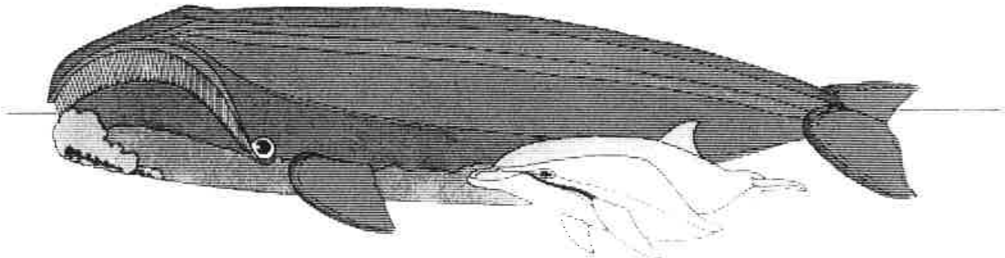
EUROPEAN RESEARCH ON CETACEANS - 6

PROCEEDINGS OF THE SIXTH ANNUAL CONFERENCE OF THE EUROPEAN CETACEAN SOCIETY, SAN REMO, ITALY, 20-22 FEBRUARY 1992



EDITOR : P.G.H. EVANS

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Proceedings of the Sixth Annual Conference
of the European Cetacean Society,
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INTRODUCTION

The fifth annual conference of the European Cetacean Society was held in San Remo between 20th and 22th February 1992. It was attended by 156 persons from eighteen countries, the highest attendance to date. The Council of the ECS are very grateful to Giuseppe Notarbartolo di Sciara, ably assisted by a team of Italian cetacean enthusiasts, for organizing a very successful conference.

The proceedings that follow are abstracts of the talks and posters presented at the conference. As for previous proceedings, the contributions have been edited only to improve clarity and maintain a uniformity of presentation. No external refereeing has taken place and much of the material presented here I hope 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 offer warm thanks to the invited speakers who came often great distances to address the society: Bill Perrin and Bob Brownell from the United States, John Hislop from Scotland, Antonio di Natale from Italy, and Alexej Birkun from the Crimea. Drasko and Alan Serman from Croatia were invited to speak but unable to attend for reasons beyond their control. However, their contribution is published here.

Finally, I should like to thank Emily Lewis for her sterling efforts in typing and helping to prepare these proceedings.

Peter G.H. Evans

A REVIEW OF CETACEAN-FISHERY CONFLICTS AND POSSIBLE SOLUTIONS

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Information from the IWC 1990 conference on gillnets and cetaceans and from other sources brings home the fact that net fisheries, and other fisheries affecting cetaceans, occur practically everywhere on the globe and that almost all of them kill or are suspected to kill cetaceans (IWC, 1991). The picture is not complete; there are several regions for which we have almost no information. For example, the minimal data available from one sub-region suggests that conflicts and incidental mortality occur throughout Southeast Asia. Similar situations exist for the coasts of Africa and South America. The very large drift net fisheries on the high seas are relatively new and cover millions of square miles of the Pacific, Atlantic and Indian Oceans.

The fisheries problem is mainly a small cetacean problem, with some exceptions, such as the kill of sperm whales, *Physeter macrocephalus*, in the Mediterranean and the catches of humpback whales, *Megaptera novaeangliae*, and right whales, *Eubalaena glacialis*, in traps and lines in North America. Whale catches have fallen dramatically over the last 30 years, but small cetacean catches have increased greatly during the same period and as yet are incompletely reported; the annual total is almost certainly in the mid or high hundreds of thousands and could be even higher.

The conflicts can be organised into two categories: those where the marine mammal is causing problems for the fishery, and those where the fishery is causing problems for the marine mammals. Examples of the first include predation by killer whales, *Orcinus orca*, on catches in the bottom longline fishery for black cod, *Anoplopoma fimbria*, in Alaska (Dahlheim, 1988), which has resulted in damages of about $2,300 per fisherman per day and deaths of offending whales; and the recent culls of several species of small cetaceans in Japan (Kasuya, 1985). Examples of fisheries harming cetaceans by taking them incidentally include the purse seine fishery for tuna, *Thunnus* spp., in the eastern tropical Pacific (Allen, 1985), gill net fisheries taking porpoises, *Phocoena phocoena*, in many parts of the northern hemisphere (e.g., Read 1990), and drift net fisheries in the North Pacific (Jones *et al.*, 1990). A very worrying development is the evolution of incidental catches into unregulated directed catches, as has happened in Peru and Sri Lanka (Reyes and Oporto, 1990).

For 190 regional cetacean populations involved in gill net fisheries and reviewed in the IWC conference, incidental catches were found to be clearly unsustainable for 8 of these, potentially unsustainable for 34, possibly unsustainable for 5, clearly insignificant for 12, probably insignificant for 7, and of unknown consequence for 114 (due to complete absence of data) (IWC, 1991). Critical cases identified among those for which at least marginally adequate data exist included the vaquita, *Phocoena sinus*, in the Gulf of California, the baiji, *Lipotes vexillifer*, in the Yangtze River, the Indo-Pacific humpbacked dolphin, *Sousa chinensis*, in South Africa, the striped dolphin, *Stenella coeruleoalba*, in the Mediterranean, the harbour porpoise in the eastern and western North Atlantic and central California, and the bottle-nosed dolphin,*Tursiops truncatus*, in South Africa. The incidental kills of dolphins in the eastern Pacific tuna fishery have caused some populations to decline, but the effects of current kills are not clear.

Reasons for concern about cetaceans in principle include:

1. They are in themselves fishery resources (Bjørge *et al..*, 1991).
2. They function as part of a natural system, for example gray whales in the Bering Sea (Nerini, 1984).
3. They have value for tourism and education, for example for whale-watching (Tilt, 1986).
4. Cetaceans, like other creatures, deserve to exist and should not be killed unnecessarily.

Potential solutions (with examples) include:

1. Close the fishery (California coastal halibut fishery - Heyning *et al.*, 1990).
2. Remove the mammals (cull or translate) (Iki Island- Kasuya, 1985).
3. Scare the animals away (Alaskan salmon fishery - Fish and Vania, 1971).
4. Release the mammals (humpback whales in cod traps - IWC, 1991).
5. Close areas to fishing (sea otters in California - Fulton, 1985).
6. Close seasons to fishing (Hector's dolphins in New Zealand - Dawson, 1991).
7. Modify fishing gear (tuna/dolphin problem in eastern Pacific - Allen, 1985).
8. Modify fishing practices (Allen, 1985).
9. Set safe limits on mammal kills (incidental kills in U.S. fisheries - Barlow *et al.*, in press).

The choice of approach depends on the situation. Each fishery is different, and each problem is different. The choice also depends on the prevailing laws and on the value systems and goals of the people who make and influence the decisions. There can be concern about the mammals and goals at three levels at least:

1. Prevent extinction of the species or population. (All, including most fisherman, would agree with this).
2. Prevent significant decrease in the population. (Most of the public and wildlife managers would probably agree, but many fishermen might disagree).
3. Prevent the killing or harm of any marine mammal, for any reason. (View held by some of the public but not many others, and usually by very few fishermen).

Experience has taught marine mammal managers in the United States that there are several logical and necessary steps to take in solving conflicts:

1. Determine the nature, extent and monetary costs of the conflict.
2. Determine the extent, size and status of the mammal population.
3. Give all involved and interested parties an opportunity to state needs and have questions answered.
4. Decide what the goals are and what legal requirements must be satisfied.
5. Develop a plan to solve the problem, with time limits and criteria of success for each step.
6. Provide the resources to carry out the plan and enforce its provisions.
7. To the extent possible, involve the fishermen and local residents in carrying out the plan.
8. Monitor the results and decide if the plan succeeded.
9. Develop a plan to mitigate any damage done to the fishery, and its provide the resources to carry it out.

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RECENT DEVELOPMENTS AND FUTURE PROBLEMS WITH LARGE-SCALE PELAGIC DRIFTNET FISHING

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During the 1980's, a rapid expansion of the high seas drift net fisheries occurred in various parts of the world's oceans. The histories for the major fisheries in the Pacific, Indian and Atlantic oceans are summarized, along with the best available data on the impact of these fisheries on selected living marine resources. These data support the concern that large numbers of marine mammals, birds and other non-target fish species were being killed in substantial numbers. This by-catch problem led to international action against large-scale pelagic drift net fishing operations.

On 20 December 1991, the United Nations General Assembly adopted consensus Resolution 46/215. This calls upon all members of the international community to implement earlier General Assembly Resolutions 44/225 and 45/197, and by 30 June 1992, reduce existing drift net fishing effort by fifty percent, and to ensure that a global moratorium on all large-scale pelagic drift net fishing is fully implemented on the high seas by 31 December 1992. The history of these resolutions and the recent action taken by the European Community Council of Fisheries Ministers on large-scale drift net fishing are also reviewed.

THE NORTH SEA FISHERY : A CASE STUDY

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CHANGES IN NORTH SEA FISHERIES AND FISH STOCKS Total landings (nominal catches) of fish from the North Sea are available from 1903 and onwards in the Statistical Bulletin published annually by the International Council for the Exploration of the Sea (ICES). Although there are differences between the weights of fish caught and those recorded as having been landed, trends in landings (Fig. 1) probably reflect trends in catches.

Many major developments in fishing technology, such as the use of steam powered vessels and the introduction of the otter trawl, originated during the last part of the 19th century. By the beginning of the 20th century, most of the present fishing grounds in the North Sea were already being exploited and annual landings were high (1,000,000 t). Landings gradually increased to about 1,500,000 t in the 1930s. During this period, fishing vessels tended to become larger and/or more powerful and there were further technical improvements to fishing gear, such as interposing long wires (sweeps) between the otterboards and the trawl to herd fish into the path of the net. Fishing continued on a reduced scale throughout the second World War, but no statistics for these years are available. Immediately after the war, landings were higher than before. Initially, this increase could perhaps be attributed to the exploitation of the greater numbers of large fish that had accumulated during the war years. However, landings continued at a high level and there was a further increase in the late 1960s. During the years 1966-76, approximately 3,000,000 t were landed each year. Current landings are slightly lower, although well above the pre-war values.

It is conventional to divide the fishery into three categories: pelagic, demersal and industrial. The pelagic fishery exploits mid-water fish, the principal North Sea species being Atlantic herring, *Clupea harengus* and Atlantic mackerel, *Scomber scombrus.* The demersal (bottom) fishery is mainly for flatfishes and cod-fishes (Gadidae) whereas the industrial fishery catches small, usually short-lived, species which are processed into fish meal and oil.

Figure 1 shows that for many years the pelagic fishery constituted about two-thirds of the total landings. However, this pattern changed during the mid to late 1960s, when the landings of pelagic species increased, then declined steeply, while at the same time the landings of demersal and industrial species increased substantially. In recent years, there have been further changes: landings of pelagic species have risen again, and are approaching their historic level. Landings of demersal species have now declined, but not to their historic level; landings of industrial species have remained high, and now represent about 50% of the total yield from the North Sea. Considerable changes have taken place in the landings of individual species within these three main components of the fishery during the post-war period, as described below.

The Pelagic Fishery (Fig. 2) For some 20 years, annual landings of herring ranged between 0.7 and 1.4 million tonnes. A rapid decline began in 1965. The estimated stock size reached such a low level that drastic management measures were taken and directed fishing for herring in the North Sea was prohibited in 1977. During the closure period the state of the stock was monitored by fisheries scientists. After a few years there was evidence of improved recruitment to the stock and the southern North Sea fishery reopened in 1981 and fishing for herring over the entire North Sea recommenced in 1983. Current herring landings are similar to those in the pre-war period.

Landings of mackerel were low for many years. However, they suddenly increased in the mid 1960s, when the Norwegian purse-seine fleet switched its attention from the depleted stocks of Atlanto-Scandian herring, first to North Sea herring and then to North Sea mackerel. Landings reached a peak of nearly 1,000,000 t in 1966. Subsequently, they declined to their present lower level. The resident North Sea mackerel stock is now small and most of the catch consists of fish belonging to the "Western" stock, a part of which enters the North Sea in summer and autumn, to feed, after spawning west and southwest of the British Isles.

The Demersal Fishery (Fig. 3) The gadoids (cod-fishes) are the principal component of the demersal fishery, although a large catch of plaice, *Pleuronectes platessa* is taken from the southern North Sea. The main gadoid species are cod, *Gadus morhua,* haddock, *Melanogrammus aeglefinus*, whiting, *Merlangius merlangus*, and saithe, *Pollachius uirens.* (Another gadoid, the Norway pout, *Trisopterus esmarkii,* is also landed in large quantities from the North Sea, but this small species forms part of the industrial fishery). Annual landings were fairly stable, at 300,-400,000 tonnes, until the mid 1960s, when there was a sudden increase. This was the start of what has been called the "gadoid outburst". During this period (which lasted from 1962 to the early 1980s) there were several outstandingly successful year-classes of haddock, whiting and cod. Stock sizes of all the major gadoid species increased and the landings more than doubled. In recent years, stock sizes have decreased to about their pre-"outburst" levels and landings have declined.

The Industrial Fishery (Fig. 4) The principal species taken by this fishery are sprat, *Sprattus sprattus*, Norway pout, and sandeels (Ammodytidae). Several species of sandeel occur in the North Sea, but most of the catches are of *Ammodytes marinus*. Landings of Norway pout and sandeels were not recorded separately in ICES statistics until 1960. In the mid-1960s similar quantities of each species were landed, but since that time there have been some pronounced changes. Sprat landings markedly increased in the 1970s, exceeding 500,000 tonnes in 1975. At that time, when the herring stock was small, sprats were more abundant and widely distributed throughout the North Sea than before or since. The sprat stock suddenly decreased around 1979-80 and landings have returned to a low level, with most catches being taken in the southern North Sea. Landings of Norway pout increased considerably in the 1960s and 1970s, during the "gadoid outburst". (Although Norway pout were particularly abundant at that time, the reported landings of Norway pout may have included considerable quantities of cod, haddock and whiting). In recent years, landings of Norway pout have declined. Sandeel landings also increased in the 1970s, and, in contrast to those of the other industrial species, remained at a very high level. More than 1,000,000 tonnes of sandeels were landed in 1989 and these fish are now the principal component of the industrial fishery.

Changes in two Representative Stocks: Herring (Pelagic) and Haddock (Demersal) Landings are influenced by factors such as fishery regulations and changes in fishing effort as well as by real changes in fish abundance. Better guidance on the state of the stocks is provided by figures on stock biomass and recruitment levels. These are routinely monitored by fisheries biologists, using fisheries-dependent and fisheries-independent data.

Details of post-war changes in stock size, exploitation rates and recruitment levels of herring are available in the 1991 report of the ICES Advisory Committee on Fishery Management (ACFM). Landings rose to a peak in the mid-1960s, and then quickly declined. The fishing mortality rate followed a different pattern, almost the mirror image of landings. After the war, the fishery was removing about 30% of the stock each year. However, the mortality rate rapidly increased in the 1960s.

During the period when landings were declining, fishing was removing about 70% of the stock per annum. Following a series of years of poor recruitment, the spawning stock biomass (SSB, the weight of sexually mature fish in the sea), declined from an estimated 4,000,000 tonnes just after the war to less than 250,000 tonnes in the middle 1970s. Since then the situation has considerably improved, although the SSB is still below its immediate post-war level. The comparatively rapid recovery was expedited by relatively high levels of recruitment throughout much of the 1980s. Several strong year-classes were produced during the period when the SSB was still at a low level. This suggests that factors operating during the early life history of the fish may determine the initial size of an individual year-class, although fishing may have a considerable influence on subsequent survival.

The times series of haddock spawning stock biomass is less complete, but the annual landings (Fig. 3) illustrate the history of this stock. Landings varied little throughout the 1940s and 1950s, but suddenly rose in the mid 1960s. The increase was due to the two exceptionally strong year-classes of 1962 and 1967. The 1967 year-class was almost certainly the strongest to have been born this century. During the last few years the size of the stock has declined markedly. However, it is probably no lower than immediately before the "gadoid outburst". During the last two decades, there has been no obvious trend in the fishing mortality rate of haddock. Haddock recruitment is extremely variable from year to year, and is not correlated with the SSB. Although the current SSB is rather low, the situation could change substantially from one year to the next, as happened in the 1960s.

Pelagic species may be especially liable to over-exploitation because their tendency to form compact shoals renders them very vulnerable to modern fishing methods. The development of sophisticated fish-detection equipment and efficient methods of capture means that some substantial catches can be taken, even when a stock is at a low level of abundance. Demersal species tend to be more dispersed so that when stocks are small, catch rates are usually low

An overview of changes in North Sea fish stocks is given by Daan *et al.* (1990). Detailed information can be obtained from the reports of the appropriate ICES Stock Assessment Working Groups.

CETACEANS, FISH STOCKS AND FISHERIES Whereas there is a large amount of information on North Sea fisheries and fish stocks, little is known about the cetaceans. It is therefore difficult to assess the impact of cetaceans on fish stocks and fisheries and *vice versa.*

Predation by Cetaceans on Fish The extent of "natural" predation on commercially exploited fish is a very topical issue and ICES is putting considerable effort into the development of new methods of assessing North Sea fish stocks, taking into account interactions between and within various commercially exploited species and, more recently, other groups of North Sea fauna.

Considerable attention has been paid to predation by fish on fish. The diets of five species of North Sea fish were described during a large scale stomach-sampling exercise in 1981 and smaller investigations in 1985, 1986 and 1987. (Another large-scale project took place in 1991, but the results are not expected to be available until 1993.) Predation by fish on fish occurs on a very large scale, annual consumption being of the order of 3,000,000 tonnes (Anon., 1991).

Attempts have also been made to estimate the weights of fish eaten by seabirds and seals. Seabirds are numerous in the North Sea and according to Bailey (1986), their annual consumption of fish is approximately one third of a million tonnes. Common and grey seals are large mammals, but they are much less numerous than seabirds. On the basis of their estimated energy requirements (Härkonen and Heide-Jørgensen, 1991; Fedak and Hiby, 1985) and their current population sizes (Anon., 1992), their combined consumption of fish in the North Sea probably lies within the range 90-155,000 tonnes *per annum.*

Although data on the numbers of cetaceans in the North Sea and their diets and consumption rates are scarce, one can still make a "guesstimate" as to their likely impact on fish stocks, relative to the other major predators. A Norwegian survey in July 1989 (Bjørge and Øien, 1990) indicated that there may be at least 80,000 harbour porpoises, *Phocoena phocoena*, in the northern North Sea. Assuming, as a first approximation, that a porpoise eats 2 kg fish per day, annual consumption by this species alone would be approximately 60,000 tonnes. However, because porpoises also occur in parts of the North Sea not covered by the survey and several other species of small and medium-sized cetaceans are also present, it seems likely that cetaceans consume more fish than seals, but probably less than seabirds. Estimates of predation are summarised in Table 1.

Competition Between Cetaceans and Fisheries There have been large changes in the biomass of herring and mackerel in the North Sea during the last 40 years. The significance to cetaceans of these changes depends on whether these fish are normally the preferred prey of cetaceans and on whether cetaceans are highly specialised feeders. If both cases are true, then large changes in the biomass of particular species may have affected cetacean populations. However, if cetaceans are opportunistic predators, able to exploit a wide range of prey, these changes may not have had such a great significance because the period when the stocks of herring and mackerel were low coincided with the gadoid "outburst', and sprats were also more abundant and widespread at that time. Currently, although gadoid stocks have returned to earlier levels, herring are again abundant.

Fisheries-Related Mortality Although cetaceans are no longer hunted in the North Sea, they are sometimes accidentally caught, and these animals often die before they can be released. It is, and is likely to remain, difficult to quantify these incidents. It is generally accepted that most northern European statistics on by-catches of cetaceans are unreliable. Accurate information is needed and the states bordering the North and Baltic Seas are soon expected to sign an Agreement, under the Bonn Convention, which includes "setting up in each country an efficient system for reporting and retrieving by-catches". However, implementing such a scheme will not be easy. It is impracticable to put observers on each of the many hundreds of fishing vessels working in the North Sea. In Scotland, the Agriculture and Fisheries Department has recently introduced a voluntary scheme under which fishermen have been asked to report all bycatches and, if the animals cannot be returned to the sea alive, to land the bodies for scientific examination.

It should be recognised that not all kinds of fishing activity are equally threatening to cetaceans. For example, although Clausen and Anderson (1988) estimated that the Danish wreck net fishery may catch about 3,000 harbour porpoises *per annum*, SOAFD staff regularly go to sea on commercial fishing vessels to estimate the numbers of fish discarded by the Scottish demersal trawl and seine fleet and not a single by-catch incident has been observed during 600 voyages, spanning a period of 10 years.

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Table 1 Estimated total annual consumption of fish by major "predators" in the North Sea.

Predator	Annual consumption (tonnes)
Fish	3,000,000
Fishing (landings)	2,500,000
Seabirds	340,000
Seals	90,000-155,000
Harbour porpoise	>60,000?
Other cetaceans	?

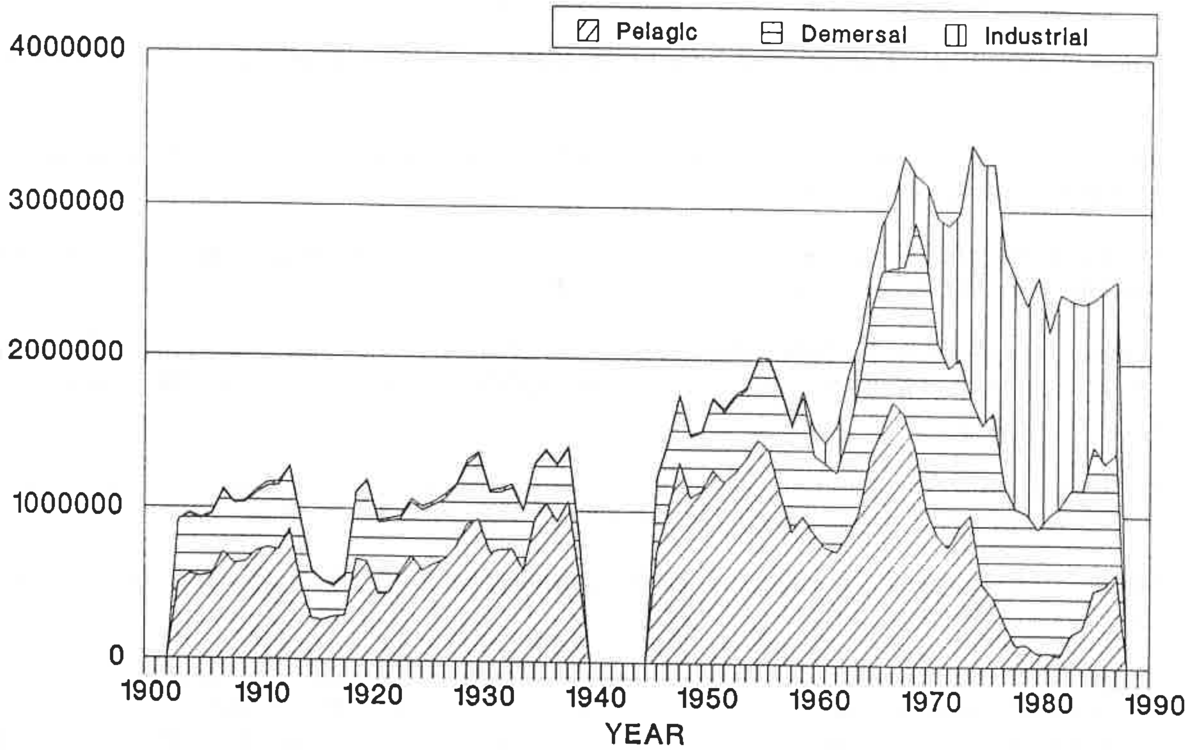

Fig. 1 Annual landings (tonnes) of pelagic, demersal and industrial fisheries in the North Sea, 1903-1987. Source: ICES Statistical Bulletin.

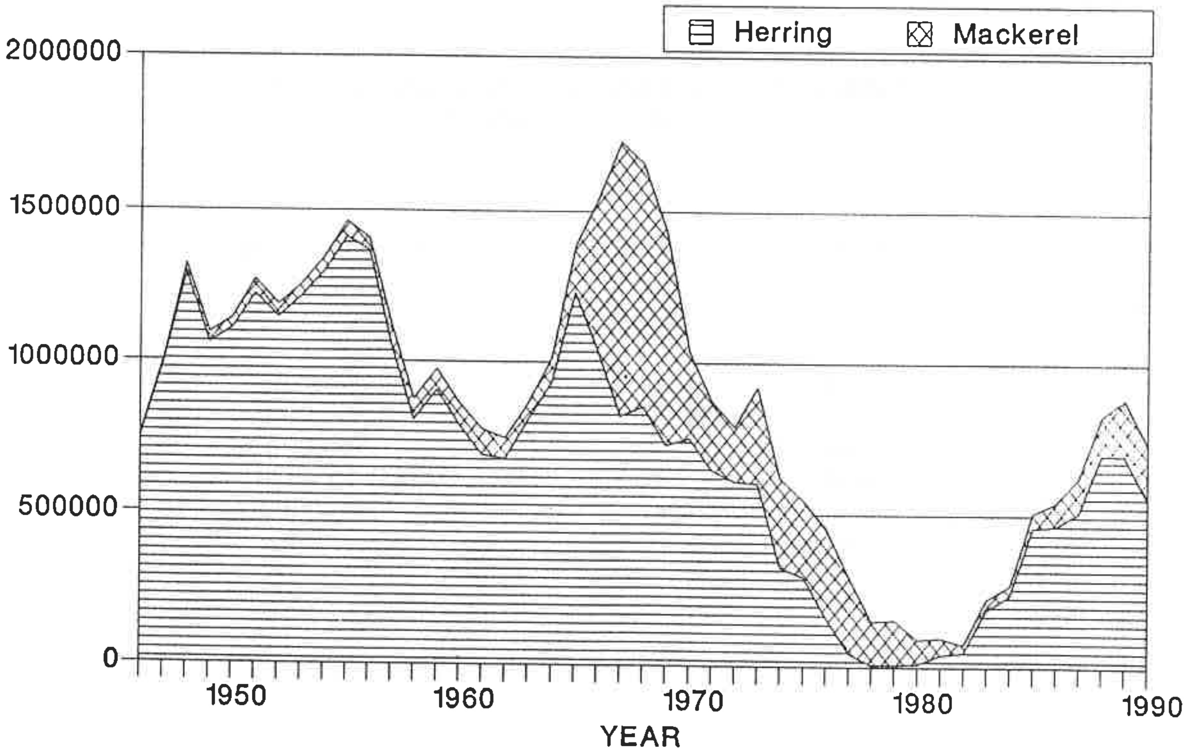

Fig. 2 Annual landings of principal pelagic species from the North Sea, 1946-1990. Source: ICES Statistical Bulletin and Assessment Working Groups.

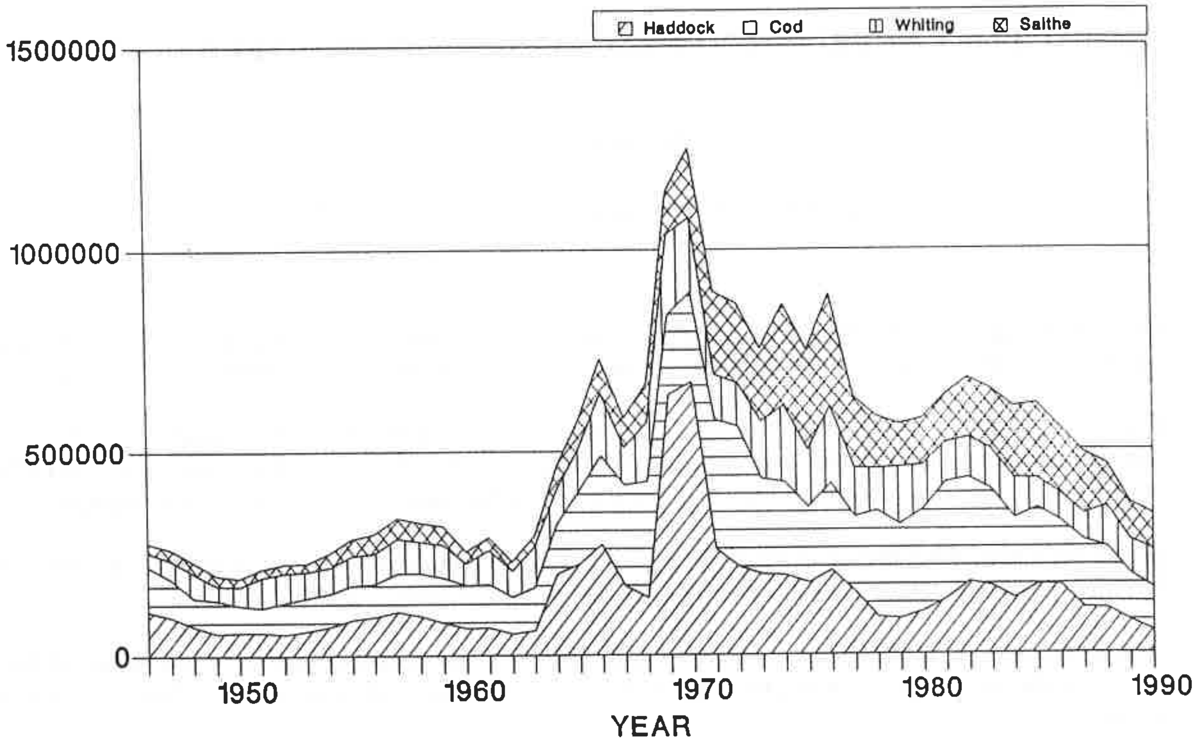

Fig. 3 Annual landings of principal gadoid species from the North Sea, 1946-1990. Source: ICES Statistical Bulletin and Assessment Working Groups.

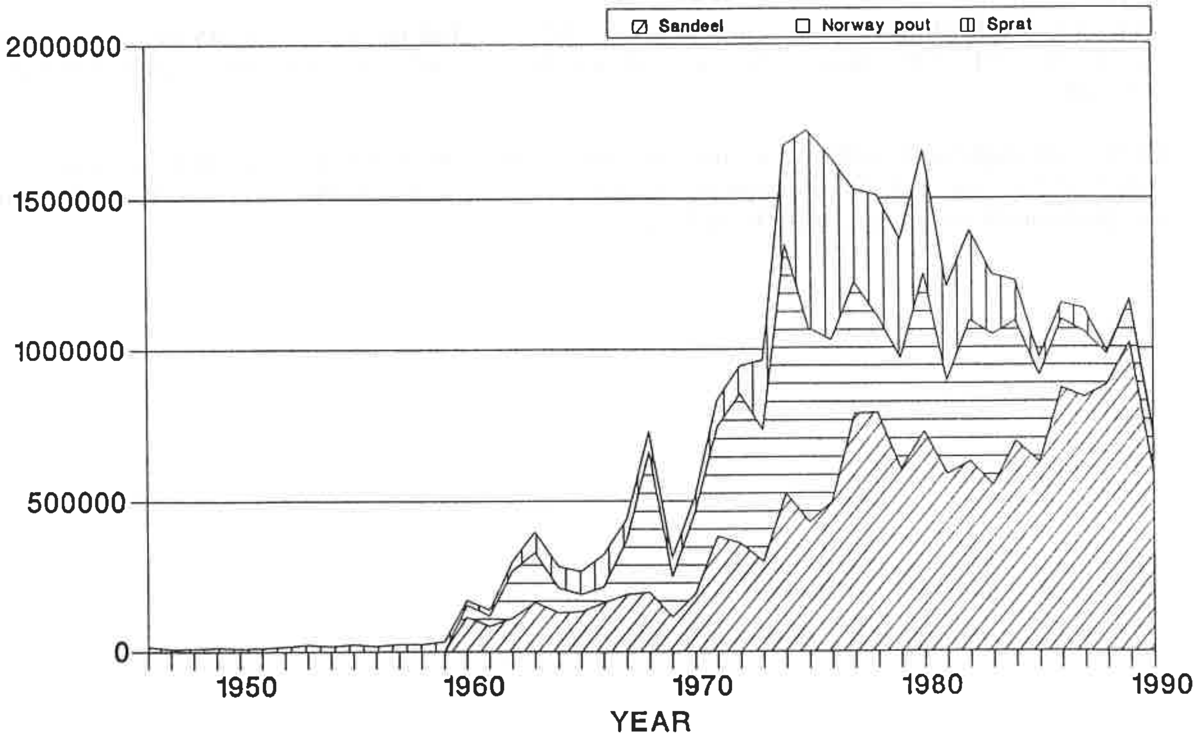

Fig. 4 Annual landings of principal industrial species from the North Sea, 1946-1990. Source: ICES Statistical Bulletin and Assessment Working Groups.

IMPACT OF FISHERIES ON CETACEANS IN THE MEDITERRANEAN SEA

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Several studies have been carried out in the last ten years to collect the first detailed information about the impact of fisheries on cetacean species in the Mediterranean Sea.

The very high number of fishermen and the variety of fishing gear used are the most important elements for the assessment of impact, even if little information is available about the stock structure of the several species of cetaceans living in the Mediterranean.

Some fisheries, like the swordfish drifting nets and bottom set nets, may have a significant bycatch , or may cause serious interactions between cetaceans and fishermen.

A general overview of interactions between fishery activity and cetaceans is reported in this paper, with the purpose of highlighting critical situations and trends in the Mediterranean Basin.

An undesirable increase in surface drift nets in North African countries is an early outcome of the better protection of cetaceans in EEC waters, as well as a consequence of driftnet mismanagement.

The very high number of set gill nets around the Mediterranean coasts are a potential source of conflict for some cetacean species (for example bottle-nosed dolphin,*Tursiops truncatus*).

Fishery management in the area must consider these kind of problems in the near future and FAO-GFCM and ICCAT are starting to take cetacean interactions into consideration, with the purpose of reducing conflicts and their impact.

PRELIMINARY REPORT ON THE INCIDENTAL CATCHES OF DOLPHINS IN THE NORTH-EASTERN ATLANTIC FRENCH TUNA FISHERY

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A small French tuna fleet (about 40 ships) has operated for a couple of years in the North-eastern Atlantic, using gill nets. The fishing season begins in May, north of the Azores Archipelago; then the fishing boats move north-eastwards following tuna, and reach the Irish Sea in September by the end of the season (Fig.1).

During the summer of 1991, nine observers were placed for one cruise on two French tuna fishing boats ("l'Enfant du Voyage" and the "Requin Bleu"). The nets were partially immersed, setting the cork-line at two metres below the sea surface.

Moreover, IFREMER (the French Institute for Research in the Sea) had organised an experimental cruise (aboard the "Gwen Drez") using a 2 km long net, of which one half was immersed 2 metres below the surface, and the other half had been laid (dropped) at the surface. A total of 577.4 km of nets was observed, of which 374.8 km were laid at the surface and 206.6 km immersed 2 metres below the surface.

Because of the disparity in the quality of observers (only IFREMER scientists were thought to be reliable), only a small part of the data were available to test the significance of the results. Table 1 provides the total number of catches by species. Tables 2 and 3 give the number of specimens caught by species, following the type of net used (surface or immersed) and when data are available, the rate of capture per km of net.

Albacore (*Thunnus alalunga*): the rate of catch is higher for "L'Enfant du Voyage" (table 2: 59.5 per km) than for the other two boats (table 3: 47.2 per km). This difference may be related to the fishing strategy. The rate of lost albacore varies from 1.8 to 2.1 per thousand depending on the ship.

Other fish: except for the blue shark and the Ray's bream (*Brama caii*), the rates of catch per km are very low. Most of the species have been sold on the market.

Dolphins: incidental catches of dolphins appear to be lower when nets are immersed, although they do still occur. Because of the low total number of dolphins caught (forty *Stenella sp.* and six *Delphinus delphis*), this difference might only be an apparent phenomenon and cannot be tested statistically. Anyway, the global rates of catches per km - 0.1 in surface nets and 0.04 in immersed nets, are pretty low.

No sea turtles or seabirds have been caught.

Testing the catches following the type of net involved, with a non parametric method (Wilcoxon), it appears that the differences observed for the majority of fish and for dolphins are not significant. The only significant difference concerns wreck fish (*Polyprion americus*):, with more individuals caught in surface nets than in immersed nets. This is not surprising given the behavior of this species with respect to any floating objects.

Considering the total body length distribution of the dolphins (Fig.2), it is clear that most of them were young specimens.

Examination of 36 *Stenella sp.* with known total body length showed that 18 were smaller than 143 cm long, 12 had a total body length between 150 and 176 cm, and only 6 were larger than 190 cm. For the common dolphin (*Delphinus delphis*), four were smaller than 180 cm long and two were larger than 200 cm.

Only a few teeth have been collected for age determination, but no time has been available up to now to analyse them. However, referring to the literature concerning the Atlantic striped dolphin (*Stenella coeruleoalba*) and common dolphins, animals smaller than 180 cm are less than 4-5 years old and sexually immature. Therefore, assuming that dolphins smaller than 180 cm long may be considered as juvenile, over 83% of *Stenella sp.* and over 66% of common dolphins that were incidentally caught were juvenile. If thisfinding is true, it may be due to a lesser ability of the use of sonar system by young dolphins and their lack of experience when faced with an attractive net full of good fish.

The aim of the experiment of net immersion 2 m below the surface was to test whether or not incidental catches of dolphins could be reduced without any significant detrimental effect on tuna catches. It appears that, even if incidental catches of dolphins cannot be eliminated altogether, they may decrease when nets are immersed.

Another interesting result of this preliminary study is the finding that over 90% of the total catches concern the albacore tuna. It may be thus concluded that this type of fishery is highly selective in terms of species.

Table 1 Catches observed in 577 km of nets

SPECIES CAUGHT		NUMBER CAUGHT
Albacore	- *Thunnus alalunga*	31,300
Dolphins	- *Stenella* sp. & *D. delphis*	46
Blue Shark	- *Prionace glauca*	1,842
Ray's Bream	- *Brama caii*	1,716
Wreck fish	- *Polyprion americanus*	30
Sword fish	- *Xiphias gladius*	40
Porbeagle	- *Lamna nasus*	6
Bluefin Tuna	- *Thunnus thynnus*	27
Sun fish	- *Mola mola*	18
Squid spp.		20

Table 2 Number of catches per species for the tuna boat "L'Enfant du Voyage". The length of net used to calculate the rate of capture may vary from one species to another, depending on the quality of the data. Only accurate data have been used here.

Net length : (km)	Immersed (28)	Surface (200)	Total (228)
Albacore	1655.00	11916.00	13571.00
rate of capture	59.11	59.58	59.52
km	28.00	200.00	228.00
Dolphins	1.00	26.00	27.00
rate of capture	0.04	0.13	0.12
km	28.00	200.00	228.00
Blue shark	33.00	256.00	948.00
rate of capture	1.74	2.05	4.16
km	19.00	125.00	228.00
Ray's bream			965.00
rate of capture			5.55
km			174.00
Wreck fish			16.00
rate of capture			0.09
km			174.00
Sword fish			19.00
rate of capture			0.08
km			228.00
Bluefin tuna			22.00
rate of capture			0.10
km			228.00
Porbeagle			4.00
rate of capture			0.02
km			228.00
Sun fish			4.00
rate of capture			0.02
km			228.00
Squid			1.00
rate of capture			0.01
km			228.00
Lost albacore			16.00
rate of capture			0.11
km			144.00

Table 3 Number of catches per species for the tuna boat "Requin bleu" and the research vessel "Gwen Drez". The length of net used to calculate the rate of capture may vary from one species to another, depending upon the quality of the data. Only accurate data have been used.

Nets length: (km)	Immersed (174.6)	Surface (174.8)	Total (349.4)
Albacore	5332.00	6732.00	12064.00
rate of capture	40.49	51.04	45.77
km	131.70	131.90	263.60
Dolphins	7.00	12.00	19.00
rate of capture	0.04	0.07	0.05
km	174.60	174.80	349.40
Blue shark	136.00	107.00	243.00
rate of capture	1.57	1.23	1.40
km	86.70	86.90	173.60
Ray's bream			751.00
rate of capture			3.34
km			224.60
Wreck fish	5.00	8.00	13.00
rate of capture	0.06	0.09	0.07
km	86.70	86.90	473.60
Sword fish	12.00	9.00	21.00
rate of capture	0.09	0.07	0.08
km	129.60	129.80	259.40
Bluefin tuna			5.00
rate of capture			0.02
km			259.40
Porbeagle			2.00
rate of capture			0.01
km			173.60
Sun fish	0	0	0
rate of capture	0	0	0
km	174.60	174.80	349.40
Squid			2.00
rate of capture			0.01
km			134.60
Lost albacore			19.00
rate of capture			0.14
km			138.60

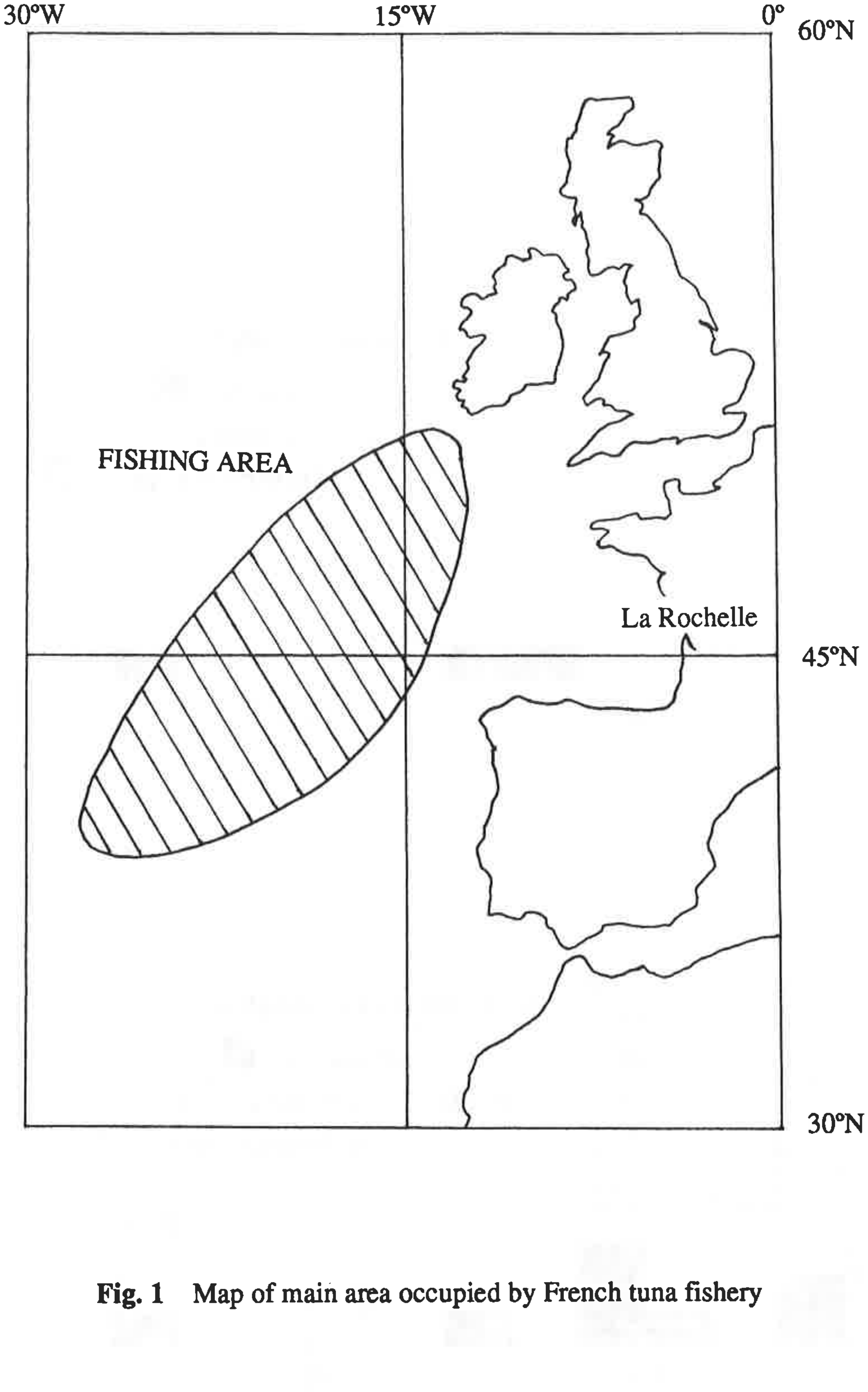

Fig. 1 Map of main area occupied by French tuna fishery

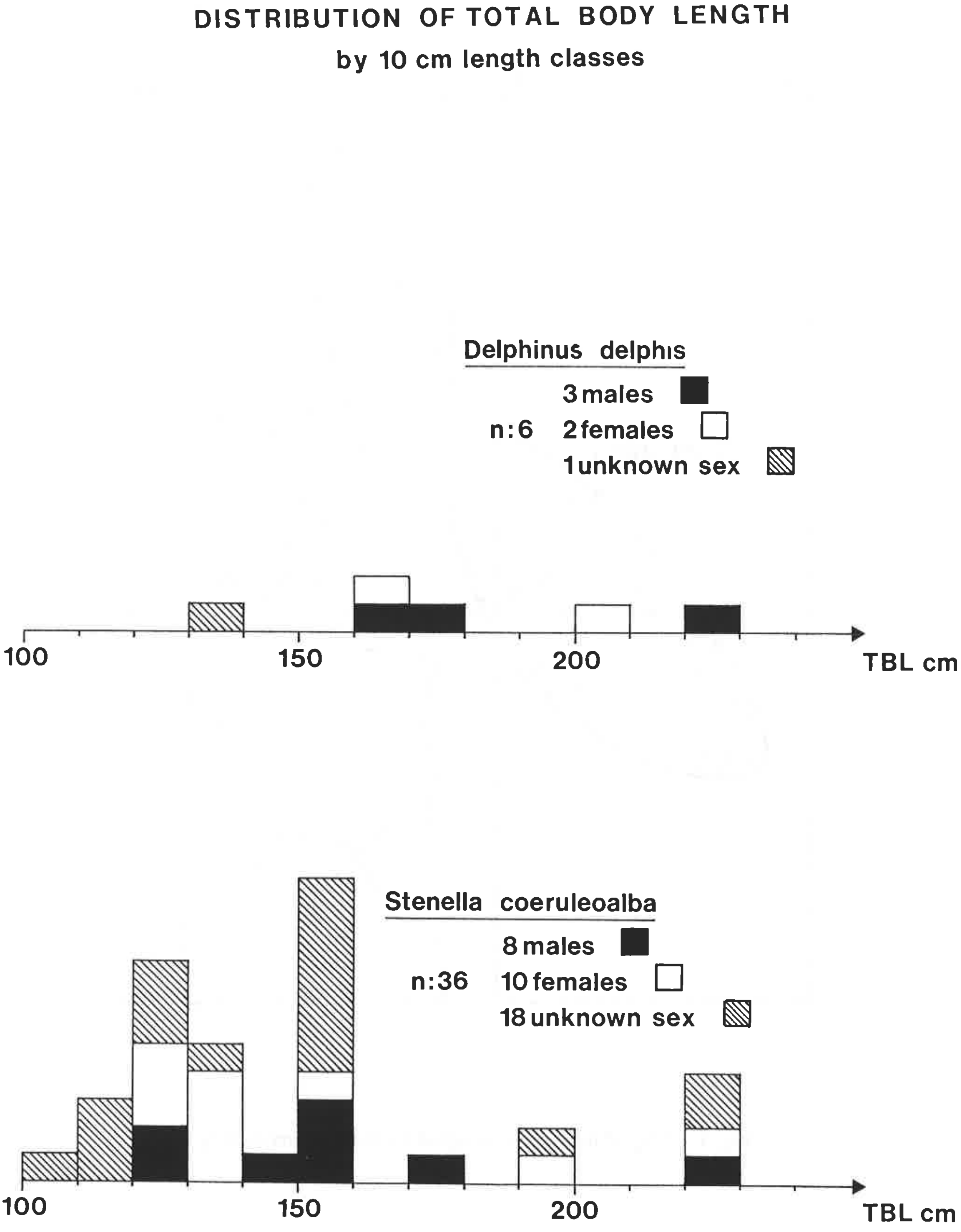

Fig. 2 Distribution of total body length, by 10 cm length classes

ACCIDENTAL CATCHES OF CETACEANS IN PORTUGAL

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INTRODUCTION Systematic surveys for cetaceans and pinnipeds along the Portuguese coast were initiated in 1976. From this time, we started collecting data on strandings and it soon became clear that an important fraction of the overall mortality recorded was directly related to fishing activities, at least after 1981, when the killing of all cetaceans in Portuguese waters became technically illegal. Until that date, up to a few hundred small cetaceans were killed every year and sold at local fish markets, either for human consumption or to be used as fishing bait. National legislation passed in 1981 (Decreto-Lei no. 263/81) protecting all marine mammals in Portuguese continental waters certainly had an immediate positive impact on species such as the common dolphin, *Delphinus delphis*, and the striped dolphin, *Stenella coeruleoalba*. However, the effectiveness of these measures upon species like the harbour porpoise, *Phocoena phocoena*, was not easy to assess, due to bycatches involving accidental drowning of these cetaceans in gillnets set by small boats quite close to the shore. In this case, the new laws possibly brought no significant benefits, and may simply have resulted in placing most cetaceans found dead by fishermen in their nets automatically beyond reach of cetologists.

RESULTS AND DISCUSSION Considerable numbers of cetaceans are killed every year during fishing operations on the Portuguese coast. Although small numbers of marine mammals are caught by trawlers and fish traps, much higher mortality rates are currently recorded for the gillnet fishery. In fact, from a total of 105 accidents reported since 1977 involving cetaceans killed in fishing gear, 66.7% of all cases are definitely attributable to gillnets and only 19% to trawls (Table 1).

Gillnets are one of the most important types of fishing gear currently being used on the Portuguese coast, and include both gillnets and trammel nets. Their use is widespread all along the coast, but the number of boats authorised to use such gear is higher in the northern and central zones (Fig. 1). Considering the richness of their marine fauna these areas are of great importance for cetaceans. The presence of a deep underwater canyon quite close to the shore at Nazare allows for a rich abyssal marine fauna there. Also the Lisboa-Setubal oceanic area is greatly influenced by the high incoming concentrations of nutrients from the Tejo and Sado estuaries nearby. Furthermore, the central zone on the Portuguese coast is well known for its rich upwelling, mostly between Capas Espichel and Sines (Fiúza, 1983).

This biological richness has directly affected the fishing effort that has developed in the area and the volume of catches by the local fisheries (Costa and Franca, 1985; Franca and Costa, 1984). It also relates to the comparatively higher number of cetaceans recorded there, both from sightings and strandings (Sequeira, 1988; Sequeira and Teixeira, 1990).

The common dolphin is not only the most common cetacean found in Portuguese waters, but also the species most frequently involved in gillnets. Other cetaceans regularly caught in the same type of nets include the harbour porpoise and the striped dolphin. The harbour porpoise is particularly vulnerable in the coastal areas around Averio and Figueira da Foz (northern Zone), where the continental shelf is wider, thus allowing for a a larger number of gillnets being set rather close to the shore. Data from early naturalists like Bocage (1893) and Norbre (1895, 1935) refer to the harbour porpoise as a very common species on the Portuguese coast. This situation has changed drastically, following a pattern similar to that recorded in other Western European countries. According to Teixeira (pers. comm.), many harbour porpoise sightings in recent years have involved animals travelling solitarily or in very small groups. Furthermore, the latest results from the national strandings survey scheme suggests a substantial decrease in the abundance of *P. phocoena* relative to other species. It was noticed that many porpoises found dead ashore had netting marks around their head and flippers.

Although not reaching the comparatively high numbers obtained for the gillnet fishery, trawling operations certainly contribute to the overall mortality of cetaceans recorded on the Portuguese coast. As is the case for gillnet bycatches, the official numbers of cetaceans recorded as caught by the trawl fishery are certainly underestimated. This occurs mostly because there are no observers on board to monitor accidental catches, but also because fishermen fail to report any cetaceans caught in their nets, because they fear legal sanctions from the authorities. Therefore, most marine mammals caught are simply thrown back into the sea. As a matter of fact, the official reports for 1977-91 refer only to 20 dolphins found dead in trawl nets (19 common dolphins and 1 harbour porpoise).

Bycatches associated with fishing traps are poorly documented. However, due to their intrinsic characteristics, this type of bottom set fishing gear is unlikely to cause high mortality. The common dolphin and the minke whale, *Balaenoptera acutorostrata*, are the only two species ever recorded to become occasionally entangled in Portuguese fishing traps.

CONCLUSIONS Although there is some basic knowledge that cetaceans are caught during fishing operations, detailed biological information on incidental mortalities of marine mammals on the Portuguese coast is still lacking. More than 50% of these mortalities are probably caused through entanglement in gillnets, with trawl incidents accounting for only a few tens of specimens killed per year. The impact of these mortalities upon the cetacean populations still remains obscure, but it is feared that some populations may already be threatened and need to be monitored urgently.

It is therefore recommended that:

a) National legislation should be reconsidered to ensure that fisherman are not in contravention of wildlife protection legislation if they inadvertently catch cetaceans. Legislation should be introduced to make the reporting of such catches compulsory.

b) Accurate information on current takes of cetaceans must be collected for all fisheries operating in the Portuguese EEZ. Priority must be given to an assessment of gillnet by-catches. On board observers may not be appropriate, since the number of boats operating gillnets in Portugal is extremely high and this type of fishing gear is often used to complement the main gear. Valuable information on bycatches could eventually be obtained from questionnaire schemes set up within the environment campaigns amongst fishermen.

c) The numbers and distribution of gillnets currently used on the Portuguese coast must be carefully monitored. This could eventually be accomplished by reviewing the licence assignment scheme in order to control the number of boats allowed for each zone, especially in heavily fished areas where the impact of gillnets on cetaceans is most important. Further studies of gear technology and positive actions on the replacement of gillnets by other types of fishing gear should be developed, bearing in mind that longlines and traps may have a comparatively small impact on cetaceans and other non-target marine fauna.

d) Detailed biological studies must be developed for those species most affected by gillnets, including the harbour porpoise and common dolphin. These studies should include assessment of abundance, seasonal distribution, population size and current trends.

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Table 1 Cetacean bycatches recorded for mainland Portugal, 1977-90

	Types of fishing gear				
Species	Gillnets	Trawls	Fishing traps	Other	TOTAL
P. phocoena	7	1	-	-	8
D. delphis	60	19	1	5	85
S. coeruleoalba	2	-	-	1	3
T. truncatus	-	-	-	-	0
B. acutorostrata	-	-	3	1	4
D. delphis	-	-	-	5	5
TOTAL N	69	20	4	12	105
%	65.71	19.05	3.81	11.43	

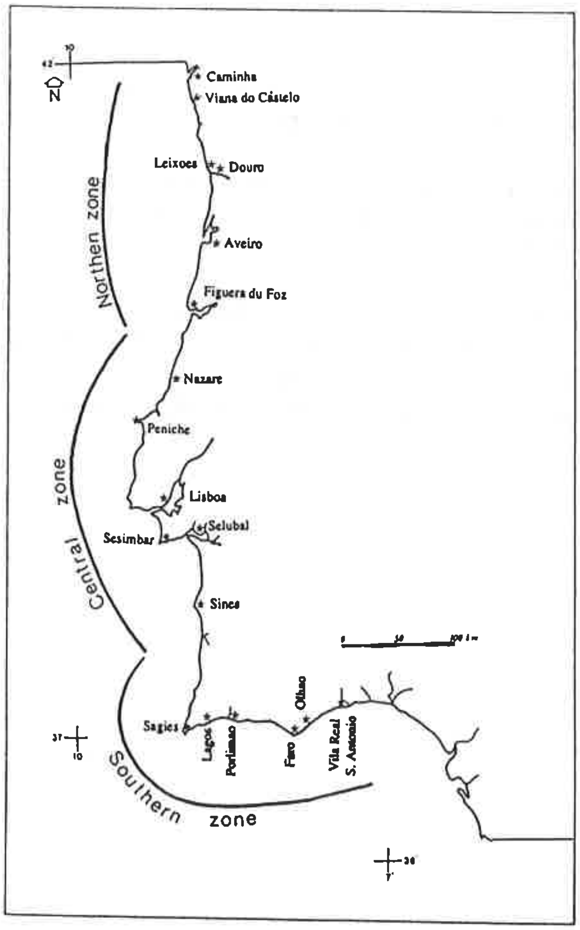

Fig. 1 Cetacean by-catches recorded for mainland Portugal (1977-1991)

CETACEAN BYCATCHES IN THE CENTRAL CANTABRIAN SEA: FISHING GEAR SELECTIVITY

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Since 1977 we have recorded data on cetacean bycatches in the Central Cantabrian Sea, both unloads and strandings, but only since 1983 have we obtained an improved survey in the five main fishing harbours of Asturias.

SPECIFIC IMPACT Our data comprise 43 catches involving 64 individuals, and over the last decade, we have obtained a mean of 4.22 catches per year. This number is not large but neither is the fishing fleet operating between 4° 31' and 7° 02' W, which comprises less than one hundred boats using nets.

These observations (Table 1) show that four species (harbour porpoise, *Phocoena phocoena*, common dolphin, *Delphinus delphis*, striped dolphin, *Stenella coeruleoalba*, and long-finned pilot whale, *Globicephala melas*) have been trapped in fishing gear, mainly gill nets of different sizes but also in purse seine nets and shark long-lines.

Up to now, drift nets have not been used in these waters and they are not allowed to be used by Spanish fishing vessels, although they have been employed by French tuna fishing boats in the Bay of Biscay since 1990. This kind of net causes the greatest damage to cetacean populations, as Podestá and Magnaghi (1989) state in the Ligurian Sea.

According to our data, the common dolphin is the species most frequently caught, representing 55.8% of the total number of bycatches. The harbour porpoise is proportionally the most affected because although it only represents 28% of the total bycatches, nearly the half of all records (strandings + bycatches) for this species in our survey have been obtained through bycatches, whereas only a quarter of common dolphin records refer to specimens caught by fishing gear. We can measure the relative impact of fishing gear for each species by means of the ratio of bycatches to strandings, obtaining a ranking for each species affected (Table 2).

GEAR IMPACT The fishing gear with the greatest impact on cetaceans in our study area are fixed nets. These nets trapped 71.5% of the animals caught, followed by purse seine nets which represent 11.5%, and shark long-lines only 8.5%. There is a clear seasonality in the distribution of bycatches with winter and spring concentrations (from November to April, more than 80% of bycatches are recorded), coinciding with the season in which most strandings are recorded.

It is possible to draw some conclusions on the relative importance of particular kinds of net in bycatches of various cetacean species.

Common dolphins are more liable to be captured by gill nets of 90 mm mesh-size, the catches by other nets being similar in number and in any case more important than the ones due to shark long-lines, with the exception of bottom trawl nets. As is well known, harbour porpoises are captured most frequently by gill nets (Read and Gaskin, 1988; Lindstedt and Lindstedt, 1989), but in our survey we have detected a major impact of nets with a larger mesh-size (250 to 280 mm), although porpoises can be captured by any of the net types that we have been considering. Striped dolphins probably show the same trend as common dolphins although we have only recorded entanglements for an intermediate mesh-size (120 mm).

Even though we cannot measure the impact of fishing gear upon the Cantabrian cetacean population, we have evidence of entanglement in 11% of stranded animals so far as causes of human induced mortality go.

DISCUSSION Comparing our data with a similar study for the French Atlantic and Channel coasts (Duguy and Hussenot, 1982), the ratio of bycatches to strandings was less in the Cantabrian Sea fisheries, although we cannot be sure that the difference is not due to varying reporting rates for bycatches. The only concurrent result in both cases was that the harbour porpoise appeared to be the most vulnerable, with gill nets the most important cause of bycatches in this species, although the different use of fishing gear on each coast does affect the catchability of the remaining cetaceans in different ways. Probably the random influence of small sample size also increases the difficulty in comparing the two results.

The tendency for small cetaceans to be entangled in gill nets can be explained by the shape of the head of dolphins and porpoises: The narrow snout of dolphins penetrates between the small mesh and the animals are retained and drown. Tests were made in the Pacific to determine the minimal mesh size necessary to avoid entanglement (Barham *et al.*, 1977). With the jaws closed, the snout could not penetrate 25 mm mesh, and with the jaws open, penetrations were greatly reduced. Frequently, porpoises are entangled by their head in larger mesh than that in which dolphins are entangled, and mesh marks are commonly observed around the eyes or in the acoustic region, depending on the size of the specimen. Dolphins are less affected by this mesh-size because of their prominent melon which makes head penetration difficult. On the other hand, animals are also entangled by their flippers, so we cannot prove any relationship between animal size and mesh size because of the scarce data available.

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Table 1 Number of bycatches recorded in the Central Cantabrian Sea by cetacean species and type of fishing gear.

	P. phocoena	*D. delphis*	*S. coeruleoalba*	*G. melas*	Total
Gill nets					
90 mm	1	6	-	-	7
120 mm	-	2	2	-	4
250-280 mm	3	3	-	-	6
unknown	4	3	1	-	8
Bottom trawls	1	1	-	1	3
Purse seines	1	3	-	-	4
Shark long-lines	1	1	-	1	3
Others	1	5	2	-	8
Total	12	24	5	2	43

Table 2 Relative frequencies of bycatches and strandings of small cetaceans in the Cantabrian Sea

	% bycatches	% strandings	bycatch/stranding
Phocoena phocoena	6.3	6.9	0.91
Delphinus delphis	10.7	31.5	0.34
Stenella coeruleoalba	1.3	12.6	0.10
Globicephala melas	1.3	5.7	0.23

BOTTLE-NOSED DOLPHINS, *Tursiops truncatus*, INTERACTING WITH LOCAL FISHERIES IN THE BALEARIC ISLANDS, SPAIN

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INTRODUCTION The Balearic archipelago, located in the western Mediterranean sea at a distance of 170 km from the Spanish coast, is composed of four main islands: Mallorca, Menorca, Ibiza and Formentera.

A preliminary survey carried out in the area in the early 1980's showed the existence of an interactive conflict between bottle-nosed dolphins (*Tursiops truncatus*) and local fishing activities. Bottle-nosed dolphins were found to take advantage of trawling and bottom gillnets to obtain food, behaviour that caused damage to nets and involved dolphin mortality because of net entanglement. This interaction provoked aggressive reactions from fishermen and led to the development of systems to scare away dolphins from the nets.

To ascertain the importance of the problem and to estimate, as far as possible, the size of the dolphin incidental catches, a field survey was carried out in the Balearic Islands in the summer of 1991.

MATERIAL AND METHODS From July to October, 1991, the most important fishing ports of Mallorca, Menorca, Ibiza and Formentera were visited to collect information from fishermen and local fishing authorities.

The Balearic fishing fleet comprises a total of 780 ships, of which 688 (88.20%) are artisanal gillnet boats, 76 (9.74%) are bottom trawlers, and 16 (1.76%) are purse seiners. In total, 138 professional fishermen (18% of the total) were interviewed. Data collected included:

- type of nets used;
- most problematic areas and season - frequency of interactions;
- number of dolphins killed - systems used to scare dolphins away from nets.

RESULTS

Interactions with fishing gear The survey showed that the artisanal fleet is the fishery most involved in the potential conflict. It uses a wide range of fishing gear which exploits different species in different seasons and areas (Fig. 1). However, bottom gillnets used to catch cuttlefish, *Sepia officinalis,* and red mullet *Mullus barbatus*, actually appear to cause the greatest conflict because they are made from thin thread and are, therefore, weaker than other nets. This fishing takes place mainly in autumn and late winter to early spring.

Conflicts with trawlers seldom occur and, because the purse-seine fleet is very small and fishes in a restricted area (Palma Bay), it only exceptionally interacts with dolphins.

Dolphin interactions are likely to produce damage to fishing gear, but no information is currently available to estimate the magnitude of this damage.

Methods to scare dolphins away from nets In the past, trawlers used dynamite and guns to keep dolphins away from nets. At present these practices are forbidden, although damage caused by dolphins to trawling nets is almost negligible today because of the use of much stronger synthetic fibres.

Artisanal bottom gillnet boats occasionally used crackers and guns to scare dolphins, and we have even had reports of direct aggression using gaffs. In Menorca, fishermen also use clothes soaked in diesel-oil tied to the nets.

Dolphin incidental catches Data collected suggest that entanglement in gillnets is the main cause of dolphin mortality. The 112 artisanal boats and the 24 trawlers interviewed reported the death of 13 dolphins incidentally caught in the last two and a half years (12 in gillnets and one in trawling nets).

Considering the size of the artisanal and trawler fleet of the Balearic Islands, we estimate that about 30 bottle-nosed dolphins are killed each year by these fishing interactions. This estimate may be lower than the actual toll because fishermen are reluctant to release information on this subject.

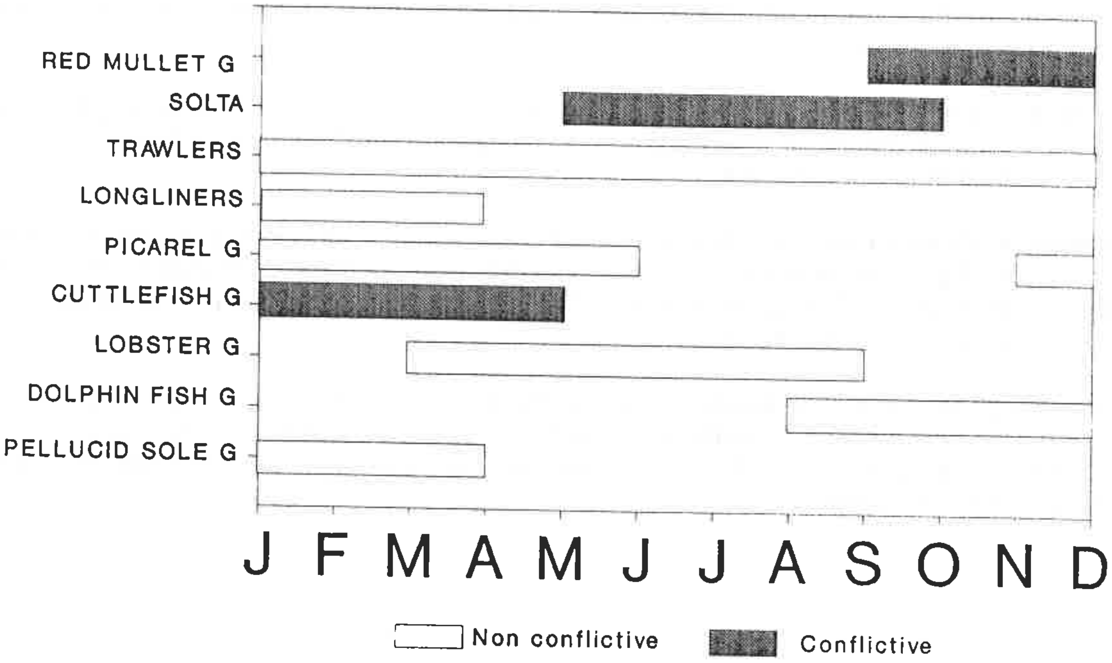

Fig. 1 Seasonality of fishing activities

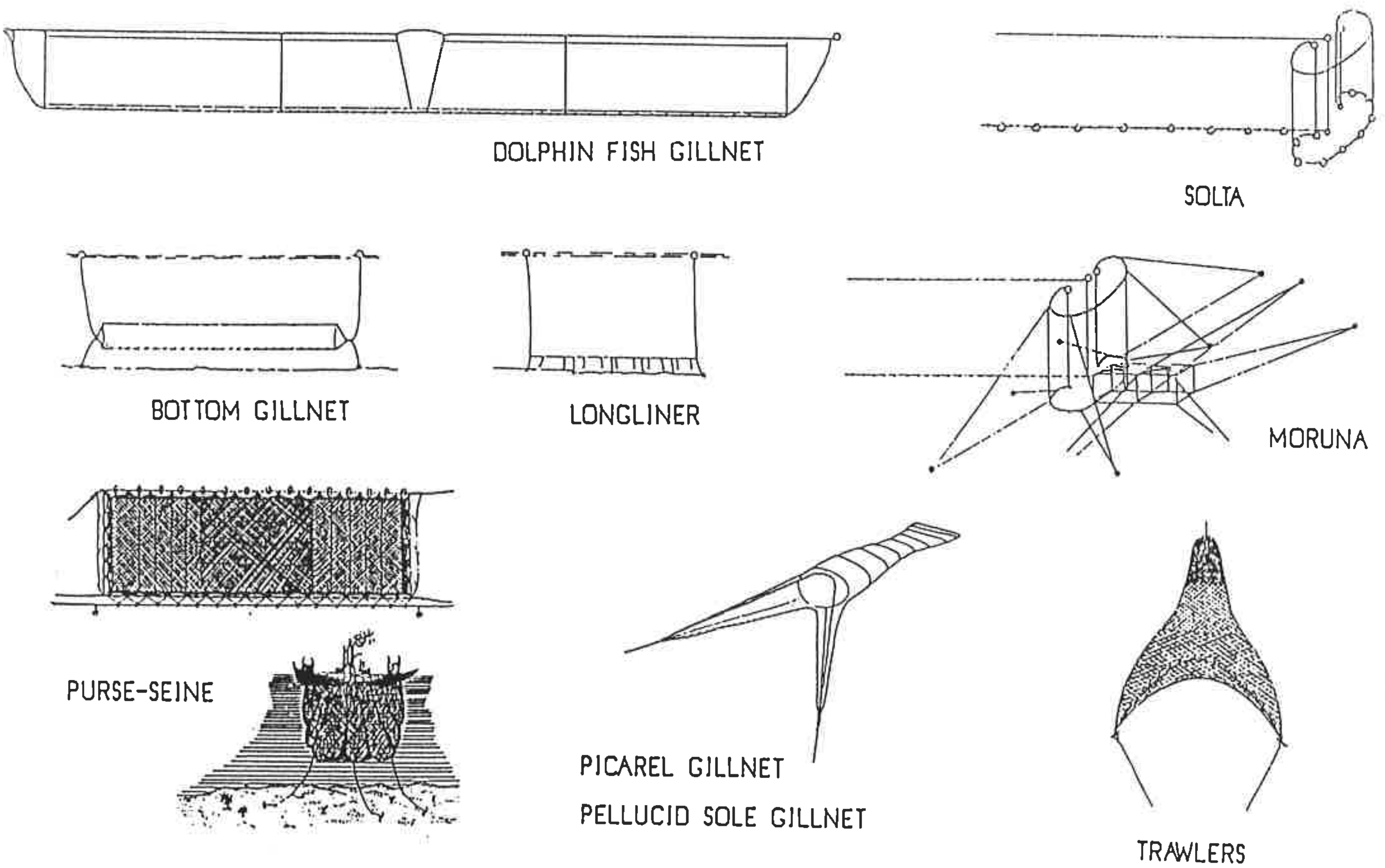

Fig. 2 Fishing gears used in the Balaeric Islands

INTERACTIONS BETWEEN BOTTLE-NOSED DOLPHINS, *Tursiops truncatus* , AND FISHERIES ALONG NORTH-EASTERN COASTS OF SARDINIA, ITALY

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The presence of populations of marine mammals in coastal waters where fishing activities of a traditional kind take place often causes certain conflicts which are hard to solve. Conflicts from the damage caused to fishing equipment and the local fishing communities by cetaceans and pinnipeds have arisen in many regions of the world.

Although these species are now protected by international legislation, the number of animals killed by exasperated fisherman remains quite high.The exploitation of the monk seal, *Monachus monachus*, in a large portion of the Mediterranean basin may surely be attributed to this factor. Not even the widespread legends and traditions concerning the supernatural and benevolent nature of dolphins has succeeded in avoiding the killing of these animals. The situation is surely not new for Italy, but it appears to be increasing with particular frequency along the coasts of Sardinia.

About one year ago, we started to study a population of bottle-nosed dolphins, *Tursiops truncatus*, living in the waters of north-eastern Sardinia, where the problem seems to be particularly serious. Sightings are carried out from the land and from inflatable and fishing boats. All those observations which allow us to evaluate the dimensions of the case in an objective way are recorded. Here, we intend only to report some preliminary findings, deferring to the near future a more detailed analysis of data which are still being collected.

The study area covers the archipelago of small islands facing the coast of north-east Sardinia, the Gulf of Olbia, the island of Tavolara, and the zone south of it reaching to the fishing harbour of La Caletta.

The monk seal was present in this area until about 40 years ago, and it probably became extinct here as a result of direct hunting by fishermen. Fishing activities in this area are carried out essentially with set nets, trawl nets and long lines; the sizes of the fishing fleets are quite small, especially for trawlers. Local fishermen do not use drift nets or surrounding nets.

LONG LINES Interactions between dolphins and long lines have never been reported.

SET NETS Trammel set nets and bottom gillnets are employed: as a rule, they are set at dusk and remain in place for periods ranging from a few hours to an entire day, according to the season. The trammels chiefly capture bottom living fish and are employed in spring and summer, whereas gillnets are used in winter to catch small pelagic fish. The set nets are made of nylon and are employed in a traditional way. They are used by fishermen for individual incomes and family subsistence.

