Cetaceans and Cetacean Research In The Indian Ocean Sanctuary

Stephen Leatherwood
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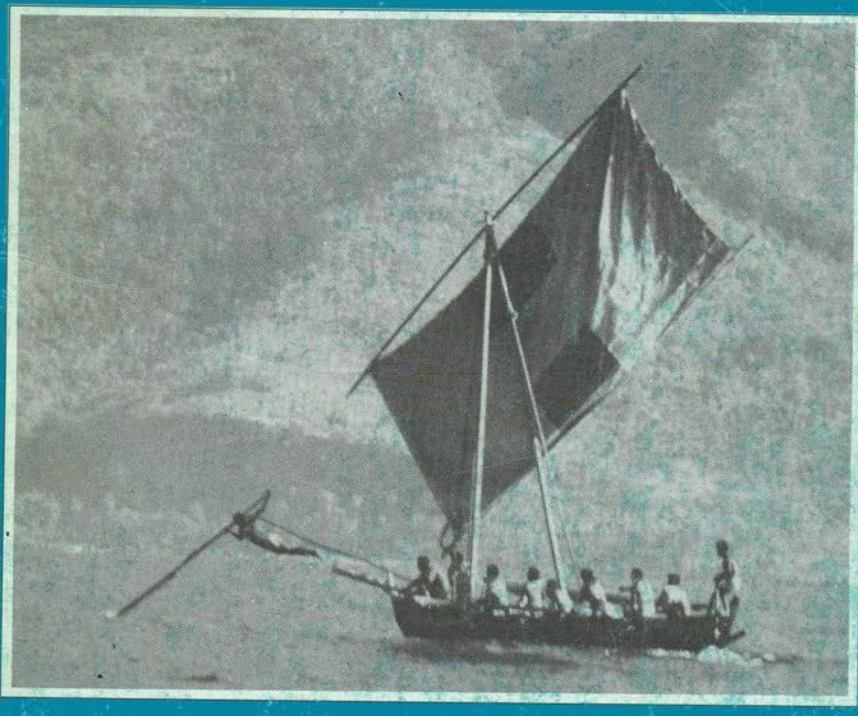

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Cetaceans and Cetacean Research

In The

Indian Ocean Sanctuary

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Marine Mammal Technical Report Number 3

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PO Box 30552
Nairobi, Kenya

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1991

UNEP

The United Nations Conference on the Human Environment (Stockholm, 5–16 June 1972) adopted a comprehensive "Action Plan for the Human Environment". In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and co-ordination within the United Nations system". The organizations of the United Nations system were invited to "adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems", and the "intergovernmental and non-governmental organizations that have an interest in the field of the environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination".

The Governing Council of UNEP chose the oceans and coastal areas as a priority on which to focus efforts to fulfil its catalytic and coordinating role.

The Oceans and Coastal Areas Programme of UNEP consists of activities related to the following interlinked sub-programs:

Global Marine Environment
Regional Seas
Living Marine Resources

Through the Living Marine Resources sub-programme, UNEP coordinates the Global Plan of Action for the Conservation, Management and Utilization of Marine Mammals (endorsed by UNEP's Governing Council in 1984) and assists countries in the protection of fisheries resources from pollution.

The Oceans and Coastal Areas Programme of UNEP is coordinated by the Programme Activity Centre for Oceans and Coastal Areas of UNEP in Nairobi and enjoys close cooperation with a large number of states as well as international, intergovernmental, regional and national organizations.

Contents

Preface

Marine mammals have been considered as resources for centuries. However, increasingly sophisticated methods of hunting, killing of 'non-target' animals in new and expanding fisheries, growing human populations, pollution and general degradation of and encroachment on habitats have all contributed to their decline. Concern for the plight of marine mammals became widespread in the early 1970s, when whales became a symbol of threats to the environment and of mankind's responsibility towards other species. This concern was formally expressed at the Stockholm Conference on the Human Environment in 1972, where recommendations were made for protecting marine mammals.

In response to the recommendations of the Conference, the Global Plan of Action for the Conservation, Management and Utilization of Marine Mammals was developed between 1978 and 1983, jointly by UNEP and the Food and Agriculture Organization of the United Nations (FAO) in collaboration with other intergovernmental and non-governmental bodies concerned with marine issues, particularly the International Whaling Commission (IWC) and the World Conservation Union, formerly the International Union for Conservation of Nature and Natural Resources (IUCN). In October 1983, the FAO Committee on Fisheries (COFI) endorsed the principles of the Plan, and in May 1984 the UNEP Governing Council followed suit. The IWC endorsed the cetacean component of the Plan at its annual meeting in June 1984, and in November of that year the General Assembly of IUCN endorsed the promotion of the Plan as a matter of high priority. This series of formal endorsements officially launched the implementation of the Plan.

The basic objective of the Plan was to promote the effective implementation of a policy for conservation, management and utilization of marine mammals which would be widely acceptable to governments and the public. The Plan was built around five concentration areas: policy formulation; regulatory and protective measures; improvements of scientific knowledge; improvement of law and its application and; enhancement of public understanding. Thirty-eight priority actions were recommended as necessary to implement the Plan under these areas.

The Plan was intended to stimulate, guide, assist and where necessary coordinate activities of existing organizations, giving emphasis to international actions, while recognizing the importance of national actions. The main organizations identified as having an important role in the implementation of the Plan included UNEP, FAO, Unesco, other specialized agencies of the United Nations, the secretariats of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the IWC, the Scientific Committee on Antarctic Research (SCAR), IUCN and the World Wide Fund for Nature (WWF) as well as governments and non-governmental organizations in general.

Following the endorsement of the Plan by the UNEP Governing Council, UNEP assumed the role of the Plan's secretariat and initiated its implementation through close cooperation with interested states and international, intergovernmental and non-governmental organizations.

Introduction

As a result of an initiative by the Government of the Seychelles, the International Whaling Commission established a Sanctuary in the Indian Ocean. This came into effect on 24 October 1979 and was originally intended to apply for 10 years 'with the provision for a general review after five years, unless the Commission decides otherwise.' Under the terms of the International Convention for the Regulation of Whaling, this meant that 'commercial whaling, whether by pelagic operations or from land stations' was prohibited. It should be remembered that as an IWC Sanctuary, this prohibition only applies to member nations of the IWC. In addition there has been and remains a divergence of views within the Commission as to its competence to regulate exploitation of any species other than 'the great whales'.

At the 1980 and 1981 Commission meetings, in response to an initiative by a meeting of Indian Ocean states, the Seychelles and Netherlands proposed, and the Commission endorsed a proposal to host a meeting of scientists to plan a programme of monitoring and research in the Sanctuary. This took place in Zeist, the Netherlands from 28 September to 1 October 1981 (Anonymous, 1981). After a series of delays, the required scientific and technical review meetings were arranged. The scientific meeting, from which this volume arises, took place in Anse-aux-Pins, Seychelles from 24–28 February 1987 under the joint sponsorship of the IWC, UNEP (the United Nations Environment Programme) and the Government of the Seychelles. The report of the meeting is published in this volume. Subsequently, a series of technical review meetings took place (IWC, 1988; 1989) leading to an extension of the Sanctuary provision for a further three years, until 24 October 1992 (IWC, 1990).

Irrespective of the divergence of views within the Commission over the management of 'small cetaceans' and their position in the Sanctuary, we believe it is important to address questions concerning their status in the Indian Ocean. In some parts of the world there is a growing trend towards complete protection for marine mammals (e.g. in North America, Australasia and western Europe). By contrast, domestic traditions and economic and subsistence requirements in many member and non-member IWC states bordering the Indian Ocean are such that marine mammals are considered, along with other wildlife, as resources available for human use. However, there is often no orderly approach towards their management. In addition to directed fisheries for marine mammals, there are numerous local fisheries which take marine mammals incidentally.

