart murmur. Several small skin lacerations and a mild mucopurulent ocular discharge from both eyes were also noted.

NUTRITION AND MANAGEMENT Feeding started with an oral rehydration fluid (Lectade, Smith Kline & Beecham). This was gradually replaced with a high fat milk replacer (Multimilk, Pet Ag) over the first 48 hours. Feed volume ranged from 60-100 ml. Attempts to increase feed volume above 100 ml were unsuccessful. Natural harbour porpoise milk typically contains 46% solids, of which 90% are fats. Multimilk contains only 33% solids, of which 55% are fats (source Pet Ag). Therefore, to maximise energy intake feeding involved small quantities administered frequently by stomach tube at two-hourly intervals through daylight hours and four-hourly at night. Energy expenditure was restricted by maintaining a high water temperature (21°C) and enforcing rest. During rest periods the porpoise was placed in a sling of soft fibre pile fabric (Vetbed), supported so that the blowhole was just above water level. Rest periods were variable through the day, depending on behaviour, but typically one hour in four was given to enforced rest. Otherwise the animal was free swimming. No weight was gained during the nursing period. Attempts to increase feed volume up to 120 ml resulted in colic characterised by reduced swimming, ventral flexion, some shivering, and occasional vomiting. Reducing feed volume, diluting feed, and treatment with Isogel quickly relieved symptoms.

CLINICAL MONITORING Respiratory rate averaged 3-5 respirations/min, occasionally rising to 8/min. The heart rate was strong and regular but characterised by a loud and constant pansystolic murmur. The heart rate ranged between 120-160 bpm with a marked sinus arrhythmia. Blood was taken from the central ventral tail vein on 26/08/94 and 29/08/94. Haematology was within reference ranges (Bossart *et al.*, 1990). Biochemistry showed raised creatinine phosphokinase (CPK) and serum alkaline phosphatase (SAP) levels. For examinations, the porpoise was removed from the pool once daily. Weight and measurements of length and girth were recorded. Wounds were cleaned and dressed with a bland ointment (Orobase, Squibb). Gentamycin ointment (Genticin, Roche) was applied to the eyes regularly.

On 1st September, 1994, the clinical condition of the porpoise rapidly deteriorated. Heart sounds became rapid and faint, respiratory rate increased, and all swimming ceased. After a short attempt at resuscitation it was decided that euthanasia was the humane option. This was performed with 2ml i.v. etorphine (Immobilon L.A., C.Vet).

POSTMORTEM FINDINGS The animal was examined at post mortem according to standard protocol (Kuiken and Baker, 1993). She was found to be of moderate nutritional status, weighed 11.5 kg and measured 87 cm from the tip of the upper jaw to the tail notch. The major pathological findings at postmortem were associated with the cardiovascular system.

Evidence of congestive heart failure included a hydropericardium consisting of approximately 10-15 ml of clear, slightly straw coloured serous fluid; extensive pulmonary oedema (both lungs were heavy, wet, congested and oedematous with white, serous, foamy exudate in the distal trachea and all branches of both bronchi); ascites (a moderate quantity of slightly straw coloured, clear serous fluid was present with the peritoneal cavity); and marked hepatic and renal passive venous congestion.

The heart was found to be abnormal. The right ventricle appeared larger in size than the left ventricle, due to massive hypertrophy of the right ventricular wall. A large ventricular septal defect was present immediately below the level of the atrioventricular valves. The origin of the aorta, approximately 1.5 cm diameter, was dextraposed centrally directly over-riding the ventricular septal defect. Below the level of the pulmonary valve, the infundibulum of the right ventricle was abnormally narrowed (approx. 4-5 mm in diameter) causing a degree of functional obstruction to right ventricular outflow (pulmonic stenosis). There was no stenosis, either valvular or supravalvular, of the pulmonary artery. The ductus arteriosus was non-patent. These developmental cardiac abnormalities constitute the classical appearance of the congenital cardiac defect "Tetralogy of Fallot". All the heart valves (atrio-ventricular, pulmonic and aortic) examined were grossly normal. This is probably the first congenital heart defect to be described in Cetacea.

DISCUSSION The Tetralogy of Fallot heart defect is considered to be both the origin of the clinically detectable heart murmur and also the cause of the (cardiogenic) congestive heart failure found on necropsy of this animal. Most of the pathological findings indicative of congestive heart failure (ascites, hydropericardium, hepatic/renal passive venous congestion) are consistent with right-sided heart failure essentially, and probably occurred secondarily to the right ventricular myocardial hypertrophy. It is also probable that developing heart failure was an underlying factor in the initial stranding of the animal. Interestingly, at no stage of the attempted rehabilitation was cyanosis clinically detectable. In other terrestrial mammalian species, including man, clinically detectable cyanosis would be a major clinical feature in most cases of Tetralogy of Fallot where a right to left shunt of cardiac blood flow existed. In this animal, the lack of clinically detectable cyanosis may be due to either a minimal degree of right to left shunting of deoxygenated blood or, alternatively, a reflection of the superior respiratory physiology and pulmonary oxygen uptake of cetaceans in general.

Although no congenital heart defects have previously been described in Cetacea, very few necropsies have been performed on cetaceans when compared to terrestrial mammals. In humans, the general incidence of all congenital heart defects is estimated at 6-8 per 1,000 live-born, fullterm births. Tetralogy of Fallot as a specific defect comprises approximately 6% of all these cardiac malformations. In domestic mammals, the pattern and incidence of congenital cardiac disease varies with the species examined. Of all the common domestic animals, Tetralogy of Fallot is most frequently diagnosed in cattle.

ACKNOWLEDGEMENTS We wish to acknowledge the considerable assistance given in the management of this case by both the staff of the RSPCA Wildlife Hospital and the members of British Divers Marine Life Rescue and Southern Marine Life Rescue.

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INCIDENTAL CATCHES OF CETACEANS BY THE SPANISH SWORD-FISH DRIFTNET FLEET OPERATING ON THE MEDITERRANEAN SIDE OF THE STRAITS OF GIBRALTAR

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INTRODUCTION The Spanish driftnet fishery in the southwestern Mediterranean is aimed at the sword-fish (*Xiphias gladius*). It is composed of 30 boats and, although classified by Spanish regulations as illegal, it was operating up until August 1994. The main fishing grounds were the Gibraltar Straits and adjacent waters, mainly an area known as "La Tunara", located 3-13 miles east of Point Europe (Fig. 1). The fishing season extends from the last week of July to the end of August.

During 1993 and 1994, 81 fishing trips were monitored by observers on board Spanish driftnet boats, to determine the operational characteristics of the fishery and the composition and quantity of incidental catches, particularly cetaceans.

MATERIALS AND METHODS During 1993, three observers made 27 trips on board five different boats, and during 1994, seven observers made 54 trips in seven boats, totalling 81 trips during the whole period of study. From any incidental catch of cetaceans occurring, the following data were collected: species, length, sex, condition (alive/dead) and fate (used or discarded). Moreover, samples of skin, blubber and muscle, teeth and the reproductive tract were collected. The length of nets deployed was estimated from GPS positions determined onboard the boats at the beginning and at the end of the settting, and also taking into account the number of pieces of net set (each of which is 72 metres long).

Fishing effort was estimated as the total km of net set (no. of operations * mean length of the net) by the fleet during each fishing season. Estimates of incidental catches of dolphins were made following the ratio method based on the bycatch rate in relation to the observer's effort, multiplied by the total number of km of net set by the fleet. Confidence intervals for these estimates were calculated using the variance estimate for the ratio method:

$$\hat{V}(\hat{t}_y) = \hat{t}_x^{\,2}\left(\frac{1}{n}\right)\left(\frac{1}{\bar{x}^2}\right)\frac{\sum_{i=1}^{n}(y_i - x_i)^2}{n-1}$$

X = km of net set Y = dolphin catches

RESULTS Boats did not operate every day due to the weather conditions. Since no data on fishing effort were available, the information about movement of the fleet collected by the observers was used to estimate the total number of fishing operations carried out during the season. Using these data, an average of 0.75 operations per day and boat was estimated. Therefore, 3% of the operations in 1993, and 10.2% in 1994 were monitored.

On average, the length of the nets set was about 3.5-4 km, each net being about 20-40 metres high. Captures of sword fish, the target species, constituted 5% of the catches in 1993 and 7% in 1994 (in terms of number of individuals). Sun fish (*Mola mola*) constituted 93% and 90% of the catches in 1993 and 1994 (Fig. 2), respectively. It should be noted, however, that almost 100% of the sea turtles and sun fish caught were alive when taken on board, and, where possible, were returned to the sea alive. During the 1994 campaign, it was estimated by observers that only 6% of the sun fish captured in the nets died on board before they were returned to water.

In total over both years, 20 common dolphins (five in 1993 and 15 in 1994) and 21 striped dolphins (six in 1993 and 15 in 1994) were caught (Table 1). From these totals, 49% were common dolphins (*Delphinus delphis*) and 51% striped dolphins (*Stenella coeruleoalba*). Overall, 37% of monitored operations in 1993, and 35.2% in 1994 produced incidental catches of cetaceans. When this occurred, usually one single animal was entangled in the net. However, in two sets in 1994, four dolphins were found entangled at the same time. All cetaceans were found to be dead when brought on board, with the exception of one common dolphin caught in 1993, which was released to the sea alive.

These results indicate a catch rate of 0.10 (1993) or 0.15 (1994) dolphins per km of net set. Total catch of dolphins was estimated at 338 animals for the 1993 fishing season (5 weeks), and 295 for that of 1994 (4 weeks) (Table 2). The impact of these removals on the affected populations is unknown. However, both species have suffered a substantial decrease in abundance over the western Mediterranean as a whole in recent years. The reasons for such a decrease are not totally clear but are thought to be a combination of habitat alteration and fishing interactions. Incidental catches are certainly a source of concern for the population maintenance of the two species in the western Mediterranean and, in particular, may be a key factor in the survival of the existing population of common dolphins.

ACKNOWLEDGEMENTS Thanks are due to the observers that participated in the trips and, very especially, to the driftnet fishermen who allowed placement of observers on board their boats. The Directorate-General XIV -Fisheries- of the European Commission (project PEM/3507) and the Spanish National Institute for the Conservation of the Nature (ICONA) funded this study.

Table 1: Number of cetaceans caught during monitored operations

	1993		1994		TOTAL	
	Number	%	Number	%	Number	%
Common dolphin	5	45	15	50	20	49
Striped dolphin	6	55	15	50	21	51

Table 2: Estimate of the incidental catch of cetaceans by the Spanish driftnet fleet in Mediterranean Waters for 1993 and 1994

YEAR	BYCATCH RATE	TOTAL ESTIMATE	CONFIDENCE INTERVALS (95%)
1993	0.101	338	{129 - 547}
1994	0.153	295	{157 - 433}

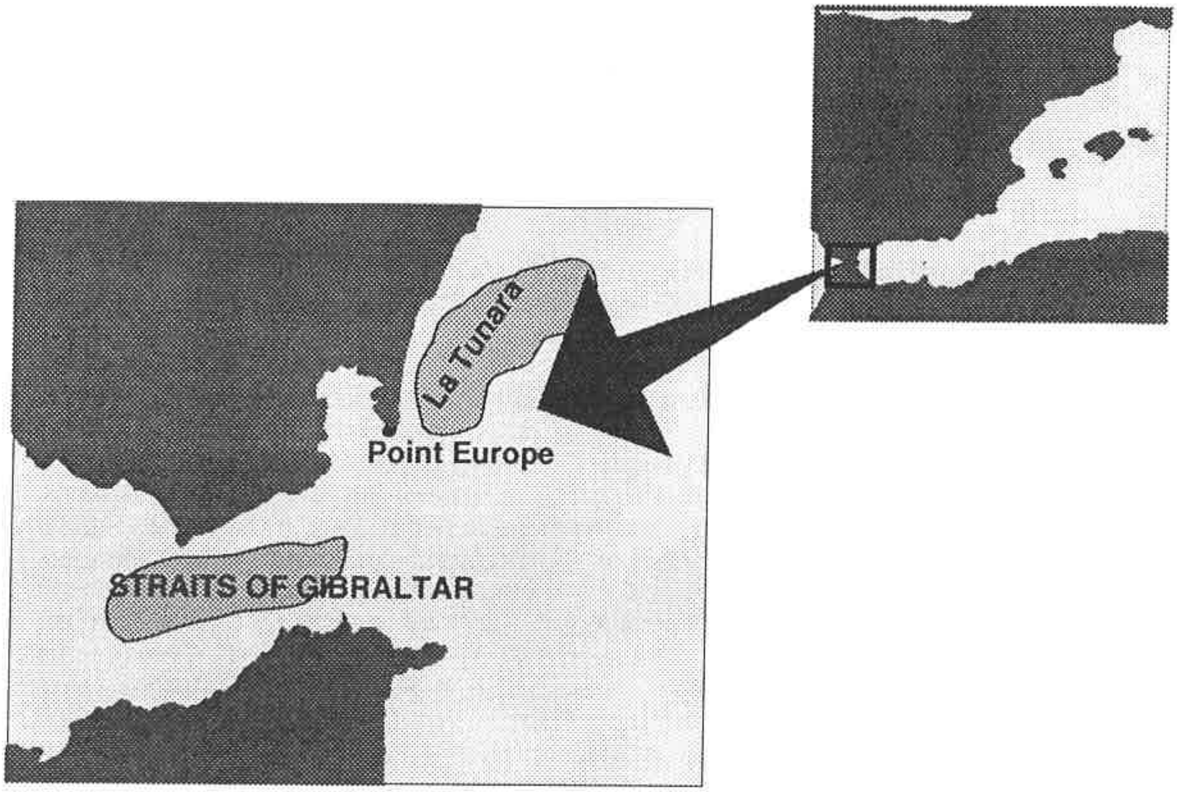

Figure 1: Fishing grounds of the Spanish driftnet fleet

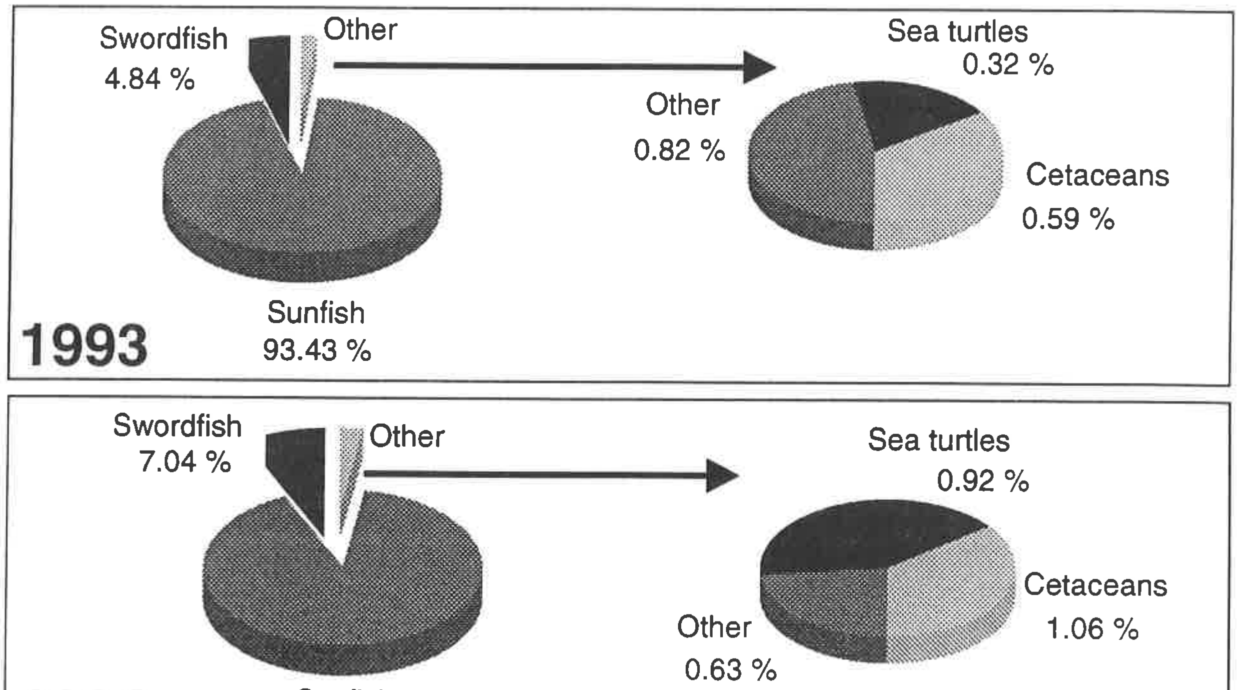

Figure 2: Catches during the monitored driftnet operations.