Schools of bottle-nosed dolphins appear to systematically cause damage to the nets which are placed in shallow waters, close to the coast. About one hour after the nets were put in place, we observed schools of four or five animals coming close to them and tearing out fish that were caught in them, making large rips in the net. The activity continued until the nets were almost empty.

The damage caused through loss of catch and loss due to time needed to repair the nets is considered to be very high, and often the nets need to be completely replaced. Similar damage is caused by seals, as older fishermen have confirmed.

TRAWLERS The interactions between the dolphins and trawlers have been different. Trawl nets are pulled along the muddy and sandy bottoms at depths of 50 to 100 metres. The harvest is largely heterogeneous and the impact of this kind of fishing on the benthic environment is surely very high.

While fishing is in progress, schools of between four and ten dolphins come within about 200 metres astern of the boat and dive repeatedly for periods of about two minutes. Although the fishermen complain about low catches in these circumstances, particularly with repect to mullet (*Mugil* sp.) and benthic cephalopods, the way in which the animals interact with the fishery is still unclear. It may be that the prey are easier for the dolphins to catch, having risen to the surface after being frightened by the net, steel cable or kites dragging on the bottom. Quantification of the damage to the potential catch is at present difficult to evaluate, and damage to the nets has been reported only rarely.

The entangling of dolphins in nets, either gillnets or trawl nets, is a very rare event and it is considered to bring bad luck. We have no data about deliberate, illegal killing of dolphins, but we have no reason to believe this was frequent until now.

Some benign acoustical systems of an artisanal and empirical kind have been tested by the fishermen to scare bottle-nosed dolphins away from the nets. The use of explosive petards and the production of metalic noises were unsuccessful except for a very short time.

It should be noted that small schools of dolphins come near the beaches and enter the small harbour of the town of Golfo Aranci when the fishing activity has been forbidden by law to allow the recovery of fish popultions.

The aim of our research is to understand the size of the bottle-nosed dolphin population and its home range, and to define the behaviour of the dolphins with respect to fishing gear. The quantification of the damage could be useful in anticipation of an alternative legislative scenario to protect marine mammals, allowing some indemnities to fishermen, in the same way as is done today for protected terrestrial fauna.

MEDITERRANEAN CETACEANS AND FISHERIES. DO THEY EXPLOIT THE SAME RESOURCES?

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INTRODUCTION In the Mediterranean, interactions between man and cetaceans have risen dramatically in recent years. An increasing number of large and small cetaceans have died as a result of being incidentally entangled by swordfish drift-nets (Notarbartolo di Sciara, 1990).

A *morbillivirus* infection was recently responsible the mass stranding of striped dolphins in the Mediterranean (Domingo *et al.*, 1991), and high PCB levels found in dead animals could be correlated with this epidemic (Borrell and Aguilar, 1991). It is also likely that the increasing noise due to boat traffic and man's activities along the coasts can disturb the "natural sound environment" of cetaceans, and could cause some interference with their hearing abilities.

Over fishing can also threaten cetaceans by the depletion of their food resources. Some odontocetes live and catch their prey in the same fishing areas exploited by man. Interactions and overlap seem to be inevitable, particularly for small odontocetes.

Summarising the results of several dietary analyses of stomach contents (Bello, in press; Carlini *et al.*, this volume; Podestà and Meotti, in press; Pulcini , this volume; Voliani and Volpi, 1990; Wurtz *et al.*, in press ; Wurtz and Marrale, in press) and on the cetacean distribution (Viale, 1985; Fabbri *et al.*, this volume), it is possible to discuss, at least qualitatively, how fisheries and small odontocetes interact along the Italian coast of the central Mediterranean .

Fishing gears, fishing areas, and distribution of some cetaceans. Tyrrhenian fisheries can be divided into three main categories, including a large variety of gear and target species: bottom trawling, pelagic and multipurpose fishing. Roughly they exploit the fishing grounds and corresponding water column between a few metres and 700 m depth. Trawling is carried out on the continental shelf, as well as on the bottom of the continental slope, with some seasonal pattern, the area being the last to be fished during the summer.

Pelagic fishing is mostly carried out by using surrounding nets or lampara nets. Nets are operated anywhere from the surface down to about 200 metres depth. They are set offshore to catch large pelagic fishes (tunas, etc) or in neritic waters for small pelagic fish (anchovies, pilchards, etc).

The last category of fishing can include various gear and may be carried out close to the coast or offshore according to the target species (i.e. sparids or hake, swordfish, etc).

As demonstrated by several research cruises, the areas where small cetaceans are conçentrated correspond to the continental slope, but at certain seasons, some species, such as striped dolphin or bottle-nosed dolphin, can extend their presence to neritic waters.

Steep slopes, as well as sea mounts, seem to be more attractive for small odontocetes in the Ligurian Sea, where the reduced continental shelf enhances these bottom characteristics. Cetaceans are commonly sighted off San Remo, Capo Noli and Portofino peninsula.

Some of these areas are only partially exploited by fisheries, with a consequent reduction in exploitation of the sea bottom and part of the water column in areas greater than 200 m depth. Here, some fishing activity, such as trawling, may be limited by the bottom topography and by oceanographic features. (It might be interesting to test how much the comparative absence of disturbance by humans promotes higher cetacean concentrations).

Commercial species in the diet of small Mediterranean odontocetes.

Table 1 summarises the results of stomach contents analysis in four species: *Stenella coeruleoalba*, *Tursiops truncatus*, *Grampus griseus*, and *Ziphius cavirostris*.

Prey species have been divided into two categories: non-commercial and commercial, and include cephalopods, crustaceans, and fishes.

The overlap with fishery target species becomes greatest in those odontocetes which also exploit neritic resources. Thus in the bottle-nosed dolphin the overlap is almost complete, and in the striped dolphin about 68% of the prey number can be ascribed to market species; while in the Risso's dolphin and Cuvier's beaked whale, the relative percentage of those species tends to be lower, presumably due to their pelagic distribution.

Among the prey species with some economic importance, some fishes seem to play an important role, the Gadidae family in particular being the most represented, *Micromesistius poutassou*, *Merluccius merluccius* and *Trisopterus minutus* all having been found in various quantities, although *M. poutassou* forms the largest number of prey per stomach, with 623 specimens recorded. This species shows wide fluctuations in abundance and is often discharged at sea because of marketing needs (low sale price).

Cephalopods were reported in all stomachs examined, non-commercial species, particularly Histioteuthids, forming the highest percentage.

CONCLUSIONS The data available on the feeding behaviour of small odontocetes in the Mediterranean give a preliminary idea of the possible interactions between man and cetaceans. Nevertheless, until now, the available data have been mostly qualitative. We do not know how many cetaceans live or are caught in the Mediterranean basin. Consequently we are unable to determine the total biomass of their prey, although it is possible to provide a rough estimate through examination of beaks, otoliths and other remains in cetacean stomachs.

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Table 1 Percentage composition of non-commercial and commercial prey in four odontocetes (last row = no. of specimens examined)

PREY	Striped dolphin	Bottle-nosed dolphin	Risso's dolphin	Cuvier's beaked whale
Non-commercial				
Cephalopoda				
Histioteuthidae	15.0		63.0	88.9
Onycoteithidae	5.2		7.5	7.6
Chiroteuthidae	0.3			0.3
Ommastrephidae				0.3
Octopoteuthidae	0.1			1.6
Sepiolidae	6.3		0.4	
Ocythoidae			3.2	
Argonautidae			0.6	
Cranchidae			1.6	
Osteichthyes				
Chauliodontidae	1.8			
Crustacea				
Pasiphaeidae	2.8			
Oplophoridae	0.3			
Sergestidae	0.3			
Commercial				
Cephalopoda				
Ommastrephidae		2.1	20.4	1.0
Loliginidae	4.8		1.6	
Sepiidae	0.9		1.1	
Sepiolidae	1.2		0.6	0.3
Octopodidae		7.8		
Osteichthyes				
Sparidae	4.7			
Clupeidae	4.8	5.0		
Belonidae	4.1			
Gadidae	47.4	60.0		
Centracanthidae		21.4		
Argentinidae		1.4		
Congridae		0.7		
Scombridae		1.4		
TOTALS				
Non-commercial	32.1	-	23.7	98.7
Commercial	67.9	100.0	76.3	1.3
No. spp. examined	35	2	4	2

STRANGE BEDFELLOWS: BUILDING COALITIONS WITH FISHERS TO PROTECT HABITAT, A CASE STUDY OF THE OLYMPIC COAST NATIONAL MARINE SANCTUARY IN WASHINGTON STATE, U.S.

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Many of the papers presented at this conference will deal with conflicts between fisheries and marine mammals such as prey competition and over-fishing or entanglements. Because of such conflicts, fishers may seem like strange bedfellows for efforts to protect marine mammals. However, there are advantages to working with fishing interests to protect marine habitats, thereby benefitting fish as well as mammals. The political clout of environmentalists and scientists can be greatly strengthened by association with diverse groups. The influence of sports and commercial fishing interests, county and tribal governments and other maritime trade groups can be helpful in the protection of critical marine habitats from threats such as the chronic pollution associated with oil and gas development and oil spills.

Although the recently adopted ban on drift nets and the current moratorium on commercial whaling are major milestones in the protection of marine species, the loss of critical habitat poses a major obstacle to the recovery of species depleted by poor management practices. Advances in ocean engineering have opened vast, previously undisturbed tracts of biologically rich continental shelf to exploration for oil, gas and mineral resources. Degradation of water quality is also increasing as the world's growing population continues to encroach on coastal resources.

The National Marine Sanctuary Program provides a unique opportunity to protect marine habitat in the United States. The Marine Protection, Research, and Sanctuaries Act of 1972 authorised the Secretary of Commerce to "designate discrete areas of the marine environment as National Marine Sanctuaries in order to protect their ecological, conservation, recreational, historical, research, educational, or aesthetic qualities". There are currently ten Sanctuaries, ranging in size from a nautical mile circle around the remains of the *U.S.S. Monitor* off North Carolina to 2,600 square nautical miles in the Florida Keys. Despite the connotation of the term, sanctuaries encourage multiple uses that are not destructive to the long-term maintenance of the resources. They are analogous to National Wildlife Refuges on land. Each National Marine Sanctuary has a unique Management Plan based on the needs and significance of the site, be it ecological or cultural. When making regulations for Sanctuaries, public input to the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, who administers the Sanctuary Program, is required by the National Environmental Policy Act (NEPA).

In 1988, Congress directed NOAA to create a Sanctuary off the Olympic Coast of Washington State. However, despite the ecological significance of this region, its importance to four coastal tribal governments, and the fact that it has been documented to contain less than 10 hours of energy, the United states government is interested in keeping the area open for energy interests in the future. The Minerals Management Service (MMS), the branch of the federal government mandated to offer large tracts of the United States' outer continental shelf for lease to oil companies, continues to oppose any programs which could permanently ban oil and gas development. This conflict of interest within the federal government has been responsible for the political morass which has caused over a year's delay in the process of designating the site.

Public comment from sport, commercial and tribal fishing interests, environmentalists, and local business people requested regulations to permanently protect the entire Washington coastline from the threat of oil spills caused by offshore oil and gas development and nearshore oil transportation. In addition, concerns were raised about military activities affecting coastal resources such as the Navy's bombing of Sea Lion Rocks within the Copalis National Wildlife Refuge. Local communities, many of which are economically depressed due to the failing timber industry, see benefits to protecting critical habitats for their renewable fishery resources and to encourage visitor dollars to the Olympic National Park, the largest tourist attraction in Washington.

The only strong opposition has come from the oil industry which does not want any new restrictions on oil exploration, development, or transportation. In addition, the Ports have expressed concern that regulations on shipping and harbour maintenance activities, such as dredging, in the Sanctuary might be economically prohibitive. Washington has the second busiest port in the world and there are no shipping lanes off the coast.

Developing coalitions with the fishers will help to overcome other industries' objections because the regulatory agency can respond to more than the concerns of environmentalists. However, support from the fishing industry does not come easily. The fishing community rarely embraces federal programs, especially when the program's title evokes an image devoid of human uses. Some fishing interests have expressed reservations about the prospect of new regulations applied to their industries and see the Sanctuary as just another layer of bureaucracy. However, when given the choice between the Department of Interior's Minerals Management Service and the Department of Commerce's Sanctuary Program, it has become obvious that sanctuaries are better than oil rigs. Although the Olympic Coast Sanctuary does not propose any additional regulations, there is some scepticism among fishers that the program will be used to provide additional protection to marine mammals in fishery conflicts, such as the harbour porpoises, *Phocoena phocoena*, which are taken incidentally in the coastal salmon gillnet fishery, or the growing numbers of California sea lions, *Zalophus californianus*..

In Washington State, the abundance of federally protected marine mammals, many of which are endangered, such as the humpback whale, *Megaptera novaeangliae*, and the northern sea lion, *Eumatopias jubatas*, recently listed as "threatened", contribute to the national significance of the area. One of the most intensively studied populations of killer whales,*Orcinus orca*, in the world occurs in Washington. The coastal migration of gray whales, *Eschrichtius robustus*, supports a dedicated following of whale watchers. In addition, Dall's porpoise, *Phocoenoides dalli*, harbour porpoise, Pacific white-sided dolphins, *Lagenorhynchus obliquidens*, false killer whales, *Pseudorca crassidens*, harbour seals, *Phoca vitulina*, California sea lions, and a transplanted population of Alaskan sea otters, *Enhydra lutrus*, significantly contribute to the coast's diversity and suitability for sanctuary designation.

Fishers sometimes have problems with marine mammals, so they can be an issue for some environmental groups in coalition building. However, for the Olympic Coast it has become apparent that if we work together to protect habitat there will be more fish for both fishers and predators, and if we do not, we could end up like Prince William Sound, working together to clean up oil.

AN EXPERIMENTAL STUDY OF THE EFFECTS OF PLEASURE CRAFT NOISE UPON BOTTLE-NOSED DOLPHINS IN CARDIGAN BAY, WEST WALES

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INTRODUCTION Many coastal areas of Europe are increasingly experiencing disturbance from a wide variety of pleasure craft - sea angling vessels, speed boats, inflatables and jet skis. Concern is frequently expressed by conservationists who believe that these vessels disturb dolphins, displacing them from preferred habitat and possibly causing them stress. Some vessels may also cause physical damage, with dolphins being accidentally cut by the propeller, as happened for example with the solitary friendly dolphin called "Freddie" at Amble in Northumberland. The recent burgeoning interest in jet skis has focused attention upon this new activity as a potential threat to coastal dolphins. In order to examine the possible effects of pleasure craft noise upon dolphins, an experimental study was conducted upon a group of free-living bottle-nosed dolphins, *Tursiops truncatus*, in Cardigan Bay, West Wales during June, 1991.

METHODS Sound characteristics from various craft (a 50 ft fishing vessel with planing hull and 240 hp inboard engine; a 17 ft speedboat with 90 hp outboard engine; a 7 ft inflatable with 6 hp outboard engine; and a Kawasaki jet ski with 650 cc engine) were analysed acoustically in the Teifi estuary, West Wales, from a standard distance of 3 metres. Underwater noise received by a Bruel & Kjaer 8101 hydrophone was passed through a 10 Hz high pass filter to remove unwanted low frequency noise due to wave motion. The signal was then amplified to a suitable level for recording. At all times, a speaker was connected to a Racal Store 4 tape recorder to monitor received sounds. An inshore marina was used for underwater noise measurement of pleasure craft in order to eliminate unwanted noise generated by inclement weather.

Each craft passed the hydrophone at a distance of three metres. Any closer than this and the rise/decline rate of the recorded signal would have been too sharp to allow enough averaging time to give accurate readings. Any farther away, and there would have been interference with the acoustic signal due to multi-path propagation from the sea-bed and the surface. The peak sound pressure level (SPL) of airborne noise was measured with a Bruel & Kjaer Sound Level Meter (Type 2230) set to A-weighting (representing the sensitivity of the human ear), and the output recorded on a Racal Store 4 tape recorder. A foam wind shield was used to minimise unwanted noise caused by wind blowing across the front of the microphone. The results were collected from repeated passes of different types of vessel at varying speeds.

Trials were then conducted at sea to measure the distances over which dolphins responded to speed boats (both actual and simulated), and to determine more precisely their behavioural response. Measurements were made of behaviour, dive durations and orientation of dolphins. Visual observations were supplemented by video footage of the dolphins, whilst sounds made underwater by the dolphins were recorded on the Racal Store 4 tape recorder.

RESULTS Narrowband and 1/3 octave plots were produced for each of the four types of vessel examined, with levels corrected for range and bandwidth. Typical underwater radiated noise spectra are presented in Figure 1. They show that although sound is produced over a spectrum of around 100 Hz to 20 kHz, most sound is generated at the low frequency end below about 1 kHz. The sound spectra are typical of cavitation by the boat's propeller. Above 2 kHz, cavitation is the most significant source of noise. The larger 50 ft inboard engined fishing boat not surprisingly produced the loudest underwater noise since it had the most powerful propulsion system. The jet ski was the quietest because it uses a water-jet propulsion system in which water is drawn into the duct and accelerated outwards, propelling the craft forwards. The direction of water can be controlled, thus steering the vessel. The water-jet is a propeller mounted in a duct within a body of steel, designed to reduce cavitation. Airborne noise for jet skis ranged from 83 dB (low speed) to 90 dB (high speed). This was lower than for the speedboat (85 dB at low speed; 97 dB at high speed), but to the human ear appeared high because of the frequency range over which the sound was made.

The noise level, L, from each vessel of sound strength, S, will decay with distance, R, according to:

$$L\ (\mathrm{dB}) = S - 20 \log R$$

The vessels will become audible when their level exceeds the background noise level. The sound spectrum shapes of all the vessels tested were very similar. This is because the dominant source of noise is the cavitation of the propeller. Thus the spectrum shape can be largely ignored; it is the sound level that is important. The hearing of bottle-nosed dolphins operates over a main sensitivity range of 10 to 120 kHz (Johnson, 1966; Ljungblad *et al.*, 1982; Van Pijlen, 1989; see also Fig. 1). From the above calculations, it is possible to predict the distances at which each vessel becomes detectable to a dolphin in a sea state 3 condition. The results are shown in Figure 2, and indicate that the jet ski can be heard up to 450 metres away; the speedboat around 800 metres (low speed) and just under 1,800 metres (high speed); the inflatable about 1 kilometre away; and the larger fishing boat a little over 1.1 km away (low speed) and 3.1 km away (at high speed). All these values increase if sea state declines.

Observations of bottle-nosed dolphins were made in the vicinity of various craft to test our theoretical findings. A 100 metre line buoyed up at the surface with floats, and marked at intervals of ten metres, was towed behind the observation vessel and used to determine the distances at which dolphins were first observed. Observations from a stationary vessel were conducted of dolphins both singly and within groups (with and without calves present). The distance from dolphins at which passes were made by (1) an inflatable and (2) a rigid hull speedboat, were recorded, together with the behavioural response of the dolphins. Behaviour was divided into four categories: transiting, foraging, milling and social, and for each, the mean dive duration and orientation to the sound source were noted. No milling or social behaviour was observed during the course of the sound disturbance trials. The experiment was repeated using a recording of the 17 ft rigid hull speed boat running in a circular pattern near the hydrophone, and played back through audio cassette player set up with a Mos-fet amplifier, monitor, and Grazeby 40 mm ball hydrophone.

Before disturbance by an actual craft, 46% of dolphin orientations were neutral with respect to the subsequent direction of the sound source. On appearance of the vessel, 150-300 metres away, 80% of dolphin orientations were away from the sound source; this subsequently declined to 58% of dolphin orientations. Dolphins responded similarly (but with a sharper negative response) to simulated vessel sound transmitted at a distance of 150 metres. About 58% of dolphin orientations were neutral with respect to the subsequent direction of the sound source. On sound transmission, this increased to 86%, and in the subsequent minute, increased further to 100%. Mean dive durations (for all trials combined) were 8.64 secs. (SE 0.987, n = 14) for transiting, and 20.52 secs. (SE 2.52, n = 33) for foraging. On disturbance, this increased to a mean value of 127.25 secs. (SE 78.94, n = 4) and subsequently to decrease to 8.92 secs (SE 1.09, n = 12). In all cases, dolphins dived in response to the sound, surfaced some distance further away from the sound source, and then made frequent short dives as they rapidly swam away. The response was greater when the disturbance was repeated in short succession. When sound disturbance occurred in the vicinity of a mother and her calf, the two immediately emitted very rapid high-frequency clicks, presumbly for quick location of one another since the response was for the calf to swim rapidly to its mother and both to move away from the sound source.

CONCLUSIONS The reaction of bottle-nosed dolphins to an approaching vessel was to make longer dives and move away from the source of the sound. This response occurred over a range of 150-300 metres at sea states of 3-4, suggesting that these were the threshold distances for an adverse reaction to boats in those conditions.

A loud boat (such as the 50 ft fishing boat) travelling relatively slowly will produce a noise which rises above the ambient level a long time before the closest point of approach, whereas in the case of a quieter boat travelling fast (such as a jet ski), the noise produced rises above the ambient level only a short time before its closest point of approach. This creates a more sudden and startling noise which is likely to frighten dolphins more than the larger boat even if the overall background noise created by such vessels could cause greater interference with daily activities if several boats were operating within a small area simultaneously.

The noise transmission, simulating a motor boat suddenly appearing within the threshold of a dolphin's hearing, produced the most marked negative response. Presumably this was the result of a startle effect, much as described earlier for jet skis on sudden approach to a dolphin. Although sounds made by these lower-powered craft will not be transmitted over such great distances, dolphins can be scared by them when the craft changes direction erratically, and particularly orients directly towards them.

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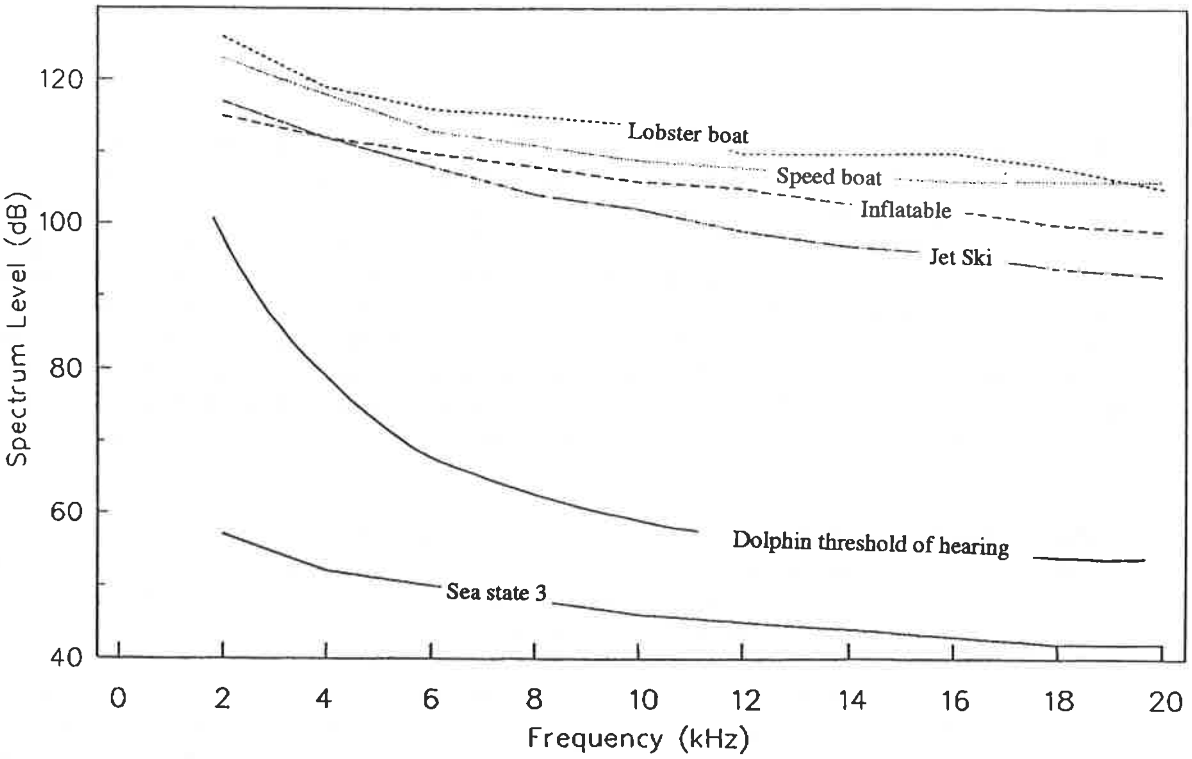

Fig. 1 Radiated Sound Spectra for jet ski, inflatable, rigid hull speed boat, and lobster fishing boat compared with bottle-nosed dolphin audiogram and sea state 3

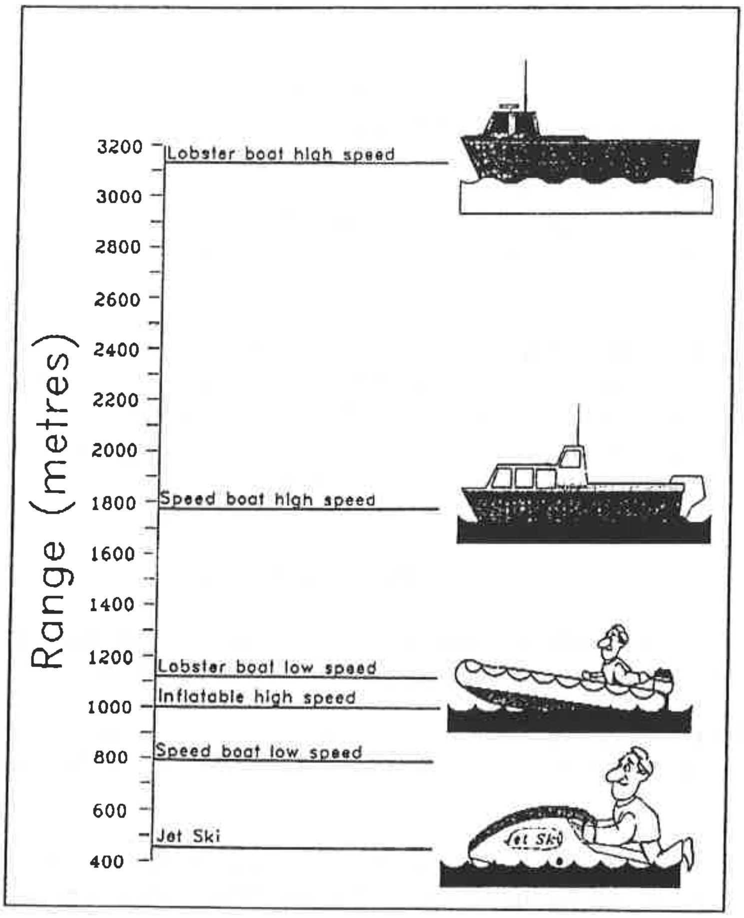

Fig. 2 Ranges of Detectability (in metres) of various sea-going craft (the range indicates the point a ehich the dolphins become aware of the above approaching vessels in a sea state 3.

PRESENT STATUS AND FUTURE OF BLACK SEA DOLPHINS

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There is little information of the native fauna of Black Sea cetaceans. Three species are known to exist: the common dolphin, *Delphinus delphis ponticus* (Barabasch-Nikiforov, 1935), bottle-nosed dolphin,*Tursiops truncatus ponticus* (Barabasch-Nikiforov, 1940), and the harbour porpoise, *Phocoena phocoena relicta* (Abel, 1905). These animals are considered as endemic species (Geptner *et al.*, 1976) with relict populations under threat of rapid decline. The most important factors involved in the depletion of dolphin numbers are commercial whaling, accidental mortality in nets, catches of live animals, water pollution, physical disorders, exhaustion of food resources and natural diseases.

LEGAL KILLING AND POACHING This form of human activity is traditional in Turkey. USSR, Bulgaria and Romania took part in the destruction of Black Sea marine mammal populations more recently (after the first World War). Mass legal killing peaked in the 1930s and 1950s, with a maximum in 1938 of 147,653 individuals taken by the USSR alone (Bodrov *et al.*, 1958). Turkish annual killing levels were approximately 40,-70,000 animals (Berzin and Yablokov, 1978). In Bulgaria and Romania, the annual take was no greater than a few thousand per year. However, the exact number of dolphins killed in the 20th century is unknown. In the USSR it probably exceeded one and a half million and other Black Sea countries together probably killed four million animals.

Although commercial killing was outlawed in 1966 in the USSR, Bulgaria and Romania, and in 1983 in Turkey, it was replaced by poaching. Evidence of mass illegal killings was detected in Turkey (Anon, 1991). In 1990, a dead harbour porpoise with bullet wounds was found on the Crimean coast (Ukraine).

ACCIDENTAL MORTALITY IN FISHING NETS AND CAPTURE TACKLE Nobody knows how many dolphins perish through the legal fishery as well as from poaching. The fish protection services of Black Sea countries do not publish such data. Two facts direct us to address this question. Of 3,459 legal fish nets examined in the Crimea during 1980-81, 113 were found to have captured unknown cetacean species in unknown quantities (Zhuravleva *et al.*, 1982). 194 dead dolphins were discovered in the drift nets of 14 Turkish schooners arrested in spring 1991 in Soviet territorial waters (Pasyakin, 1991).

Since the 1960's, when the first Black Sea dolphinaria were opened, hundreds of animals have perished due to the imperfect capture technique called "aloman-catch". As a rule, these "accidental" drownings are not registered officially.

MAINTENANCE IN CAPTIVITY There are six stationary Black Sea dolphinaria; Russia, Georgia, Bulgaria and Romania each possess a dolphinarium, and the Ukraine has two dolphinaria. More than 150 marine mammals (primarily bottle-nosed dolphins) can be placed in their pools and open air cages at any one time. The majority of dolphinaria share common defects: there are no water preparing and sterilizing systems, the circulation of water is very slow, pool equipment is archaic, and buildings are in need of reconstruction and repair.

Black Sea countries have no strict legal requirements for the use of captive cetaceans for science, commerce or other purposes. Every year 2-4 dozen animals of reproductive age are captured to replace dead dolphins. The destiny of such captive animals is clear: a short working life for humans, followed by disease and death in conditions not even approximating veterinary stands achieved in west Europe and north America. The most frequent causes of death in captive dolphins are multi-bacterial pneumonia and septicaemia. An important role of allergies and secondary immune deficiencies was detected during the pathogenesis of diseases infectious to cetaceans (Birkun *et al.*, 1990).

In recent years, the exploitation of dolphins has intensified and the number of small provisional dolphinaria for public display of cetaceans has increased. Export of bottle-nosed dolphins has expanded also, for example into Israel and Yugoslavia. It is known that during the touring of captive cetacean exhibitions, dolphins which die are replaced with newly caught animals. Capture of wild animals is cheaper and simpler for the owners than attempting captive breeding programmes. Ideas of captive breeding are therefore rarely realised.

WATER POLLUTION It is thought that chronic water pollution is a strong limiting factor on dolphin populations. High concentrations of chlorinated hydrocarbons were found in the blubber of stranded animals (Table 1). However, as yet, we know nothing about heavy metal and radio-active residues in dolphin tissues.

Intensive faecal pollution of coastal waters causes poly-microbial attacks on marine mammals. Sixty species of micro-organisms, including various intestinal bacteria, are detected in the respiratory tracts of bottle- nosed dolphins and harbour porpoise (Table 2).

PHYSICAL INJURIES Industrial expansion in the Black Sea (growth of shipping, gas and oil output, etc.) causes a great deal of harm to cetaceans. 4% of stranded animals examined in 1989-91 had traumas (wounds, fractures, haemaromas) presumably caused by physical damage. At the same time, 17% of dolphins had gastric lesions similar to stress-related ulcerations. In one case, it was concluded that physical stress was the initial cause of the animal's death.

INSUFFICIENCY OF FOOD RESOURCES Sharp declines in fish abundance have been observed in the Black Sea. It has not been possible to determine levels of interspecific competition between dolphin species (Morozova, 1986), but only seriously sick animals have been observed with signs of starvation.

NATURAL DISEASE The most common natural diseases observed in stranded and "incidentally" caught animals include nematodes, pneumonia and sinusitis, trematodous gastritis, intestinal cestodosis, dermatomycosis, lymphnoditis and hepatitis. The main cause of death in wild Black Sea cetaceans is pulmonary nematodosis (list of helminths in Table 3), complicated by bacterial (and viral?) super-infections. 100% of harbour porpoises, 67% of bottle-nosed dolphins and 49% of common dolphins examined in 1989-91 had destructive lesions in their lungs.

In spring 1990, an outbreak of mass mortality amongst cetaceans occurred. Unprecedented numbers of carcasses were found on the Crimean (Table 4), Taman's (Russia) and Bulgarian coasts. The majority of the stranded cetaceans (82%) were harbour porpoise, and of these 80% were immature animals. This mass die-off was probably caused initially by an unknown viral infection, and is thought to have resulted in the mortality of several thousands of animals.

CONCLUSION The compound effect of these influences on cetacean survival, is a significant cause for the decline of cetacean populations in the region. The essential signs of this process are: break-up of dolphin schools and decrease in school size; a change in habitat use in species such as harbour porpoise and bottle-nosed dolphins from the preferred coastal ranges to open sea waters; and critical reduction of animal numbers (Table 5). According to the most recent recorded data, only 96+/-30 thousand common dolphins, 7+/-3 thousand bottle-nosed dolphins and 10+/-3 thousand harbour porpoise remained in the Black Sea in 1987 (Sokolov *et al.*, 1990). Estimates were stopped five years ago, resulting in a lack of information about post-epizootic changes in the status of cetaceans.

The future of Black Sea cetaceans does not appear to be promising: the prospect of the loss of these animals by the year 2000 is very real. The question of protection of these cetaceans thus becomes one of their survival. Some measures undertaken in the 1960s-1980s, such as placing the bottle-nosed dolphin into the Red Data Books of the USSR, Russia, Ukraine and Georgia, have not brought about the expected effects. Up to the present day, the former USSR countries have not signed the Convention on Protection of Wild Fauna and Flora and Natural Habitats in Europe. This multilateral agreement in 1979 listed all three species of Black Sea dolphins as strictly protected animals. However, newly established Black Sea states are not among the participants of the Global Plan of Action for the Conservation, Management and Utilisation of Marine Mammals.

The activities of Black Sea countries in the protection of cetaceans operate independently and are financed extremely badly. There are no national or regional programmes in this direction. Many significant state problems have priority over the conservation of wild animals. Therefore, it is unlikely that the near future will bring state assignments for the development of any serious project for saving Black Sea cetaceans. Thus, the complicated, unstable economic and social situations in the Black Sea region are main catalysts for marine mammal degradation. At present, international and local non-government wildlife welfare organisations have not defined their attitude to the existing situation.

What sponsors can do to help in the realisation of the Black Sea Marine Mammal Survival Programme? Four projects (as a minimum) are in need of equipment and financial support:

(1) Elaboration of judicial defence;
(2) Resumption of estimates of animal numbers;
(3) Continuation of pathobiological research;
(4) Creation of dolphin hospitals and captive breeding programmes.

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Table 1 Organochlorine residues (ppm) in the blubber of stranded Black Sea cetaceans

Species (number)	Total HCCH*	Total DDT
Delphinus delphis (2)	1.70 + 0.63	26.74 + 4.22
Tursiops truncatus (2)	6.91 ∓ 0.14	55.66 ∓ 9.96
Phocoena phocoena (19)	17.21 ∓ 1.66	101.18 ∓ 13.81

* hexachlorcyclohexan

Table 2 Micro-organisms isolated from expiratory are of Black Sea dolphins

Genus	Species	Genus	Species
Pseudomonas	*mendocina*	*Photobacterium*	*sp.*
	alcaligenes	*Actinobacillus*	*lignieresii*
	pseudoalcaligenes		*equuli*
	cepacia	*Micrococcus*	*luteus*
	gladioli		*roseus*
	acidovorans	*Staphylococcus*	*aureus*
	testosteroni		*epidermidis*
	facilis		*saprophyticus*
	lemoignei	*Streptococcus*	*faecalis*
Flavobacterium	*tirrenicum*		*faecium*
	rigense	*Sarcina*	*sp.*
	lutescens	*Bacillus*	*subtilis*
Alcaligenes	*faecalis*		*badius*
	eutrophus		*brevis*
	aquamarinus		*circulans*
Escherichia	*coli*		*coagulans*
Citrobacter	*freundii*		*firmus*
	diversus		*laterosporus*
Klebsiella	*pneumoniae*		*lentus*
Enterobacter	*aerogenes*		*licheniformis*
Serratia	*sp.*		*megaterium*
Hafnia	*alvei*		*pantothenticus*
Edwardsiella	*tarda*		*polymyxa*
Proteus	*vulgaris*		*sphaericus*
	mirabilis		*stearothermophylus*
Providencia	*rettgeri*		*medusa*
Morganella	*morganii*	Nonidentified	diphtheroids
Vibrio	*proteolyticus*	*Candida*	*krusei*
Aeromonas	*hydrophila*		*utilis*
	caviae	*Penicillium*	*sp.*

Table 3 Helminths of Black Sea dolphins

Parasites	Localization	*Delphinus delphis*	*Tursiops truncatus*	*Phocoen phocoen*
Trematodes				
Campula palliata	liver	*		
Synthesium tursionis	bowels		*	
Pholeter gastrophylus	stomach	+	+	*+
Braunina cordiformis	stomach, bowels		*	
Cestodes				
Diphyllobothrium stemmacephalum	bowels	*	*	*+
Diphyllobothrium latum	bowels			*
Nematodes				
Anisakis simplex	stomach, bowels			*
Halocercus taurica	lungs			*+
Halocercus kleinenbergi	lungs	*		
Halocercus ponticus	lungs			*+
Stenurus ovatus	lungs, blood-vessels		*	
Stenurus minor	cranial sinuses, respiratory tract, blood-vessels			*+
Skrjabinalius cryptocephalus	lungs	*		
Pseudaliidae gen. sp. (larva)	bowels, blood-vessels			+
Crassicauda sp.	cranial sinuses	+	+	+
Nonidentified nematodes (calcificated)	lungs	+	+	

* Borcea, 1935; Delamure, 1955; Greze *et al.*, 1975
\+ own observations

Table 4 Total number of stranding registered on the Crimean coast in 1989-1991

Month	1989	1990	1991
January	-	16	2
February	6	19	6
March	12	97	1
April	27	54	1
May	19	38	0
June	4	11	0
July	9	8	3
August	7	7	0
September	1	9	0
October	9	8	1
November	1	2	0
December	9	1	0
Total	104	270	14

Table 5 Quantity of Black Sea dolphins

Years	Numbers (thousands)	Sources
before 1930	1500	Zemsky *et al.*, 1986
before 1940	500	Kleinenberg, 1956
	800 - 1000	Morozova, 1981
before 1950	2000	Arsenyev, 1980
1976 - 1980	102 - 190	Zhuravleva *et al.*, 1982
1981	145	Zhuravleva *et al.*, 1982
	300 - 350	Zemsky *et al.*, 1986
1983	120	Kirilyuk and Zelenaya, 1986
1983 - 1984	55 - 60	Yukhov *et al.*, 1986
1985 - 1987	113 ± 30	Sokolov *et al.*, 1990
1988 - 1992	?	

MARINE MAMMAL CONSERVATION STATUS AND RESEARCH IN THE EASTERN ADRIATIC SEA

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Marine mammals in the Eastern Adriatic Sea include two very interesting and valuable species: the bottle-nosed dolphin (*Tursiops truncatus*, Montagu 1821) and the almost extinct Mediterranean monk seal (*Monachus monachus*, Herman 1779). Our present knowledge of the ecology, population trends and biology of these species is extremely scarce and inadequate.

Research on marine mammals and conservation efforts along the Croatian Adriatic coastline and islands in the past have concentrated upon conservation and survival of the highly endangered monk seal. Although legally protected since 1935, the remaining population seemed to be steadily declining to near extinction due to intense competition with fisheries (Gamulin-Brida, 1979; Sergeant *et al.*, 1979). The Croatian Biological Society and its Group for Endangered Animal Species, initated in 1978 an inquiry into seal sightings along Croatian islands and coastline, which resulted in 21 reports by 1983 along the coasts of Lastovo (11), Peljesac (4), Hvar (2), Mljet (1), Brusnik (1), Palagruza (1) and Pag (1) (Gomercic *et al.*, 1984). The collaboration with K. Ronald (1984a,b) of the University of Guelph and the League for Conservation of the Monk Seal (Newsletter 1982, 1984) encouraged a campaign for the raising of public awareness for this endangered species in the Adriatic Sea through the educational system. The most recent sightings of the monk seal were reported in 1989-90 in the Dubrovnik aquatorium: Peljrsac (1), Orasac (1-pair), Konavoske stijene (1 pregnant female). The most recent European interest in the remaining Mediterranean monk seal population is very reassuring (Beudels and Beudels, 1992).

The present activities concentrate mostly upon research on the bottle-nosed dolphin, its population ecology and biology. The work in the Cres-Losinj area, in the degraded Northern Adriatic, initiated by G. Notarbartolo di Sciara and G. Bearzi of the Tethys Research Institute, Milano, is exceptionally promising. As the top predator, this dolphin may be at particular risk in the degraded marine environment of the Northern Adriatic. Reproductive health and intra-uterine development of both marine mammal species could be seriously endangered (Reijnders, 1986; Greenpeace, 1990). Much more research in the Adriatic and knowledge in this area should evidently be acquired as soon as possible in the future.

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NORTHWESTERN MEDITERRANEAN SURVEY: 4TH ANNUAL REPORT

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After four years of field research with our sailing ship, taking place year round and over different major basins of the Western Mediterranean Sea, the present study now concentrates in the Liguro-provençal basin.

Among the six species regularly observed, three pelagic species have been regularly sighted during all seasons: striped dolphin, *Stenella coeruleoalba*, fin whale, *Balaenoptera physalus*, and Risso's dolphin, *Grampus griseus*. Observations of bottle-nosed dolphin,*Tursiops truncatus*, long-finned pilot whale, *Globicephala melas*, and sperm whale, *Physeter macrocephalus* occurred in summer and autumn only. For various reasons, summer excepted, our effort is scarce in the typical biotype of *Tursiops*; the sperm whale accounts for roughly one per cent of the total number of sightings; the pilot whale is rarely seen in winter along the northern continental shelf (Fig. 1).

Despite being given a high level of importance, surveys outside the summer period only account for 32% of the total effort, during which 28% of the sightings were gathered (Table 1). The only major gap between effort and results is for the spring season: a detailed look at the weather conditions indicates that almost all spring surveys were performed with wind conditions of Beaufort 3 to 4, above which the sightability from a small platform decreases strongly.

Particular aspects highlighted in this paper will be the semi-quantitative processing of our data on the striped dolphins in the Liguro-provençal basin, with attention to the possible influence of time and season. Other topics include a summary of the results of fin whale photo-identification, behavioural observations of Risso's dolphin, and the occurrence of pilot whales in the region.

1) The status of *Stenella coeruleoalba* in the Liguro-provençal basin

Because little dedicated work was done in this area, the quantitative status of the striped dolphin, and its possible seasonal variation, is poorly assessed (at the time of writing, details about the Greenpeace survey of 1991 were not known). Our continuous field research in the area allows us to address the problem with a simple approach, which may be used to arrive at an order of magnitude for the dolphin population.

294 sightings obtained during three years are used in the analysis; total effort in the region amounts to 45 legs of 25 to 50 miles length, performed during days of open sea cruises with wind conditions less than Beaufort 4. For each of these legs, we calculate the "linear density of sightings" (LDS), dividing the number of pods sighted by the length of the track.

The LDS varies between 0.000 (no sightings) and 0.250 pod per mile, thus reflecting the spatio-temporal heterogeneities of striped dolphin distribution in the area (Fig. 2). In this paper, the area of study, roughly an area of 100 miles by 100 miles, is considered as a whole: no attempt is made to stratify into geographical subsectors.

Each LDS represents the situation over the route cruised at a given time. All legs combined give an average LDS of 0.104 schools per mile, with a standard deviation of 0.60; the histogram shows a rather unimodal distribution.

If we stratify the data by year, we obtain decreasing mean values for 1989, 1990 and 1991 respectively (Table 2). A 't' test at a confidence level of 0.05 suggests that these differences are not significant, although the differences between the years 1989 and 1991 are significant at a level of 0.10.

If we stratify by season, we obtain average LDS for winter, spring, summer, and autumn. With the exception of spring, all values are in the same range (Table 3). The spring mean LDS of 0.073 pods per mile is probably the result of weather conditions significantly worse than at other seasons.

If we cross stratify by year and season, we obtain a rather more coherent picture for all but those sub-samples that rely on too few data (Fig. 3). It appears that the LDS of 0.104 pods per mile may well be considered as a guide value for subsequent processing. As a next step, we try to evaluate the surface density of schools, or SDS, in terms of schools per km^2, or at least as an order of magnitude; for this purpose, we use the basic formula:

SDS = LDS/PSW   Where PSW is the Practical Search Width in metres.

The practical search width is the perpendicular distance from the trackline, within which almost all schools of *Stenella* are sighted; it is a key factor, in the same way as the effective search width used by the line transect method. In our study, the PSW is determined from experience and depends on several parameters such as observation effort, eye height above sea level, wind and light conditions, for a given species (Table 4). Obviously the PSW also varies with the animals' own behaviour. However, it is impossible to take this parameter as an accurate and fixed value. Because all legs under consideration were covered during visibility conditions of 4 to 6, we take 600 metres as a guide value for the PSW.

Combining an LDS of 0.104 pods per mile and a PSW of 600 m, we obtain an order of magnitude of 0.093 schools per km^2 for the surface density; but because of biases induced by this method, we prefer to consider the surface density as a function of two variables, which can then be traced for given ranges of LDS and PSW (Fig. 4):

$0.5 \times 0.104 < \text{LDS} < 1.5 \times 0.104$ in pods per mile
$0.5 \times 600 < \text{PSW} < 1.5 \times 600$ in metres

The value for the surface density of schools should be somewhere on the traced surface, but it is unlikely to be in the top left corner. Given the histogram of LSD and the rather conservative value taken for the PSW, we expect the surface density to be between 0.05 and 1.12 pods per km^2.

Combining these surface densities of pods with the mean school size leads to densities of dolphins:

$0.093 \times 13 = 1.11$ dolphins per km^2, obtained as the guide value.

The next step would be to extend this dolphin density estimate to the area supposedly covered by the survey, i.e. the Liguro-provençal basin. However, the data need to be further processed and the approach refined before going ahead with such an analysis.

A better evaluation of the practical search width and an increase of the sample size would increase the accuracy of this approach, which can otherwise be compared to a line transcet method processing of our data.

2) Other points of interest

Photo-identification of fin whales Our efforts will be placed within a collaborative study. The results are:

- 39 pods sighted in 1991 (29 "Singles", 7 "pairs", 2 "trios", and one group of 5 animals).
- 13 pods approached successfully, giving rise to 18 individuals correctly pictured.

The modest success rate is due to sea and light conditions, the low speed of the sailing ship, and mixed species sightings. About half of the individuals photographed feature a distinctive fin.

Behaviour of Risso's dolphins Two pods of *Grampus* were observed off Antibes on two successive days in August; four recognisable individuals were seen in both pods, according to the photo-identification results. In both cases, the group numbered about 14 animals, including 2 juveniles. During high activity phases, the following series of events would typically occur:

A group of 8 to 10 adults assembles within a range of 100 metres. One, or two, large individuals raise their tail flukes high above the water, whilst other animals approach. A troubled scene occurs during a few seconds, shortly followed by a series of breachings.

This scenario was repeated several times in both schools, lasting 20 to 70 seconds; it is possible that these behaviours are connected with reproductive activity.

Group structure of long-finned pilot whales The opportunity was taken to observe large schools of pilot whales along the northern continental shelf. Large formations are spread over great distances, which makes it difficult to assess group structure. From a particular example, we draw the following description:

A core group of 70 to 80 animals would occur, with no apparent size segregation. Several subgroups spread out within a few kilometres of the central component and whose composition is variable. For example, we noted three intermediate-sized males travelling in tight formation, a loose assembly of mother and juveniles in the presence of a large bull, and an assembly of 20-25 individuals displaying the full range of sizes. Young calves were seenonly in medium- or large-sized subgroups. Numerous social behaviours, like breaching or fluke slapping, take place in the pods, but no breeding was witnessed.

ACKNOWLEDGEMENTS We thank Dr Beabrun (EPHE) for his efficient support.

Table 1 Seasonal variation in effort and cetacean sightings

Season	**Days at sea as % of total**	**Sightings as % of total**
Winter	8%	11%
Spring	15%	4%
Summer	68%	72%
Autumn	9%	13%

Table 2 Annual variation in mean number of sightings of striped dolphin schools per mile. 1989-91.

Year	1989	1990	1991
Mean no.	0.125	0.112	0.089
S.D.	0.61	0.60	0.54

Table 3 Seasonal variation in mean number of sightings of striped dolphin schools per mile.

Season	Winter	Spring	Summer	Autumn
Mean no.	0.124	0.073	0.100	0.126
S.D.	0.74	0.32	0.52	0.73

Table 4 Practical search width for striped dolphin, with eyes 3 m above sea level

Wind	0	1,2-	2+,3	4	5	6,7	>8	Beaufort
C.Vis.	6	5	4	3	2	1	0	*
Breach	6000	4000	3000	2000	800	400	100	Metres
Travel	2000	1000	600	300	100	20	10	Metres

* minus 1 for residual swell, cloudy weather, sun lower than 20 degrees.

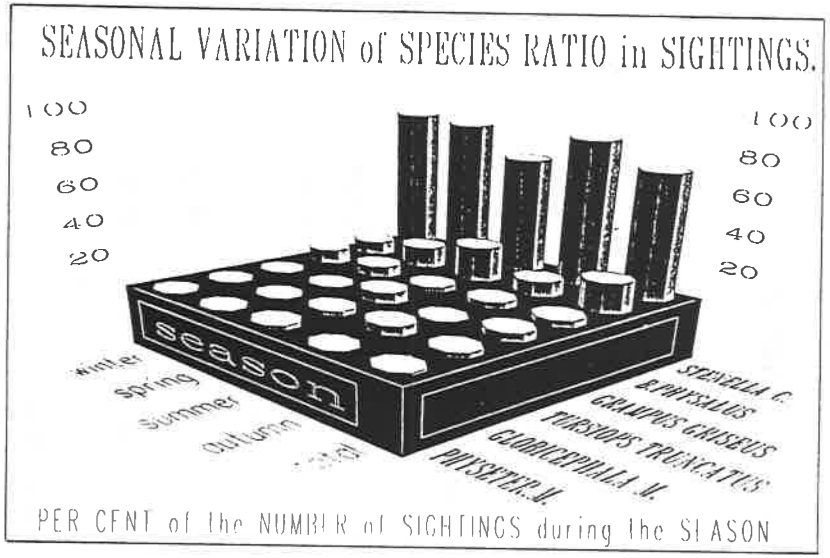

Fig. 1 Seasonal variation of species ratio in sightings

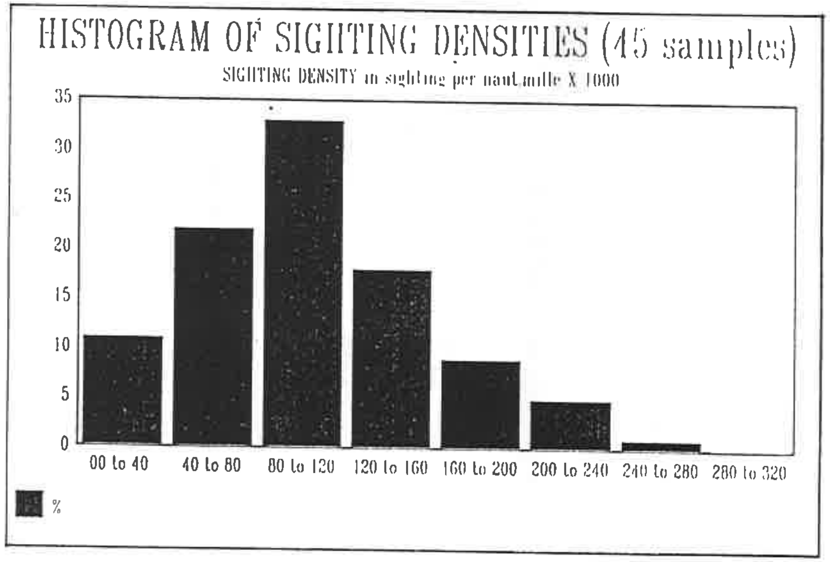

Fig. 2 Sightings densities

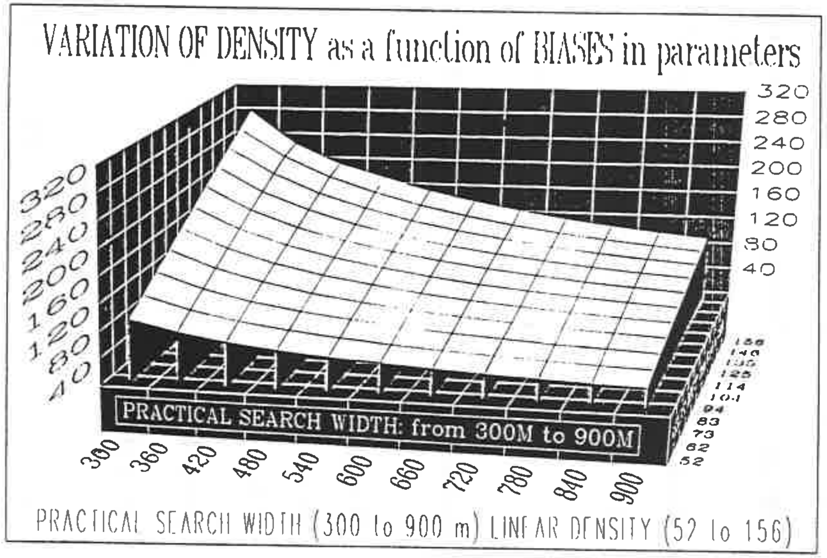

Fig. 3 *Stenella coeruleoalba* Sighting density/year &/season

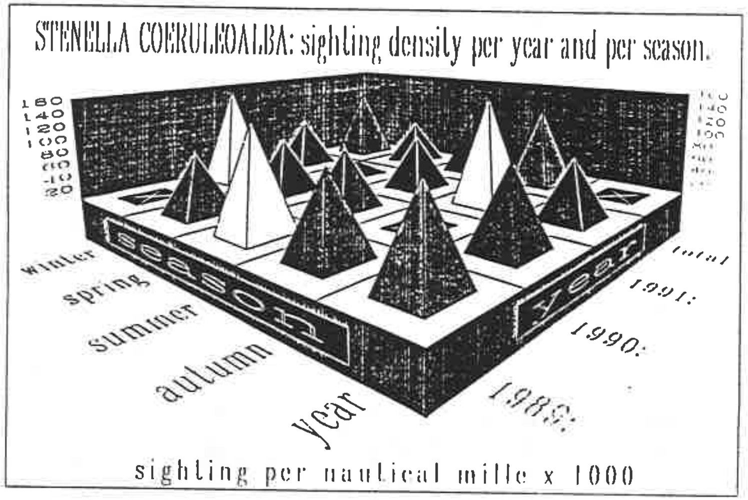

Fig. 4 Variation of density as a function of bias in parameters

PRELIMINARY OBSERVATIONS OF THE CETACEAN FAUNA OF THE CANARY ISLANDS

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The Canary Islands comprise seven islands and several islets of volcanic origin, located in the Atlantic Centro-Oriental Region (27°37' - 29°25' N and 13°20' - 18°10' W), and together with the Azores, Madeira, Salvages, Cape Verde and part of West Africa they constitute the Macaronesian archipelagoes. Knowledge of the biology of cetaceans around these islands and also that of the whole Atlantic Centro-Oriental Region is poor. Lack of information is mainly due to the absence of observers in the area, and only a few references are known (Richards, 1936).

At the beginning of the 1980s, we started a study of the biology of stranded cetaceans on the 1500 km coastline of the Canaries. However, coverage was not uniform, due to the lack of an effective network for recording strandings. This problem was solved with the development of the "Program of Study of Cetaceans Stranded on the Canary Archipelago", during 1991. The populations of short-finned pilot whales, *Globicephala macrorhynchus* and bottle-nosed dolphins, *Tursiops truncatus*, local to the waters of Tenerife Island are presently being studied.

In the present paper, we aim to give an introduction to the general characteristics of the cetacean fauna of the Canary Islands, derived from 72 strandings (102 specimens) and occasional sightings.

Currently, 19 species have been recorded: two belonging to the family Balaenopteridae, ten to the Delphinidae, five to the Ziphiidae and one each to the families Kogiidae and Physeteridae. Most of these are pelagic species and/or cephalopod feeders. This fact may be related to the great depths surrounding the coasts of the islands and the supposed abundance and richness of cephalopods in these waters.

Most frequent strandings which occur are Cuvier's beaked whale, *Ziphius cavirostris*, sperm whale, *Physeter macrocephalus*, pygmy sperm whale, *Kogia breviceps*, and bottle-nosed dolphin. The relative frequency of strandings of each of these species may reflect their relative abundance around the archipelago (Fig. 3).

The seasonal frequency of strandings indicates two peaks within the annual cycle, one during spring and a second during autumn, particularly in the months of June and October. These results are probably as consequence of mass strandings which occured in both months. A minor peak in February may also be due to a single stranding incident of a large number of animals. Finally, our data are compared with those from neighbouring areas, in Table 1.

ACKNOWLEDEGMENTS We thank Aurelio Martin, Robert Vonk, and Tyd Canaris S.L for all their support.

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Table 1 Distribution of different species of cetaceans from the Atlantic Centro-oriental according with bibliography consulted.

SPECIES	REGIONS							
	AZ	MA	CA	MR	SA	MU	SE	CP
BALAENOPTERIDAE								
B. musculus					●			
B. borealis						●		
B. edeni							●	
B. acutorostrata		●	●					
B. physalus			●			●	●	
M. novaeangliae								
BALAENIDAE								
B. glacialis		●						
DELPHINIDAE								
D. delphis		●	●	●		●	●	●
G. griseus			●	●		●	●	
G. melaena			●			●		
G. macrorhynchus	●	●	●				●	
L. hosei			●					
S. bredanensis		●	●			●	●	
S. coeruleoalba	●	●	●				●	
S. longirostris						●		
S. clymene							●	
S. frontalis	●		●			●		●
S. attenuata								●
S. teuszii					●	●	●	
T. truncatus	●		●	●		●	●	●
O. orca			●	●		●	●	
P. crassidens	●			●				
p. electra							●	
F. attenuata							●	●
KOGIIDAE								
K. breviceps	●	●	●				●	
K. simus								●
PHYSETERIDAE								
P. macrocephalus	●	●	●					
ZIPHIIDAE								
H. ampullatus	●		●					●
M. bidens	●	●						
M. densirostris	●	●	●					
M. europaeus			●					
M. mirus		●						
Z. cavirostris			●	●				●
PHOCOENIDAE								
P. phocoena				●	●	●	●	

KEY AZ: Azores MA: Madera CA: Canarias MR: Morocco SA: Saharah
MU: Mauritiania SE: Senegal CP: Cape Verde

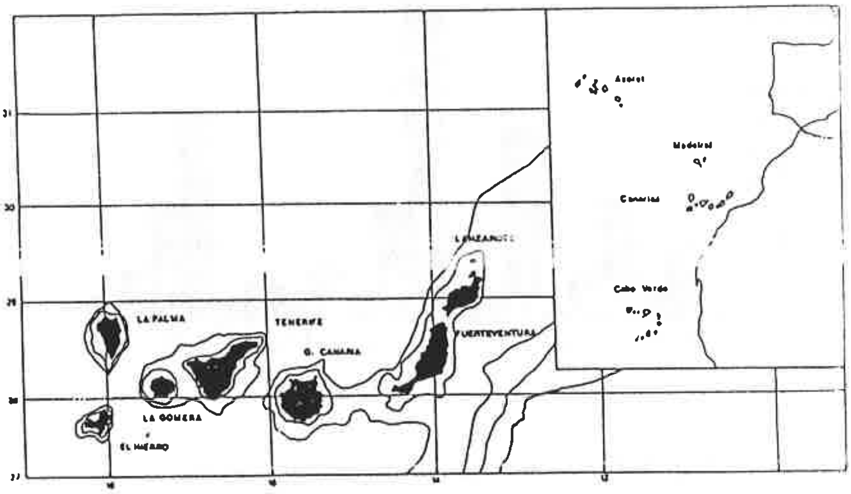

Fig. 1 The Canary Islands present a pronounced character of typical oceanic islands, and due to the lack of continental shelf, produces great depths near the coast. The physical-chemical parameters of this water, especially the salinity and temperature, differ to that of corresponding latitudes. This is a consequence of the influence of the Canary Current and the upwelling off the African coast.

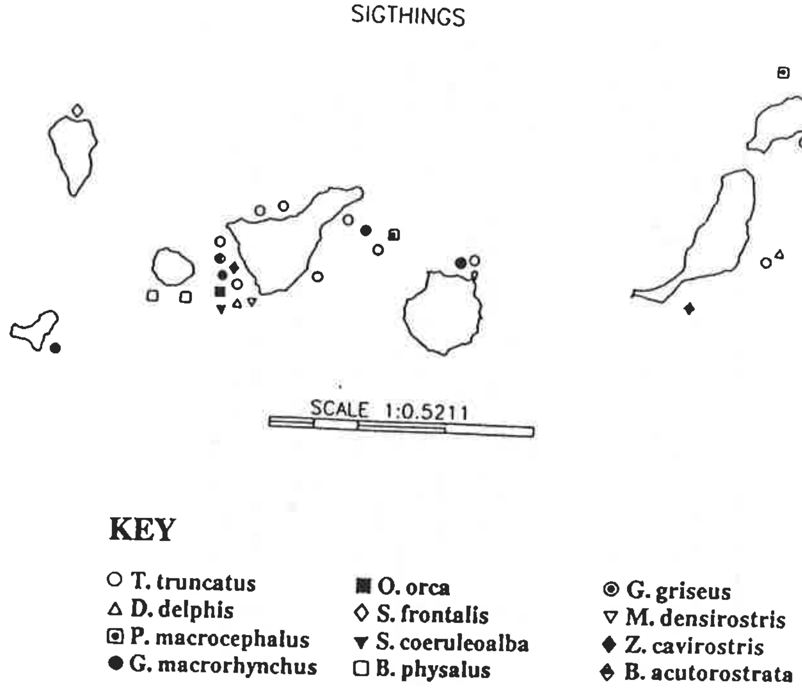

Fig. 2 Distribution of occasional sightings

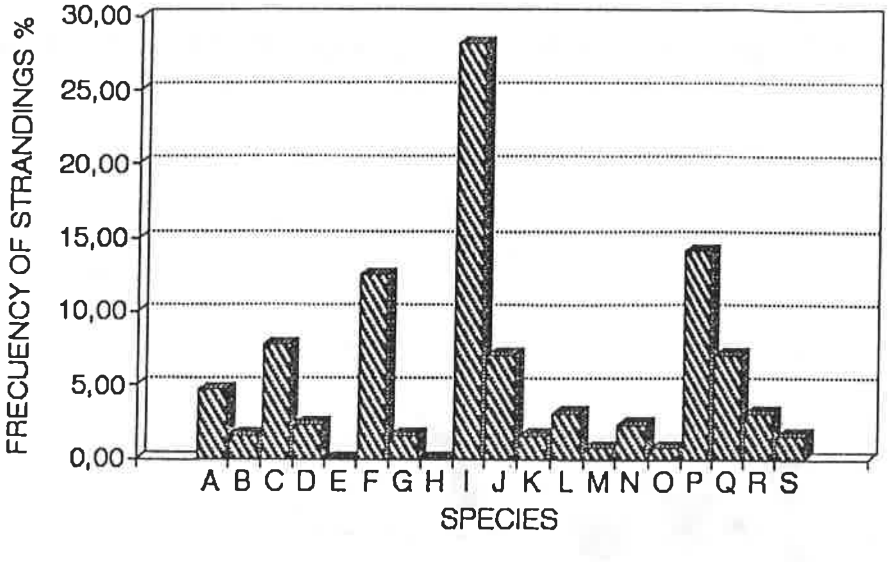

Fig. 3 Frequency of strandings of species

A : *D. delphis*
B : *L. hosei*
C : *T. truncatus*
D : *S. coeruleoalba*
E : *S. frontalis*
F : *G. macrorhyncus*
G : *G. melas*
H : *O. orca*
I : *Z. cavirostris*
J : *M. europaeus*
K : *M. mirus*
L : *M. densirostris*
M : *H. ampullatus*
N : *S. bredanensis*
O : *G. griseus*
P : *P. macrocephalus*
Q : *K. breviceps*
R : *B. acutorostrata*
S : *B. physalus*

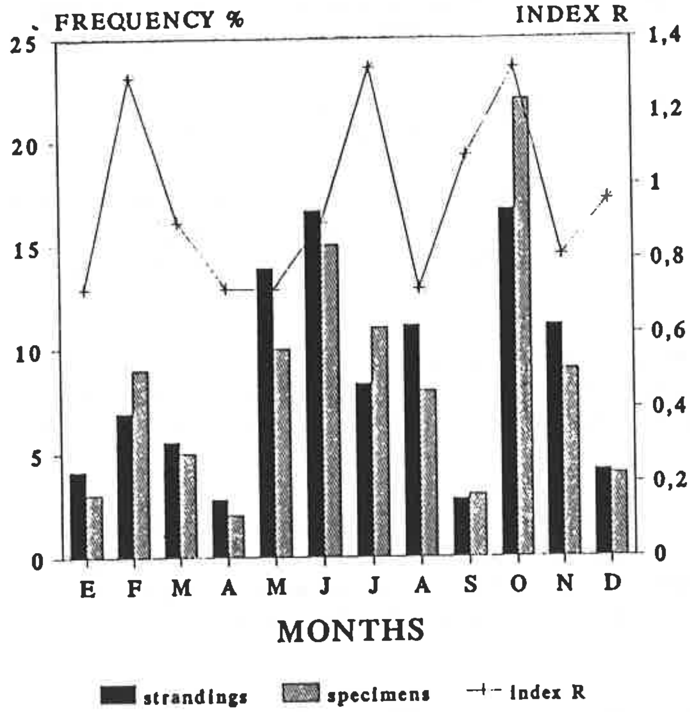

Fig. 4 Seasonal frequency of strandings and specimens
Index R: number of specimens / number of sightings.

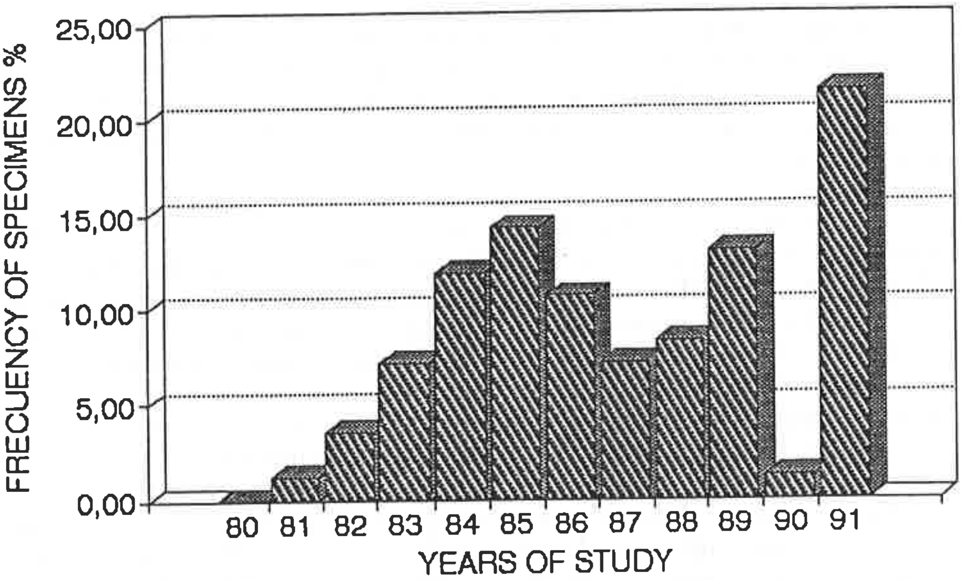

Fig. 5 Annual frequency of strandings

CETACEAN SIGHTINGS PROGRAMME IN THE CENTRAL TYRRHENIAN SEA: RESULTS OF THE SECOND YEAR OF ACTIVITY

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As we reported last year during the meeting in Sandefjord (Marini *et al.*, 1991), our group is carrying out a programme of sighting cruises in the Central Tyrrhenian Sea using the ferry boats of the National Railway Board that sail between the peninsular coast of Italy and Sardinia.

Twelve months of field work, along the same route, was carried out from October 1990 to September 1991. The aim was to check the results on seasonal variation in occurrence of each species obtained in the first year, and to begin a long term study of status changes for the most frequent species (striped dolphin, *Stenella coeruleoalba,* and fin whale *Balaenoptera physalus*).

The number of trips has been lower than that of last year (66 versus 102), for logistic reasons. Furthermore, on the experience of the first year of field work, we decided not to make observations in particularly bad weather and seas. Conditions were favourable in the first months of the year. The number of sightings has also been clearly lower than the first year (209 versus 411) (Table 1).

The presence of fin whales has been confirmed, as in the previous year, to occur throughout the year, with a peak in the spring-summer period and a low in the last months of the year (Fig. 1). School sizes have remained low, never being larger than three specimens.

Of particular interest has been the presence of a school of three animals which remained almost a month (between June and July) in the same area, about thirty miles off the peninsular coast. This may indicate the presence of sufficient quantities of upper trophic level resources in this area of the Mediterranean Sea. One individual animal was seen breaching in September.

Striped dolphins were also most frequently seen in both years during the spring-summer period, but they were more consistently present throughout the year than was the case for fin whales (Fig. 2). We have often observed relatively large schools of striped dolphins (up to forty or fifty animals). The groups appeared to have a particular structure, with females, calves and adults placed in a large group in the centre and couples or solitary adults on the periphery at a certain distance. This may be due to a need for surveillance for potential predators, or to increase prey searching efficiency. A similar situation occurs in several species of monkey and baboon, and some other group-living mammals.

Sightings of sperm whales, *Physeter macrocephalus*, and long-finned pilot whale, *Globicephalus melas*, (two sightings of each species) have been recorded this year for the first time. The rare occurrence of these species makes it difficult to explain their widespread distribution as documented by other authors both in the Ligurian Sea and the Tyrrhenian Sea. It may be that they move westwards into the waters between Sardinia and the Balearic Islands, or they are particularly afraid of the noises of the ferries, or perhaps they are more active during the night.

Other species seem to have a more sporadic presence in this area. These include members of the family Ziphiidae which have been observed twice this year, indicating that their occurrence in the area is less rare than previously suspected. Bottle-nosed dolphins, *Tursiops truncatus*, are sighted fairly regularly in both coastal areas. Risso's dolphins, *Grampus griseus*, are relatively common, especially in the eastern part of the transect area.

A third year of observations is now being carried out.

ACKNOWLEDGEMENTS This research is carried out with a grant from the Environment Bureau of the Provisional Administration of Rome, and with the collaboration of the National Railway Board.

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Table 1 Cetacean sightings in the Central Tyrrhenian Sea

Date	Trips	Sc	Tt	Dd	Gg	Zc	Gm	Pm	Bsp	Unsc	Unmc	Unlc	Unc
10.90	8	15		1	1			1	6	3	1		4
11.90	5	8											1
12.90	4	6	1		2					1		1	1
01.91	6	4							4	1		1	2
02.91	4	3								1			
03.91	6	8			1		1		2				
04.91	4	12			2	1			5	1			
05.91	6	15	3		1		1		4		2		1
06.91	7	11			1	1			3	3			1
07.91	6	6	1		2				6				3
08.91	5	11	3					1		6		1	
09.91	5	14	2						2	1			1
TOT	66	113	19	1	10	2	2	2	32	17	3	3	14

Total No. Sightings = 209

KEY:

Sc = *Stenella coeruleoalba*
Tt = *Tursiops truncatus*
Dd = *Dephinus delphis*
Gg = *Grampus griseus*
Unsc = Unidentified small cetaceans
Unlc = Unidentified large cetaceans

Zc = *Ziphius cavirostris*
Gm = *Globicephalus melas*
Pm = *Physeter macrocephalus*
Bsp = *Balaenoptera* species
Unmc = Unidentified medium cetaceans
Unc = Unidentified cetaceans (size unknown)

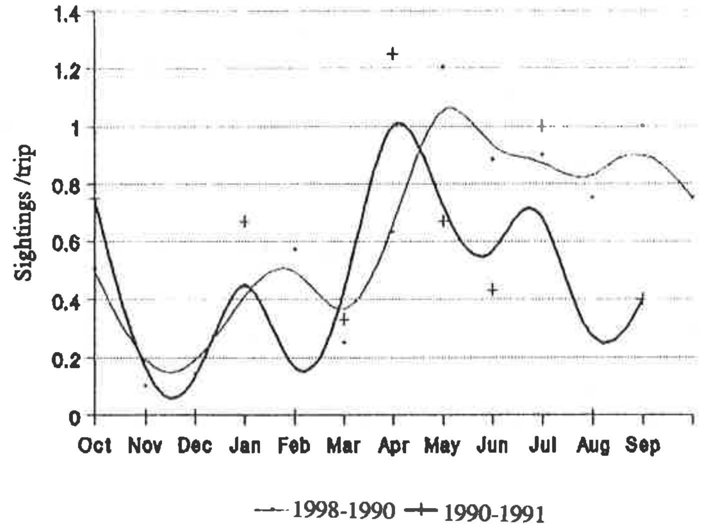

Fig. 1 Sightings of *Balaenoptera* sp.