This problem was recognised at a Symposium and Workshop co-sponsored by the IWC and UNEP, amongst others, held in California in October 1990 (the report and proceedings will be published as a volume in the IWC Special Issue Series). That meeting also recognised the serious threat posed by the expanding far-seas fisheries that are known to kill marine mammals incidentally. For example, high seas driftnet fleets recently banned from the South Pacific have begun to relocate to other grounds including the Indian Ocean. Although few reliable data exist on either the extent of these operations or the takes of marine mammals, it is thought that at least 160 vessels are currently operating in the region and the numbers are increasing. From the records of the gillnet fleets elsewhere, it is likely that thousands, perhaps tens or even hundreds of thousands of marine mammals may be being killed. There is almost no information on the abundance and status of the marine mammal populations involved, nor is research being carried out that will provide such information in the foreseeable future.

It should also be remembered that despite the term 'Sanctuary' being used, protection is only extended to the great whales in the context of commercial whaling. There is no provision for protection of critical habitats, for example, nor regulations concerning pollution either from land or at sea. Recent examples of 'die-offs' of marine mammals from the North Atlantic (seals, whales and bottlenose dolphins – e.g. Kennedy *et al.*, 1988; Geraci, 1989; Geraci *et al.*, 1989) and Mediterranean (striped dolphins – Aguilar and Raga, 1990) have at least implicated high chemical pollutant levels as a factor. A similar large die-off occurred in the Persian Gulf in 1986 involving several dolphin species and dugongs. Although almost nothing is known of pollutant burdens or effects of pollutants on marine mammals in the Indian Ocean, the one detailed study for this region shows high and persistent levels in marine mammals off Natal (Cockcroft *et al.*, 1989).

It is clear that the existence of an IWC Sanctuary does not mean that marine mammals in the area are exempt from the problems facing marine mammals elsewhere in the world. Indeed, it could be argued that not only do the same problems exist but that relatively little research effort is being put into solving them.

The contributions in this volume represent some of the work that has been (or is being) carried out on cetaceans in the Indian Ocean. The limitations of the research documented will be apparent. We believe, however, that they do provide a useful background to any plans to increase and direct research on cetaceans within the Indian Ocean. From the review papers it is clear that the Indian Ocean is home to a tremendous variety and abundance of marine mammals. From research reports it is clear that there are numerous opportunities for meaningful research. We sincerely hope that this volume encourages initiation of new research projects within the region.

The editorial standards we have adopted reflect to some extent the infancy of cetacean research in the Indian Ocean. Even so, not all papers submitted were accepted for publication. All papers included benefited significantly from two or more reviewers who were given the option of remaining anonymous. We would like to thank here the many scientists who generously donated their time to review the manuscripts, including: W. Amos; F. Awbrey; P. Best; J. Calambokidis; A. Collet; P. Corkeron; J. Cubbage; M. Gallagher; P. Hammond; J. Heyning; R. Hoelzel; J. Horwood; S. Katona; A. Martin; M.K. Marx; T. O'Shea; D. Odell; C. Potter; R. Reeves; P. Reijnders; D. Rice; G. Ross; D. Rugh; P. Thompson; P. van Bree; W. Watkins; H. Whitehead; H. Winn; F. Wood; and R. Zilber.

We would also like to thank those people who helped in organising the meeting, in typing and retyping papers and tables and in redrawing figures, in particular: Helen Coulson; Julie Creek; Stella Duff; Ray Gambell; Martin Harvey; Kathy Kangas; and Fiona Redford.

S. Leatherwood and G.P. Donovan,
Cambridge, December 1990

REFERENCES

Aguilar, A. and Raga, J.A. 1990. Mortandad de delfines en el Mediterraneo. *Politica Cientifica* 25:51–4.

Anonymous. 1981. *Report of the Workshop to Plan a Programme of Scientific Research On Cetaceans in the Indian Ocean Sanctuary*. Ministry of Cultural Affairs, Recreation and Social Welfare, Netherlands. 105pp.

Cockcroft, V.G., De Kock, A.C., Lord, D.A. and Ross, G.J.B. 1989. Organochlorines in bottlenose dolphins from the east coast of southern Africa. *S. Afr. J. Sci.* 8:207–18.

Geraci, J.R. 1989. Clinical investigation of the 1987–88 mass mortality of bottlenose dolphins along the U.S. central and south Atlantic coast. Final report to [US] NMFS, US Navy and the Marine Mammal Commission (unpublished). 63pp.

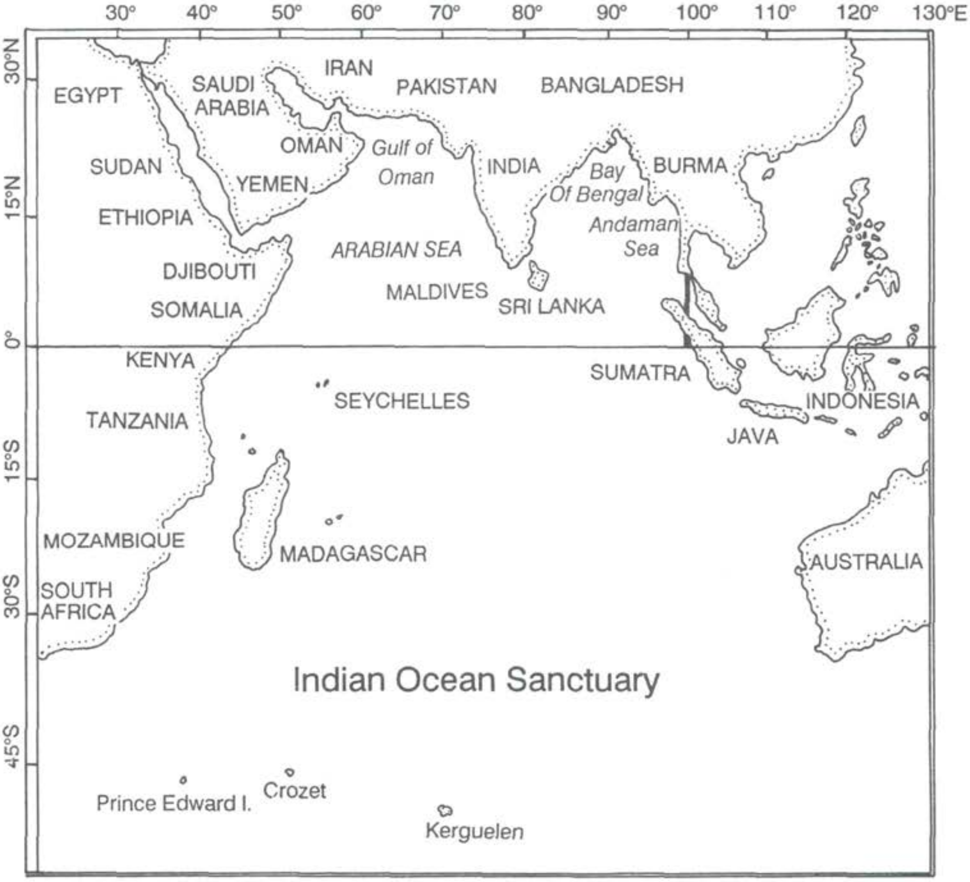
Geraci, J.R., Anderson, D.M., Timperi, R.J., St. Aubin, D.J., Early, G.A., Prescott, J.H. and Mayo, C.A. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. *Can. J. Fish. Aquat. Sci.* 46(11):1895–8.