PRELIMINARY STUDY ON CENSUS DATA ABOUT THE INTERACTION BETWEEN DOLPHINS AND FISHING ACTIVITY IN THE SICILIAN FISHERIES

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INTRODUCTION The needs of the Mediterranean small pelagic fishermen do not seem to be compatible with the needs of the conservation of marine mammals (particularly dolphins). The small pelagic fishermen maintain that high numbers of dolphins, in a certain sea area, compromise the abundance of the pelagic fishes (sardines, anchovies, etc.), and simultaneously cause heavy damage to their purse seines, which are very expensive. From the other point of view, dolphins are killed by the fishermen, both accidentally through bycatches and intentionally with shotguns. The fishermen over-estimate the daily diet of small pelagic fish per dolphin at 50-60 kg. In contrast, data from scientific literature suggest a value of 8-16 kg of small pelagic fish per dolphin per day (Watson, 1981; Viale, 1985). It is true, however, that the dolphins cause significant damage to the fishermens' nets (Marini *et. al.*, 1991; oral and personal communications from Terrasini, Sciacca, Mazara, Trapani, Lampedusa Fisheries). Over the years, this problem has become very dramatic and it has produced disputes between ecologists and fishermen, fishermen and local government, and so on, and it seems to compromise the community policies for conservation and for the fishery in those particular areas of the Mediterranean Sea.

This work is part of a two-year research programme on the study of the interactions between dolphins and fishery activities in the Sicilian Channel and in the South Tyrrhenian Sea. This project is developing in two parallel directions. Along the first one, we will collect biological and statistical data on dolphins and small pelagic fisheries by logbooks and by interviews with fishermen. Along the second, we are studying the possibility of repelling dolphins away from a particular sea area which is important to the fishermen. In this work, we present the preliminary results obtained for the first phase, i.e. the analysis of census data collected during the first year of research.

MATERIALS AND METHODS Initially, we planned to develop the census data collection in the fisheries shown in Fig. 1. In Fig. 2, the structure and consistency of the Sicilian Fisheries investigated after the first year of research are shown.

We planned to collect the information during the fishery cruises (visual census) and by interviews with fishermen. Periodically, twice every year (in spring and in autumn), a given number of ships had two shipboard observers to verify the sightings and data recording procedures (Hewitt, 1985; Holt, 1987; Holt and Sexton, 1990). We distributed a work form (and a data recording guide), through which information was collected on the structure of fishing fleets and on the interaction between dolphins and fishery activities (namely species of dolphins, damage to nets, etc.). All Presidents of the Sicilian Fishermen's Associations gave their complete co-operation to collaborate with this project.

RESULTS The collection of the biological data was largely compromised with respect to the original plan because of the reduced budget of the project and because of an insufficient compatibility between our sampling procedure and the work procedure of fishermen. The average economic damage for each net for one year is about 10,-15,000 ECU for a net entanglement and about 7,-11,000 ECU for an encircled net. For all fisheries examined, the damage produced by dolphins in the region of 20-30% of the annual fishing income. The fishermen further estimate that the loss of small pelagic fish biomass inside the nets after the dolphin raids is about 40%. In order to estimate the main value of dolphin bycatches in the Sicilian fishery under examination, it is necessary to consider a five-year period, since the event is very rare for a fishery to have dolphins trapped by entanglement or encircled by nets. In the last five years, the total was about 6-7 specimens, whereas, in the last three years, the stranding of dolphins in the examined areas amounted to about 7-8 specimens (Fig. 2).

At this stage of development of our project (i.e. after the first year), the results are partial and qualitative. In the Sicilian fisheries the food competition between fishermen and dolphins is very strong. In this interaction, both parts pay and lose something. The main ways by which the dolphins pay to have food during this interaction are through bycatches and by the dolphins being killed intentionally by fishermen. The fishermen lose in terms of damage to their nets, which are usually very expensive, and by reduced catches due to dolphins consuming them.

We found out, by means of preliminary analysis of biological data, that the scale of the problem faced by fishermen is greater than that by the dolphins at least for the kind of fishery that we studied (namely artisanal and purse seine). For other methods of fishing, the damage to the dolphin community is much more important, for example where pelagic driftnets are used in Isola delle Femmine sea-area (near Palermo), about 8-10 specimens a year for 15 vessels are caught. The quantity of bycatches is lower than the amount of dolphins killed by fishermen. In any case, the total amount seems to be comparable to the natural mortality of dolphins. Up to now, we do not know the natural mortality of dolphins in the Sicilian fisheries because of lack of scientific information, but qualitative consideration using available information seems to confirm this estimation.

The preliminary analyses of data on the consistency and species of dolphins, and by means of video and photo images, and descriptions from fishermen (colour, behaviour, etc.) seem to confirm that the main populations are bottlenose, striped, and common dolphins, both for the Sicilian Channel and South Tyrrhenian Sea, as previously concluded by other authors (Marini *et. al.*, 1991). Up to now, the evaluation is qualitative but, at the end of project, we plan to have a more precise estimation of relative populations.

CONCLUSIONS The preliminary conclusions from our data analysis can be summarised as follows:

- the most abundant species of dolphins in the Sicilian Channel and in the South Tyrrhenian Sea are: bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*), and striped dolphins (*Stenella coeruleoalba*).
- the amount of dolphin bycatches is very low for the two types of fishery that we have considered for our study, that is those net fisheries which encircle and entangle prey.
- the amount of economic damage on the nets, caused by dolphins, is very high.

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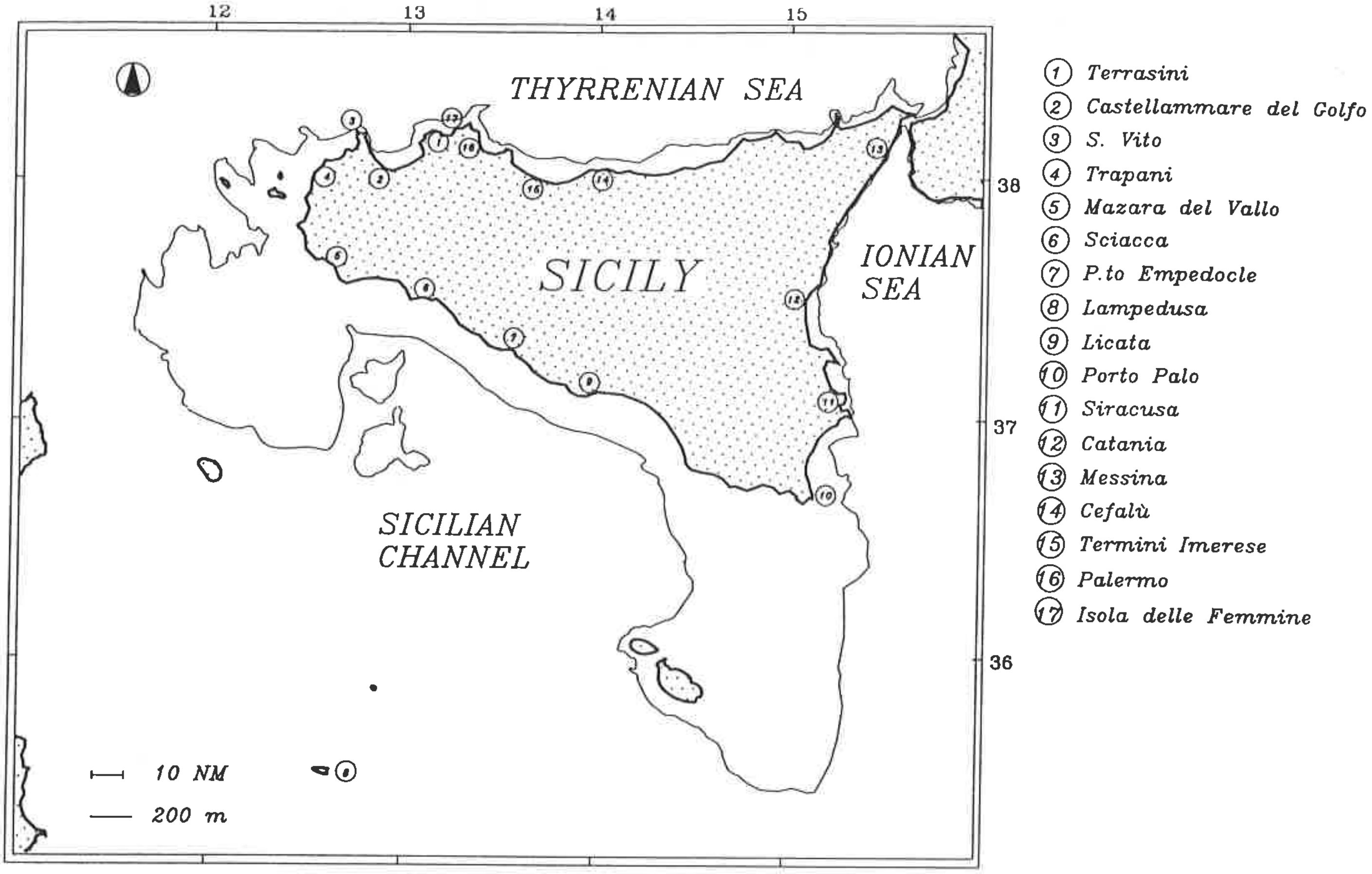
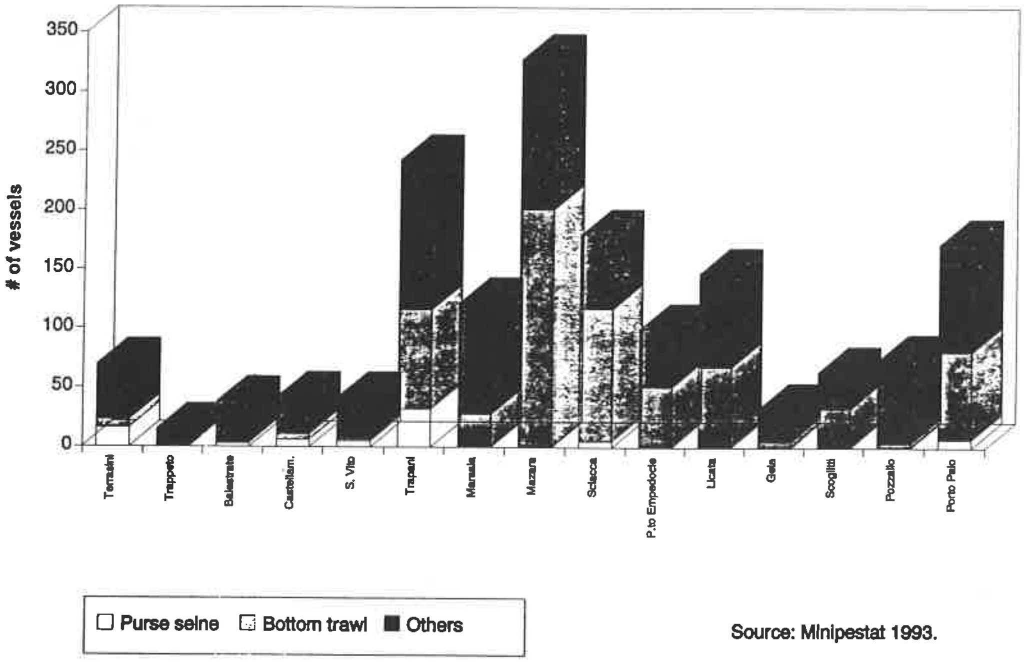


Fig. 1. Geographical distribution of the main Sicilian fisheries.



Source: Minipestat 1993.

Fig. 2. Histogram representing structure and consistence of south-west Sicilian fisheries.

SURFACING BEHAVIOUR OF HARBOUR PORPOISES INSIDE HERRING WEIRS

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INTRODUCTION The behaviour of captive harbour porpoises (*Phocoena phocoena*) has been infrequently studied (Akamatsu *et al.*, 1994; Hatakeyama and Soeda, 1990), and results may reflect circumstances of captivity or animal health. It is not known how the behaviour of captive porpoises compares to that which occurs in their natural environment. This study analyses the behaviour of wild porpoises temporarily held inside herring weirs, and compares it to that of captive porpoises.

METHODS Five herring weirs were monitored during August and September 1994 on the east coast of Grand Manan Island, Bay of Fundy, New Brunswick, Canada. Harbour porpoises regularly enter weirs and often stay in the weir for a period of days. Spatial and temporal behaviour of six porpoises was monitored during a total of 23.25 hours. Weirs were divided into three main zones with inner and outer sections (Fig. 1). Time and type of disturbances (ferries, vessels, acoustic device - for details see Lien *et al.*, in press) were recorded. Two harbour porpoises held in one tank at the Dolphinarium Harderwjik, Netherlands, were observed on 30 and 31 August, 1994. Spatial and temporal patterns were recorded for 82 minutes with the same methods as above. If not stated otherwise, a Kruskal-Wallis test was employed with $\alpha = 0.001$.

RESULTS Popoises in weirs exhibited diving periods which averaged 30.9 ± 0.8 s. Short dives (9.7 ± 0.2 s) and long dives (81.8 ± 1.8 s) could be distinguished. The porpoises mainly exhibited a very regular surfacing pattern (Fig. 2). On two days out of 7, animal 6 remained at the surface for extended periods (26.8 ± 1.3 s) (Fig. 3). Only animal 6 reacted to disturbances. All animals significantly preferred the outer area of the weir (G-test, $\alpha = 0.001$). The average dive time for Dolfinarium captives was 24 ± 2 s. No clear diving pattern was evident (Fig. 4). None of the animals used space equally (G test, $\alpha = 0.05$).

DISCUSSION The diving pattern of the porpoises in weirs corresponds to pattern B described by Watson (1976). This pattern is typical for feeding porpoises (Gaskin *et al.*, 1975; Watson, 1976). Thus, the diving patterns in our study could indicate that the porpoises were feeding inside the weir. Lying at the surface has been interpreted differently (Andersen and Dziedzic, 1964; Gaskin *et al.*, 1975; Watson, 1976). Animal 6 lay at the surface only during the last two days of observations after it had displayed pattern B diving behaviour for five days. This sudden change in behaviour might indicate sickness. The observation time of the captive porpoise was very limited. Longer observation of these animals is planned.