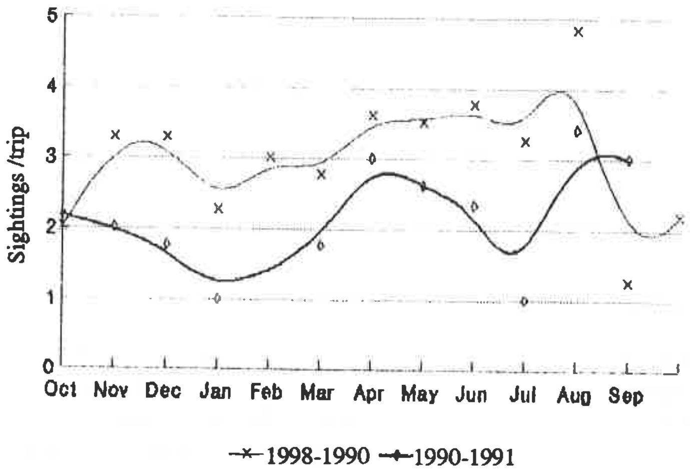

Fig. 2 Sightings of *Stenella coeruleoalba* (summed up with Not Identified small cetaceans) (sea conditions <3)

GREENPEACE REPORT ON TWO YEAR RESEARCH IN THE LIGURIAN SEA

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INTRODUCTION A research programme for the study and conservation of cetaceans has been conducted under the Greenpeace Mediterranean Seas Project since 1989. Since 1990, research has been carried out in the Ligurian Sea.

The research was conducted in eight 25-nautical mile wide strips, from San Remo (43°49'N, 70°46'E) to Portovenere (44°03'N, 9°51'E).

The presence of cetaceans was verified and, whenever possible, individuals were photo-identified. Planned transects were made totalling 192 hours (988 nautical miles) in 1990, and 387 h (1840 nm) in 1991.

The research was carried out benignly, without, so far as we know, any harm or stress to the animals. Considering the importance of the Ligurian and Ligurian-Provençal Sea areas for several species of Mediterranean cetaceans, Greenpeace has proposed the setting up of eight marine sanctuaries (Fabbri, in press) to preserve the essential qualities of this region for feeding and breeding by Mediterranean cetaceans.

MATERIALS AND METHODS Chartered vessels and sailing boats belonging to volunteers were used following transects with pre-determined tracklines. During the entire research period, sightings were conducted by two final year students studying Natural Sciences, occasionally helped by other students or researchers already engaged in the study of cetaceans.

Cameras with lenses of 50, 135, 200 and 300 mm, and professional black and white, and colour films with film speeds of 200 and 400 ASA, were used for photo-identification. In order to assess sighting frequencies, we have divided the number of sightings of each species by the total sighting time, excluding night hours. Repeated sightings of the same group have been clustered together as a single data point.

RESULTS AND DISCUSSION A total of 63 sightings of groups was made; 52 of these included individuals of one or more of five species, while 11 sightings were not identified. Table 1 shows the number and relative percentages of sightings of each species. There were fewer sightings of groups in 1991 than in 1990, despite the greater research effort in the second year due to rather more prolonged periods of weather suitable for surveying. The overall reduction in sightings was due mainly to the reduction in the most frequently seen species, the striped dolphin, *Stenella coeruleoalba* (Fig. 1). Table 2 summarises striped dolphin sightings by group size. For further analysis, we have excluded eight sightings made in August 1990 because no surveys were made during that month in 1991, and eight sighting in June 1991 which were made in transit to the designated survey zone. Corresponding adjustments were made to the estimated hours of survey in each year and to the total distances traversed.

Considering that the severe virus epidemic which affected the striped dolphins only began to manifest itself in Italy after the 1990 survey (Raga & Aguilar, in press), a decline might be expected from 1990 to 1991 in the numbers of groups seen per hour or mile of survey, and/or in the group size. A one-tailed t-test suggests, however, that the group sizes actually increased; the best estimate of the increase is from about 12 to 15, i.e. an increase of 32% ($p = 0.09$). 16 groups of striped dolphin were seen in 1990 during 150 h of survey, covering about 900 nm., while in 1991 only 12 groups were seen in 263 h (1580 nm).

With the null hypothesis that number of groups had not changed, the expected numbers of sightings would have been 10 in 1990, and 18 in 1991. The difference between observed and expected sightings is highly significant (Chi-square, $p = 0.02$). The best estimate is that the number of groups declined by 57% from 1990 to 1991. Taking both changes into account, the number of individuals is estimated to have been reduced by 45%.

We hypothesise that the epidemic reduced the numbers of individuals in some groups so much that the few surviving animals in those groups joined other groups and thus augmented them. Such phenomena of fusion/splitting of groups have been noted in *Grampus* and *Balaenoptera.*

During our 1991 survey, a pair of fin whales, *Balaenoptera physalus*, was sighted three times over an eight day period, always at the same latitude and at a distance of only three miles in longitude between the first and the third sighting. A tendency for fin whales to remain in the same place for a period of time has previously been noted in the Central Tyrrhenian Sea (Marini, pers. comm.).

In Table 3, the frequencies of sightings are arranged by water depth. Most species were seen most frequently in the 800-1200 metres zone, but a single bottle-nosed dolphin,*Tursiops truncatus*, seen repeatedly, was always in water less than 200m deep. These observations are consistent with published reports that striped dolphins and fin whales (not infrequently together) are often seen on the edge of the continental shelf/slope (or near sea-mounts) (Evans, 1987).

In our surveys, striped dolphins were seen in mixed groups with Risso's dolphins, and with common dolphins, *Delphinus delphis*. One common dolphin was seen alone about twenty miles southwest of San Remo. The habit of this species to swim solitarily or in pairs has been reported by Di Natale (1983) and Dintheer (1983).

CONCLUSIONS The apparent decline in the striped dolphin during a short period of intense epidemic is not, of course, conclusive evidence of a connection, but these findings are strongly indicative. Vigorous collection of more information relating to this problem is required. A possible decline in the immunological defences of striped dolphins affected late in 1990 by morbillivirus, as a consequence of the high concentrations of PCBs in stranded animals, has been reported by Borrell & Aguilar (in press).

PCB concentrations considerably higher than those noted in individuals of the same species sampled in the Atlantic, was detected by Focardi *et al.* (1991), in the blubber of fin whales sampled in the Ligurian Sea. Considering that PCB contamination results from intake of food organisms and that the Ligurian basin is one of the best regions of the Mediterranean for feeding by fin whales and other cetaceans, it is not unlikely that the presence of organochlorine compounds such as PCBs in the Ligurian Sea may be seriously affecting, directly or indirectly, animals at high trophic levels such as the cetaceans that live in or seasonally enter this region.

Another current and growing threat to cetaceans may be maritime traffic. The fin whale seems to be the species most exposed to accidents with boats (Di Natale & Mangano, 1983; Duguy *et al.*, 1983; Duguy & Vallon, 1977). Furthermore, intensive commercial traffic in the Ligurian Sea can evidently give rise to serious damage to the ecosystem as has occurred with the accidents of the Haven and the AGIP Abruzzo tankers. In addition, during the summer, large yachts frequently traverse this area and powerboat races are held at several localities within it. Protective measures for cetaceans that therefore must be considered include:

(1) enforcement of speed limits for pleasure boats;
(2) limitation of powerboat racing;
(3) full implementation of an emergency response to collisions, and oil or chemical spills.

Such measures would be facilitated by giving the area a special status so far as cetaceans are concerned. The implementation of the measures already envisaged in the Action Plan for the Conservation of Cetaceans, recently adopted by all Mediterranean coastal states under the Barcelona Convention (UNEP, 1991), is the goal of Greenpeace's Mediterranean Sea Project, of which the proposal for the creation of a pelagic sanctuary in the Ligurian and Ligurian-Provençal basins is an essential part.

AKNOWLDGEMENTS We particularly want to thank Sidney Holt for his statistical evaluation of data and for having peer reviewed the study; Xavier Pastor, Greenpeace Mediterranean Sea Project Coordinator, for his help in funding the research; Mark Simmonds of Thames Polytechnic, for his valuable comments in peer reviewing; Gabriella Guerra, Greenpeace Italy, Mediterranean Sea Project assistant, for her important work in writing and correcting the paper; and Rosalba Bonaccorsi for gathering some of the data.

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Table 1 1990-1991 recorded schools

Species*	Sightings 90	Sightings 91	Sight.% 90	Sight.% 91
S.c.	17	14	54.8	43.8
G.g.	3	8	9.7	25
B.p.	3	3	9.7	9.4
T.t.	1	1	3.2	3.1
D.d.	-	2	-	6.2
N.I.	7	4	22.6	12.5
Tot.	31	32	100	100

* S.c.	Stenella coeruleoalba
G.g.	Grampus griseus
B.p.	Balaenoptera physalus
T.t.	Tursiops truncatus
D.d.	Delphinus delphis
N.I.	No identified

Table 2 Striped dolphin. Percentage frequency of individuals per school

Individuals per school

	<5	6-10	11-15	16-20	21-25	26-30	31-35	Tot.	Tot. groups	Mean N.
1990	11.8	41.2	17.6	23.5	0	5.9	0	100	17	11.4
1991	7.7	7.7	46.1	7.7	7.7	15.4	7.7	100	13	16.5

Table 3 Sighting frequency in relation to depth (groups / hours) (1/100) (1990-1991 pods; repeat sightings included)

	A	B	C	D	E	F	G	H	I	L	M	N
S.c.	0,6	0,2	1,1	0,6	1,2	1,1	0,6	0,2	-	0,4	0,4	0,2
G.g.	-	-	0,4	0,4	1	0,2	-	-	-	-	0,2	-
B.p.	-	-	-	-	0,4	0,2	-	-	-	-	-	-
T.t.	0,4	-	-	-	-	-	-	-	-	-	-	-
D.d.	-	-	-	-	-	-	0,2	-	-	-	-	0,2

Classes of depth

A	0-200
B	200-400
C	400-600
D	600-800
E	800-1000
F	1000-1200
G	1200-1400
H	1400-1600
I	1600-1800
L	1800-2000
M	2000-2200
N	2200-2400

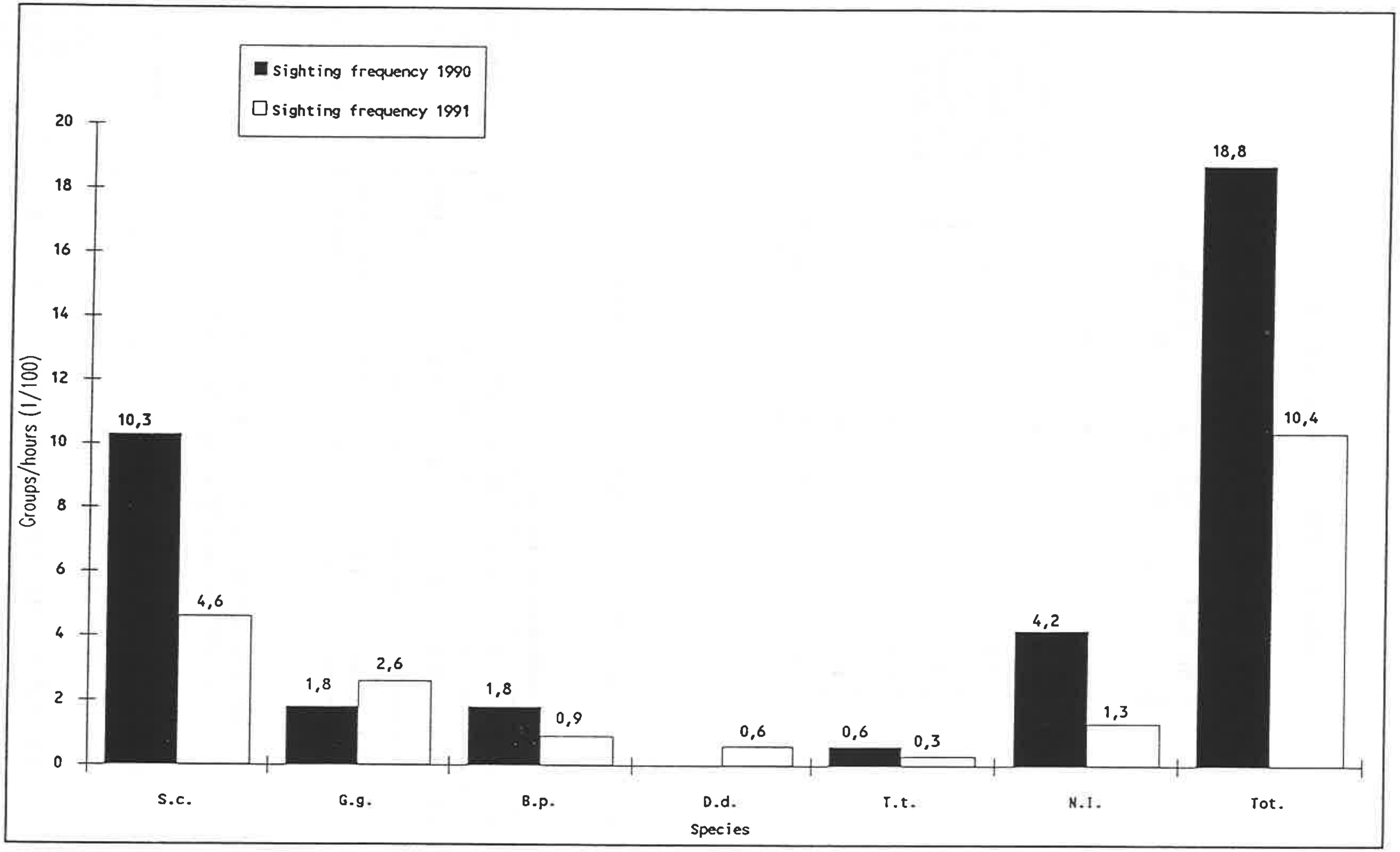

Fig. 1 Overall sightings of cetacean groups in 1990 and 1991

DISTRIBUTION AND FREQUENCY OF CETACEANS IN THE WATERS ADJACENT TO THE GREEK IONIAN ISLANDS

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INTRODUCTION Very little information exists concerning the distribution and abundance of cetaceans along the western shore of Greece, in the Ionian Sea. Ondrias (1965) mentions the presence of *Balaenoptera physalus*, *Sibbaldus musculus* (= *B. musculus*), *Physeter catodon, Ziphius cavirostris, Phocaena phocaena* (= *Phocoena phocoena*), *Delphinus delphis, Tursiops truncatus, Orcinus orca, Globicephalus melaena* (= *Globicephala melas*), and *Grampus griseus* in Greek waters. Although many of the reports on which such species accounts are based are doubtful and unverifiable, the presence in the Greek Ionian Sea of at least some of these species can be expected, based on reports from the Italian (Notarbartolo di Sciara *et al.*, 1991) and Albanian (Puzanov and Lamani, 1956; Lamani *et al.*, 1976) portions of that sea. To verify which cetacean species are most commonly found today in the Greek Ionian waters, a series of dedicated cruises were organised in the region in summer 1991.

MATERIALS AND METHODS Research cruises were conducted aboard a 15 m-long sailing vessel from 3 July to 19 September, 1991. The study area comprised between 40°8.93'N and 38°27.19'N, 18°30'E and the Greek mainland, and included the Otranto Channel between Italy and Albania, and the Greek islands of Kerkyra, Lefkas, Kefalonia and Ithaca (Fig. 1). Observation sessions were carried out by at least one trained observer on each side of the vessel. For the purpose of calculating sighting frequencies, observations were made mostly in calm weather, and sighting data were discarded when wind speed exceeded Beaufort 3 (5.4 ms^{-1}). Observation sessions began or ended, when applicable, with sunrise, sunset, departure, arrival, or deterioration of weather conditions. For each sighting position, group size and composition, direction of movement, water depth and distance from the nearest coast were recorded. Sightings frequencies were calculated for each species by dividing the number of groups sighted by the total observation time. Frequencies were multiplied by 100 to avoid an excessive number of decimal points.

RESULTS During 421.7 h of observation, 25 cetacean groups were sighted in good weather conditions. Three sightings, made with wind speeds exceeding Beaufort 3, were considered only for group size calculations. Five cetacean species were observed, including, in order of decreasing frequency (Table 1, Fig. 2): the bottle-nosed dolphin, *Tursiops truncatus* (2.13 sightings/100h); striped dolphin, *Stenella coeruleoalba* (1.90); common dolphin, *Delphinus delphis* (1.19), and fin whale, *Balaenoptera physalus* (0.47). The Cuvier's beaked whale, *Ziphius cavirostris*, was sighted once.

Bottle-nosed dolphins were mostly seen in proximity to Paxoi and among Lefkas, Meganisi, Cephalonia and Ithaca; sightings of this species near Othonoi and the Kerkyra Channel were rare. The largest groups of *Stenella coeruleoalba* were sighted in the Otranto Channel; three sightings were recorded west of Lefkas, always at distances greater than 28 km from the nearest coast. Common dolphins were only observed in Lefkas bay, close to

Skorpios and Meganisi Islands, and in the channel demarcated by Levkas, Cephalonia and Ithaca. *Balaenoptera physalus* was recorded only twice in two different parts of the study area: the first sighting was northeast of Othonoi and the second, south of Antipaxoi. *Ziphius cavirostris* was observed for a few seconds only, during the first fin whale sighting.

Group size statistics are shown in Table 2. The largest groups were of striped dolphins (mean = 10.1, SE = 3.05), followed by common dolphins (mean = 10.08, SE = 3.22) and by bottle-nosed dolphin (mean = 8.03, SE = 2.03). Fin whales were always sighted alone.

Data on depth and distance from the coast are summarised in Table 3. Striped dolphins were the most pelagic, followed by the Cuvier's beaked whale and by fin whales. By contrast, bottle-nosed dolphins and common dolphins were found in relatively shallow waters close to the coast.

DISCUSSION This research must be considered only as a preliminary investigation of the distribution and abundance of cetaceans in Greek Ionian waters. *Tursiops truncatus* was the most frequently observed cetacean. Not surprisingly, this well-known coastal species was regularly seen in waters shallower than 100 m and at a short distance from the coast. By contrast, fin whales, striped dolphins and the Cuvier's beaked whale confirmed their pelagic habits.

The frequent sightings of *D. delphis*, a species believed to be declining throughout most of its range in the Mediterranean Sea (Duguy *et al.*, 1983), were a surprise. The predictable presence of common dolphins in specific locations of the study area suggests a certain degree of site fidelity in the region by this species. It is unclear why common dolphins, known as pelagic cetaceans, were always observed within short distances from the coast and in shallow waters.

ACKNOWLEDGEMENTS This research was funded by Europe Conservation and by the paying volunteers who participated in the cruises. We wish to thank all of them, as well as the crew of the "De Gomera", the sailing boat on which the research was conducted.

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Table 1 Sighting frequency of five cetacean species observed in the Greek Ionian Islands. Frequencies are expressed as number of sightings per 100 hours of observation. Two groups of striped dolphins, sighted in poor weather conditions, were discarded from claculations.

Species	Sightings	Frequency
Bottle-nosed dolphin	9	2.13
Striped dolphin	8	1.90
Common dolphin	5	1.18
Fin whale	2	0.47
Cuvier's beaked whale	1	0.23

Table 2 Group size statistics for three delphinid species, (N = number of groups sighted; SE = standard error)

Species	N	X	SE
Striped dolphin	10	10.10	3.1
Common dolphin	6	10.08	3.2
Bottle-nosed dolphin	9	8.03	2.0

Table 3 Mean depth (m) and mean distance from the nearest coast (km) of the sighting location of five cetacean species

Species	N	Depth	SE	Distance	SE
Striped dolphin	10	799	141.4	20.7	2.3
Cuvier's beaked whale	1	450	-	5.6	-
Fin whale	2	362	87.5	7.9	2.3
Common dolphin	6	167	42.5	2.2	0.8
Bottle-nosed dolphin	9	65	6.8	4.7	1.3

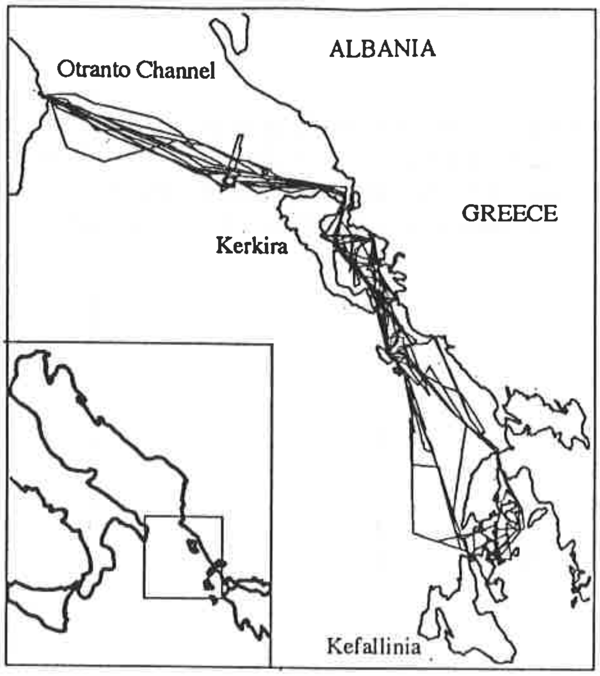

Fig. 1: The study area.

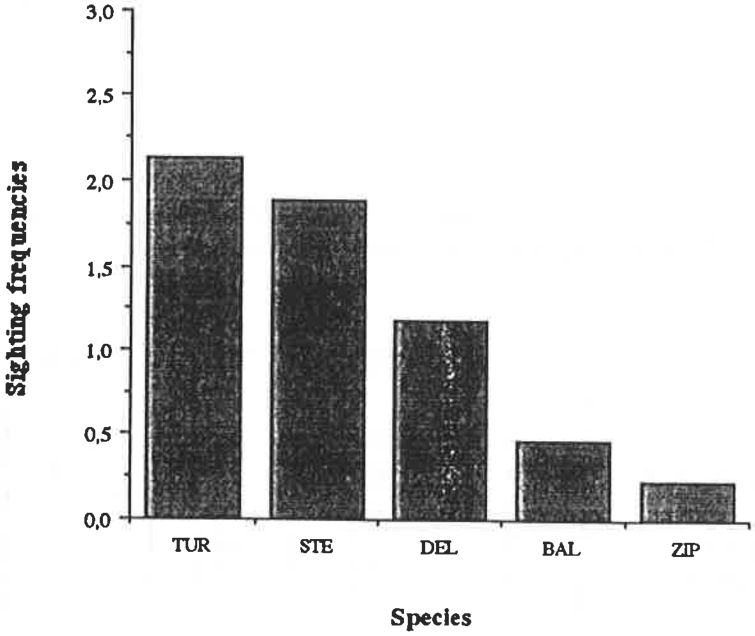

Fig. 2: Sighting frequencies distribution for five cetacean species. Data as in Table 1. TUR = bottlenose dolphins; STE = striped dolphins; DEL = common dolphins; BAL; fin whales; ZIP = Cuvier's beaked whale.

CETACEAN SIGHTING REPORTS BY AMATEURS: A TWO-SIDED COIN.

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INTRODUCTION Collecting information on the distribution and ecology of cetaceans using dedicated vessels is a very costly enterprise. Taking advantage of the opportunities provided by a number of non-professional observers, such as yachting people, sailors, fishermen, ferry passengers, and seamen in general, to gather information on the occurrence of cetacean species in a given area, seems therefore a logical consideration. Such practice has in fact been adopted by several authors in the past (e.g. Pilleri, 1970; Di Natale, 1979; McBrearty *et al.*, 1986). However, the collection of sighting data from amateurs requires a large effort for the dissemination of the sighting forms and for minimal training of the observers, including the organisation of awareness campaigns, the preparation of instruction sheets or manuals, the necessary follow-up procedures, etc. It may be questioned whether such effort is justified by a real advance in zoological knowledge. Furthermore, the publication of uncertain data might introduce important biases in the already scarce scientific literature on this subject. The aim of our investigation, based on five years of collection of sighting data from non-professional observers in Italy, is to provide a constructive critique of this research method.

METHODS A popular cetacean sighting reporting program, called *"Compagnia dei Cetonauti"*, was started in Italy by the Tethys Research Institute in 1986 and continues to date. Although the program had no geographic limitation within the entire Mediterranean Sea, the vast majority of the data was collected in the seas surrounding the Italian peninsula and islands. In parallel, a popular sighting program was organised in the Italian seas in cooperation with Greenpeace Italy during summer 1989. Finally, sighting data collected in the Italian coastal zone were also provided by the crew of the pollution-monitoring fleet managed by Castalia S.p.a. from 1989 to 1991.

All programme participants were clearly informed by us that only sighting reports supported by photographic or video documentation would be accepted for the data analysis. In addition to specially made forms, an easily readable booklet (Notarbartolo di Sciara, 1986) was distributed to all participants as an aid in cetacean identification and reporting. In addition, training sessions were carried out for the Greenpeace and the Castalia programmes.

RESULTS A total of 618 sighting reports was collected, involving nine cetacean species. Of these, in spite of the clear instructions given, only 131 (21.2%) were supported by photographic or video documentation.

Our analysis of the documented reports revealed that 90 (68.7%) were correctly identified; the remaining had a wrong indication, or no indication at all.

The results presented here are based on the verified reports only. Species sighted included: the fin whale, *Balaenoptera physalus* (26 reports, 19.8%), sperm whale, *Physeter* *macrocephalus* (9, 6.9%), killer whale, *Orcinus orca* (2, 1.5%), long-finned pilot whale, *Globicephala melas* (3, 2.3%), Risso's dolphin *Grampus griseus* (14, 10.7%), bottle-nosed dolphin, *Tursiops truncatus* (33, 25.2%), striped dolphin, *Stenella coeruleoalba* (37, 28.2%), and common dolphin, *Delphinus delphis* (7, 5.3%) (Table1). Sightings of Cuvier's beaked whales, none of which were documented, were not considered in this analysis.

To evaluate differences in species identification abilities concerning the different species, a ratio was calculated between correct and incorrect identification for eight species. Although our sample size is still too limited to allow an evaluation of significance, some differences among species are apparent (Fig. 1). Killer whales, pilot whales and Risso's dolphins scored best, perhaps because of their conspicuous appearance. Fin whales, striped dolphins and common dolphins were intermediate. Sperm whales and bottle-nosed dolphins ranked lowest.

DISCUSSION In spite of the clear instructions given, a very low percentage (21.2%) of the sighting reports collected were documented. The analysis of these revealed a rate of correction higher than expected (68.7%), perhaps due to the training efforts made. We suggest that in a more general situation, the percentage of reports with the species correctly identified would be lower. Even in our controlled situation, however, more than 30% of the reports represent incorrect data, especially so far as the less conspicuous species are concerned, including bottle-nosed dolphins and striped dolphins, the most important Mediterranean cetacean species in terms of abundance.

Certainly the increasing availability of inexpensive and simple cameras (still and video) will afford the collection of greater numbers of verifiable reports, which may eventually yield appreciable results if a sufficiently large report database is organised.

If such conditions are not respected, however, we maintain that the scientific scope of this research method is of limited value, and that the risk of polluting the literature with incorrect results is unacceptably high.

The positive side of the coin, rather than concerning the progress of scientific knowledge, in our opinion relates mostly to the important effect of such popular sighting programs within the mainframe of nationwide campaigns to promote awareness and involvement of the public in cetacean conservation. However, it must be cautioned that the scientific treatment of the data collected through such sighting campaigns must be handled with care, to avoid the publication of large amounts of inaccurate data.

ACKNOWLEDGEMENTS We wish to thank the Edizioni del Cormorano for printing the *Manuale del Cetonauta* and for cooperating with the Tethys Research Institute in launching the *Compagnia dei Cetonauti*. Data from "Operazione Cetacei 1989" were kindly provided by Greenpeace Italy. The cooperation of Castalia S.p.a. and of the *Ispettorato Centrale Difesa Mare*, Italian Ministry of Merchant Marine, is greatly appreciated. We also would like to extend our gratitude to the more than 600 yachting people who have participated in our programme *Compagnia dei Cetonauti*, providing us with the data necessary for the preparation of this paper.

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Table 1 Summary of reports

Species	N	%
Fin whale	26	19.8
Sperm whale	9	6.9
Killer whale	2	1.5
Long-finned pilot whale	3	2.3
Risso's dolphin	14	10.7
Bottle-nosed dolphin	33	25.2
Striped dolphin	37	28.2
Common dolphin	7	5.4

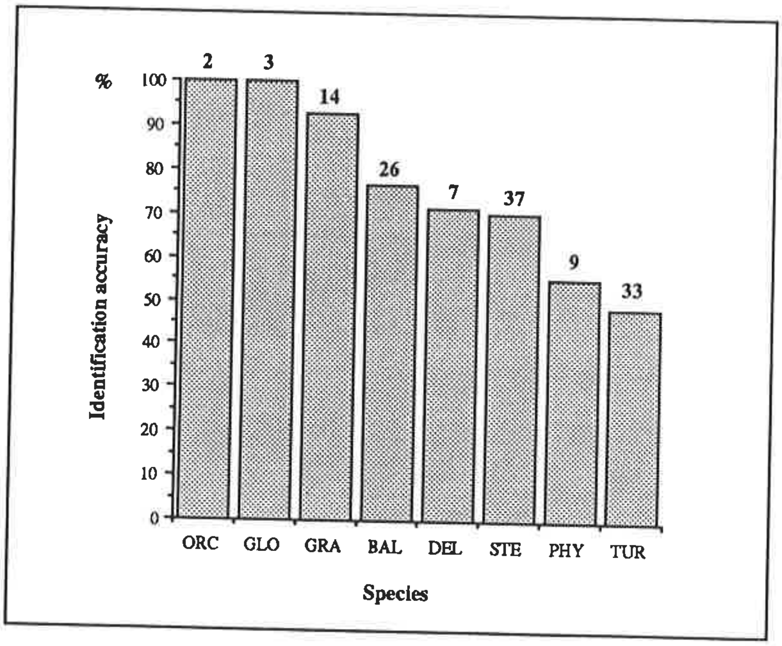

Fig. 1 Rate of report correctedness divided by species.

KEY

ORC = killer whale
GLO = pilot whale
GRA = Risso's dolphin
BAL = fin whale
DEL = common dolphin
STE = striped dolphin
PHY = sperm whale
TUR = bottle-nosed dolphin

OCCURENCE OF THE SEI WHALE, *Balaenoptera borealis*, IN THE MEDITERRANEAN SEA.

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INTRODUCTION A lot of Rorquals stranded or sighted in the Mediterranean Sea were not properly identified. Some of them were reported as being sei whale *Balaenoptera borealis*, or blue whale, *Balaenoptera musculus*, without any scientific criteria. Therefore, to date there is no formal data for the blue whale and only one stranding (Filella, 1974) and one sighting (Bombard, 1958) for the sei whale in the Mediterranean Sea.

MATERIALS Old naturalist reports of whale strandings and sightings are well known and regularly revised to identify the species concerned. Therefore nobody could hope to make any great discoveries through these kinds of documents.

During 1991, in collaboration with GECEM (*), we collected new information such as old post-cards, amateur photographs, samples and other useful things to confirm or reject the identification of some whales.

RESULTS

1) Sei whale. Using early century post cards showing sufficient details, we were able to find old data pertaining to a sei whale. It was the stranding of a 15.2 m long, 22 ton whale at Valras Plage, France, on the 5th June 1921. After checking that the photographs were printed without inversion, we noticed two diagnostic details: the white fringed black plates on the right jaw and the throat grooves ending just past the midpoint between the pectoral fin and the navel (Table 2).

At sea (Table 1), we only accepted the sighting of two animals moving together 25 nautical miles SSE from Port Cros Island France on 30th August 1987. The observer, an experienced whale-watcher, knowing the other four species of rorqual well, was attracted by the unusual "jizz" (**) of the two animals (Ripoll T. in litt.). The poor quality and bad incidence of the slides do not allow an estimate of the size, shape and position of the dorsal fin. No white patch could be seen on the right jaw of either of the two whales neither at the surface, nor during under water swimming observations. The size of the two animals was similar and estimated to be less than 16 m when compared to the sail boat.

2) Blue whale Through our researching into samples, we found a baleen plate collected by a local resident from a rorqual stranded at Port Leucate, France, at the end of February 1985. Some of the characteristics of this plate (color, diameter of fringes, etc.) correspond to those of the blue whale (Yochem *et al.*, 1985). Unfortunately, the carcass was destroyed off shore by the sanitary services before being examined by cetologists and to date no photographs of the entire animal could be found. This animal may have been a blue whale. If further research confirm its identity, it will be the first documented in the Mediterranean Sea.

CONCLUSION To collect data through local residents' encounters is a hard, thankless task needing diplomacy and a good knowledges of the country's habits. Most information is not useful but some of it gave us the opportunity to discover a second stranding and a second sighting of sei whale and, perhaps, the first data concerning blue whale in the Mediterranean Sea (Fig.l).

* G.E.CE.M., Groupe d'Etude des Cétacés de Méditerranée.

** "jizz" comes from "GIS", General Impression and Shape, a term created by radar observers during the second world war to recognise foreign planes. GIS was transformed to jizz" by bird watchers to describe the way it is possible to identify a bird (and by extension all kinds of animals, people, cars, etc) at a glance using feelings and other subjective criteria.

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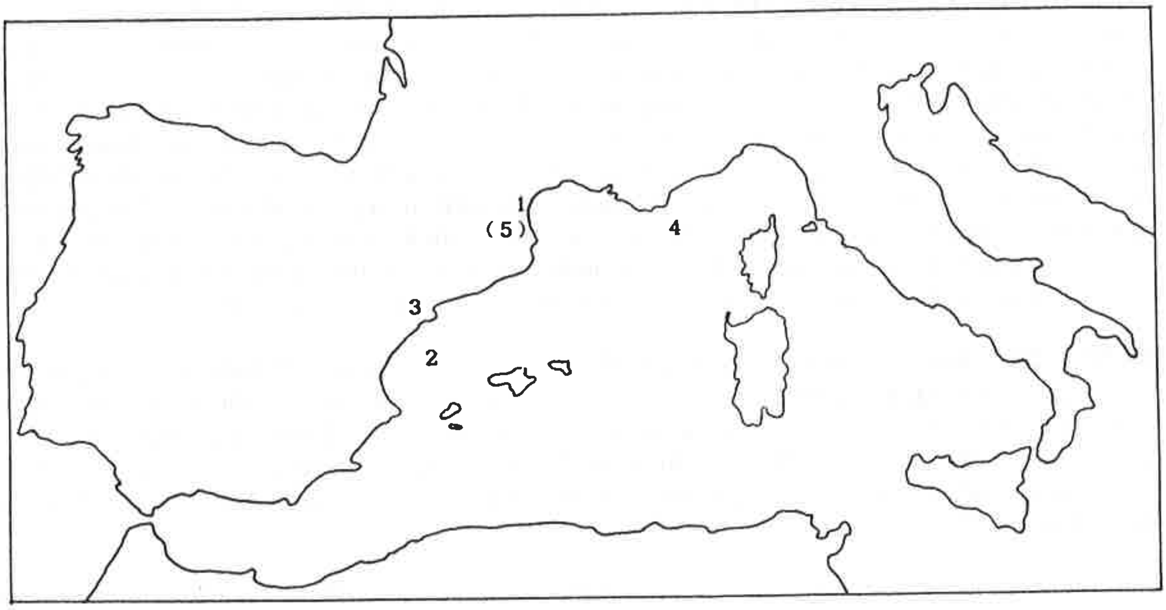
Table 1 Sightings of Sei whale, *Balaenoptera borealis.*

1st	June	1952,	near Columbreta Islands. Valencia Gulf, Spain, 1 albinos filmed (Bombard, 1952) .
30th	Augt	1987,	25 nautical miles SSE Port Cros Island, France, 2 individuals.

Table 2 Strandings of Sei whale, *Balaenoptera borealis.*

5th	June	1921,	Valras Plage. France. 15.2 meter long.
25th	Sept	1973,	Punta del Fangar, Ebro delta, Spain, 7.3 meter long young female, (Filella, 1974) .



I	Sei whale, *Balaenopterea borealis,*	5th	June	1921.
2	Sei whale, *Balaenopterea borealis,*	1st	June	1952.
3	Sei whale, *Balaenopterea borealis,*	25th	Sept	1913.
4	Sei whale, *Balaenopterea borealis,*	30th	Augt	1987.

(5) Blue Whale (?), *Balaenopterea musculus* (?), end February 1985.

Fig. 1 Distribution of sightings and strandings of *Balaenoptera borealis* and *B.musculus* in the Western Meiterranean Basin

PHOTO-IDENTIFICATION AND BEHAVIOURAL OBSERVATIONS OF FIN WHALES SUMMERING IN THE LIGURIAN SEA

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INTRODUCTION The fin whale, *Balaenoptera physalus*, the most common mysticete in the Mediterranean Sea, is particularly frequent during the summer months in the western Ligurian Sea between Corsica and the mainland coast of Italy and France. Details of the habits of fin whales in this region, as well as information on their migratory destinations and relationship to other North Atlantic fin whale populations, are still unavailable. The results of vessel-based surveys of fin whales in the Ligurian Sea during the summers of 1990 and 1991, as the first part of a long-term research on this species, are reported. The initiation of a photo-identification catalogue and the investigation of ecological and behavioural patterns are used for the preliminary description of this temperate latitude population. In addition, 42 biopsy samples were collected for genetic and contaminant analyses; the results of the contaminant analyses are presented by Focardi *et al.* (this vol.).

MATERIALS AND METHODS Research cruises were conducted aboard a 15-m long sailing vessel with auxiliary engine, between 6 June and 19 September, 1990, and between 2 June and 5 October, 1991. The study area comprised the offshore waters between Western Liguria and Northwestern Corsica. The water temperature ranged during the seasons from 18 to 28°C, with an average of 23.4°C. Routes were chosen to maximise sightings, and were determined daily on the basis of the previous days' experience. Observations were conducted by a minimum of one observer on either side of the boat. Observation time was considered for computations only when weather conditions were favourable, with a wind speed of less than 18 km/h and with visibility greater than 100 m. Observations consisted of uninterrupted bouts, the beginning or end times of which were determined when applicable, by departure or arrival time, sunrise, sunset and crossing of weather condition thresholds. Sighting frequencies were calculated by dividing the number of individuals sighted during each bout by the duration (in h) of that bout.

RESULTS Whales were encountered 107 times, for a total of 127 individuals sighted in two years. The sighting frequencies for 1990 and 1991 varied significantly, for reasons unknown (Fig. 1). Sighting frequencies increased in late June, and appeared to be declining in the autumn. Ninety-three sightings were selected for an analysis of the ecological relationships of the sighting locations, such as water depth and distance from the nearest coast (Table 1).

The mean group size throughout the two field seasons was 1.48, with a maximum of six. On most occasions whales were encountered alone; occasionally, two or more individuals were found together (Fig. 2).

Of the 127 fin whales sighted, 62 (49%) could be identified individually. The characters used to identify the whales, in accordance with the North Atlantic Fin Whale Catalogue, include dorsal fin shape, body pigmentation, and scars (Agler *et al.*, 1990). Most whales had recognisable scars, the majority of which were attributed to lampreys. Whenever possible, both sides of the whale were photographed, although a greater effort was concentrated on photographing the right side of the whale.

A catalogue number was assigned to each individual, followed by a letter indicating its dorsal fin type. To consider an animal identified, seven different characters were used, including the dorsal fin, the blaze and/or the chevron; to confirm a re-sighting, three characters were used (Agler *et al.*, 1990).

Nine whales were re-sighted once (14.5% of the total number of identified whales), always within a particular season, with sighting intervals varying between 2 and 95 days. However, there were no re-sightings from one summer to the next. Individual associations changed always between sighting and re-sighting, indicating a large variability in social aggregation. Newborn and juveniles (< 11 m length) were not seen.

On 13 occasions, defaecating whales were observed, and faeces were collected in 11 cases; their analysis revealed the marked predominance of *Meganyctiphanes norvegica*, the principal euphausiid in the study area, suggesting active feeding by the whales.

Fin whales were observed 23 times in association with striped dolphins, *Stenella coeruleoalba.* On four of these occasions, the dolphins were "bowriding" the whales.

Respiration data, recorded from 17 solitary individuals, are presented in Table 2. All respiration intervals greater than 3 minutes were considered to be dives.

CONCLUSIONS This two-year study confirmed the presence of significant numbers of fin whales in the Ligurian Sea during the summer months. Although we cannot provide conclusive evidence of a migration pattern of this population, the available data suggest that fin whales move into the Ligurian Sea on a summer trophic migration from unknown wintering groups. The increase in apparent abundance from June to July coincides with the seasonal pattern observed in more northerly oceanic feeding grounds, and circumstantial evidence such as the defaecation episodes, indicate that whales actively feed in this area.

Likewise, the decline of whale abundance in the autumn is suggestive of a seasonal migration similar to that observed in other mysticete species. However, given the limited range of surveys, the possibility of relatively local movements accounting for this decline cannot be dismissed. The very low re-sighting rate of recognisable individuals, and the lack of re-sightings across two consecutive years, suggest that the whale population size might be greater than expected, and that a longer period of study will be needed to provide quantitative data by means of photo-identification.

ACKNOWLEDGEMENTS This research was funded by Europe Conservation, the City of San Remo, the Interdisciplinary Centre for Bioacoustic Research of the University of Pavia, and the Italian Ministry of Merchant Marine. We wish to thank Mr. Gianni Cozzi and Mr. Pierfranco Gavagnin, Portosole San Remo, for their support and hospitality. M. Acquarone, S. Airoldi, G. Benazzo, J. F. Borsani, E. Cussino, G. Gnone, C. Morbioli, R. Pettinella, E. Valsecchi, and M. C. Venturino helped with the collection of data at sea. L. Orsi Relini analysed the faecal material.

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Table 1 Depth and location for 93 fin whale sightings

	$\overline{X}$	SE	RANGE
DEPTH (M)	2248	36.5	1000-2670
DISTANCE FROM THE NEAREST COAST (KM)	40.7	1.72	5.6-71.3

Table 2 Fin whale blow and dive statistics

	N	$\overline{X}$	SE	RANGE
No. of blows / surfacing	47	7.30	0.43	3-15
Blow interval (s)	161	26.1	1.70	4-134
Dive duration (s)	58	484.5	26.76	180-880

Fig. 1 Fin whale sighting frequencies in 1990 and 1991

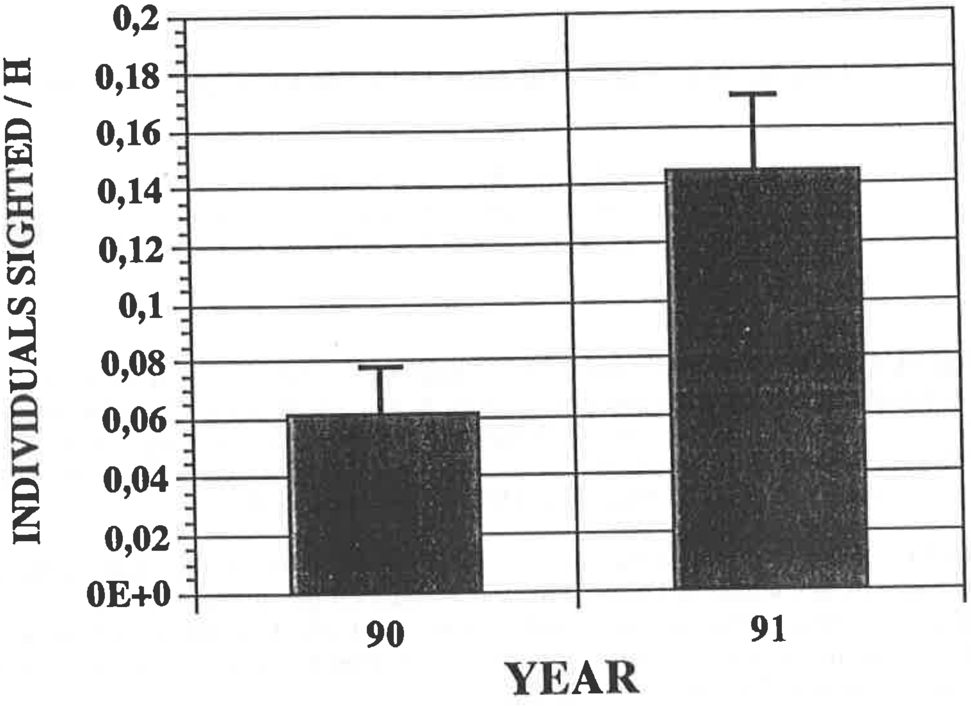
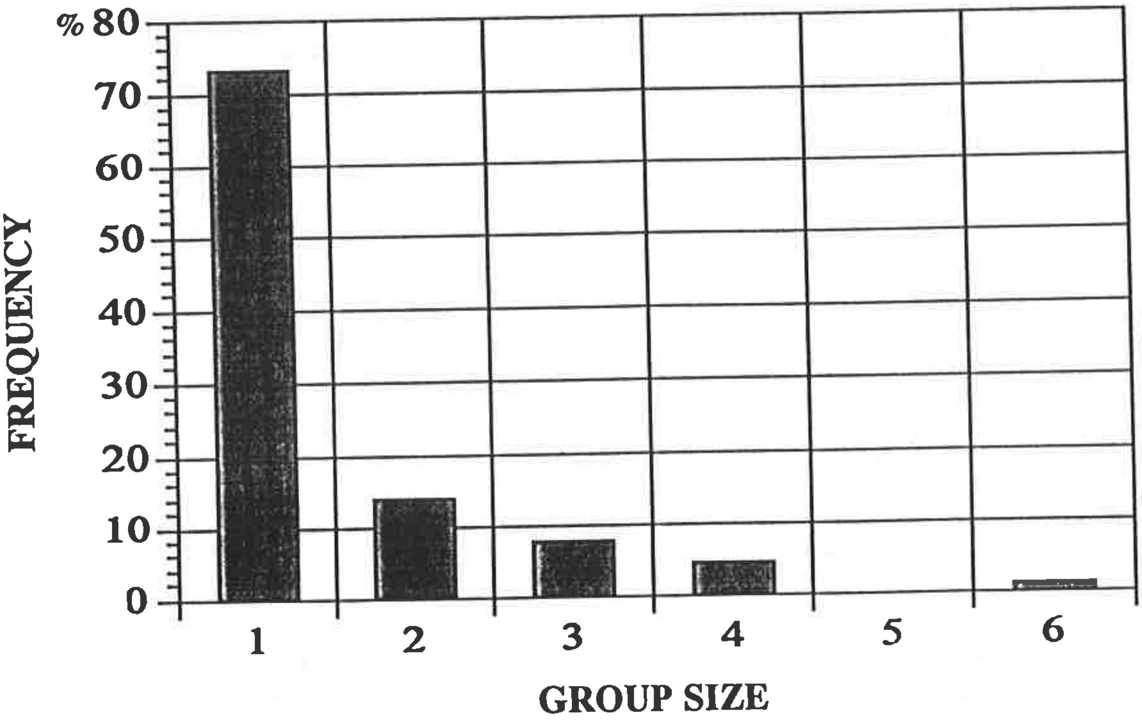


Fig. 2 Frequency distribution of fin whale group sizes (1990 and 1991 combined). Mean group size = 1.48.



FIN WHALE, *Balaenoptera physalus*, SURFACING RATES IN WEST GREENLAND

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INTRODUCTION An estimate of fin whale surfacing rates is a necessary part of the cue-counting method of abundance estimatation, as carried out in West Greenland (Hiby *et al.*, 1989). A mean surfacing rate of 36 surfacings per whale per hour was used in the 1987 and 1988 estimates. This mean surfacing rate is calculated on the basis of data collected during a survey in the North Atlantic in 1982 (Hiby *et al.*, 1984).

Hiby (IWC, 1991) concluded that the best available estimate of fin whale surfacing rates is 54.7 surfacings per whale per hour. This value reduced the abundance estimates from West Greenland by 34% (Hiby in IWC, 1991). The Scientific Committee of the International Whaling Commission at the same meeting recommended that studies of surfacing rates from West Greenland should be conducted.

This paper reports on the preliminary results from such studies carried out in West Greenland in 1991.

METHODS A total of approximately 40 hours of data on fin whale surfacing rates were collected during August 1991 near Ummannaq and Qeqertarsuaq/Godhavn, West Greenland. Observations of fin whale dive times were made from land at locations situated 10-70 metres and 20-100 metres above sea level at Ummannaq and Qeqertarsuaq/Godhavn, respectively. Water depths in the observation areas ranged from 100-400 metres at Ummannaq and from 60-600 metres at Qeqertarsuaq/Godhavn. Watch was kept in all daylight hours, weather permitting. At both locations, two observers collected the data using binoculars, digital stopwatches, and dictaphones. The data collected included the following:

- date;
- weather conditions;
- presence or absence of boats and/or ice;
- start time of observation;
- total observation time;
- number of whales;
- time of each blow to the nearest second.

All data were recorded until visual contact with the whales was lost either due to the distance becoming too great, or to poor weather conditions or ice in the area.

In the analysis, usable observation time is the sum of individual observation periods each exceeding 30 minutes (Gunnlaugsson, 1989). The observation periods all consist of continuous breathing and diving cycles from the first time the whale is observed until it disappears. The surfacing rate is defined as the number of surfacings per whale per hour. For each observation period exceeding 30 minutes (N=26), a mean surfacing rate was calculated. A total weighted mean surfacing rate was then calculated. We compared weighted mean surfacing rates from:

- two observation areas (Ummannaq and Qeqertarsuaq/Godhavn);
- two categories of group size: single whales or 2-3 whales (groups larger than three whales were not observed);
- two time periods: 0900 h to 1800 h, and 1800 h to 0900 h (although no observations were carried out between 2400 h and 0900 h).

RESULTS The total observation time was 39:38:01 (hour:min:sec). Of this, a total of 28:23:37 (hour:min:sec) consisted of periods each exceeding 30 minutes (usable observation time).

For usable observation time, we obtained a weighted mean surfacing rate of 64.67. However, we found a difference between Ummannaq and Qeqertarsuaq/Godhavn. The surfacing rate was 59.04 for Ummannaq and 68.88 for Qeqertarsuaq/Godhavn (Table 1). We have not tested this difference statistically.

Our results indicate that surfacing rates are higher when only one whale is present in the area than when 2-3 whales are together. When only one whale is present, the surfacing rate is 73.56 from Ummannaq and 73.89 from Qeqertarsuaq/Godhavn. When 2-3 whales are together, the surfacing rate is 52.16 from Ummannaq and 67.64 from Qeqertarsuaq/Godhavn (Table 2).

Also, our results indicate a higher surfacing rate in the evening than during daytime. In the period from 0900 h to 1800 h, the surfacing rate is 48.46 from Ummannaq and 66.8 from Qeqertarsuaq/Godhavn. From 1800 h to 0900 h, the surfacing rates were 81.46 and 69.39 from Ummannaq and from Qeqertarsuaq/Godhavn, respectively (Table 3). It should be noted that the latter surfacing rate from Qeqertarsuaq/Godhavn is based on only one observation. Neither of these comparisons are tested statistically.

DISCUSSION Our results indicate that the surfacing rate could depend on the observation area, the number of whales present, and time of day of the observation.

We found a mean surfacing rate of 64.67 blows per whale per hour. Hiby (IWC, 1991) concluded that the best available estimate of fin whale surfacing rates is 54.7 surfacings per whale per hour. This difference in mean surfacing rate could be explained by a number of parameters such as those listed above.

It might be due to differences between the observation areas. We found for instance a higher mean surfacing rate in Qeqertarsuaq/Godhavn than in Ummannaq, but we have not statistically proved this. The difference between Ummannaq and Qeqertarsuaq/Godhavn might simply be due to too few data, although this has to be further investigated.

However, the most interesting finding is that the value of 54.7 surfacings per whale per hour is calculated mainly on the basis of observations carried out when only one whale was present. It was our impression during observations that the surfacing rates were higher when only one whale was present in the area than when two or three whales were together. This showed to be true for both Ummannaq and Qeqertarsuaq/Godhavn. This might indicate that the whales have a different behaviour when alone, since we observed more blows between dives in observations including only one whale. If this is the case the mean surfacing rate referred to in Hiby (IWC, 1991) is higher than it would be if corrected for this possible bias. This would lead to an even bigger difference between Hiby's and our results.

It was also our impression during observations that the surfacing rate was higher during the evening than during daytime. This is interesting since aerial surveys in Greenland are mainly carried out between 0900 h and 1800 h. We observed that the whales spent much time at or near the surface during the evening. Often they made small circles on the surface and showed their flippers and tail. This could be due to feeding behaviour. Our results indicate a possible difference in surfacing rates between 0900 h and 1800 h and between 1800 h and 0900 h. If the data referred to in Hiby (IWC, 1991) is mainly obtained between 0900 h and 1800 h, the value of 54.7 surfacings per whale per hour should perhaps instead be compared to the mean value of 59.89 surfacings per whale per hour (Table 3), which we calculated from data collected in this period. Nevertheless, the other parameters, which could also influence on the surfacing rate, are not considered.

At this point we have too few data to test any of our hypotheses statistically. If however they turn out to be true, these parameters should be considered when calculating a mean surfacing rate to be used for cue-counting abundance estimates.

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Table 1 Weighted mean surfacing rates for observation periods exceeding 30 minutes calculated as surfacings per whale per hour.

Location		**Surfacing rate**
Ummannaq	(N = 12)	59.04
Qeqertarsuaq/Godhavn	(N = 14)	68.88
Total	(N = 26)	64.67

Table 2 Weighted mean surfacing rates for observation periods exceeding 30 minutes calculated as surfacings per whale per hour.

Location/Number of whales	One whale	2-3 whales
Ummannaq	73.56 (N=5)	52.16 (N=7)
Qeqertarsuaq/Godhavn	73.89 (N=4)	67.64 (N=10)
Total	73.70 (N=9)	62.09 (N=17)

Table 3 Weighted mean surfacing rates for observation periods exceeding 30 minutes calculated as surfacings per whale per hour.

Location/Time of day	9 am - 6 pm	6 pm - 9 am
Ummannaq	48.46 (N=7)	81.46 (N=5)
Qeqertarsuaq/Godhavn	66.80 (N=12)	69.39 (N=1)
Total	59.89 (N=19)	77.48 (N=6)

CUVER'S BEAKED WHALE, *Ziphius cavirostris*, ON THE IBERIAN PENINSULA

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The study of the Cuvier's beaked whale, *Ziphius cavirostris*, on the Iberian Peninsula has always been difficult because of its pelagic habits. Due to this fact, strandings of this species on our shores are relatively scarce.

The distribution of strandings and other observations of this species on the coasts of the Iberian peninsula are presented on a map, with an approximate idea of their frequency (Fig. 1).

A list of all strandings is given in Table 1, including date, location, numbers, and the name of the observer/literature reference.

Table 1 List of all records of Cuvier's beaked whale from the Iberian Peninsula, between 1889 and 1991.

NO.	DATE	LOCATION	NATURE OF RECORD	REFERENCE
1	18.06.1889	Puerto Chic, Santander	Caught	Castrillo, 1986
2	1893	Santofía, Santander	Stranded	Linares & Rioja, 1894
3	12.04.1896	Santander	Stranded	Echegaray, 1978
4	03.06.1897	Santander	2 stranded	Cabrera, 1914
5	02.06.1898	Sardinero, Santander	Caught	Rioja, 1906
6	03.1919	Matar, Barcelona	Stranded	Cabrera, 1919
7	09.1917	Alvero, Portugal	Specimen	Teixeira, 1977
8	03.1919	Mataro, Barcelona	Specimen	Cabrera, 1919
9	25.05.1991	Malaga	Caught	Cabrera, 1919
10	05.06.1940	Valle Niz, Malaga	Stranded female	Bellon, 1943
11	16.03.1943	Roquetas, Almeria	Stranded	Lopez-Neyra, 1943
12	29.01.1944	Valencia	Stranded fem.	Sala de Castellaranu, 1945
13	05.06.1944	El Arenal, Mallorca	Stranded male	Lozano Rey, 1947
14	05.09.1944	Torredembarra, Tarragona	Caught female	Vallmitjana, 1946
15	07.11.1961	Torre Zanyamel, Mallorca	Stranded	Casinos & Vericad, 1976
16	04.01.1964	Ago, Santander	Stranded	Cendero, 1976
17	08.1964	Ribamontà, Santander	Stranded	Cendero, 1976
18	08.1964	Can Simont, Mallorca	Stranded	Alcovel & Mayol
19	1965	Peniche, Portugal	Specimen	Teixeira, 1979
20	07.04.1965	Pollença, Mallorca	Stranded	Delvosalle & Duvigneaud, 1967
21	12.03.1970	Lastres, Oviedo	Caught	Norés
22	20.03.1970	Badalona, Barcelona	Stranded female	Filella, 1971
23	08.1972	Binibeca, Menorca	Stranded	Casinos & Vericad, 1976
24	29.01.1973	Garraf, Barcelona	Stranded	Casinos & Filella, 1975
25	25.03.1973	Camp de la Bota, Barcelona	Stranded female + foetus	Filella, 1975
26	15.04.1973	Gijon, Oviedo	Caught male	Nores
27	13.06.1973	Estartit, Gerona	Stranded female	Casinos & Filella, 1975
28	19.12.1973	Bogatell, Barcelona	Stranded female	Casinos & Filella, 1975
29	02.05.1974	Santander	Stranded male	Cendrero, 1976
30	22.02.1977	Peniche, Portugal	Stranded	Teixera, 1979
31	03.04.1977	Peniche, Portugal	Stranded male	Teixera, 1979
32	15.05.1977	Oporto, Portugal	Specimen	Teixera, 1979
33	02.12.1979	Cabanes, Costellón	Stranded	Aguilar, Grau & Filella, 1980
34	09.08.1981	Es Vive, Ibiza	Stranded female	Grau *et al.*, 1986
35	05.09.1981	NW Coast	Specimen	Aguilar *et al.* , 1983
36	07.10.1981	Matozinhos, Portugal	Stranded female	Reiner, 1982
37	11.10.1981	Delta del Ebro, Tarrag	2 stranded vertebrae	Grau *et al.*, 1986
38	04.11.1981	Mamola Beach, Granda	Female	Rey & Cendrero
39	06.05.1982	San Ciprián, Lugo	Male	Penas *et al.*
40	31.05.1982	San Pedro de Muel, Portugal	Stranded	Rodeia
41	1983	Finisterre, Coruña	Specimen	Penas *et al.*
42	01.04.1983	Villaviciosa (Oviedo)	Stranded female	Norés, 1986
43	28.04.1983	Lisboa, Portugal	Stranded	AVG
44	14.08.1983	Vimerio, Portugal	Stranded	Martinho
45	07.1984	Llanes, Oviedo	Stranded	Norés *et al.*, 1990
46	14.05.1985	Santoña, Santander	Stranded female	Castrillo
47	13.10.1985	43°49' N - 03°48' W	10-14 observed.	Cendrero
48	02.1988	Riberia, Coruña	Stranded	Fdz. de la Cigoña, 1990
49	09.02.1990	El Grove, Ponteverdra	Stranded male	Fdz. de la Cigoña, 1990
50	19.01.1991	El Grove, Ponteverdra	Stranded male	Fdz. de la Cigoña, 1991

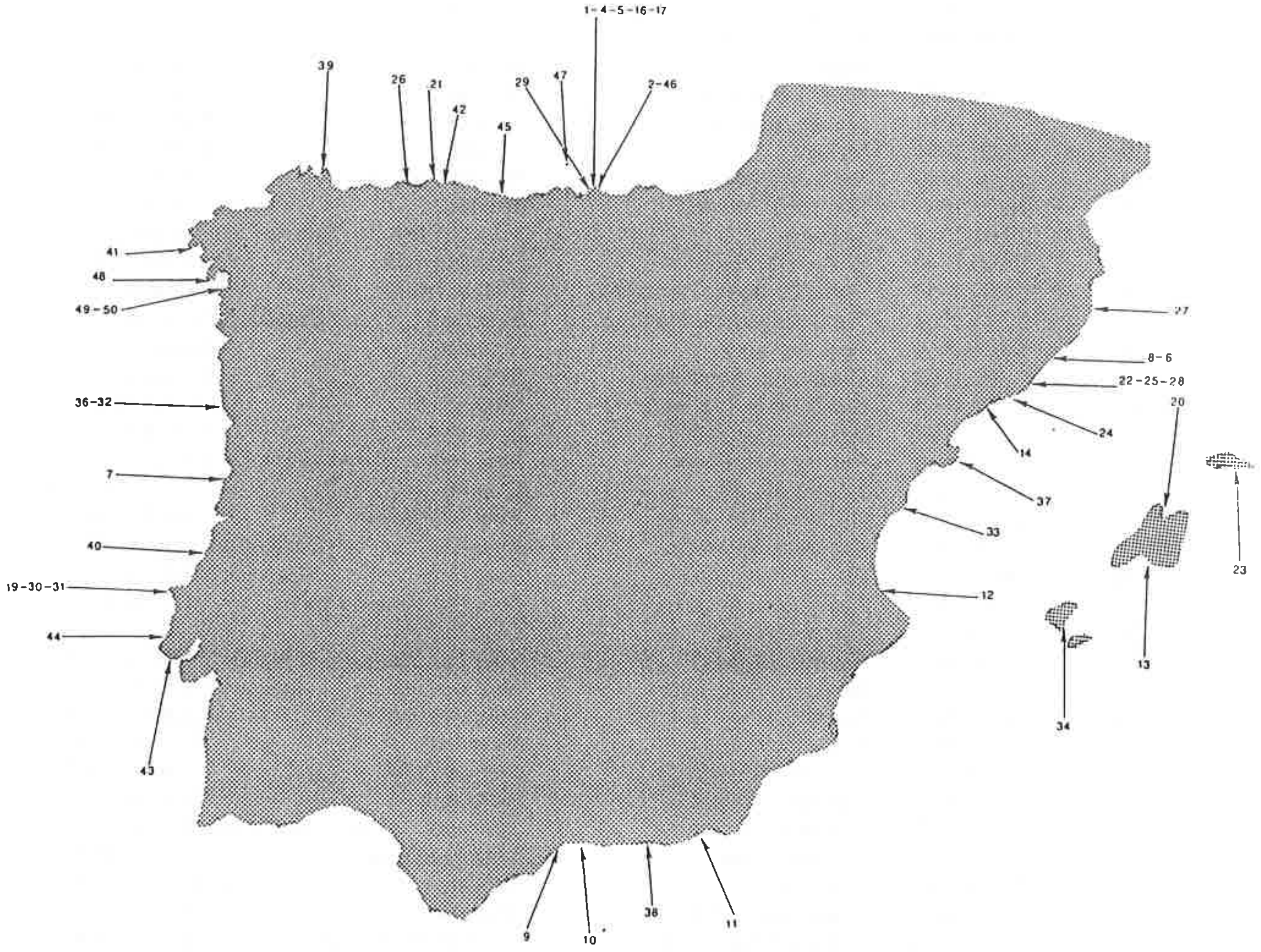

Fig. 1 Geographical distribution of records of Cuvier's beaked whales *Ziphius cavirostris*, in the Iberian Peninsula and Balearic Islands

FIRST ACCOUNT ON THE BIOLOGY OF CUVIER'S BEAKED WHALE, *Ziphius cavirostris*, IN THE CANARY ISLANDS

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INTRODUCTION Cuvier's beaked whale *Ziphius cavirostris* is a species with a wide distribution in warm and temperate deep-waters. With a low relative frequency of records (Fig. 1), the information regarding its biology is rather fragmentary and nothing is known about its abundance. Up to the present, several specimens stranded on coasts have been examined, and the present paper shows the preliminary results with reference to these data. Most strandings have occurred in June but with secondary peaks in strandings in February and November (Fig. 2).

MATERIALS AND METHODS Specimens were measured according to Norris (1961), and during necropsies we took special care with stomach contents, parasites and gonads.

RESULTS (a) BIOLOGY

Feeding habits It is known that Cuvier's beaked whales, *Z. cavirostris*, feed on a wide variety of mesopelagic organisms, especially squid, crustaceans and in the last instance, fishes. The stomach contents of nine animals have been examined, and most of the prey items are being identified at present (see Table 1).

Reproduction Information on reproductive parameters of this species is rather scarce. Omura *et al.* (1955) reported that the mean length of sexually mature males was 5.50 m. Weight of the gonads from specimens necropsied by us is as follows;

- In a physically mature male of 529 cm stranded on Las Playitas (Fuerteventura), the right and left testes size were 341 and 350 g respectively.
- Another specimen from Guazimeta (Lanzarote) of 365 cm length had testes weighing 30 and 20 g respectively. In two males stranded on Tazacorte (La Palma) of 485 and 508 cm length, the left and the right testes weighed 72 and 83 g respectively. There are no data on the reproduction for females.

Growth We used the degree of ossification of the epyphysis of the flippers to determine the state of physical maturation of the specimens. However, there is limited information with respect to this. Except the Las Playitas male, all specimens examined by us (a female of 430 cm and three males of 488, 529, and 365 cm) were immature.

(b) EPIZOITS AND PARASITES

Epizoits We have found in several specimens large numbers of pseudo-stalked barnacles *Xenobalanus globicipitis* (Steenstrup, 1851) particularly on the flukes.

Ectoparasites Some copepods of the genus *Pennella* (Sphonostomatoidea: Pennellidae) have been observed embedded on the skin of the flanks of some individuals. In a specimen from Las Galletas (Tenerife), several unidentified cyamids "whale-lice" (Amphipoda: Cyamidae) were collected.

Endoparasites We have recorded some species of nematodes. Worms belonging to the genus *Anisakis* (Ascaridia: Anisakidae) have been collected from the stomachs of four specimens (Raga, pers. commn.). This nematode has been reported previously for the species (Kenyon, 1961; Fordyce *et al.*; 1979). Particularly high is the incidence of heavy infestation caused by the nematode *Crassicauda* sp. (Nematoda: Spirurida) in the kidneys; this parasite was found in all the specimens examined by us to date. The cestode *Phyllobothrium* sp. was found encysted in the blubber.

On the skin of many specimens we observed oval scars inflicted by the "Cookie-Cutter" shark *Isistius brasiliensis* (Scualiformes: Scualidae). The dorsal surface and flanks of numerous males show extensive scarring due to intra-specific aggression between individuals. Diatoms often cover the skin of some individuals.

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Table 1 Stomach contents of stranded Cuvier's beaked whales.

KEY LT = Length S = Squid F = Fish C = Crustaceans

	SEX	LT	S	F	C
Z. cavirostris	♂	485	●		
Z. cavirostris	♂	508	●		●
Z. cavirostris	♂	529			
Z. cavirostris	♂	365		●	
Z. cavirostris	♂	488	●		
Z. cavirostris	♀	435	●	●	●
Z. cavirostris	♀	612	●	●	●
Z. cavirostris	♀	430			
Z. cavirostris	♀	540		●	

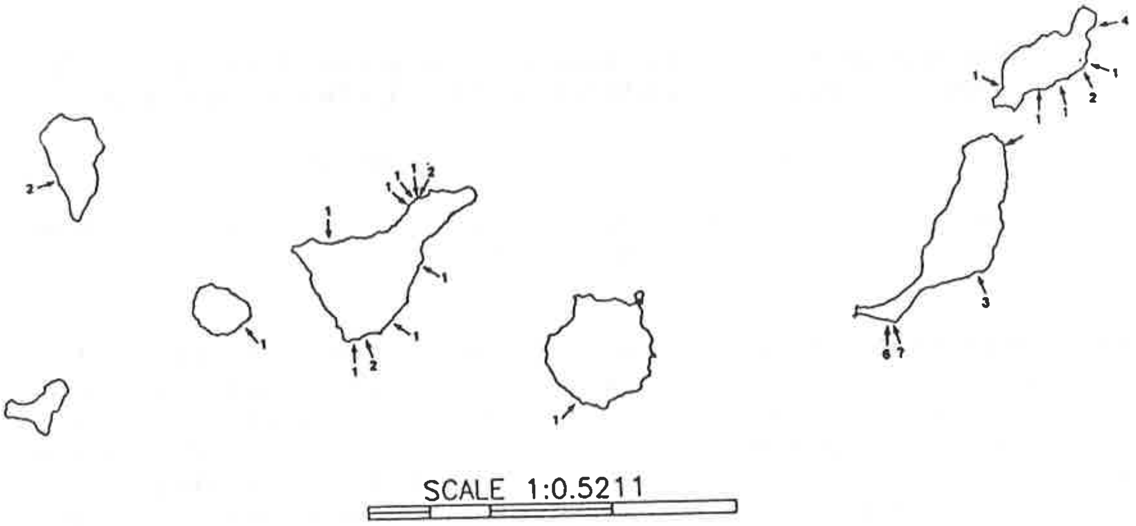

Fig. 1 Distribution of stranded Cuvier's beaked whales recorded in the Canary Islands.

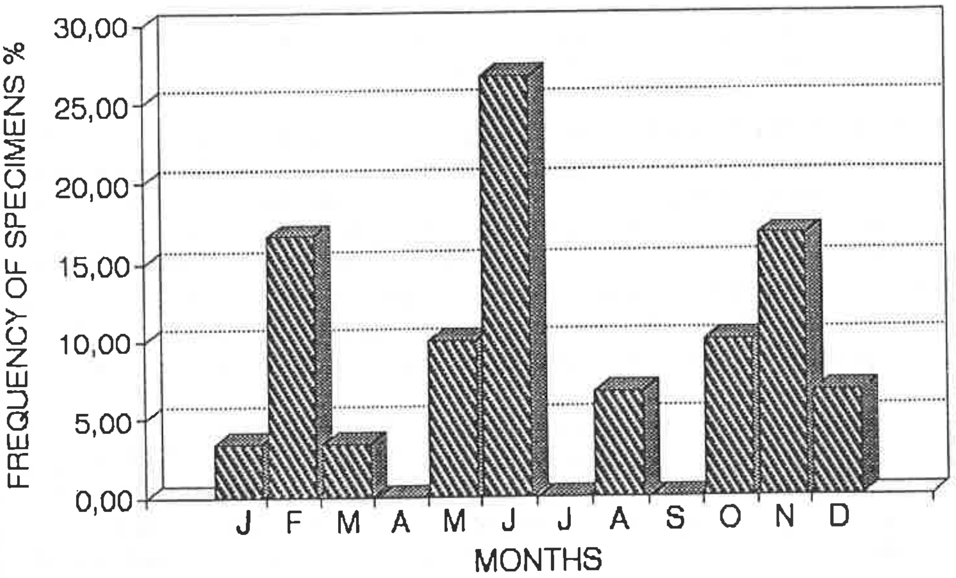

Fig. 2 Seasonal frequency of strandings of Cuvier's beaked whales in the Canary Islands.

A DWARF SPERM-WHALE, *Kogia simus*, STRANDED IN BRITTANY: SECOND RECORD FROM ATLANTIC EUROPEAN WATERS.

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INTRODUCTION Marine mammals found stranded on the coasts of France have been permanently recorded since 1976 by a network of field correspondents coordinated by Dr R. Duguy. Although such an approach cannot help in assessing absolute population sizes of oceanic species, it does provide valuable insights into long-term trends of their relative abundance (e.g. Hussenot *et al.*, in prep. for a synthesis of strandings in Brittany). Additionally, considerable basic biological data have been drawn from stranded specimens of the most common species (e.g. Collet and Harrison 1981, and others). However, it is now generally believed that the populations sampled through stranding surveys are not necessarily representative of the populations living offshore and, consequently, that further biological information should be obtained by using other sampling procedures. Nevertheless, for the rarest species, biological information is so scarce that data derived from stranded animals are still of value.

Some species are rare in European stranding records but common in adjacent areas, whereas others are uncommon and/or poorly known worldwide. The dwarf sperm-whale (*Kogia simus*), belongs to this latter catagory since, following Klinowska (1991), "[Its] abundance and status..... is unknown," and "the major need is for more information on distribution, numbers, ecology and behaviour".

In this paper, we make a preliminary report on one very well preserved specimen of dwarf sperm-whale, recently founded stranded in Brittany.

METHODS AND RESULTS The animal was found still alive in very shallow water near Port-Louis (southern coast of Brittany, France - Fig. 1) on the 24 October, 1991. As the local firemen were attempting to get the animal back into the sea, it vomited blackish liquids with some parasitic worm, and died. It was then identified from external features and number of teeth as a male dwarf-sperm whale, and removed from the fire station to Oceanopolis, Brest, for further examination. A plaster cast of the whole body was taken and a necropsy then carried out. Although none of is a pathologist, we tried to follow the guidelines proposed by T. Kuiken (unpublished report) for gross post-mortem studies.