International Whaling Commission. 1988. Chairman's Report of the Thirty-Ninth Annual Meeting. *Rep. int. Whal. Commn* 38:10–31.

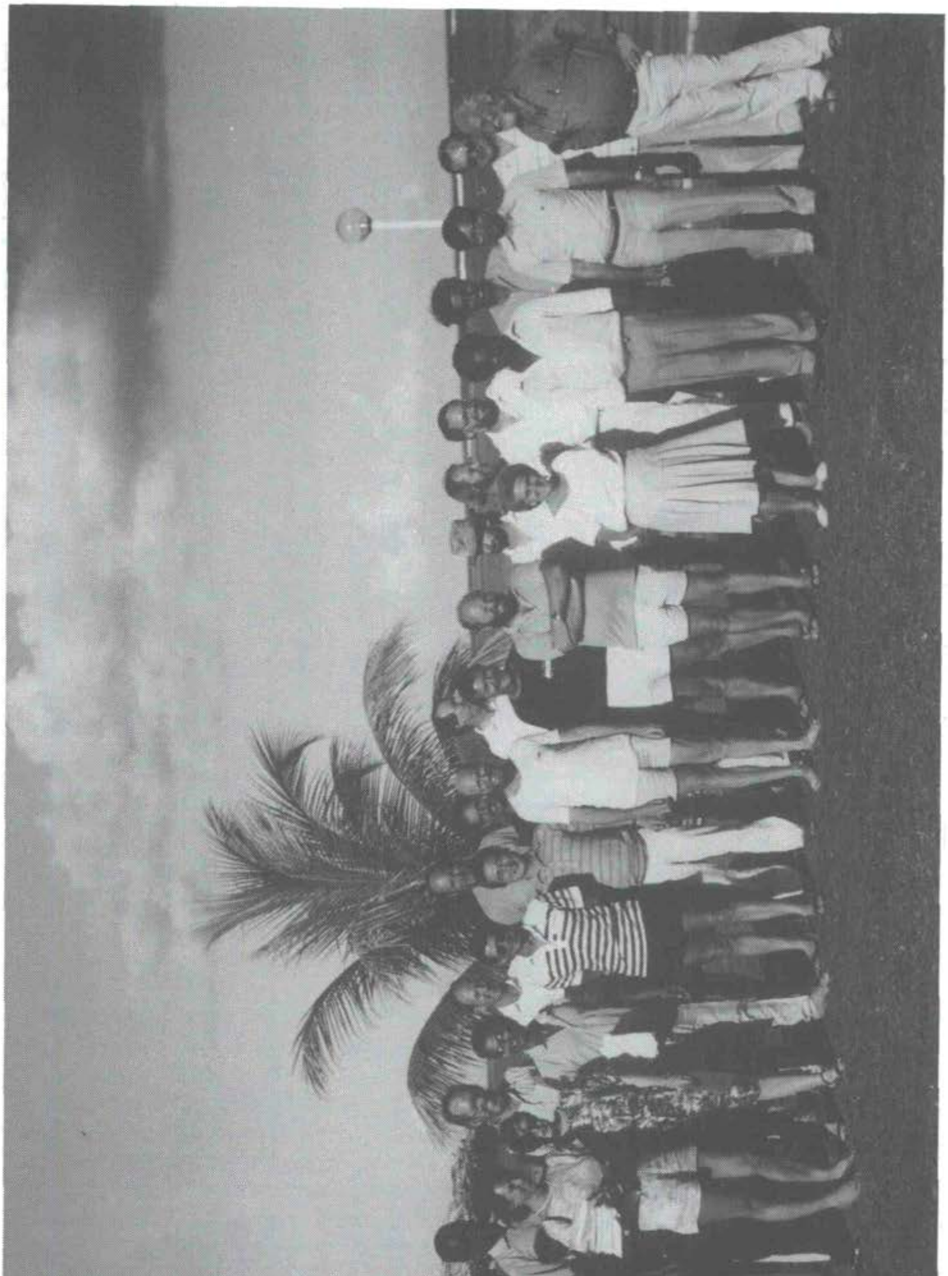
International Whaling Commission. 1989. Chairman's Report of the Fortieth Meeting. *Rep. int. Whal. Commn* 39:10–32.

International Whaling Commission. 1990. Chairman's Report of the Forty-First Annual Meeting. *Rep. int. Whal. Commn* 40:11–37.

Kennedy, S., Smyth, J.A., McCullough, S.J., Allan, G.M., McNeilly, F. and McQuaid, S. 1988. Confirmation of cause of recent seal deaths. *Nature, Lond.* 335(6189):404.



In accordance with Article V(1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Indian Ocean Sanctuary. This comprises the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red and Arabian Seas and the Gulf of Oman; and the waters of the Southern Hemisphere in the sector from 20°E to 130°E, with the Southern boundary set at 55°S. This prohibition applies irrespective of the classifications of baleen or toothed whale stocks in the Sanctuary, as may from time to time be determined by the Commission. This prohibition will apply until 24 October 1992 unless the Commission decides otherwise.



Participants at the Scientific Meeting to Review the Indian Ocean Sanctuary, Seychelles, 24–28 February 1987.

Report of the Scientific Meeting to Review the Indian Ocean Sanctuary

Edited by S. Leatherwood and G.P. Donovan

1. INTRODUCTION

The meeting was held at the Reef Hotel, Anse aux Pins, Seychelles, from 24 to 28 February 1987, with the co-sponsorship of the International Whaling Commission (IWC), the Government of the Seychelles and the United Nations Environment Programme (UNEP). The agenda, list of participants and list of documents submitted are given as Annexes A, B and C, respectively.

M. Guy Lionnet, Chairman of the Seychelles Natural Environment Council, welcomed participants to the meeting on behalf of the host Government.

Leatherwood and Subasinghe were elected co-chairmen, with Donovan and Best as rapporteurs.

1.1 History of the Sanctuary proposal

The history of activities leading up to the Sanctuary proposal (Anonymous, 1979) by the Seychelles Government in 1979 was reviewed by Holt. Contributory factors were identified as the political independence of the Seychelles, the declaration of a 200 mile EEZ (and the protection of marine mammals within it), the wishes of coastal states and the release of the 1979 IUCN report on the establishment of marine reserves, especially for Cetacea.

1.2 The IWC response

The IWC response to the Sanctuary proposal was reviewed by Gambell. Under paragraph V(1)(c) of the Convention, the Commission agreed in 1979 to the cessation of commercial whaling in the waters of the northern Indian Ocean from the coast of Africa to 100°E (including the Red and Arabian Seas and the Gulf of Oman) and in the southern Indian Ocean between 20°E and 130°E and north of 55°S (see Fig. on p. 3). This decision became effective on 24 October 1979, with the provision for a review after five years (IWC, 1980a). The present meeting was intended as the response to the scientific component of the review process (see IWC, 1984b; 1985; 1986; 1987).

It was noted that while the Sanctuary provision undoubtedly referred to the large whale species normally managed by the IWC, there was no consensus within the Commission as to its competence to regulate the smaller species. However, as the Scientific Committee had a mandate from the Commission to consider small cetaceans at a purely scientific level, it seemed reasonable that in a review of the research activities within the Sanctuary, consideration should be given to all cetacean species.

1.3 Highlights (summary of meetings held to consider research relevant to the Sanctuary, after its inception)

The meeting noted that three meetings had been held since the inception of the Sanctuary, to discuss research within it. The first of these, held in Zeist in 1981 and co-sponsored by Seychelles and the Netherlands (Anonymous, 1981), had some financial support from the IWC, as well as direct input from the Scientific Committee (IWC, 1982b). The other two meetings, held in Colombo in 1983 (report unpublished) and

Cochin in 1983, received no financial support from the IWC and were the result of initiatives by Indian Ocean States. A sub-committee was set up to collate and summarise the scientific findings; their report is given as Annex D.