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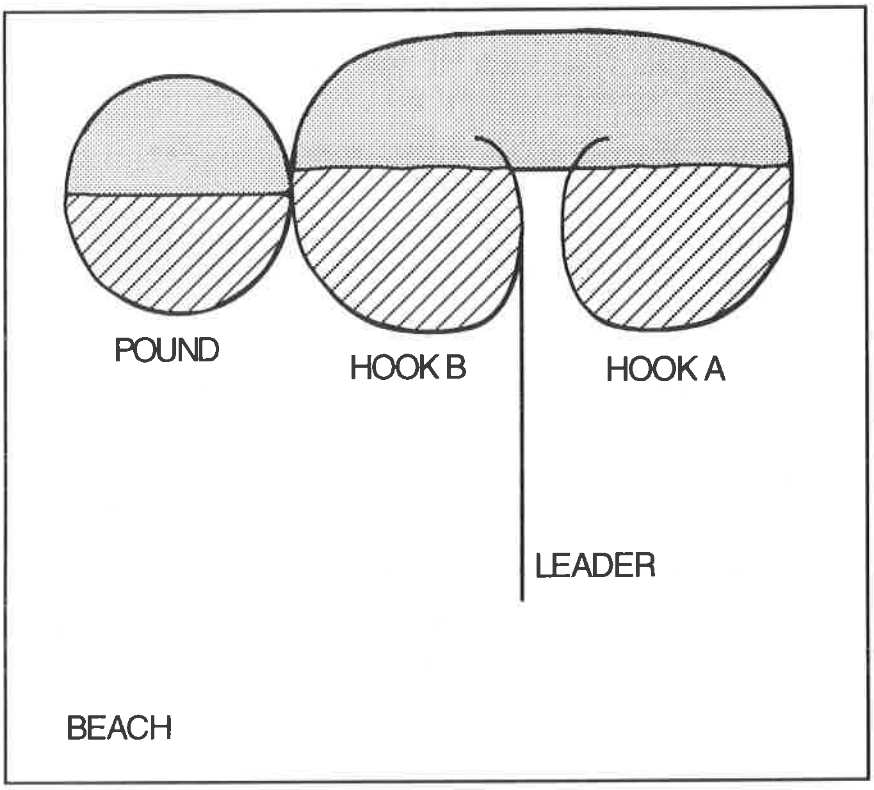

Fig. 1: Sketch of a weir. The dotted areas represent the outer section, the hatched areas represent the inner section.

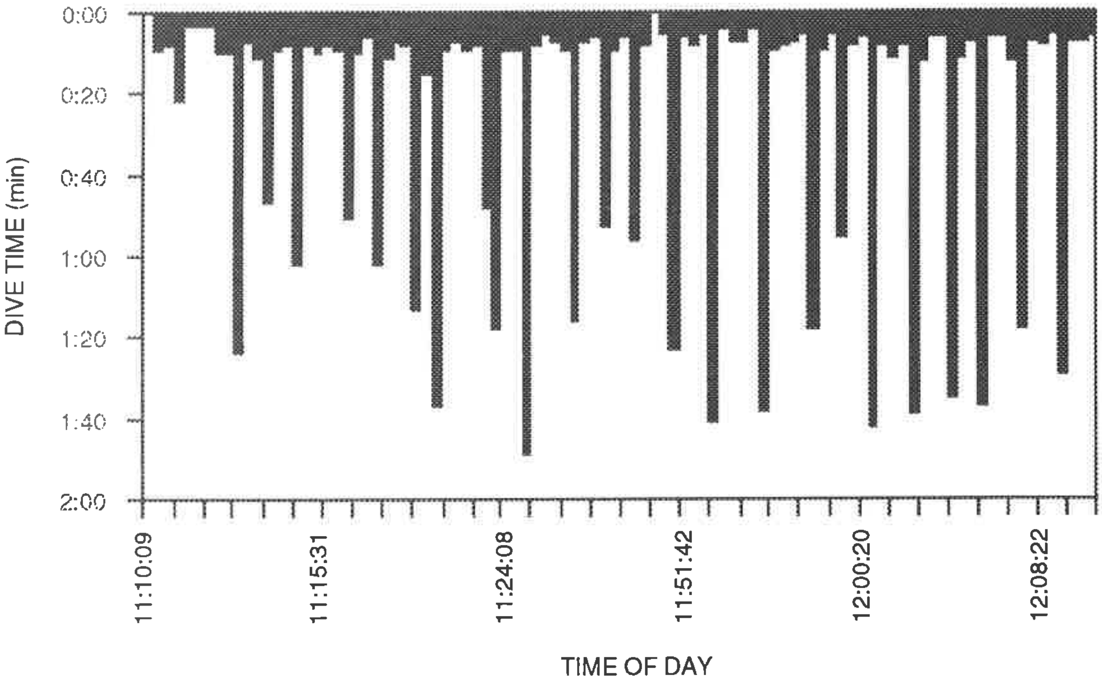

Fig. 2: Dive times of animal 6 on Aug. 26. Suspended columns represent dive times.

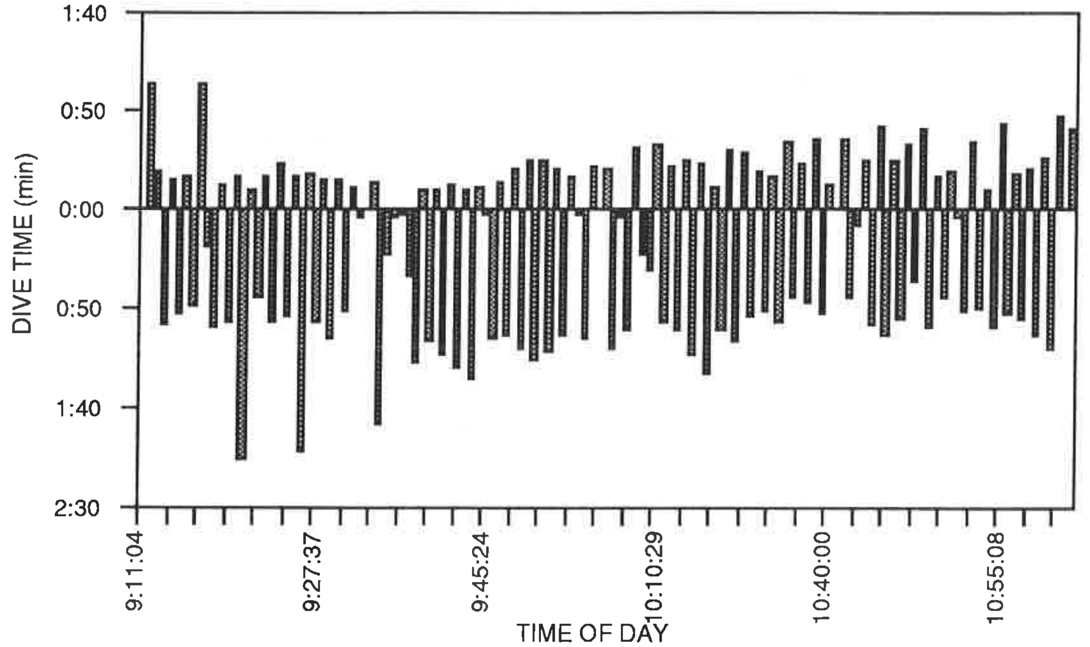

Fig. 3: Surfacing pattern of animal 6 on Sep. 03, 09:10 - 11:15. Suspended columns represent dive times, standing columns represent time at the surface.

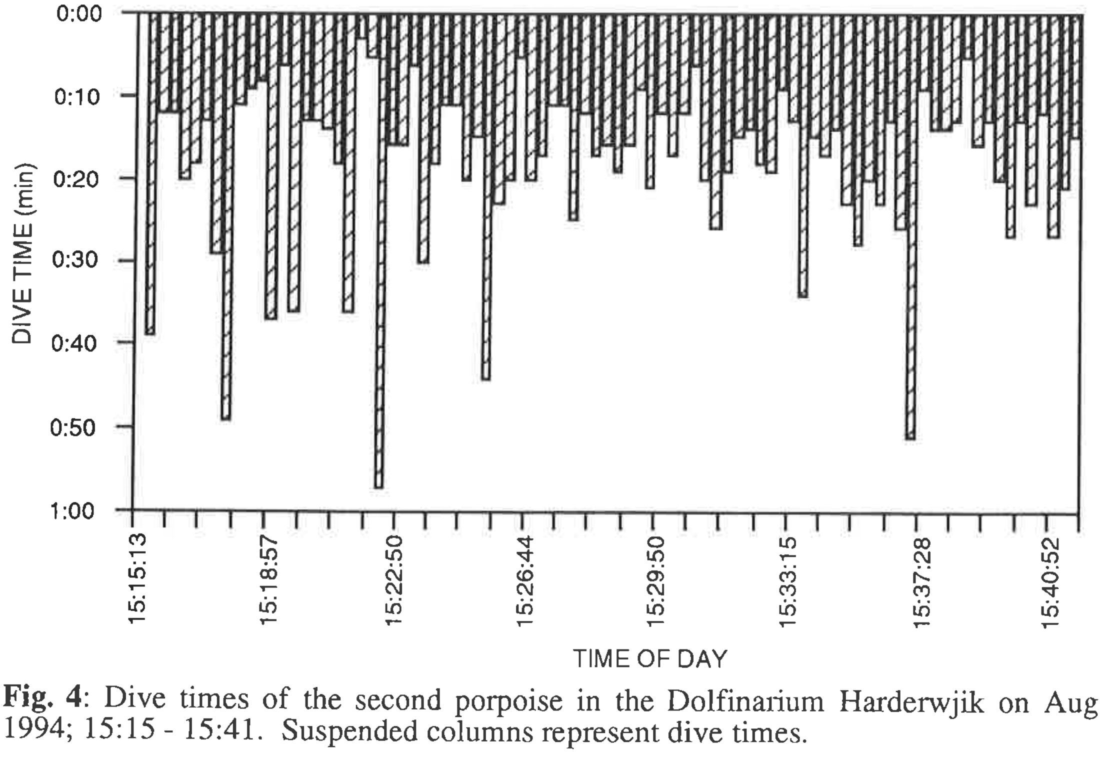

Fig. 4: Dive times of the second porpoise in the Dolfinarium Harderwjik on Aug. 30, 1994; 15:15 - 15:41. Suspended columns represent dive times.

PARAMETERS OF LIFE HISTORY OF BYCAUGHT EAST ATLANTIC WHITE-SIDED DOLPHINS (*LAGERORHYNCHUS ACUTUS*)

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Bycaught white-sided dolphins were brought ashore by Dutch trawler fisheries in 1993 and 1994. All 47 animals were dissected and studied extensively, most of them at the First Dutch Workshop on 'Pathology of Bycaught Cetaceans' held in Ijmuiden in May 1994.

Life history parameters such as age composition, reproductive status and the relation between blubber thickness, subcutaneous fat thickness, heart weight and total body weight are discussed.

PATHOLOGICAL FINDINGS IN BYCAUGHT EAST ATLANTIC WHITE-SIDED DOLPHINS (*LAGENORHYNCHUS ACUTUS*) RELATED TO ACCIDENTAL ENTRAPMENT IN TRAWLER FISHERIES

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Forty-seven bycaught white-sided dolphins (*Lagenorhynchus acutus*) were brought ashore by Dutch trawler fisheries in 1993-1994 and examined according to a modified ECS standard necropsy protocol. Most of these animals were examined during the First Dutch Workshop on pathology of bycaught cetaceans held in Ijmuiden in May 1994.

The pathological findings specifically relating to the death of the animals by accidental entrapment in nets, and their relative rate of occurrence, are discussed. Such lesions include the ones related to sharp and blunt trauma, lung pathology related to death by submersion, and others.

THE BLACK SEA COMMON DOLPHIN EPIZOOTIC IN 1994

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INTRODUCTION A previous Black Sea cetacean epizootic occurred during 1989-90, affecting three dolphin species, with the harbour porpoise (*Phocoena phocoena relicta*) population suffering the most (Birkun *et al.*, 1992; Birkun and Krivokhizhin, 1993). The origin was not clearly known. Recent immunohistochemical examination of those harbour porpoise lung samples did not confirm the morbillivirus ethiology (S. Kennedy, *pers. comm.*).

MATERIALS AND METHODS In 1991-94, the study of cetacean strandings on the Crimean Peninsula coast was continued by means of an active search of beached animals as well as by the recording of all accessible information coming from various observers.

RESULTS The number of stranded dolphins and porpoises noted in 1991-93 was considerably less than in the previous two years (Table 1). Then, in 1994, during a short-term period (from mid July to the first week of September) a great number (25) of moribund and dead common dolphins were observed off the Crimean coast (Table 2 and Fig. 1), compared with the preceding seven months when only one stranded common dolphin was found. A similar situation was noted in Ukraine near Odessa (two cases), in Rumania (nine cases) and in Russia near Anapa (seven cases). The total number of beached animals remains unknown, because of the absence of a strandings network in the majority of the Black Sea countries.

Eighty-four percent of dolphins stranded in Crimea were alive when they reached shore, most of them dying within a few hours. Five animals were transported to the open sea and released; their fate remains unknown. Three individuals taken for veterinary examination and treatment, died in rehabilitation centres, 3-72 hours after arriving.

Floating and live-stranded dolphins had the following signs of illness: abject passivity, limited mobility, drifting on the surface, disco-ordinated movements, physical weakness, frequent breathing, tachycardia, emaciation, and changes in white blood cell ratio (leucopenia, lymphocytopenia, uneosinophilia). Common post-mortem findings were as follows: empty gastro-intestinal tract, necrotic stomatitis, gastritis, enteritis and hepatitis, chronic pneumonia and necrotic bronchitis, fibrous atrophy of spleen and lymph nodes, and focal lesions in brain tissue (gliomatosis). No macroparasites were found in dissected animals. The injuries in the mouth cavity, stomach, bowels, liver and bronchi were not accompanied by significant inflammatory reaction (there was only moderate macrophage accumulation with single giant cells).

CONCLUSIONS Unidentified viral infection is the most probable origin of the Black Sea common dolphin epizootic in 1994. Fibrous degeneration of spleen and lymph nodes provides morphological evidence that the animals were immunosuppressed.

ACKNOWLEDGEMENTS This work was supported by the Ministry of Environmental Protection of Ukraine and by Marineland-Antibes. We are grateful to Boris Zhurid, Ludmila Kamayeva, Gabriela Plotoaga, Vladimir Podkladkin for significant information. Our thanks also, to all collaborators of BREMA Laboratory and Laspi Dolphinarium for their assistance.

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Fig.1. Geographical distribution of common dolphin strandings in the Black Sea (1994)

Table 1 Annual variation in cetacean strandings on the Crimean coast

YEARS	HARBOUR PORPOISES	COMMON DOLPHINS	BOTTLENOSE DOLPHINS	UNIDENTIFIED DOLPHINS	TOTAL
1989	46	10	3	44	103
1990	225	38	20	12	295
1991	4	2	3	5	14
1992	4	-	4	1	9
1993	5	6	1	4	16
1994	1	26	3	5	35
TOTAL	285	82	34	71	472

Table 2 List of common dolphin strandings recorded in the Black Sea countries in 1994

NO.	DATE	LOCATION	SEX	LIVE/DEAD	OUTCOME
		Observations in Crimea			
1	18.05	Laspi Bay	F	D	-
2	26.07	Sevastopol	M	L	died in 30 min
3	31.07	Sevastopol	?	L	unknown
4-6	July	Sevastopol	?	D	-
7	July	Sevastopol	?	L	died during 1 h
8	10.08	Laspi Bay	M	D	-
9-11	13.08	Frunze	?	D	-
12	14.08	Sevastopol	F	L	died during 1 h
13	14.08	Sevastopol	?	L	released
14	14.08	Pribrezhnoie	?	L	released
15	15.08	Kerch	?	L	released
16	20.08	Sevastopol	M	L	died during 1 h
17	21.08	Alushta	?	L	unknown
18	21.08	Miskhor	F	L	unknown
19	21.08	Miskhor	?	L	unknown
20-21	21.08	Sevastopol	?	L	unknown
22	24.08	Uglovoie	?	L	released
23	27.08	Foros	M	L	died in 3 h
24	28.08	Yevpatoria	M	L	died during 1 day
25	28.08	Yevpatoria	?	L	died in few min
26	04.09	Yalta	F	L	died in 3 days
		Observations outside Crimea			
27-28	July	Constantsa	?	L	unknown
29	August	Odessa	?	L	released
30	August	Odessa	?	L	died in few min
31-37	Jul-Sept	Anapa region	?	L&D	unknown
38-44	Jul-Sept	Rumania	?	L&D	unknown

TOXICITY ASSESSMENT OF PCB ISOMERS INCLUDING NON-*ORTHO* COPLANAR PCBS IN CETACEANS FROM THE WESTERN MEDITERRANEAN SEA

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INTRODUCTION Persistent lipophilic organochlorine contaminants have been reported in several species of marine mammals (Kannan *et al.*, 1993; Tanabe *et al.*, 1993). As these vertebrates are lung-breathing animals, they are mainly exposed to organochlorine contaminants through diet. Since many of them are top predators, they are exposed to very high concentrations of these xenobiotics. Cetaceans in particular have a low detoxification capacity and this contributes to the accumulation of organochlorines in their tissues, especially the blubber (Tanabe *et al.*, 1988).