No obvious reason for its stranding and death was found on external examination, and the skin was free of any parasite and necrosis. In the integument, blubber parasites were present at rather high densities in the anal area, and at very low densities, if at all, elsewhere. No adverse symptom was found in either the musculo-skeletal, respiratory, cardiovascular or urogenital systems, and the nervous system was not investigated. The alimentary tract was characterised by high nematode infestation in the stomach and fore-stomach, and by obtrusion by tightly hardened, black faecal material in a one metre long section of the small intestine. Food materials observed consisted of accumulated loose squid beaks with no flesh remains at all, thus indicating that the whale had not been feeding for a while.

Further information will be available as the analyses of the following tissues and organs (teeth, reproductive tract, tissues for histopathology, tissues for pollutants, parasites and stomach contents) are achieved.

DISCUSSION Both *Kogia* species are rather poorly known toothed whales inhabiting temperate to tropical waters worldwide. They are often referred to as rare species but this may be partly due to their inconspicuous behaviour at sea and their small size (Caldwell & Caldwell, 1989; Klinowska, 1991). However, stranding data suggest that they are not uncommon in a few areas: in southern United States, South Africa, and Japan the ranges of both species widely overlap but the dwarf sperm-whale is apparently more restricted in range latitudinally. Population sizes are unknown in Florida, but at least the latter species appears to be significantly less numerous than its congener (Caldwell & Caldwell, 1989).

In accordance with these gross distributional data, both species are not resident in European waters, although they occasionally strand from Gibraltar to the British Isles, the pigmy sperm-whale, *Kogia breviceps*, being more prevalent. Indeed, since the recognition of the two *Kogia* species (Handley, 1966), seven pygmy sperm-whales have been found stranded in Portugal and Spain - five in France and one in the British Isles (Evans, 1980; Penas-Pitino & Pinerio Seag, 1989 and Duguy's report 1966 to 1991) whereas only one dwarf sperm-whale has ever been identified from the European Atlantic coasts (Duguy, 1987) and another one from the Mediterranean Sea (Baccetti *et al*, 1991). Consequently the present observation is, to our knowledge, only the second record of a dwarf sperm-whale from Atlantic European waters and is the best preserved specimen.

Other species of tropical Atlantic origins, mainly from Florida and the Gulf of Mexico, can also be found in Brittany: Fraser's dolphin, *Lagenodelphis hosei*, short-finned pilot whale, *Globicephala macrorhynchus*, leatherback turtle, *Dermochelys coriacea*, loggerhead turtle, *Caretta caretta*, have been recorded. Sun fish, *Mola mola*, and flying fish (unidentified Exocetidae) have also been recorded, as well as some planktonic forms (*Velella* sp. and *Physalia* sp.).

Although their occurrence may not be driven by one single phenomenon, the significance of these sightings and any temporal variation (purely incidental, cyclical, or trends) are unknown. The careful recording of such events in areas which are distributional limits for these species may help in monitoring global faunistic changes. Such an approach is now being carried out for rare fishes observed in southwest Britain (Swaby & Potts, 1990). The addition of data from cetaceans, turtles and other organisms may provide somewhat more consistency to hypotheses and conclusions inferred from these rare events.

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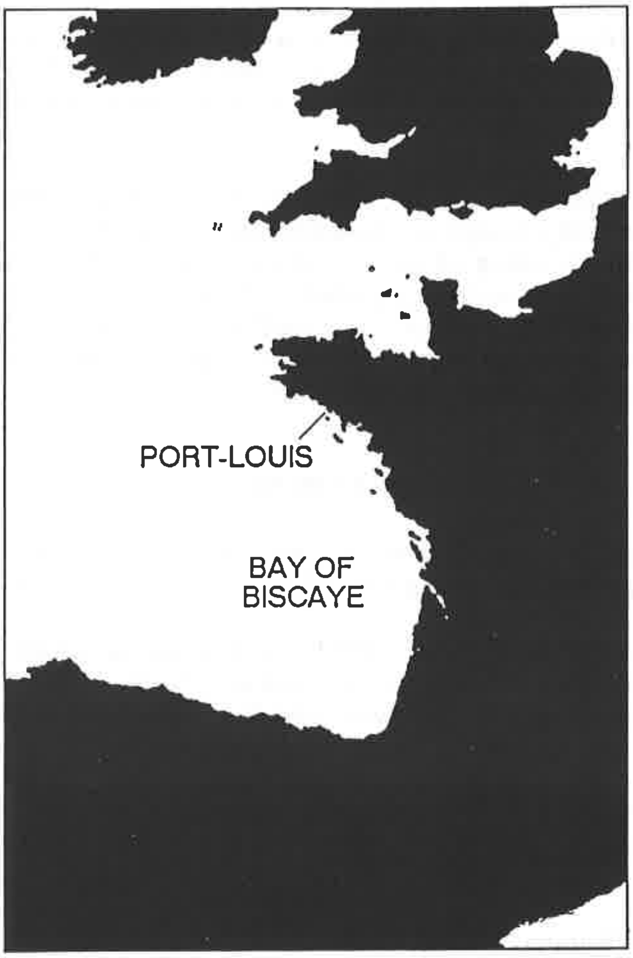

Fig. 1 Location of stranded dwarf sperm-whale

PRESENCE AND INDIVIDUAL RECOGNITION OF LONG-FINNED PILOT WHALE, *Globicephala melas*, IN THE LIGURO-PROVENÇAL BASIN

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INTRODUCTION Previous studies have documented the presence of long-finned pilot whale, *Globicephala melas*, in the Mediterranean (Vallon *et al.*., 1976, Leatherwood *et al.*, 1978), but little is known about their etho-ecology and abundance in this sea. This preliminary research concerns some short-finned pilot whale sightings, obtained during our oceanographic cruises "Cetacei del Mediterraneo" and the "Missioni G. Relini". These sightings enabled us to start an etho-ecological study on short-finned pilot whales in the open sea, and to collect photographic material useful for a photo-identification catalogue of individuals of this species.

METHODS The oceanographic cruises "Cetacei del Mediterraneo" were carried out annually from 1986 until today, annually, during the summer period on board the R/V Minerva of CNR, in an area bounded by 41°20' - 44°20' N and 5°30' - 10°00' E (Liguro-Provençal Basin). This area has been covered by uniform transects along which we studied the species of cetaceans sighted.

The methods used are direct observation, line-transects, individual recognition, surface and underwater film, and continuous reading of the echosounder to show the presence of possible cetacean prey. Whenever possible, the animals were always approached closely in a small outboard boat, to facilitate behavioural observations and photo-identification. For individual recognition, we used both colour slides and black-white film, taken with a 35 mm. camera and 70-210mm zoom lens .

RESULTS Of the 12 species in the Mediterranean Cetacean Fauna, eight have been sighted during the cruises "Cetacei del Mediterraneo" (Giordano A. 1988, 1990). Of these, *G. melas* comes sixth in annual frequency of sightings. We observed short-finned pilot whales in three different years (1988, 1990 & 1991), with a total of five sightings. All these were located in pelagic waters over a depth of 2,000 metres. The echo-sounder readings relating to the *G.melas* sightings did not show any significant biomass of potential prey. On the other hand, the observed behaviour, which showed a limited repertoire, did not indicate a hunting attitude (Table 1).

The schools were composed of small subgroups of about ten individuals, which during the period of the observation seem to maintain some structure and a subgroup arrangement with individuals separated by some hundred metres one from another. All the observed subgroups comprised adults and calves, and in three cases we also noted newborn animals (neonates). One of the subgroups showed the nursery structure type, i.e. calves and neonates, attended by two adults. From underwater observations, it was possible to see a large number of females present, which, as already described in the genus *Globicephala* (Heimlich-Boran J.R. *et al.*, 1990; Miyashita T. *et al.*, 1990), suggests matrilinear subgroups.

At present, the study of individual features has allowed photo-identification of twelve individuals, derived from two sightings in 1990(B) and 1991(A). For individual recognition, we used both dorsal fin shape and marks present on the dorsal part of the body.

CONCLUSIONS These first and preliminary results indicate a significant presence of short-finned pilot whales in the area studied, which is repeated annually in the same zone.

This species seems to be particularly suitable for study using photo-identification techniques, due to its gentle and calm behaviour, the gregarious structure, and the high heterogeneity of individual features found in these animals. However, it will be necessary in the future to observe if these features evolve and in what manner. This research will be continued next year , with the hope of increasing the knowledge of this interesting species in the Mediterranean.

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Table 1 School number and behaviour observed in Short-finned Pilot Whales, *Globicephala melas*.

		BEHAVIOUR		
CRUISES	**SCHOOL SIZE**	**Slow swimming**	**Tail slapping**	**Spy hopping**
1988 Relini	50	*	*	*
1990 A Giordano	20	*		
1990 B Giordano	10	*	*	*
1991 A Giordano	50	*	*	*
1991 B Relini	40	*		

POPULATION ABUNDANCE OF STRIPED DOLPHINS INHABITING THE WESTERN MEDITERRANEAN SEA

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INTRODUCTION During the striped dolphin die-off of 1990, hundreds of dolphins were found dead along the Mediterranean coasts of Spain, France, Morocco and Northwestern Italy (Aguilar and Raga, 1990). Dead animals were also observed at sea and it is likely that many more dolphins were never recovered. It was impossible therefore, to evaluate the total number of dead animals. The lack of any population estimates for this species in the affected area meant that the effect of the epizootic on the population could not be assessed.

Several short cruises organised by Greenpeace and the University of Barcelona, and an aerial survey organised by the University of Barcelona and the Institute for Nature Conservation of Spain (ICONA), were conducted during the die-offs to investigate the effects of the mortality in some of the affected areas. The results suggested that changes had occurred in the size and composition of striped dolphin schools for these areas. However, it was not possible to estimate the abundance of the remaining population because the number of sightings for each survey was insufficient. In August 1991, Greenpeace, in collaboration with the University of Barcelona and the Sea Mammal Research Unit in UK, organised a five weeks sightings cruise in the western Mediterranean with two major objectives.

The first objective was to determine the distribution of striped dolphins in the area during this time of the year, in terms of both geographical location and oceanography. The second objective was to estimate the density and absolute abundance of striped dolphins in the area after the die-off and, in so doing, to establish a reference for future work. With such a basis, changes in population status could be monitored in future years.

METHODS The time available for the survey did not allow coverage of the entire western Mediterranean basin in a single cruise. Therefore, priority was given to surveying those regions affected by the die-off. The only parts not covered were the Tyrrenian Sea and the southeasternmost parts of the basin, from the Ionian Sea to the Sicily Channel, where the die-off was not detected during the 1990 outbreak.

The cruise track was designed to provide a representative sample of data for each sub-area, with tracks organised in a systematic zig-zag or saw-toothed pattern for efficiency, with a random element introduced to determine the starting point of the tracks in each sub-area.

Figure 1 shows the different areas as well as the cruise track. The survey was conducted using the Greenpeace vessel MV "Sirius", a 46m ship with a cruising speed of 10 knots. The observation platform was situated 8m above sea level. Each school of cetaceans sighted was approached to confirm the species and school size.

Line transect sampling methods (Burnham *et al.*, 1984) were used to analyse the data and to calculate an estimate of striped dolphin abundance for the whole area. The data analysis was undertaken using the recently developed computer program DISTANCE (Laake and Buckland, 1991) which allowed the calculation of variation using so-called Bootstrap methods. The calculation of effort and the size of the area surveyed was carried out using specifically designed software routines. An analysis of the effort data satisfied by Beaufort scale was carried out to determine whether or not data collected at higher Beaufort scale should be discarded.

RESULTS

Variation of school size Before the epizootic, most of the schools were moderate in size (70% of the school were composed of 1-20 animals), and groups larger than 50 individuals were present but scarce. During the die -off, 70% of the schools observed during the short survey cruises ranged from 1 to 5 animals, and big groups appeared almost non-existent. After the die-off, the average size of the striped dolphin schools was smaller than before it, but the average size was greater with more big groups than during the event. Of course, given the short period of time that had elapsed since the die-off, this should not be seen as an actual recovery of the population, but it could indicate a regrouping of the survivors into a smaller number of schools of similar sizes to before.

Estimate of abundance The total number of striped dolphin schools sighted was 126, of which 114 were primary sightings made during Beaufort scales 0 to 3. The distance sailed under these conditions while on effort was 4,360.5 km. For this preliminary analysis, the data from all sub-areas were pooled.

Average school size was estimated to be 19.7 animals with a coefficient of variation (CV) of 17.4%. The average number of schools encountered was 0.0227 schools/km with a CV of 20.3%.

The total number of animals in the area surveyed can be estimated at 225,000, with a CV of 27.8%. The lower 95% confidence interval is 131,000 and the upper 95% confidence interval is 386,000.

ACKNOWLEDGEMENTS Thanks are due to all the people who participated in the cruise, on board the "Sirius" and, very especially, to the crew that patiently adjusted their work to the needs of the field work. Marius Tresànchez was of great assistance in the preparation of the software routines. The Spanish Institute for the Conservation of the Nature (ICONA) and the Interministry Commission for Science and Technology of Spain (CICYT) (project NAT90-1255-E) funded the participation of the members of the University of Barcelona in the project.

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• FIGURE 1

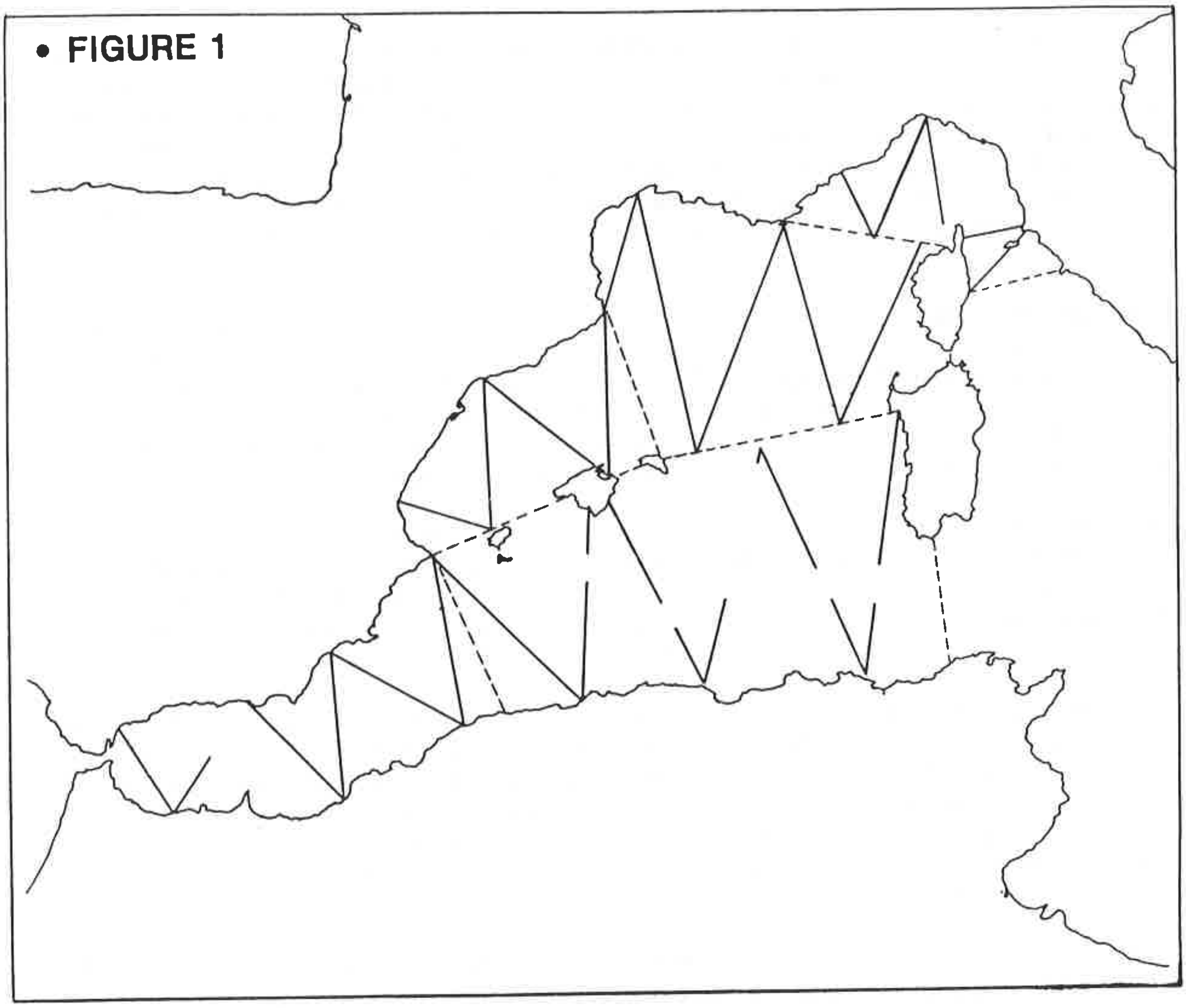

Fig. 1. Map of transect lines used during survey of Western Mediterranean

CETACEANS IN THE PERSIAN GULF: AFTER THE WAR

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The Gulf war, fought in the early months of 1991, resulted in unprecedented environmental damage. The world´s largest oil spill, estimated at four to eight million barrels, entered the sea (MEPA, 1991) and the burning of over 700 oil wells in Kuwait caused atmospheric pollution and resulted in oil lakes and rivers, and toxic fall-out.

There is very little information on the distribution and abundance of marine mammals in the Gulf, but it is possible that the Gulf war oil spills have had an effect on marine mammals. Indeed, it is likely that there could be long term effects on these and other groups of species from the input of toxic material to the Gulf marine environment as a result of the war. One aim of the Greenpeace work survey in the Gulf was to collect information on the marine mammals in the area in order to provide both baseline data for further work and to gain an indication of any impact the oil spills may have had on these animals.

METHODS Between 12 August and 5 October, 1991, we conducted surveys in both deep and shallow coastal waters. We collected data on species, group size, number of calves and behaviour of the animals. The positions of sightings were taken using a global positioning system and marked on charts. During he surveys dolphins were photo-identified individually using marks on their backs and flukes (Defran *et al*, 1990; Würsig and Jefferson, 1990). This should provide baseline data for future work.

Deep Water Surveys Surveys were carried out from the MV "Greenpeace" in waters deeper than 10m during passages between anchorages (see Fig. 1). The ship usually sailed during daylight at speeds of 16-20 km per hour. The total survey distance covered by the MV "Greenpeace" was 1,690 km during 105 hours. One observer was in the crow's nest, 18.5m above sea level, and another on the bridge deck, 6m above sea level.

Shallow Water Surveys Surveys in shallow coastal waters less than 10m deep were carried out from small inflatables. The coastal waters of Saudi Arabia within 1.5km were surveyed between Abu Ali and Khafji. One inflatable was used, travelling at an average speed of 10 km per hour to survey the coast at distances of between 500m and 1km from the land. A total of 400km in 39.5 hours was surveyed. Kuwait Bay was surveyed using three inflatables, travelling 500m apart, carrying out 24 transects running north to south. A total of 290km was surveyed in 30 hours.

In Iran, surveys were carried out in the Khowr-e Musa River from Bandar Khomeini to the river mouth, and between Ganaveh and Dohat Deylam Bay. In the river, one inflatable was used to survey 70km in 7 hours. In the coastal waters, three inflatables were used, travelling parallel to each other 500m apart and parallel to the coast at distances of 500m, 1km, and 1.5km from the land respectively. A total of 280km was surveyed, over a period of 30 hours.

RESULTS A summary of the observations can be seen in Table 1. 117 sightings (groups) of marine mammals were made, totalling 455 individuals of 4 cetacean species. Sixty-nine sightings were of Indo-Pacific humpback dolphins, *Sousa chinensis*, 39 were bottle-nosed dolphins, *Tursiops truncatus*, four were finless porpoises, *Neophocoena phocaenoides*, and two were common dolphins, *Delphinus delphis*. There was also one record of a mixed group of humpback and bottle-nosed dolphins, and two of unidentified dolphins which were most likely single separate sightings of bottle-nosed dolphins and humpback dolphins respectively.

With the exception of one animal, all humpback dolphins were close to land, in water less than 10m deep. Group sizes ranged from 1-13 animals. Bottle-nosed dolphins were seen in waters further from the shore, at depths greater than 10m, with the exception of two animals in a group of humpback dolphins. Group sizes ranged from 1-10 animals. All sightings of finless porpoises were in the far north of the Gulf: a group of two and a group of five were sighted in Kuwait Bay about 2km from shore; the other two groups, one of three and the other of four animals, were in Iran, about 1km from shore. The two common dolphin sightings, one in Saudi Arabia and the other in Iran, were both in deep waters far from the shore. One group consisted of two and the other 12 individuals.

Amongst 174 bottle-nosed dolphins sighted, we observed eight calves, representing 4.5% of the total observations of this species. Of the 253 humpback dolphins observed, 13 calves were seen, representing 5.1% of observations of this species.

Photo-identification records were made of seven humpback dolphins and two bottle-nosed dolphins in Saudi Arabia, 21 humpback dolphins in Kuwait, and seven humpback dolphins in Iran .

DISCUSSION Prior to this survey, very little was known about cetaceans in the Gulf. Some workers believed that they were very rare in certain areas. Very few reports have been produced, although ROPME (Regional Organisation for the Protection of the Marine Environment) (1986) has tried to collect data on strandings. From this survey, we intended to gain an overview of the species found in the area, and their relative abundance. However, it must be recognised that, with the exception of Kuwait Bay, it is not possible to make estimates of population sizes from this survey. The entire Kuwait Bay was surveyed in very good conditions for sighting, with 60 humpback dolphins recorded and 21 photo-identified.

In this study we found that humpback and bottle-nosed dolphins were the most prominent species, but generally occupying separate ecological niches. Humpback dolphins were found close to shore in shallow waters; bottle-nosed dolphins were found in deeper waters further from the coast. These were also generally the findings of Saayman et al. (1972) off the south-eastern Cape coast of South Africa. They also reported, as is quite common, bottle-nosed dolphins in shallower waters close to shore as did, for example, Würsig (1978) in Argentina, Shane (1990) in the Gulf of Mexico, and Hansen (1990) in California. We found no evidence of this in the Gulf. With the exception of two bottle-nosed dolphins in a group of humpback dolphins, we never saw bottle-nosed dolphins in water shallower than 10 m or closer than 16 km offshore.

The percentage of bottle-nosed dolphin calves (4.5%) observed is quite low relative to other reports. In the Gulf of Mexico, Shane (1977) reported 7.6% calves and Henningsen (1991) reported 6.7% . Off the coast of California, Defran *et al.* (1986) reported a figure of 9.0% and Hansen (1990) found 7.2% calves in his study groups. A possible explanation for the low figure reported here is that most of the bottle-nosed dolphin sightings were bowriding, whereas mothers with young calves may not bowride as often as others. However, it is not known whether the low number of calves is typical for the Gulf or if it was particular to 1991. In addition, if one compares the figure of 5.1% calves for humpback dolphins, with Saayman and Tayler's (1979) findings of 10.0% calves for this species off the south-eastern Cape coast of South Africa, the Gulf value is again very low. It is therefore important to carry out investigations into the reproductive rate and success of bottle-nosed and humpback dolphins in the Gulf.

The photo-identification record of dolphins in this area should provide valuable information for future studies of, for example, migratory patterns, reproduction and home ranges. This information is important to assess the degree of human impact on the animals in the area. This is especially important in areas such as Kuwait Bay where there are high levels of fishing and boating activities and pollution threats.

Between late February and mid April, 1991, at least 93 marine mammals died in the western Gulf, including 14 dugongs, 57 bottle-nosed dolphins, 13 humpack dolphins, one finless porpoise, and eight unidentified cetaceans (Preen 1991). Most of the carcasses were found south of the main oil spill impacted areas, hence it is possible that they were not directly the result of the Gulf War oil spills, although the precise cause is not known. However, no necropsies were performed on the animals.

The main threats that these animals face in the immediate future probably result directly from the Gulf war oil spills. Much oil remains in the coastal areas, either on the shore or in shallow waters where oil is returning to the water with every high tide, often re-forming slicks. In addition to the physical and chemical effects of oil in sediments and water, there remains large amounts of volatile chemicals in the air from the oil which can cause lung diseases. This was demonstrated in sea otters, *Enhydra lutris*, after the Exxon Valdez oil spill in Alaska, 1989 (Osborne and Williams 1990) and could be even worse in the Gulf since Kuwait crude oil contains a much higher volatile fraction than Prudoe Bay crude oil.

Dolphins are particularly threatened by oil because, even though they can detect it, they do not appear to avoid oil slicks (Smultea andWürsig, 1991). Twice during this survey, we observed dolphins travelling in oil slicks when clean water was close by: one group of two bottle-nosed dolphins, 40km offshore at Safaniyah, were observed for 10 minutes, surfacing 30m from clean water. A second group of four humpback dolphins - three adults and one calf, in Manifah Bay, were observed for more than 20 minutes in an oil slick with clean water about 500m away. Preen (1991) also reported dolphins surfacing in oil sheen.

The high level of oil pollution introduces a large amount of persistent toxic chemicals such as poly-aromatic hydrocarbons (PAHs) and heavy metals into the food web (Hansen 1985). Animals such as cetaceans, at the top of the food chain, concentrate these chemicals in their tissues (EIA, 1991). There has already been two recent major die-offs of marine wildlife, in 1983 and 1986 (ROPME, 1986). This included several hundred dolphins and, in the case of the 1983 die-off, occurred after a large oil spill, the Nowruz oil spill (MEPA, 1989).

The oil is concentrated in coastal areas and bays so that humpback dolphins and finless porpoises are particularly vulnerable to extreme levels of oil pollution. Both these species are listed on Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (IUCN 1991), recognising that these species are endangered. It is possible that the Gulf populations are isolated and therefore even more vulnerable. Therefore, it is vital that these, and other significant areas such as breeding and feeding grounds, are monitored and protected from oil pollution and other threats to their survival.

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Table 1 The number of observations of cetaceans in the northern Gulf

Species	No. sightings per group	No. indivs.	Calves		Location	
			No.	%	Coastal <10m	Offshore 10m>
Humpback dolphin	69	253	13	5.1	+	
Bottle-nosed dolphin	39	174	8	4.5		+
Finless porpoise	4	14	0	0	+	
Common dolphin	2	14	0	0		+
Not identified	2					
Mixed group :						
humpback/bottle-nosed	1				+	
TOTAL	117	455	21			

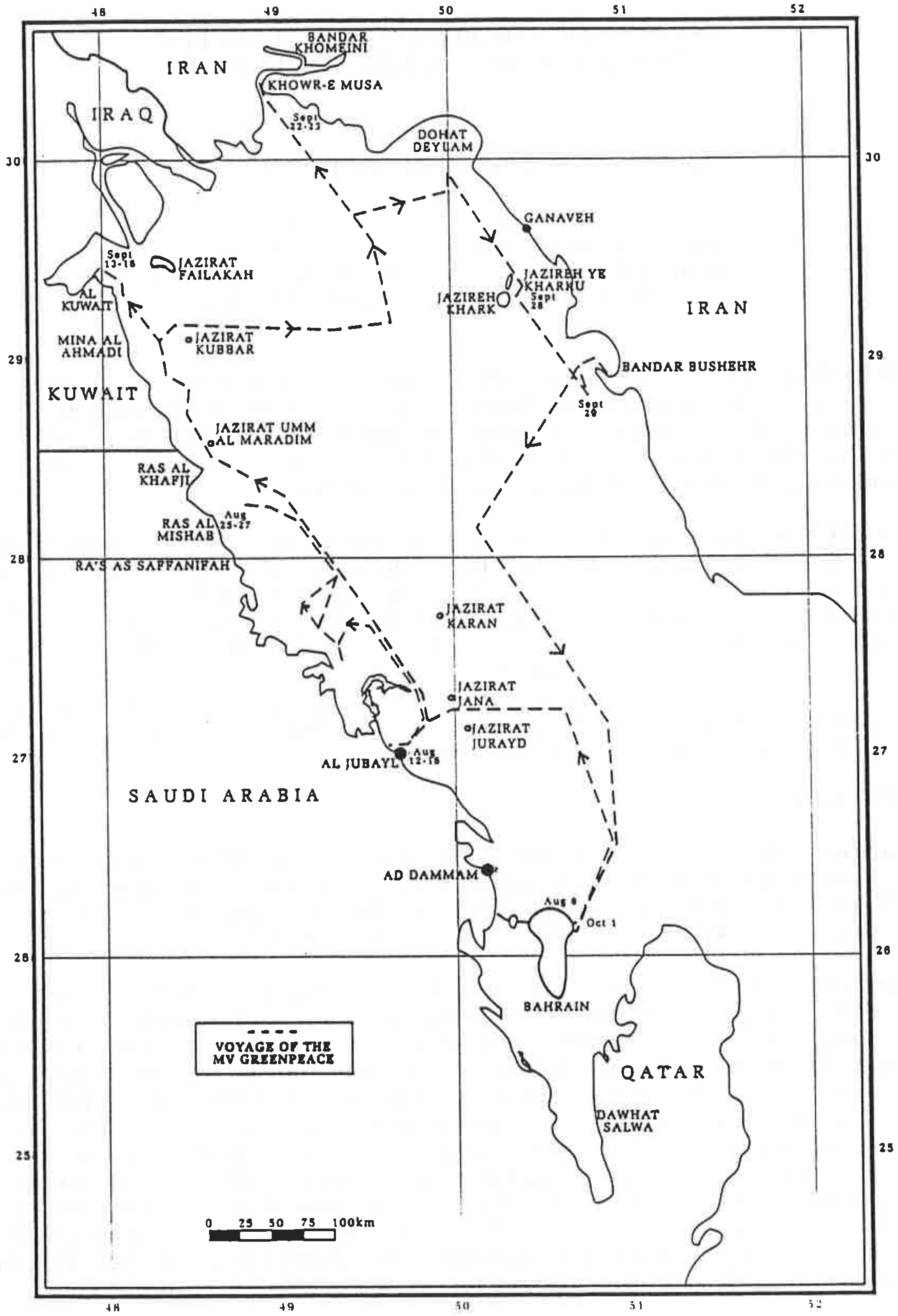

Fig. 1 The voyage of the MV Greenpeace

THE ECOLOGY OF BOTTLE-NOSED DOLPHINS , *Tursiops truncatus* , IN THE MORAY FIRTH.

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INTRODUCTION The Moray Firth (NE Scotland) contains the only known resident group of bottle-nosed dolphins,*Tursiops truncatus*, in the North Sea. There is little information on the ecology and status of these animals. This photo-identification study in the Inner Moray Firth began in 1989 with the aims of investigating the size, status, residency, distribution and social structure of this population.

METHODS A combination of direct observation and photo-ID were used during surveys made in a 5.5 rigid hulled motor boat. Photographs were taken with an autofocus camera fitted with a 75-300mm zoom lens. Individual dolphins were identified from photographs by scratches, nicks, pigmentation patterns and deformities on their dorsal fins and flanks. Studies were conducted between July and September in 1989, May and November in 1990. and then continuously from March 1991. In 1990 and 1991, surveys were expanded to cover a standardised route over a distance of some 40km twice a month. Ten of these surveys were run in 1990, with regular surveys from March 1991. Data collected before August 1991 were analysed for this presentation.

RESULTS

Numbers In 1989, between 40 and 49 individuals were identified. With increased effort, between 88 and 110 animals were sighted in 1990, and between 61 and 66 recognised in 1991. Since the third survey of 1990 (May), over half of the animals seen on each trip had previously been identified. This pattern continued through 1991.

Residence Many individuals sighted in 1989 were re-sighted in the two following years (cluster 1 of Fig. 1). In addition, many animals were identified from one year to the next (cluster 2), although the majority of individuals were only identified within a single year (cluster 3). Of these, many were seen in 1989 and 1990 and thus had ample opportunity to have been re-sighted. The pattern of re-sightings may have been explained partly by the markings that were used for identification. Dolphins with nicks on dorsal fins, distinctive colour patterns or deformities were significantly more likely to be seen from one year to the next, compared with animals identified from rakes and lesions (Kolmogorov-Smirnov Test: $P < 0.00001$, K-S = 3.499, n = 134). Thus, consideration of animals with longer-lasting marks resulted in increased estimates of residence. Nevertheless, many animals with these markings were only seen within a single year. It would therefore appear that some animals have used the study area for only limited periods.

Distribution Groups of dolphins were encountered throughout the survey route, although distinct concentrations occurred particularly around the entrances to the inner firths (Fig. 2). There were marked seasonal and between-year differences in the proportions of animals using different parts of the area. For example, during summer 1990 more individuals were seen in the outer parts of the area; in May and June, 1991, a similar trend continued. However in July, the pattern reversed and the majority of animals were encountered in the innermost areas.

DISCUSSION AND SUMMARY Many more bottle-nosed dolphins appear to be using the Inner Moray Firth than was previously suspected, with over 88 identified within a single year. Many of these animals were re-sighted throughout the study and would, therefore, appear to be resident. Animals were most often encountered within and around the entrances to the inner firths which are constricted areas of relatively deep water (up to 55m), and are subject to strong tidal flows (up to 5 knots). The numbers of animals using these areas varied both seasonally and between years. Little is known of the diet of these dolphins but these distribution and movement patterns appear to coincide with the seasonal migration patterns of salmonids upon which the dolphins are often seen to predate.

Future work will attempt to evaluate the true size and status of the population using "Mark-recapture" techniques. However, for these models to be applied, their assumptions must be validated. Models may assume that the population is closed. This study has found that the population within this study area is not entirely closed since certain individuals appear to move in and out of it. Models may assume that "tags" or marks are not lost. By restricting our analysis to animals with the more permanent marks, this assumption can be withheld. Additionally, models may assume that individuals in the population mix randomly, i.e. have no social structure. Further analyses aim to investigate this more fully.

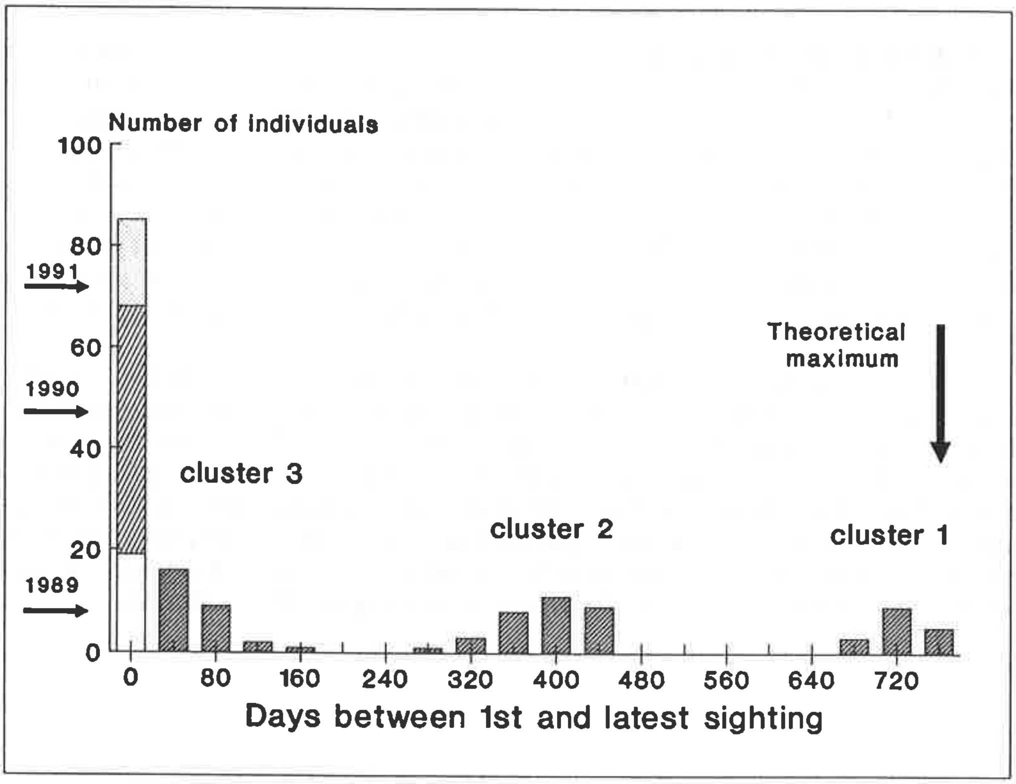

Fig. 1 Frequency plot of the number of days between the first and latest sighting of individuals.

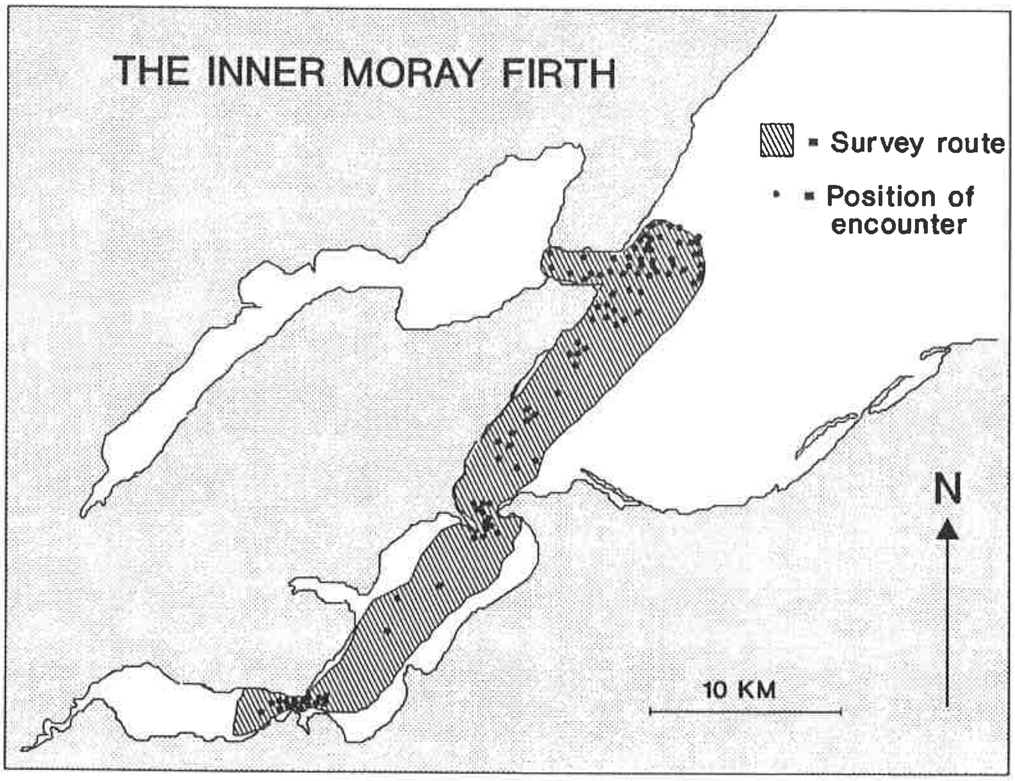

Fig. 2 The area of the inner Moray Firth surveyed with positions of encounters with dolphins superimposed.

BOTTLE-NOSED DOLPHINS OFF THE CANARY ISLANDS

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INTRODUCTION Very little is known about free-ranging Atlantic bottle-nosed dolphins, *Tursiops truncatus*, in eastern, sub-tropical, offshore waters. The majority of studies have been conducted in western coastal regions of this ocean, and have focused on populations which inhabit shallow waters. The Canary Island archipelago, situated about 100 km off the north west coast of Africa, has long supported reports of dolphins, and constitutes an excellent area to study pelagic populations of bottle-nosed dolphins. A feasibility study on the bottle-nosed dolphins occurring off the west coast of Tenerife Island was conducted opportunistically from October 1989 to June 1991, within the framework of an investigation on short-finned pilot whales, *Globicephala macrorhynchus*. Analysis of the first twelve months is presented in this paper.

MATERIALS AND METHODS The study area included the west coast of Tenerife Island, the coastal waters around La Gomera Island, and the inter-island channel, from about 28°20' N to 27°54' N and 16°40' W to 17°20' W. The area is used on a regular basis by recreational boats and ferry services. A 4.9 m inflatable Zodiac and a 14 m sailboat were used as research platforms for surveys and photo-identification of dolphins.

Surveys were primarily conducted for tracking short-finned pilot whales and were not designed in the traditional transect scheme. Bottle-nosed dolphin data were collected incidentally whenever they were encountered. Records included date, survey start and end times, time and location of occurrence, group heading, gross behaviour (resting, feeding, play, travel), school size, number and presence of sex/age groups (especially calves and adult males), presence of other species, sea state and temperature. Locations were estimated from triangulation bearings on three or more points of land. Bearings were taken every time the boat changed its course or cetaceans were encountered.

Photographs were taken of groups to record occurrence, and of individuals for identification purposes. Individual identification was based on dorsal markings, especially fins, in the technique first used on bottle-nosed dolphins by Würsig and Würsig (1977). Photographic equipment used were Nikon 35mm cameras with both manual and autofocus zoom lenses (up to 300mm focal length). Data backs on all cameras provided date and time information on photographs. Black and white 400 ASA film (Ilford XP1) was used for the bulk of photo data, although colour print film (125 ASA) and colour slide film (100 and 200 ASA) were also used occasionally. Pictures of dolphins were analysed using the method described by Defran *et al.* (1990).

The study area was divided into 2km by 2km quadrats, providing a grid of 34 by 24 cells for analysis. Survey data were entered into a customised computer plotting program which triangulated locations from the compass bearings to known landmarks. All data were calculated as x/y coordinates corresponding to the latitude and longitude. In addition to plotting the boat survey track, the number of occurrences, observation effort and sighting durations were summed for each cell. Seasonal occurrence in the area was calculated from the number of dolphin sighting days as a proportion of the number of effort days during the study period. The probability of sightings per cell was similarly calculated using total sighting time as a proportion of total effort time.

RESULTS Bottle-nosed dolphins were observed in 199 sightings in 57 sorties (51.3% of 111 sorties). Effort time totalled 562.5 hours. Sighting/encounter time of dolphins totalled 49 hours (8.71 % of total effort). Bottle-nosed dolphin sightings tended to be concentrated in an area of about 18 km by 12 km, between the 1,000m and 2,000m depth contours.

Bottle-nosed dolphins were present throughout the year but with great variation in numbers from month to month (Fig. 1). They appear more abundant during summer and early autumn, with a clear single peak in September. A smaller peak in March may be the result of the small number of effort days during this month. Measurements of sea surface temperature indicate a maximum in summer and early autumn, with a single peak in September. This closely mirrors bottle-nosed dolphin seasonal occurrence (Fig. 2).

Ninety-eight individual dolphins were identified from over 1,300 pictures. The photographic data collected were not sufficient for reliable estimates of the population size, nor for making conclusions about group structure or surfacing associations. No statistical analysis was carried out, as the sample size was still too small. Nevertheless, some assumptions can be made about range and site fidelity of several individuals. Twenty-one individuals (21.4 %) were re-identified, from 1 to 4 times and with sighting intervals from 2 to 211 days. Some of the dolphins were together every occasion that they were observed, as happened with animals #23, #24 and #25, seen on five different days. They were first recorded south of La Gomera Island, and three months later, off west Tenerife, 40 km away. This shows that the study area was used by some individuals over long periods of time, exhibiting a certain site fidelity.

At least 15 newborn calves were noted in the study area during the 12 months used in this analysis. Groups with calves varied in size from 4 to 37 individuals. The mean percentage that calves represented in each of those groups was 22.6% with a minimum of 10% and a maximum of 50%, but no relationship was found between this percentage and the number of individuals present in a group. All newborn calves were observed in August and September. Given a gestation period of 12 months, mating activity must also increase at this time of year. No evidence of a second calving peak, as suggested by Hohn (1980), was found.

Bottle-nosed dolphins were seen with short-finned pilot whales on 111 out of the 199 dolphin sightings (55.8%), many times in close association. These are the only two cetacean species which occur year-round in the Tenerife area. Other species seen sporadically were common dolphins, *Delphinus delphis*, striped dolphins, *Stenella coeruleoalba*, Risso's dolphins, *Grampus griseus*, Cuvier's beaked whale, *Ziphius cavirostris*, and fin whales, *Balaenoptera physalus*, although never observed in association with bottle-nosed dolphins.

CONCLUSIONS The waters between the islands of Tenerife and La Gomera provide a unique opportunity to study this species in the lesser-known Eastern Atlantic Ocean. The animals are readily located here year-round with some annual variation corresponding to water temperature. It is unclear why the southwest coast of Tenerife is such an area of concentration for bottle-nosed dolphins. This area is a zone that is very sheltered from the prevailing trade winds. An "Island Mass Effect" occurs in this area, where the water leeward of the island does not mix with the surrounding waters, with the consequent accumulation of nutrients and increased development of the trophic chain. This also creates calmer and more stable waters (Hernández Leøn, 1986). Although the relationship between bottle-nosed dolphin sighting concentration and the "island mass effect" is not proved, this could suggest a reason for a cetacean preference in this area.

This initial study succeeded in establishing the permanent presence of offshore bottle-nosed dolphins in a range readily accessible to investigators. The collection and collation of a dorsal fin catalogue of the animals in the area has been started, which, with the addition of data from further years of study, will help determine population size, movement patterns and population dynamics of these animals.

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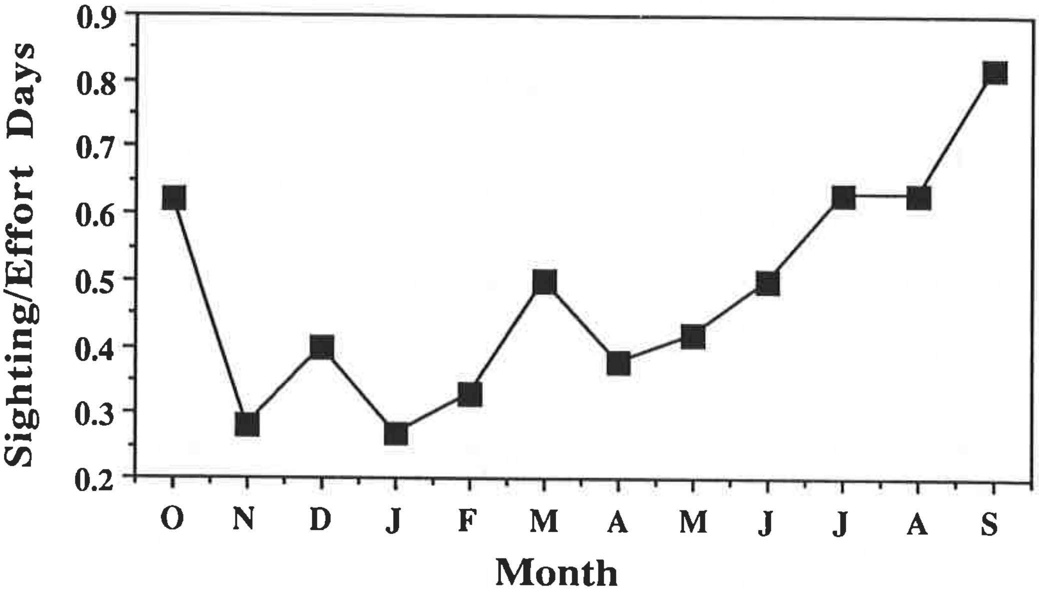

Fig. 1 Sighting per unit effort of all *Tursiops* sightings during October 1990 through to September 1990

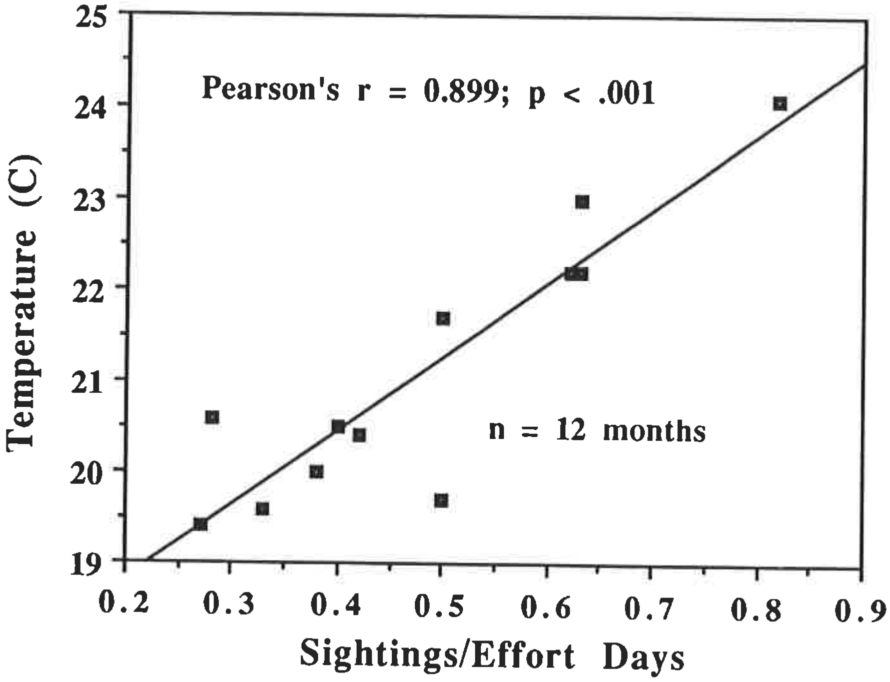

Fig. 2 Sightings per unit effort days compared to monthly average temperatures

CONTRIBUTION TO KNOWLEDGE OF GEOGRAPHICAL DISTRIBUTION OF BOTTLE-NOSED DOLPHINS, *Tursiops truncatus*, OFF THE COASTS OF NORTHWESTERN SARDINIA

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INTRODUCTION The bottle-nosed dolphin, *Tursiops truncatus* (Montagu, 1821), a cosmopolitan species present in the coastal waters of the Mediterranean Sea, is the object of numerous studies concerning its biology and ethology. One of the techniques used for study is individual photo-identification, first applied in the late 1970's in various parts of the world. This makes it possible to define the parameters of natural populations of cetaceans (Würsig, 1978; Shane, 1980; Wells *et al.*, 1987).

This technique was adopted to make a contribution to the knowledge of the distribution and the numbers of *T. truncatus* present in two coastal areas of Northwestern Sardinia. The research, funded by Ministero Marina Mercantile, took one year (1991) to complete and involved a series of sightings.

MATERIALS AND METHODS The two sample areas are the Golfo dell'Asinara (Punta Scorno 41°07'60 N, 8°19'20 E; Castelsardo 40°55'10 N - 8°42'80 E) and the coastal strip between Capo Argentiera (40°44'30 N, 8°08'10 E) and Punta Poglina (40°29'50 N, 8°20'30 E) (Alghero), of size 750 km^2 and 500 km^2 respectively. Four seasonal surveys of sightings were carried out, totalling 39 days: 21 in the Golfo dell'Asinara, 18 in Alghero.

For the surveys at sea, two suitable motorboats were used. Transects were covered in the two areas at a constant speed of 5 - 7 knots. For the sightings, the following equipment was used: Zeiss 8x30B binoculars, Nikon F-801 cameras with lenses Nikkor AF 80-200 mm/f1-2.8 zoom, 75x300 mm/f4.5-5.6 zoom, and 28-85 mm/f3.5-4.5 zoom, Kodak Ektachrome 64, 100, and 200 ASA films, and Sony video 8 CCD-V95E PRO video cameras.

All sightings were photographed and the material later selected for individual photo-identification using the techniques elaborated by Würsig & Jefferson (1990). The diverse features of the dorsal fins of the dolphins photographed are shown on a standard fin elaborated on the computer using WINDOWS program.

RESULTS The scant bibliographical data on the distribution of *T. truncatus* off the coasts of Sardinia made it necessary to operate over much greater areas (750 and 500 km^2) than those considered by Weigle (1990), or by Shane (1990), who conducted similar research over areas of 230, 140 and 34 km^2.

In all, 1237 nautical miles were covered and 225 hours of observation carried out, giving an average of 31.7 miles and 5.76 hours per day. Approximately 900 slides were taken. A total of 81 individuals were observed, of which 28 were photo-identified. During the surveys at sea, no other species of cetaceans was observed. Table 1 summarises the data collected for each area during sightings.

Group sizes of dolphins observed varied from 1 - 13 individuals for the Golfo dell'Asinara, with a mean of 4.5 per sighting; and from 4 - 8 individuals with a mean of 5.3, for Alghero.

The identification of juvenile dolphins differed greatly for the two areas: only once in the Golfo dell'Asinara (11 % of sighting days) and four times (57 %) in Alghero.

On the basis of data obtained during this year's research, indices of frequency, expressed as numbers of individuals per mile and per hour travel time, can be compared for the two areas (Table 2). Density values expressed as numbers of dolphins per km^2 are 0.057 for the Golfo dell'Asinara and 0.064 for Alghero. These values, although calculated from a limited time period, are considerably lower than those in the literature. Hansen (1983) reports densities of 2.23 - 3.10 dolphins/km^2 for Seal Beach (La Jolla, CA). Leatherwood and Show (1980) report values of 0.52 for the Gulf of Mexico, while Shane (1980) reports a range of 1.4 - 4.8.

So far as the identification of bottle-nosed dolphin individuals in the Golfo dell'Asinara is concerned, 14 were photo-identified out of a total of 44 dolphins sighted. Only one individual (PT 610) was observed on two different days, during the spring survey (Table 3, Fig. 1).

The percentage of individuals photo-identified is higher in the zone of Alghero: 14 out of 37 individuals were identified. Three of these (AHO 100, AHO 110, AHO 120) were sighted in the winter survey on two different days; a fourth individual (AHO 220) was observed on three different occasions during the spring and summer surveys (Table 3, Figs. 2 & 3).

CONCLUSIONS The spatio-temporal distribution of bottle-nosed dolphins in the Golfo dell'Asinara makes it possible to hypothesise why this species follows a spatial pattern that is correlated with bottom gradients of between 50 and 70 m, often frequented by local trawlers. Groups of bottle-nosed dolphins have in fact been observed several times following the wake of such fishing-boats. The low density values of bottle-nosed dolphins per km^2, though incomplete compared with those recorded in other zones, tend to suggest that a single group lives in the area, divided into smaller units and distributed over a large area in order to ensure greater feeding probabilities. This might be a strategy of adaptation possibly to the intense fishing activity.

So far as Alghero is concerned, where sightings were concentrated between Punta della Ghiscera and Punta Poglina, the identification of one individual 40 days after its first sighting, and of three other individuals on two subsequent days supports the theory that groups may be resident in the area. This is also supported by the result that sightings per outing (sighting frequency) is 43%, for both areas, notably higher than that recorded in other areas in Italy (Di Natale, unpubl. data).

ACKNOWLEDGEMENTS We would like to thank S. Cherchi, P. Podda, and A.R. Sardu for their invaluable help throughout the course of this work.

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	Golfo dell'Asinara					Alghero				
	WIN	SPR	SUM	AUT	Total	WIN	SPR	SUM	AUT	Total
Number of days	3	6	6	6	21	5	4	5	4	18
Number of sighting	-	3	3	3	9	2	2	2	1	7
Number of T. truncatus	-	10	19	15	44	9	10	13	5	37
Number of juv. dolphin	-	-	2	-	2	1	1	1	1	4
Miles	28	147	224	251	650	128	135	184	140	587
Hours of observation	6	27	37	49	119	26	24	31	25	106

Table 1 Summary data on seasonal sighting survey in the Golfo dell'Asinara and Alghero.

	Golfo dell'Asinara	Alghero
T. truncatus/miles	0,0657 (0 - 0,3824)	0,0630 (0 - 0,0706)
T. truncatus/hours of navig.	0,3793 (0 - 2,677)	0,3457 (0 - 0,8571)
Density/km^2	0,057	0,064

Table 2 Density and abundancy index for the Golfo dell'Asinara and Alghero.

individuals	APR	MAY	MAY	JUN	JUL	JUL	SEP	SEP	OCT
PT600	●	◊	◊	◊	◊	◊	◊	◊	◊
PT610	●	◊	●	◊	◊	◊	◊	◊	◊
PT620	◊	◊	●	◊	◊	◊	◊	◊	◊
PT630	◊	◊	●	◊	◊	◊	◊	◊	◊
PT700	◊	◊	◊	●	◊	◊	◊	◊	◊
PT710	◊	◊	◊	◊	●	◊	◊	◊	◊
PT720	◊	◊	◊	◊	●	◊	◊	◊	◊
PT730	◊	◊	◊	◊	●	◊	◊	◊	◊
PT740	◊	◊	◊	◊	●	◊	◊	◊	◊
PT800	◊	◊	◊	◊	◊	◊	●	◊	◊
PT810	◊	◊	◊	◊	◊	◊	●	◊	◊
PT820	◊	◊	◊	◊	◊	◊	●	◊	◊
PT830	◊	◊	◊	◊	◊	◊	◊	◊	●
PT840	◊	◊	◊	◊	◊	◊	◊	◊	●

individuals	JAN	JAN	MAY	MAY	JUL	JUL	OCT
AHO100	●	●	◊	◊	◊	◊	◊
AHO110	●	●	◊	◊	◊	◊	◊
AHO120	●	●	◊	◊	◊	◊	◊
AHO200	◊	◊	●	◊	◊	◊	◊
AHO210	◊	◊	●	◊	◊	◊	◊
AHO220	◊	◊	●	◊	●	●	◊
AHO300	◊	◊	◊	◊	●	◊	◊
AHO310	◊	◊	◊	◊	●	◊	◊
AHO320	◊	◊	◊	◊	◊	●	◊
AHO330	◊	◊	◊	◊	◊	●	◊
AHO400	◊	◊	◊	◊	◊	◊	●
AHO410	◊	◊	◊	◊	◊	◊	●
AHO420	◊	◊	◊	◊	◊	◊	●
AHO430	◊	◊	◊	◊	◊	◊	●

Table 3 Summary of 34 photo-identified individuals during seasonal surveys in the Golfo dell'Asinara (PT) and Alghero (AHO). Solid circle indicate photo-identified bottlenose dolphins.

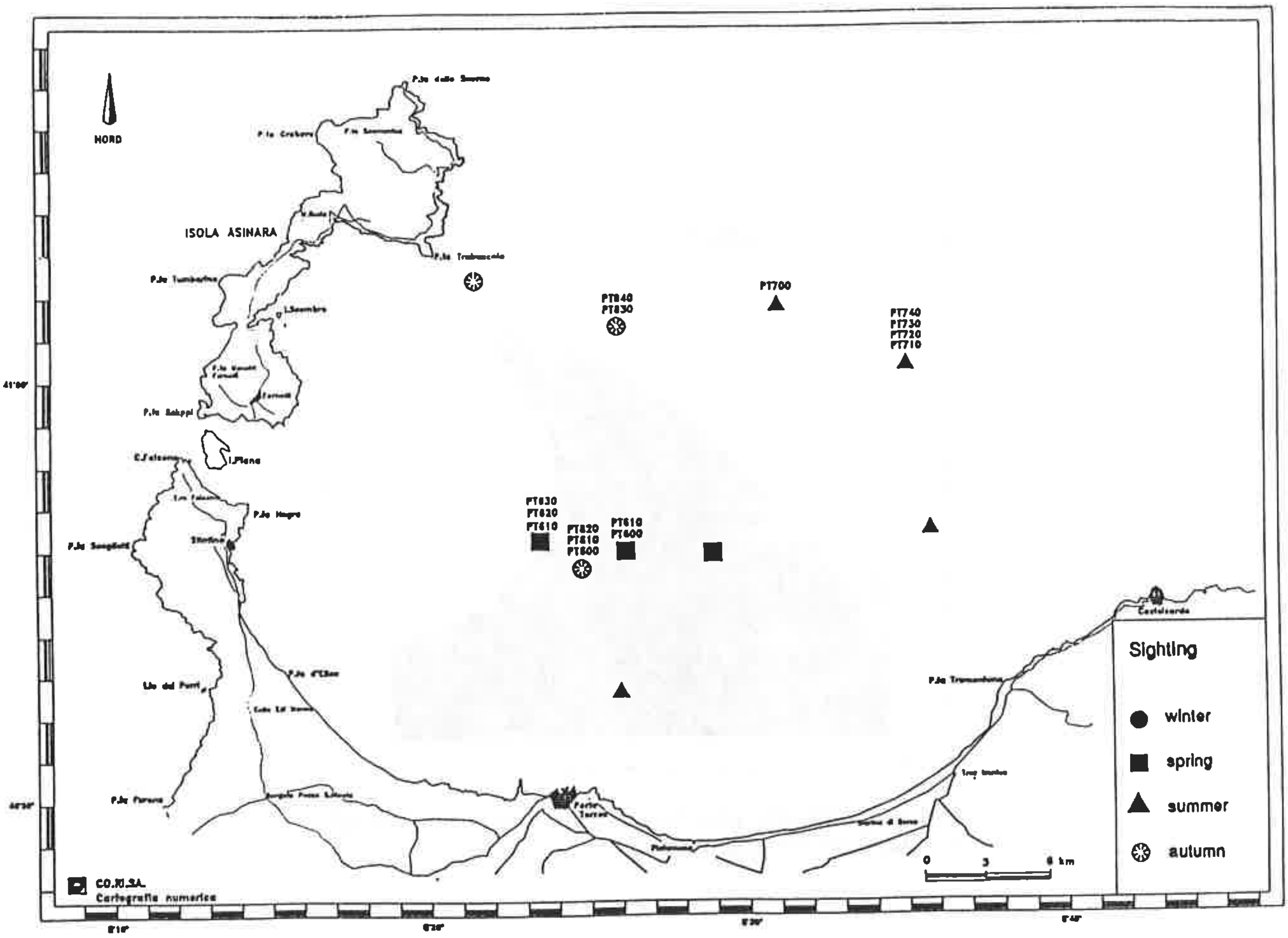

Fig. 1. Golfo dell'Asinara - Map of the bottlenose dolphin sighted during the study.

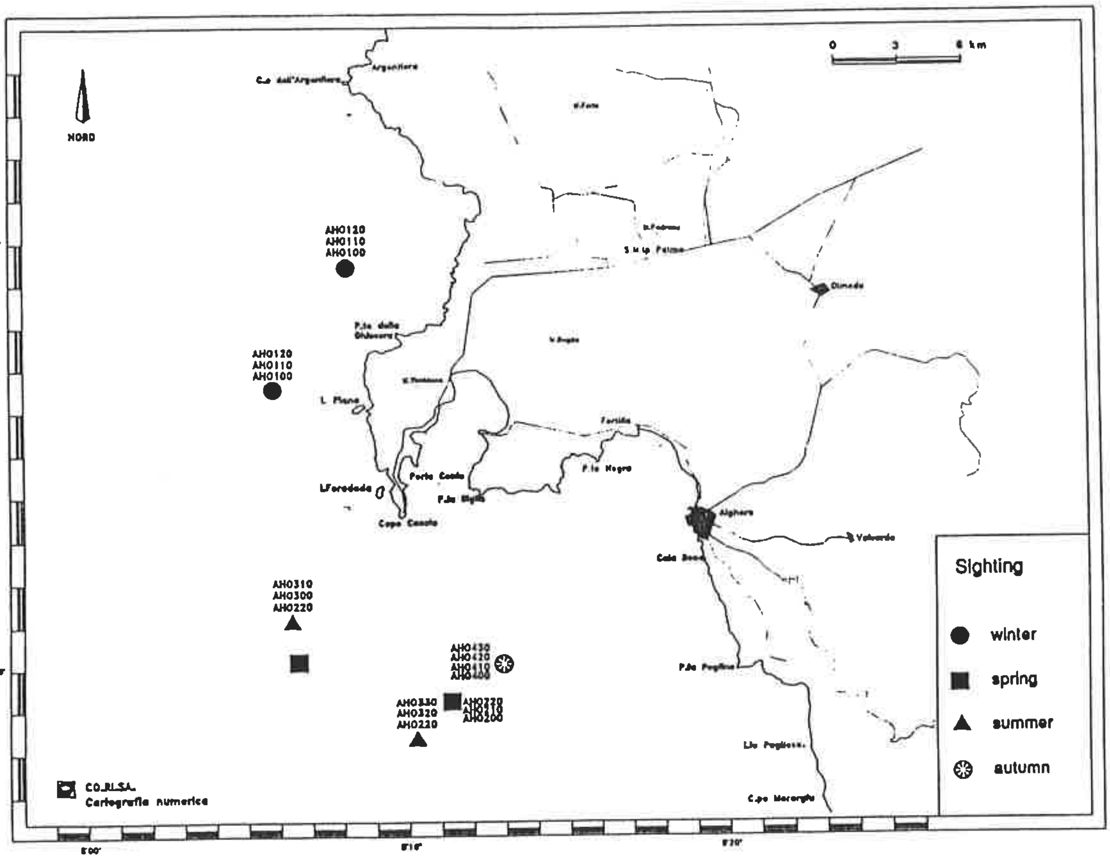

Fig. 2. Alghero - Map of the bottlenose dolphin sighted during the study.

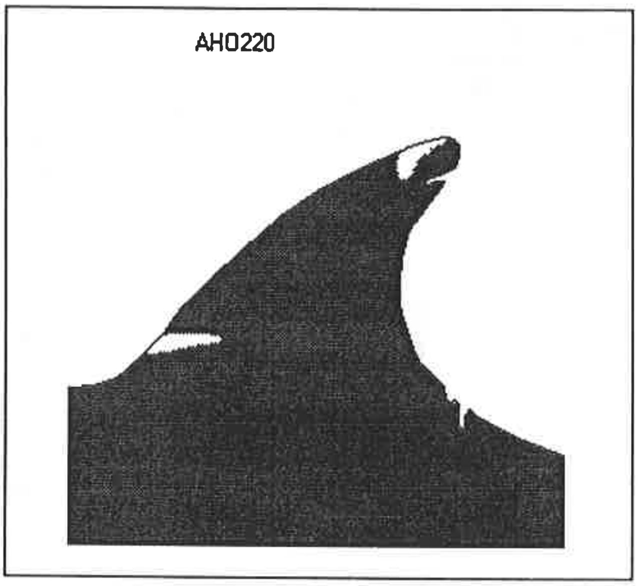

Fig.3 Computer photo-elaboration of dorsal fin of AHO220 bottlenose dolphin

PRELIMINARY OBSERVATIONS OF BOTTLE-NOSED DOLPHINS NEAR THE ISLAND OF TAVOLARA, SARDINIA.

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INTODUCTION To evaluate the feasibility of a long-term population study of bottle-nosed dolphins, *Tursiops truncatus*, in the waters off Northeastern Sardinia, adjacent to the proposed marine reserve of Tavolara, a series of surveys were conducted in June 1991. A small inflatable craft was used to observe and photo-identify the dolphins, with the purpose of collecting information on their presence, density and distribution in that area. The total duration of the survey was 57.55 h, including 21.67 h spent in close proximity to the dolphins. The dolphin sighting frequency was 0.488 h^{-1}. Eight groups were sighted, totalling 57 individuals. Mean group size was 7.13 (SE = 2.11). Twelve individuals were identified on the basis of permanent natural marks on their dorsal fins; 2 were re-sighted in the course of the study. Behavioural observations were also performed, but the presence of our boat seemed to affect significantly the behaviour of these dolphins, which appeared to be quite diffident and difficult to approach as compared with other Mediterranean bottle-nosed dolphins populations. Interviewed local fishermen maintained that dolphins regularly follow their boats when trawling, occasionally damaging their nets and disturbing their activities. However, only 6% of the trawling boats inspected by us (N = 34) had dolphins in their vicinities. The animosity of fishermen against the dolphins and their hostile attitude (e.g., shootings) towards them might explain the difficulties we encountered in our attempts to approach and observe the animals.

MATERIALS AND METHODS This preliminary study was conducted from 5 to 26 June, 1991, aboard a Novamarine 2, 4.60 m inflatable craft with fibreglass keel, powered by 25 hp and auxiliary 4 hp Suzuki outboard engines. Bottle-nosed dolphins were photographed using a Minolta Maxxum 8000i AF camera with Minolta APO 80-200 mm f2.8 zoom lens. The film used was Ektachrome EPR 64 ISO colour transparency film. The position of the boat was determined using a GPS Magellan NAV 1000 Plus.

During 9 of the 22 days in the field the unfavourable conditions of the sea prevented any survey. In the remaining 13 days, we spent 1,391 min searching for dolphins during good weather conditions (Sea 0-2 Beaufort), 765 min navigating with unfavourable conditions (Sea >2 Beaufort), and 1,297 min in the proximity of dolphins, giving a total of 3,453 min (57 h 33 min). The survey was conducted in the waters adjacent to the island of Tavolara, both near the coast and offshore (up to 9 km from the coast), in an area between 40°50'00 and 41°05'00 N (Fig. 1). The presence of the dolphins was visually assessed by at least one experienced observer, while navigating at an average speed of 30 km/h. Trawling boats were approached when encountered and the presence of dolphins was verified by carefully observing the wake of the boat for at least 5 minutes. We inspected a total of 34 trawling boats, 26 of which were trawling at the time and 8 raising or dragging the net at the surface.

RESULTS AND DISCUSSION The average time spent searching for dolphins during good weather conditions was 2 h 03 min, with a sighting frequency of 0.488 h^{-1}. This value indicates a high density of dolphins, compared with the mean sighting frequency for bottle-nosed dolphins in the Tyrrhenian Sea (Notarbartolo di Sciara *et al.*, 1991). Bottle-nosed dolphin groups were sighted both near the coastline (at times only a few metres from the steep cliffs of Tavolara) and offshore, as far as 6.5 km from the coast. Eight groups of dolphins were encountered in seven different days, totalling a minimum of 57 individuals. In two cases, the composition of the group changed during the course of the sighting. Group sizes ranged from 2 to 18 individuals, with a mean of 7.13 (SE = 2.11). Juveniles and calves (*sensu* Shane, 1990) were often seen; newborns were never encountered. On the basis of permanent natural marks on their dorsal fins, 12 individuals were photo-identified (Fig. 2), two of which were re-sighted in the course of the study, 3 and 9 days later respectively. The difficulties in approaching the animals and the diffidence of most dolphin groups towards our boat is partly responsible for the low yield (12/57 = 21%), given that a larger number of individuals had distinctive marks.

All major behavioural states, such as travel, feeding, socialising, milling and mixed (Shane, 1990) were observed, but the presence of our boat seemed to significantly affect the dolphins' behaviour. For this reason, the behavioural data collected in the field were not quantitatively analysed. The hostile attitude of local fishermen towards dolphins, and the reported occurrence of dolphin shootings, may be an explanation for the diffident behaviour shown by the animals. Interviewed fishermen of Golfo Aranci maintained that dolphins regularly follow their boats when trawling, occasionally damaging their nets and disturbing their activities; however, the real occurrence of this interaction is not clear. Only 2 (6%) of the 34 trawling boats inspected by us had dolphins in their vicinities, and we never observed dolphins engaged in feeding activities in the wake of a trawling boat.

It is a well known fact that bottle-nosed dolphins feed on netted fish and damage nets, both in various Mediterranean areas and in several other areas throughout the world (Leatherwood, 1975; Di Natale and Notarbartolo di Sciara, in press). However, the hostile attitude of some fishermen is not necessarily the rule. Near the island of Losinj (Croatia), for example, where dolphins frequently damage the nets and feed in the wake of trawling boats, fishermen show a tolerant attitude towards the animals and dolphin shooting reports in the last ten years have been extremely rare. Not surprisingly, dolphins in that area are comparatively very friendly and easy to approach (Bearzi *et al.*, this vol.).

ACKNOWLEDGMENTS This research was funded in part by Europe Conservation. The inflatable boat was provided by Novamarine 2, Olbia. We are grateful to Benedetto Cristo for local assistance and to Aurelio Galli for his friendly, continued support.

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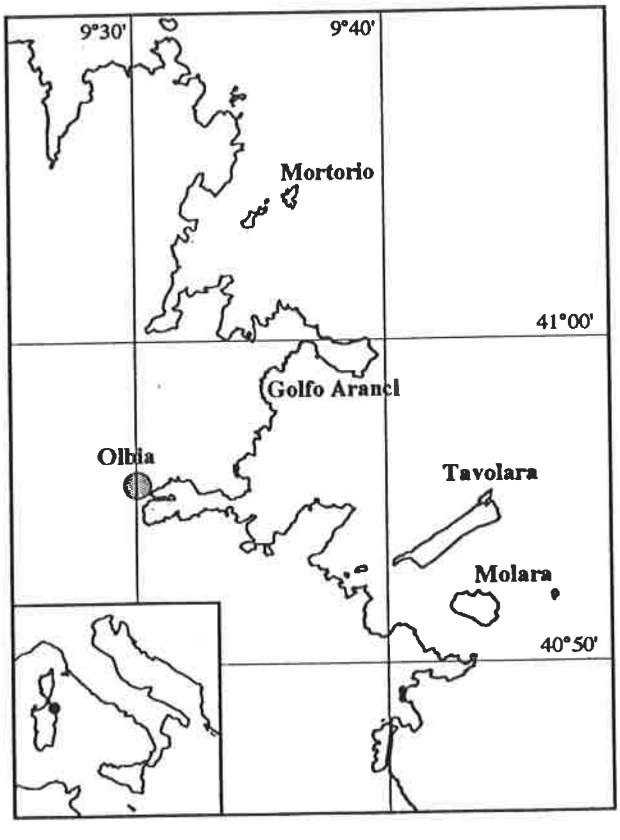

Fig. 1 The study area

BOTTLE-NOSED DOLPHINS OFF CROATIA: A SOCIO-ECOLOGICAL STUDY

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INTRODUCTION Bottle-nosed dolphins, *Tursiops truncatus*, occurring in the clear waters adjacent to the islands Losinj and Cres (Croatia), were observed from small inflatable craft during the summers of 1988, 1990, and 1991. The principal objective was to undertake a long-term field effort to investigate Adriatic bottle-nosed dolphin biology, ecology and behaviour. Methods included photo-identification and focal group behavioural sampling. Repeated sightings of recognisable individuals demonstrated a high degree of site fidelity in several individuals, although the area appears to be frequented by a large number of transient individuals. Major behavioural states were compared and related to group size, season and time of day. Dolphins spent most of their time feeding or foraging for food, mostly in the morning and evening hours, in groups of a few individuals. Towards mid-day, they aggregated with other groups and social behaviour increased. A variety of feeding-related behaviours were observed, including association with bottom trawlers: the relative importance of this human-related activity in the area is discussed.