2. PAST RESEARCH

2.1 Review of relevant research activities and main results

Several of the papers presented to the meeting discussed work carried out since the Sanctuary was established. SC/F87/S3 reviewed modern research activities on large cetaceans in the Indian Ocean Sanctuary area before and after creation of the Sanctuary. The author noted that Sanctuary designation appeared to have had a different effect on research in northern and southern portions of the Sanctuary. In the northern portion there had been an abrupt increase in research based on benign techniques. In the southern portion no such positive effect on research appeared to have taken place. Discussion of this appears under Item 2.2.

Papers SC/F87/S5, 6 and 8 concerned the 'Tulip' project. SC/F87/S5 briefly described the research techniques used during this project. Some of the results were presented and discussed in relation to the Sanctuary and the objectives for a research programme formulated at Zeist (see Annex D).

A 'benign' methodology had been developed which allowed effective studies of sperm whales to be conducted offshore. The study has yielded new (and in some cases unexpected) information on social behaviour, surface and underwater behaviours, patterns and correlates of behavioural activities and vocalisations, diving behaviour and diet. In addition, the project contributed to wider objectives, such as raising public awareness and encouraging research projects by Indian Ocean states.

The author noted that the project had addressed, to a greater or lesser extent, all of the Zeist objectives. It further demonstrated that effective research can take place within a Sanctuary, that such research contributes to the aims of the Sanctuary and that the Sanctuary not only provides a uniquely suitable research location but can also encourage funding. It was also noted that the methodology developed during the 'Tulip' project was now being successfully used off the Galapagos Islands (Whitehead, 1987).

SC/F87/S6 examined the seasonality of mating in the northern Indian Ocean by comparing the months when large males had occurred in historical catches, had stranded and had been seen during the 'Tulip' project. The time of calving off Sri Lanka was indicated by observations, during the 'Tulip' project, of small calves and of a birth.

In some whaling areas, such as the Seychelles and Zanzibar 'grounds', males occurred throughout the year. In other areas their presence may have been seasonal. However in the area as a whole, the males' pattern of seasonal distribution does not conform to either the typical Northern or the typical Southern Hemisphere mode. The extent to which a simple annual seasonality should be expected in this monsoonal tropical area was questioned.

SC/F87/S8 (see Alling, 1986) summarised the 320 incidental sightings of 13 different small cetacean species made during the 'Tulip' cruises. Charts showing the location of each sighting in each year were provided and indices of abundance for each species calculated. A preliminary analysis of group size and behavioural activities for each species was attempted.

The meeting noted that while these incidental sightings had some searching effort data associated with them, this had not been organised in a systematic manner, observations being strongly linked to the habitat and movements of sperm whales. In addition, the sightability of small cetaceans from the research vessel 'Tulip' was not ideal. Photographs (especially at night with flash for bow riding animals) had proved an effective method of confirming species identification and comparing species between areas.

It was regretted that the 'Tulip's' work had ceased in 1984 when the funds had expired, although it was noted that some work on blue whales off Sri Lanka was continuing and that the National Aquatic Resources Agency (NARA) of Sri Lanka had taken over studies of incidental catches of delphinids.

Papers SC/F87/S11 (see Ross *et al.*, 1986) and 12 (see Ross *et al.*, 1989) described work carried out on bottlenosed dolphins off the Natal and Transkei coasts. The longshore distribution of bottlenosed dolphins was investigated between Tugela River Mouth (29°13′S/31°30′E) and the Transkei border (31°06′S/30°10′E), based on sighting rates at anti-shark net installations, capture rates in those nets and some other observations (SC/F87/S11). Six areas similar in length (32.7 km-41.3 km) appeared to represent preferred areas by bottlenosed dolphins. Behavioural data suggest that one of these is the home range of a local population. Dolphins were caught at random along the coast.

Population estimates of bottlenosed dolphins, *Tursiops truncatus*, were obtained from aerial survey data for the north and south coasts of Natal (five replicates) and the Transkei coast (two replicates) from 23 April – 5 May 1985 (SC/F87/S12). Data from a similar single survey in June 1980 were added to increase the sample size. Counts of dolphin groups and numbers were made in a 1 km wide strip transect along the water's edge. Strip transect population estimates ±95% confidence intervals for the north coast ranged from 141 ±178 to 211 ±250. Estimates for the south coast were much higher, ranging from 610 ±1,452 to 954 ±8,342. The very broad confidence limits were due to low sample size and high variances for group density and size. Minimum counts for the north Natal, south Natal and Transkei coasts were 327–387, 100–125 and 635–735 dolphins, respectively. Population estimates based on maximum counts made in areas preferred by bottlenosed dolphins were 483 and 219–249 for the north and south coast of Natal, respectively. Low estimates on the south coast may reflect offshore movements due to increased water turbidity. Alternatively, given that available data suggest that catches of dolphins in anti-shark nets along the Natal coast exceed the probable natural rate of increase, the low estimates may reflect a true population decline. A re-evaluation of the status of bottlenosed dolphins in this region is needed urgently.

The possible decline of these dolphin populations as a result of gillnets is indicative of the potential effect such nets may be having elsewhere in the Indian Ocean Sanctuary area (see Item 6.1).

SC/F87/S9 and 10 reviewed all information available through 1986 on distribution, abundance, seasonal movements and involvement in fisheries of 'blackfish' (killer, false killer, pilot, pygmy killer and melon-headed whales) and Risso's dolphin, respectively. All species are represented by sightings, strandings or collections in all major regions of the sanctuary except the rarely surveyed mid-ocean regions. All are involved in both directed fisheries and incidental/accidental mortality in fisheries, largely gillnet fisheries. Killer (and perhaps false killer) whales are responsible for interference with and damage to catches of longline fisheries and tuna in far-flung portions of the Indian Ocean Sanctuary.

Two of the participants, G. and J. Small, described their on-going work on cetaceans of the Somalia coasts which began in September 1985 and will continue until May 1987. During cruises, as part of a fisheries feasibility study funded by the World Bank for the Somalia Democratic Republic, they recorded incidental observations of cetaceans off the Somalia coasts in the Gulf of Aden and Indian Ocean north of 7°N. Associated data, on sighting effort, vessel activity, hydrography and environmental conditions, are available. Sightings were also recorded during a limited aerial survey at the Horn of Africa. Between

September 1985 and December 1986, a total of 271 sightings of marine mammals was recorded, in areas and with peaks as described below.

Sixty-six sightings of large cetaceans were made in the Gulf of Aden and Indian Ocean, especially at the Horn, in April, May and October-December. Positive identifications included: 16 of Bryde's whales, in the Gulf and off the Horn, in April, September and October; 7 of sperm whales, over sea mounts and through the Gulf, in December, May and June, including some calves; 6 of blue whales, in the eastern Gulf (5) and Indian Ocean (1), from October to December. A total of 206 sightings of small cetaceans was made in the Gulf and throughout surveyed areas of the Indian Ocean. Positive identifications included: 32 of bottlenosed dolphins, in water 2-1,500m, in Gulf and Indian Ocean but primarily on an 80m plateau in the Indian Ocean, two forms seen, one more heavy bodied; 25 of spotted dolphins, primarily on an 80m plateau in the Indian Ocean; 22 of spinner dolphins, Gulf and Indian Ocean; 15 of common dolphin, scattered in Gulf and Indian Ocean but primarily Indian Ocean; 9 of pilot whales, in the eastern Gulf and Indian Ocean; 6 of Risso's dolphins, in groups of 6 to over 200, scattered through the Gulf; 4 of hump-backed dolphins, Djibouti Harbour and scattered through the Gulf; 3 of killer whales, eastern Gulf and at 8° in Indian Ocean, January, February and November; and 1 each of melon-headed and false killer whales and striped dolphin, all in the Gulf.