The position of the chlorine atoms in the biphenyl ring is of crucial importance for the bioaccumulation and metabolism of PCBs. Among the 209 different PCB congeners, mono-, di- and non-*ortho* PCBs have a dioxin-like structure and toxicity, being isostereoisomers of 2,3,7,8-tetrachlorodibenzo-p-dioxins (2,3,7,8-TCDD), the most harmful xenobiotic. Non- and mono-*ortho* PCBs cause immune disorders, carcinogenesis, and other pathologies in mammals (Safe, 1993).

The aim of this study was to determine PCB concentrations in four species of cetaceans from the Western Mediterranean Sea: the common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), sperm whale (*Phiyeter macrocephalus*) and the bottlenose dolphin (*Tursiops truncatus*), and to analyse any differences in relation to species. The toxic risk for these species is assessed in terms of Toxic Equivalents (TEQs), based on the Toxic Equivalency Factors (TEFs) proposed by Safe (1990).

MATERIALS AND METHODS

Sampling Blubber was excised from the mid-dorsal region of cetaceans found stranded along the Spanish Mediterranean coast during 1992 (Fig. 1). Available biological parameters are shown in Table 1. The blubber was wrapped in aluminium foil and stored at -20°C until analysis.

Chemical analysis Extraction of PCBs from blubber of dolphins, separation and quantification of individual PCB isomers and congeners including non-*ortho* coplanar PCBs by high resolution-gas chromatography (HRGC-ECD), and confirmation of PCB isomers by high resolution gas chromatography-mass spectroscopy (GC-MS) were performed as described by Tanabe *et al.* (1987).

RESULTS AND DISCUSSION

ΣPCBs ΣPCB concentrations in cetacean blubber, on a wet weight basis, are shown in Table 2. Highest values were found in Risso's dolphins, followed in order by bottlenose dolphins, sperm whales, and common dolphins (Fig. 2). The only specimen of bottlenose dolphin examined also showed very high levels of PCBs (233 μg/g), while in sperm whales and common dolphins, values were about two orders of magnitude lower than in Risso's dolphin (x=10.6 and x=4.8 μg/g respectively).

PCB congeners We identified 53 congeners in blubber of the species analysed, including coplanar ones (Table 3). The predominant hexaCBs were congeners 22'44'55' (IUPAC-153) and 22'344'5 (IUPAC-138) and the predominant heptaCB was 22'344'55' (IUPAC-180). Most of the residues (70-80%) consisted of hexa- and heptachlorobiphenyls in all species except the sperm whale, in which high concentrations of pentachlorobiphenyls, especially 22'344' (IUPAC-85), were found (Fig. 3). This pattern is similar to that found in dolphins dying of morbillivirus in the Mediterranean in 1991 (Kannan *et al.*, 1993).

The concentrations of the most toxic congeners (non-, mono- and di-*ortho* PCBs) are reported in Table 4. In all species, there was a general trend of di->mono->non-*ortho* PCBs. Non-*ortho* PCBs 33'44' (IUPAC-77), 33'44'5 (IUPAC-126) and 33'44'55' (IUPAC-169) were found at levels of around 1 ng/g in all species except Risso's dolphin, in which they were an order of magnitude higher (Tables 1 and 4).

Toxicological aspects For mono-, di- and non-*ortho* PCB congeners, the 2,3,7,8-TCDD Toxic Equivalents (TEQs) were calculated using the Toxic Equivalency Factors (TEFs) proposed by Safe (1990). Single chemical contributions to total toxicity changed in relation to their concentrations (Fig. 4), by virtue of the higher toxic potential of mono-*ortho* congeners (see TEF values in Table 4). The contribution decreases in the order mono->di->non-*ortho* PCBs in bottlenose and Risso's dolphins, and mono->non->di-*ortho* PCBs in common dolphin and sperm whale. TEQ values for coplanar PCBs showed a trend of PCB126>PCB77>PCB169 in all species except the common dolphin, in which it was PCB169>PCB126>PCB77. Total TEQs were 0.4 ng/g in common dolphin, 1.1 ng/g in sperm whale, 22.7 ng/g in bottlenose dolphin, and 102.9 ng/g in Risso's dolphin.

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Table 1: Biometric data of single animals.

Species	sex	lenght (cm)	analyzed tissue	sampling area
G. griseus 1	f	290	blubber	Catalan coasts
G. griseus 2	m	231	blubber	Catalan coasts
T. truncatus	-	-	blubber	Catalan coasts
D. delphis 1	m	206	blubber	Alboran Sea
D. delphis 2	m	208	blubber	Alboran Sea
D. delphis 3	f	109	blubber	Alboran Sea
D. delphis 4	m	112	blubber	Alboran Sea
D. delphis 5	f	144	blubber	Alboran Sea
P. macrocephalus 1	f	500	blubber	P. de Mallorca
P. macrocephalus 2	m	800	blubber	P. de Mallorca
P. macrocephalus 3	f	850	blubber	P. de Mallorca

Table 3: PCB congeners mean percentage in the analysed species.

IUPAC number	common dolphin (n=2)	sperm whale (n=3)	Risso's dolphin (n=2)	bottlenose dolphin (n=1)
PCB-4	0,04	1,45	0,04	0
PCB-7	0,01	0,04	0,006	0,002
PCB-18	3,34	0,85	0,57	0,22
PCB-15	0,65	0,11	0,15	0,07
PCB-24	0,10	0,22	0,126	0,04
PCB-28	0,02	0,21	0	0
PCB-34	0,04	0,04	0,04	0,07
PCB-20	0,07	0,02	0,01	0,04
PCB-33	0,31	0,04	0,04	0,33
PCB-52	0,96	0,23	0,12	0,30
PCB-47	0,14	1,27	0,90	0,55
PCB-44	0,06	0,06	0,16	0,06
PCB-42	1,50	0,70	0,36	0,13
PCB-40	0,25	0,66	0,04	0,03
PCB-67	0,95	0,54	0,34	0,15
PCB-70	0,19	0,14	0,16	1,06
PCB-102	0,70	0,24	0,37	0,15
PCB-60	3,43	4,25	2,79	0,99
PCB-101	1,44	1,25	2,04	0,59
PCB-99	1,74	1,52	1,62	1,46
PCB-83	8,01	0,43	1,79	0,24
PCB-85	0,08	23,02	0,10	0,01
PCB-110	0,10	0,47	0,26	0,15
PCB-151	1,57	0,53	1,36	1,37
PCB-118	1,11	2,40	3,27	5,60
PCB-134	0,35	0,71	1,68	0,71
PCB-133	5,58	6,34	1,63	2,36
PCB-105	1,26	1,14	0,40	0,90
PCB-153	16,47	12,49	21,61	25,86
PCB-141	0,10	0,95	0,04	0
PCB-176	2,71	1,67	2,70	1,85
PCB-137	0,77	0,66	0,86	0,66
PCB-138	12,25	11,17	14,67	15,02
PCB-178	1,15	0,73	1,05	0,95
PCB-187	3,99	2,51	4,54	4,43
PCB-183	1,66	1,00	1,60	1,90
PCB-128	0,22	0,88	0,28	0,73
PCB-174	6,37	4,67	7,44	6,59
PCB-177	2,36	1,56	2,33	1,88
PCB-156	0,18	0,42	0,46	0,82
PCB-172	0,44	0,84	0,57	0,56
PCB-180	8,53	3,56	12,34	11,56
PCB-199	0,30	1,62	0,66	1,30
PCB-170	5,45	3,25	4,58	5,13
PCB-196	0,05	0,03	0	0
PCB-201	0,81	0,61	0,91	0,85
PCB-195	1,21	1,28	1,67	1,45
PCB-207	0,14	0,19	0,14	0,17
PCB-194	0,79	0,57	1,08	1,00
PCB-206	0,03	0,04	0,05	0,04
TOTAL	99,98	99,58	99,95	100,33

Table 2: ΣPCBs means (µg/g wet wt) and coplanar congeners (33'44'-TeCB, 33'44'5-PeCB and 3'44'55'-HeCB) concentrations (ngg wet wt) in Cetaceans.

Species	ΣPCBs	PCB 77	PCB 126	PCB 169
G. griseus 1	466.2	23,9	19,4	2,07
G. griseus 2	2061.3	5,02	3,92	1,00
T. truncatus	233.7	2,83	3,66	1,41
P. macrocephalus 1	11.8	0,64	0,45	1,00
P. macrocephalus 2	9.5	0,62	0,61	0,11
P. macrocephalus 3	10.5	2,03	2,56	0,36
D. delphis 1	7.2	0,49	0,24	0,42
D. delphis 2	4.4	2,03	0,17	0,87
D. delphis 3	6.6	0,39	0,15	0,37
D. delphis 4	2.3	0,21	0,13	0,10
D. delphis 5	3.8	1,18	0,06	1,47

Tabel 4: Mean concentrations (ng/g w wt) and 2,3,7,8-TCDD (pg/g wet wt) in the ana_ lyzed species.

		T. truncatus		*G. griseus*	
Di-ortho	TEF	Conc.	TEQ	Conc.	TEQ
128	0,00002	1701,6	34,0	3513,8	70,3
137	0,00002	1536,7	30,7	10934,3	218,7
138	0,00002	35119,2	702,4	185411,6	3708,2
153	0,00002	60456,9	1209,1	273175,2	5463,5
170	0,00002	11989,8	239,8	57949,4	1159
180	0,00002	27009,8	540,2	155944,8	3118,9
194	0,00002	2342,2	46,8	13680,1	273,6
Tot.		140156	2803	700609	14012
Mono-ortho					
60	0,001	2305,1	2305,1	35218,8	35218,8
105	0,001	2115,9	2115,9	5100,6	5100,6
118	0,001	13084,3	13084,3	41321,3	41321,3
156	0,001	1927,6	1927,6	5843,3	5843,0
Tot.		19433	19433	87484	87484
Non-ortho					
77	0,01	2,8	28,3	14,5	144,7
126	0,1	3,7	365,9	11,7	1170,0
169	0,05	1,4	70,6	1,5	77,0
Tot.		8	465	28	1392
TOTAL		**159597**	**22701**	**788121**	**102888**
Di-ortho		*P. macrocephalus*		*D. delphis*	
128	0,00002	93,69	1,87	10,9	0,2
137	0,00002	70,39	1,41	37,2	0,7
138	0,00002	1184,73	23,69	593,8	11,9
153	0,00002	1324,63	26,49	797,9	16,0
170	0,00002	345,06	6,90	264,0	5,3
180	0,00002	377,61	7,55	413,4	8,3
194	0,00002	60,02	1,20	38,3	0,8
Tot.		3456	69	2156	43
Mono-ortho					
60	0,001	450,4	450,4	166,2	166,2
105	0,001	120,85	120,85	61,0	61,0
118	0,001	254,27	254,27	53,9	53,9
156	0,001	44,96	44,96	8,8	8,8
Tot.		870	870	290	290
Non-ortho					
77	0,01	1,1	11,0	0,9	8,6
126	0,1	1,2	121,0	0.2	15,2
169	0,05	0,4	6,0	0,7	33,0
Tot.		3	138	2	57
TOTAL		**4329**	**1077**	**2448**	**390**

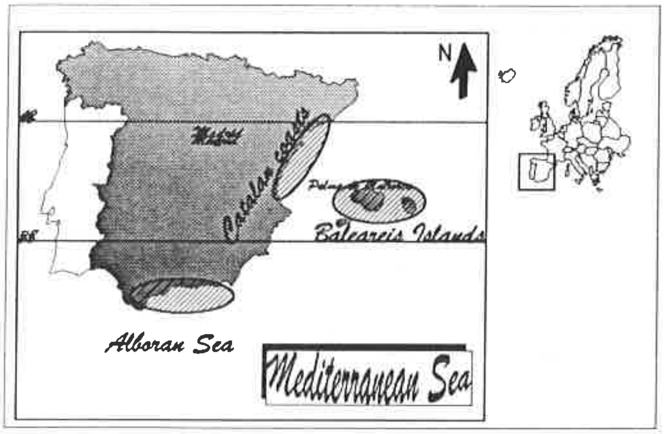

Fig. 1: Sampling area.

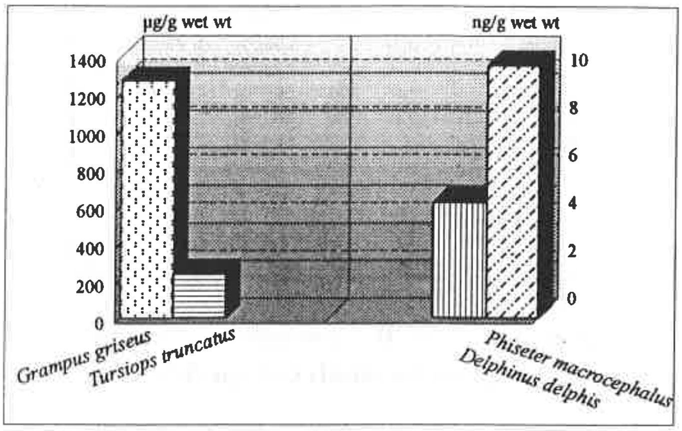

Fig. 2: PCB concentration in the analyzed species.

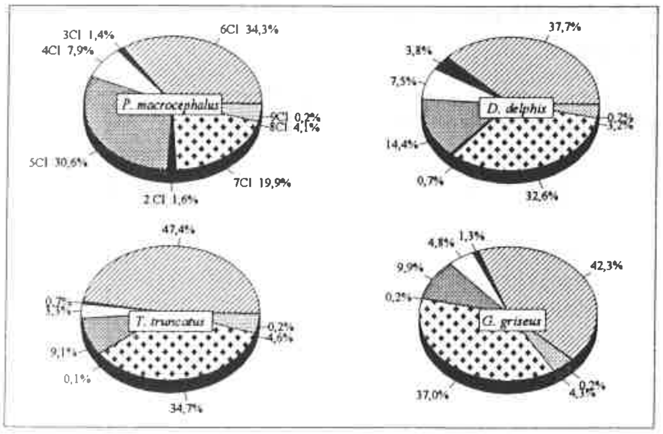

Fig. 3: PCB isomer composition in the analyzed species.