MATERIALS AND METHODS In the summers of 1990 and 1991, following a preliminary reconnaissance study in 1987 and 1988, we conducted a study of the social ecology of a population of bottle-nosed dolphins, *Tursiops truncatus*, in the coastal waters of Croatia, in the Northern Adriatic Sea. Our study area, adjacent to the islands of Losinj and Cres, is approximately 900 km^2 in size, with waters relatively deep (maximum depth is about 100 m) and clear. The observation platform used was a Novamarine 2 4.6 m inflatable boat with fibreglass keel, powered by 25 hp and auxiliary 4 hp Suzuki outboard engines. The position and the speed of the boat were determined using a GPS Magellan NAV 1000 Plus.

Study methods included photo-identification and, in 1991 only, focal group behavioural sampling (every 3 min), following the method proposed by Shane (1990). The presence of dolphins was visually assessed by at least two experienced observers, while navigating at an average speed of 30 km/h. Encountered dolphins were followed as long as possible, recording every change in group number and composition and photo-identifying all the group members every time such a change occurred. Bottle-nosed dolphins were photographed using a Minolta Maxxum 8000i AF camera with a Minolta APO 80-200 mm f2.8 zoom lens. The photographs were taken using Ektachrome EPR 64 ISO colour transparency film. A portable tape recorder was used to dictate observational data. For photo-identification purposes, only dolphins with nicks or other permanent marks on both sides of their dorsal fin were considered, while scrapes, scratches and wound marks were used to confirm the number of animals in a group, and changes in group composition (Würsig and Jefferson, 1990). Because of the inconsistent methods used in the preliminary observations during 1987 and 1988, only the photographs obtained during those years were considered from those data.

In summer 1990, 122 h 32 min were spent searching for dolphins with good weather conditions (Sea 0-2 Beaufort) and 80 h 12 min near the animals; in summer 1991, time searching for dolphins with good weather conditions was 80 h 23 min, whereas 140 h 06 min were spent observing the animals. Total time spent in close proximity to dolphins was 220 h 18 min.

Trawling boats were approached when encountered during the surveys, and the presence of dolphins was verified by carefully observing the wake of the boat for at least five minutes. A total of 49 boats engaged in trawling activities were inspected (33 in 1990, and 16 in 1991).

RESULTS AND DISCUSSION

Sighting Frequency The average time spent searching for dolphins in both years with good weather conditions was 2 h 06 min, resulting in a sighting frequency of 0.4 groups sighted h^{-1}. The value indicates a high density of dolphins in the area, as compared to the mean sighting frequency for bottle-nosed dolphins in the Northern Adriatic Sea (Notarbartolo di Sciara *et al.*, in press).

The sighting frequency of the dolphins in summer 1991 was significantly higher than in summer 1990 (t-test $P \leq 0.001$). By contrast, there was no significant change within either summer. It is interesting to note that, contrary to 1990, in 1991 there was a drastic reduction of tourism and commercial fishing due to the Yugoslavian war.

Photo-identification data A total of 82 individuals could be identified, based on permanent marks. Of these, 16 were seen in 1988, 35 in 1990, and 69 in 1991. The re-sighting rate, both overall and for individual dolphins, was much higher in 1991 (Table 1). The rate of discovery of identified individuals (Fig. 1) seems to indicate that, in spite of such a high re-sighting rate, there are many transient dolphins in the area. Nevertheless, many individuals do seem to occupy our study area for long periods.

Behaviour Several different behavioural states were considered, which were grouped into four categories, as proposed by Shane (1990). The resulting behavioural budget is shown in Fig. 2. It is evident that dolphins in our study area, during the summer, spend most of their time in feeding-related activities. Group size ranged from 1 to 30 individuals, with a mean of 5.7 (SE = 0.31). Groups were extremely fluid, with animals frequently leaving one group to join another; a change in group size or composition occurred with a mean frequency of 2 hours. Juveniles and calves were often seen; newborns were encountered only twice in 1990, and once in 1991. Solitary individuals and isolated mother-calf pairs were frequently found, possibly indicating a low predation pressure in the area (Norris and Dohl, 1980).

The occurrence of different behavioural states changed with time of day. Feeding-related activities peaked in the morning and late afternoon, and decreased in the middle of the day; social activities showed a mirror pattern, being most common in midday hours, and least in early morning and late afternoon. Furthermore, group size also seemed to be related to time of day, with larger groups being observed during midday, and smaller groups in the morning and late afternoon. Accordingly, group size varied significantly in different behavioural states (t-test, $P \leq 0.001$), the major difference being between dive/feeding groups (mean = 5.07) and socialising groups (mean = 9.88).

Interactions with fishing boats Following trawlers was an important feeding strategy for bottle-nosed dolphins in the area. Dolphins stationed themselves in the wake of the boat about 300 m from its stern and dived for 2-5 min, presumably catching fish stirred up by the net or even inside the net. Eleven of the boats inspected in 1990 and six in 1991 were followed by the dolphins. In 1991, because of the war, fishing boats were much scarcer, but the percentage of boats inspected with dolphins in their wake was about the same.

However, the percentage of dolphins seen near fishing boats in that year was smaller, perhaps indicating that the resource "fishing boat" had lost importance for the dolphins during wartime.

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Table 1 Summary of identified individuals

YEAR	**1988**	**1990**	**1991**
TOTAL IDENTIFIED	**16**	**35**	**69**
resighted from previous years	—	**17,1 %**	**46,4 %**

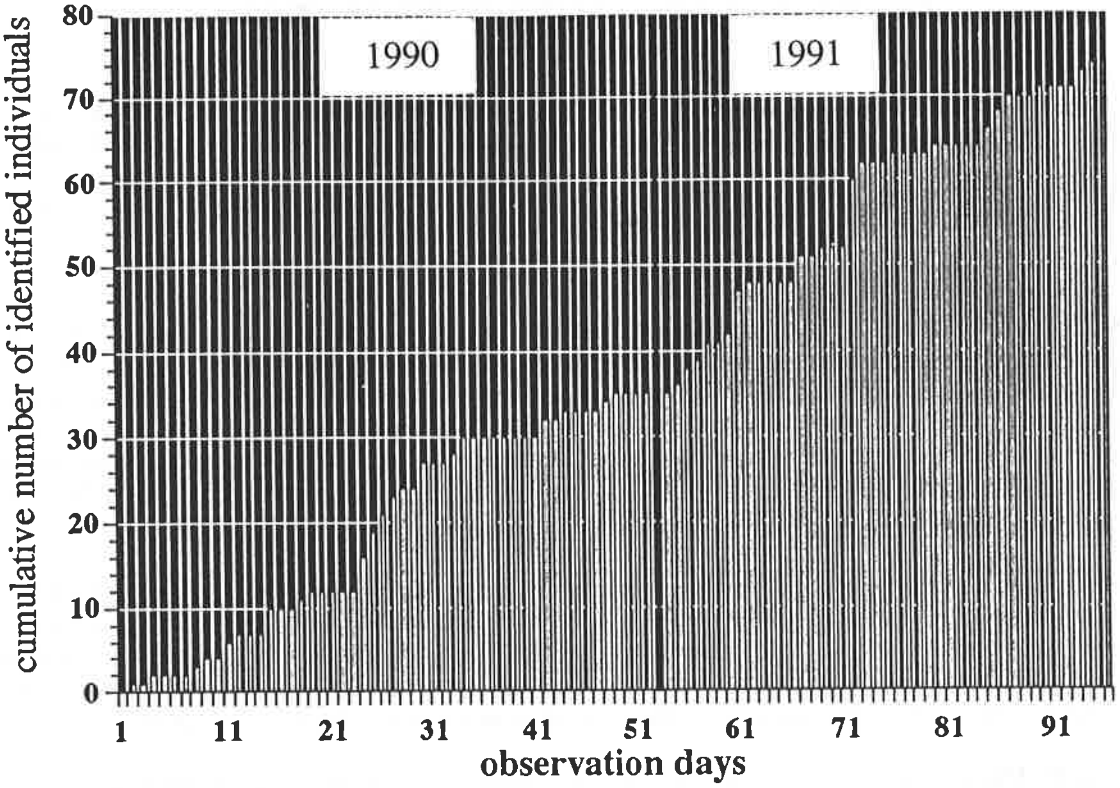

Fig. 1 Rate of discovery

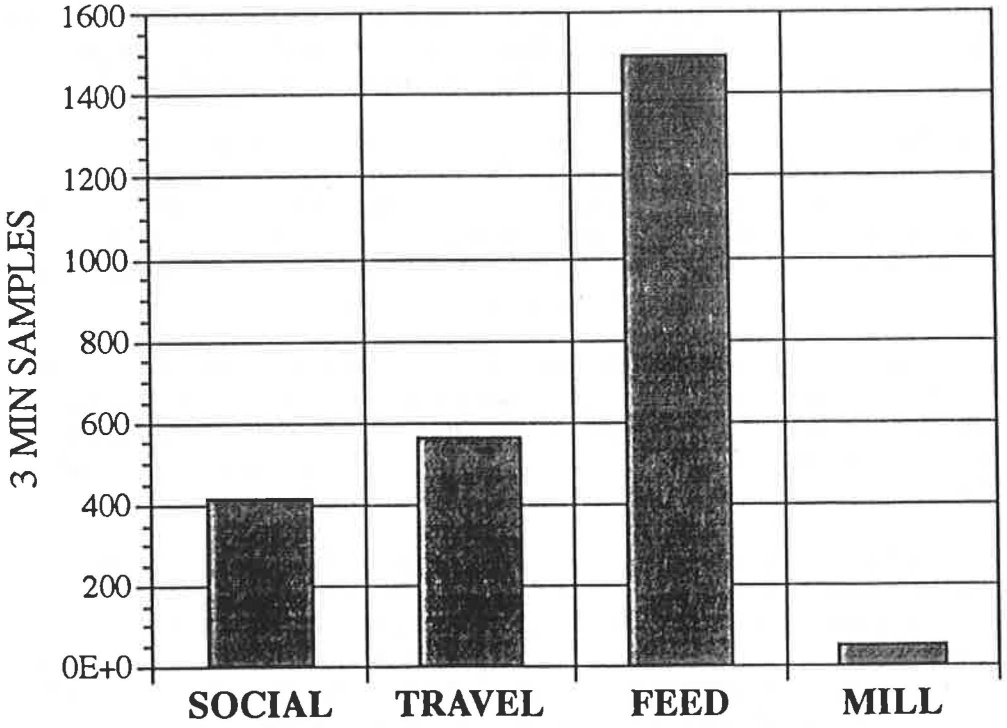

Fig. 2 Behavioural budget

MACROPLANCTON, *Meganyctiphanes norvegica*, AND FIN WHALES, *Balaenoptera physalus*, ALONG SOME TRANSECTS IN THE LIGURIAN SEA

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INTRODUCTION The euphausiid shrimp, *Meganyctiphanes norvegica*, is a key species in the food webs in the Liguro-Provençal basin, both in pelagic and demersal environments, and a relationship between it and the presence of fin whales, *Balaenoptera physalus*, has been supposed since the seventies (Duguy and Vallon, 1977; Viale, 1985). It is known to be present in large numbers (Franqueville, 1971); however, its distribution in space and time is not known in detail, nor have the movements of the fin whales in relation to this resource been studied exhaustively.

Large-scale sampling was performed over the shortest possible period in order to ascertain the summer distribution of *M. norvegica* at the same time as *B. physalus* reaches its maximum concentration in the western Ligurian Sea. This study is intended to give an idea of the situation in August and we consider that several such studies will be necessary in order to provide a clear picture of the overall relation between the two species.

SAMPLING Over a period of two weeks using the R/V Minerva (CNR), an area of 8600 nm^2 was covered, with 20 sampling stations located along three transects: (A) Genova - Calvi; (B) Monaco - Calvi; and (C) Marseilles - Gulf of Porto (Fig.1). During the work at sea it became necessary to set up an additional series of stations along a line approximately perpendicular to transect B. The main hydrological characteristics of the area were registered by 26 CTD profiles. Hydrological stations were generally positioned at the beginning and/or end of the hauls. Measurements of conductivity, temperature and depth were carried out by a ME - Meerestechnik - Elektronik bathysonde CDT.

The standard haul for macroplankton, at each station, consisted of an oblique tow of a 15 feet (2x2 mm mesh in the cod end) open I.K.M.T., from 750 m to the surface in stages. The haul lasted two hours at a ship speed of about 3 knots. The collected macroplankton was sorted out into the following main subdivisions: Fish, Cephalopods, crustacean Decapods, *M. norvegica,* other euphausiids, other crustaceans, Pteropods, and jelly macroplankton, which were measured in terms of their volume.

Since there are about 12-13 hours of daylight in August, observer teams were organised to work in shifts; each team was made up of two people who, by staying on the vessel's highest platform, assured that the whole visual field was covered. They recorded every sighting of a whale with its geographical position. They experienced no difficulties because the sea was calm during the entire length of the cruise.

The existence of a relationship between the abundance of *B. physalus* and *M. norvegica* was verified by means of a non parametric statistical technique: the rank correlation coefficient of Spearman (Siegel, 1956). The test was applied to 17 units of areas of 100 nautical square miles for which both the sightings and the I.K.M.T. data on *M. norvegica* were available. Whale abundance was expressed as a ratio of miles of route/sighting transformed into an ordinal scale. This was: 1 = 3 miles/fin whale; 2 = 6 miles/fin whale;

3 = 10 miles etc.; 4 = >10 miles, etc.; 5 = no sighting. *M. norvegica* abundance was expressed as the volume obtained in the standard haul.

The significance of r_S was checked by the formula: $t= r_S\ (N-2)/(1-r_S)^{-1}$ proposed by Kendall (1948), which is distributed as Student's 't'.

RESULTS

a) HYDROLOGY At each station, the width of the surface water was identified by analysing vertical sections of temperature. The lower boundary of surface water was recognised as the depth in which there is an absolute temperature minimum, before the increase which is characteristic of the intermediate waters. The frontal systems along the transect were identified by an analysis of the isopicnal lines.

Transect A The layer of the superficial waters is wider near the coastal area than offshore. Off Genoa these waters are 230 m deep (the maximum recorded during the cruise) and off Calvi they are about 170 m. Two minima were recorded in the central section (97 and 130 m). These may be due to divergences.

Transect B The smallest width of surface waters (about 70 m) was registered along transect B, at the end of station B3 (about 30 nm. from Monaco). The line of divergence is nearer to the French than to the Corsican coast. This summer asymmetry in the position of upwelling was already reported by Stocchino and Testoni (1977) and Bethoux *et al.* (1988).

Transect C Along transect C, the width of surface water is relatively homogeneous, averaging 120 m except for a feature which can be explained by a convergence at the end of the station C6.

b) MACROPLANKTON and *M. norvegica* The total volume of macroplankton obtained by standard hauls varied from 305 cc to 1816 cc; the highest values were obtained along transect B.

While some components remained fairly constant, *M. norvegica* proved to be most variable, with a clear dominance at stations B1, B2 and B3. Therefore it was necessary to establish additional sampling points along a new transect (D) perpendicular to B, in order to map the extent of this very concentrated population of *M. norvegica.* As an overall picture, *M. norvegica* proved to be denser in a triangular area (at a conservative estimate which reflected the sampling design), whose base was parallel to the Ligurian front and whose apex, pointing towards Monaco, extended across the frontal line. This area, or "hot spot" of *M. norvegica*, covered about at least 400 square nautical miles; its southern border corresponded to the dome of intermediate waters. The mean value of *M. norvegica* inside the hot spot was 930 +/- 407 ml per haul versus 67 +/- 58 ml per haul outside the area. The peak (1355 ml) was registered in the station D2 approximately 23 nm south of San Remo. Given that the euphausiids have a high rate of avoidance of plankton nets, the recorded quantities are assumed to reflect only a small part of the biomasses in the sea.

c) POPULATION STRUCTURE OF *M. norvegica* The sampled stock of *M. norvegica* consisted basically of two age groups (possibly 0 and 1 groups) and had a size structure which varied according to a latitudinal gradient along each transect: a northern configuration with the dominance of old shrimps (stations A1, A3, B1, B2, C1) gradually turned into a southern configuration with the dominance of young shrimps (stations C4, C6, C8, B6, B7, A7, A9); in the hot spot, the relative importance of the two groups was similar.

d) NAVIGATION AND WHALES The R/V Minerva covered, along the four transects, about 610 nm in 147 hours of daylight navigation. Minerva's cruising speed is 12 knots, but sampling and hydrological measures (CTD) reduced the speed to an average of 4.15 knots.

In twelve days of navigation, 52 fin whales were seen. All data have been transferred onto the chart. In order to locate the area with the highest density of whales, a square grid (each square has a side of 10 nm) was superimposed on the route. In each square, the miles covered have been calculated and then correlated with the number of whales sighted. As previously indicated, a scale of nautical miles per sighting was derived.

e) RELATIONSHIP BETWEEN WHALES AND ABUNDANCE OF *M. norvegica* The distribution of *B. physalus* was compared to the distribution of *M. norvegica*. The value $r_s = -0.441$ shows a significant correlation between the abundances of the two species ($t = 2.284$ with 15 d.f. and $p < 0.05$). The overall picture seems interesting, especially because the mapping of *M. norvegica* may help to explain the movements of the fin whales. In our opinion, such studies should be repeated at least once every season.

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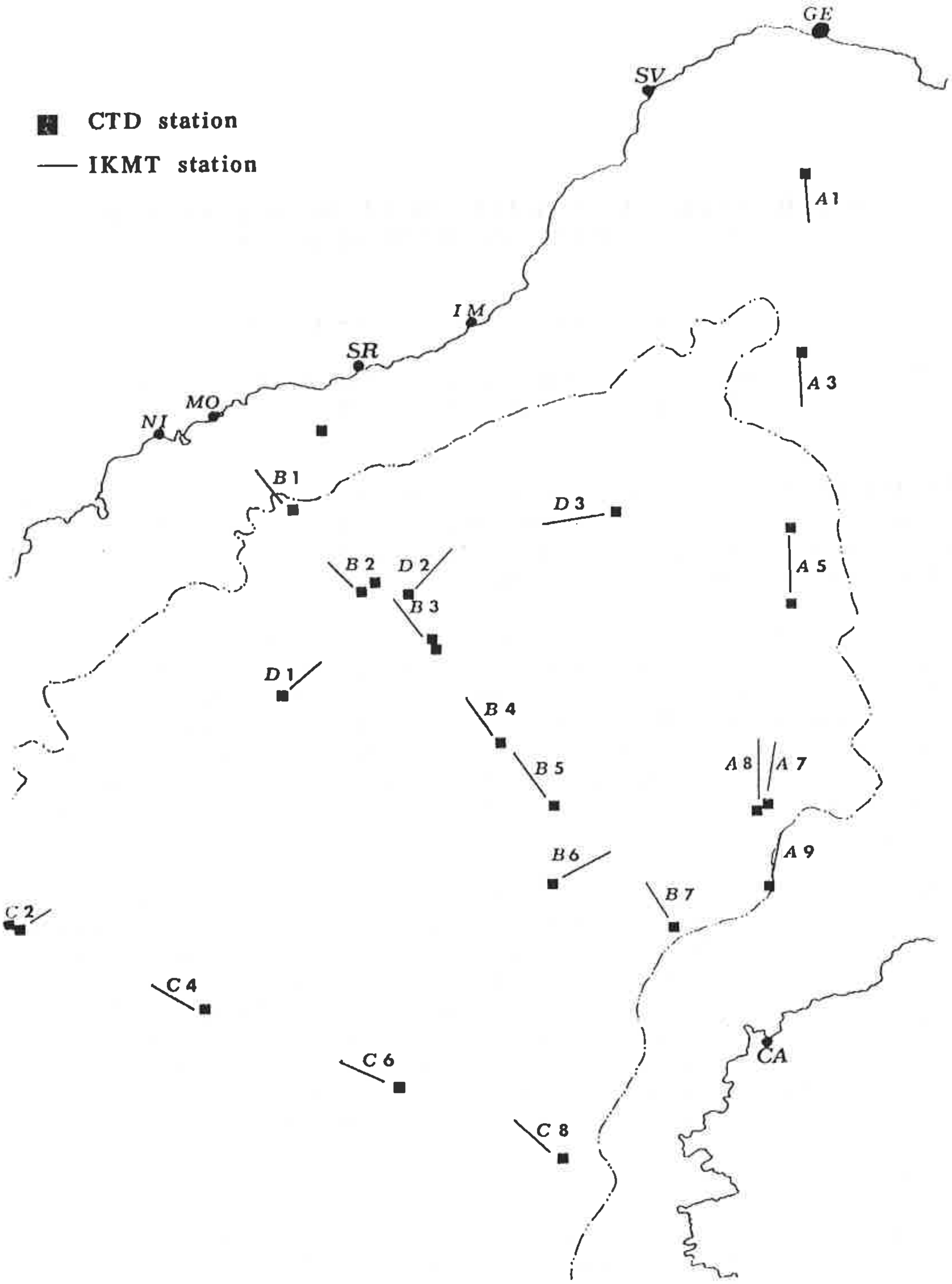

Fig. 1 Sampling carried out during the cruise of Minerva, August 1991

SUMMER FEEDING OF THE FIN WHALE, *Balaenoptera physalus*, IN THE LIGURO-PROVENÇAL BASIN

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INTRODUCTION Baleen whales are euryphagous, as are almost all cetaceans, and fin whales are able to utilise a variety of prey in different geographical areas. However, if euphausiids are available, these are the preferred, if not their only, food (Jonsgard, 1966; Mauchline and Fisher, 1969; Kawamura, 1980).

Only in the nineteen seventies was the presence of fin whales in the Northwestern Mediterranean basin related to the richness of food (Duguy and Vallon, 1977; Viale, 1985) and some analyses of the ingested biomass were carried out. Viale conducted an autopsy of a specimen killed in July 1972 and found in the stomach "an orange coloured mash apparently identical to that found in the stomachs of basking sharks". In such material, crustacean fragments were recognisable, but the species could not be identified. However, from indirect information on macroplankton (Franqueville, 1971), the euphausiids possibly concerned could be listed.

Much work on these shrimps has been carried out at Villefranche (Casanova, 1970; Casanova Soulier, 1974; Pagano, 1976; de la Bigne, 1986), and today their abundance and importance in the Liguro-Provençal basin are well known. Our knowledge of the feeding habits of large cetaceans in this area remains poor. The very simple and harmless method of collecting faecal material was apparently not practised even if, during the 1905 cruise of Prince Albert of Monaco, it was noted that "...entre Monaco et Calvi... une Balénoptère (*B. physalus*) ayant laissé des traces rouges...le filet ayant rapporé une crevette rouge (Acantephyra), l'idée vient que la coloration rouge des traces laissées par le Cétacé provient peut-tre de ce qu'il s'était nourri de crevettes semblables" (Richard, 1936)

This study is based on such sampling.

SAMPLING During cruises of the R/V Minerva (CNR, Italy) in the Liguro-Provençal basin (August 1990 and 1991), many fin whales were approached for research purposes (A. Giordano) or occasionally met during macroplankton samplings (L. Orsi Relini). When defaecation of the fin whale was observed from the ship, tenders and/or divers were prepared to collect the sample. The faecal mass is red and light; it remains in the surface water for a short time, after which it breaks up and sinks. Samples from six whales were filtered through a hand net and preserved in formalin solution; however, two of these from the same station were pooled because of the impossibility of distinguishing single whales in a group. The collection was augmented by small samples from ten whales collected in summer 1991 by the team of the Istituto Tethys who were working in the same area.

The last sample of faeces was obtained during the dissection of a fin whale which died on 30 April, 1991 as the result of a collision with a ferry not far from Bocche di Bonifacio. It was a male, of 17.5 m total length, which was transported to Genoa harbour (the whale had been caught on the bow of the ship), where the Centro Studi Cetacei (Museum of Natural History of Genoa and Milan) took charge of it for the collection of study material.

The food items were studied under a dissecting microscope, and mandibles were measured by means of a micrometric-ocular lens. A collection of mandibles of *M. norvegica*, ranging in length from 12 - 39 mm, was also measured in order to verify the correlation between total length and mandible length. The euphausiids of this sample were collected by means of an IKMT oblique tow from a depth of 750 m to the surface (August 1991).

MORPHOLOGICAL ANALYSES The fifteen summer samples proved to be almost identical in terms of composition. Faeces were formed of amorphous materials such as mucus, bits of soft tissue, and fragments of crustacean exoskeletons: appendages, uropods, pieces of carapaces, saetae, and eroded branchial tufts. Sometimes fragments of crustacean eyes with residual dark pigments were also found. Because of their colour and form, the dominant food items were the mandibles of *M. norvegica*, and all the other most important fragments have been traced back to this species. Sometimes thin bristles derived from the baleen were also found.

The spring sample appeared to be slightly different, since chitinolitic processes seem to have progressed after death, and the crustacean remains, including mandibles, were more fragmented and very fragile. However, in this sample, residues of *M. norvegica* were likewise dominant; very minute remains of what appear to be planktonic protozoa (radiolarians) were also found.

BIOMETRIC ANALYSES From each sample, sub-samples were analysed in order to obtain a quantity of mandibles suitable for a length- frequency distribution. The measures of mandibles were transformed into total length of shrimps (Fig. 1). The ingested euphausiids ranged from 11 to 39 mm total length. The size structure of the prey suggests that two age groups were present. Three whales had eaten both groups (Fig. 1a, b, f), two whales the youngest group (Fig. 1c, d), and one mainly the largest *M. norvegica.*

COMPARISON WITH IKMT SAMPLING In terms of range of sizes, the ingested *M. norvegica* overlap those caught by I.K.M.T. Additional information on population structure may be obtained if data on *Meganyctiphanes* in the area are available. Quantitative and qualitative aspects of the horizontal distribution of *M. norvegica* have recently been determined by means of a large-scale sampling programme using transects in the Liguro-Provençal basin (Relini et al., 1992).

It is well known that euphausiids have a high rate of avoidance of plankton nets and probably the large IKMT takes only a fraction of the standing biomass. However, comparing the quantities collected in a standard haul, routine captures were distinguished from very abundant ones. These were located in areas which were considered "hot spots" of *M. norvegica*. The sampled stock of *M. norvegica* essentially comprised two age groups and had a size structure which varied along a latitudinal gradient: a northern coastal assemblage dominated by old shrimps which gradually merged into a southern offshore assemblage dominated by young shrimps. In the hot spots, the relative importance of the two groups was similar (Relini et al., this volume). In terms of population structure, three whales apparently fed at the hot spots, one on northern groups and two, including the whale killed at Bonifacio, on the southern group.

DISCUSSION From the present analysis of faecal residues, the following preliminary conclusions may be drawn:
1) In summer, in this northern area of the Western Mediterranean basin, the fin whale consumes only *M. norvegica*..
2) The feeding season apparently begins in spring.

3) At any particular location, euphausiids of all available sizes are consumed.
4) By comparing the ingested sizes with the horizontal large-scale distribution of *M. norvegica*, it was possible to determine the location of their feeding grounds. This new approach promises a much better knowledge of the relationship between whale and prey.

Some basic aspects remain to be clarified. What is the real biomass of *M. norvegica* in the area? What sizes of fin whale can it sustain? Where does the fin whale go in winter? Do other Mediterranean feeding areas and/or other euphausiid prey exist?

However, in general, there seems to be an interesting "use" of *M. norvegica* by fin whales which does not differ from the exploitation of other euphausiids in other seas. The predation by whales on *Euphausia superba* has been studied by Marr (1962): shrimps of various sizes, from the sixth furcilia onward, constitute the food mass. The whales feed only on *E. superba* throughout the Antarctic summer. Consequently, the krill has a sufficiently long period available for reproduction without strong predation pressure. The same appears to be true in the Ligurian Sea, where predation stops in winter, probably at the same time as *M. norvegica* starts to breed (Casanova 1974).

If defaecation occurs in surface waters, it may contribute to nutrient cycling in the water column (Katona and Whitehead, 1988), also providing direct food in the form of organic residues rich in fats, chitin, pigments, including traces of vitamin A (which is located mainly in the eyes) to detritivorous zooplankton (probably including prey of the same *M. norvegica*). A final question that may be asked is whether the fin whale exploits its main resource without endangering it.

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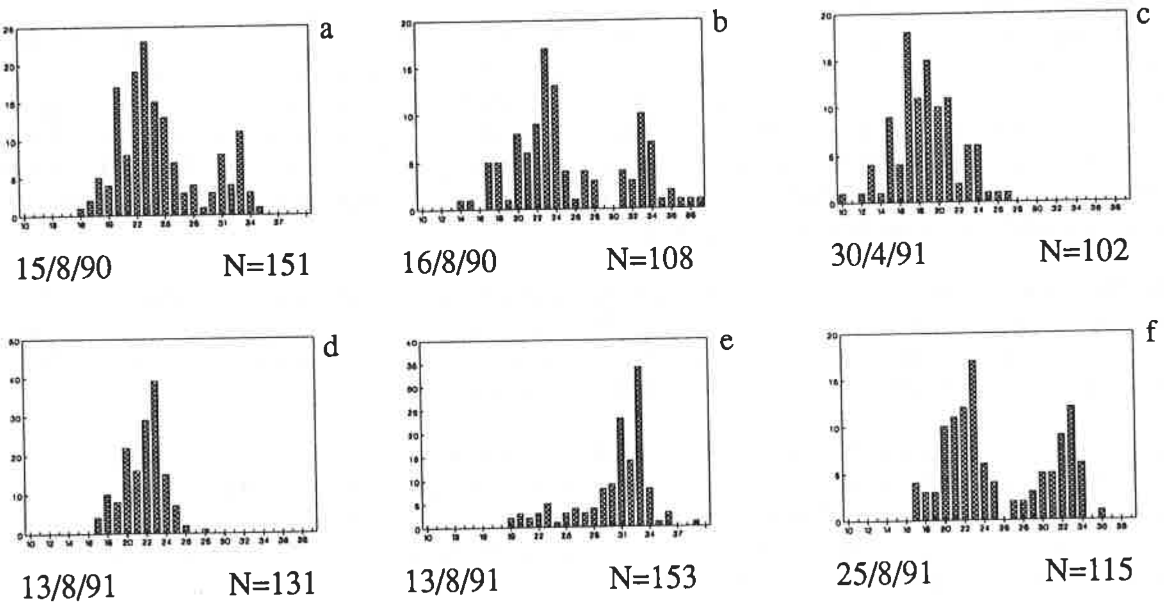

15/8/90 N=151

16/8/90 N=108

30/4/91 N=102

13/8/91 N=131

13/8/91 N=153

25/8/91 N=115

Fig. 1 *Meganyctiphanes norvegica* as prey of fin whales

FEEDING OF THE PILOT WHALE,*Globicephala melas*, IN THE LIGURIAN SEA: A PRELIMINARY NOTE.

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INTRODUCTION. The fin whale, *Balaenoptera physalus*, and the pilot whale, *Globicephala melas*, appear to be more frequent in the Ligurian Sea than elsewhere in the Western Mediterranean. For the first species, the relationship with available food has recently been demonstrated, whilst for *G. melas*, a study of the diet has been undertaken to verify if particular prey exist in this area. As a first step, we consider data from the literature and old collections of study material. In particular, the stomach contents of a specimen killed in the 1960s will be described. During that period, some hunting of small cetaceans persisted in the Ligurian Sea, both for the preparation of "musciame"* and for sport. Material collected in relation to these activities is interesting because it probably belongs to healthy animals, while in the case of stranded cetaceans there is the suspicion that the diet may have been affected by a general stress condition.

MATERIALS. The pilot whale was a pregnant female (with a foetus of 41 cm), captured along the Eastern Ligurian Riviera in September 1967, measuring 3.5 m total length, and weighing about 485 kg. The stomach content was represented by two crowns of arms and buccal masses, a few remains of pens, lenses and beaks of cephalopods: 22 upper and 33 lower beaks were found. The lower beaks were used to identify the ingested cephalopods (Clarke, 1986). Using a collection of cephalopods obtained by pelagic sampling and deep-trawl fishing, the lower rostral length-dorsal mantle length and lower rostral length-weight relationships were calculated for the most important cephalopod prey. Based on these, an estimate of the ingested biomass is given.

RESULTS. The stomach content is made up entirely of cephalopods (Table 1), which formed an estimated biomass of 16.7 kg. This weight probably corresponds to more than one meal, since both muscular tissue and beaks were present; it represents 3.4% of body weight, and is probably the daily food intake (Sergeant, 1962).

Three species of Histioteuthidae were recorded, forming 60.5 % of the total biomass. These are ammonium rich, neutrally buoyant squids which are distributed in offshore waters from the surface to the greatest depths. The most abundant species, *H. reversa* is also the species most commonly captured by I.K.M.T. in the area (Franqueville, 1971; Orsi Relini, 1992). Sizes varied between 4.1 and 10.6 cm M.L.

H. bonnellii is a large species (up to six kg in our collection) which makes up the greatest proportion by weight. The estimated sizes of ingested specimens varied between 11 and 16.5 cm M.L., corresponding to a mean weight of 1,224 g. *H. elongata* is a rare species, whose lower beak is poorly known. We have never obtained it by I.K.M.T., nor by commercial deep-trawl fishing. However, we have found some dead specimens floating on

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*"Musciame" was a food used on board Ligurian vessels from the time of sailing. It consisted of fillets of meat derived from small cetaceans (*Stenella coeruleoalba, Tursiops truncatus, Delphinus delphis, Steno bredanensis, Grampus griseus* and *Globicephala melas*). Every muscular tissue was used to prepare approximately cylindrical 25 - 30 cm long sticks which were salted and dried in the air during navigation.

the surface of a water column of more than 2000 m depth. We believe that it lives at bathypelagic levels; only one beak is present, with an estimated weight of 550 g.

The second largest share of prey comprises Ommastrephidae. All identified specimens were *Todarodes sagittatus*, although some partially eroded beaks remain undetermined. *T. sagittatus* can be found offshore in surface waters at night, or along the slope during the day, but generally not further out than the 1,000 m bathymetric line. In the upper water columns of the Ligurian Sea, *T. sagittatus* is replaced by *Ommastrephes bartrami* (Orsi Relini, 1990).

The third share, but of lesser quantitative importance, is represented by two species of Onychoteuthidae, both mainly epipelagic (at least for the observed sizes).

DISCUSSION The diet of short-finned pilot whales in different geographical areas is compared in Table 2. The pilot whale sometimes also takes fish, amounting to c. 10% of total weight of food (Sergeant, 1962; Desportes, 1985). A supposed predation on tuna (Scordia, 1939) was probably mistaken, given that in the Atlantic Ocean an association between pilot whale and bluefin tuna was observed when both were feeding on *Illex illecebrosus* (Sergeant, 1962). When there is a choice, muscular squids (Clarke, 1986) seem to be the preferred food; this was observed both in Newfoundland for *I. illecebrosus* and near the Faroes for *T. sagittatus*. In the Western Mediterranean, if we exclude stranded individuals, we have only a few records of the stomach content of *G. melas*. These were described by Joubin in the reports of the cruises undertaken by Prince Albert of Monaco (Richard, 1936). A young male (4 m, killed at Capo Palos, Alboran Sea) and the present gravid female ate about 50:50 of muscular and ammonium-rich squids, while two adult males (4.92 and 4.5 m length) fed up to 100% on Ommastrephidae. One of the latter animals had on its skin the print of the suckers of the club of an ommastrephid squid (now on public display in the Oceanographic Museum, Monaco), which in our opinion can be assigned to *O. bartrami*. This species is the largest, strongest and fastest swimming member of the family in the Mediterranean. It could be the target of pilot whales, or at least, of the older and stronger members of their groups, especially if they have evolved social hunting behaviour.

ACKNOWLEDGEMENTS We would like to thank Dr. M. Mariani, Director of the Acquario e Civica Stazione Idrologica of Milan, who has given us the opportunity to study the stomach contents of the specimen killed on September 1967. Cagnolaro (1969) described the specimen and its foetus.

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Table 1. Stomach contents of a single specimen of*G. melas* in the Ligurian Sea.

Species	No.	%	Estimated weights Mean (g)	Total (g)	Total (%)
H.bonnellii	5	15.1	1224.4	6122.1	36.6
H.reversa	14	42.4	146.0	2045.3	12.2
H.elongata	1	3.0	550.0	550.0	3.3
HISTIOTEUTHIDAE	20	60.5	-	8717.4	52.1
T.sagittatus	9	27.3	865.9	7793.8	46.6
Ommastr.n.e.i.	2	6.1	50.0	100.0	0.6
OMMASTREPHIDAE	11	33:4	-	7893.8	47.2
A. lichtensteini	1	3.0	60.0	60.0	0.36
O. banksi	1	3.0	45.5	45.5	0.27
ONYCHOTEUTHIDAE	2	6.0	-	105.5	0.63
Total	33	99.9	-	16716.7	99.93

Table 2 Cephalopods in the diet of long-finned pilot whales, *Globicephala melas*

Cephalopod family (%)	Ligurian Sea present specimen	Ligurian Sea Richard (1936)	Alboran Sea Richard (1936)	Newfoundland Sergeant (1962)	France Clarke (1985)	Clarke (1985)	Faroe Islands Desportes 1988	Desportes et al (1988)
No. of beaks	33	-	-	-	52	353	3600	3800
No. of samples	1	2	1	29	6	2	35	168
Ommastrephidae	33.3	*	*	100.0	21.2	96.3	96	50.8
Onychoteuthidae	6.1	-	*	-	-	-	-	-
Brachioteuthidae	-	-	-	-	9.6	-	-	1.1
Enoploteuthidae	-	-	-	-	-	3.7	-	-
Histioteuthidae	60.6	-	*	-	9.6	-	-	0.3
Cranchiidae	-	-	-	-	26.9	-	-	-
Gonatidae	-	-	-	-	-	-	4	40.4
Loliginidae	-	-	-	-	21.2	-	-	0.03
Sepiolidae	-	-	-	-	1.9	-	-	1.6
Sepiidae	-	-	-	-	1.9	-	-	-
Octopodidae	-	-	-	-	7.7	-	8.7	
others	-	-	-	-	-	-	0.1	1.26
Total	100.0	-	-	100.0	100.0	100.0	100.1	104.1

* Cephalopod families identified in the stomach contents without counts of total specimens ingested.

A PRELIMINARY INVESTIGATION INTO THE RELATIONSHIP BETWEEN THE DISTRIBUTION OF RISSO'S DOLPHIN AND DEPTH.

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INTRODUCTION Since 1989, Greenpeace, via the Mediterranean Sea Project, has conducted research on cetaceans. From 1990, great attention has been devoted to the Ligurian and Ligurian-Provençal basin. The Risso's dolphin (*Grampus griseus*) is mentioned as a pelagic species living in deep waters (Cagnolaro *et al.* , 1983) and usually at depths of around 1000 metres (Gannier and Gannier, 1990). Sightings of this species collected by Greenpeace and the Cetacean Research Group are analysed in relation to depth and distance from the coast.

MATERIALS AND METHODS Data were collected during Greenpeace research campaigns in 1989, 1990 and 1991, using hired vessels or sailing boats belonging to volunteers, and during other cetacean campaigns of the Cetacean Research Group (Table l). The Greenpeace sightings were conducted by two final year students studying Natural Sciences and who had already experience of the identification of the different species, and data collection at sea. For every sighting, the number of specimens in the group, their behaviour, direction of travel, and the presence or absence of calves were recorded.

Whenever possible, specimens were " photo-identified" using 35 mm cameras, with lenses of 50, 135 and 300 mm focal length and Kodachrome 64 ASA slide films or Ilford 400 ASA negative film (Würsig & Jefferson, 1988; Defran, *et al.*, 1988). Sightings were recorded on charts 1501 and 1502 of the C.N.R. bathymetric map (1969) and on the Oceanographic Institute of the Military Navy nautical map (1987).

Information came from volunteers (considered here only those which included photographic material and with point geographical coordinates).

RESULTS AND DISCUSSION Viale (1982) reported Risso's dolphins at a minimum distance of about 20 miles from the coast. We found that the largest number of sightings were within five miles from shore (Fig. l), with an average distance of 15 miles, as similarly reported in the literature (13 miles) by Notarbartolo di Sciara *et al.* (1990). However, within the area explored most thoroughly (25 miles from the coast), the distance of sightings from the coast was strongly correlated with depth.

As shown in Fig. 2, most sightings collected within a zone of 5 miles from the coast have been made in areas that included the most suitable feeding depth (here assumed to be 600 metres). On the other hand, the frequency of sightings outside the 5-mile zone increased in those areas around this depth.

The 55 sightings of this species reported here were analysed in relation to water depth and the distance to the nearest point of the coast. Figure 3 shows that sightings are most frequent in areas of less than 1,000 metres depth. Those sightings in deeper waters occurred usually near sea mounts (i.e. areas where the seabed is unusually high). These data apparently agree with the feeding habits of the species, as reported in studies on the stomach contents of stranded specimens. Mesopelagic cephalopods, particularly *Ancistroteuthis lichtensteinii, Histioteuthis bonnellii, Histioteuthis reversa, Todarodes* *sagittatus,* seem to constitute an important part of the Risso's dolphin's diet (Wurtz *et al.*, in press). All these species live in waters deeper than 300 metres, and those belonging to the genus *Histioteuthis* are usually found on the sea bed between 600 and 700 metres depth (Wurtz *et al.*, 1979).

During the 1991 Greenpeace survey in the Ligurian Sea, a group of Risso's dolphins was sighted several times over eight days. Thirteen individuals were photo-identified using dorsal fin features and natural scars on their bodies. The group was sighted for the first time about 20 miles off San Remo. During the first two sightings, the group comprised about 30 animals, including two calves. We were able to recognise this group thanks to the presence of a female with a notched dorsal fin, constantly together with her calf. After the third sighting, we noted the school size decreased to about 15 animals, while the other part of the group disappeared. From this time, it was possible to see only one calf.

As shown in Fig. 4, the group moved first from south to north and then west to east, remaining in a sea strip ranging in depth from 600 to 1000 metres. It is evident that this group was tending to remain in an area deeper than 600 metres, known to be an area of high cephalopod productivity (Repetto, N., pers.comm.)

CONCLUSIONS The distribution of the Risso's dolphin appears to be affected by depth and distance from the coast, and influenced by the features of the continental shelf. This may affect the teutophagic habits of the species. Further research may be necessary for a better understanding of Risso's dolphin feeding ecology.

In the Western Ligurian Sea, where the continental shelf is quite reduced in extent and where Risso's dolphins seem to occur most frequently (Duguy *et al.*, 1983), this species can find a suitable feeding area very close to the coast. This could make the species locally vulnerable to several human activities.The U.N.E.P. Action Plan for the Conservation of Cetaceans in the Mediterranean Sea (U.N.E.P., 1991) has requested states to implement measures such as:

a) prevention and elimination of pollution;
b) elimination of incidental catches and fishing gears;
c) prevention of over-explotation of fisheries resources;
d) protection of feeding, breeding and calving grounds

These need to be implemented immediately.

Furthermore, it is believed that maritime traffic of pleasure and commercial boats may seriously endanger cetaceans, interfering with their intra-specific communication and echo-location (Collet, 1991). In this respect, speed limits for pleasure boats, and the prohibition of off-shore competitions are necessary in areas where cetaceans are frequent.

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Table 1 Geographical position and sources of sightings

DATE	LAT.	LONG.	SOURCE
05/07/91	43°34'N	07°45'E	*
05/07/91	43°44'N	07°51'E	*
06/07/91	43°42'N	07°48'E	*
08/07/91	43°42'N	07°45'E	*
11/07/91	43°46'N	08°00'E	*
12/07/91	43°47'N	08°10'E	*
12/07/91	43°47'N	08°15'E	*
12/07/91	43°50'N	08°18'E	*
16/07/91	44°08'N	08°38'E	*
19/07/91	44°15'N	09°01'E	*
30/06/90	44°14'N	09°16'E	*
16/07/90	44°16'N	08°42'E	*
30/08/90	44°04'N	08°24'E	*
11/06/89	41°46'N	09°31'E	**
11/06/89	41°44'N	09°30'E	**
12/06/89	41°48'N	09°34'E	**
10/07/89	38°52'N	09°51'E	**
10/07/89	38°55'N	09°28'E	**
19/07/89	38°52'N	13°49'E	**
17/07/91	38°09'N	13°32'E	**
17/07/91	38°11'N	13°24'E	**
24/05/81	42°10'N	09°50'E	***
04/05/83	43°32'N	07°07'E	***
09/07/84	43°29'N	07°07'E	***
04/06/85	42°30'N	08°00'E	***
11/08/86	44°16'N	08°57'E	***
03/08/87	43°05'N	0~°21'E	***
21/07/88	43°42'N	07°36'E	***
22/08/89	43°53'N	09°23'E	***
16/08/91	44°12'N	08°SS'E	***
25/03/81	42°35'N	03°45'E	***
14/04/81	43°45'N	07°49'E	***
22/05/81	43°40'N	07°17'E	***
22/08/80	43°09'N	06°37'E	***
15/06/81	43°00'N	05°53'E	***
05/07/81	43°34'N	05°10'E	***
14/05/82	42°43'N	05°10'E	***
19/08/82	42°25'N	07°28'E	***
06/07/82	42°23'N	05°49'E	***
09/07/82	42°06'N	05°04'E	***
03/07/83	42°57'N	05°02'E	***
27/08/83	41°22'N	09°10'E	***
21/06/83	43°40'N	09°07'E	***
30/07/83	38°22'N	11°56'E	***
27/01/76	43°06'N	09°21'E	***
21/08/76	43°24'N	07°00'E	***
12/06/76	43°05'N	07°09'E	***
12/07/77	43°07'N	09°22'E	***
01/01/78	43°06'N	08°13'E	***
14/08/78	43°01'N	08°02'E	***
25/06/79	42°13'N	08°28'E	***
04/06/79	42°1O'N	06°06'E	***
23/07/78	43°38'N	07°12'E	***
14/10/78	43°01'N	06°46'E	***
16/08/91	38°03'N	14°01'E	***

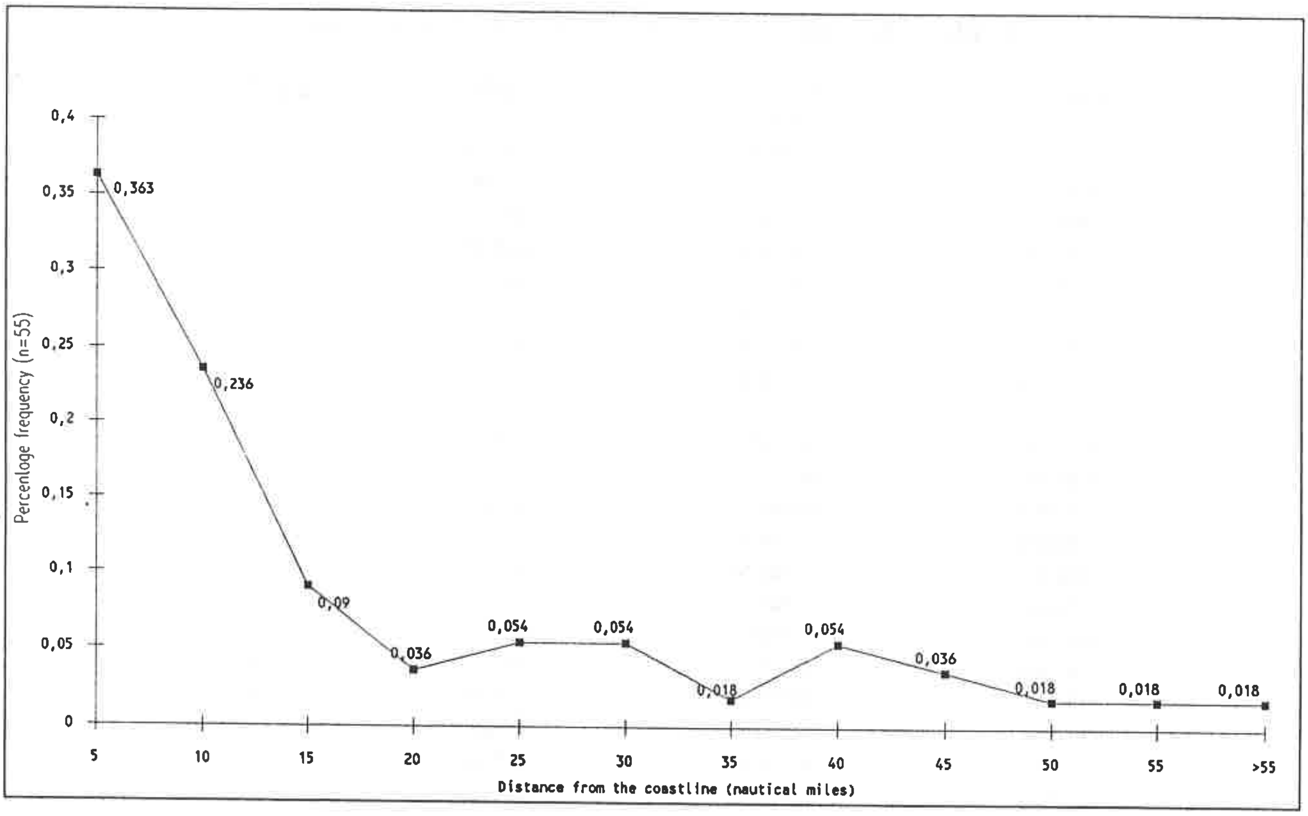


Fig. 1 Sightings in relation to the distance from the coastline

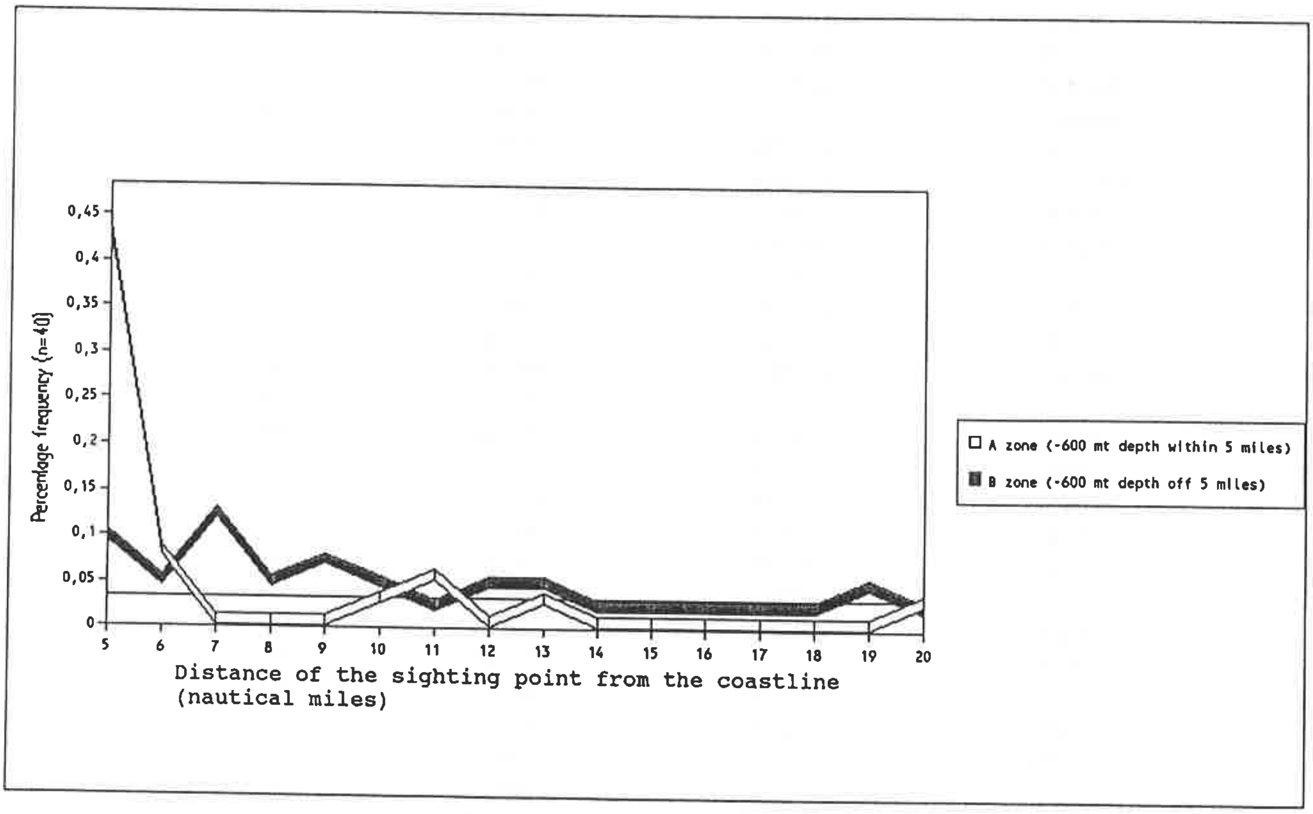


Fig. 2 Frequency of sightings in relation to the distance from the coast and sea bottom features

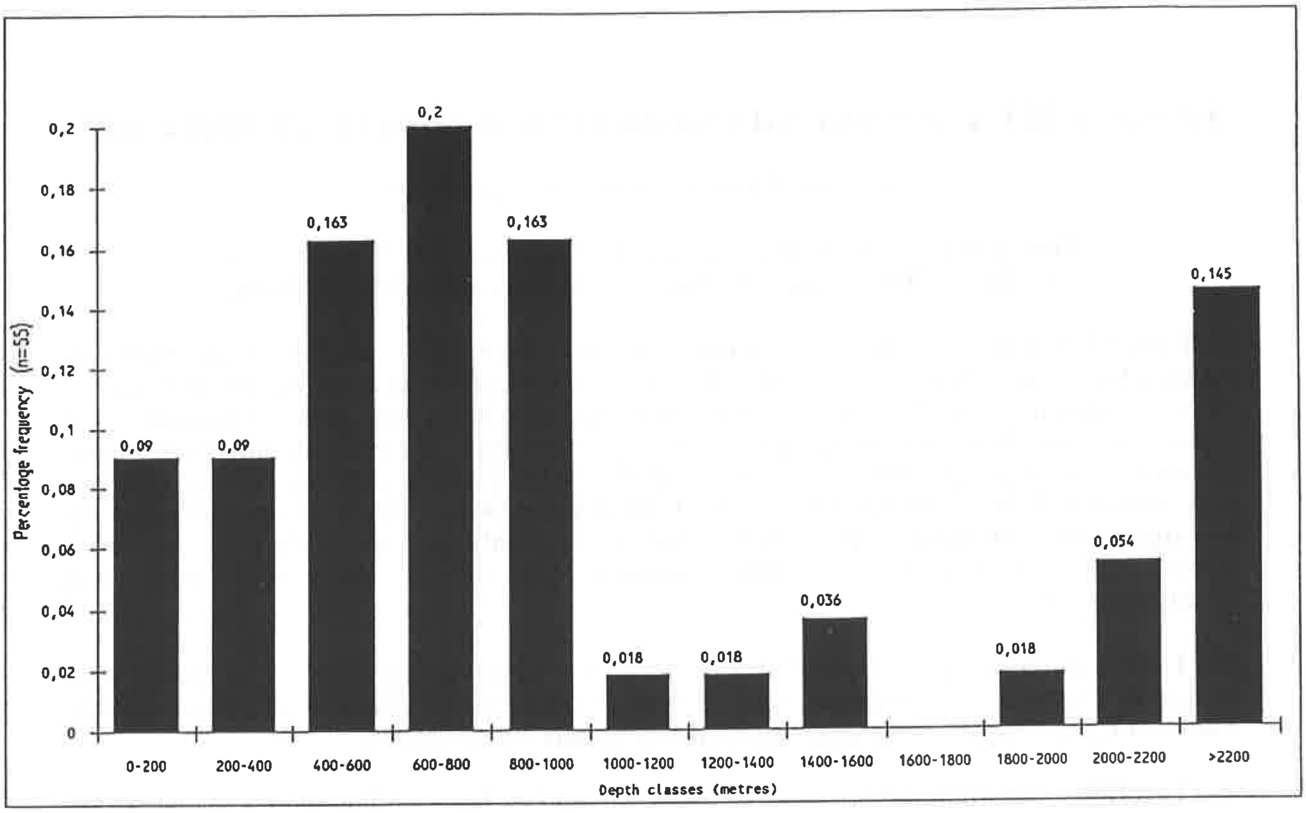
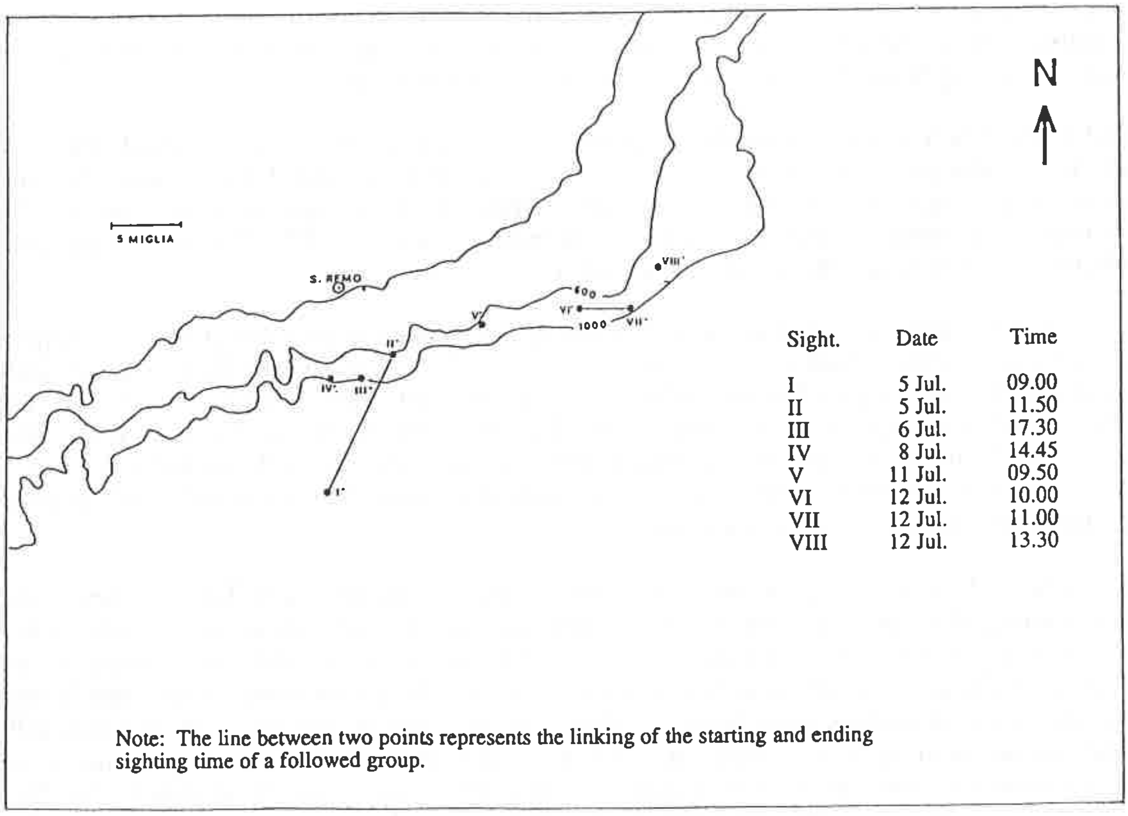


Fig. 3 Frequency of sightings in relation to the depth



Sight.	Date	Time
I	5 Jul.	09.00
II	5 Jul.	11.50
III	6 Jul.	17.30
IV	8 Jul.	14.45
V	11 Jul.	09.50
VI	12 Jul.	10.00
VII	12 Jul.	11.00
VIII	12 Jul.	13.30

Note: The line between two points represents the linking of the starting and ending sighting time of a followed group.

Fig. 4 Movements over eight days of a group of Risso's dolphins in the Ligurian Sea.

HUNTING BEHAVIOUR OF KILLER WHALES ON CROZET ARCHIPELAGO

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INTRODUCTION The killer whale, *Orcinus orca*, is a social predator living in matriarchal groups (Bigg *et al.*, 1990). The species is distributed in all oceans and seas of the world but is more abundant in cold waters. Killer whales are top-level predators and opportunistic feeders; they are known to feed on a wide array of prey including fish, marine mammals and seabirds. Studies conducted in the North East Pacific have shown that two sympatric populations, genetically isolated (Hoelzel and Dover, 1991) are specialised in the hunting of two different types of prey. One feeds mostly on fish while the other feeds mostly on marine mammals. A similar situation may exist in Antarctica (Berzin and Vladimirov, 1983).

Off Crozet Archipelago, killer whales consumed a wide variety of prey, including fish, penguins, *Eudyptes sp.*, elephant seals, *Mirounga leonina*, and occasionally large whales. The hunting techniques of elephant seals and penguins are described.

METHODS The hunting behaviour of killer whales has been studied over a 3-year period from the coast of Possession Island. Results are based on observations conducted from 25 October 1987 to 10 January 1989; 1 October to 26 December 1989; and 2 October to 9 December 1990. During the study period, 18 pods including 72 whales have been photo-identified (Guinet, 1991), and killer whales were observed for a total of 866 hours. Killer whales can be observed all year round but are seen on a daily basis from October to December. While the whales were hunting, their acoustic behaviour was monitored using Sonobuoy hydrophones with a frequency range of 1 Hz to 12 kHz.

RESULTS AND DISCUSSION: 45 predations on penguins were observed. Penguins could be caught along the coast (n= 13), in particular those covered with seaweeds which affected the escape movements of the prey. Most of the penguins were caught when porpoising in groups to enter the bay of the breeding colony (n=32). The hunt of penguins tended to be solitary and the whales were silent.

A total of 29 captures of elephant seals, including 24 weaned pups were observed. Elephant seals were generally hunted along the sandy beaches. Two pods, A and B, were particularly involved in this hunting technique. When hunting elephant seals along the beach, the same whale tended to occupy the same position in a bay, from bay to bay and year to year. Seven elephant seal pups were captured by female killer whales stranding intentionally, 14 pups at the river mouth and three while swimming along the shore. Subadult and adult elephant seals were all captured in the open water.

Killer whales killed their prey either by striking them with their tail fluke or their snout. When hunting elephant seals, killer whales were acoustically very quiet: only contact clicks were exchanged between pod members. Over 16h, twelve recordings were analysed and 125 of these clicks were detected. The tendency for the whale to remain silent when hunting seals, and their responses to different artificial noise sources, suggest strongly that killer whales locate them by passive listening. When a seal was located, close range contact calls (Fig. 1) were produced as the attack was launched. In response, killer whales within 50 to 300 metres converged on the attacking whales. When the elephant seal was under attack or captured, long distance excited calls (Fig. 1) were produced for eight out of the eleven cases where the acoustic behaviour was monitored. In reaction to the production of these calls, likely to be motivated by the size of the prey, distant killer whales belonging to the same pod, but also other pods, arrived porpoising to the location to the attack.

According to the data obtained during that study and available in the literature, the size of the hunting unit within a pod (adult whales and large juveniles) allows killer whales off Crozet Archipelago to successfully hunt large pinnipeds. However to successfully hunt baleen whales, killer whales have to associate. Such association is suggested to take place, as we witnessed an unidentified species of baleen whale under the attack of at least ten killer whales.

While it is likely to be efficient in terms of hunting success to hunt marine mammals silently, in order to surprise them, I suggest that the adaptive value of the production of long distance excited calls when a large prey is located is to allow the adjustment of the size of the hunting unit within a pod but also between pods according to the size of the prey.

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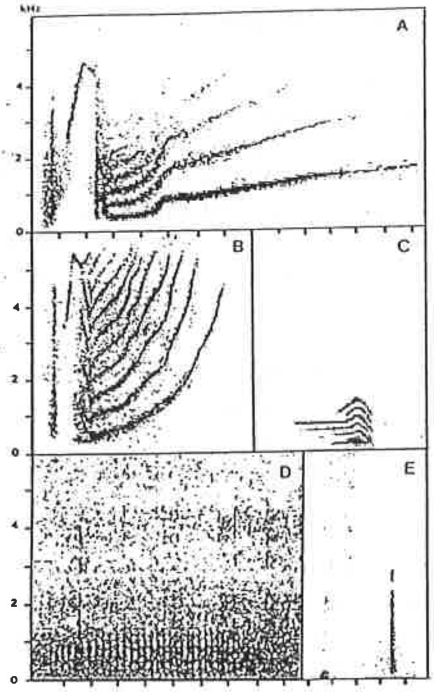

Fig. 1 Sonograms of calls commonly used by killer whales of Crozet Archipelago.

KEY A: Long distance stereotyped calls, B: Excited form of A;
C: Close range contact calls, D: Click train; E: Contact clicks.

SOCIAL STRUCTURE OF SHORT-FINNED PILOT WHALES, *Globicephala macrorhynchus* , OFF TENERIFE, CANARY ISLANDS

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INTRODUCTION The life history and reproductive biology of short-finned pilot whales, *Globicephala macrorhynchus*, has been illuminated through shore whaling data (Kasuya and Marsh, 1984). There has been a need to examine the behavioural implications of these findings in a free-ranging population. A regularly-occurring group of short-finned pilot whales was located off the western coast of Tenerife in the Canary Island archipelago off Northwest Africa. This is a report on a 22-month study, conducted from October 1989 through July 1991, covering the initial findings of pilot whale patterns of occurrence and social structure.

MATERIALS AND METHODS Field operations were based in the town of Los Cristianos, on the southwest coast of Tenerife. Two vessels were used: a 4.7 m. Zodiac inflatable and a 13.1 m. sailing ketch. The primary method for assessing social structure was the photographic identification of individual whales. Whales were primarily identified on the basis of scars on the trailing edge of the dorsal fin and secondarily by dorsal fin shape. Films were examined using a Photovix II Film Video Processor, which allows negative or positive images to be relayed to a video screen for magnification and viewing. Prints were made for a photographic catalogue and compared with both past documentation and subsequent identifications, in order to confirm repeat sightings. Identifications from all frames of film were entered onto computer to aid in cross-referencing multiple sightings of the same individuals.

Field work was conducted from October 1989 through July 1991. The majority of the search effort was conducted within eight km. (five miles) of the coast, centred along the 1000 m. (3280 ft.) depth contour off the southwest coast of Tenerife, around the port of Los Cristianos. Additionally, eight 145 km. (91 mile) transects were conducted around Gomera Island and five transects were conducted along the west coast of Tenerife, to the northwest tip of the island at 28° 20' north latitude. Sampling effort occurred, on average, about seven times a month.

RESULTS Short-finned pilot whales were observed on 155 days for 541.8 hrs. out of a total effort of 229 days and 1124.2 hrs. Whales were seen during all months (Fig. 1). There was no obvious trend to sighting per unit effort results. The whales did not appear to occur in the area with any seasonal pattern, although the occurrence of specific individuals may have varied seasonally.

All pilot whale observations occurred within a 130 sq. km. area, along a 30 km. stretch of coast between 27°58'N and 28°08'N latitude, and 16°41'W and 16°52'W longitude, indicating a strong preference for the 1000 m. depth contour off southwestern Tenerife. Pilot whales were never documented in any of the outlying surveys to northwest Tenerife and Gomera.

Photographs from 74 days have been examined for whale identifications. Four hundred and forty-five individuals have been identified (Fig.2). This does not include sightings of "cleanfin" animals, which may represent as many as 20% of the animals per day. Thus, the 445 whales identified here represent only a proportion of the whales which use the Tenerife area. The number is likely to be closer to 550 or 600.

Two hundred and seventeen of the identified whales (49%) were seen only once. The remaining 228 whales showed a variety of patterns of occurrence. Many whales (117, or 26%) were seen only two or three times and could be clumped with the one time animals as transient visitors to the region. Other whales were seen cyclically, occurring in the study area for a number of days and then not seen until a year later. These may be seasonal visitors to the area. Twenty-one whales were seen ten times or more (up to 17 for one individual). These whales were seen regularly throughout the study period and represent 'resident' animals; however, even some of these 'residents' were not seen for three or four months. These regular users of the region were observed in stable groups of five to ten. One group consisted of one adult male, an adult female, and a mother with her three calves. Some groups of males also showed stable associations, often travelling peripherally to female/calf groups. These stable groups occasionally mixed with each other, forming large assemblages of up to 60 whales.

CONCLUSIONS Many elements of pilot whale social organisation remain unknown, but a few conclusions can be drawn. The core units of pilot whale groups appear to be somewhat extended families, centred around at least one adult female with her immature offspring. Most groups appear to contain additional adult females. In one case, the other adult female did not have calves of her own. She could be a post-reproductive female associating with her daughter. The question of the role of adult males in pilot whale groups is still unclear. In some cases we have observed long term associations between adult males and these female units. Genetic studies of long-finned pilot whales of the Faroe Islands have found that the adult males were not the fathers of the newborn calves in the group (Amos *et al.*, 1991). If this is also the case with short-finned pilot whales, the stable associations between adult males and adult females may represent kin relationships and the males are not breeding within their social group because of inbreeding constraints. Genetic biopsy sampling of resident social groups could provide a resolution to this question.

It is interesting to compare our findings for pilot whale social structure with that for other species of Delphinidae. Only the killer whale, *Orcinus orca,* and the bottle-nosed dolphin,*Tursiops truncatus*, have been been well-studied and they appear to have very different forms of social organisation. Killer whales live in highly stable pods, which consist of matriarchal units of at least one post-reproductive female with up to three generations of offspring (S. Heimlich-Boran, 1986). Uniquely, neither sex appears to emigrate from its natal pod. In contrast, bottle-nosed dolphins appear to live in smaller stable units, without a high proportion of post-reproductive females (Würsig and Würsig, 1977; Wells *et al.*, 1987). These core units associate somewhat freely, and with a high degree of group mixing. Age/sex classes appear to be more highly segregated, with adult males moving between stable female bands to breed and juvenile males segregating amongst themselves.

For pilot whales, we know from biological data that there is a high proportion of post-reproductive females. These females would be expected to continue to associate with their multi-generational offspring, forming larger core units as in killer whales. Amos *et al.* (1991) concluded that long-finned pilot whales lived in matriarchal social groups based on the degree of genetic relatedness between females. With adult males, the expected situation is less clear. The typical mammalian explanation would be that males, being the larger sex, might be expected to compete with other males for access to females, and to emigrate from their natal group to avoid inbreeding. However, killer whales remain in their natal group and appear to breed only with co-occurring pods in seasonal aggregations. It is likely to be true for all cetaceans that females breed promiscuously and males have little guarantee of paternity. Consortships and female guarding are very difficult in a three-dimensional environment such as the open ocean. Pressures to stay in stable social groups may be high for a coordinated group predator such as the killer whale, thus resulting in a lack of emigration for adult males. In the case of pilot whales, there is still not enough information about the ecological pressures on group stability. Further study is needed on the feeding ecology of pilot whales before completely understanding their social organisation.

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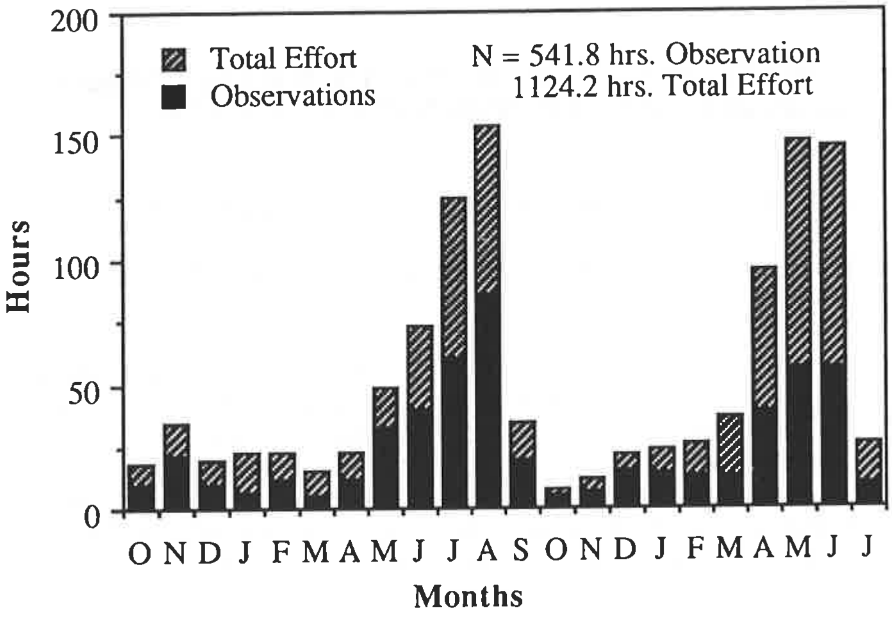

Figure 1 Summary of total effort and observations of pilot whales off Tenerife from October 1989 through July 1991. Peak effort occurred during two Earthwatch-sponsored sessions.