The meeting considered this series of observations particularly valuable because of the collection of associated sightings effort, and the lack of knowledge of the cetacean fauna of the region. It was **recommended:**

(1) that UNEP and the IWC contact the Government of Somalia and the World Bank, requesting the release of the scientific data collected during the World Bank project;

(2) that UNEP consider funding the analysis of these data.

The meeting expressed its thanks to the Smalls and its hope that the available environmental and ecological data would be incorporated in any final analysis.

Other papers to the meeting concerned continuing studies which began before the inception of the Sanctuary.

SC/F87/S2 analysed the distribution of nine species of whales using Japanese sighting records for the past twenty years. It showed that the Indian Ocean Sanctuary is inhabited in austral summer by a large proportion of the stocks of Bryde's, sperm, right, sei, pygmy blue and fin whales, but that the major portion of stocks of the humpback, ordinary blue, minke and male sperm whales are segregated in higher latitudes. Killer whale concentrations are present in both the Sanctuary and the higher latitudes. Among seven baleen whale species, sei and right whales apparently feed in a common area in the Sanctuary, while minke, ordinary blue and humpback whales in a common area to the south of the Sanctuary. Local concentrations of right, humpback, blue and fin whales coincided with the distribution of past whaling grounds.

The meeting recognised the great importance of this large and comprehensive data base and urged that such surveys continue in the Sanctuary and surrounding waters. Length composition data for some of the sightings were available but not on the computer data base from which the paper was prepared. Interest was expressed in the area south of Madagascar, where concentrations of blue, humpback and Bryde's whales were encountered. It was noted that this region was also of interest to physical oceanographers, so that a cooperative cetological/oceanographic cruise might be a possibility. The presence of humpback whales nearer equatorial regions than expected was mentioned, especially during summer when one might have expected most of the population to have been in high latitudes.

SC/F87/S16 described Australian studies to monitor the recovery of right and humpback whales. Aerial surveys have continued since 1976, annually for right whales and from 1976–82 and again in 1986 for humpbacks. For the former, detailed information is now being obtained on the following: distribution along the southern coast; links with other groups and sub-groups (i.e. off Southern Australia); population structure (mostly singles or pairs on the coast, with cows and calves predominating in the latter); incidence of natural markings ('light phase' animals, and those with white and grey blazes, are relatively few, as off Argentina and in contrast to South Africa); calving interval (mainly three years); and on population size – very probably increasing, now probably around 100 animals, and with a similar number reported off South Australia. In 1982, the abundance index obtained from the humpback survey was twice that recorded in 1963, the last year of coastal whaling on this population; the 1986 results were highly suggestive of a continuing increase. The Group IV population size, if around 800 in 1963, is now likely to be approaching 2,000.

The meeting noted that although these important data had been gathered over the years on a very modest budget, even this level of funding was not guaranteed and may well be reduced (particularly for right whale surveys) in the near future. It draws attention to its view of the importance of such monitoring, expressed under Item 2.2.

2.2 Impact of existence of the Sanctuary on research

The Sanctuary was set up and projects established during a period when many other events significant to the management and study of whales were taking place. These included the earlier cessation of whaling by two Indian Ocean coastal states and the 1982 IWC decision to declare a pause in commercial whaling from the 1986 coastal and 1985/86 pelagic seasons. The relationships among these events which affected actions within the Sanctuary are complex, and make attempts to isolate the impact of the Sanctuary, alone, on research, difficult. Other global developments in the early 1980s, which, although not directly connected with whales and whaling, changed the economic climate for funding most scientific research, are also reflected in the degree to which proposed projects were implemented. Progress should therefore be evaluated in that light.

Nevertheless, as shown in a number of papers submitted to this meeting, the existence of the Sanctuary has benefited some research. This was particularly the case for the programme of behavioural research on sperm and blue whales carried out by the 'Tulip' (SC/F87/S5) but was also evident in the development of interest in cetacean research in certain Indian Ocean states, notably Sri Lanka (SC/F87/S9, 10). In other areas, however, particularly in the southern Indian Ocean (where the majority of research had been carried out before), there was no corresponding expansion of research. However, this does not appear to be related to the introduction of the Sanctuary but is more likely to due in some degree to factors related to decisions to cease whaling. Research and funding are, of course, closely associated. While the existence of the Sanctuary was followed by a notable inflow of research funds into the northern Indian Ocean, principally from non-governmental sources, this was not matched by increases in research funding by the IWC or Indian Ocean coastal states (with the exception of Sri Lanka), particularly in the southern area.

In order to encourage the continuation of research by Indian Ocean states, and to prevent further erosion of national research funding in the region, the meeting believed that discussion of research in the Sanctuary should be incorporated into the Comprehensive Assessment, with the following objectives:

(1) the continuation of behavioural research on undisturbed whale populations that is of potential importance to the management of large whales;

(2) the long-term monitoring of the recovery of depleted stocks, which could help refine estimates of the range in which the yield of a whale stock may lie; and
(3) the use of the Sanctuary as a 'control' area in the event of a resumption of commercial whaling elsewhere.

3. SCIENTIFIC ASPECTS OF THE EFFECTIVENESS OF THE SANCTUARY IN MEETING THE OBJECTIVES OF THE COMMISSION

The Committee noted that establishment of the Indian Ocean Sanctuary was one element in achieving some of the major objectives of the Commission (e.g., to conserve stocks of whales and to promote studies related to whales and whaling).

The Commission itself has not formally agreed on a list of objectives for the Indian Ocean Sanctuary. However, it is possible to glean the following scientific 'objectives' from discussion of the Sanctuary as reflected in Chairman's and Scientific Committee reports (IWC, 1979a; b; 1980a; b; 1981a; b; 1982a; b; 1983a; b; 1984a; 1986) and in the discussion document provided by the Seychelles (Anonymous, 1979):

(1) The Sanctuary should provide an ecologically coherent area where whale populations are protected from whaling for a specified period, avoiding the possibility of stocks being alternately exploited and protected in the short term as a result of small changes in assessments.
(2) In terms of appropriate research, the Scientific Committee (IWC, 1982b) stated that:

(a) it should provide sufficient information to assess stocks of large whales and small cetaceans;
(b) it should permit direct comparison of the status of species and/or populations protected by the Sanctuary provision and exploited or unexploited stocks of the same species in other areas;
(c) the opportunity should be taken to carry out relevant investigation of certain kinds which would be impossible or more difficult to undertake in areas where whaling continues.

In its review of cetacean research in the Sanctuary (IWC, 1982b), the Scientific Committee considered three main headings under which research could be implemented within the Sanctuary: open ocean research on large whales; research on large whales by coastal states; and examination of other sources of information.

The Scientific Committee was not, however, at that time able to formulate specific proposals within those headings, although it did identify seven sources of relevant information (incidental takes, strandings, systematic sightings, historical records, observations of whales from platforms of opportunity, research catches and captive animals).