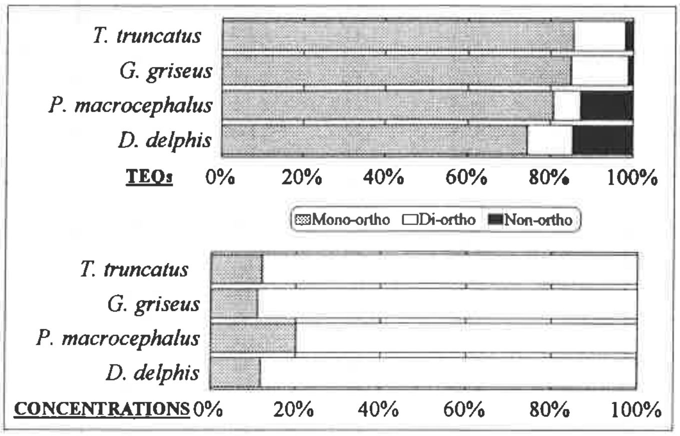

Fig. 4: Comparison between mono-, di- and non-*ortho* PCBs concentration and TEQs values.

DDT AND PCBs IN LA PLATA DOLPHINS (*PONTOPORIA BLAINVILLEI*) FROM ARGENTINA: AGE AND SEX TRENDS

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INTRODUCTION Organochlorine pollutants are highly persistent and accumulate along trophic webs, reaching high concentrations in marine mammals. These pollutants have been associated with reproductive impairment and depression of the immune system in marine mammals, both being determinant features for the long-term maintenance of a population. La Plata dolphins are highly coastal and often inhabit estuarine waters and other regions where organochlorine pollutants are abundant. In the last decades, their abundance has decreased in most of their range due to frequent incidental catches in gillnets. The aim of this study is to establish the age- and sex-related pattern of variation of organochlorine pollutant concentrations in these caught individuals.

MATERIALS AND METHODS Blubber samples from 43 males and 31 females caught in gillnets off Necochea (Argentina) during the period 1988-92 were collected and analysed for organochlorine pollutants. The analytical procedures included an extraction of the lipidic phase with n-hexane in Soxhlet, clean-up of the extract with sulphuric acid, and injection in an ECD capillary gas-chromatograph. Age was determined by counting growth layer groups in the dentine of teeth. Reproductive status was established by macroscopic and microscopic examination of gonads and associated reproductive tissues.

RESULTS AND DISCUSSION

Concentrations Mean concentrations of DDTs and PCBs, broken down by sex, are depicted in Table 1. These levels are low and are not considered to represent a threat to the maintenance of the population. In the mid 1970s, O'Shea *et al.* (1980) detected similar concentrations of PCBs but strikingly higher concentrations of DDT in specimens from Uruguay, which indicates that exposure to DDT has decreased in recent years. Variation of pollutant levels among components of the population was large: the tDDT and PCB concentrations of immature males were indistinguishable from those of immature females, but those of adult males were significantly higher than corresponding values of adult females ($p < 0.05$). tDDT levels in adult males were significantly higher than immature individuals of both sexes, but no significant differences were found in the PCB levels of different aged males On the other hand, adult females carried significantly lower PCB concentrations than immatures of both sexes, but no significant differences were found with tDDT.

These results are generally consistent with the pattern observed in most cetaceans: an increase in organochlorine pollutant levels with age in males and in immature females, but a decrease in mature females because of reproductive transfer of pollutants to offspring. However, no relationship was found between concentrations of organochlorines and age in females, although this result is probably the consequence of the biased representation of age-classes in the sample due to selectivity of incidental capture in gillnets. Thus, of the 31 females examined, only five were mature, although still quite young (five or six years old) and had therefore completed only a few reproductive cycles, so the potential for reproductive transfer was limited. In males, tDDT increased with age ($p < 0.05$) (Fig. 1), indicating that the rate of DDT incorporation is greater than the rate of excretion and degradation, and matching previous findings in other cetacean species. No significant trend in PCBs was observed, although biases in the age composition in the sample may again account for this negative finding.

Ratios Three congeners were chosen to study the pattern of PCB variation: 149 (2, 3, 6, 2', 4', 5' hexachlorobiphenyl), 174 (2, 3, 4, 5, 2', 3', 6' heptachlorobiphenyl) and 153 (2, 4, 5, 2', 4', 5' hexachlorobiphenyl). The first two have a ring with two adjacent carbons unsubstituted and therefore their metabolisation rate is likely to be high. In contrast, congener 153, predominantly found in vertebrates, is a recalcitrant form which resists degradation because it does not contain adjacent unsubstituted carbons. These ratios %149/PCB, %174/PCB and %153/PCB (depicted in Table 1) are considered to be useful indicators of the overall rate of degradation and excretion of PCBs. Comparing these ratios with comparable values in the Aroclor 1260 standard, it appears that %149/PCB remained similar to the initial mix (7.2 vs 7.4) while the %174/PCB decreased (2.1 vs 5.5) and %153/PCB increased (17.3 vs 9.6). This indicates that congener 174 and, to a lesser extent, congener 149 suffered a certain degree of metabolisation. However, it cannot be discerned in this study whether this process occurred within the dolphin body or, in contrast, whether it is the result of the overall action of the trophic web. On the other hand, congener 153 has probably remained unaltered, but its relative abundance increased because of the decrease in the abundance of the other more degradable forms. The ratios %DDE/tDDT, %174/PCB and %153/PCB did not show either significant differences between sexes or any significant trend with age. However, the %149/PCB decreased significantly ($p < 0.05$) with age in females (Fig. 2), but did not show any significant trend with males. The ratio %DDT/PCB showed a significant increase with age in males ($p < 0.01$) (Fig. 3), but no trend in females. Moreover, it was significantly higher in mature males than in both immature males and mature females. This variation is consistent with that found in previous studies and demonstrates a higher accumulation rate of DDT than of PCBs with age.

ACKNOWLEDGEMENTS A. Borrell was supported by a post-doctoral fellowship from the CIRIT (Direcció General de Recerca de la Generalitat de Catalunya). This study was funded by CICYT project AMB94-0399.

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Table 1

TOTAL		**Age (years)**	**% lipids/ w. weight**	**tDDT**	**PCB**	**% DDE/tDDT**	**% tDDT/PCB**	**% 149/PCB**	**% 174/PCB**	**% 153/PCB**
	Mean	2,80	81,32	1,55	1,93	62,66	70,66	7,19	2,08	17,27
n=74	St.d.	2,06	11,08	1,58	1,02	8,09	35,62	2,17	0,62	1,50
MALES										
Immature	Mean	1,40	79,72	1,33	1,92	61,93	61,60	7,41	2,02	17,18
n=25	St.d.	0,87	15,04	1,51	1,01	6,47	32,15	2,09	0,35	1,44
Mature	Mean	5,11	82,40	2,54	2,51	59,87	93,32	7,75	2,22	17,62
n=18	St.d.	1,69	7,24	2,15	1,25	4,60	47,14	2,73	0,41	1,05
FEMALES										
Immature	Mean	2,01	82,54	1,26	1,72	66,08	67,45	6,94	2,02	17,13
n=26	St.d.	1,20	7,66	0,95	0,73	10,20	25,35	1,79	0,88	1,79
Mature	Mean	5,60	79,16	0,51	0,96	58,60	51,05	5,46	2,24	17,18
n=5	St.d.	1,24	16,05	0,27	0,33	8,21	11,23	1,54	0,71	1,74

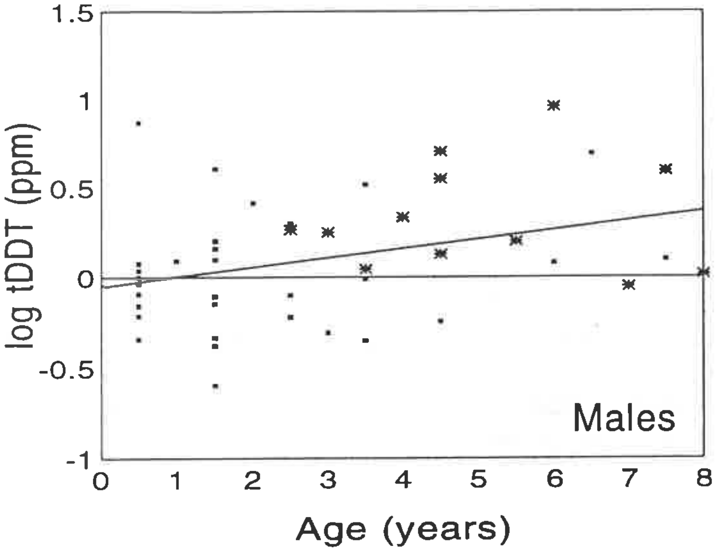

Figure 1

Y=0.052X-0.047
r=0.33

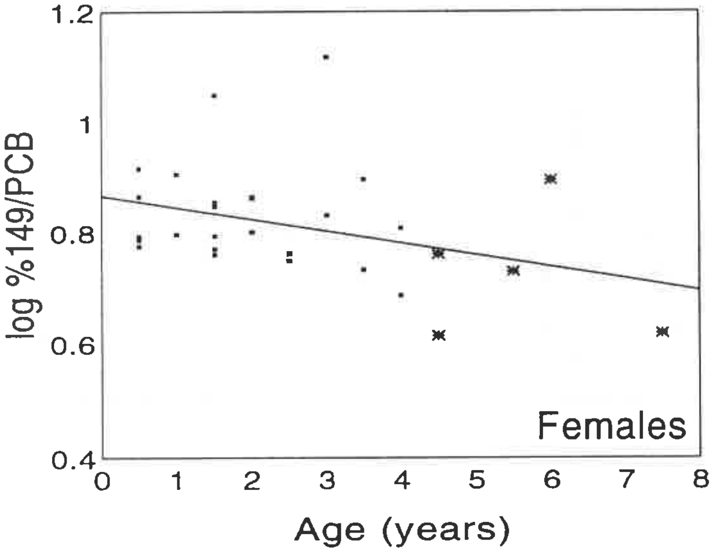

Figure 2

Y=-0.022X+0.087
r=0.37

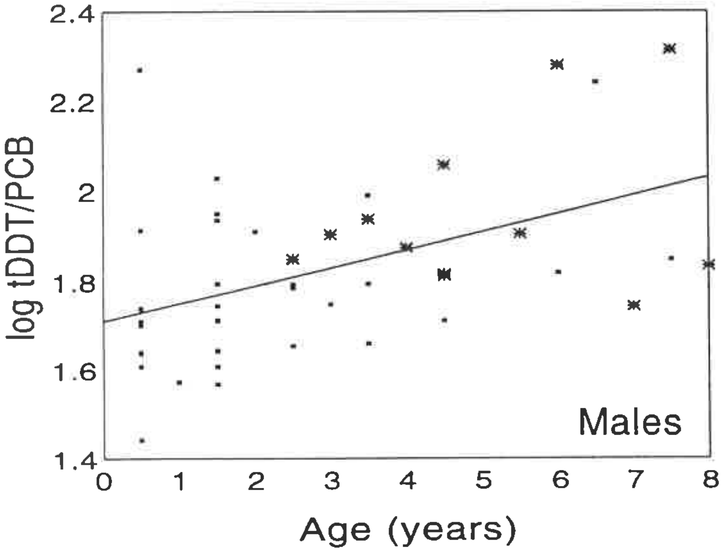

Figure 3

Y=0.04X+0.04
r=0.43

MERCURY ANALYSIS AND NECROPSY FINDINGS IN SMALL CETACEANS IN GERMAN WATERS OF THE NORTH AND BALTIC SEAS

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INTRODUCTION Many toxicological studies deal with the occurrence of different toxins in marine mammals. Despite some of them revealing high values of these toxins, only very little is known about their actual effects on the health of marine mammals. Moreover, almost no basic information is available concerning the health status of small cetaceans from German waters. Therefore, in this study, we concentrated on mercury and its possible effects on small cetaceans from the German waters of the North and Baltic Seas.

MATERIALS AND METHODS In this study, 57 stranded or bycaught harbour porpoises (*Phocoena phocoena*) and three white-beaked dolphins (*Lagenorynchus albirostris*) from the North and Baltic Seas were examined. The carcasses were weighed and measured, and four teeth were removed from each for age determination. The nutritional status was judged by measuring the blubber layer in four different locations and by evaluation of the state of the muscles. Pathological examinations were carried out according to the recommendations of the First European Cetacean Society Workshop on Cetacean Pathology (Kuiken and Garcia-Hartmann, 1993). Analysis of mercury burden was performed on muscle, liver, and kidney by the atomic-absorption-spectrometry method for total mercury, and by liquid-gas chromatography with electron-capture-detection for methyl-mercury.

All organs were examined histopathologically. Routinely, hematoxylin-eosin, and, if necessary, special staining methods were applied. For immunocytochemical detection of morbillivirus antigen, the avidin-biotin-peroxidase complex (ABC) method on paraffin embedded lung tissue was applied. Bacteriological examination was carried out on tissue samples from lung, liver, kidney, spleen, intestine and mesenteric lymph nodes. All parasites from contaminated organs were classified. Stomach contents and faeces were also examined for parasites. Statistical tests were performed.

RESULTS Analysis of mercury showed that the liver had the highest contents of total mercury and methyl-mercury. Total mercury and methyl-mercury increased with age of cetaceans (Fig. 1). The levels of total mercury in harbour porpoises ranged between 0.6 and 450 mg/g (dry weight of liver), the levels of methyl-mercury between 0.2 and 26 mg/g (dry weight of liver). Comparable mercury levels were already found in harbour porpoises from other areas of the North Sea (Joiris *et al.*, 1991). They were higher then those reported from Greenland (Paludan-Muller *et al.*, 1993).

No difference in total mercury and methyl-mercury burden was observed between stranded and bycaught animals, or between males and females. Contamination in cetaceans from the North Sea was significantly higher than in those from the Baltic Sea.

The majority of the macroscopical and histopathological lesions were due to parasitic infections. The most affected organ system was the respiratory tract, followed by the alimentary system and the liver (Table 1). Two-thirds of the animals showed different types of pneumonia with different degree and extension. This was the cause of death in nine stranded animals. The bacteriological examination yielded no increased incidence of a specific bacterial infection. In four cases, septicaemia caused by ß-hemolytic streptococci was found. Immunocytochemically, morbillivirus-antigen was not observed in the examined animals.

Specific lesions, as described for domestic animals and man in acute or chronic intoxication by mercury, could not be detected. Moreover, no lesions could be related to changes known from mercury poisoning in marine mammals. The rank correlation analysis demonstrated a highly significant correlation between increasing mercury level and decreasing nutritional state. In addition, increasing pathological changes of the lung became evident. Therefore, an influence of the mercury levels on the health state of the cetaceans cannot be excluded. However, further studies, especially of the immune system of small cetaceans, are urgently required.

CONCLUSIONS It can be concluded that none of the pathological lesions could be directly related to inorganic or organic mercury poisoning. But the rank correlation analysis showed that an influence of mercury levels on the state of health of the cetaceans cannot be excluded. The possibility that the diagnosed lesions did originate from an increased susceptibility to diseases must remain open, and further studies especially of the immune system of small cetaceans, are urgently required.