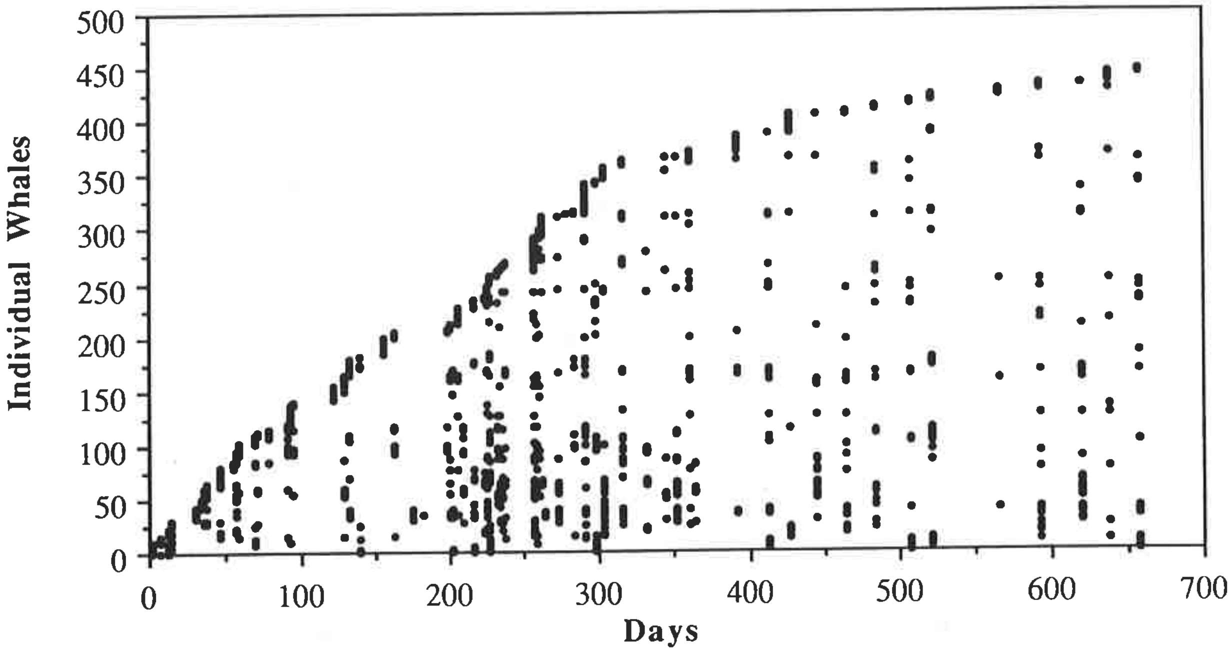

Figure 2 Sighting records of 445 individual whales between October 1989 and July 1991. Each dot represents a photographic documentation of a given whale on a given day.

BEHAVIORAL DEVELOPMENT OF HUMPBACK WHALES (Megaptera novaeangliae) IN THE SOUTHERN GULF OF MAINE

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Since 1980, we have studied the behaviour and ecology of humpback whales (*Megaptera novaeangliae*) from commercial whale watching and dedicated vessels out of Gloucester Massachusetts, U.S.A. Our studies are centred around the northern end of Stellwagen Bank, a sandy glacial deposit off the Massachusetts coast where humpbacks congregate to feed on sand eels, *Ammodytes americanus*, between April and December of each year. Individuals were identified by photographs of the pigment pattern on the ventral side of the flukes and the shape and scarring of the dorsal fin (Katona and Whitehead, 1981).

During sightings, the sequence and timing of behaviours from an ethogram of 64 different behaviour types were recorded on focal animals. Behaviours were grouped by category: aerial behaviours (including flipper slaps, belly-up flipper slaps, lobtails, belly-up lobtails, tail breaches, and five types of full body breaches), social/inquisitive behaviours (including trumpet blows, rolls, head-ups (high and low), belly-ups, tail stands, and single bubbles), and surface feeding behaviours (feeding lunges, bubble clouds, bubble rows, bubble nets). The classification of behaviour types was based on the authors' experience observing each behaviour in particular contexts.

To examine changes in behavioural rates of maturing animals, we used only data collected from individuals first photographed as calves. By doing this, we ensured that behaviours were correctly assigned to the proper age class. The resultant data set consisted of behavioural observations on 76 animals, although sample size decreased as age increased. This is due to: (1) observations of individuals who were not re-sighted after any given age; and (2) increased numbers of calves identified in the second half of the study period (Clapham and Mayo, 1990). In order to make the data on all ages comparable, behavioural frequencies were transformed into rates by dividing the total number of occurrences of a behaviour by the total number of observation hours for that year class.

Aerial behaviours were found to peak in known aged animals at years 2-3, and decrease dramatically at 5-6 years of age to levels below that seen at other ages (Fig. 1). This was due more to the number of times behaviours were displayed given any aerial activity occurring, as opposed to the overall number of observations in which any aerial activity was recorded. Social/inquisitive behaviours were consistent throughout the period, and showed a slight increase at ages 5-6 (Fig. 1). Finally, feeding behaviours gradually increased from very low rates among nursing calves to much higher levels in 6 year old animals.

While each behavioural trend is interesting in itself, it is only in relation to each other that the shifts in time budgets allow insight into the developmental process (Fig. 1). Clearly, whales showed a trend of declining aerial activity as their body grew larger, and they moved towards maturity at 5-6 years of age (Matthews, 1937; Chittleborough, 1965; Clapham and Mayo, 1990). Younger whales may have had surplus energy available for aerial activity; they are not constrained by the energetics of breeding, and it was important that "play" behaviours be used to perfect social actions that will be used extensively after maturity (Whitehead, 1985). Further, the smaller body size presumably required less energetic cost per aerial behaviour. Social behaviours remained constant throughout development, as the young animal was increasingly a part of the adult social organisation as it approached maturation (Weinrich and Kuhlberg, 1991). Surface feeding, however, increased in importance in relation to the other behaviours so that six year old animals spent more time feeding than engaged in social or aerial activity. This was expected; the amount of stored energy plays a determining role in breeding success of both males and females (Lockyer, 1981; Darling, 1983; Tyack and Whitehead, 1983; Weinrich and Kuhlberg, 1991).

The lack of surface feeding among one and two year old humpback whales likely reflected two factors. Young animals appeared to spend much of their feeding time engaged in sub-surface feeding (Weinrich *et al.*, 1985; Belt *et al.*, 1991); because of the supposition inherently involved in assigning sub-surface feeding, these periods were not included in calculations of feeding behaviour display rates. Additionally, bubble feeding appeared to develop through practice when the whale was two years old. Figure 2 shows that the rate of 'single bubbles' ("bls" - < 3 m patches of light effervescence) increased dramatically when the whale was two, then reduced again at three. When one further examines the rate of 'bubble clouds' ("blc" - dense patches of effervescence, 7-10 m across, followed by a feeding lunge) and 'bubble cloud behaviours' ("cld" - dense patches of effervescence similar to that of a bubble cloud, but not followed by a feeding lunge), a similar trend between the two behaviours was seen until age 3, at which point bubble clouds became far more common. We hypothesise that two-year old whales were using single bubbles to strengthen their abilities in bubble feeding, which was successfully and consistently used in prey capture starting at age 3.

Further evidence for the two-year point being a critical age for learning feeding behaviour comes from documentation of a novel feeding behaviour, 'lobtail feeding,' which has spread through the population in the past 10 years (Fig. 3). This behaviour involves the whale slapping its tail on the surface before diving and completing a bubble cloud sequence. We hypothesise that the tail slap either stunned and momentarily stopped the prey, or marked a prey location for the whale as it dived. The incidence of whales using this behaviour has increased gradually from 0% in 1980 to over 50% in 1989 (Fig. 3).

What is more striking is a comparison of which whales displayed this novel feeding behaviour. We split the whales' observed surface feeding into two groups - those first photographed, and therefore alive, before 1982 (either in our sighting records, or those found in Mayo *et al.* (1985)), and those first photographed after 1982. The latter group included primarily calves and whales first photographed as small juvenile whales, also likely to be born after 1982. In the former group, only 13 out of 104 animals (12.5%) used lobtail feeding; among those animals first photographed after 1982, 82 of 146 animals (56.2%) used the lobtail feeding technique. Among those animals of known maternal descent who used lobtail feeding, only 3 out of 20 whales had mothers who also employed lobtail feeding. Hence, much of the learning had to be culturally, and not matrilineally, based (Weinrich *et al.*, in press.).

Seven different humpback whales were seen engaged in apparent incompetent or practice lobtail feeding when two years old. These animals have been repeatedly seen slapping their tails down, and blowing bubble patches, but did not appear to be feeding. In one case animal "Porcupine," a two-year old female, was seen engaged in this activity on at least seven separate occasions over a two month period in 1991. In cases where these animals have been seen surface feeding in subsequent years, they have all been seen to use lobtail feeding. This further indicates that when the animal was two years old it went through a critical learning period where surface feeding behaviour was developed. Since that is over a year after typical separation from the mother (Baker *et al.*, 1987; Clapham and Mayo, 1990; Baraff *et al.*., in prep.), it further implicates the importance of cultural learning in humpback whales.

In conclusion, our data suggests that development in humpback whales, like that of many other mammals, involves a complex combination of play (or practice) behaviour and shifting energetic needs. Further, development appears to be influenced by cultural learning in addition to the more traditional matrilineal learning previously documented in humpback whales (Clapham and Mayo, 1987, 1990; Baker *et al.*, 1990).

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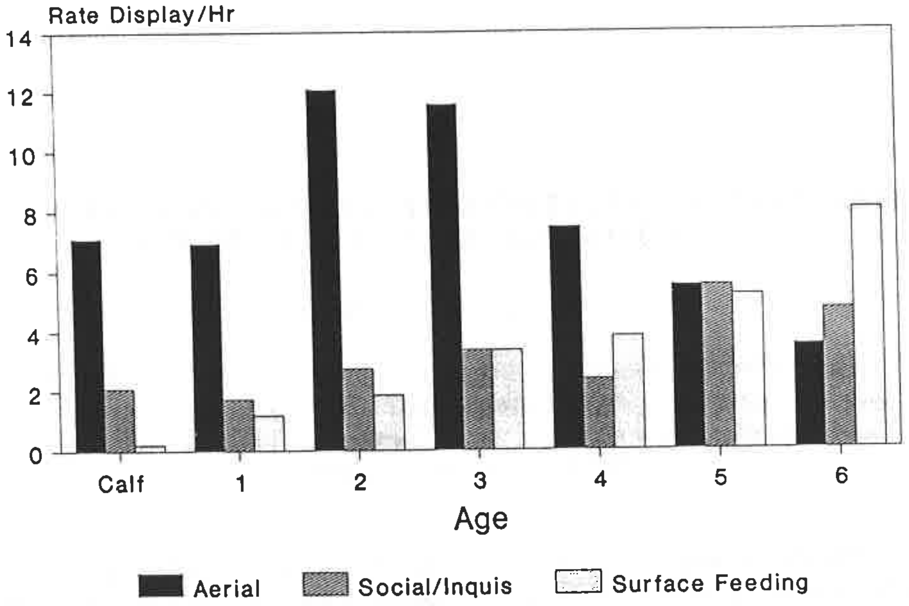

Fig. 1 Rates of Display (per hour) of aerial, social/ inquisitive, and surface feeding behaviours by year class. Data from 1982-1989.

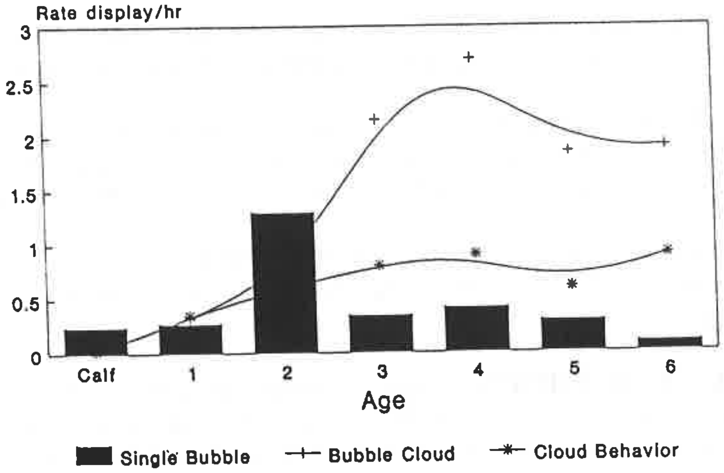

Fig. 2 A comparison of the rate of single bubbles (bars) with bubble clouds and cloud behaviours (see text for behavioral definitions). Note the rapid increase in bubble clouds in the year following the sudden increase in single bubbles.

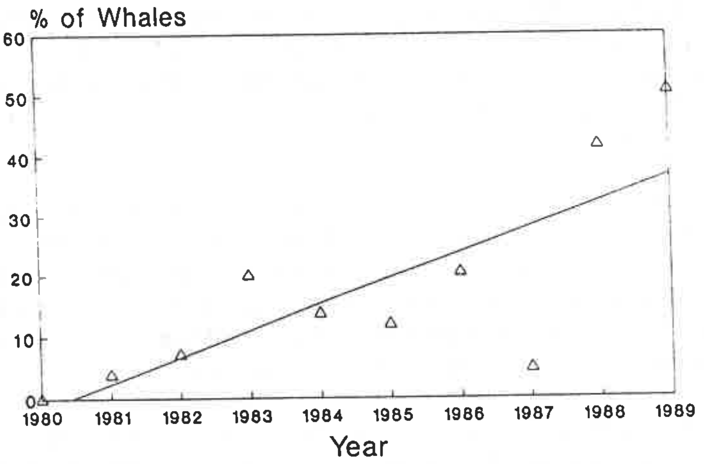

Fig. 3 The percentage of whales seen surface feeding in each year, 1980-1989, who used the lobtail feeding technique.

INTERSPECIFIC VARIATION OF TESTIS SIZE IN CETACEANS: A CLUE TO REPRODUCTIVE BEHAVIOUR?

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INTRODUCTION Competition between males to fertilise females can take place either through male to male aggression during the mating season or through sperm competition. Sperm competition exists when females mate freely with more than one male and competition for reproducing ova takes place at the gamete level, that is, once the spermatozoa have been ejaculated into the genital tract of the female (Parker, 1984).

In species in which sperm competition occurs, males have large testes in order to ensure generous production of spermatozoa, and sexual dimorphism in body size is usually absent.

Previous research on cetaceans in this regard is limited to the work of Kenagy and Trombulak (1986), who examined variation in testes size in mammals, including a limited set of cetacean species, and of Brownell and Ralls (1986), focused on mysticetes.

This paper presents the results of a survey on the interspecific variation of testes weight on 54 cetacean species and its relationship with sexual dimorphism in body size and reproductive behaviour.

MATERIAL AND METHODS Data on testes weight, adult male body weight and sexual dimorphism in body size for 54 species of cetaceans were extracted from the literature. Because organ weight tends to follow non-linear relationships with body weight, these data were log-transformed and analysed with standard techniques of regression and analysis of the variance. Differences between taxa were examined through variation in the residuals to the fitted regression line.

RESULTS AND DISCUSSION Figure 1 shows the overall relationship between testes weight and adult male body weight in mammals. Cetaceans do not differ much from the trend common to terrestrial mammals, although the analyses of the variance carried out on the residuals of the two groups shows that cetaceans have slightly but significantly larger testes than terrestrial mammals ($p< 0.05$).

Kenagy and Trombulak (1986) expected aquatic mammals to have smaller testes relative to their body size than terrestrial ones. Nevertheless, our results show exactly the opposite, that is, that cetaceans have larger testes than the rest of mammals. It is unclear why this difference exists, although factors associated with an aquatic mode of life, such as length of copulation, potential dilution of sperm in water, or alteration of spermatozoa by salt water present in the vaginal tract of females may account for it.

Figure 2 shows the relationship between relative testes weight and adult male body weight in cetacean species grouped by families. As can be seen, members of the families Delphinidae, Phocoenidae, Kogidae and Balaenidae have larger testes than those predicted

Delphinidae, Phocoenidae, Kogidae and Balaenidae have larger testes than those predicted by the regression equation, while the Ziphiidae and the Pontoporidae have relatively smaller testes than expected.

It is suggested that those families with proportionally larger testes would rely more intensely on sperm competition, while in those with smaller testes, competition between males would be essentially resolved through direct individual aggression during the mating season.

The information available on reproductive behaviour is limited for most species, for which reason this hypothesis cannot be confirmed. However, the body of the older males of some species with large testes, such as bottle-nosed dolphins,*Tursiops truncatus*, or long-finned pilot whales, *Globicephala melas*, is heavily scarred, and this appears to indicate that battles with other males, characteristic of polygynous systems, are not uncommon. For this reason, it is likely that both systems of male competition exist in these species.

In many mammals, the existence of sexual dimorphism in body size is frequently used as an indicator of direct competition between males to copulate with females and, thus, of lack of sperm competition. However, relative testes mass and sexual dimorphism in body size do not appear to be positively associated in cetaceans. Indeed, largely dimorphic genera, such as *Inia*, *Physeter*, *Globicephala* or *Orcinus*, tend to have larger testes in contrast to some balaenopterids, where males are known to behave aggressively during the breeding season. In humpback whales, the males are not larger than females as might be expected; indeed, on the contrary, they are a little smaller.

It is unclear why this rule that appears to be general for most mammals is not fulfilled for cetaceans. However, body size may be the result of other evolutionary forces apart from the need for a powerful body to ensure strength during reproductive fights.

ACKNOWLEDGEMENTS Genevieve Desportes made available unpublished data on testes weight from *Lagenorhynchus acutus* and *Globicephala melas*. Javier Corcuera contributed with valuable suggestions at different stages of the work.

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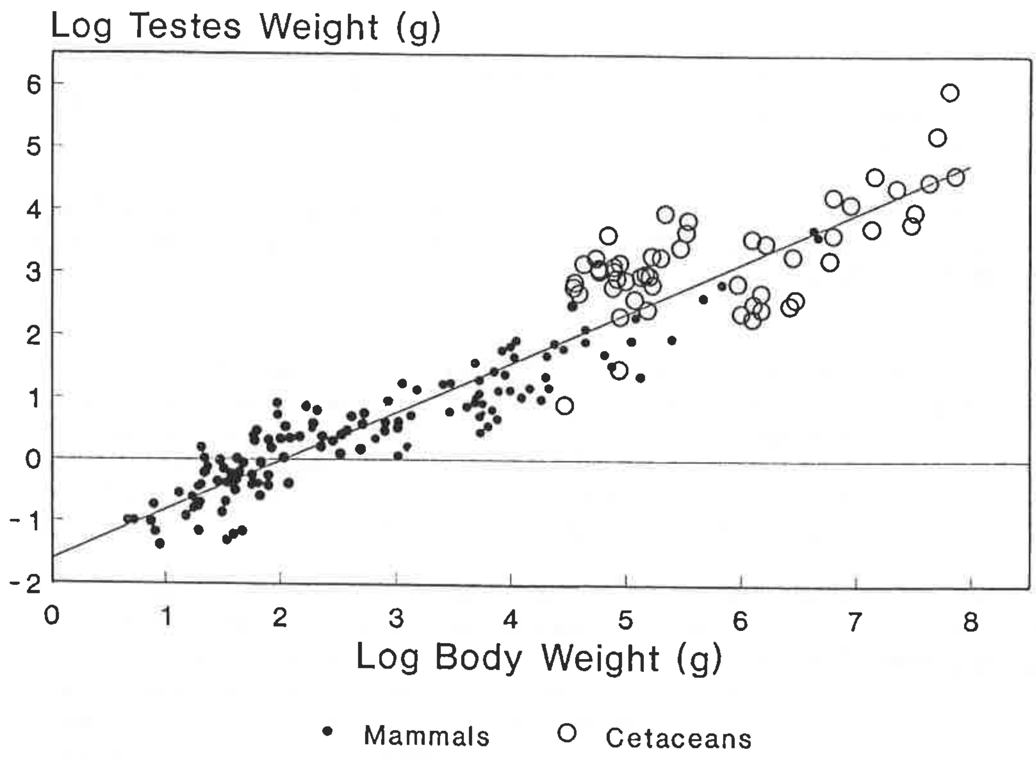

Fig. 1 Relationship between log-testes weight and log-body weight in terrestrial mammals and cetaceans.

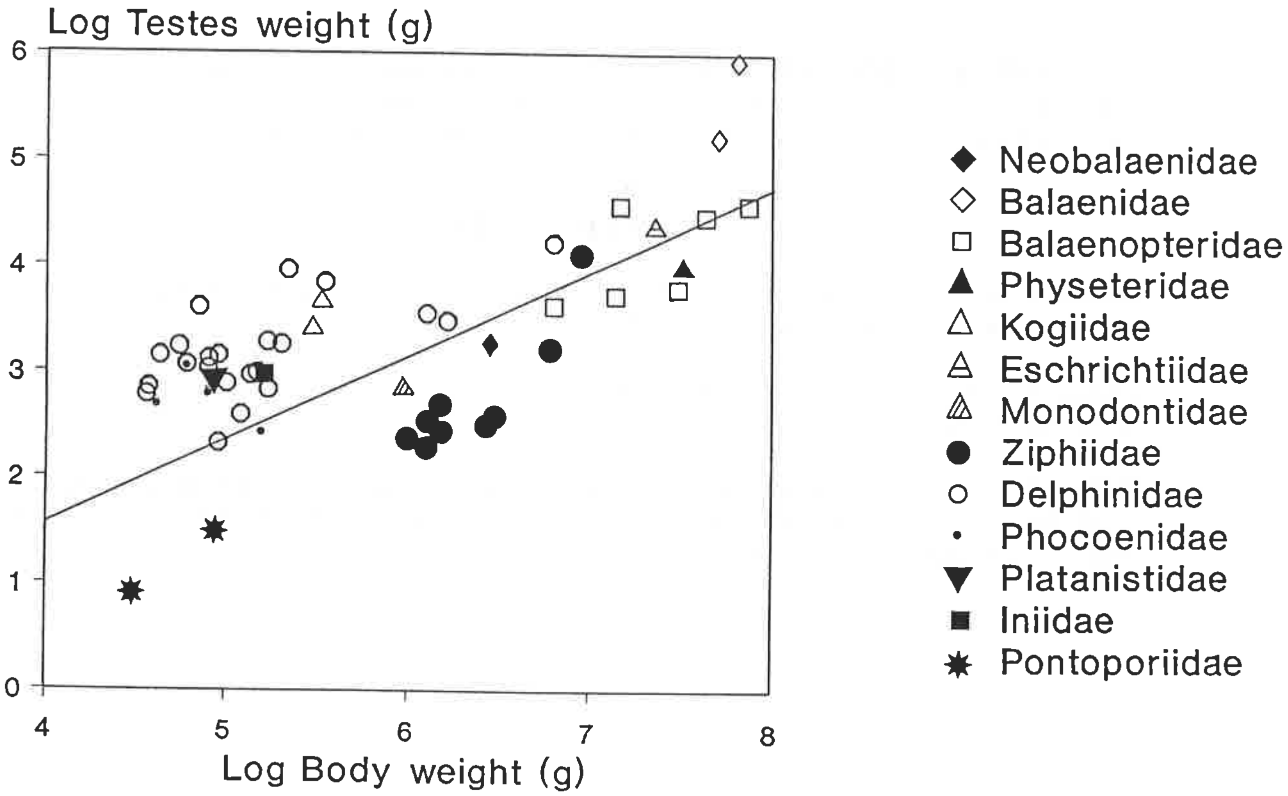

Fig. 2 Relationship between log-testes weight and log-body weight in different cetacean families.

A PORTABLE DSP WORKSTATION FOR REAL-TIME ANALYSIS OF CETACEAN SOUNDS IN THE FIELD

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INTRODUCTION A PC-based DSP workstation configurable at different levels, as a portable or desk top workstation, with or without real-time capabilities, was developed to suit specific requirements of bioacoustic research. The workstation, hereafter named DSPW, combined with conventional recording equipment, covers a wide range of needs typical of bioacoustical studies, such as low cost, IBM compatibility and great flexibility (Pavan, *in press*).

The actual portable version of the DSPW is based on a 16 MHz 80386SX/80387 laptop PC with 120 Mb Hard Disk, a VGA LCD display, two 8 bit ISA slots, internal battery and external 12 Vcc powering with photovoltaic panels for continuous operation and battery recharge. The portable DSPW is actually configurable at two levels:

The **basic level** is supported by an AD/DA board (Audiologic Audio Board Plus, made in Italy) with two I/O channels, 16 bit resolution, variable gain, sampling rates 22050, 32000, 44100, 48000 s/s, on board anti-aliasing filters. This board allows direct hard disk recording and playback of analog audio signals with CD or DAT quality.

The **advanced level** is supported by an AD/DA board (Microstar DAP 2400/6, made in USA) with 16 input and 2 output channels, 12 bit resolution, variable gain, sampling rate up to 235000 s/s on a single channel. Moreover, the board has a Digital Signal Processor (DSP) for real-time acquisition and processing of signals. External anti-aliasing filters must be provided on both input and output channels.

The DSPW is equipped with software designed to acquire, store, edit, analyse and replay signals as well as analyse them in real-time. Spectrograms are displayed in 16 colours, assigning a different colour or grey level to every 6 dB increment, thus allowing a 96 dB dynamic range.

FILE ANALYSIS The software designed to operate on digital signal files generated by both levels, the basic and the advanced, as well as files generated by the Kay SonaGraph DSP 5500, is entirely menu and mouse driven. Available analysis and display functions are waveform, envelope, inst. spectrum, spectrum versus time (spectrogram and 3D waterfall), cepstrum versus time, and zero-crossing. Spectrograms of unlimited length can be printed with dot-matrix EPSON-FX compatible printers.

REAL-TIME ANALYSIS The advanced level allows true real-time spectrographic analysis and display of audio signals and, with some limitations, of ultrasonic signals. Hard disk direct recording can be done up to 100k s/s depending on the disk speed (up to 200k s/s on a RAM disk). Spectrographic analysis (128, 256, 512 FFT sizes, Hanning or Hamming Window) can be performed in true real-time up to 42k s/s, in pseudo real-time up to 200k s/s and in triggered mode up to 128k s/s with signal blocks up to 16k samples in size. True real-time analysis means that spectra on overlapping or, at least, consecutive blocks of samples are continuously computed and displayed. Pseudo real-time analysis means that spectra on non-consecutive blocks of samples are computed and displayed in real-time. An external conditioning unit to provide amplification, high-pass and anti-aliasing filtering of analog signals is required.

APPLICATION AND DISCUSSION The workstation is widely experienced in a variety of field and laboratory applications related to both behavioural research and acoustic monitoring and censusing activities for wild-life management. Real-time processing and display of signals is required in monitoring and revealing acoustic activity, both in audible and ultrasonic range, during behavioural experiments and observations. Moreover, real-time techniques have proved to be useful in acoustic monitoring and censusing methods.

The portable DSPW was successfully applied in a cetacean acoustic survey in the Aeolian archipelago and the western Ionian sea (Italy) (Borsani *et al.*, this vol.). An OPC towed hydrophone array (basically consisting of two pre-amplified hydrophones spaced 6.5 m from one another in order to allow directional hearing) was towed at reasonably slow speed (about 2 knots) to collect sounds while the ship was in motion (Fig. 1). The DSPW allowed a number of applications dedicated to an improvement of the recording quality and a more efficient finding and censusing of cetaceans by means of real-time spectrographic analysis of received sounds. Software capable of approximating the direction of an impulsive sound source by measuring the arrival time differences on the two hydrophones, was also tested to acoustically find and track sperm whales, *Physeter macrocephalus*. This software actually operates in a triggered mode on two channels and requires a good Signal to Noise Ratio to accurately detect and process sperm whale clicks in real-time. In this way we are able to locate animals and discriminate clicks emitted at a different bearing by two or more individuals (Fig. 2).

The results achieved so far show that the application of Digital Signal Processing techniques and computers to bioacoustic research can provide a remarkable insight in the understanding of the acoustic behaviour of animals and in monitoring their acoustic activity for both scientific and applied research (Watkins *et al.*, 1972; Clark, 1980; Cummings *et al.*, 1985; Spiesberger *et al.*, 1990). Further improvement of the DSPW and of the listening devices will be achieved to better satisfy requirements for a multi-purpose instrument well adapted to bioacoustic research and acoustic surveys on cetaceans.

ACKNOWLEDGEMENTS Thanks are due to Fabrizio Borsani who carefully read the manuscript and gave valuable suggestions. The cruises were organised in collaboration with the Tethys Research Institute and Europe Conservation Italy. Financial support for the research and for the development of the instrumentation was provided by the Italian "Ministero Marina Mercantile, Ispettorato Centrale Difesa Mare".

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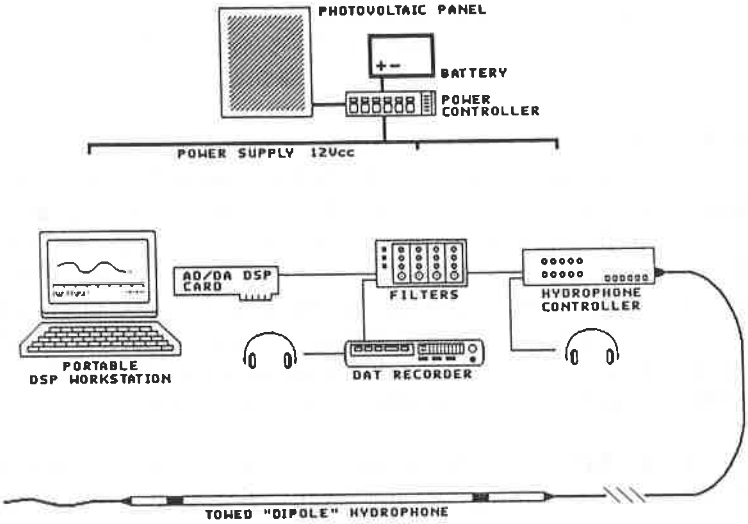
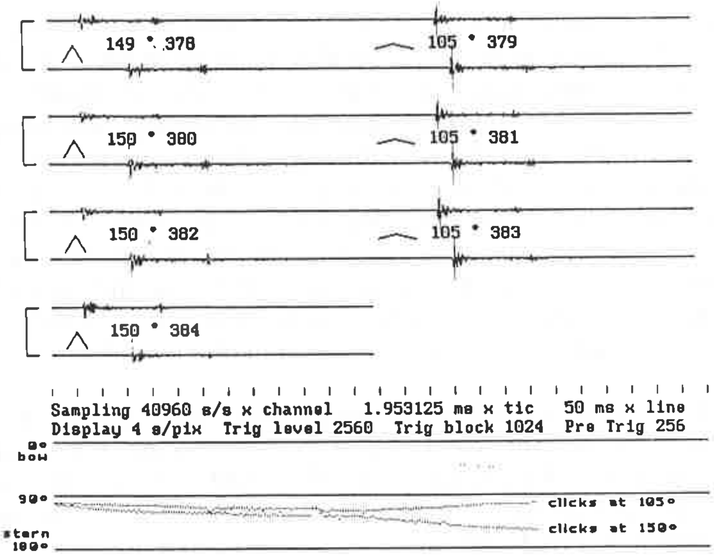


Fig. 1. The portable workstation connected to underwater listening devices.



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Sampling 40960 s/s x channel   1.953125 ms x tic   50 ms x line
Display 4 s/pix  Trig level 2560  Trig block 1024  Pre Trig 256
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Fig. 2. Real-time dual channel envelope display of a click sequence from two sperm whales. Triggered acquisition with arrival times on the two hydrophones and plot of the estimated direction.

CETACEAN SOUND ARCHIVE:
COLLECTION OF SOUND RECORDINGS FROM CETACEANS OF THE MEDITERRANEAN

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INTRODUCTION From 1987 to 1991, sound recordings from six free-ranging odontocete species occurring in the Central Mediterranean Sea were recorded. During more than fifty encounters we met a considerable number of animals and recorded their vocalisations using traditional reel-to-reel analog tape recorders, R-DAT recorders and both stationary and towed underwater transducers. Out of the whole of the recorded material, 21.5 h of sound recordings, concerning six odontocete species, were selected to be included in a sound archive catalogue (C.E.S.AR.) based on a commercial database. The aim of the C.E.S.AR. is to allow access to data on the acoustic capabilities of cetaceans occurring in the Mediterranean for both study and conservation purposes.

MATERIALS AND METHODS Cetacean species were recorded in their natural environment from auxiliary sailing vessels up to 19 m long. The animals were approached with procedures developed in order to minimise affecting their behaviour. Ships were almost completely silenced by shutting off the engines and turning off all noisy gear when recording with stationary hydrophones; when recordings were made by means of a towed hydrophone array, however, the ship's speed and course were optimised in order not to produce sharp underwater noise.

The sound archive consists at present of 26.5 hours of sound recordings, including 21 analog tapes and 16 digital audio tapes. Analog tapes were recorded on a Uher 4400 Report Monitor recorder and digital tapes on a Casio DAT DA-2 recorder. ITC 8073 hydrophones were suspended from the standing ship for stationary recording of animals in the surroundings. An OPC towed hydrophone array, consisting of two pre-amplified hydrophones spaced from each other in order to allow directional hearing, was towed at slow speed to record while moving. Recently, a portable PC-based DSP workstation (Pavan, this vol.) allowed a number of applications dedicated to an improvement of the recording quality and an immediate evaluation of the sounds recorded by means of real time spectrographic analysis and, finally, to a more efficient finding of cetaceans by means of software capable of approximating the direction of a sound source.

Laboratory analysis of the recordings considered the basic parameters such as type of sound (e.g. whistle, click, pulse train, etc.), duration, and frequency-time structure. The analysis was performed on both a Kay Sonagraph DSP 5500 and on a PC-based DSP workstation equipped with an optical data storage device. This DSP workstation and the analysis software were developed by G. Pavan.

A PC-based DSP workstation equipped with an optical data storage device allows interactions among archives aimed at linking data of variable origin, such as photographs and sound spectrograms, to a most complete set of information on single animals or animal groups.

and sound spectrograms, to a most complete set of information on single animals or animal groups.

STRUCTURE OF THE CATALOGUE The sound archive catalogue, based on a commercial database, DBase III, was organised in records containing a number of fields shown in Table 1.

Field "ID" links sound spectrograms of particular interest (such as "codas" from individual sperm whales, *Physeter macrocephalus*, or sperm whale groups) and photographs or digital maps of particular subjects (such as maps from flukes of sperm whales) to the sound archive.

Field "sp code" lists codes of species contained in each single record: these codes are identical to those used in a large database on marine mammal literature (Watkins *et al.*, 1988).

Out of 26.5 hours of recordings of underwater sounds, 21.5 were attributed to odontocetes; Absolute duration in minutes, percent distribution, and quality subdivision of available recordings per species are listed in Table 2.

ACKNOWLEDGEMENTS Financial support for this research and for the development of the instrumentation was provided by grants from the Italian Ministero Marina Mercantile, Ispettorato Centrale Difesa Mare, from the Tethys Research Institute and from Europe Conservation Italy. We gratefully acknowledge Greenpeace Italy for providing us with recording opportunities during a cruise in 1989.

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Table 1

TAPE_CODE	D007
TYPE	DAT
SIDE	
TRACK	
SPEED	48 kHz
RECORDER	Casio DAT DA-2
CUE	
PRG_NUM	
TIME	00:00-43:45
DURATION	43'45"
SUBJECT	voca sperm whale
SPECIES	«Physeter macrocephalus»
SP_CODE	BA2A
ID	ac.42:20; ph.C2#3,30
QUALITY	2-3
DATE	22/07/1991
LOCALITY	Aeolian Islands north of Filicudi, 38°41'40 N, 014°29'65 E
AREA_CODE	MED
OPERATOR	J.F.Borsani
INSTITUTE	
ARCHIVE	CIB Original
COPY	
REFERENCE	91 C2 #147
DISTANCE	2 nmi
TRANSDUCER	OPC Towed Array
FILTERS	HP 3 kHz, LP 30 kHz
REC. TIME	13:24
TEMPERATURE	
WEATHER	Beaufort 2
BEHAVIOUR	regular clicking, creaks, codas (/// /)x3, blow rate ca 1blow/3 s
BEHAV_CODE	424 221 225 153 933
N_INDIVID	>1
NOTE	sighted and photo-identified 1 animal, codas 42:20, no biopsy

Table 2

	a	b	c
Physeter macrocephalus	654	50.7	73.4
Globicephala melas	70	5.4	100.0
Grampus griseus	149	11.4	62.4
Tursiops truncatus	75	5.8	46.7
Stenella coeruleoalba	30	23.9	55.2
Delphinus delphis	35	2.7	100.0

a= minutes available, b= % of total, c= thereof % of good quality

AN ACOUSTIC STUDY OF SPERM WHALES, *Physeter macrocephalus,* AND OTHER CETACEANS IN THE SOUTHERN TYRRHENIAN AND WESTERN IONIAN SEAS.

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INTRODUCTION The central Mediterranean Sea is known to host a variety of cetacean species. Particular areas, like the Ligurian Sea, have proved to be of special conservation interest (Notarbartolo di Sciara *et al.*, in press). It is a primary concern to scientists to produce absolute abundance estimates of cetaceans in this particular area, in order to integtate research and conservation efforts. Qualitative investigation of the ecology of the fin whale, *Balaenoptera physalus*, one of the most abundant cetacean species in this area during summer, is already in progress (Zanardelli *et al.*, in press). This work is likely to produce abundance estimates for such target species in the future. However, sperm whales, also known to occur in this area, spend a considerable amount of their time underwater, thus making population size estimates by means of visual assessment a difficult task. On the other hand, sperm whales do vocalise while diving, and they perform various acoustic behaviours (Watkins, 1980).

Basic components of their vocalisations were first described by Schevill and Worthington (1957). The first available published recordings are by Schevill and Watkins (1962). A more detailed analysis of sperm whale sounds was provided by Backus and Schevill (1966). Acoustic censusing, a non-obtrusive method used to assess sperm whale populations, has been proposed by Whitehead and Gordon (1986). We consider it important that population size estimates of sperm whales in the Ligurian Sea are provided, and have therefore chosen the acoustic approach to censusing. The aim of this paper is to test various equipment and techniques in an area frequented by sperm whales so as to fit the requirements of acoustic methods using small budgets.

MATERIALS AND METHODS From 1st - 25th July, 1991, we conducted an acoustic study of sperm whales aboard the 15 m motor-sailing boat, *Aysen*, in the waters north and east of Sicily where sperm whales were most likely to be abundant, according to the oceanographic features of those seas and our previous experience (Notarbartolo di Sciara *et al.*, in press). Searches for whales were performed both by listening underwater and by systematic spotting. A hydrophone array was towed at speeds ranging from 3.5 - 7.5 km h^{-1} on courses chosen to theoretically maximise encounters with whales. Sounds were recorded continuously on a Casio DA-2 R-DAT recorder during tracking, except for the time needed to change tapes.

RESULTS Sperm whales were heard and recorded during three of 110 listening sessions. Based on the laboratory analysis of sound recordings, at least seven whales were present in the area. Of these, two individuals 14-16 m long were seen at the surface in waters 400-1400 m deep, as close as 0.5 km from shore, and were tracked acoustically for 4 and 6 h, respectively. The second individual was identified by photographing the posterior edge of the flukes. Other data collected from this whale included mean dive duration (mean = 48 min, n=5, SE=2.9), mean surface time (mean = 15.8 min, n=6, SE=0.7) and mean blow rate (mean = 3.1 min^{-1}, n=6, SE = 0.2).

Sounds recorded from these two particular individuals fell within three main categories: regular click patterns, fast click patterns and codas (Watkins and Schevill, 1977). Regular click series, sometimes including slower click series, were often followed by faster click series: these showed variation in pulse rate and duration among and within click series. Fast click series were mostly followed by short periods of silence. Emphasis in the amplitude of particular frequencies was noticed in some click series and codas. These have yet to be investigated with regards to eventual artifacts due to the recording equipment. Codas were often followed by silence and by the surfacing of at least one whale. No more than one individual was seen at the surface at a time. No underwater sounds were heard while whales were at the surface. While at the surface, the whales travelled at an estimated maximum speed of up to 5.5 km h^{-1}, whilst average speed was estimated to be around 3.5 km h^{-1}. Whales sounded at a steep angle from the surface and "fluked up" at each dive. Whales started clicking a few seconds after diving. In most cases, beginning or ceasing sound production by one whale caused an immediate response from nearby animals, by joining the chorus or by stopping, respectively. Synchronous clicking by two widely separate whales was occasionally heard.

During the cruise, one group of Risso's dolphins,*Grampus griseus*, and 13 groups of striped dolphins,*Stenella coeruleoalba*, were also found, and their underwater sounds recorded.

DISCUSSION In conclusion, the equipment developed for this study achieved a number of goals, including: (1) acoustic detection of sperm whales up to a distance of at least 7.5 km, providing that the weather conditions were good and that vocalisations were produced above the thermocline; (2) acoustic tracking of the whales by means of binaural hearing; (3) testing a software developed to calculate the approximate bearing of the sound source location; (4) the use of a portable PC-based workstation for the analysis of sounds in real time (Pavan, this vol.); (5) continuous recording of whale acoustic activity for several hours; and (6) counting the whales present in the study area through the analysis of collected recordings. Finally, the entire acoustic equipment including computers and power supply suited our requirement since it was easily transported and of comparatively low-cost, tough effective.

ACKNOWLEDGEMENTS We thank Dr. Jonathan Gordon for letting us buy one of his used hydrophone arrays and Oliver Chappel who engineered the earliest version of the amplifier-power supply unit for the array. Financial support for the research and for the development of the instrumentation was provided by the Italian Ministero della Marina Mercantile, Ispettorato Centrale Difesa Mare and by Europe Conservation Italy.

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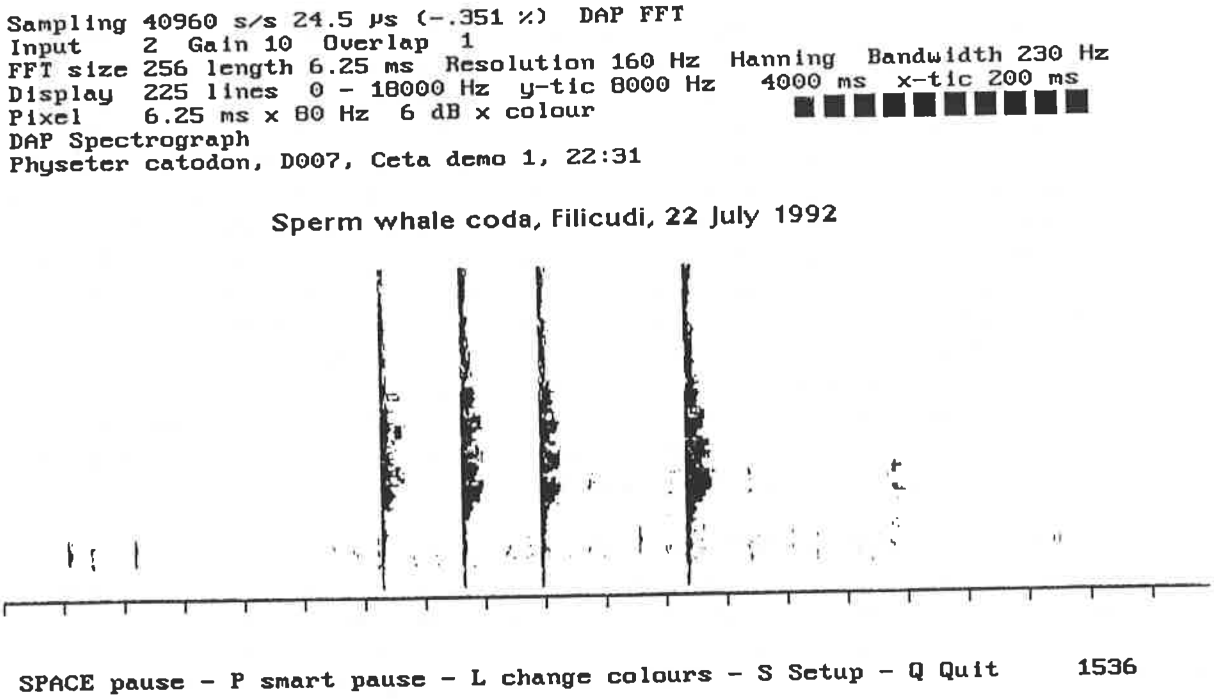

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Sampling 40960 s/s 24.5 µs (-.351 %)  DAP FFT
Input    2  Gain 10  Overlap  1
FFT size 256 length 6.25 ms  Resolution 160 Hz  Hanning  Bandwidth 230 Hz
Display  225 lines  0 - 18000 Hz  y-tic 8000 Hz    4000 ms  x-tic 200 ms
Pixel    6.25 ms x 80 Hz  6 dB x colour            ■■■■■■■■■■
DAP Spectrograph
Physeter catodon, D007, Ceta demo 1, 22:31

                 Sperm whale coda, Filicudi, 22 July 1992

SPACE pause - P smart pause - L change colours - S Setup - Q Quit     1536
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Fig. 1 Spectrogram of Sperm whale coda

EXPLOITATION OF THE NON-ACOUSTIC SENSES IN RELATION TO THE ENTANGLEMENT PROBLEM

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INTRODUCTION Although the prohibition of fisheries undoubtedly prevents cetacean entanglements, this solution is not feasible in all situations, particularly where local communities depend on fishing to provide basic nutritional and economic needs. It is also increasingly clear that preventing entanglements is not simply a matter of making the nets and other gear more acoustically "visible" - even species with sonar capabilities do not employ this sense all the time, and it may be that additional warnings or tactics invoking other senses could be effective.

The traditional five senses are sight, hearing, touch, smell and taste. But this list, based on human experience, fails to allow for the diversity of available environmental information exploited within the general animal kingdom. A classification based on stimuli to which sense organs are known to be responsive is more useful: mechanical receptors mediate touch, pressure, position, tension, acceleration, vibration and sound; thermal receptors respond to temperature in the skin or central nervous system; light receptors, which include the eyes and other photosensitive structures such as the skin, pineal body, and parts of the midbrain, are sensitive to radiation at wavelengths between the near ultraviolet and the red; chemical receptors, which respond to particular molecules and ions, include those involved in smell and taste; electrical receptors, present in many aquatic vertebrates, are sensitive to natural voltage gradients in the environment and to the electrical effects of muscle contraction in nearby animals as well as to the electric signals generated by special organs in certain fish, and can also detect electrical changes caused by the movements of the aquatic animals themselves in the earth's magnetic field; magnetic receptors respond to weak magnetic fields such as that of the earth (Waterman, 1989).

MECHANICAL AND THERMAL RECEPTORS Sound is excluded from this discussion, and there may seem to be little scope for the use of the other stimuli mediated by mechanical receptors, since they either require the animal to be in contact with the obstruction (touch) or are simply providing the animal with information about its own position and movements in the water. Thermal cues might also be discarded, since there is no practical way to change the temperature of a net, or of the water in the vicinity of a net. However, there is the possibility (which has often been suggested or implied, but not so far properly investigated) that cetaceans might be using water currents or temperature gradients as a travel cue. In this case, simply orienting the gear parallel to the cue providing the travel path instead of across it could be useful.

LIGHT RECEPTORS In the case of cetaceans, the only known light receptors are the eyes. There are, however, severe constraints on vision in water. Water absorbs light several thousand times more rapidly than pure air, and in addition, visibility is degraded by the scattering of light both by the water itself and by particles suspended in it. Even in bright sunlight near the surface in clear water, vision may not be able to resolve small objects more than 20m or so away. Most cetacean species have good vision both above and below the water, but fish also have well-adapted eyes, and improving the visibility of nets for the benefit of cetaceans may interfere with their primary fishing function by aiding the fish to avoid the nets too. However, it is possible that for some special applications (such as nets protecting bathing beaches from sharks - which are primarily for deterrence, and where the capture of aquatic organisms is not a required function), improving the visibility of nets set in clear water could be helpful, at least during the day. No improvements in net visibility, however, would help in turbid conditions. Illuminating nets at night, or the use of luminous nets, in clear conditions might be worth investigating. The question of whether lights, or luminous net materials, might attract cetaceans would also need attention.

Vision above water may be dismissed, because cetaceans spend very little time with their eyes above the surface, but there are suggestions in the literature (e.g. Pike, 1962) that animals "spy-hopping" or leaping above the surface could be obtaining visual travel or food finding cues. It might therefore be worth exploring the effect of enhancing the surface visibility of nets by day and by night, particularly where deployment takes place along known cetacean migration routes. The means whereby net visibility to cetaceans could be enhanced would need to take into account what is known of their visual capabilities and poor colour perception, as well as the probable cognitive interpretation of the visual signals - all of which may well be species specific (Herman, 1980; Schusterman, Thomas and Wood, 1986).

CHEMICAL RECEPTORS Odontocetes are known to have a good sense of taste, and mysticetes have at least the neuro-anatomical remains of a sense of smell (Nachtigall, 1986). However, the distinction between these sensory modalities is not as clear in the aquatic environment as on land, because both olfaction and taste can be mediated by substances dissolved in water. The term "chemoreception" provides a convenient way to refer to both senses. Water is an excellent chemical solvent and carrier. Substances released or deposited by an organism may remain detectable for long periods of time, or disperse over great distances. Chemoreception might provide cetaceans with social information (e.g. on the reproductive state of conspecifics), spatial information (e.g. following salinity or other chemical gradients), or food-finding information (e.g. following the trail of excreta left by food species). Fish are known to exploit chemical information in these ways (Hara, 1986). Some fish also produce chemical alarm signals when damaged or frightened, and there are some indications in the literature that this might be true for cetaceans also.

A cetacean travelling on the chemical trail of a potential mate may well not be paying much attention to other environmental information, and inadvertently run into a net. However, even if we knew the nature of such a chemical trail, testing the water for this kind of dilute, and possibly complex, chemical gradient before deploying nets is most unlikely to be feasible or acceptable in a practical fishing situation. The same is true for most chemical gradients providing potential spatial information, but simple tests, such as for salinity gradients, could be made during normal fishery monitoring, to check whether gear orientation in relation to the gradient was reflected in the cetacean entanglement (or fishing success) rate. Natural fibre nets have to be treated in order to preserve them from rot. Traditionally, a variety of oils, tars and other substances have been used (e.g. Evans, 1874), which are likely to leave a distinctive chemical trail in the water. Even modern nets receive some chemical treatment. All nets would leave a characteristic chemical trail as soon as they contained fish. If cetaceans are accustomed to locate schools of prey through the chemical characteristics of the trail of excreta and so on left behind, it may be that the chemical characteristics of net contents act as a similar attractant. It is also possible that animals learn to follow the chemical trail of empty nets, as a potential aid to food capture.

Kuznetsov (1990) and Nachtigall (1986) performed controlled experiments on the chemoreception abilities of trained dolphins, but these methods cannot be used in the field. Klinowska *et al.* (1987, 1989) used a simple controlled technique for testing the reactions of untrained, free-swimming animals to chemicals in the water. Such a system could be used to explore reactions to the chemical characteristics of water in which samples of traditional and modern nets have been soaked, and reactions to fish excreta can be similarly tested. It would be particularly interesting to pursue the idea of a cetacean chemical alarm substance also, if some ethical means to collect appropriate samples for analysis can be found. If chemical signals from nets and their contents do prove to be attractants, some practical way to modify the chemical signals will need to be explored. Otherwise, such attractive "broadcasting" of information about the presence of nets may well be sufficient to negate all other efforts to keep cetaceans away.

ELECTRICAL AND MAGNETIC RECEPTORS Some aquatic mammals (e.g. platypus - Scheich *et al.*, 1987; star-nosed mole - Gould *et al.*, 1989) can locate prey through detection of the electrical effects of muscle contraction, but there is at least anecdotal evidence that cetaceans lack this ability (Snyderman, 1987). Cetaceans do appear to use information about the flux density of the earth's magnetic field (total field) as a guide for their travels, generally swimming parallel to the geomagnetic contours, i.e. in areas with low geomagnetic field gradient (Klinowska, 1990a; Kirschvink, 1990). Compass direction, which uses directional geomagnetic field information, does not appear to be involved. Entanglements should therefore be minimised if nets are deployed only parallel to geomagnetic contours (so that animals could swim past) and not perpendicular to the contours (forming a barrier across the normal travel paths). This is another idea which can be tested quite simply, if a well-monitored fishing operation deploying very long nets can be found taking place in an area where a sufficiently detailed geomagnetic survey has been carried out. All the additional data gathering required is that the exact positions of the set nets be noted. The rate of cetacean catch can then be calculated in relation to the geomagnetic characteristics of the area. If successful, this approach would be simple and cheap to implement in well-surveyed areas, requiring only the purchase of the appropriate geomagnetic charts. In other areas it would be more difficult and expensive, because the local field characteristics would need to be checked with a magnetometer, crews would require instruction in the acquisition and interpretation of this data, and potential fishing time would be lost in the process.

CONCLUSIONS Two general approaches to the prevention of entanglements emerge from reviewing cetacean non-acoustic senses (Klinowska, 1990b; Klinowska and Goodson, 1990). The first involves modification of gear deployment, and would apply to animals using environmental information such as the geomagnetic field, currents, temperature or salinity gradients as travel cues. This simply consists of orienting the gear parallel to the environmental cue providing the travel path instead of across it. The extra data required to test this approach can easily be collected during routine fishery monitoring. However, if the target species of the fishery should happen to be using the same travel cues as the cetaceans, re-orientation of gear will not be practical. Nevertheless, this approach deserves serious consideration, because it is easy to test, and if effective, would not be difficult or expensive for many fisheries to implement.

The second approach involves gear modification. Increasing the visibility of gear underwater might be useful in some restricted circumstances, and it may even be worth exploring whether improving visibility above water would be helpful, but care is needed to ensure that such modifications really do provide cetaceans with meaningful information, that they do not act as an attractant, and they are economically feasible. Although little is known of the role that chemoreception plays in cetacean food finding and social behaviour, it is a sense which can be invoked from a distance in water. Urgent investigation is required to elucidate the role that chemical cues may have in attracting or alerting cetaceans to nets, because such broadcast signals could well negate any other efforts to prevent entanglement. It would not be simple to devise a way to alter chemical signals, unless it turns out that cetaceans themselves have, or recognise, some chemical alarm signal which could be imitated.

It is unlikely that any single solution will prove to be a universal panacea, and, equally, failure of one strategy in a particular case need not mean that it is therefore universally useless. The situation is more likely to be complex, with different strategies required for different fisheries. Even if none of the suggested approaches turns out to be feasible, a great deal of new information on cetacean (and fish) behaviour will have been obtained.

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DOLPHIN SONAR SIGNAL ANALYSIS;
FACTORS AFFECTING FISHING NET DETECTION.

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INTRODUCTION In this paper, some limitations of dolphin sonar in the context of net-like targets are discussed. Parameters to be considered when attempting to apply acoustic engineering techniques to the design of efficient 'cats eye' type passive acoustic reflectors, intended to be used to reduce the incidental mortality of small cetaceans in commercial gill-net fishing operations, are also considered (Goodson *et al.*, 1990; Mayo & Goodson, this vol.).

The sonar behaviour of a solitary wild bottle-nosed dolphin,*Tursiops truncatus*, observed while resident in the sea close to Amble, (Northumberland, UK) provides repeatable and interpretable patterns while this animal is searching for and catching fish. The pulse repetition frequency (PRF) during foraging includes identifiable rate modulation characteristics, which can be used to classify the emissions into Foraging Search (no target detected), Initial Target Detection (locking-on) and subsequent Interception (range-locked). A further mode appears to occur at short ranges, where the high PRF may be used to sustain the swim bladder of the target fish in a resonant condition (Goodson *et al.*, 1990; Goodson & Datta, 1991).

Although a number of attempts to increase the acoustic detectability of fishing nets have been made in recent years, the methods employed have been ineffective in achieving a reduction in cetacean by-catch (Dawson, 1991). In general, the techniques employed did not consider the wavelength-dependent resolving power of dolphin sonar signals, the directivity of the reflectors or the behaviour-related restrictions imposed by the animal. Furthermore, the problem is now seen to be one of target classification and not simply a problem of detection in noise (Au & Jones, 1991). In other words, it may be difficult for dolphins to interpret weak diffused echoes from nets as a life-threatening hazard, when experience has taught them that quite similar 'volume scattered' echoes, returned by algae or by entrained air bubbles, are penetrable zones to be ignored, especially when a discrete fish target can be detected on the far side.

ECHO PERCEPTION OF SMALL TARGETS Sound propagating underwater obeys physical laws, and the mechanisms of reflection are well established in the literature. For a surface to reflect an echo, the material must offer a discontinuity to the propagation of sound, i.e.the product of density and sound velocity (rC) of the material must differ appreciably from that of seawater. Water/air interfaces reflect well, as do most water/metal transitions, whereas polymer materials, e.g. nylon/water, do not. In this latter case, a significant proportion of the incident energy is simply transmitted through the interface.

For a target to return geometrical 'specular' reflections or 'glints' with directional properties, the dimensions of the reflecting surface need to be large with respect to the wavelength of the incident radiation. If the reflector dimensions are too small (in wavelength terms), the intercepted energy is simply scattered, and the proportion of reflected energy returned towards the source falls very rapidly with decreasing size (Rayleigh scattering).

For a dolphin fishing at night and/or in turbid waters, the use of eyesight as a sense to assist the detection and capture of prey can be assumed to be ineffective, and sonar is probably its primary sense. The dolphin transmits a brief, intense 'broad band' sound impulse or click, and detects the echoes returning from objects ensonified by this click during the interval between the transmissions. The dolphin's melon, functioning as a beam former of very limited acoustic aperture, is unable to project this wide band signal without severe frequency dispersion or 'colouration'. The higher frequency spectral components in the 'click' are therefore seen to be concentrated into an intense, tight (10^o), forward-looking beam, lower frequency components being spread over progressively wider angles. When sampled on an axis, the click energy is normally found to have a strong peak near 120kHz (Au 1980), although the spectral peak may appear to shift if the animal transmits at reduced source levels. The bottle-nosed dolphin is known to perceive sound frequencies up to 140khz. The published audiograms for this species (Johnson 1966) show that the animal has the sensitivity to detect high frequency echoes at 120kHz efficiently. The exploitation of such high frequency components is essential to resolve the presence of small fish-like targets.

In seawater, a frequency of 120kHz corresponds to a wavelength (l) of 12.5mm, and hence any echo-producing target needs to be assessed in terms of this dimension. Sub-wavelength dimensions do not produce specular reflections; they simply scatter the intercepted energy in all directions, and thus generate very weak echoes back towards the ensonifying source.

Typical gill-net mesh is made from very thin polymer filaments or twine, joined at intervals by knots to form square or diamond apertures, chosen to trap the target fish by wedging near the gills. The twine or monofilament material is significantly smaller in diameter than the 12.5 mm critical wavelength, and as a result intercepts a minute proportion of the incident acoustic energy. The length of filament or twine between knots provides the only dimension to the structure that exceeds 'l'. For any echo to be detectable depends critically on the incident energy arriving perpendicular to such components, so that the scattered sound energy returned towards the source sums coherently from the length dimension. Unfortunately the knotted structure and the overall flexibility of the net ensure that only small zones of mesh meet these criteria at any given instant.

Gill-net echoes returned towards the dolphin comprise many very weak 'glints' which appear to come from a zone (defined by the range and beamwidth of the dolphin's transmission) with diffused and variable position. In contrast to the characteristic discrete echo of a fish, the difference is clearly significant. Fish echoes (especially those from fish with a swim-bladder) appear very strong and return from a specific position. Sequential echoes from a swimming fish will be intensity-modulated cyclically, due to the tail beat action. The (non-spherical) swim bladder is thus presented at changing angles to successive dolphin clicks. Such characteristic changes in the fish target-strength are likely to assist the dolphin in classifying the echoes as 'alive and moving' and also provide clues to the physical size of the target. The discrete fish echo is easily detectable at ranges well beyond those at which the fishing net can be perceived, and the comparative acoustic transparency of the net is probably a major cause of the dolphin's perception problem.

FORAGING BEHAVIOUR In foraging mode, the (Amble) dolphin emits loud clicks (source levels in the order of 210 - 217 dB re 1 mPa have been measured), repeated at slow repetition rates, normally in the range of 8 to 20 Hz. Since the transmission of such an intense sound must mask weak echoes returning from very long range, and since the transmitted sound is attenuated by square law spreading and by absorption (as is the returning echo), the exploitable detection range must be limited to the period between transmitted impulses. In shallow water, reverberations of the preceding pulse raise the noise floor, which further restricts the detection range.

From repetition rates, the maximum search ranges observed in 2 to 5m water depths (limited by reverberation noise) appear to be of the order of 80 or 90 metres, with 70 metres being most typical. Fish seen to be regularly caught and swallowed whole are around 35-40cm in length (salmonids). Occasionally larger fish are taken (max 60cm), but these all appear to require energetic slapping activity by the dolphin to break them down to swallowable size. (We noted that the fish head may be discarded in such cases.) The pattern which has emerged suggests that fish of sizes much larger than 35-40cm are opportunist, rather than primary targets. The acoustic target strength of swim bladdered fish of these dimensions is approximately of the order of -35 dB (re a 2m radius sphere).

NET DETECTABILITY The acoustic target strength of polymer gill-net material is difficult to assess in simple terms. However, the most recent published figures (Au & Jones, 1991), measured at very short range, provide useful maximum values applicable to angles of approach in the azimuth plane only. Worst-case detection must also consider the combined effect of azimuth and elevation approach angles that are not normal to the plane of the net. However, it is very clear that the echoes returned by gill-netting are extremely weak by comparison to those from fish. A simple numerical comparison of fish against net 'target strength' indicates that dolphins ought to be able to detect many types of gill-net, from ranges perhaps as far away as 9 metres. If this theoretical 'detection' distance is regarded as providing an adequate 'stopping distance', then clearly other factors must be involved in entanglements. It should be noted that a floating headline on the sea surface does not add to the detectability of the structure, as wave-trough masking effects and strong thermal gradients near the surface hinder their ensonification. When deployed sub-surface, such headline components provide dramatically better sonar targets than the suspended net mesh.

TARGET DETECTION BEHAVIOUR When the (Amble) dolphin detects a fish target, its transmission behaviour changes. While searching, in the absence of targets, the slow PRF is characterised by some inter-click time irregularity (a clearly visible effect when viewed on an oscilloscope display). The onset of target detection normally involves a sudden increase in the PRF, which may be preceded by a very brief cessation of transmissions. The PRF typically takes several pulse/echo periods before settling to a steadily increasing rate with precise inter-click timed intervals (range-locked interception behaviour).

TARGET INTERCEPTION Although referred to as 'range-locked' behaviour, and in the examples examined, the pulse rate during interception appears closely correlated to the target's range, it is more reasonable to interpret this behaviour as an attempt by the animal to extract the maximum possible number of echoes from the target during interception. Transmitting a PRF above that determined by the target range must result in masking the arrival of the wanted echo by the succeeding transmission. The tight PRF lock on the target is normally maintained (in the absence of a successful evasion manoeuvre by the target) from the initial detection range down to a relatively short range. However, the terminal PRF observed during several, known-to-be-successful, fish 'takes' did not appear to exhibit a consistent pattern. Frequently, the steadily increasing PRF appeared to stabilise before termination, settling briefly at a particular frequency.

Given that a physiological limit to the maximum PRF must exist, it seems that the usefulness of attempting to maintain the 'range' locked data rate at very short ranges (<4m) is unprofitable. However, during interception of the larger swim bladdered fish, the PRF may match and stimulate the swim bladder bubble into sustained resonance. Spectrograms of some fish echoes (detected as they passed very close to a hydrophone) appear to demonstrate the onset of a narrow-band low-frequency tonal component which would support this hypothesis. Although the hearing of the bottle-nosed dolphin is relatively poor at such low frequencies, and the animal is unlikely to need further data to define its prey's position, it would still seem that the dolphin can benefit from sustaining this swim bladder stimulus behaviour as the fish may lose its ability to exploit the 'Mouthner' escape reflex under these conditions (Canfield & Eaton, 1990).

CONCLUSIONS The sonar guided target intercept behaviour of the bottle-nosed dolphin may be seen to exclude detection of secondary targets once the PRF 'locks' to the fish. That the dolphin is observed to forage successfully and to catch fish in an obstacle filled environment, i.e. close to rocks, cliffs, harbour walls etc., would appear to support an argument that much environmental data is retained from prior exploration of the habitat and the animal may 'navigate' within a memory mapped environment during target interception.

This hypothesis, currently being tested by an inter-disciplinary research group at Loughborough and Cambridge Universities, requires that unfamiliar (net) obstructions be made acoustically detectable at the dolphin's maximum sonar search range. Based on the Amble dolphin's observed behaviour, the net target strength must therefore significantly exceed -35dB (at 120kHz) when observed within the animal's high frequency (10^o) beamwidth. Several prototype designs for small efficient acoustic reflectors, which return this echo strength, regardless of the direction of the incident sound, have been completed. These devices are now at the early stages of testing, using both wild and (naive) captive dolphins. The preliminary results from these tests appear encouraging, as they clearly indicate long range detection and seem to stimulate positive avoidance behaviour. However, the minimum distribution pattern necessary to deter penetration of the net structure at close range has still to be optimised and the effects within a commercial fishery have not yet been evaluated.

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INTERACTION BETWEEN WILD DOLPHINS AND A MOORED BARRIER: INITIAL RESULTS FROM THE 1991 MORAY FIRTH TRIAL

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INTRODUCTION Studies of a solitary wild bottle-nosed dolphin, *Tursiops truncatus*, indicate that this animal prefers a maximum prey size of the order of 30-35 cm (Bloom, 1990; Goodson *et al.*, 1990; Goodson & Datta, this vol.). This size corresponds, in salmonids, to an acoustic target strength of about - 35 dB (ref a 2m radius sphere), which the dolphin appears able to seek out to a range of about 70 meters. If, before a fish interception chase is initiated, the dolphin can be made aware of the presence and position of a gill-net barrier, the risk of a collision may be minimised. To this end, a number of small, but efficient, acoustic reflectors have been designed which consistently return a slightly stronger echo than that of the largest prey targeted, with a view to attaching these across the face of the fishing net. An experimental procedure to test the reflectors with wild dolphins was devised and tested at the end of September, 1991.

THE SITE The site chosen for the test was the Moray Firth, Northeast Scotland. Researchers from Aberdeen University have identified a local population of approximately 150 individual bottle-nosed dolphins, many of which regularly swim within 200-600m of the shore near the entrance to the Cromarty Firth. There is good visibility from adjacent 50m cliffs and the seabed in the zone of interest is flat (hard sand) with a minimum water depth of 7 meters. A barrier, consisting of a buoyant head rope from which weighted thin rope tails were attached, was deployed perpendicular to the shore line, across the predicted path of the dolphins. One particular prototype reflector was attached at 2 m intervals to the rope tails, which were spaced 2m apart. The head-rope was 200m long, half used as control and half supporting a grid of reflectors, comprising an obstruction 100m x 7m deep overall.

EQUIPMENT AND PROCEDURE A detailed list of equipment used is given in Table 1. The experiment extended that described by Silber (1989), with the dolphins being tracked by their breathing positions using an electronic theodolite; their underwater acoustic activity was simultaneously monitored. The theodolite employed was also capable of working as a distance measuring device, and in this mode the instrument could be used to accurately measure its height above the sea level. Subsequent measurement of horizontal and vertical angles enabled the Northings and Eastings of each breathing position, and of the head rope barrier, to be calculated and plotted. The times of these readings were also recorded.

To back up the theodolite readings, two video cameras and voice-logging recorders were in use. The underwater sounds, received from the sonabuoy hydrophone by radio telemetry, were recorded on a four-track instrumentation machine, together with timecode and a voice log. A second receiver simultaneously fed the telemetry to an R-DAT digital recorder.

RESULTS Control sightings and recordings, made before the barrier was deployed, confirmed that dolphins passing in groups of 1 or 2, and occasionally up to 30, did swim parallel to the cliff at a predictable distance off-shore. As the barrier was first being deployed on 27th September, a group of dolphins approached. There was considerable acoustic activity and all the animals diverted to avoid the barrier, taking an inshore passage. Later the following morning, the inshore anchor of the barrier dragged, but for that afternoon and most of the next morning, animals were observed passing between the end of the barrier and the shore in a narrow zone of very shallow water. The barrier was repositioned during the morning of 29th September to obstruct the inshore passage.

On 30th September, some thirty animals, comprising three distinct groups, were observed passing the outer end of the barrier during a one hour period. The track of a pair of animals leading the first group is shown in Figure 1. After tracking this pair through the test zone, and while the members of the second group were still passing, a lone animal was seen to surface some 55m from the centre of the net. The subsequent track of this animal is plotted in Figures 2, 3 and 4. The solitary animal retreated, at apparent speeds of about 3-4m/sec, to a distance of 170m. This apparent retreat from the barrier was interrupted several times, the animal backtracking briefly while swimming at much slower speed. The animal finally altered course to join the track of the main group and, closely following this, swam past the outer end of the barrier. The track of the earlier groups and of the straggler then deviated from the general north-easterly swimming direction, and the animals appear to have investigated the back of the barrier (closest plotted point of approach = 55m) before leaving the area, continuing along the line of passage which would have been predicted in the absence of the barrier. Subsequent analysis of the recorded underwater sounds demonstrates no obvious echolocation activity which can be assigned to the approaching lone dolphin until 7 seconds before the first surface plot made as it retreated. At that time a burst of clicks at a repetition rate indicative of target detection at 20m range is apparent. Slow motion replay of the video record shows that at the first surfacing position the animal is swimming rapidly away from the barrier. This is the single recorded close approach to the barrier made during the study period, although a large number of animals, (50 or more during daylight hours), passed the site each day. The remarkable similarity between the two tracks can be seen by comparing figures 1 and 2.

CONCLUSIONS The tracks reconstructed to date seem to indicate that the more alert animals leading the groups became aware of the barrier position at a maximum range of 150 to 170m, a much greater range than predicted. However two significant factors may help to explain this:

(1) The dolphins were approaching in a direction normal to the plane of the barrier. At a range of 170m a 10^o beamwidth will excite nearly simultaneous echoes from the reflectors spread along approximately 30m of the barrier, which effectively increases the target strength. This would not be the case if the animals approached from a more oblique angle, as the multiple echoes then arrive sequentially.

(2) The quiet sea, sea state 2 or less, provided excellent acoustic conditions, and a very flat sandy seabed contributes little confusing reverberation.

The solitary animal may have been travelling in a low awareness 'resting' state. Whether its behaviour was triggered by the activity of other animals beyond the barrier, or by one of the random loud clicks that have been occasionally noted from other resting animals, has not been established. However, if an unmodified gill-net had been in the position of the test barrier, this individual seems a likely candidate for entanglement.

Although the data obtained in this first field test are limited, and our detailed analysis is still incomplete, the test results appear promising and exceeded our expectations. The protocol we employed needs further refinement but generates useful interaction data at rates far faster than in a commercial fishery and without any risk to animals. To optimise the reflector design and distribution spacings, a much larger scale test is planned to take place as soon as research funds are available.

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Table 1 Equipment employed

Radio equipment
Wideband sonarbuoy (UEL30059) modified for extended life.
Marine band communications by hand held marine band transceivers (4).
The telemetry was received using: FT9600 (2), an Icom R1 and an A 7 R 2002 communication receivers.

Audio Recording Equipment
Racal Store 4 DS - High speed instrumentation recorder.
Aiwa HD-S1 R-DAT - Digital Audio Cassette Recorder.
Nagra IV S-J - Reel to reel audio recorder.

Timecode
Yam EBU Timecode generator and reader.

Video equipment
Sony Broadcast Hi-8, a VHS camcorder (N10) and a JVC portable recorder

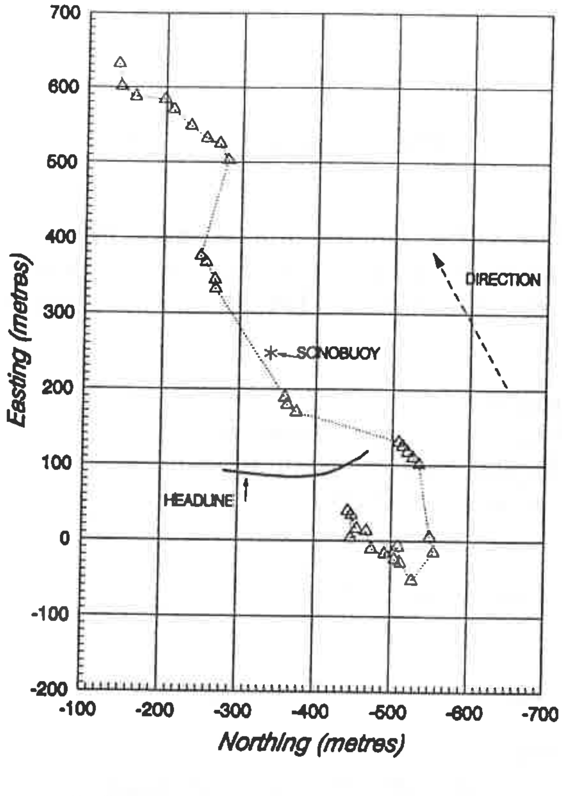
Total Station (Theodolite)
Sokkisha Set 5 together with an EDM prism and data logger.