The Zeist Workshop (Anonymous, 1981 and Annex D) reviewed the Scientific Committee's proposals and came to three main conclusions:

(1) the five year time constraint for estimating population size was unrealistic; population assessments substantially better than those already available would be unlikely within five years;
(2) research within the Sanctuary should be coordinated with research in adjacent areas, particularly to the south, because the ranges of few large whale populations lie entirely within the Sanctuary;
(3) the IWC's ability to identify and assess whale populations' status, ecological roles and vulnerability to human activities, such as pollution, would be enhanced by information obtained from biological and behavioural work in an area undisturbed by whaling for a substantial period of time.

In that context, the Zeist meeting prepared its own list of research objectives within the Sanctuary, the first of which was to satisfy the Scientific Committee's needs, particularly in obtaining adequate information on whale distribution, abundance, reproduction and other assessment-related matters.

The Zeist meeting's list of projects was formulated with that and the other objectives in mind. The present meeting therefore agreed that the list constituted a research framework within which, had they been implemented as proposed, many of the Scientific Committee's research needs, and hence those of the Commission, could well have been met. The extent to which those projects have in fact been implemented is detailed in Appendix 1 of Annex D.

It was also noted that since the Zeist meeting, developments in the IWC (e.g., the introduction of a 'pause' in commercial whaling, the undertaking of the Comprehensive Assessment) have necessarily resulted in changes of emphasis and the introduction of new aspects of scientific research in the Sanctuary (see Item 6).

4. SCIENTIFIC CONTRIBUTION OF THE SANCTUARY TO THE COMPREHENSIVE ASSESSMENT OF WHALE STOCKS AND THE CETACEAN COMPONENT OF THE GLOBAL PLAN OF ACTION FOR MARINE MAMMALS

This meeting draws the attention of the Administrative Meeting to the fact that the Sanctuary may also contribute to non-scientific objectives of the IWC and the Global Plan of Action (FAO/UNEP, 1985) not considered here. In this latter case, Recommendations 21, 25, 26, 28–31 and 38 are particularly relevant. (Annex E details the Recommendations summarised or referred to by number in this report.)

4.1 Comprehensive Assessment

The IWC has recently committed itself to a Comprehensive Assessment of whale stocks (Donovan, 1989) which, in broad terms, is concerned with obtaining enough information for the rational management of whale stocks on a sustainable basis.

It has already been suggested (Item 2.2) that aspects of research in the Sanctuary be incorporated into the wider context of the Comprehensive Assessment. SC/F87/S1 discusses some of the roles a Sanctuary might play in the management of whaling (see Item 6).

In general, the Sanctuary, assuming it is continued after the recommencement of whaling elsewhere, will allow the establishment of long-term projects of benefit to the Comprehensive Assessment, without the prospect of disruption of these due to whaling. It may also foster and encourage research which, while it may not appear to be of immediate direct value to management, may well become so later (e.g., research into new methodologies or into ecological subjects such as feeding strategy). In this latter case, experience has shown that one of the major features of the Sanctuary has been the focus it has provided which has been important in obtaining funds from non-government sources (one might expect priority in IWC funding to be given to projects directly related to the Comprehensive Assessment), and to stimulating interest in non-IWC Indian Ocean coastal states.

The meeting noted that many of the projects on large whales developed at Zeist (summarised in Appendix 1 of Annex D) will be of direct or indirect relevance to the Comprehensive Assessment either in terms of general application throughout the world (e.g. 7 and 16) or in assessing the status of stocks within the Sanctuary (e.g. 1, 2 and 3).

4.2 Global plan

The Indian Ocean Sanctuary has a number of features which relate directly to scientific and administrative aspects of the Global Plan of Action for the Conservation, Management and Utilisation of Marine Mammals.

Specifically with respect to the scientific aspects, the Sanctuary has since its inception contributed and may be expected to continue to contribute directly to the objectives of the Plan through the following Recommendations:

Recommendation 5 – the monitoring of kills of cetaceans in fishing and other gear and in floating debris;
Recommendation 14 – the development of cetacean conservation areas;
Recommendation 15 – furthering the IUCN workshop proposals on cetacean sanctuaries;
Recommendation 21 – the establishment of voluntary stranding and sighting networks in some countries;
Recommendation 25 – the encouragement of informal cooperation between governments for cetacean conservation;
Recommendation 26 – the convening of this meeting as a joint IWC/UNEP activity; and
Recommendation 38 – the preparation of the proceedings of this meeting which may serve as a background document for consideration at the Global Plan review meeting.

The continued existence of the Sanctuary, as presently conceived, also may be expected to contribute to the Global Plan of Action for the Conservation, Management and Utilisation of Marine Mammals through:

Recommendation 2 – the initiation of discussions among Indian Ocean states of a mutual policy for cetacean conservation;
Recommendation 8 – the occurrence and effects of pollutants on cetaceans;
Recommendation 9 – the monitoring of effects of man-induced environmental changes on cetaceans;
Recommendation 11 – the initiation of studies on the effects on cetacean populations of expanding fisheries directed towards the mammal's food supply;
Recommendation 12 – the identification of cases in which specific protective measures should be taken by individual governments or groups of governments; and
Recommendation 17 – the incentive hereby created for Indian Ocean states to identify shared resources to ensure that these resources are properly managed.

5. BOUNDARIES OF THE SANCTUARY

5.1 Scientific implications of the present boundaries and of any suggestions for change

The original proposal for the Sanctuary (Anonymous, 1979) had included a southern boundary at the ice-edge. The rationale was that the Sanctuary would then represent a coherent ecosystem and include the full range of the stocks of the large whale species occurring in the Indian Ocean.

In its discussion of the original proposal (IWC, 1980b, p.49) the Scientific Committee had been unable to agree on an appropriate southern boundary, some members favouring the ice-edge boundary and others a boundary at 40°S or in the 'vicinity of the Antarctic Convergence'.

For various reasons (Anonymous, 1979 suppl.), the original proposal was revised to incorporate a southern boundary at 55°S (thereby not interfering with pelagic minke whaling south of the Sanctuary) and this was adopted by the Commission.

Since then, the IWC has enacted a pause in commercial whaling and the two nations involved in pelagic minke whaling have indicated that this will cease after the current (1986/87) season.

The meeting agreed that extending the Sanctuary to the Antarctic would enhance its ecological coherence by including the total latitudinal range of the whale species within it. It would also serve to fulfil the Sanctuary objective to avoid the possibility of short term variation in catch levels should whaling resume. It was noted that the 1983 Colombo meeting (see Annex D) had recommended such an extension.

There was also some discussion of the scientific value of designating an area in the Antarctic where neither exploitation of whales nor their food supply took place, although this of course would require action by CCAMLR as well as the IWC.

The meeting noted that the question of stock boundaries for all species will be addressed during the Comprehensive Assessment and agreed that the details of possible adjustments of the boundaries, including the longitudinal boundaries, could be more appropriately discussed after those results become available.

5.2 Possible sub-areas within the Sanctuary for special purposes

In previous discussions of sanctuaries, the Scientific Committee had noted that for conservation and/or other scientific reasons, certain areas such as breeding grounds might require measures in addition to the prevention of direct exploitation (e.g. limitation of industrial development or other environmental disturbance). While these are in themselves outside the IWC's direct competence, the Commission has, in the past, encouraged member states to take the requisite action on a national basis by drawing their attention to the matter. This has also been the case for problems concerning small cetaceans, where there is disagreement within the Commission as to its competence to regulate catches of these animals or whether they are included in the provisions of the Sanctuary.

The Committee had identified two categories of sub-areas which might require special consideration:

(1) critical habitats;
(2) areas of special scientific interest.

In the former category, examples include the protection of the local environment from specific threats (such as to right whale nursery areas) or to local populations of cetaceans being reduced by entrapment in gillnets or other fishing gear.

The latter category includes areas where conditions for long-term studies of animals are good and need to be preserved (e.g. blue whales off Sri Lanka) or where long-term studies have already commenced.