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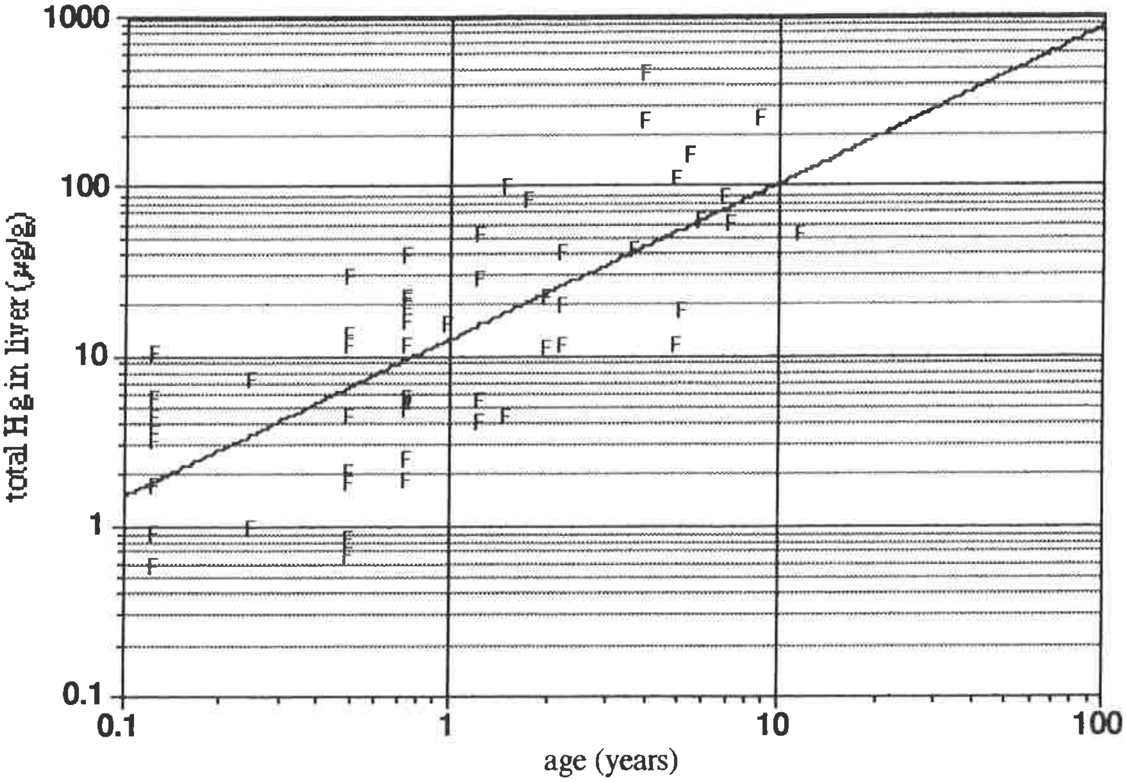

Fig. 1: Correlation-analysis between age (years) and total mercury in liver (µg/g dw)

Table 1: Main pathological findings

Pathological findings	Strandings	By-catches	Total
Respiratory system			
Pulmonary edema	27	30	57
Pulmonary congestion	6	15	21
Parasites	21	21	42
Pneumonia	23	19	42
Alimentary System			
Parasites	13	15	28
Parasitic nodules	4	4	8
Ulcera	6	3	9
Gastro-enteritis	6	2	8
Liver			
Parasites	11	9	20
Parasitic nodules	9	7	16
Cholangitis/Pericholangitis	9	10	19
Skin and subcutis			
Netmarks	0	30	30
Panniculitis	2	3	5

METHYLMERCURY GENOTOXICITY IN THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) LYMPHOCYTES IN VITRO

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Dolphins are subjected to several threats connected to human activities. Among these, the chemical contamination of the marine environment is of major concern. Occupying a terminal position in the marine food web, they are typical endpoints in the biomagnification of persistent pollutants such as mercury. In fact, mercury measured in tissues and organs of adult dolphins is at its highest levels among marine organisms. It has been demonstrated that part of the metal absorbed (as methyl mercury, MMC) with the prey, is degraded and accumulates in the liver as insoluble granules. However, the toxic effects induced by this xenobiotic on dolphin health are largely unknown.

In the present study, the potential of MMC to induce DNA damage in the bottlenose dolphin lymphocytes was investigated by microgel electrophoresis. Samples of blood were obtained from dolphins reared at the Adriatic Sea World (Riccione, Italy). Lymphocytes were treated in suspension culture for one hour with different MMC concentrations (1 to 8 μg/ml) before being subjected to individual cell eletrophoresis. Moreover, the cytotoxicity of MMC was assessed by dye exclusion technique performed on aliquots of the cell culture. Our preliminary results demonstrated that MMC has a genotoxic effect on cultured lymphocytes in a dose-related manner, including more than a four-fold increase in the proportion of the damaged cells, at the maximum dose (8μg/ml), with respect to controls ($p < 0.0001$). Moreover, the degree of induced DNA fragmentaion was comparable to that of reduced cell viability (8μg/ml, viability >79%).

These results were compared with data from the literature on the effects of MMC in human and rat lymphocytes. This comparison showed that cell viability remained high after exposing dolphin lymphocytes to a dose of 8 μg/ml, while it reduced to less than 70% after exposing human and rat lymphocytes at doses of 4 and 2 μg/ml respectively. Furthermore, MMC was less effective at inducing DNA fragmentation in dolphins as in human and rat lymphocytes ($p < 0.01$ at the dose of 2 μg/ml). The ecological significance of this "robustness" in dolphin lymphocytes was discussed.

Cs-137 AND K-40 IN HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) ORIGINATING IN IRISH AND BRITISH COASTAL WATERS

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INTRODUCTION Concern has been expressed about the health and status of small cetaceans in European waters for a number of years. The increase of pollutants in the marine environment has been identified as one of the possible causes of observed population declines. Studies have shown that such top level marine predators tend to accumulate a wide variety of environmental contaminants such as organochlorines, heavy metals, and radionuclides. There is, however, little data on radioactivity levels in marine mammals. The large number of cetaceans annually stranding on Irish and British coasts, and those incidentally caught in fishing nets off these coasts, have provided an opportunity to assess the impact of radionuclides in the marine environment on the top predator level of this ecosystem.

HARBOUR PORPOISE The harbour porpoise, *Phocoena phocoena*, is the smallest and most frequently observed (and stranded) cetacean in Irish waters. Most sightings are within 10 km of land, although offshore movement is known to occur in some populations in winter. They are bottom feeders, specialising on small schooling fish such as herring, sprat, Norway pout and poor cod. Harbour porpoise appear to be seasonal breeders, giving birth during the summer months. They are relatively short lived, with a life expectancy of about 15 years. Although the most frequently observed, this species appears to have declined in the last 30 years along the southern North Sea and Channel coasts. Causes of decline probably include coastal pollution, changes in fish stocks, and, in certain areas, accidental drowning in fishing nets.

RADIOACTIVITY IN THE MARINE ENVIRONMENT Radioactivity in the marine environment arises mainly from the presence of naturally occurring radionuclides (for example K-40). In recent decades, the activity levels have been enhanced by the addition of man-made radionuclides (for example Cs-137), sources of which include controlled and accidental discharges from nuclear installations and weapons fallout. The most important source affecting the Irish marine environment has been the discharge of low level radioactive waste from the nuclear fuel reprocessing plant at Sellafield on the north-west coast of England.

SAMPLING AND ANALYSIS The 25 harbour porpoise samples analysed for their radionuclide content originated from Irish and British coastal waters. These porpoises were caught or stranded between 1989 and 1993. The length, weight, and sex of each porpoise was determined. Ages were calculated from the growth rings in teeth. The muscle tissue was analysed for gamma emitting radionuclides by high resolution spectrometry. Samples were counted for approximately 24 hours using a germanium detector linked to a multichannel analyser and a DEC VAX computer system.

OBJECTIVES

(1) To determine the activity concentrations of Cs-137 and K-40 in the muscle tissue of harbour porpoise;
(2) To examine the potential influence of age, sex, length, weight and capture/stranding site and date on the Cs-137 activity concentration in the muscle tissue;
(3) To estimate the concentration factor (CF) for Cs-137 in harbour porpoise muscle tissue;
(4) To assess both the external and internal dose rate contributions from Cs-137 and K-40.

RESULTS The median Cs-137 and K-40 activity concentrations in muscle tissue were found to be 2.6 $Bq.kg^{-1}$ respectively. The Cs-137 activity concentration appears to be related to the capture/stranding area. However, no correlation was found between the activity concentration and the age, sex, length, weight or capture/stranding date. The CF for Cs-137 in harbour porpoise muscle tissue was estimated to range from 30 to 425. The average annual internal and external dose rates from Cs-137 were calculated to be 4.4 e^{-3} mGy and (1.22 - 16.3) e^{-5} mGy respectively, while those resulting from K-40 were calculated to be 0.27 mGy and 7.1 e^{-3} respectively.

CONCLUSIONS The Cs-137 activity concentration in harbour porpoise is higher than that found in other marine organisms from similar locations, reflecting its position as a top level predator in this ecosystem. The Cs-137 activity concentration appears to be related to the capture/stranding area. The estimated concentration factor for Cs-137 in harbour porpoise muscle tissue is comparable to those measured in other studies. Cs-137 dose rates from internal sources are significantly higher than those from external sources, however, both are much lower than the natural background rate due to K-40.

Table 1 Summary of Cs-137 and K-40 radioactivity levels in harbour porpoises from British and Irish coastal waters

	A	B	C	D	E	F	G	H	I	J
1	Sample code	Date	Length	Sex	Age	Weight	Area caught/stranded	Cs-137	Cs-134	K-40
2	1992/159	4/7/92	1.59	F	22	54.6e	Bamburgh (east EN)	2.7±0.7	<1.1	100.8±13.3
3	1992/4b	4/3/92	1.22	M	5	25.8e	Holme (east EN)	2.4±0.6	<1.0	106.5±13.5
4	1992/208	3/11/92	1.59	F	22	54.6e	Aberystwyth (Wales)	9.1±0.8	<0.7	70.6±9.1
5	1992/209	4/11/92	1.22	F	5	47.1e	Ynyslas (Wales)	8.0±1.3	<0.9	98.6±14.3
6	HP 9/93	3/9/93	1.2	F	2	27.9e	East coast (Ireland)	33.4±2.6	<0.9	85.4±15.8
7										
8	Cork by catch 1	3/8/90	1.25	F	2	28.2	Dingle	<0.9	<1.7	NM
9	Cork by catch 2	Apr-93	1.19	M	2	26.3	Loop Head	<2.0	<1.4	NM
10	Cork by catch 3	14/4/93	1.51	F	4	49.2	S.W. coast	<1.2	<1.0	NM
11	Cork by catch 4	21/4/90	1.24	F	2	34	Courtmacsherry	2.1±0.8	<2.7	NM
12	Cork by catch 5	27/4/93	1.17	F	2	25.7	Sligo	2.7±1.5	<1.3	NM
13										
14	HP 16	10/12/91	1.45	M	*	35.2e	Courtmacsherry	<1.6	<2.3	NM
15	HP 18	5/12/92	1.24	F	*	30.7e	Ballycotton	2.0±1.1	<1.1	NM
16	HP 19	9/1/93	1.45	F	*	45.0e	Long Strand Co Cork	<3.9	<3.5	NM
17	HP 20	15/2/93	1.35	F	3	38.2e	Cork Harbour	2.2±0.8	<0.6	NM
18	HP 21	14/2/93	1.22	M	2	25.8e	Trabolgan, Co Cork	1.9±0.7	<1.0	NM
19	HP 5/93	20/3/93	1.38	M	4	32.3e	Kilkee	<0.7	<0.6	85.4±12.2
20	HP 6/93	29/3/93	1.58	M	5	40.4e	Cork	2.5±1.0	<0.8	NM
21	HP 8/93	6/6/93	1.45	M	6	35.2e	Bettystown Co Meath	42.3±4.7	<1.3	NM
22										
23	SMRU 93/7	15/8/93	0.84	M	0	8.5	Hoylake (west EN)	24.9±1.6	<0.8	68.1±12.9
24	SMRU 93/10	22/8/93	1.33	M	7	24.3	Aberaeron (Wales)	9.4±1.4	<1.3	87.7±18.7
25	SMRU 93/11	29/4/93	1.26	M	1	30	Hornsea (east EN)	2.2±0.6	<0.9	90.3±12.6
26	SMRU 93/12	27/7/93	1.43	M	7	32.5	Llanrhystud (Wales)	7.3±1.2	<1.3	99.7±18.9
27	SMRU 93/13	1989	1.06	M	1	15.5	Fishguard (Wales)	5.34±1.9	<9.3	54.0±27.5
28	Cork by catch 11	6/11/93	1.21	M	1+	34	51°36' 6°43' (W'ford)	<2.0	<1.9	124.4±28.6
29	Cork by catch 12	11/8/93	0.94	M	0	15.5	off Sligo	3.1±1.3	<1.3	107.1±20.3

THE BUBBLE-SCREEN™: AN ALTERNATIVE METHOD TO THE USE OF NETS IN DOLPHIN FACILITIES

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Nets are used in dolphin facilities to move groups of animals from one pool to another, or to isolate specific animals for medical treatment. The use of nets can be very dangerous for dolphins because they may panic when driven towards them, and there is a risk of entanglement of their fins and snout. This can lead to the dolphin drowning if not rescued promptly.

To exclude these risks, an alternative method to the use of nets was tested in the Parc Astérix Dolphinarium at Plailly, France. A bubble-screen was used to isolate one or a pair of dolphins from a group of five bottlenose dolphins (*Tursiops truncatus*) for various periods of time (5-20 min.) during three experimental trials that took place between 1 and 31 January, 1994.

The bubble-screen device comprised:

1. an electric air-compressor (Atlas Copco, model: LX 108, delivery: 4.3 m^3/h, portable, silent, easily set-up and non-polluting);
2. a sprinkler hose (holes 2 cm-spaced);
3. lead weights to help maintain the hose on the bottom of the pool (these were each of 1 kg attached to the hose at 1 m intervals);
4. a hoisting rope to help install the hose on the bottom of the pool;
5. two aluminium poles to help move the hose on the bottom of the pool; and
6. a hose trolley.

The bubble-screen was successful on all three occasions in deterring isolated dolphins from going through to join their group. It can therefore be used to isolate individuals in a group of dolphins as an alternative method to the use of nets. It can be utilised during medical care, for feeding and training of dolphins. The bubble-screen shows several advantages over nets: the device presents no risk of accident to the animals, is inexpensive, portable, easily set-up and requires only two individuals to operate it.

Experiments are currently under way to test the device for moving dolphins from one pool to another.

ACKNOWLEDGEMENTS We wish to thank 3B-Diving Gear and the Parc Astérix for their support in this project.

WHALEWATCHING - ECOTOURISM AND RESEARCH - A SCOTTISH POINT OF VIEW

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Sea Life Surveys (SLS) is a commercial whalewatching business which operates off the west coast of Scotland. Set up in 1990, SLS aims to conduct scientific research and education by involving the general public in sensitive, practical ecotourism.

Using the example of SLS, the following subjects are discussed:

- How to combine the demands of credible scientific research based on sound fieldwork and data analysis with the needs of the paying public
- The value of longterm data collection programmes and the need for standardised methods for collecting and processing data
- The potential negative impact of ecotourism and the need for guidelines and education to minimise this
- The value of public involvement in the field of funding
- The importance of involving the local people and interests in any regulation and legislation
- Achieving the right balance between research and commerce.

"ONDE DAL MARE" AN OUTLOOK OVER THE MEDITERRANEAN

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INTRODUCTION Together with the WorldWide Fund for Nature (WWF), Fondazione Cetacea started a project called "ONDE DAL MARE" [Waves from the Sea] in 1993. It is a radio-telephone network (VHF Radio, channel 74 - 156.725 MHz; phone number +39-541-693675; Email cetacea@iper.net) that has been established to make communication easier of both cetacean and turtle sightings and environmental problems in general.