Computer
Walters 386 Notebook (IBM compatible).

Base Vehicle
Ford Camper, equipment transport cross country by Shogun 4 x 4.

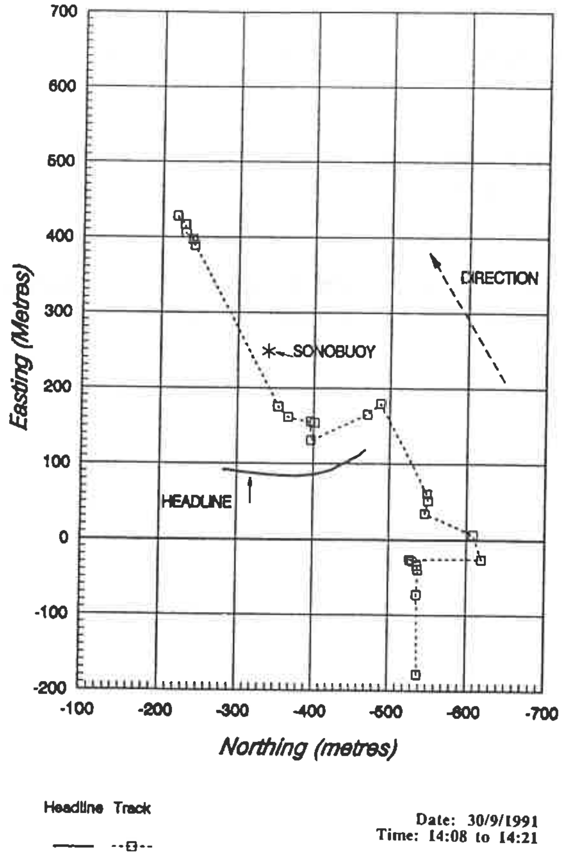
Boats
7m hard chine double hull motor boat.
Zodiac inflatable with outboard motor.

The test barrier
A 200m headline made up to the same specification as the headline of the current Eastern Atlantic tuna gill-nets, used to support the reflectors.



Date: 30/9/1991
Time: 14:25:33 to 14:36:55

Fig. 1 Track of the dolphins leading first group.



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Time: 14:08 to 14:21

Fig. 2 Track of solitary dolphin to same scale as Figure 1

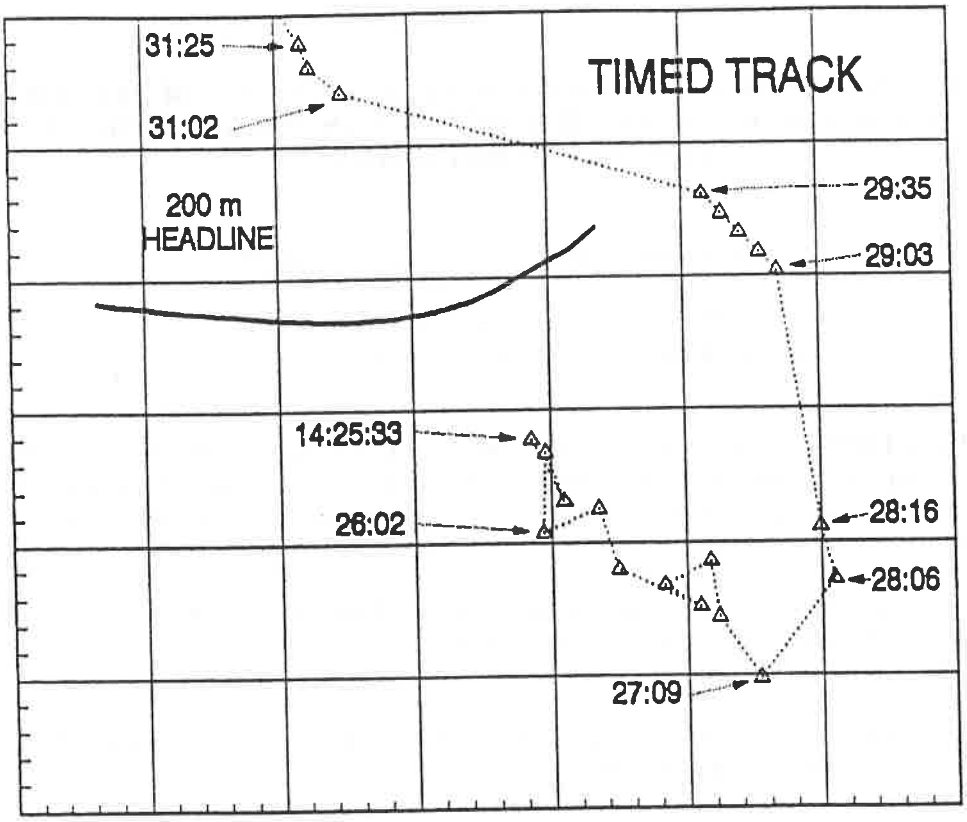

Fig. 3 Timed track of solitary dolphin.

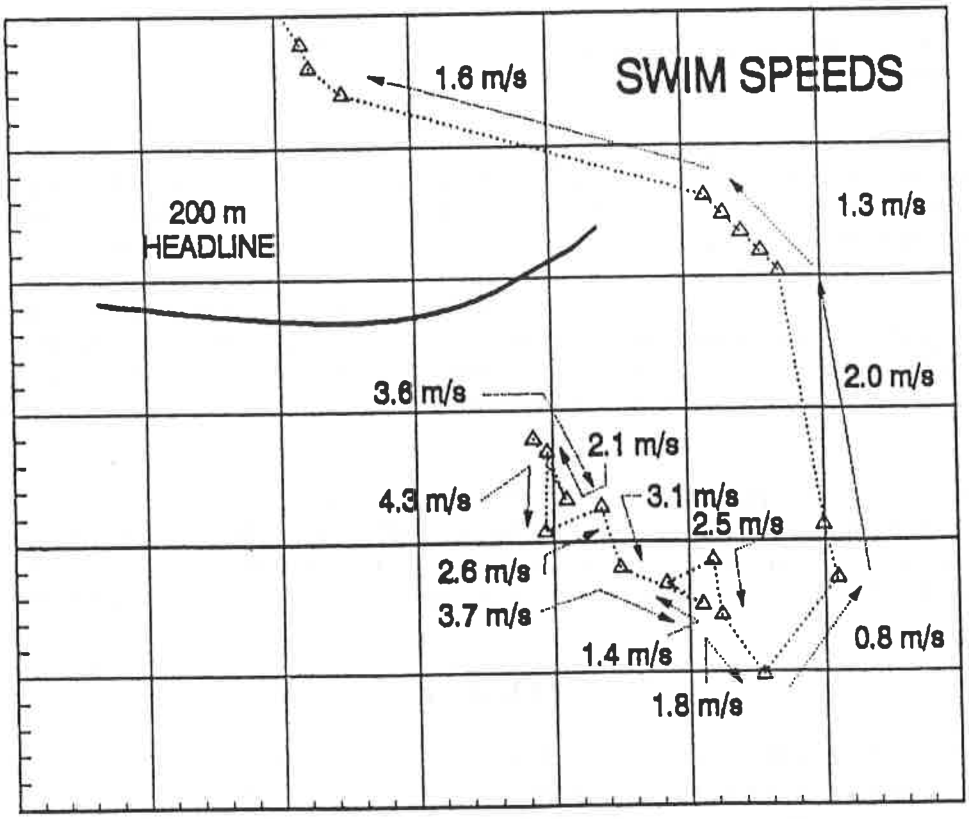

Fig. 4 Solitary dolphin swimming speeds.

CEPHALOPODS FROM THE STOMACHS OF CUVIER'S BEAKED WHALE (*Ziphius cavirostris* CUVIER, 1823) STRANDED AT FIUMINO, CENTRAL TYRRHENIAN SEA.

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INTRODUCTION Little is known about the biology of the Cuvier's beaked whale in the Mediterranean. According to Viale (1985), this species is gregarious, strictly teuthophagus and prefers frontal zones, where contact between two water masses generally produces an enrichment of animal biomass.

Strandings along the Italian coasts of the central Mediterranean have been reported by Tortonese (1963), and, more recently, by Cagnolaro *et al.*, (1986) and Centro Studi Cetacea (1987, 1988, 1990 and 1991).

Stomach contents of specimens stranded on the eastern coast of Sardinia have been described by Podestà and Meotti (1991).

MATERIALS AND METHODS Cephalopod remains have been obtained from a specimen of Cuvier's beaked whale (female, 505 cm total length) stranded near Fiumicino (Rome), central Tyrrhenian coast. Only lower beaks have been identified and measured as lower rostral length (LRL), according to methods described by Clarke (1986a).

RESULTS Eight cephalopod species have been identified by examination of 233 lower beaks (Table 1).

DISCUSSION Ziphiids are known to dive deep and for long periods of time (Ridgway and Harrison, 1986; Clarke, 1986b). Their diet reflects this ability. All cephalopod species found in the stomachs of our Cuvier's beaked whales were oceanic and mid-water animals. They live offshore above the continental slope or associated with sea mounts.

Both muscular and ammoniacal cephalopod species have been found, but the latter are more frequently represented (more than 95% of the identified prey number). These cephalopods are also slow swimming and with a relatively low calorific value (Clarke, 1986b) and this implies some special physiological adaptation in the Cuvier's beaked whale.

The main food item is represented by *Histioteuthis reversa* which is a small histioteuthid, maturing at 50mm dorsal mantle length (Clarke, 1966). Nevertheless, the stomach contents are characterised by some large beaks belonging to *Todarodes sagittatus*, *Histioteuthis bonnelli* and *Octopoteuthis sicula*, whose estimated weight ranged between 3 and 10 kg.

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Table 1 Identity of lower beaks found in the stomachs of *Z. cavirostris*. Relative number (N) and percentage (N%) of the identified prey.

Prey Specimens	N	N%
Histioteuthis bonnellii	18	7.7
Histioteuthis reversa	202	86.7
Toderodes sagittatus	3	1.3
Ommastrephes bartramii	1	0.4
Ancistroteuthis lichtensteini	4	1.7
Octopoteuthis sicula	3	0.4
Chiroteuthis veranyi	1	0.4
Heteroteuthis dispar	1	0.4
TOTAL	233	100

CRUSTACEAN REMAINS FROM THE STOMACHS AND FAECES OF SOME MEDITERRANEAN CETACEANS. AN ILLUSTRATED SHEET.

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INTRODUCTION The crustaceans play an important role in the trophic webs of several marine ecosystems (Nelson, 1981). Some components of this taxa are very abundant in the macroplankton (Franqueville, 1971), and are more or less consistently involved in the feeding of a number fish species as well as in the food webs of the marine mammals.

During the analyses of the stomach contents of striped dolphin, *Stenella coeruleoalba* (Meyen, 1833), collected in the Ligurian Sea (Wurtz and Marrale, 1991), and of the faeces of *Balaenoptera physalus* (L. 1758), collected during 1991 Greenpeace cruise in the Ligurian Sea, we have recognised various crustaceans, and precisely the sergestids *Sergestes arachnipodus* (Cocco, 1832), and *Sergia robusta* (S. I. Smith, 1882), the carideans *Acanthephyra pelagica* (Risso, 1816), *Pasiphaea multidentata* (Esmark, 1886, and *Pasiphaea sivado* (Risso, 1816), and the euphausiid *Meganyctiphanes norvegica* (M. Sars, 1857).

The most common remains of these species are mandibles, gastric mills, petasma and telson. These parts are generally useful tools to identify the species and to determine their size (Wurtz and Marrale, 1991). Nevertheless their identifications is often possible only by a investigator of such taxa, because of the specialized systematic books does not always describe all the anatomical features of the species. So the aim of this work is to present an illustrated sheet of the most common remains in the stomach contents of odontocetes and mysticetes in order to facilitate the identification of crustaceans as food item of these animals. The figures corresponding to *A. pelagica, P. multidentata, P.sivado,* and *M.norvegica* are reported in Relini Orsi and Wurtz (1975) while, the petasmae of *S. arachnipodus* and *S. robusta* in Crosnier and Forest (1973), Fig. 106 a,b,e and 112 c,d respectively. We present here some original drawings of anatomical features of *S. arachnipodus* (Fig. 1) and *S. robusta* (Fig. 2). Drawings were made with the aid of a camera lucida using a Leitz compound microscope.

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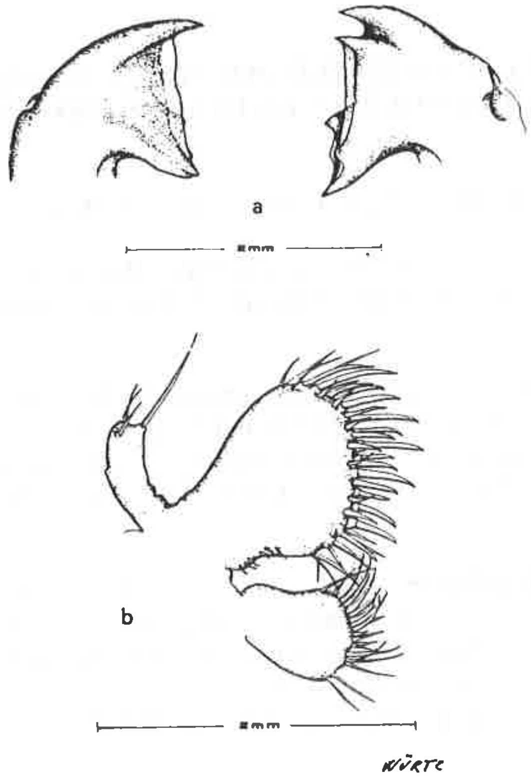

Fig. 1. *Sergestes arachnipodus.* (A) mandible, (B) maxillula.

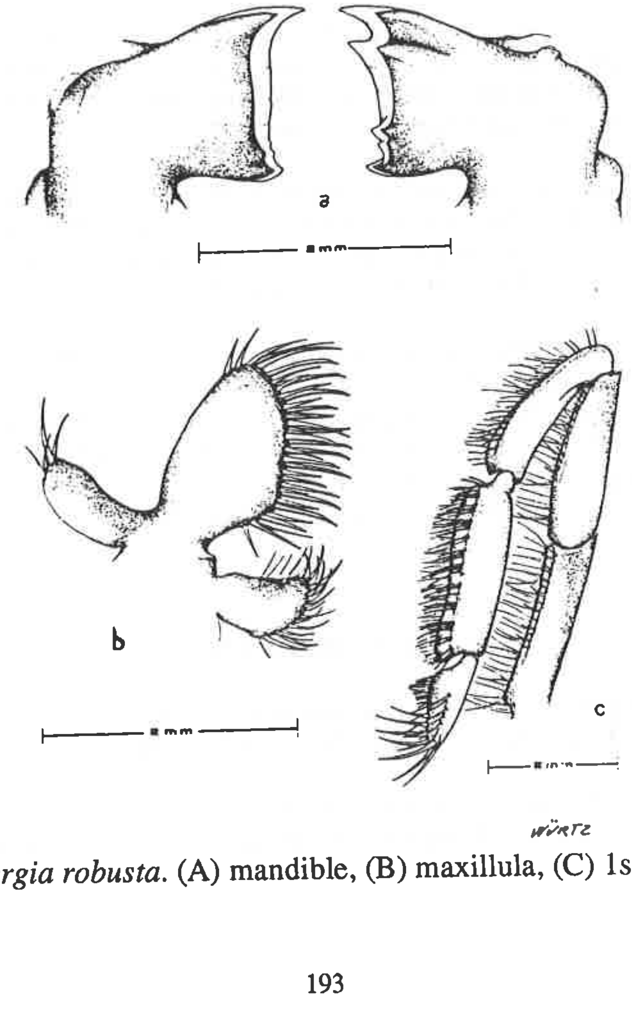

Fig. 2. *Sergia robusta.* (A) mandible, (B) maxillula, (C) 1st maxilliped

STOMACH CONTENTS OF STRIPED DOLPHINS, *Stenella coeruleoalba*, (Meyen, 1933) FROM THE SOUTH-CENTRAL TYRRHENIAN COAST.

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INTRODUCTION Striped dolphins are known to feed on fishes, cephalopods and crustaceans. According to Duguy *et al* (1979) and Viale (1985) this species is preferentially teuthophagus, while it is recognised by other authors as "generalist" eater (Cagnolaro *et al.*, 1983; Cagnolaro *et al*, 1986; Desportes, 1985; Wurtz and Marrale, in press; Bello, in press).

MATERIALS AND METHODS Stomach contents from sixteen striped dolphins have been analysed. The animals were stranded along the coast of south-central Tyrrhenian sea, during the period 1986-91. Males were represented by six specimens, and seven were females. In the remaining three specimens, the sex was not identified because of their bad condition. The total length ranged between 111 cm and 225 cm. Strandings occurred all year around.

RESULTS Table 1 summarises the results on the basis of the prey number (N) and the occurrence (F), that is the number of stomachs containing one or more specimens of each food category (Hislop, 1980).

CONCLUSIONS The samples confirm the striped dolphin as a generalist eater. Nevertheless, the cephalopods are better represented than in the specimens from the Ligurian Sea (Wurtz and Marrale, this vol.). Oceanic and neritic squids contribute to the prey list as well as midwater and benthic cephalopods.

Considering these results together with those from the Ligurian specimens, the same can be stated about bony fishes. Thus striped dolphins exploit not only the resources swimming in the water column corresponding to the continental slope, but also predate in the shelf area, as demonstrated by the frequent sightings near the coast.

The differences among the prey composition presented here and the list given by Wurtz and Marrale (this vol.) and Bello (in press) demonstrate that striped dolphin trophic preferences vary by the areas but likely more according to seasons as observed by Desportes (1985), in effect in our samples fishes and crustaceans have been observed only in the stomach of the animals found stranded in spring and summer. Unfortunately, until now the samples are too small to allow the prey allocation to investigate a seasonal trend in the striped dolphin feeding behaviour.

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Table 1 Identity of lower beaks found in 16 specimens of striped dolphin.
(N) number of prey and relative percentage (N%);
(F) occurrence and relative percentage (F%).

Prey specimens	N	N%	F	F%
Histioteuthis bonnelli	124	36,9	10	62,5
Histioteuthis reversa	58	17,3	5	31,3
Ancistroteuthis lichtensteini	24	7,1	9	56,3
Onychoteuthis banksii	4	1,2	1	6,3
Chiroteuthis veranyi	6	1,8	3	18,8
Illex coindetii	6	1,8	3	18,8
Todarodes sagittatus	23	6,8	8	50
Todaropsis eblanae	11	3,3	3	18,8
Loligo vulgaris	13	3,9	2	12,5
Octopoteuthis sicula	1	0,02	1	6,3
Heteroteuthis dispar	48	14,3	5	31,3
Sepietta oweniana	7	2,1	3	18,8
Pasiphaea sivado	2	0,6	1	6,3
Sergestidae	2	0,6	2	12,5
Boops boops	7	2,1	1	6,3
Total	336	100		

CEPHALOPODS FROM THE STOMACHS OF RISSO' S DOLPHINS , *Grampus griseus* , (Cuvier, 1812), STRANDED ALONG THE CENTRAL TYRRHENIAN COAST.

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INTRODUCTION In the central Mediterranean, sightings and strandings of Risso's dolphins, *Grampus griseus*, have been reported since 1811 (Cuvier, 1812) and, more recently, by Arbocco (1969), Di Natale (1983), Viale (1985), Cagnolaro *et al* (1986) and Centro Studi Cetacei (1987, 1988, 1990 and 1991).

Distribution, herd composition and migratory behaviour in the same area have been described by Di Natale (1983), Viale (1985), and Fabbri *et al*, (this vol.). Stomach contents have been analysed by Clarke and Pascoe (1985), Desportes (1985), Podestà and Meotti (1991), and Wurtz *et al.* (this vol.). Some other information on the diet of Risso's dolphin are given by Richard (1936), Tamino (1953), Viale (1985) and Carlini (1988).

MATERIALS AND METHODS Two Risso's dolphins were stranded along the coast of Latio (Central Tyrrhenian sea) in January 1988 and January 1991. The first animal was a female 290 cm long; the second was a male 312 cm long. The stomachs contained cephalopod remains and five *Loligo vulgaris* specimens. According to Clarke (1986b), only lower beaks were identified and measured as lower rostral length (LRL) for squids and lower hood length (LHL) for octopods and cuttlefish.

Nevertheless, the occurrence and only the numerical methods (Hyslop 1980) are applied here, as preliminary analysis.

RESULTS A total of 254 lower beaks were identified. Table 1 summarises the composition of the stomach contents and shows that eleven cephalopod species are represented by beaks.

DISCUSSION The present observations support the general belief that Risso's dolphin eat cephalopods exclusively. The present collection of beaks contributes to a better knowledge of *Grampus* diet, five cephalopod species not previously recorded in the stomachs of the specimens collected in the Ligurian Sea (Podestà and Meotti, 1991; Wurtz *et al*, in press): *Illex coindetii, Loligo vulgaris, Sepia officinalis, Ocythoe tuberculata* and *Argonauta argo* have all been identified.

In the Ligurian Sea, *Grampus* is generally sighted where deep water lies close to the coast and the continental slope is steep (Fabbri *et al*, this vol.). As with other teuthophagus cetaceans, *Grampus* find prey both in the water column and on the bottom of the continental slope which is reached by long and, very probably, very deep dives (Clarke, 1985, 1986b).

On the other hand, the mixture of neritic cephalopods such as *Loligo*, *Sepia* and *Eledone* shows that this species also catch prey on the continental shelf.

The presence of epipelagic octopods together with midwater necktobenthic species demonstrate that *Grampus* exploit the whole of the cephalopod resources living in the water column corresponding to the continental slope and the outer edge of the shelf.

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Table 1 Identity of lower beaks. Relative number (N) and percentage (N%) of the identified prey specimens. (*) shows the presence of each prey item in the 1988 and 1991 specimens.

Prey specimens	N	N%	1988	1991
Histioteuthis reversa	122	47.1		*
Histioteuthis bonnellii	11	4.2		*
Illex coindetii	44	17		*
Toderodes sagittatus	47	18.1		*
Ancistroteuthis lichtensteini	3	1,1		*
Loligo vulgaris	7	2,7	*	*
Sepia officinalis	5	1,9		*
Heteroteuthis dispar	1	0,3		*
Ocythoe tuberculata	15	5,7		*
Argonauta argo	3	1,1		*
Eledone sp.	1	0,3		*
TOTAL	259	100		

STOMACH CONTENTS OF A RISSO'S DOLPHIN, *Grampus griseus*. DO DOLPHINS COMPETE WITH FISHERMEN AND SWORDFISH, *Xiphias gladius* ?

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On 14th April, 1991, a dead Risso's dolphin, *Grampus griseus* (Cuvier, 1812, Cetacea: Delphinidae) was found stranded ashore at Torre Specchia (Lecce, Italy), on the south-west Adriatic coast. The specimen was a female, 3.2 m in length. It lacked all teeth from the right mandible and appeared to be underweight, as if it had suffered starvation (R. Basso, pers. comm.).

Prey remains consisted solely of cephalopod beaks. Identification of lower beaks was made using Clarke (1986) and by comparison with assembled beak samples. Forty-two upper and 66 lower beaks were counted. Most of them were worn down by digestion.

The following species were identified (number of specimens in parenthesis):

SEPIOLIOIDAE: *Heteroteuthis dispar* (2);

TEUTHOIDEA: *Histioteuthis bonnellii* (40), *Histioteuthis reversa* (10), *Histioteuthis* sp. (2), *Onychoteuthis banksii* (2), *Anistioteuthis lechtensteinii* (1), *Chiroteuthis veranii* (1), *Todarodes sagittatus* (3), Unidentified teuthoids (3);

OCTOPODA: *Argonauta argo* (1), *Ocythoe tuberculata* (1).

All identified cephalopods are oceanic. Most of them (86.4%) belong to bioluminescent species (Fig. 1).

Risso's dolphin's feeding periodicity is not well understood. Indeed, according to one report (Cataldini and Bello, 1987), a specimen fed upon a long-line bait during night time. Considering that (1) Risso's dolphins possibly catch their prey (all or part) in the dark; and (2) some prey items are small-sized (less than 5cm total length), for example *H. dispar* and juveniles of other species; (3) most items are bioluminescent; it can be supposed that these dolphins use eyesight in addition to echolocation to detect prey. Indeed, Young and Roper (1976) and Young *et al.* (1980) showed that bioluminescent cephalopods use their own light as a counter-illuminating mechanism to conceal themselves. However, teuthophagus dolphin visual acuity needs to be tested in connection with the counter-illumination mechanism in different prey species. Tests should involve continuous or intermittent light emission, measures of the intensity of light produced and photophore resolution to evaluate the effectiveness of concealment.

COMPETITION WITH FISHERMEN This issue has also been discussed by Wurtz *et al.* (this vol.).

Detailed analysis of Risso's dolphin stomach contents are reported by Clarke and Pascoe (1985), Desportes (1985), Podestà and Meotti (1991), Wurtz *et al.*, (in press), Carlini *et al.*, (this vol.), Bello and Pastore (in press) and here in this present paper. According to these, it appears that Risso's dolphins can feed both in oceanic and neritic zones. Of ten specimens, six had fed in oceanic midwater and four on the continental shelf.

Risso's dolphins compete with fishermen only when feeding in the neritic zone. In fact, its oceanic prey (cephalopods) are not sought after by man. *T. sagittatus*, the only cephalopod occasionally caught by fishermen, is very low prized and is not the target of any fishery.

Incidentally, it is not known whether Risso's dolphins feed regularly on the continental shelf, or if neritic feeding occurs only, or mainly, in distressed animals. Fabbri *et al.*, (this vol.) report that Risso's dolphins are most abundant where the bottom is 400 to 1,000 m depth.

COMPETITION WITH SWORD FISH The comparison between the Risso's dolphin and the sword fish, *Xiphias gladius* L., is appropriate in that the latter is a large teuthivorous predator and is the target of an important fishery in the Mediterranean.

Data about sword fish feeding habits in the Mediterranean are reported by Bello (1991, in press). The feeding spectrum of the Mediterranean Risso's dolphin is derived from available sources, such as Podestà and Meotti (1991), Wurtz *et al.* (in press), and Bello and Pasrore (this vol.) and present results.

Swordfish food comprises mostly cephalopods (91.8% biomass). The single most important item is *T. sagittatus* (65.5% biomass). The feeding spectra for Risso's dolphin is limited to cephalopods, as it is for swordfish (Table 1). The two spectra overlap by 25.9%. About half of such overlap is due to *A.. lichtensteinii.*

Swordfish are more generalist feeders than Risso's dolphins, though preferring muscular, fast swimming ommastrephid squids, as opposed to Risso's dolphins which are strictly teuthophagus and favour slow moving, neutrally buoyant histioteuthid squids. Therefore, these two large oceanic predators occupy different feeding niches.

In conclusion, according to the above reported data, there is only partial competition between Risso's dolphins and swordfish and, in turn, between Risso's and the swordfish fishery.

ACKNOWLEDGEMENTS I am grateful to Mr. Basso for providing the stomach content material and the information about the stranded animal. My warmest thanks to Prof. L. Orsi Relini for her precious comments on this note.

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Table 1 Stomach content percent composition of Risso's dolphin and swordfish. * = including species that overlap less than 1%, viz. *H. dispar, A. lesueurii, O. banksii, O. tuberculata and A. argo.*

	Risso's dolphin					Swordfish
	A	B	C	D	Weight	
T. sagittatus	0.0	7.3	17.8	4.8	7.5	55.1
A. lichtensteinii	17.9	9.1	10.1	1.6	11.6	14.6
Histioteuthis spp.	6.2	81.1	62.0	82.5	73.4	2.2
Cranchiidae	4.6	0.0	2.3	0.0	2.5	2.7
other cephalopods*	1.3	1.8	2.4	11.1	5.0	25.4

KEY

Risso's dolphin: Only identified prey-cephalopods were taken into account for percentage computation. Number of prey items: $n_A = 151$ $n_B = 55$, $n_C = 129$, $n_D = 63$, Sn = 398.

A = data from Prodestà and Meotti (1991)
B = data from Wurtz *et al.* (in press)
C = data from Bello and Pastore (in press)
D = present results

Swordfish: Only the cephalopod fraction of stomachs were taken into account for percentage computation. Number of prey-cephalopod items = 185. Number of examined stomachs = 38. All data from Bello (1991).

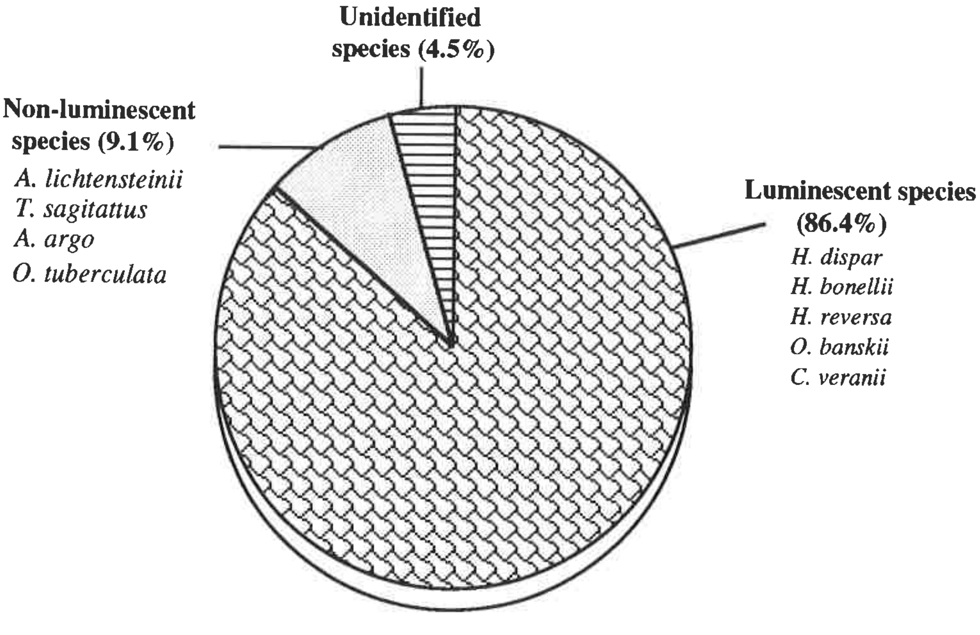

Fig. 1 Risso's dolphin (*Grampus griseus*) stomach content composition (% prey items).

PIGMENTATION PATTERNS OF THE STRIPED DOLPHIN, *Stenella coeruleoalba*, (MEYEN, 1833) IN THE CENTRAL MEDITERRANEAN SEA

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INTRODUCTION During a series of cruises organised by the Tethys Research Institute in the seas surrounding Italy, a large number of photographs were taken of striped dolphins, one of the most common cetacean species in the Mediterranean Sea. From these, the high variability of colour patterns of this dolphin species clearly emerges. Variability of colour pattern in striped dolphins was noted throughout its world's range, such as along the Oregon coast (Kellogg and Scheffer, 1947), the seas adjacent to Japan (Kellogg and Scheffer, 1947), the western North Atlantic (Fraser and Noble, 1970; Mercer, 1973), the eastern North Atlantic (Fraser and Noble, 1970), the eastern North Pacific (Fraser and Noble, 1970), the western North Pacific (Fraser and Noble, 1970), the western Indian Ocean (Fraser and Noble, 1970), and the Mediterranean Sea (Busnel *et al.*, 1968; van Bree *et al.*, 1969; Fraser and Noble, 1970; Robineau, 1972; Mörzer Bruyns, 1974; Sylvestre, 1985). Our aim is to describe the colour variability of striped dolphins from the Central Mediterranean Sea.

METHODS The analysis presented here is based on 267 colour slides (Ektachrome 64, Ektachrome 100, and Kodachrome 64) taken from 1986 to 1991 of c. 325 individuals observed during research cruises organised by the Tethys Research Institute in the Central Mediterranean Sea, including the Ligurian and Corsican Seas, the Tyrrhenian Sea, the Ionian Sea, and the southern Adriatic Sea.

The terminology of the different parts of the coloration (Fig. 1) was taken mostly from W.F. Perrin (pers. comm.).

RESULTS A high degree of variability was observed in most components of the coloration patterns. The principal patterns and their observed variations are the following:

CAPE: A dark region, clearly delimited, extending dorsally from the **eye stripe** to a point on the dorsal ridge of the tail stock. It borders cephalically with the **eye stripe**, ventrally with the **spinal blaze**, and caudally with the **flank field**. The cape is generally uniformly pigmented, except for a sector of the **melon** comprised between the blowhole and the **eye stripe**. Here, a dark line is usually found connecting medially the blowhole with the anterior margin of the melon; on either side of this line, two triangular areas exist having a generally lighter, irregular pigmentation. The **posterior margin** of the cape is usually well defined, and terminates on the dorsal ridge of the tail stock usually at about one third of the tail stock length from the dorsal fin insertion; occasionally it is not well-defined, and seems blurred by parallel lines of lighter colour. Sometimes it extends further caudally, up to more than half of the tail stock; more rarely, it terminates just behind the insertion of the dorsal fin.

SPINAL BLAZE: A white or light-grey region extending cephalically from the centre of the posterior region of the cape (ventral to the dorsal fin base), that reaches the **eye stripe.** The spinal blaze borders dorsally with the cape, and ventrally with the **eye-to-anus stripe**. The borderline between cape and blaze in the head region is usually lower than in oceanic striped dolphins, resulting in a wider cape. The posterior end of the blaze intruding into the cape is among the most variable character, ranging from almost complete absence to a prolongation nearly reaching the insertion of the dorsal fin; this end can either be clear cut or fringed. The coloration of the blaze is also very variable, from pure white (same as the coloration of the **ventral field**), to light grey.

FLANK FIELD: A moderately pigmented region (lighter than the **cape**), bordering anteriorly with the **cape** and the **spinal blaze**, ventrally with the **eye-to-anus stripe**, and posteriorly with the **caudal fin**. The flank field is counter-shaded, with a grey coloration darker dorsally, becoming lighter to almost white ventrally. Coloration is often irregular, mottled or striped. There is often a clear demarcation line dividing the darker dorsal portion of the flank field from the lighter ventral portion; such a line occasionally protrudes anteriorly into the cape, reaching and intersecting the blaze. This results in a darkening of the cape in that region, suggesting a cape/flank field overlay similar to what was observed in other delphinids (Perrin, 1972).

EYE-TO-ANUS STRIPE: A thin, dark stripe extending caudally from the eye, and becoming progressively wider in the genital region. It can originate either above or just posterior to the eye. The eye-to-anus stripe can be very contrasting or almost faded; in this case only the anterior portion of it may be visible.

STRIPE SUBTENDING EYE-TO-ANUS STRIPE: A short stripe, thinner than the **eye-to-anus stripe**, usually originating from it and extending posteriorly into the **ventral field**, terminating just caudal to the flipper insertion. However, this stripe is often entirely separated from the **eye-to-anus stripe**, and originates posteriorly to the eye, underneath the origin of the **eye-to-anus stripe**. Occasionally it is so faded that its presence is almost undiscernible.

EYE STRIPE: A thin grey stripe connecting the eyes anteriorly, running between the anterior margin of the melon and the rostrum. The eye stripe, which widens around the eye, is not always entirely visible, particularly under the melon.

VENTRAL FIELD: A white region delimited dorsally by the **eye-to-anus stripe**. Cephalically, it merges gradually into the darker pigmentation of the mandible.

ROSTRUM: The upper portion of the rostrum is dark grey, as dark as, or darker than the **cape**. It can be either uniform grey, or with a lighter blaze running medially and widening at the tip. The mandible is dark grey around the lips, rapidly lightening on the chin into the white coloration of the ventral field.

FLIPPER: Dark grey on both sides, occasionally with a lighter blaze in the middle portion of the upper side.

DORSAL FIN: From the pigmentation standpoint, it is indistinguishable from the cape. A dorsal fin blaze (*sensu* Mitchell, 1970) was never seen.

CAUDAL FIN: Dark grey, similar to the dorsal fin. Its leading edge and its base of attachment to the tail stock is usually lighter. There are often slight blazes parallel to the trailing edge.

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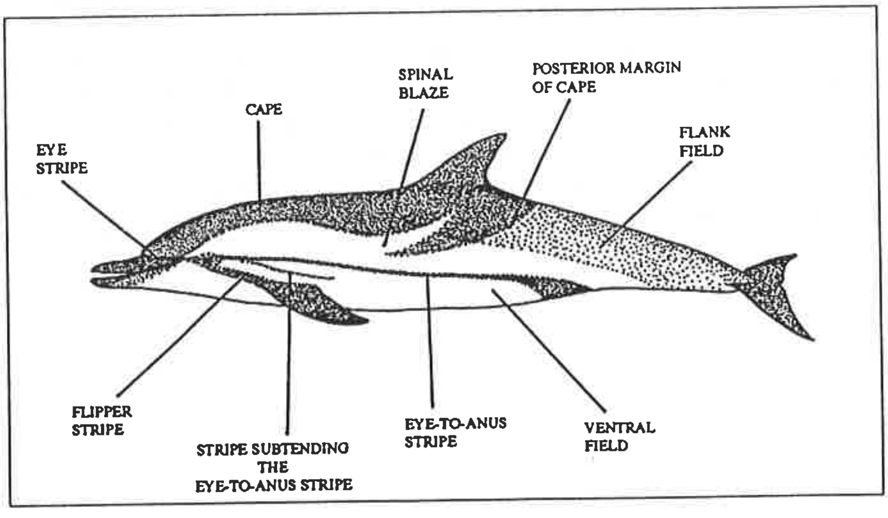

Fig. 1 Colour pattern terminology for the striped dolphin

CAN WE TELL MORE THAN AGE FROM TOOTH GROWTH LAYERS IN CETACEANS ?

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Teeth are recognised as useful tissues for determining age accurately in cetaceans, by means of the growth layer groups that form regularly in dentine and cementum. Anomalous mineralisation patterns are now recognised in teeth, and there is increasing evidence for linking these anomalies with specific underlying causes.

This paper addresses some of the types of tooth mineralisation anomalies which are common to several species, including harbour porpoise, *Phocoena phocoena*, short-finned pilot whale, *Globicephala macrorhynchus*, long-finned pilot whales, *Globicephala melas*, sperm whales, *Physeter macrocephalus*, and striped dolphin, *Stenella coeruleoalba*, and identifies possible causative factors.

The types of anomalies discussed include pulp stones, marker lines, mineralisation interference, dentinal resorption and cemental disturbances. Comparison of harbour porpoise teeth, collected mainly from by-catch, from the United Kingdom, Norway, Denmark, Canada and southern California, U.S.A., demonstrate regionally different incidences of anomalies. Greater similarities were seen between Canada and Norway, and United Kingdom and Denmark, with California standing alone. However, all regions show a high incidence of marker lines at ages 2-4 years, the usual age range of sexual maturation.

The regional differences may be due to environmental factors or inherent stock differences. A marker line appears regularly within a short time after being taking into captivity, in California short-finned pilot whale teeth, and may be linked to stress and nutritional problems at this time. Incidence of marker lines in Northeast Atlantic long-finned pilot whales from the wild off Iceland and Faroes, indicate regional differences, as also do anomalies such as dentinal resorption which also appear to vary between sexes.

Factors which require further investigation in relation to tooth anomalies include environmental changes in climate, sea temperature, marine production and food availability, as well as life history events such as sexual maturation, pregnancy and lactation. All these factors may create stress in the animal, which, if severe, may give rise to mineralisation anomalies in the teeth. The long-term hope is that such anomalies may provide more information on individual life histories other than mere age.

CYTOARCHITECTURAL STUDIES OF THE CORTEX OF THE HARBOUR PORPOISE, *Phocoena phocoena* (LINNE, 1758)

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Whales are highly developed animals with a high intelligence. But nobody knows what intelligence is. At present it is not possible to draw a conclusion about intelligence from the archi- and cytoarchitecture of the brain. In spite of this fact, an attempt is made to compare human and harbour porpoise cortices.

The folding of the brain, and with it, the enlargement of the cortical surface, increased during evolution. A primitive brain contains only a few folds; highly developed mammal brains, however, have many folds. Cetacean brains have more folds than human brains. If we postulate that the folding of the brain is an indication of its phylogenetic development, we have to accept that the cetacean brain is the most advanced brain of all mammals. But it is also assumed that the configuration of a brain has no influence on its efficiency.

The efficiency of the brain depends firstly on the thickness of the cortex and the cortical lamination (Fig. 1). When comparing a human and a harbour porpoise brain, the cortex of the human brain is up to 5 mm. This is bigger than the cortex of the harbour porpoise which is up to 3.5 mm. But the porpoise's brain has more folds, and therefore the surface of the brain is two times larger than the surface of the human brain.

Generally the human cortex has six layers. The olfactory regions of the harbour porpoise (Fig. 1 A) have three or five layers only. By the packing of nine layers, the speaking centre in the brain of the harbour porpoise is much bigger than the comparable centre in the human brain with only seven layers (Fig. 1 E).

Secondly, the efficiency of the brain depends on the numerical density of the neurons and glia cells, the high density of the synapses of the neurons, and the nervous connection between the different nerve cells. The forms of the nerve cells are similar to those of human brains (Fig. 2).

The numerical density of nerve cells in the human cortex is 10,000 to 30,000 per cubic mm (Leonhardt, 1985). Studies of the packing density of neurones and glia cells in dolphin limbic cortices lead to an estimate in distinct parts of 5,600 to 105,000 per cubic mm (Garey and Leuba, 1986; Morgane *et al.*, 1986).

The ramification of the neurons, the connection between the cells, and the accumulation of synapses at the neurons, is comparable to the human nervous system (Fig. 3).

By comparison with the cyto-architecture of the human (Brodmann, 1909; Creuzfeld, 1983), and porpoise cortical fields, the olfactory system of the harbour porpoise is reduced but remains functional. The visual system of the harbour porpoise is poorly developed, and is inferior to the one of dolphins and human beings. However, the acoustic system is highly developed. With its equipment of the speaking centre, the harbour porpoise should be able to speak. The extension of motor areas demonstrates the high agility of the harbour porpoise. The cytoarchitecture of the motor fields demonstrate the high efficiency of the motor system, which is much better developed than the human motor system. By the important accumulation of free nerve endings, and the large collection of nervous end corpuscles, in the integument, the harbour porpoise has the highest sensory development of all mammals. This is not reflected in the somato-sensory areas. The equipment of the somato-sensory fields are comparable to those in dolphins and humans (Fig. 4).

However, at present it is not possible to make any statement about the efficiency of the brain by its neural equipment. All animals possess a central nervous system which is a necessity for life; this includes all whales.

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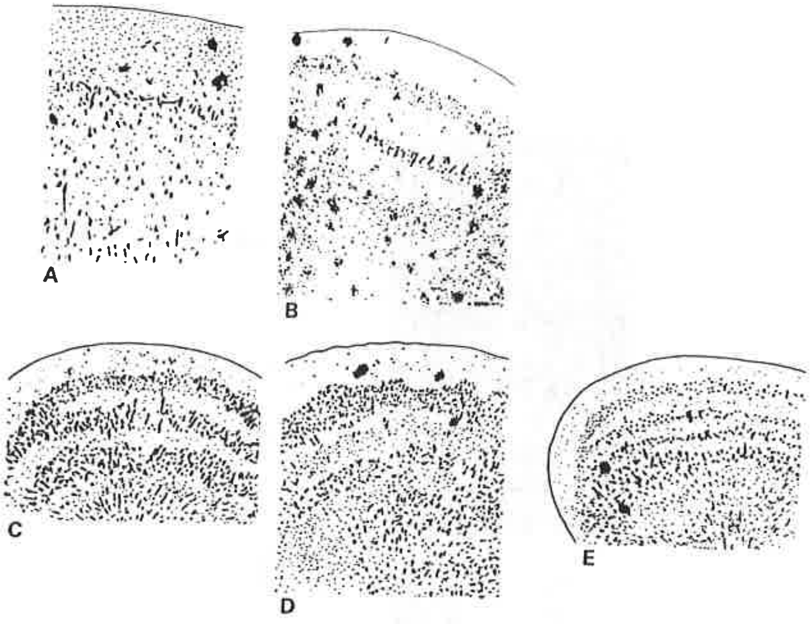

Fig. 1 Examples of the lamination of one olfactory area (A), an optic area (B), a motor area (C), the centre in the attenuation area (D) and the motoric speaking area E).

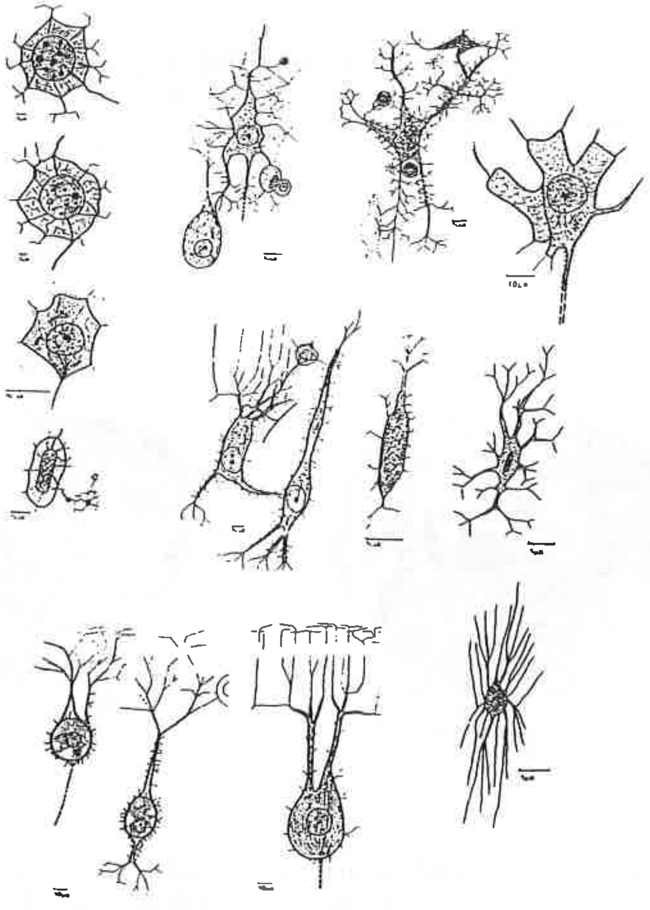

Fig 2 Various forms of neuron and ganglia cells of the harbour porpoise, *Phocoena phocoena.*

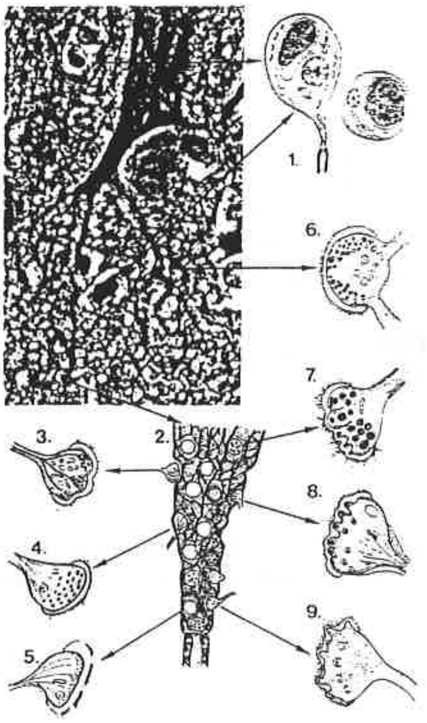

Fig 3 The foot of a large pyramidal cell, 1000 X, accompanied by blood-brain-barriers (1.), 3000 X . The axon hill of the pyramidal cell (2.) 7000 X, and its synapses (3.-9.).

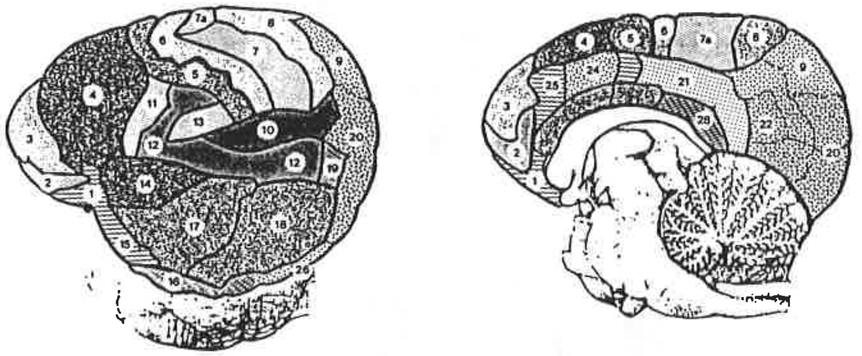

Fig. 4 The cyto-architectonic fields in the telencephalon of the harbour porpoise: the olfactory system, 1, 15, 23, 25; the optical system, 2, 9, 18, 20, 22, 26; the acoustical system, 7, 9, 10, 11, 12, 13, 16, 17, 18, 21; the somatosensory system, 2, 3, 6, 7, 8, 9, 11, 16, 28.

BARNACLES ON WHALES

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A review of the extensive, but scattered literature concerning observations of barnacles on cetaceans revealed a lack of a comprehensive synthesis of available data. This study attempts to remedy this. In total, the review revealed that eleven barnacle species have been reported from some 35 species of cetaceans (Fig. 1).

The literature review, supplemented with an examination of photographs and specimens from the Zoological Museum of Copenhagen, made us aware of the intriguing diversity in size and shape that exists among these animals (Fig. 2). Their appearance may reflect adaptation to life on a whale, and this diversity makes it relatively easy to identify species from each other as well as from other groups of barnacles.

The barnacles follow several life strategies varying from host specific (*Cryptolepas rhachianecti*) to generalist (e.g. *Conchoderma auritum*) and in their method of attachment. In general, barnacles are most commonly found on the rostrum and all extremities of the host. This may in part reflect the need to maximise current flow for feeding.

The barnacles can also be sub-divided into two categories with respect to the hardness of substrate. This sub-division coincides with the taxonomic one, where sessile species (suborder *Balanomorpha*) are found more or less embedded in soft tissue (e.g. *Coronula diadema, Tubicinella major*), while stalked species (suborder Lepadomorpha) are found on hard tissue such as teeth or baleen or even other barnacles (*Conchoderma auritum, Conchoderma virgatum*). Whereas the former group contains host specific species and has adapted accordingly, the latter group appears to treat cetaceans as just another convenient hard substrate amongst a wide variety of "objects", ranging from ships to other marine mammals.

It is generally believed that barnacles are mostly found on slow moving cetaceans and on those that are not deep diving. However, in our studies we have not found evidence to support this view.

There appears to be some doubt, from reading the literature, as to whether these barnacle species should be considered as commensals or as ectoparasites. This is partly due to the fact that few detailed investigations have been carried out to determine this and partly because of a rather sloppy use of terminology in studies where the reporting of barnacles has been only a minor portion of a wider study. Nevertheless, a review of the available information in the literature, coupled with an examination of specimens from the Zoological Museum of Copenhagen, indicates that most of these barnacles should be regarded as commensals since they only penetrate as far as the epidermis. However, it remains true that little is known about the growth mechanism of barnacles into the skin and any physical stress they may cause their hosts.

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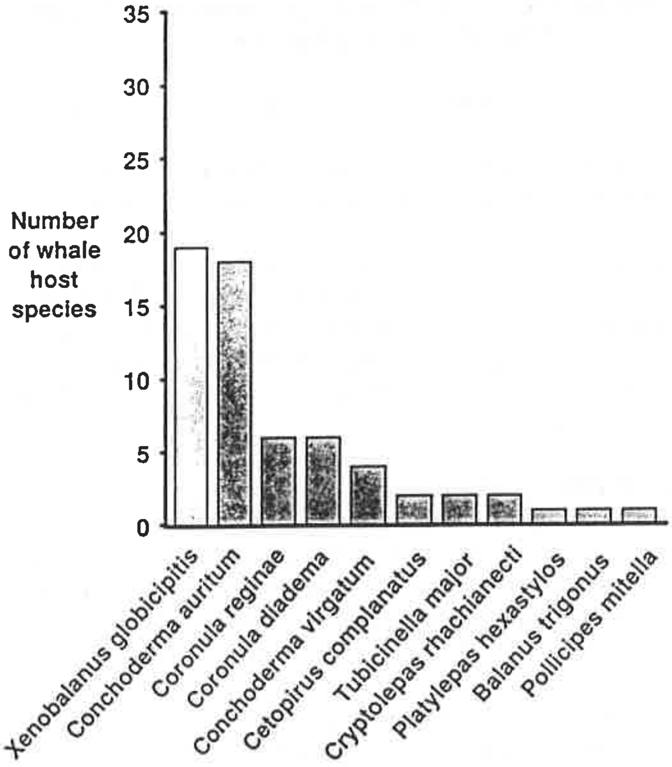

Fig. 1 The distribution of 11 species of barnacles on whale hosts. Total number of whale hosts is 35 species.

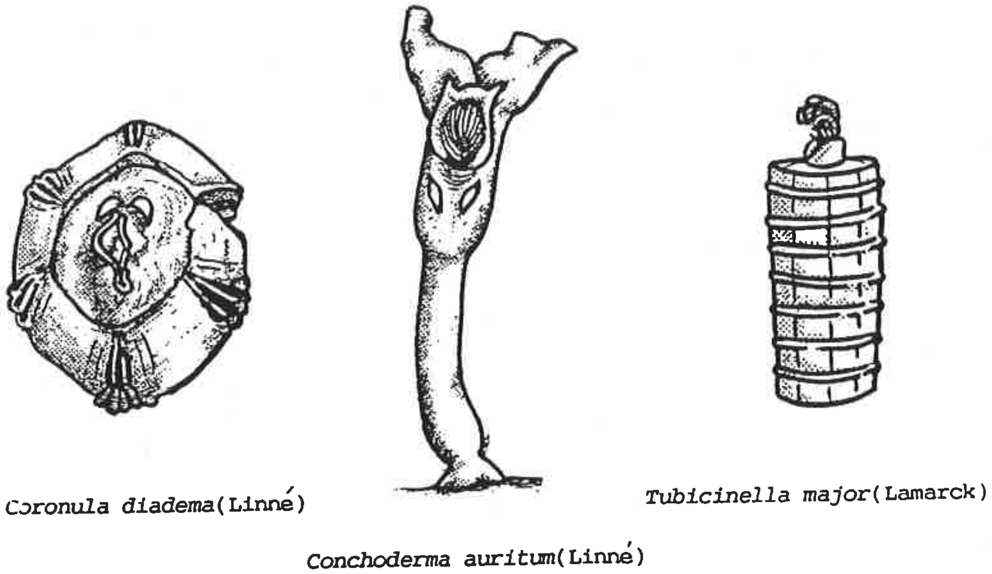

Fig. 2 Three different species of barnacles to illustrate the different morphologies.

PATTERNS OF COLONIZATION OF *Pholeter gastrophilus* IN *Stenella coeruleoalba* AND *Phocoena phocoena*

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INTRODUCTION *Pholeter gastrophilus* is a trematode species which is found in many odontocetes (at least in ten species), mainly encysted in the sub-mucosa of the stomach. However, its biology and ecology are poorly known. In this preliminary study, we make a crude comparison of its colonisation pattern in two of its common hosts: the striped dolphin (*Stenella coeruleoalba*) and the harbour porpoise (*Phocoena phocoena*). We also report some new possible pathological effects.

MATERIALS AND METHODS We analysed the stomach and duodenal ampulla of 46 Mediterranean striped dolphins affected by the viral epizootic of 1990, and 20 harbour porpoises by-caught in British waters in 1991. Each of the stomach compartments was cut open in a standardised manner and was carefully examined. Cysts were detected with either visual or touch inspection. When suspected, incisions were made on the mucosa to confirm their presence.

In order to compare the size of cysts between compartments, a number of cysts were removed at random and examined under a stereo microscope. Cysts found in 22 of the striped dolphins and in eight harbour porpoises were measured to the nearest mm.

RESULTS AND DISCUSSION There are substantial differences between the prevalence of *P. gastrophilus* in *S. coeruleoalba* and *P. phocoena,* partly due to the relative number of calves and juveniles in both species (Table 1). (Anyway, prevalences could be much higher, since the parasite is sometimes found in the sub-mucosa, although there is no gross evidence of cysts - see Geraci *et al.*, 1978).

The relative frequency of the parasite in each compartment is very similar in both species, according to the following sequence in decreasing order: main stomach, pyloric stomach and connecting channel (Table 2). No parasites occurred in either the mechanical stomach or the duodenal ampulla, although *P. gastrophilus.* has been occasionally reported in those sites in previous studies.

In both species, the main stomach shows higher prevalence and mean number of cysts (Table 3). This apparently suggests that it is the most favourable site for *P. gastrophilus.* However, considering the average cyst size, cysts in the pyloric stomach were significantly larger in the striped dolphin but not in the harbour porpoise (Tables 4a, 4b). Since a random sample revealed a significant positive correlation between cyst size and number of worms ($r = 0.83$, $n = 16$, $P<0.01$), we may conclude that the main stomach could offer the best habitat in the harbour porpoise, but this needs further confirmation in the case of the striped dolphin. In future, studies of the actual number of worms per animal will be established.

Nevertheless, it is also remarkable that the occasional presence of large cysts occurs in the pyloric stomach alone.

The distribution of *P. gastrophilus* in the main stomach might suggest a tendency to be located closer to the opening of the connecting channel in both species. This is indicated both by some aggregation, with a higher cyst size around the opening. However, this trend has not been tested statistically yet, and the reasons for this distribution are still unclear.

We conclude that the colonisation pattern of *P. gastrophilus* is quite similar in striped dolphins and harbour porpoises, but this cannot possibly be extended to other host species (see Balbuena, 1991, for the pilot whale, *Globicephala melas*.; Zam *et al*., 1971, for the bottle-nosed dolphin, *Tursiops truncatus*.) .

Twenty one per cent of the cysts in striped dolphins were at least 7.8 x 5.9 x 3.8 cm in size, some of them weighing over 100 g. These values are strikingly high, at least in this host, when compared with previous studies (3-4 cm in diameter - Raga *et al*., 1985). The cysts in the connecting channel were also large relative to the diameter of this passage.

In the literature, no important pathological effects related to *P. gastrophilus* have been reported. Commonly, this species is associated with a typical local fibrotic reaction elicited by its presence on the stomach walls (Woodard *et al*., 1983; Howard *et al*., 1983; Dailey, 1985). Only Dollfus (1973-4) described a case of an intestinal cyst in a striped dolphin causing an almost complete occlusion of the intestinal lumen. Although the stomach walls are flexible enough to adapt to different volumes, such large cysts may hamper stomach evacuation in some cases (increasing the peristaltic pressure). This may depend, among other factors, on the natural turgency of these compartments, the location of the cysts (narrow passages), and their net growth direction (in- or outwards the stomach cavity).

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Table 1 Age-class of animals (percentage)

	calf	juvenile	adult	unknown	prevalence of *P. gastrophilus*
1: *P. phocoena*	25.0	30.0	40.0	5.0	45%
2. *S. coeruleoalba*	2.2	10.9	65.2	21.7	87%

1. data provided by SMRU, Cambridge
2. data provided by Dept. Animal Biology, Barcelona

Table 2 Prevalences per compartment

	forestomach stomach	main channel	connecting stomach	pyloric *ampulla*	duodenal
P. phocoena (n=20)	0	53.8	9.7	38.5	0
S. coeruleoalba (n=46)	0	57.6	11.9	30.5	0

Table 3 Average number of cysts per compartment

	main stomach	connecting channel	pyloric stomach
P. phocoena	5.85	1.00	2.00
S. coeruleoalba	3.19	1.33	1.89

Table 4a Average size of cysts over compartment (in cm)

	main stomach	connecting channel	pyloric stomach
P. phocoena	1.17 x 0.92 (n=15)	-	0.37 x 0.37 (n=11)
S. coeruleoalba	1.99 x 1.93 (n=31)	4.25 x 2.88 (n=4)	4.39 x 3.65 (n=19)

Table 4b Results of the ANOVA between the main and pyloric stomach

Dimensions	*S. coeruleoalba*+	*P. phocoena*++	
Length	14.7*	16.4*	F
Width	11.7*	10.6*	

* Significant at level 0.01
\+ Data transformed in ln (x)
++ Data transfomed in ln square route x

PARASITOLOGICAL FINDINGS IN STRIPED DOLPHINS, *Stenella coeruleoalba*

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INTRODUCTION Since 1955, Delyamure claimed that parasitism was a major factor in the natural mortality of cetaceans and infestation with helminths was implicated strongly as the cause of death of some stranded dolphins (Dailey *et al.*, 1973, 1976). In this study we examined 14 striped dolphins, *Stenella coeruleoalba*, for parasites to assess a possible relationship between parasitism and the death of the animals.

MATERIALS AND METHODS All the dolphins studied were stranded along the coast of the Ligurian Sea (Italy) from August 1990 to September 1991. Head, lungs, liver, pancreas, stomach and intestinal tract were examined and processed by parasitological techniques. The helminths recovered were counted and the morphological features studied according to Delyamure (1955), Davey (1971) and Gallego *et al.*, (1979). Cestoda and Trematoda specimens were stained with aceto-alum carmine solution. Richness (R), abundance (A), prevalence (P) and density (D) were calculated. The relationship between host and parasite was measured by the k value of the negative binomial distribution. All the parasite specimens have been deposited in the Department of Veterinary Parasitology at the University of Milan (Italy).

RESULTS The results are shown in Table 1. All the dolphins were infected. Eleven helminth species (4 Cestoda, 3 Trematoda, 3 Nematoda and 1 species belonging to the phylum Acanthocephala) were found. Mean richness was 5.2 species of parasites per host. 36% of hosts harboured five species and 14%, eight species. The average worm burden was 267 (range 31-800). Only one specimen had more than 800 worms. 36% of hosts studied were infected with 100 to 200 worms. *Tetrabothrium forsteri*, *Pholeter gastrophilus* and *Skrabjnalius guevarai* were the most abundant and the most frequent species (A= 50.5, P= 93%; A = 86, P = 79%; A = 49.7, P = 86% respectively). *Campula rochebruni*, *Phyllobothrium dellphini, Monorygma* and *Stenurus ovatus* had high prevalences (P > 64%) but low abundance (A < 29).

CONCLUSIONS Our results showed the helminth community in *Stenella coeruleoalba* contains both frequent and abundant species, and infrequent and rare ones. Many of the helminth species recovered in this survey were previously reported for specimens stranded on Mediterranean coasts (Raga *et al.*, 1985, Gallego *et al.*, 1979 and Canestri-Trotti *et al.*, 1990). *Tetrabothrium foresteri*, *Campula palliata*, *Bolbosoma vasculosum*, and *Anisakis simplex* complex were the first record in Italy. *Strobilocephalus triangularis* was previously found by one of us (Manfredi, unpubl. data). It is difficult to compare our data for worm burdens with those of others. Most surveys done in recent years have been mainly descriptions of species or some features of the lesions in a few hosts. However, the k values calculated for the most abundant helminth species, to analyse the association between host and parasite, showed good aggregation. Although our results do not indicate a direct relationship between parasitism and death of stranded dolphins, it should be emphasised that some parasite species can be responsible for severe injuries. Moreover, *Pholeter gastrophilus*, which is found in cysts in the stomach wall, and the lungworm *Skabjnalius geuvarai*, on account of its location, frequency and abundance in the host population, could be the species most involved in the diffusion of paramyxovirus, recently recovered from stranded cetaceans, and could be a possible contributing factor to the death of the dolphins.

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Table 1 Composition of the parasite community of *Stenella coeruleoalba*

	range	A	D(%)	P(%)	k
Skrjabinalius guevarai	0 - 209	49.71	18.59	85.71	0.55
Stenurus ovatus	0 - 018	4.50	1.68	64.28	
Anisakis simplex complex	0 - 035	4.10	1.54	64.28	
Pholeter gastrophilus	0 - 566	85.57	32.01	78.57	0.32
Cammpula rochebruni	0 - 099	25.21	9.43	85.71	0.81
Campula palliata	0 - 010	1.64	0.61	42.85	
Tetrabothrium forsteri	0 - 470	50.50	18.89	92.85	0.10
Strobilocephalus triangularis	0 - 013	1.92	0.72	28.57	
Bolbosoma vasculosum	0 - 003	0.19	0.16	21.42	
Monorygma grimaldii	0 - 075	14.21	5.30	64.28	0.53
Phyllobothrium delphini	0 - 115	29.42	11.01	85.71	1.06

KEY
A (abundance) = Mean number of parasites per host.
D (density) = % of one parasite species in total parasite species
P (prevalence) = frequency of parasite occurrence
k = constant of overdispersion

THE USE OF PHOTOGRAPHY TO MONITOR DERMAL DISEASE IN WILD BOTTLE-NOSED DOLPHINS, *Tursiops truncatus*

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INTRODUCTION There has been concern that the health of some coastal populations of small cetaceans has declined in recent years. To assess the extent of such a phenomenon, comparative data are required on mortality rates and disease prevalence between areas and over time. It is not usually practical to capture cetaceans, and the opportunities to examine stranded animals are often rare and open to bias. Therefore, techniques which permit remote measurement of disease are required.

During a photo-ID study of around 100 individual resident bottle-nosed dolphin, *Tursiops truncatus*, in Northeast Scotland, we observed an unusual variety of skin lesions and coloration patterns (Thompson and Hammond, 1992). This poster display presented further work which aimed to assess the prevalence and development of these lesions.

MATERIALS AND METHODS Bottle-nosed dolphins were observed from a 5.5 metre rigid hulled boat during regular standardised surveys between 1989 and 1991. Photographs of the dorsal fins and flanks of these animals were taken with an autofocus camera fitted with a 75-300mm zoom lens. The exposed slide films were processed and viewed on a light table or with a slide projector. The lesions observed were categorised into a range of broad groups. The best picture of each of the 90 animals seen in 1990 was then viewed using a slide projector and screen. These photographs were then scored for the presence or absence of each lesion type to obtain a minimum estimate of prevalence within this population. The photographs of the ten animals seen most often between 1989 and 1991 were then selected. Individual lesions on these animals were followed through time and their changes noted.

RESULTS The prevalence of different lesions varied from 2-89%, with 84 of 88 identifiable dolphins possessing one or more types.

Dark lesions appeared most often, and ranged from small circular discs (alone or in a reticulate pattern) to extensive darkened areas. They were observed on 89% of animals (n=74).

De-pigmentation was characterised by unusually pale or white areas of skin. Such areas occurred in distinct circles, in rings around other lesions or over larger areas, with distinct or diffuse margins. 73% of animals were observed with these (n=63).

Recessed and encrusting lesions consisted of extensive pitting or inflammation of the skin; these conditions appeared to be rare occurring on 2% of animals (n=86).

An unusual pastel sheen was observed on 37% of animals (n=67) occurring in association with other lesion types or on its own.

Ring lesions appeared similar to descriptions to "tattoo" lesions resulting from infection by dolphin pox virus. They were observed on 61% of live animals (n=70) and were also observed on a stranded dead animal.

Patches of orange lesions were observed on several animals (6%), particularly calves

Of the animals, 2% were observed with conformational deformities or marked dorsal malformations (n=87).

By examining serial sequences of photographs of the same dolphins, some lesions were observed to grow, others remained static, some progressed from one variety to another (Fig. 1.) whilst others appeared to heal.

CONCLUSIONS AND FURTHER RESEARCH We suggest that photographic surveys may provide a useful tool for studying disease in wild dolphins. This study may be expanded with:
(1) comparative photographic surveys which could be used to estimate the prevalence of these conditions in populations from areas of different environmental quality.
(2) longer term studies to monitor the development of particular lesions and keep a check on the survival of affected individuals.
(3) pathological examination of stranded animals to identify the causative agents of these conditions. Tentative diagnoses may also be possible through comparison of visible lesions with those of known causation in captive animals.

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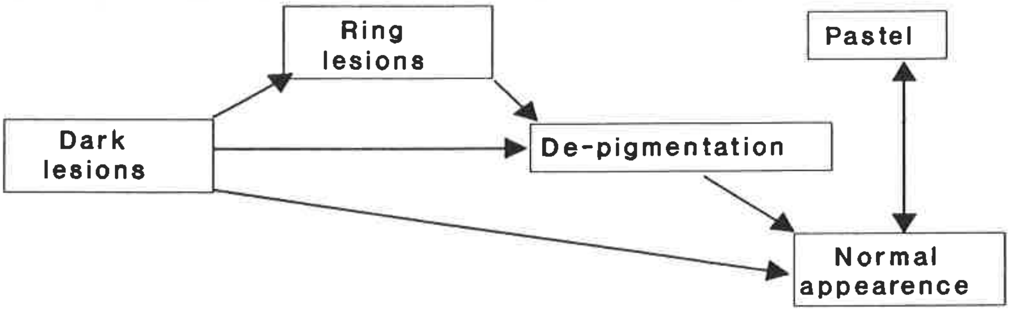

Fig. 1 Observed changes of individual lesions

HEAVY METAL CONCENTRATION AND PATHOLOGY OF TWO HARBOUR PORPOISES STRANDED ALONG THE BELGIAN COAST

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In the frame of an interdisciplinary programme on the toxicology and pathology of seabirds and marine mammals found along the Belgian coast, southern North Sea, this preliminary paper reports some findings concerning two harbour porpoises, *Phocoena phocoena*: and adult female (56 kg, total body length 172 cm) on January 31 and a juvenile male (21 kg, 123 cm) on February 2, 1990. Both were considered as being dead for less than 24 hours.

From the pathological point of view, the most important finding was the adrenal cortex hyperplasia of the zona fascicularis in both specimens, a lesion that can only be associated with chronic exposure to toxins such as organochlorines.The female showed generalised lymphoid depletion, which can partly be explained by the adrenocortical abnormalities.

Membranous glomerulopathy in the female can be associated with heavy metal toxicity and endocrine disorders: renal infraction observed in the young male could have resulted from a thrombo-embolisation phenomenon, probably in relation to parasite migration.

Multiple parasites were observed in the male (not in the female), the reasons for which are not yet clear.

Heavy metal concentrations seemed normal when compared with literature data, with the exception of high Cd levels in liver and kidney, as well as high Zn concentrations in the blubber. Mercury levels were, as expected, much higher in the old female than the young male; the relative methyl Hg contamination was low in the old animal. These results entirely fit in the general trends of mercury contamination in the harbour porpoise (Joiris *et al.*, 1991).

HEAVY METALS AND ORGANOCHLORINES IN COMMON DOLPHINS, *Delphinus delphis*, STRANDED ON THE FRENCH ATLANTIC COAST

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The following small cetaceans stranded on the Atlantic French coasts between 1977 and 1990 were collected, species identity determined, measured, and samples of muscle, liver, kidney and blubber were deep frozen: 29 common dolphins, *Delphinus delphis*, 5 bottle-nosed dolphins, *Tursiops truncatus* and 2 striped dolphins, *Stenella coeruleoalba.* They were analysed for their content in total Hg, Zn, Pb, Cd, Cr, Ti and Cu, and some of them for MethylMercury and organochlorines (PCB's and pesticides), as well as for liquid content.

This report discusses data on the common dolphin.

RESULTS

TOTAL MERCURY (SHg) load increased with age. Since the age was not yet determined for all samples, we recognised two age groups: juveniles and adults (limit at 190cm total body length, corresponding to approx. 9 years). SHg concentrations were in muscle, liver and kidney: 2.3, 9.2 and 5.5mg Hg/ g weight respectively (median values) for the juveniles, and 9.3, 150 and 21 for the adults; the differences between juveniles and adults are highly significant ($P<0.01$ in a Mann-Whitney test). No difference was detected between males and females, in either age group. Similar results on the effect of the age (length) and on the differences in the contamination of different tissues were already obtained for small cetaceans (e.g. Wagemann and Muir, 1984; André *et al.*, 1991; Joiris *et al.*, 1991). Methyl mercury (MeHg) concentrations also increased with age, but at a much lower rate. As a consequence, the ratio MeHg to SHg (%MeHg) was strongly decreasing with increasing SHg level, t.i. with age (Fig.1, Table 1), providing a confirmation of the existence of a slow mineralisation process in small cetaceans (Koeman *et al* ., 1973; Thibaud and Duguy, 1973; Capelli *et al.*, 1983; Joiris *et al.*, 1991).

This resulted, for older adults, in very high concentrations of inorganic Hg in the liver (up to 620 mg Hg/g dw) and four times higher liver to muscle and liver to kidney ratios for adults than for juveniles, a situation very similar to the one in harbour porpoise, *Phocoena phocoena* (Joiris, *et al.,* 1991). In this last case the level of detoxification was also determined (in prep.): about 50% of the inorganic Hg in the liver of the adults was not bound to metallothioneins nor to selenium, and were thus potentially toxic.