The Meeting recommends that the Scientific Committee considers the need for special provisions in certain areas and informs the Commission so that it can encourage nations to take appropriate action.

6. FUTURE ACTIVITIES

6.1 Future research and management in the Indian Ocean contributing to IWC objectives

The role of sanctuaries in achieving the general objectives of the IWC in the management of exploited whale stocks is examined in SC/F87/S1.

The meeting recognised that a long-term sanctuary has a unique and essential scientific role in the management of whale stocks for sustainable exploitation, on the assumption that whaling will resume some time in the future outside it. Examples of this role include:

(1) the study of the ecology of whales, particularly allowing comparative studies of stocks within a sanctuary with exploited stocks elsewhere;
(2) the development and calibration of assessment methods;
(3) the monitoring of the recovery of depleted whale populations.

An example of (2) was given as the development of census techniques for sperm whales using combined visual and acoustic surveys in conjunction with information on the diving and acoustic behaviour of whales (Whitehead, 1987). With regard to (3), the Scientific

Committee has given such research a high priority (IWC, 1986). This meeting noted that the role of such studies in refining estimates of yield from whale stocks requires that monitoring continue through the range of stock abundance at which exploitation would normally occur.

As recorded earlier, research of value to both the Comprehensive Assessment of whale stocks and long-term management has occurred within the Indian Ocean Sanctuary. The meeting expected that continuation of the Indian Ocean Sanctuary would lead to further contributions to these activities.

The meeting noted that the location and extent of a sanctuary or sanctuaries required to fulfil a role in management will require consideration under the Comprehensive Assessment. Nonetheless, the meeting noted that the existing Indian Ocean Sanctuary has formed a valuable nucleus which has already led to achievement of some of the benefits of a sanctuary. In addition, in this context, the earlier discussion on altering the boundaries of the Sanctuary is relevant.

Two specific areas requiring action were discussed in some detail. The first concerned one of the proposals from Zeist which had not been implemented, i.e. the establishment of a strandings and sightings network. The meeting noted the value of such networks, recognising that although their utility was dependent on associated effort measurements, they could be particularly useful in stimulating public and scientific interest in areas where the knowledge of cetaceans is very limited. A sub-group was set up to discuss practical ways of assisting the establishment of such networks; their report is given as Annex F.

The second concerned the question of cetacean entanglements in gillnets and other fishing gear (and see Recommendation 5 of the Global Plan). Almost all participants, from both IWC and non-IWC states, reported incidental captures of cetaceans in fisheries off their coasts. In view of this, the meeting reiterates the recommendation of the Scientific Committee (IWC, 1986) for a Workshop to be held on the incidental take of cetaceans (both large and small) in gillnet fisheries, with the major objectives being to:

(1) identify new and expanding gillnet fisheries which take cetaceans;
(2) investigate how and why entanglement occurs;
(3) estimate mortality and assess its impact on cetaceans; and
(4) consider possible ways of reducing levels of gillnet mortality in cetaceans.

6.2 Future research and management in the Indian Ocean contributing to the Global Plan of Action for Marine Mammals

The meeting considered that the implementation of the research programme proposed previously at the Zeist meeting, and as amended at this meeting, would contribute significantly to answering several recommendations of the Global Plan of Action for the Conservation, Management and Utilisation of Marine Mammals, endorsed by UNEP, IWC, FAO and IUCN.

The meeting **recommends** that Indian Ocean states seriously consider implementing these activities, within the context of the IWC and/or within the context of the Regional Seas Programme of UNEP, or in cooperation between Governments, IWC, UNEP and other regional or international organisations.

It also **recommends** that UNEP, the IWC and its individual member states provide assistance to Indian Ocean coastal and Island nations, in the form of scientific advice, training opportunities and training fellowships, to enable these states to improve their capabilities with regard to the study and management of cetaceans in the Indian Ocean; and that coastal and Island nations of the Indian Ocean consider broadening, within the Regional Seas Programme of UNEP, the concept of the IWC Sanctuary to cover those species of cetaceans found in coastal waters which may not be covered by the Sanctuary in its present form.

6.3 Involvement of scientists from Indian Ocean countries in research work

The meeting recognised that research in the Indian Ocean Sanctuary was the responsibility of all IWC member nations, but that those bordering the Indian Ocean had a special responsibility in maintaining a long-term interest in research. The meeting also agreed that a greater involvement in research of scientists from Indian Ocean coastal states that were not members of IWC was desirable. In the latter connection, the Commission and its individual member states should take note of Recommendation 20 in the Global Plan of Action for Marine Mammals, encouraging the training of scientists working on marine mammals.

7. PUBLICATION OF DOCUMENTS

The meeting agreed that Leatherwood and Donovan should edit the papers from this meeting, together with any relevant unpublished papers from earlier meetings, in accordance with IWC editorial policy. Nielsen indicated that UNEP would fund the publication, which would appear in a relevant UNEP series.

8. ADOPTION OF REPORT

The meeting thanked all who had helped with the meeting arrangements, particularly Mrs Verity Hunter, who typed the report, and the management of the Reef Hotel.

REFERENCES

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83:376–94.

Anonymous. 1979. The Seychelles Initiative. Paper IWC/31/6 presented to the International Whaling Commission, July 1979 (unpublished).

Anonymous. 1981. *Report of the Workshop to Plan a Programme of Scientific Research On Cetaceans in the Indian Ocean Sanctuary*. Ministry of Cultural Affairs, Recreation and Social Welfare, Netherlands. 105pp.

Donovan, G.P. 1989. Preface [to the volume *The Comprehensive Assessment of Whale Stocks*]. *Rep. int. Whal. Commn* (special issue 11):iii-v.

FAO/UNEP. 1985. Marine Mammals: Global Plan of Action. *UNEP Reg. Seas Rep. Stud.* No. 55:[iv]+1–115 + Annex ([viii]+1–223).

International Whaling Commission. 1979a. Chairman's Report of the Thirtieth Annual Meeting. *Rep. int. Whal. Commn* 29:21–37.

International Whaling Commission. 1979b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 29:38–105.

International Whaling Commission. 1980a. Chairman's report of the Thirty-First Meeting. *Rep. int. Whal. Commn* 30:25–41.

International Whaling Commission. 1980b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 30:42–137.

International Whaling Commission. 1981a. Chairman's Report of the Thirty-Second Annual Meeting. *Rep. int. Whal. Commn* 31:17–40.

International Whaling Commission. 1981b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 31:51–165.

International Whaling Commission. 1982a. Chairman's Report of the Thirty-Third Annual Meeting. *Rep. int. Whal. Commn* 32:17–42.

International Whaling Commission. 1982b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 32:43–149.

International Whaling Commission. 1983a. Chairman's report of the thirty-fourth Annual Meeting. *Rep. int. Whal. Commn* 34:20–42.
International Whaling Commission. 1983b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 33:43–190.
International Whaling Commission. 1984a. Chairman's report of the thirty-fifth Annual Meeting. *Rep. int. Whal. Commn* 34:13–34.
International Whaling Commission. 1984b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 34:32–181.
International Whaling Commission. 1985. Report of the Scientific Committee. *Rep. int. Whal. Commn* 35:31–152.
International Whaling Commission. 1986. Report of the Scientific Committee. *Rep. int. Whal. Commn* 36:30–140.
International Whaling Commission. 1987. Report of the Scientific Committee. *Rep. int. Whal. Commn* 37:28–145.
Ross, G.J.B., Cockcroft, V.G. and Butterworth, D.S. 1986. Offshore distribution of bottlenosed dolphins in Natal coastal waters and Algoa Bay, Eastern Cape. *S. Afr. J. Zool.* 18:643–6.
Ross, G.J.B., Cockcroft, V.G., Melton, D.A. and Butterworth, D.S. 1989. Population estimates for bottlenose dolphins *Tursiops truncatus* in Natal and Transkei waters. *S. Afr. J. Sci.* 8:119–30.
Whitehead, H. 1987. Social organization of sperm whales off the Galapagos: implications for management and conservation. *Rep. int. Whal. Commn* 37:195–9.