This project was appointed by both the Italian Department of Environment and Postmaster General and relies on the co-operation of both the Customs and Inland Revenue Service and the Coastguard. Rimini M.A.R.E. Society has also subsequently joined the project and has been charged with overseeing the communication of any environmental damage.

AIMS The main aims of this project are:

- to increase both public awareness of the problems with our seas and their inhabitants and research efforts.
- to set up a data base to help monitor the marine environment through real time communications.
- to alert relevant Public Institutions of any environmental damage discovered.
- to support the Italian Stranding Network with the communication of both cetacean and turtle sightings.

The project "Onde dal Mare" would also:

- provide scientific and logistic support to the Italian Department of Environment and on a larger scale to all the Public Institutions involved in the safeguard of the environment.
- promote the planning of a EIS (Environmental Information System) aimed both at the management and the control of marine environmental problems.

CONCLUSIONS One of the most interesting possibilities is to extend this project to other Mediterranean countries.

The main innovative feature of the project is the use of a radio communication system as a substitute for sighting cards, up until now, distributed in the rest of Europe.

Considering aims and employed techniques, "Onde dal Mare" has the intention of operating in several geographic areas of the Mediterranean.

Eventually by considering the potential of EIS (Environmental Information System) that employs the GPS (Global Positioning Systems), we believe that in the near future this technology, once applied to networks operating with methods proposed by "Onde dal Mare", will represent an effective tool for the monitoring of the marine environment.

ACKNOWLEDGEMENTS We kindly acknowledge the Department of Environment, the Postmaster General, the Italian Customs and Inland Revenue Service and the Coastguard, Soc. Co-op. M.A.R.E. Rimini, WWF Italy, Comune di Riccione, and Regione Emilia-Romagna.

PROJECTS AND PERSPECTIVE OF A RESEARCH PROGRAMME ESTABLISHED AT THE DOLPHIN REEF, EILAT, ISRAEL

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INTRODUCTION As a result of discussions among biologists from Israel, Germany and Russia, an International Laboratory of Dolphin Behaviour Research has been established in the northern part of the Red Sea. This laboratory is located within the Dolphin Reef, Eilat, and has been operating since summer 1994. Its aim is to conduct non-invasive research on four topics: (1) dolphin social behaviour, including communication, learning and cognition; (2) problems of dolphin rehabilitation; (3) marine mammal distribution in the Red Sea. and (4) therapy projects with mentally retarded children.

SITE, ANIMALS, AND LABORATORY The Dolphin Reef site covers a water area of c. 14,000 square metres with a depth of 15 metres. It is separated from the Gulf by a large-meshed plastic wall that allows an inflow and outflow of various marine organisms, including different sorts of fish. Although the water of the Gulf is polluted occasionally from coastal civilization or industry, there is evidence that water quality is quite good: various species of corals, for instance, have started to grow and flourish around and within the site since it was built five years ago. The study on marine life is supervised by Lev Fishelson (Tel Aviv University), and, to date, a co-operative programme begins with Avi Baranes (The Interuniversity Institute of Eilat).

Originally, two adult male and three adult female bottlenose dolphins (*Tursiops truncatus ponticus*), all from the Black Sea, were living in this semi-free confinement. In 1992, a first calf (female) was born, followed by the births of two further calves in 1994 (males, both born in June, on the same day).

Our observation confirmed that, with the exception of the newborn calves, all dolphins feed on self-caught fish. Nevertheless, they are offered additional food four times a day (c. 10 kg. of carefully defrosted fish such as sardines or whiting, and squid). This feeding takes place during four shows that include soft training programmes. Between 9 am and 4 pm and, during the intervals between shows, guided groups of visitors are allowed to swim within a restricted area of the site, where they may be approached by the dolphins. To date, all these activities or interactions have been recorded on tape by a supervising control camera fixed on the roof of an observation tower overlooking the site. Details about the social structure of the group, and especially the dominance hierarchy of the males are given in a separate report (see Veit and Bojanowski 1995, this volume).

As it has been built on a platform 10 m above sea level overlooking the whole site, the laboratory provides an ideal opportunity for dolphin observation. The laboratory is equipped with computers connected to video cameras (one on the roof of the lab, one underwater plus two mobile cameras, one being for underwater use), and two hydrophones (usually fixed) that allow a continuous recording of behavioural data.

Since 1994, the large-meshed wall of the site is equipped by a gate (2 m wide) that is opened according to a particular schedule. However, only one of the males uses this gate for regular excursions to the Gulf (Fig. 1). Currently, we are investigating both the causes and consequences of this behavioural idiosynchracy, for example by investigating the problems of other dolphin individuals in passing or using the gate, respectively. These projects profit from other studies dealing with vocal behaviours during stressful situations (Sidorova *et al.*, 1986; Schrader and Todt, 1993).

BEHAVIOURAL RESEARCH During the initial period of our study (start: May 1994), emphasis was on observations and recordings concerning communication and social behaviours, including the birth and behavioural development of the calves. Much of the data recording was done by the various cameras and hydrophones. Analyses of data were supported by computers and software packages which, for instance, provided displays of dolphin vocalisations (frequency spectrograms, power spectrograms, etc.). Any experimental approach was preceded by detailed observations. The methodological concept was based on guidelines given elsewhere (Todt and Hultsch 1980; 1995; Todt 1986; Todt et al. 1992), and included the following three procedures:

Continuous recording: the recording of behaviours and events occurring in the dolphin's environment takes place in a temporally coherent manner. In this way, it is possible to later examine the dynamics of behavioural processes, for example by methods of time series analysis. In addition, it is possible to identify intrinsic causes of behavioural modifications and to distinguish them from immediate responses to external stimuli.

Multi-channel recording: parallel use of equipment for recording behaviours of individual dolphins and other organisms (for example humans). This allows the study of different channels (specific individuals, or behaviours, or stimuli) in either a separate or an interrelated manner.

System-wise recording and analyses: these procedures supplement the multi-channel recording by a method which allows one to record and also treat the data system-wise. To prepare for this procedure, either specific individuals or dyads (triads, etc.) of specific individuals are taken as 'one system', and then investigated in terms of relationships between their different behaviours. Concurrently, such behaviours are treated separately from the behaviours of other 'systems'. In a further step of research, possible covariations among the behaviour patterns of systems and events occurring in their respective contexts are studied.

Our study began with collecting biological baseline data for forthcoming inquiries into social behaviour, and also the mechanisms of communication or cognition of bottlenose dolphins. Therefore, we examined the spatial distributions of dolphins within the site, and tested especially, whether and when they preferred to stay at particular areas, for instance in relation to specific events such as shows or visits of human swimmers (Fig. 1). After this first step, we are now dealing with more specific projects.

LIST OF PROJECTS (1) Features of environmental and circadian distributions of behaviours (Todt *et al.*, 1982; Bel'kovich, 1991); (2) Organisation, dynamics and use of signals (Todt and Hultsch, 1980, 1995; Tyack, 1986; Janik *et al.*, 1994); (3) Social learning and social intelligence (Todt, 1975, 1992; Pepperberg, 1986; Herman, 1991; Hultsch, 1993); (4) Dominance/subdominance relationships (Östman, 1991; Veit, Dipl. Thesis, 1995); (5) Mother/calve relationships (Sayigh *et al.*, 1990; Riechelmann *et al.*, 1993; Bojanowski, Dipl. Thesis 1995); (6) Chasing & attacking versus playful interactions (Todt, 1986, 1992; Bel'kovich, 1991); and (7) Sexual interaction and bonding (Hultsch and Todt, 1984; Östman, 1991).

Although the Dolphin Reef/Eilat is a commercial enterprise, financed through approximately 250,000 visitors each year, the scientific board of the laboratory is convinced that the research on these matters will provide excellent results. Scientists who are interested in a collaboration on one of the projects are invited to send a letter to one of the authors. On written request, raw data of dolphin behaviours (audio and video recordings, etc.) can be provided as soon as the administrative pre-requisites have been prepared.

DOLPHIN REHABILITATION PROJECTS AND RED SEA ECOLOGY

Originally, our programmes of dolphin rehabilitation included attempts to help the animals leave the site and explore or use the open part of the Red Sea. Now, these plans have been modified, and focus on two objectives. One will deal with problems of dolphins when leaving their familiar area or orienting within a novel environment. As for such problems, we have collected data that point to specific proximate causes. To prepare the animals with coping with these orientation problems, we use equipment to train the dolphins with acoustic signals generated by individual specific pingers.

The other objectives will target a prior study of marine mammal distribution within the northern part of the Red Sea. The project is guided by Eli Geffen, Nature Conservation, Israel, who has developed a sophisticated programme of population research. The study will begin with collecting and analysing biological data on the distribution of the four most common dolphin species within the area: bottlenose dolphins (*Tursiops truncatus*), spotted dolphins (*Stenella attenuata*), long-snouted spinner dolphins (*Stenella longirostris*) and Risso's dolphins (*Grampus griseus*). The study will be continued by applying methods of DNA-comparison (Roy *et al.* 1994) and will include investigations of ecological issues and migration patterns of marine mammals. There is a good chance that these areas of the project can be carried out in collaboration with Jordanian and Egyptian scientists.

THERAPY PROGRAMMES WITH HUMAN HANDICAPPED The therapy programmes at the Dolphin Reef site have already begun with autistic children. The experience covers a period of more than twelve months and has proven quite positive in the past. Also children with Down's syndrome were successfully included in the therapy. As a result of this, a novel line of DET projects (Dolphin Environment Therapy) is beginning in 1995. These projects will be supervised by Ilan Kutz, Tel Aviv University, and will use methods previously applied for example in the United States (Nathanson and Faria, 1992). The Laboratory of Dolphin Behaviour Research at Eilat will be linked to the programme by dealing especially with the psychobiological aspects of this sort of endeavour.

ACKNOWLEDGEMENTS We thank Roni Zilber, managing director of the Dophin Reef, and Maya Zilber, chief trainer at the Dolphin Reef, for their support of our research. Both were always interested in any research matters and, without their contribution, the laboratory would not exist at all. Students from our Berlin laboratory, too many to name, were enthusiastic with collecting and analysing data.

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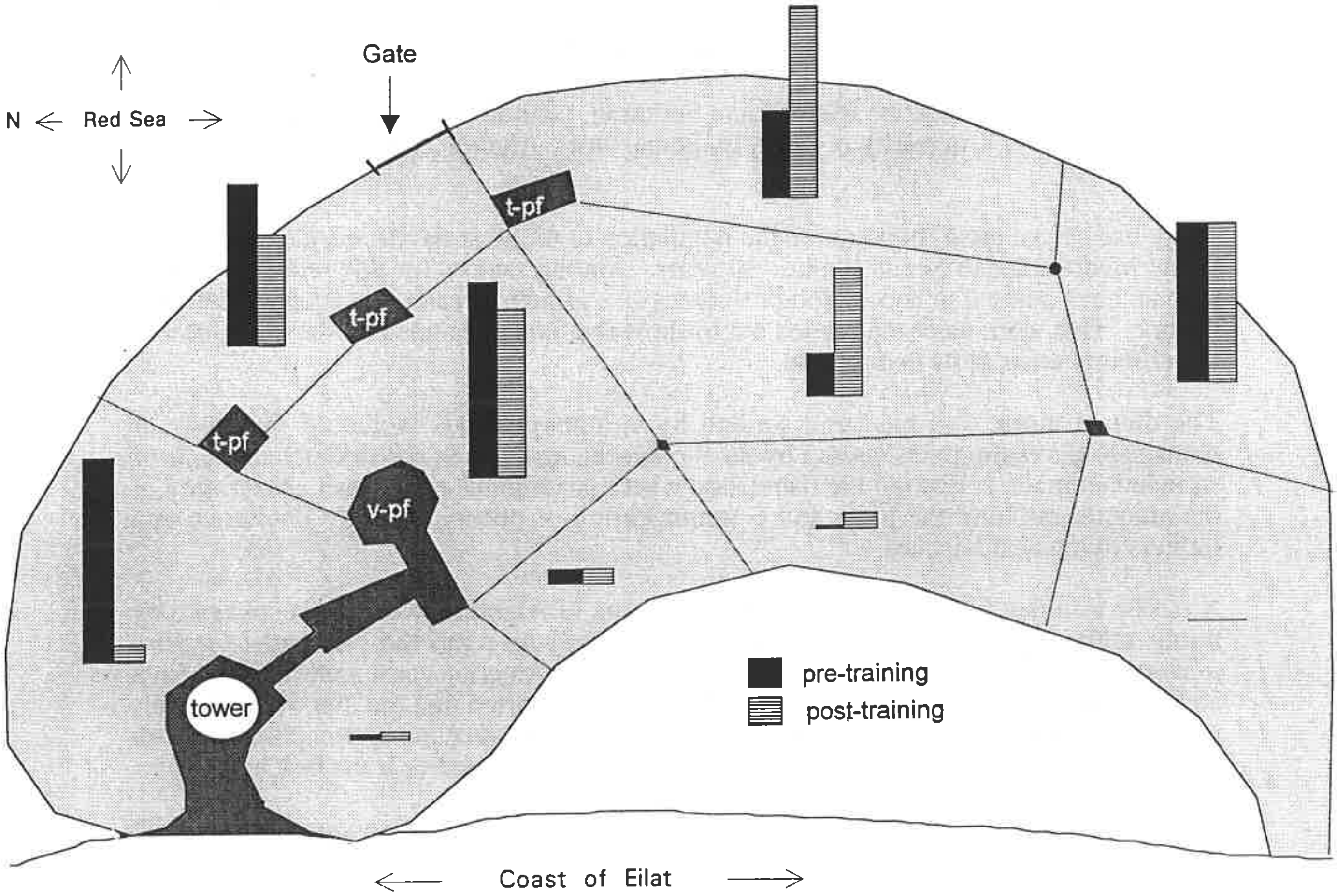

Fig. 1 Scheme of the Dolphin Reef site showing spatial distribution of dolphins in relation to particular contexts (black columns: 30 minutes before show encounters; striped columns: 30 minutes after show encounters). Data base: observation time of 120 hours (t-pf: 'training platform' ; v-pf: visitor platform'). Straight lines within the site are not real and indicate site divisions that served for data sampling. Note: Dolphins use the less preferred area (S/W corner) for individual retreat (e.g. while giving birth).

FOOD OF THE MEDITERRANEAN MONK SEAL (*MONACHUS MONACHUS*, Hermann, 1779)

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There has been a great reduction in the population of monk seals (*Monachus monachus*) in the Mediterranean Sea in the last 30 years. Among factors for this reduction, some authors have pointed to lack of food resources as a principal reason for such an alarming decline. This work has been carried out to show the food consumed by the monk seal in the different areas of its distribution.

The diet of monk seal has been studied by various methods including the study of damage to the fishing nets caused by the monk seal, analysis of the stomach contents of stranded animals, collecting the fish debris where the animals rest, direct observation of the animals catching the prey, and communication of observations by fishermen and farmers living near beaches.

It can be said that 97% of species of the fish fauna of Algerian waters are consumed by monk seals. The anchovy (*Engraulis encrassicholus*) and the pilchard (*Sardina pilchardus*), which are fished in great quantity over the Algerian coast appear to represent an important part of the monk seal diet. It has been reported that the diet of monk seals in Algerian waters includes a variety of species of crustaceans and cephalopods, in addition to grapes, potatoes, tomatoes and other crops cultivated near the beaches.

This large spread in diet demonstrates the opportunistic feeding behaviour of monk seal, making it an excellent example of a species with a catholic diet.