OTHER HEAVY METALS do not seem to show any trend as a function of body length. The most striking results are the high Cd concentrations on the one hand (2-42 mg/g dw in kidney), and the strong correlation between Zn and Cu levels on the other (Fig. 2). This may be linked with a possible binding of both Zn and Cu to metallothioneins, but it remains unclear why other heavy metals, like Cd, were not included in similar correlations.

PCB's and ORGANOCHLORINE pesticide concentrations do not appear extremely high, with values of 200 mg S PCB'S/ g lipid weight, (expressed as Arochlor 1254 standard mixture) in melon and blubber (35 in a juvenile), 200-300 in liver and 500-700 in muscle. Among the pesticides, DDT's were detected in a range of 5-1 mg/ g lw. They were, as expected, mainly DDE but some high DDT levels could reflect the existence of a recent contamination.

CONCLUSIONS Pinnipeds and cetaceans present the exceptional phenomenon that their health status, or especially their reproduction potential may actually be affected by pollution, in nature, as was the case for raptors in the 1960's. It is generally recognised that the main threat is due to high PCB concentrations. These effects of PCB's could be at the origin of viral mass mortalities of marine mammals, by repressing their immunological defence mechanisms, or alternatively as a consequence of physiological stress, such as viral infection or starvation. Concerning both interpretations, PCB's might anyway hinder the recovery of populations after the occurrence of mass mortalities.

In the framework of a broader study of stable pollutants, however, it appears that one should take into account the level of the other residues as well. In our results, this seems to be the case for Hg and, possibly, for Cd.

Mercury contamination of small cetaceans and its evolution in time could be interpreted as follows: they are contaminated by methyl mercury, the main form of mercury in their food. Most of the mercury is present as MeHg in juveniles where it is accumulating in lipids. Later on, it is then slowly mineralised and re-mobilised (or first re-mobilised, as it seems to be the case for two dolphins from the Tyrrhenian Sea (Carlini and Fabbri, 1989), and then mineralised), and is accumulating as inorganic Hg in the liver, where it reaches very high levels. A detailed study of the speciation of this inorganic Hg is necessary, in order to detect which portion is detoxified by metallothioneins or selenium, or remains potentially toxic. Thus the possibility remains that only PCB's, but also inorganic Hg, might influence the health status of older animals.

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Table 1 Mercury contamination of common dolphins stranded on the French Atlantic coast: total mercury (SHg) and methylmercury (MeHg); mg/g dry weight. (see text).

		MUSCLE				LIVER				KIDNEY				RATIO		
		Med.	mean	s.d.	n	Med.	mean	s.d.	n	Med.	mean	s.d.	n	l/m	k/m	l/k
ΣHg	*juveniles*	2.3	2.5	1.2	8	9.2	11.2	9.2	12	5.5	6.5	4.0	8	4.1	2.4	1.7
	adults	9.3	11.9	7.1	5	151.0	217.0	158.0	16	21.1	24.6	25.5	12	16.2	2.3	7.1
MeHg	*juveniles*	1.3	1.3	1.0	2	1.1	2.2	2.6	4	3.0	2.4	1.2	3	0.9	1.4	0.4
	adults	9.1	9.1		1	11.8	12.1	3.6	10	4.7	5.1	4.0	9	1.3	0.5	2.5

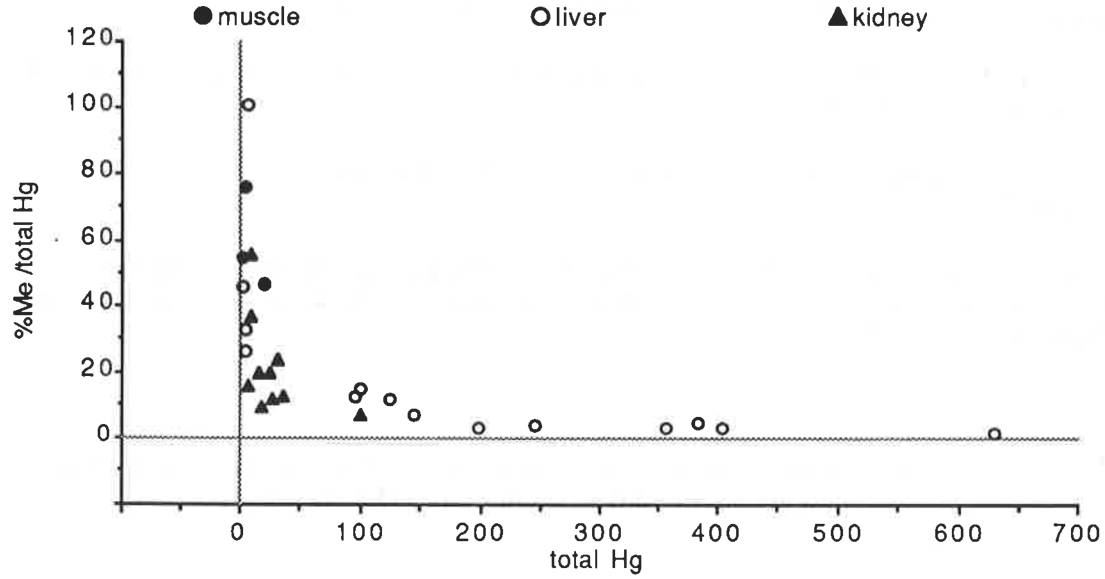

Fig. 1 Percentage of methyl mercury (%MeHg) in muscle, liver and kidney of common dolphins, *Delphinus delphis*, stranded on the French Atlantic coast, as a function of total mercury contamination (mg/g dry weight).

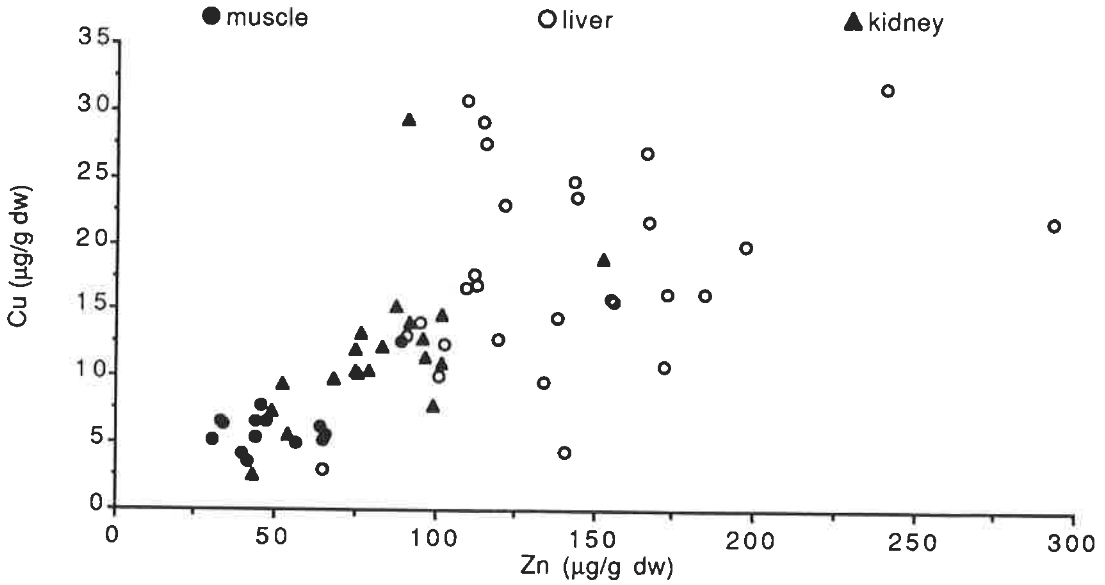

Fig. 2 Copper (Cu) concentration on muscle, liver and kidney as a function of zinc (Zn) content in common dolphins, *D. delphis*, stranded on the French Atlantic coast.

TOTAL AND ORGANIC MERCURY IN TISSUES AND ORGANS OF FIN WHALES , *Balaenoptera physalus*.

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INTRODUCTION Mercury has been detected in tissues of marine mammals in a wide range of concentrations. Some cetacean species have shown to accumulate mercury in their liver with age (Honda *et al.*, 1983; Honda *et al.*, 1987), but only a fraction of total mercury detected was found in organic form. This suggested that a de-methylating activity could take place in this organ, in which selenium was probably involved.

Studies concerning mercury in baleen whale species are scanty. Possible reasons are related to the low mercury content in their tissues and the lesser availability of these species.

This study presents data on distribution pattern of total and organic mercury among tissues of fin whales. Age, sex and length relationships for both forms of the metal have been examined.

MATERIALS AND METHODS Muscle and liver tissues from 31 fin whales and kidney tissue from five of them have been analysed for total and organic mercury content. The specimens corresponded to fin whales caught by the whaling industry during the whaling seasons of 1983 and 1984.

Samples were kept frozen in polyethylene bags at -20°C from the dissection of the whale until analysis. Total and organic mercury were determined by CV-AAS with pre-concentration over gold. Organic mercury was extracted according to the method described by Capelli et al. (1979).

RESULTS Table 1 lists mean concentrations of total and organic mercury in fin whale tissues. The highest concentrations of total mercury were found in the liver, followed by the kidney and muscle tissues. The fraction of organic to total mercury was highest in the muscle, followed by the liver and the kidney.

Total and organic mercury concentrations in the muscle and in the liver followed a log-normal distribution. Total mercury (log) in both tissues and organic mercury (log) in the liver showed a significant increase with the age of the animals ($p< 0.05$) (Figs. 1-3). No significant differences were found between males and females regarding the age accumulation pattern, nor in mercury concentrations.

No significant changes have been observed for the ratio of organic to total mercury in muscle and liver with the age.

In both sexes, a positive relationship has been found for total and organic mercury concentrations between liver and muscle tissues.

DISCUSSION The mercury concentrations found in the present study are in agreement with those reported in the literature for mysticetes (Nagakura *et al.*, 1974; Wagemann and Muir, 1984; Honda *et al.*, 1987). Mean concentrations are considerably lower than those found in odontocete species, probably due to the lower position of the former in the marine food chain.

The distribution of the metal among tissues follows the same pattern described for seals and toothed whales: the highest concentrations are found in the liver, while the higher ratio of organic/total mercury is found in the muscle. Koeman *et al.* (1975) suggested a detoxifying activity occurs in the liver of marine mammals, by means of which methylmercury is converted to the less harmful inorganic mercury. In the muscle, methylmercury would be firmly bound through carbon-mercury and -SH linkages (Gaskin, 1982). Fin whales accumulate mercury with age, but to a lesser extent than has been described for toothed whales.

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Table 1 Total (HgT) and organic (HgO) mercury concentrations in tissues of fin whales, *Balaenoptera physalus*. Mean concentration (ng/g), standard deviation ranges.

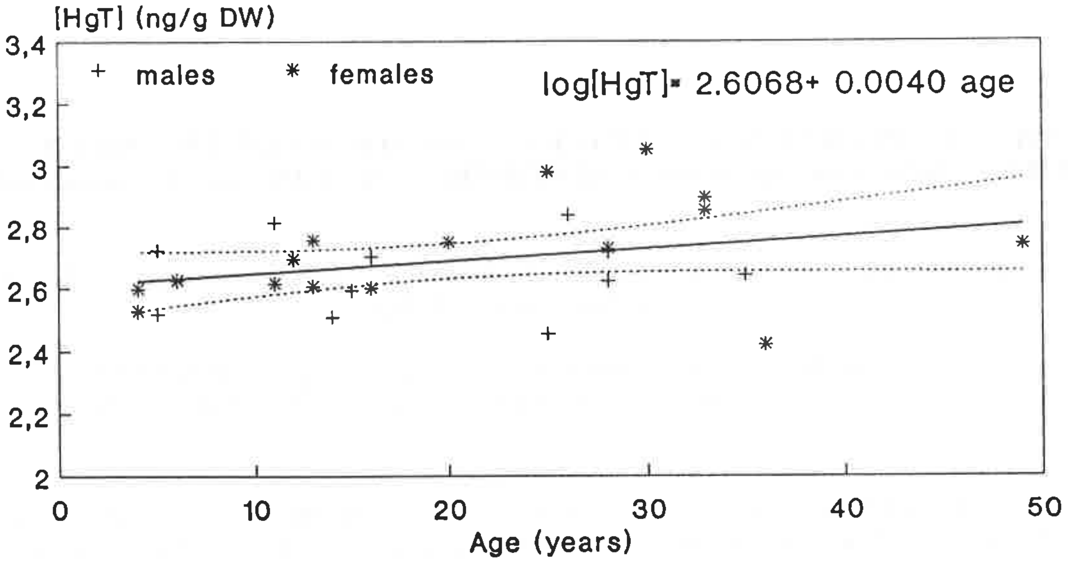

Fig. 1 Relationship between total mercury concentrations(log) in the muscle, and age

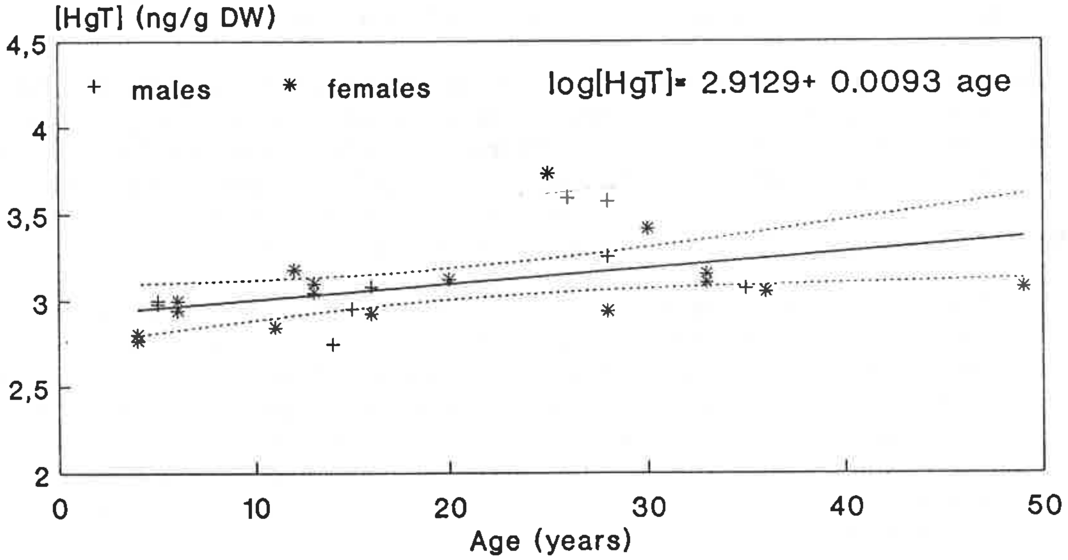

Fig. 2 Relationship between total mercury concentrations (log) in the liver, and age

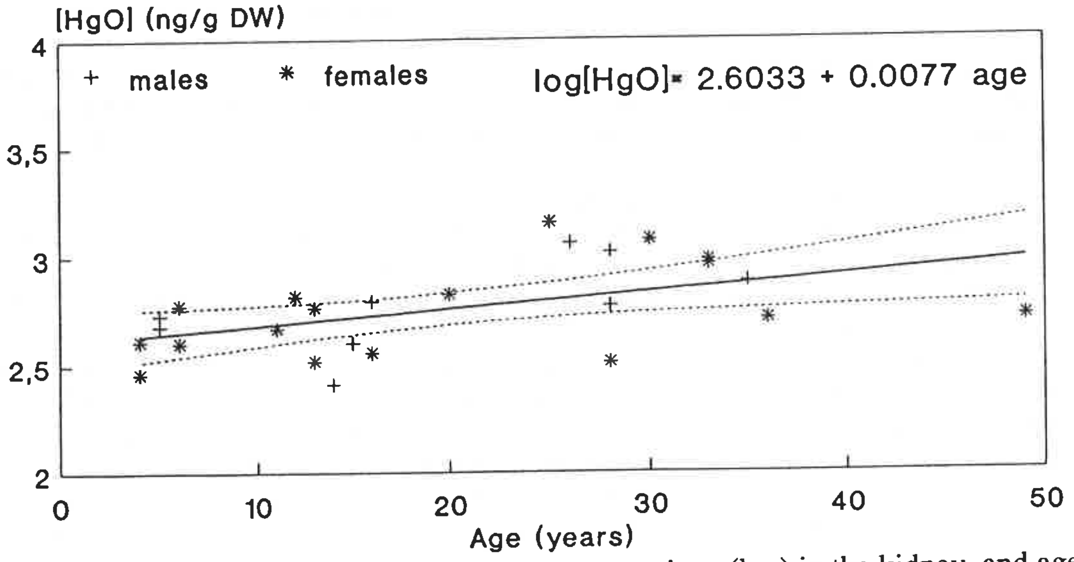

Fig. 3 Relationship between total mercury concentrations (log) in the kidney, and age

ORGANOCHLORINES AND TRACE ELEMENTS IN SKIN BIOPSIS OF FIN WHALE *Balaenoptera physalus* AND STRIPED DOLPHIN, *Stenella coeruleoalba*

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INTRODUCTION The Mediterranean Sea is a very vulnerable ecosystem due to the fact that it is almost closed and surrounded by highly populated countries. Many studies have shown a high level of bioaccumulation of organochlorines and mercury in organisms belonging to the highest trophic levels. Cetaceans are large, long-lived predators, and as such are efficient biological accumulators of persistent environmental contaminants. They are also known to be very sensitive to the toxic effects of xenobiotics.

Here we report the preliminary results of a study aimed at assessing the presence and levels of organochlorine compounds in two Mediterranean cetacean species, the planktophagous fin whale, *Balaenoptera physalus*, and the largely teuthophagous striped dolphin, *Stenella coeruleoalba*. These animals have different roles in the pelagic trophic chain of the western Ligurian Sea. They were sampled during the summers of 1990 and 1991 to assess the levels of the most common persistent contaminants of the northern Tyrrhenian Sea.

MATERIALS AND METHODS In the western Ligurian Sea, samples of subcutaneous blubber were collected from 35 free-ranging whales using biopsy darts launched with a crossbow and from thirty bow-riding dolphins by means of biopsy tips mounted on a two metre long poles (Focardi *et al.*, 1991). The material was immediately placed in liquid nitrogen. For analysis of chlorinated hydrocarbons, samples were freeze-dried and extracted in Soxhlet with n-hexane; the analytical method used was high resolution capillary gas chromatography. The extracted organic matter was 90% of total sample with a Standard Deviation of 5%.

For the analysis of trace elements, an aliquot of freeze-dried material was digested in a teflon bomb with nitric acid and analysed by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION Capillary gas chromatography revealed the presence of hexachlorobenzene (HCB), op' and pp' isomers of DDT and its derivatives DDD and DDE in both species, and about 25 PCB congeners in the subcutaneous tissue of all the biopsies.

The results of 1991 (Fig. 1) show that the levels of DDTs, in fin whales, varied from 0.45 to 16.7 mg/kg on a lipid basis; pp'DDE had the highest levels with an average of 3.5 mg/kg and a maximum of 11.9 mg/kg. The ratio pp'DDE / DDTs was similar in all samples ($x = 0.72$; Standard Deviation = 0.06). The total amount of polychlorinated biphenyls (PCBs) was calculated as the sum of the 23 congeners identified and quantified, that constituted more than 90% of the total residues. PCBs ranged from 0.78 to 16.4 mg/kg, with an average of 7.7 ppm and a S.D. of 3.9. The ratio DDTs / PCBs was 0.73 with a S.D. of 0.22. For stranded dolphins DDTs varied from 9.1 to 69.7 mg/kg. The average of pp'DDE was 19.3 mg/kg (S.D. = 11.2) and the ratio pp'DDE / DDTs was 0.72 (S.D. = 0.09). The level of PCBs ranged from 11.3 to 93.2 mg/kg; the average was 51.4 mg/kg with a S.D. of 18.8 mg/kg. The ratio DDTs/PCBs had a mean value of 0.53 (S.D. = 0.23). In both species, the levels of hexachlorobenzene (HCB) were very low with an average of 0.31 mg/kg (S.D. = 0.29) in *Stenella coeruleoalba* and 0.11 mg/kg (S.D. = 0.06) in *Balaenoptera physalus.*

Comparison of the biopsy results of fin whales in 1990 and 1991 (Fig. 2) showed a statistically significant decrease in DDTs and an increase in PCBs ($p<0.001$). These findings require confirmation in future years.

Detailed examination of PCB composition both in stranded dolphins and in fin whales shows that the most frequent congeners were hexachlorobiphenyls and heptachlorobiphenyls. Among the latter, 22'44'55' (also known by IUPAC no. 153, Ballschmiter and Zell, 1980) predominated and was the most abundant component in all cases; the other abundant hexachlorobiphenyl was 22'344'5' (IUPAC no. 138). Among the heptachlorobiphenyls the most abundant were 22'33'44'5, 22'344'55' and 22'34'55'6 (IUPAC nos. 170, 180 and 187). No significant differences were found in the fingerprint of the PCBs within the same species and between the two species, indicating a similar mode of intake and metabolism. This is certainly linked to the fact that these congeners are very persistent and resistant to metabolic breakdown (Tanabe *et al.*, 1988; Focardi et al., 1991).

As far as heavy metals are concerned (Fig. 3), *Stenella coeruleoalba* showed mercury levels from 5 to 20 times higher and cadmium about three times higher than *Balaenoptera physalus*. Lead was slightly higher in the latter. Dolphins are exceptional bioaccumulators of mercury which is mainly stored in inorganic form (Itano *et al.*, 1984). This was also reflected in the epidermal samples in which levels as high as 23 mg\kg w.w. were recorded. Cadmium is often found in organisms feeding on molluscs, so that they accumulate to higher levels than in planktophagous species.

In conclusion, as expected from the different feeding habits, the levels of chlorinated hydrocarbons and heavy metals differed markedly in the two species. HCB, DDTs, PCBs, Hg and Cd levels in *Stenella coeruleoalba* were significantly higher than *Balaenoptera physalus* ($p<0.001$). It is interesting that the bioaccumulation factor (BAF) in blubber and epidermis of these species was from seven to eight orders of magnitude higher than in water. The non-destructive sampling used to assess the pollutants in this study promises to be a valid method for extensive future research.

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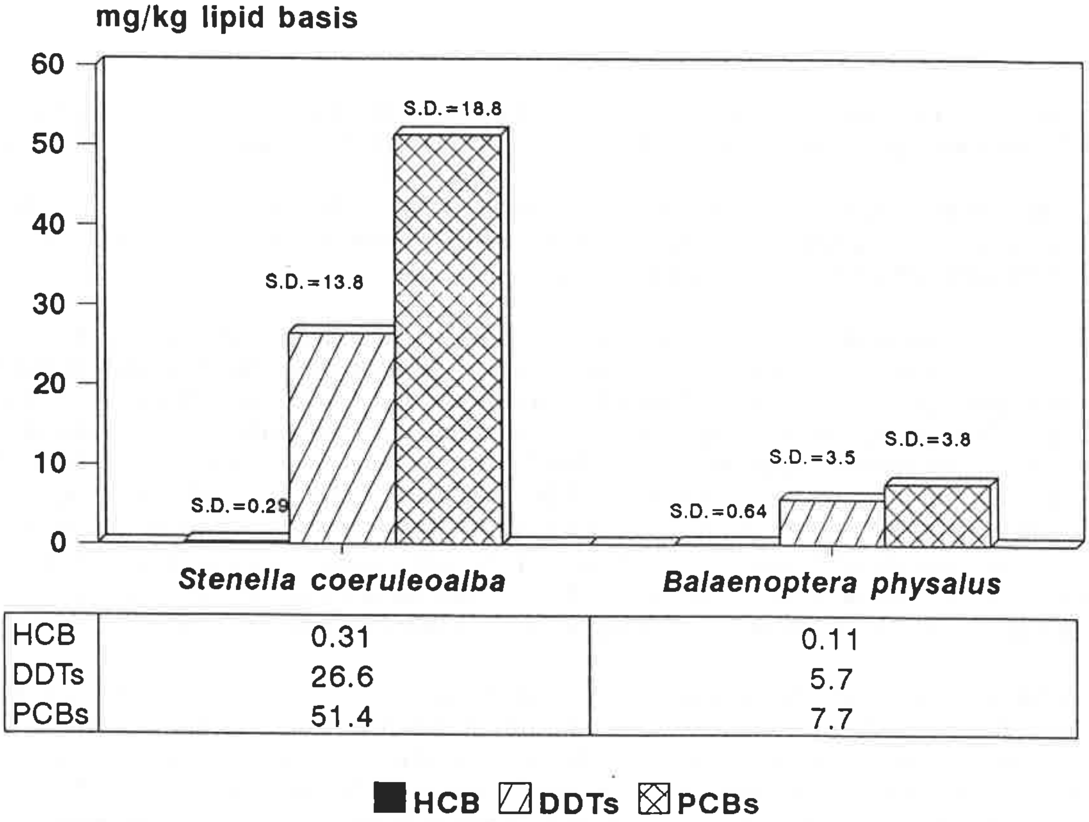
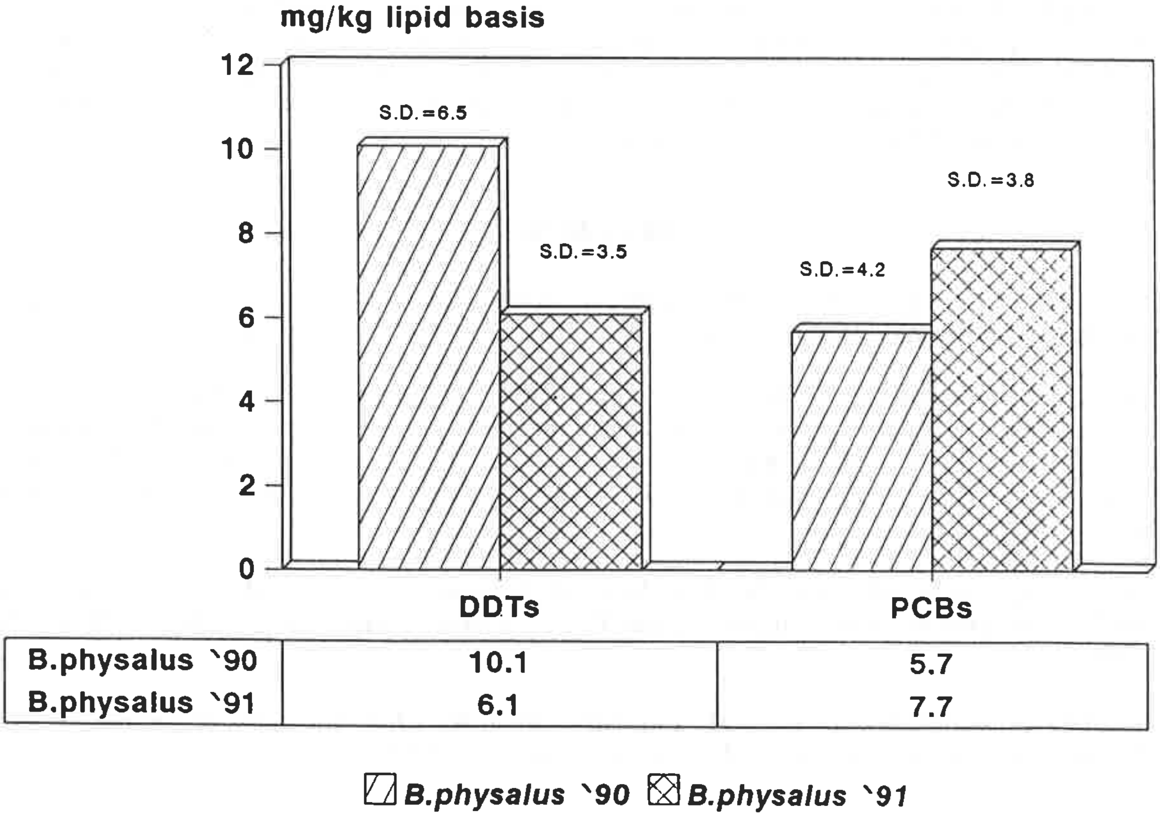


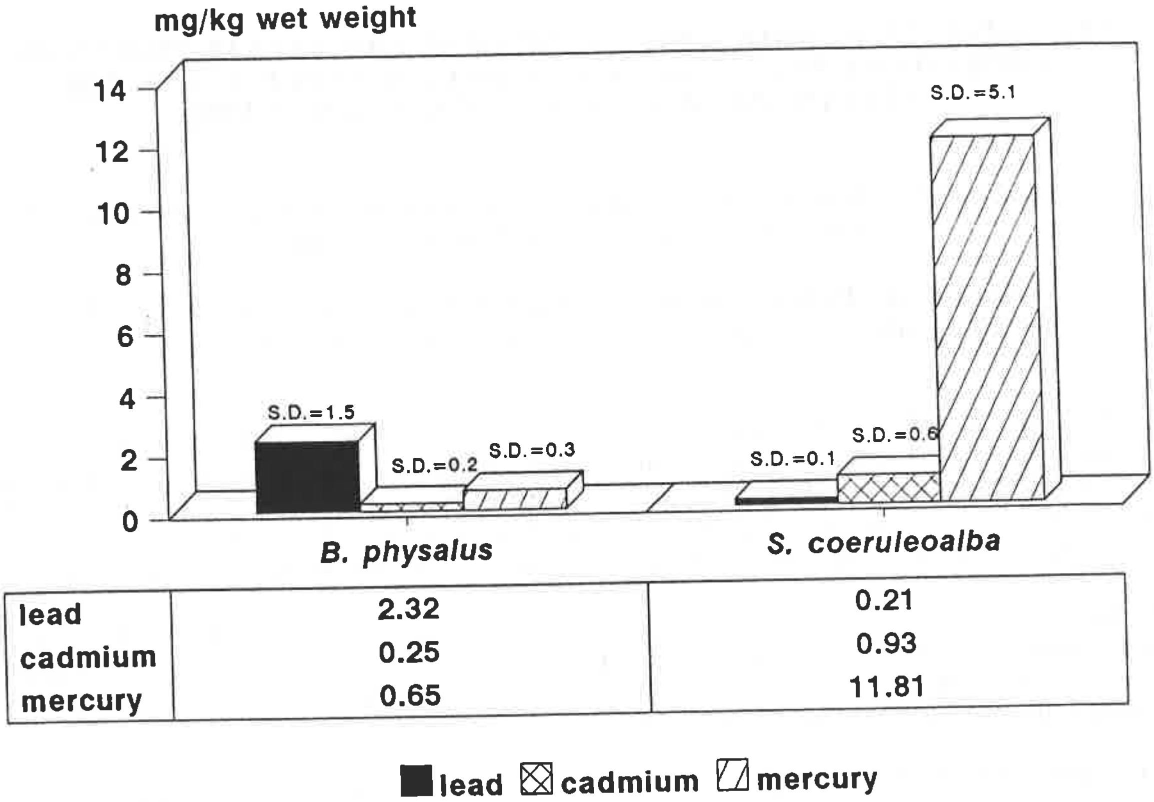
	Stenella coeruleoalba	*Balaenoptera physalus*
HCB	0.31	0.11
DDTs	26.6	5.7
PCBs	51.4	7.7

Fig.1 - Organochlorines in skin biopsis (year 1991).



	DDTs	PCBs
B.physalus `90	10.1	5.7
B.physalus `91	6.1	7.7

Fig.2 - Comparison of the biopsy results in finback whales in 1991 and 1990.



	B. physalus	*S. coeruleoalba*
lead	2.32	0.21
cadmium	0.25	0.93
mercury	0.65	11.81

Fig. 3 - Heavy metals in skin biopsis

CHLORINATED HYDROCARBONS AND HEAVY METALS IN TISSUES OF STRIPED DOLPHINS, *Stenella coeruleoalba*, STRANDED ALONG THE APULIAN AND SICILIAN COASTS (SUMMER 1991)

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INTRODUCTION Increasing importance has recently been given to the interaction between environmental contaminants and man's and animals' health. In the field of marine mammals, the mass stranding of dolphins is not a new occurrence, but it has probably increased with environmental contamination. A high intake of xenobiotics could cause impairment of immune responses which would favour infection by bacteria and viruses.

In the present study, chlorinated hydrocarbons and heavy metals (Hg, Cd and Pb) were determined in the tissues and organs of striped dolphins, *Stenella coeruleoalba*, stranded along the Apulian and Sicilian coasts (Southern Italy) in the period June - September 1991. The lengths of seventeen specimens were from 105 cm to 205 cm.

MATERIALS AND METHODS For the analysis of chlorinated hydrocarbons, freeze dried material was extracted in Soxhlet with n-hexane; the extract was subjected to sulphuric acid clean-up, followed by Florisil chromatography. The analytical method used was high resolution capillary gas chromatography, with electron capture detector (Ni63) and an SBP-5 (30 m) bonded phase capillary column.

For heavy metals, about 0.1 g of lyophilised material was digested in a Teflon bomb with 2.0 ml of nitric acid. The solution obtained was analysed by atomic absorption spectroscopy. The cold vapour technique was used for mercury and the graphite furnace was used for cadmium and lead. In view of the variable water content of the stranded material, the results are expressed in mg/kg dry weight.

RESULTS AND DISCUSSION The results of organochlorines (Table 1) revealed the presence of hexachlorobenzene (HCB), op' and pp'DDT and its derivatives DDE and DDD, and many PCB congeners in all the striped dolphins analysed. Organochlorine concentrations are listed in decreasing order: blubber, melon, liver and muscle. This order is closely correlated with the lipid content of the tissues and confirms previous reports.

The levels of HCB were low in all samples. The DDT and its derivatives, particularly pp 'DDE, were very high. pp 'DDE constituted about 80% of the DDTs in all tissues analysed.

Capillary gas chromatography revealed the presence of 23 congeners. It is interesting that the PCB fingerprint did not vary significantly between the different samples; more than 50% of the residues consisted of only four congeners: 22'44'55', 22'344'5', 22'33'44'5 and 22'344'55', also known by IUPAC numbers 153, 138, 170 and 180 (Ballschmiter and Zell, 1980).

There were remarkable differences in total PCBs and DDTs between male and females, and a direct correlation with age (determined on the basis of the length) in either sex. Until sexual maturity, males and females of the same age show similar levels of organochlorines.

Subsequently, the female may transfer much of her load of lipo-soluble contaminants to her young, first through the placenta and later in the milk (Tanabe *et al.*, 1987; Aguilar & Borrell, 1988). It is thought that the different total quantities of PCBs and DDTs found in females of the same length, and thus presumably of a similar age, is due to different numbers of pregnancies or to sterility, in which case accumulation is greater.

Of the heavy metals (Table 2), only cadmium and mercury are of interest. Mercury levels in the present samples of striped dolphins, *Stenella coeruleoalba*, were particularly high, reaching as much as 1500 ppm (dw) in the liver. Such concentrations are not surprising and have been reported for Mediterranean and oceanic dolphins of the same species (Martoja and Viale, 1975; Itano *et al.*, 1984). The cadmium levels found are in agreement with those of other authors (Honda *et al.*, 1983).

These metal levels, particularly those of mercury, are not such as to cause mortality or impaired physiological function. The situation is rather one of naturally high accumulation levels. Nevertheless, the possibility of interactions between metals and lipophilic contaminants should be studied, as these could enhance the effect of the latter.

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Table 1 Chlorinated hydrocarbons concentrations (mg/kg dry weight) in tissues of striped dolphin, *Stenella coeruleoalba*.

	HCB liver	HCB muscle	HCB blubber	HCB melon
Sample size	12.00	5.00	14.00	3.00
Median	0.17	0.012	0.45	0.61
Geometric mean	0.16	0.015	0.46	0.67
Minimum	0.01	0.005	0.19	0.45
Maximum	1.70	0.073	2.30	1.08

	DDT liver	DDT muscle	DDT blubber	DDT melon
Sample size	12	4.0	14	4
Median	12	1.3	53	61
Geometric mean	9	1.4	50	57
Minimum	1	0.4	10	17
Maximum	53	7.4	349	168

	PCB liver	PCB muscle	PCB blubber	PCB melon
Sample size	12	5.0	14	4
Median	33	1.0	82	73
Geometric mean	21	1.8	78	69
Minimum	2	0.5	21	34
Maximum	136	11.2	470	127

Table 2 Heavy metal concentrations (mg/kg dry weight for liver, kidney and muscle; mg/kg wet weight for skin) in tissues of striped dolphins, *Stenella coeruleoalba*

	Hg liver	Hg kidney	Hg muscle	Hg skin
Sample size	11.0	5.0	7	14
Median	321.8	25.3	31.8	4.1
Geometric mean	238.3	27.1	19.7	4.3
Minimum	20.6	13.5	2.8	0.7
Maximum	1535.7	48.7	251.6	14.3

	Cd liver	Cd kidney	Cd muscle	Cd skin
Sample size	12.0	5.0	7.00	14.00
Median	2.8	10.3	0.18	0.04
Geometric mean	3.7	14.3	0.15	0.04
Minimum	1.4	6.7	0.02	0.01
Maximum	16.2	42.6	0.40	0.14

	Pb liver	Pb kidney	Pb muscle	Pb skin
Sample size	12.0	5.0	7	14
Median	1.4	0.2	0.2	0.4
Geometric mean	1.1	0.3	0.3	0.5
Minimum	0.2	0.2	0.2	0.2
Maximum	4.3	0.5	1.1	5.4

WHALE REMAINS IN A NORTHERN SPANISH ROMAN SITE?

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INTRODUCTION Whale hunting in the Bay of Biscay has been historically documented from the 11th century AD onwards (Lefévre, 1933), with sparse references to an earlier tradition whose beginnings have not been precisely stated.

From this perspective, archaeological data can be extremely helpful in order to complement historical sources because High Middle Age written records are so painfully scarce. Despite the richness of achaeozoological reports for the Cantabrian coast, from prehistoric times, no such approach has been undertaken in historic periods so far. This work is the first one of its kind and the start of an archaeological approach to whaling in this area.

ARCHAEOLOGICAL BACKGROUND The whale remains described below were found during the 1989 excavation campaign in the Roman site of Cimadevilla (Gijón, province of Asturias), more precisely to the west of the Roman Gate in the wall. It was part of the basement of a 16th-17th century house which was placed against the wall (Fig. 1). Because the basement of this house has a mixture of materials from different periods it is not clear at this stage whether the vertebra should be assigned to one particular period. A complementary finding has been the discovery of a small fish factory from Roman times, which includes a warehouse very close to the place where the whale bone appeared (C. Ochoa, pers. comm.). The fact that the remains are burned precludes C14-dating.

DESCRIPTION OF THE FIND The morphology coincides with a caudal vertebra of an adult black right whale, *Eubalaena glacialis*, (a mounted skeleton of which hangs in the San Sebastian Palacio del Mar Aquarium and was visited and compared by one of us (J. A. Pis- Millán)). The morphology of Balaenopteridae and Physeteridae differs too much to be considered. We do not know to what extent bowhead, *Balaena mysticetus*, resembles the black right whale but the former, being boreal, does not seem to be such an apt candidate as the latter. We have not seen material from the grey whale, *Eschrichtius robustus*, a species from the Pacific whose possible presence has been reported in the North Sea during Medieval times (De Smet, 1981).

The caudal epiphysis is partially fused to the centrum. The neural apophysis, two-thirds of the lower vertebral body and 2-3 cm of its anterior surface are missing. The vertebral body is ventrally limited by two straight trasverse cuts converging ventrally to define a subcentral dihedral. In the right posterior facet, one finds a series of irregular, small but deep, incisions while in the very flat cranial portion there exists one clear ablation caused by entire chopping or erosion.

The vertebra appears partially burned in its posterior portion (particularly in the area with irregular incisions) and in the facets left by the transverse cuts, while in the external portions only the sides of the centrum exhibit signs of having been submitted to the direct action of the fire. In both flat surfaces (cranial and caudal), there are abundant remains of mortar.

DISCUSSION There is a clear sequence of manipulation exhibited by the vertebra, with primary cuts (exhibiting the action of fire) and secondary cuts (whose facets have not been burned).

The most parsimonious explanation would attribute the primary chopping to the operation of butchering the carcass after which the bone was submitted to the action of fire. During this second process, parts of the vertebra probably protected by resistant conjunctive tissue, were not burnt. The causes for burning the bone probably have to do with the procurement of fat (blubber) inside the spongy osseous matrix and this can perhaps also account for the primary fracturing.

The secondary fracturing, the irregular incisions, and the abrading of the cranial portion, probably have to do with secondary uses given to the bone, in particular as an auxiliary tool for construction. This would also explain the presence of mortar and the situation in which it was found at the site. Many historical sources along the Cantabrian coast from the Basque Country to Galicia record the use of whale bones for construction though the documents usually speak about the ribs and maxillar bones, the vertebrae being reserved rather as furniture (stools) (Ciriquiain, 1961). Our evidence of the bone being used as a provider of blubber to be later boiled and turned into oil is less conclusive, though this seems to have been the main objective of whale hunting in Mediaeval times (Ciriquiain, *op. cit.*). The exposure to fire of this vertebra is unusual in the remaining bones found along the Cantabrian coast and suggests a more primitive technique than the well developed one in the Mediaeval whaling factories.

Obviously, with the data at hand, we have no clue as to how the animal was obtained. Olaus Magnus (1562) explains how stranded whales were exploited during the 16th Century in Scandinavia, even though stranding was occasionally induced. Whale remains along European coasts have been repeatedly reported but are not usually dated (De Smet, 1981), and prehistoric finds of large cetaceans seem to be a minute fraction of all cetaceans records in excavation sites (Clark, 1947). In our case, a Roman Age finding would be an extremely early date for whale use if not hunting.

It should be noted in this context, that stranded whales could have been, if not a predictable, at least a rather frequent resource along the Cantabrian coast. Just as a reference, we can mention in Asturias from 1900-1933 the existence of eight fin whale strandings, not being a coastal species as black right wales were, and so with a much lower possibility of stranding.

CONCLUSIONS Even though the evidence of meat procurement is circumstantial, the bone recovered implies a double use of the remains: as a construction material and as a combustible agent. Whether this latter use has to do with meat processing, blubber retrieval or oil manufacture is left open to debate, though all three possibilities are plausible inferences from historical and ethnological records.

The dating of the vertebra is uncertain because the mixed materials do not allow a certain chronology. The use of whale bones is known in the construction of Mediaeval buildings but vertebrae were not usual, and the burnt surfaces suggest a more archaic manipulation than mediaeval techniques, to obtain or use whale blubber.

If, as we still would like to believe, the vertebra comes from the Roman occupation layers of the site, its existence reveals the practice of a systematic use of whale remains along Cantabrian coasts much earlier than any written sources indicate.

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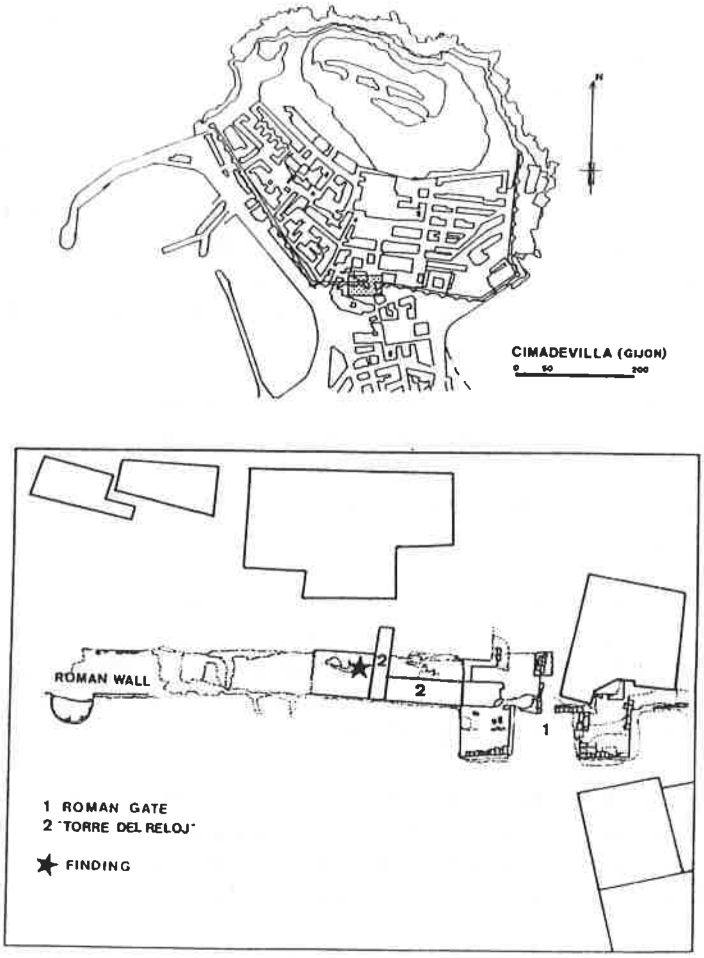

Fig. 1 Sketch plan of Roman site at Cimadevilla (Gijón, province of Asturias).

COMPARATIVE STUDY OF FREE-DIVING IN TWO SPECIES: DOLPHIN AND MAN

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INTRODUCTION Diving physiology has been studied for years in man, and deep-diving competition still goes on . The aim of this paper is to show the reasons why humans cannot dive as deep as cetaceans do. This study will compare cetacean with human performances. Some definitions are made first :

Diving: immersion to varying depths in a liquid element
Apnea: momentary interruption of pulmonary ventilation
Free-diving: immersion in a liquid element with voluntary
interruption of pulmonary ventilation.

Depth record in man is now 118 metres (Umberto Pelizzari, Oct 1991). For cetaceans, it is the sperm whale with 2,250 metres. The length of time measured for man's apneic is 6 min. 13 secs (U. Pelizzari, 1990), versus the sperm whale with an approximate time of 90 min.

Three characteristics of the aquatic environment are important and influence diving performances :

(1) Density
(2) Thermal conductivity
(3) High pressure

The hydrodynamic profile of dolphin is a great advantage.

Four factors govern performance in diving:

(1) Resistance to hypoxia (lack of oxygen)
(2) Thermo-regulation
(3) Resistance to the effects of pressure increase
(4) Resistance to the after-effects of decompression

(1) RESISTANCE TO HYPOXIA This is the main factor which limits the length of the dive. Four aspects appear as such:

(a) Intake of oxygen at the surface
(b) Transportation and storing of oxygen
(c) Use and economy of oxygen
(d) Respiratory regulation

(a) Intake of oxygen at the surface is more efficient in dolphins than man as they possess several anatomical characteristics :

- tighter blowholes
- shorter tracheas
- arytenoepiblotideal tubes, which avoids the inhalation of water by design
- great thoracic and pulmonary flexibility
- double blood supply to alveolar walls
- a greater number of pulmonary alveoli

Physiological characteristics which are important include:

- higher tidal volume
- higher ventilation coefficient
- a better ventilation performance
- a better absorption of oxygen

(b) Transportation and storing of oxygen Many anatomical and physiological aspects are helping the dolphin in this way:

- higher blood volume and well developed vascular networks
- higher haemoglobin level
- higher red blood cell haemoglobin content
- higher oxygenating capacity of haemoglobin
- higher myoglobin level

(c) The use and economy of oxygen during diving is helped in dolphins by:

- a pronounced bradycardia (more important than in human divers)
- an intense peripheral vasoconstriction
- variable circulatory patterns based on oxygen sensitivity of tissues
- maximal use of oxygen in the alveoli

(d) Dolphin respiratory regulation is adapted to an aquatic life. This action seems to be a voluntary one and is influenced by oxygen levels in the blood (and not by carbon dioxide as in humans). The arteriovenous shunts slow down the flow of carbon dioxide to the brain, Consequently the dolphin's buffer capacity is higher.

(2) THERMOREGULATION IN WATER

The dolphin shows:

- a low body surface / volume ratio
- a very thick subcutaneous fat layer, except fins and fluke where a reversed thermo-regulatory system take place ("periarterial venous retia")
- a higher metabolism at rest. The dolphin has an appropriate thermo-regulatory system, enabling it to save energy and increasing endurance.

(3) RESISTANCE TO PRESSURE INCREASES This is very important during deep dives. The animal is resistant to hyperbaric accidents because of:

- a huge, thoracic flexibility (important number of floating ribs)
- well-developed vascular networks
- small cranial cavities; middle ear and sinuses reduced with expansion of vascular networks in these cavities during dives.

(4) RESISTANCE TO DECOMPRESSION The appearance of nitrogen bubbles in the blood. Dolphins have enhanced resistance due to the following:

- the compression of the alveoli inhibits gas exchanges
- the vascular networks stop nitrogen bubbles
- the coagulation rate is low and avoids intravascular coagulation (which appears in man). The dolphin shows a very active heparin, a low platelet count and factor XII (Hageman factor) deficiency.

CONCLUSIONS Cetaceans, with pinnipeds, are the best divers for depth and "holding breath". If we want to dive more frequently and at greater depths, we need to learn more from these mammals and their physiology.

This paper is an abstract of a veterinary thesis. More details (and a copy of the thesis **"Etude comparative de la plonge en apnue chez le dauphin et chez l'homme"** in French) may be obtained from the author at Nantes Veterinary School, Bibliotheque de L'école Nationale Veterinaire de Nantes, E.N.V.N., Route de Gachet B.P 527, 44020 Nantes cedex, France (Tel. No. 33-40-68-77-77)

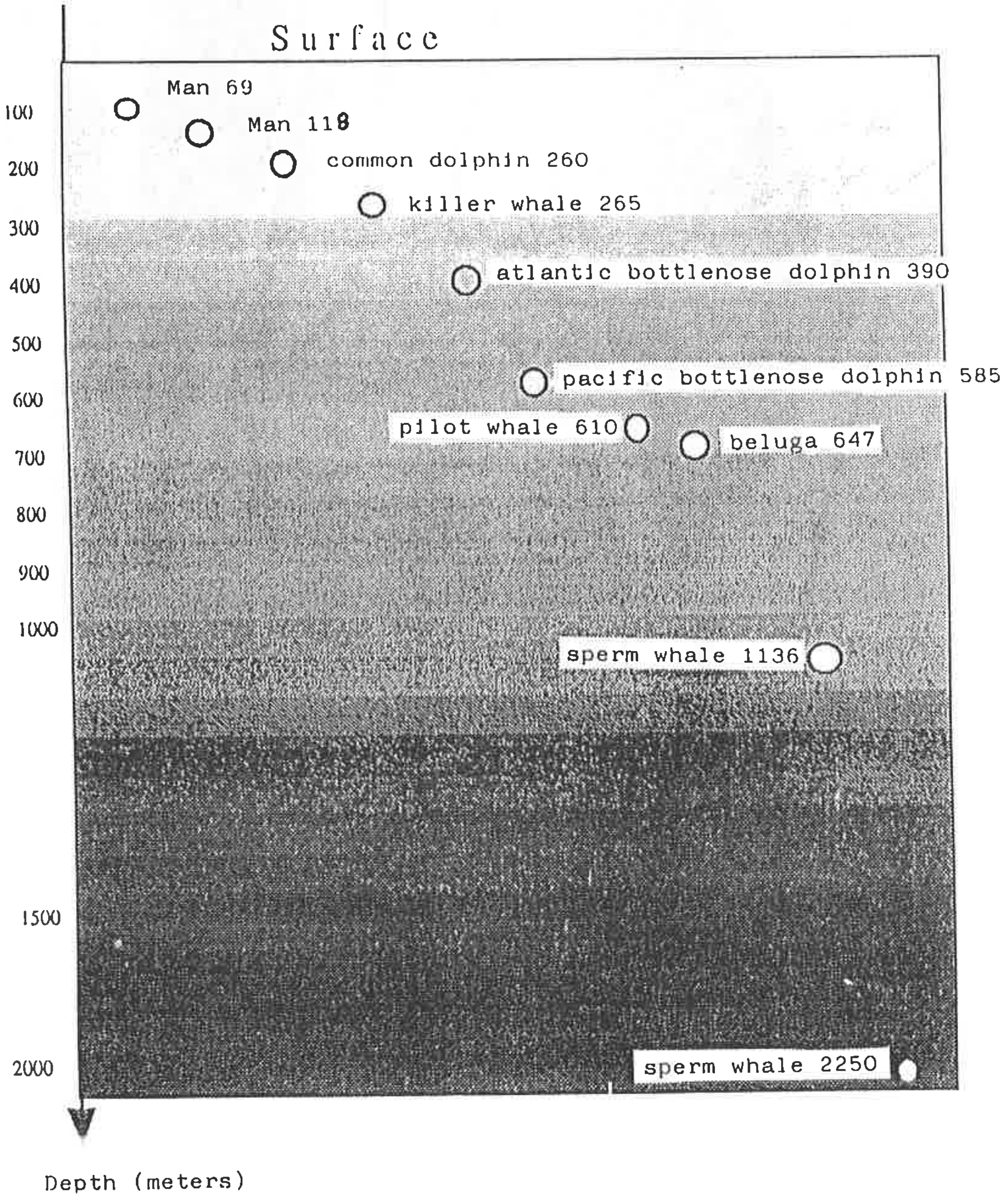

Fig. 1 List in order of importance of free diving depths reached

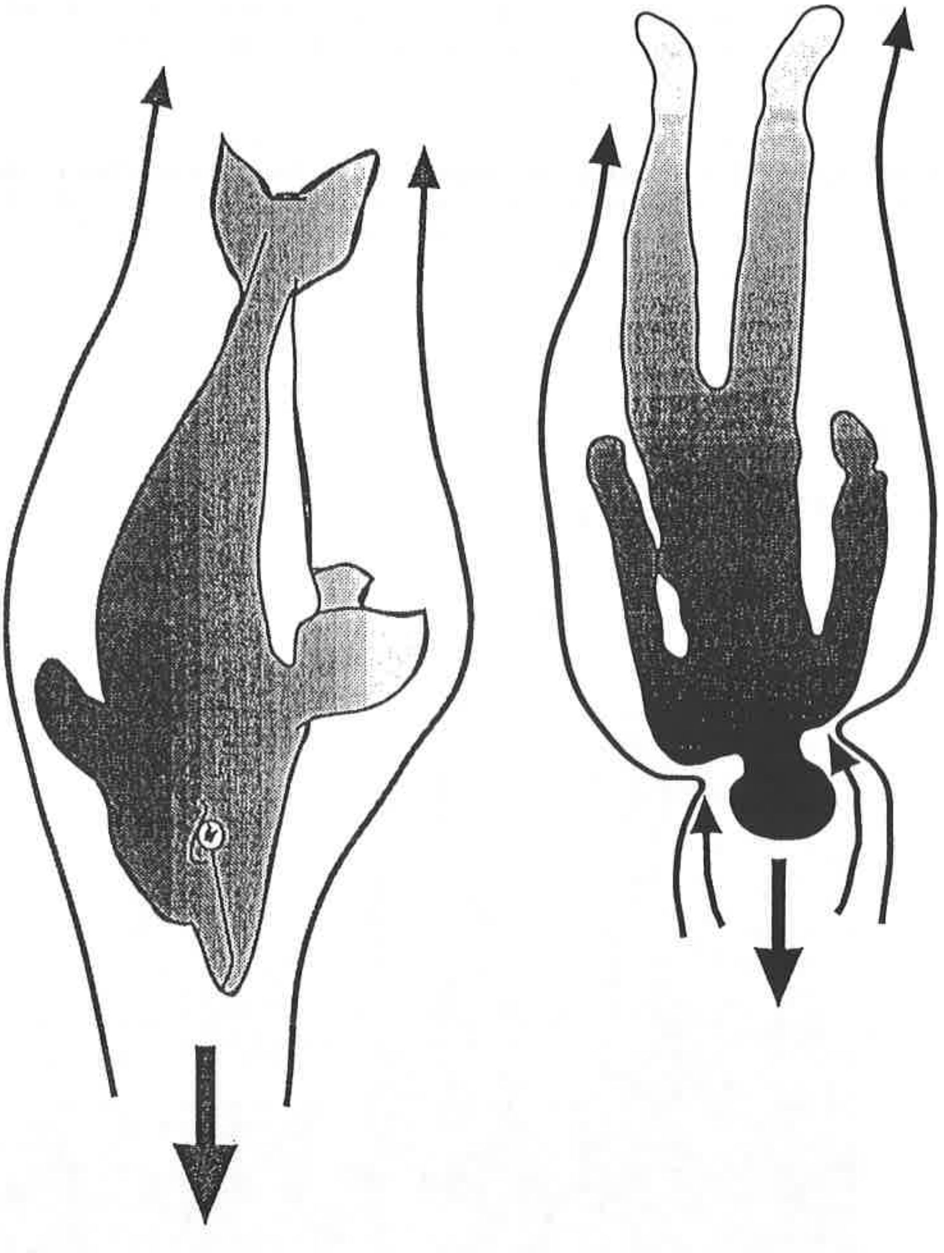

Fig. 2 Hydrodynamic profile dolphin / man

→ Drag ➡ Direction of dive

BEHAVIOURAL SLEEP IN A NORTHERN FUR SEAL, *Callorhinus ursinus*

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INTRODUCTION Comparative Sleep Research is one important way to understand the functions of sleep in different animals and their adaptations to different ecological situations (Webb, 1979; Allison and Chichetti, 1976; Zepelin and Rechtshaffen, 1974; and Tobler, 1984). The classical sleep stages, which were originally defined in humans (Berger, 1930) using Electron-cephalography (EEG), are in principle also present in all other mammalian and avian species (Tobler, 1984).

The study of sleep in aquatic mammals led to some very surprising results: (1) Dolphins, Porpoises and Otariidae (seals) showed uni-hemispheric Slow Wave Sleep (Quiet Sleep or "Deep Sleep"). This means that each brain hemisphere sleeps alternately, when the other one is awake or in a shallow sleep-stage (Mukhametov, 1984; Mukhametov *et al.*, 1988). (2) With the exception of the most primitive mammals, the egg-laying *Monotremata*, Dolphins and Porpoises are the only warm-blooded animals that never show any sign of Active Sleep (also called Paradoxical Sleep, REM (Rapid Eye Movements) -Sleep or "Dream-Sleep"). These almost unique features within the homoiothermic vertebrates may reflect the return of primary terrestrial ancestors of the modern whales and seals to an aquatic environment (Mukhametov 1984).

The aim of this study was to develop and test behavioural categories for seals in order to distinguish different stages of sleep and wakefulness and to compare these findings with EEG results.

METHODS Observations were made in a roofed open-air basin of approximately 3 x3 x 1.5m at the Black Sea Station of the Severtsov-Institute. The subject of this study, an approximately 7 year old female northern fur seal, *Callorhinus ursinus*, named "Mathilda", lived in different dolphinaria for more than 6 years. Before measurement started, she took about one week to adapt to the new surroundings. The observers were hidden from the animal in a hut which borders the basin. They looked out of a small window, which was above the wall of the basin' and allowed the observers to look down at the animal from a distance of about 2.5 m while sitting at a table. Registration of time and duration of main stages, such as Active Wakefulness (AW) - see below - and substages like swimming, grooming etc. (not included in this paper) was carried out with the help of a computer program (actogram), which was developed by the senior author of this study (Oleg Lyamin). Observations during night-time were only possible using a 100 Watt bulb, which hung approximately 2.5 m above the middle of the basin. Eye Configuration and AS-Phenomenons were observed using binoculars.

The experiment was sub-divided into 3 parts:

Stage I: Low water level (approx. 0.25m) and offer of a platform for resting (days 1-4).
Stage II: High water level (approx. 1.3m) without platform (days 5-34).
Stage III: Same conditions as Stage I (days 35 and 36).

About twenty 24h continuous observation sessions were made alternately by 3-4 different observers, which were all experienced in the application of the behavioural categories. The adaptation time of about one week was used to modify the behavioural categories developed by Ursin and Sterman (1981) in adult cats, for studying sleep in seals:

Main stages:
Active Wakefulness (AW):

- -General State (GS): typically movement (short episodes of quiescence possible).
- -Body Position (BP): sitting, standing, walking or swimming.
- -Head Position (HP): head up(right).
- -Eye Configuration (EC): eyes permanently open.

Quiet Wakefulness (QW):

- -GS: typically quiescence (short episodes of movement possible).
- -BP: sitting or lying.
- -HP: typically head down (if head up, only slightly moving).
- -EC: eyes permanent open - periodically closed (not longer than 29 sec).

Changes between AW and QW were only registered, if the new stage is kept for more than 10 sec without coming back to the old one.

Quiet Sleep (QS):

- -GS: quiescence.
- -BP: lying or sitting.
- -HP: typically head down (if head up, not moving).
- -EC: eyes permanent closed for more than 30 sec.

Active Sleep (AS):

- -GS: quiescence with frequent jerky body movements, most prominent at the head (neck), extremities, vibrissae, ears and nostrils.
- -BP: lying (muscle hypotonia!).
- -HP: head down (muscle hypotonia!).
- -EC: generally closed or half opened. REM.

A change from QS to AS was only registered if the AS phenomena had a longer duration than 30 sec.. In water, fur seals show a typical sleeping posture, the so called: "Ring". A distinction was made between QW and QS only through the frequency of movements and the time of eye-closure. A distinction between QS and AS was made from the presence of jerky body movements or REM; and in water, additionally by the sinking of the head with its nostrils under the water surface due to muscle hypotonia.

RESULTS

Stage I: The amount of both sleep stages QS and AS increased from the first day to the fourth day of the experiment (7.1 - 19.8% vs. 0.9 - 4.4% of 24 h observation time respectively). At the same time, there was a decrease of both wakefulness-stages, particularly AW, from 39.0 - 27.8%. The animal slept exclusively on the platform (Fig. 1).

Stage II: The first 24 h after raising the water level and removing the platform at the fifth day of the experiment, "Mathilda" was in AW all the time, usually swimming. Within the 30 days of this stage in the experiment, she never showed less than 78.9% AW. QW increased from zero to 10.8%; QS from zero up to 15.5%. AS was not detected (Fig.1).

Stage III: After reducing the water level to Stage I conditions and offering again a platform for resting, the animal showed higher levels for QW (59.6 vs. 50.8%) and lower levels for AW (22.6 vs. 39.0% compared with Stage I). The amounts of both sleep stages QS and AS were slightly lower than in Stage I: QS (19.1 vs. 19.8%) and AS (3.0 vs. 4.4%) (Fig.1).

DISCUSSION Although the water level in Stage I of the experiment was very shallow, "Mathilda" never slept in water, but exclusively on the platform. *Callorhinus ursinus* seems to prefer to sleep on land if it is available.

During the first 4 days, the increase of the amount of sleep on the one hand and the decrease of wakefulness on the other, reflects an increasing habituation of the animal to the new basin. We do not know whether this process had already reached its final stage, because we were forced to interrupt this at day 5 in order to have enough time for the main part of the experiment: the High Water level Conditions. These are in a way similar to open-sea conditions, in which *Callorhinus ursinus* live for more than two months every year, when they migrate from the northern North Pacific Ocean to more southern latitudes during autumn and on their way back in spring. During this time, the species must be able to sleep in the open sea and to survive with a smaller amount of sleep. Our data show a reduction of total sleep time (both QS and AS) from 24.2% to zero at the first day of Stage II and to a maximum of 15.5% at day 32.

The absence of AS for at least one month might be due to difficulties in detecting short and less prominent episodes of AS during sleep in water. Electro-physiological research on our species showed a clear reduction of the amount of AS in water to about 0.3%, compared with 3.6% on land (Mukhametov *et al.*, 1988). A comparison of our results with these data show a high degree of conformity (Table 1). We do not understand so far, how northern fur seals are able to survive long periods of at least one month with half the amount of sleep and less than 10% of AS compared with sleep on land.

If our results prove to be representative for this species (Oleg Lyamin will repeat the experiment with another two individuals of *Callorhinus ursinus*), then it would appear that sleep rebound is not used to compensate sleep deficiency (see the results of Stage III - there was even a reduction of total sleep time as well as both QS and AS compared with Stage I). Therefore, it might be possible that Otariidae seals are able to reduce their demand for sleep, even under physically exhausting conditions, to a surprisingly low level for higher mammals. This would be very interesting for all hypotheses on the functions of sleep (Webb, 1979; Karmanova, 1982; Meddis, 1975), especially AS (Fishbein and Gutwein, 1977; Vogel, 1979). Although it is not possible to detect such surprising results as the presence of uni-hemispheric sleep in some marine mammals, it is possible to achieve interesting knowledge about sleep in animals, using behavioural techniques only.

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Table 1 Comparison between our results and data obtained after Mukhametov *et al.* (1988) following EEG-investigations (Mean values for four individual seals). There is a general agreement between these two data sets.

	on Land EEG	on Land Behav.	in Water EEG	inWater Behav.
Awake	69.6 %	75.7-89.8 %	83.8 %	78.9-100 %
Sleep	30.4 %	08.0-24.2 %	16.2 %	00.0-15.5 %
Active Sleep	03.6 %	00.0-4.4 %	00.3 %	00.0-00.0 %
Quiet Sleep	26.8 %	07.1-19.8 %	15.9 %	00.0-15.5 %

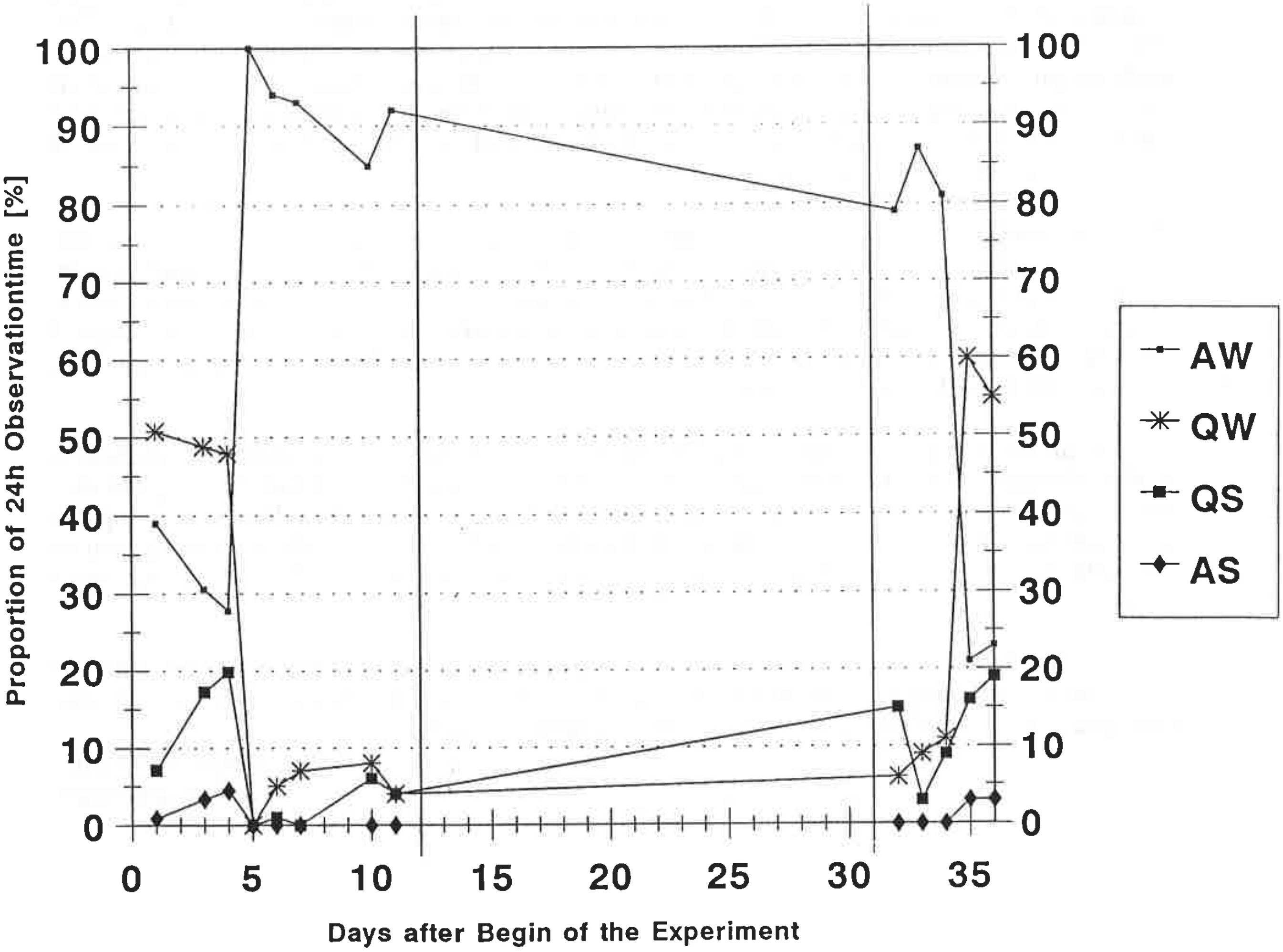

Fig. 1 Main Stages of the Sleep-Wakefulness-Cycle of the Northern Fur Seal "Mathilda" during the three stages of the experiment. Lines at day 12 and day 31 indicate that there are no data available within this period. Abbreviations - AW: Active Wakefulness; QW: Quiet Wakefulness; QS: Quiet Sleep; AS: Active Sleep.

FIFTH ANNUAL REPORT OF THE EUROPEAN CETACEAN SOCIETY: 1991

Membership of the European Cetacean Society totals 292 (after the San Remo Conference) from 25 countries (20 European), with UK (52), Germany (47), the Netherlands (36), Italy (27), Denmark (23), And Spain (21) having the highest representation. Other member countries include Belgium, Czechoslovakia, Faroes, Finland, France, Iceland, Ireland, Norway, Poland, Portugal, Romania, Sweden, Switzerland and Australia, Canada, Japan, Peru and USA.

A successful conference was held at Sandefjord, Norway between 21-23 February, on the theme *Marine Mammal die-offs*. Unfortunately, the attendance was limited to 85 persons from fourteen countries, due to circumstances such as the cost of attending the conference and problems related to the Gulf war. Three invited speakers attended: David St Aubin from Canada, Ilona Visser from the Netherlands, and Bernd Würsig from USA. The abstracts of that meeting were published as proceedings under the title *European Research on Cetaceans - 5*.

A workshop on cetacean pathology was held in Leiden, the Netherlands between 13-14 September 1991, organised jointly by Thijs Kuiken and Manuel Garcia Hartmann. It was attended by 52 persons from 12 European countries, and three visitors from the USA. The aim of the workshop was to bring together people working on cetacean pathology, discuss methods and techniques of sampling and to agree on a minimum protocol. The result draft protocol is circulated for comments to the general membership with this newsletter. The report of the workshop, including the final protocol, will be published as a special issue of the newsletter during the summer.

Three newsletters were produced during the year. One includes the special report on the sightings workshop held in Palma be Mallorca on 1 March 1990; the other two review recent research and new items in Europe and elsewhere in the world, conservation issues, cetacean meetings and publications, and with requests for information or biological material. We are very grateful to Marjan Addink and Loke Bakker for their dedicated support with regard to the newsletter.

The Councils of the ECS and the European Association for Aquatic Mammals (EAAM) tried to develop a closer cooperation of the two societies, at the same time allowing the two bodies to keep their separate identities. This will result in 1992 in an exchange of delegates at annual meetings and an exchange of information, each of the societies having agreed to circulate the information provided to its membership through newsletters or any other means.

Finally, the European Cetacean Society continued to provide advice to government departments and non-governmental organisations in various European countries; it also provided specialist information to a number of public esquires.

Geneviève Desportes
Hon. Secretary

FINANCIAL REPORT FOR 1991, UP TO 19 FEBRUARY 1992

CREDIT	£
Balance at 18 February 1991	3867.29
Balance from Dutch account	1514.96
Cash and Balance from Sandefjord conference	1105.81
Membership fees	1507.15
Sale of Proceedings, etc.	31.50
Interest	280.36
	8307.07

DEBIT	£
Conference related expenses	1365.88
Secretarial	323.38
Production of proceedings	695.00
Postage	717.71
	3101.97

BALANCE	5205.10

Philip Hammond
Hon. Treasurer

EUROPEAN CETACEAN SOCIETY

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 two new groups (covering the North & Baltic Seas and the Mediterranean Sea respectively) have been set up. The names and addresses of contact persons for all the 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, if necessary carrying out translations into the language of that country. Their names and addresses are also given at the end of this note.

A newsletter is produced three times a year for members, reporting current research in Europe, recent publications and abstracts, reports of working groups, conservation issues, legislation & regional agreements, local news, and cetacean news from other parts of 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, five 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, and Sandefjord (Norway) in 1991.

At intervals, workshops are also held on particular topics, and the results published as special issues of the newsletter. A workshop on the harbour porpoise, held in Cambridge (England) in 1988, was published as newsletter no. 6, whilst a sightings workshop held in Palma de Mallorca (Spain) in 1990 is published as newsletter no. 10.

Membership is open to *anyone* with an interest in cetaceans. The annual subscription is **£12.50** for full and institutional members, or **£7.50** for those who are 25 years of age or younger, full-time students or unwaged. Payment may be made at the Annual Conference in pounds sterling or the currency of the host country. During the year, payment may be made by UK cheque, Eurocheque or bank draft in pounds sterling to *European Cetacean Society* ; if made by cheque in any other currency, £6 should be added to cover exchange charges. Please send subscriptions to the Treasurer, **Dr. P. Hammond, SMRU, c/o British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK.** Payment in excess of the membership fee will be gratefully received as a donation to the Society.

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