GREY SEAL ECO-ETHOLOGY: STUDY OF THE DISTRIBUTION OF PUPPING AREAS FROM AERIAL PHOTOGRAPHS

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INTRODUCTION More than 100,000 grey seals (*Halichoerus grypus*) annually breed on the shores of the British Isles and this population is increasing. As part of a study from the influence of habitat on social behaviour of breeding grey seals, I investigated the distribution of pups on aerial photographs of five Orkney islands from 1986 to 1991. Pictures are taken annually by the Sea Mammal Research Unit (NERC, UK) in order to estimate pup production. The distribution of pups can be used as an indication of the distribution of the breeding seals on the coast, leading to a better understanding of the ecological requirements of the species. The pup production of Orkney is increasing as a whole but there is considerable variation between breeding sites. An increasing number of seals coming ashore to pup could induce the concentration of individuals on peculiar areas (increasing density), the colonisation of new areas (dispersion of pupping over space), and/or an increasing duration of breeding season (dispersion of pupping over time). These hypotheses are now under investigation.

METHODS White pups are highly visible on enlarged aerial photographs. I have described their distribution by the number of pups lying on each available substrate and by the nature of this distribution (random, clustered or regular). The level of aggregation can be quantified by a mean crowding index (mean number of neighbours by pup within a defined surrounding area). Grids of 20 m x 20 m cells were overlaid on the island's coast, each cell was given a value equivalent to the number of pups lying in it, and the grids were processed by spatial statistics using geography software (IDRISI).

PRELIMINARY RESULTS

Pup distribution Pups are not randomly distributed along the shore but are concentrated in certain zones. The surface used for pupping in Orkney can be classified into vegetation (central part of the islands), and the shore where two types of areas are observed: rocky zones with highly variable accessibility for seals, and sedimentary zones (sand, gravel, shingle or boulder). The occupation of the shore region by pups roughly corresponds to the accessibility from the sea.

Pup distribution over the breeding season On Holm of Faray, the occupied surface over the 1991 season increases first and then decreases slightly after the birth peak. Pup density (mean number of pups per occupied cell) and mean crowding (mean number of neighbours per pup) are greatest at the beginning of the breeding season and regularly decline with time. In the early and mid-season, the pup distribution in occupied areas shows a clustered pattern (variance/mean density >1). At the end of the season, the pattern becomes regular (variance/mean density <1).

Pup distribution over the recent years Changes in pup production in recent years cannot be directly linked to the area available to seals for breeding, but this study shows that an increasing (decreasing) pup production on an island is always associated with an increasing (decreasing) occupied surface (Fig. 1). Rocky zones are always less occupied by pups than sedimentary zones, even when a large surface area of rock is available. This seems mainly due to poor accessibility from the sea. Most of the pups are settled in sedimentary zones, so the changes in the number of those pups over the years are generally representative of the changes in the number of pups on the entire island (Faray, Ruskholm), while the number of pups found in vegetated regions only changes when the variation of pup production is very large (Lingaholm from 1989 to

1991) (Fig. 2). When freshwater streams (drainage ditches or natural streams) are used as access routes into vegetated areas (and maybe for thermoregulation), the number of pups found in vegetation zones extending to inner areas of the island is quite high, and the changes in the numbers of those pups then reflect the changes of the numbers of pups on the entire island (Muckle Greenholm).

ACKNOWLEDGEMENTS Thanks go to Dr C. Duck. This study is a part of a Ph.D thesis funded by the F.R.I.A (Belgium), Ethology Laboratory, University of Liege, in collaboration with the Sea Mammal Research Unit, NERC, and the Polar Ecology Laboratory, Vrije Universiteit van Brussels.

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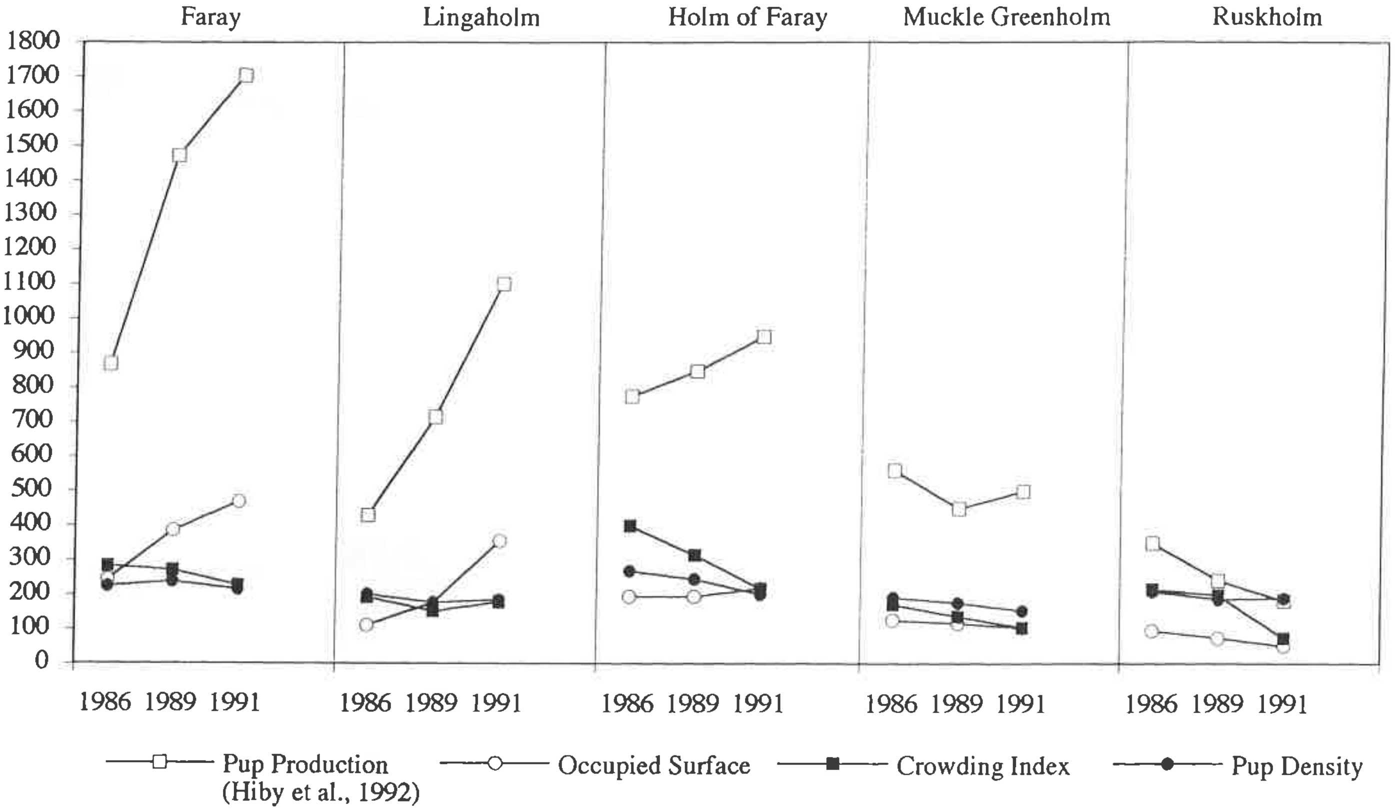

Fig. 1 Variation of the pup production (nbr of pups) from Hiby *et al.*, 1992, surface occupied by seals (nbr of 400m2 cells occupied by at least 1 pup), mean crowding index (X100) and mean pup density (X100).

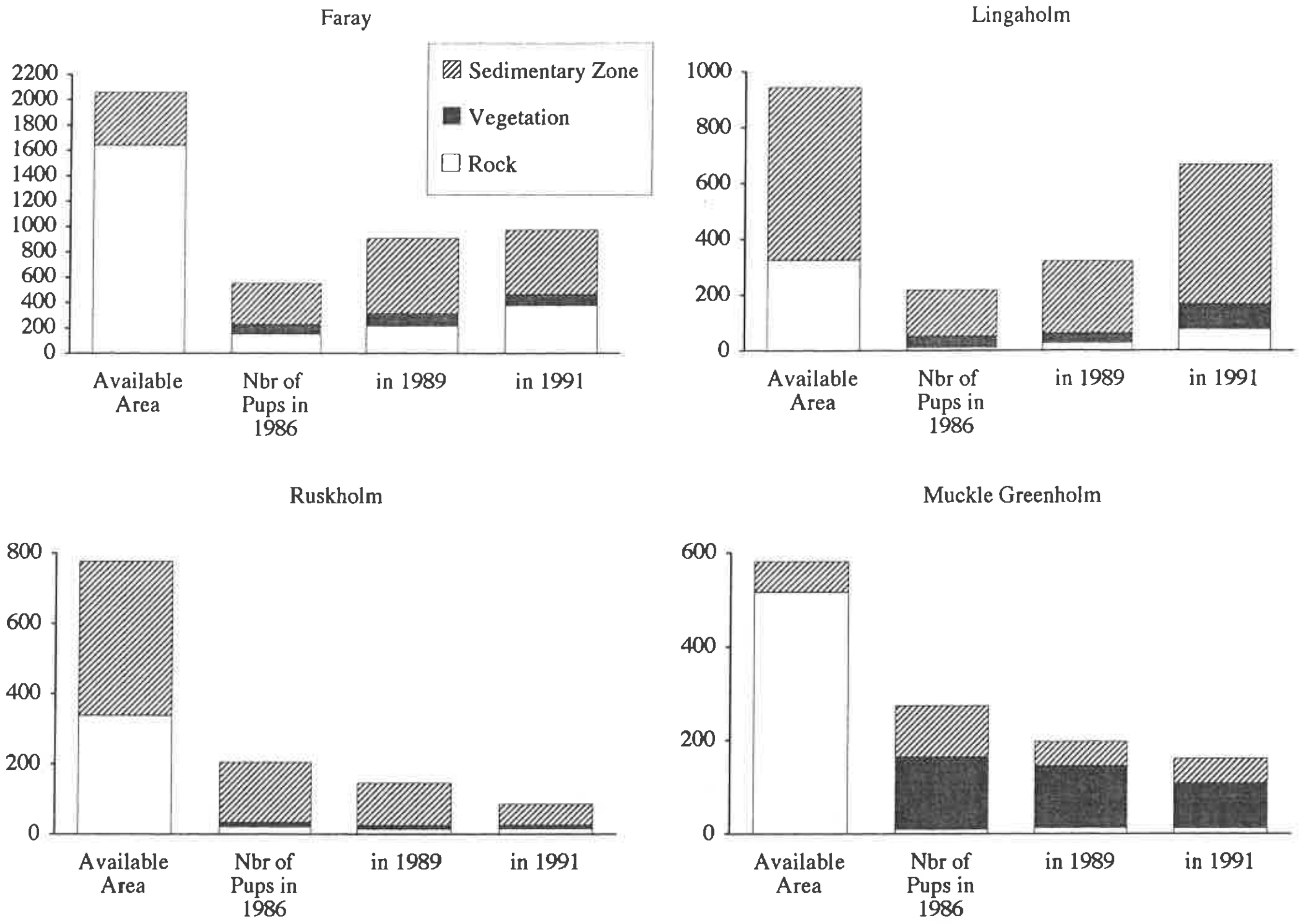

Fig. 2 Available shore area (m2) and changes in the number of pups counted on each substrate over the last years for 4 Orkney islands.

EIGHTH ANNUAL REPORT OF THE EUROPEAN CETACEAN SOCIETY: 1994

Paid-up membership of the European Cetacean Society at the start of the Lugano Conference totalled 378, from 36 countries (25 European), with UK (66), Germany (60), France (46), Italy (42), Spain (31), the Netherlands (20), and Denmark (14) having the highest representation. Other member countries include Austria, Belgium, Croatia, Czech Republic, Faroe Islands, Finland, Greece, Iceland, Ireland, Norway, Poland, Portugal, Romania, Russian Federation, Slovenia, Sweden, Switzerland, Ukraine, and Algeria, Australia, Canada, Hong Kong, Japan, Peru, South Africa, Tunisia, and USA.

A very successful conference was held in Montpellier, France between 2-5 March 1994, on the theme "The Role of Protected Areas in Cetacean Research and Conservation", with an attendance of 238 persons from twenty countries. Four invited speakers addressed the society: Richard Sears and Martin Hall from North America, Erich Hoyt from UK, and Giuseppe Notarbartolo di Sciara from Italy. A workshop on *Tursiops* and a pathology workshop were organised at the conference, and they will form special newsletters in the future. The abstracts of the conference were published as proceedings under the title "European Research on Cetaceans - 8".

Three newsletters were produced during the year, reviewing recent research and news items in Europe and elsewhere in the world, conservation issues, cetacean meetings and publications, and Society business. We are very grateful to Marjan Addink and Joke Bakker for their dedication in helping Peter Evans with the editing of the newsletter.

The collaboration with the European Association for Aquatic Mammals (EAAM) continued in 1994. As agreed between the two Societies, the 1995 EAAM annual conference was announced in the ECS newsletter, and the EAAM did likewise with our own conference. Delegates were exchanged at the annual conferences. In 1996, the two societies will be holding their annual conferences in Portugal and the committees of both are working together so that they are temporally adjacent to one another for ease of attendance.

Finally, the European Cetacean Society has continued to provide advice to government departments and non-governmental organisations in European countries, and specialist information for various public enquiries. Official contact was made with the ASCOBANS Secretariat, and the ECS provided a statement at the first ASCOBANS meeting held in Sweden in September 1994.

FINN LARSEN
(Hon. Secretary)

FINANCIAL REPORT FOR THE YEAR UP TO 3 FEB 1995

Credit Balance as of 28 Feb 94	**£3,377.50**

Credit	£
Membership	7,344.40
Conference income	1,543.35
Sale of Proceedings	292.88
Interest	24.27
Total Income	£9,204.90

Debit	£
Secretarial expenses at SMRU and for Newsletter	585.86
Council members' expenses	1,609.42
Publications	5,489.00
Office supplies (paper, envelopes, etc)	258.22
Postage	1,961.32
Conference expenditure (invited speakers, etc)	891.26
Design (logo, letterhead, envelopes, etc)	400.00
Total Expenditure	**£11,195.08**

Balance as of 3 February 1995 £1,387.32

PHILIP HAMMOND
(Hon. Treasurer)

EUROPEAN CETACEAN SOCIETY - 1995

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). Recently, some of these have been disbanded, having served their purpose, and a new group (covering the Mediterranean Sea) has been established. The names and addresses of contact persons for all working groups are given at the end.

Contact persons have been set up in each European member country, where appropriate, to facilitate the dissemination of ECS material to members, sometimes carrying out translations into the language of that country. Their names & addresses are given below.

A newsletter is produced three times a year for members, reporting current research in Europe, recent publications & abstracts, reports of working groups, conservation issues, legislation & regional agreements, local news, and cetacean news from around the world.

There is an annual conference with talks and posters, and at which the annual general meeting is held. The results are published as annual proceedings, under the title *European Research on Cetaceans*. Besides the present volume, eight 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, and Montpellier (France) in 1994. 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; and no. 23 - a workshop to review methods for the field study of bottlenose dolphins held in Montpellier (France) in 1994.

Membership is open to *anyone* with an interest in cetaceans. The annual subscription is **DM 60** for full and institutional members, or **DM 35** for those who are 25 years of age or younger, full-time students or unwaged. Payment may be made at the Annual Conference in German Marks or the currency of the host country. During the year, payment must be in German Marks by **Eurocheque** or any other cheque drawn to a German bank, payable to the *European Cetacean Society*. You are advised not to send cash. Membership fees can also be paid by **credit card** or **transferred directly** to the following ECS-account:
Dr Roland Lick, Treasurer, ECS, Postbank Hamburg (FRG), Account No. 789584-205, Bank Code 200 100 20 (giving your name and calendar year for membership fee.)

Payment in excess of the membership fee will be gratefully received as a donation to the Society.

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