Annex A

Agenda

1. Introduction
   - 1.1 History of the Sanctuary proposal
   - 1.2 The IWC response
   - 1.3 Highlights (summary of meetings held to consider research relevant to the Sanctuary, after its inception)

2. Past research
   - 2.1 Review of relevant research activities and main results
   - 2.2 Impact of existence of the Sanctuary on research

3. Scientific aspects of the effectiveness of the Sanctuary in meeting the objectives of the Commission

4. Scientific contribution of the Sanctuary to the Comprehensive Assessment of whale stocks and the cetacean component of the Global Plan of Action for Marine Mammals
   - 4.1 Comprehensive Assessment
   - 4.2 Global Plan

5. Boundaries of the Sanctuary
   - 5.1 Scientific implications of the present boundaries and of any suggestions for change
   - 5.2 Possible sub-areas within the Sanctuary for special purposes

6. Future activities
   - 6.1 Future research and management in the Indian Ocean contributing to IWC objectives
   - 6.2 Future research and management in the Indian Ocean contributing to the Global Plan of Action for Marine Mammals
   - 6.3 Involvement of scientists from Indian Ocean countries in research work

7. Publication of documents

8. Adoption of report

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Annex C

List of Documents

SC/F87/S

1. de la Mare, W.K. Factors in evaluating the Indian Ocean whale sanctuary.*
2. Kasuya, T. and Wada, S. Distribution of large cetaceans in the Indian Ocean appeared in the Japanese sighting records.*
3. Payne, R. Research on large cetaceans in the Indian Ocean Sanctuary area before and after establishment of sanctuary status.
4. Gambell, R. A preliminary account of the positions of sperm whales sighted off Durban, 1954–1968.
5. Gordon, J.C.D. The World Wildlife Fund's Indian Ocean sperm whale project: scientific research inside a cetacean sanctuary.*
6. Gordon, J.C.D. A note on the seasonality of breeding of Indian Ocean sperm whales.
7. Hembree, D. Cetacean sightings in the Indian Ocean Sanctuary by IDCR vessels en route to Mauritius.
8. Alling, A. Incidental records of small cetaceans in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984).
9. Leatherwood, S., Prematunga, W.P., Girton, P., McBrearty, D., Ilangakoon, A. and McDonald, D. Records of the 'Blackfish' (killer, false killer, pilot, pygmy killer, and melon-headed whales) in the Indian Ocean Sanctuary, 1772–1986.*
10. Kruse, S.L., Leatherwood, S., Prematunga, W.P., Mendes, C. and Gamage, A. Records of Risso's dolphins, *Grampus griseus*, in the Indian Ocean, 1891–1986.*
11. Ross, G.J.B., Cockcroft, V.G., Cliff, G. and Richards, H.W. The longshore distribution of the bottlenosed dolphin *Tursiops aduncus* on the Natal coast.
12. Ross, G.J.B., Cockcroft, V.G. and Melton, D.A. Population estimates for bottlenosed dolphins *Tursiops aduncus* in Natal and Transkei coastal waters.
13. Lichter, A.A., Praderi, R. and Castello, H.P. Right whale (*Eubalaena australis*) stranding and sighting South American network: a co-operative project.
14. Bwathondi, P.O.J. A review of the past, ongoing and planned activities in Tanzania related to marine mammals.
15. Leatherwood, S. Whales, dolphins and porpoises of the Indian Ocean cetacean Sanctuary: a catalogue of available information. (Hubbs Marine Research Center Technical Report 87– 197. 207pp.)
16. Bannister, J.L. Southern right and humpback whales: Western Australia.
17. Robineau, D. Centre National d'Études des Mammifères Marins: Review of activities in the Indian Ocean Sanctuary.
18. Rizvi, S.H. Niaz. Whales in Pakistani waters.
19. de Moussac, G. French purse seiners' sightings of whales starting in 1982.* (Data incorporated into Robineau, this volume).

* published in this volume.

Annex D

Summary of Meetings held to Consider Research Relevant to the Indian Ocean Sanctuary, After its Inception

ZEIST WORKSHOP

A Workshop to plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary was convened in Zeist, Netherlands, from 28 September to 1 October 1981, under the sponsorship of the Governments of Seychelles and Netherlands and with the support of the IWC, IUCN and World Wildlife Fund (Anonymous, 1981). The Workshop agreed on a set of objectives for a research programme in the Sanctuary. It is worth repeating these here since they may provide a template against which to evaluate the studies that have been conducted so far. They were:

(1) to satisfy the needs of the IWC Scientific Committee particularly in obtaining adequate information about the distribution and abundance of whales, their reproductive behaviour and related matters relevant to assessment of stocks;
(2) to obtain scientific information pertinent to assessing and realising the economic, cultural and scientific values of living cetaceans;
(3) to enhance the understanding of the ecological roles of cetaceans in marine biological systems and to permit assessment of the impact of human activities on recovering and unexploited populations;
(4) to focus attention on the development and application of benign research techniques;
(5) to foster investigations on the frontiers of research on living cetaceans, such as communication, navigation, behaviour and physiology of diving;
(6) to ensure the establishment of centres of research on cetaceans in the Indian Ocean and to further communication about cetacean research among Indian Ocean coastal states and between them and others involved in such research.

It was considered that a programme of research having these objectives would contribute to a number of broader programmes of marine scientific activity, including the International Decade of Cetacean Research, the UNEP/FAO Global Plan of Action for the Conservation of Marine Mammals and the World Conservation Strategy.

The Workshop formulated 24 research projects. In this process, it was noted that a five year constraint for providing population estimates that had been suggested by the Scientific Committee in 1980 was unrealistic. The list included methodological projects and species-oriented projects. With regard to the former, doubts were expressed as to whether it was timely to draw up a long-term research programme. Although the information that eventually comes from long-term studies far outweighs, in quantity and quality, any arising from short surveys, the necessary literature review had not yet been done and it was considered that a number of exploratory field trips were needed to identify suitable locations for intensive study of selected species. It was also agreed that it would be necessary to coordinate research within the Sanctuary with that in adjacent areas, especially to the south.

The identified projects were derived from an exploration by the Workshop of five loosely defined problems:

(a) planning and coordinating sightings surveys and other remote sensing;

(b) understanding behaviour and ecology by making close encounters from surface vessels and submersibles and by diving;
(c) determination of distribution, migration and population identity;
(d) obtaining information and materials from strandings, incidental/accidental catches and from scientific samples; and
(e) acquiring information from old records (log books, port records, etc.) and about existing biological materials and sighting data.

The Report of the Zeist Workshop was discussed at the 1982 Scientific Committee meeting (IWC, 1983). The only proposal which received any comments was proposal 18 (as listed in Appendix 1), which the sub-committee on minke whales regarded as impractical given the state of the art for the identification of minke whales. There was little general comment on the Report by the Scientific Committee and no discussion by the Commission (as reflected in the Chairman's Report) other than a notation that it had 'received' the Report. At that meeting, however, the Commission did endorse the holding of the present scientific meeting (although it had envisaged it's being held a little earlier) noting that activity would be 'centred' on species listed in the Schedule.

INTERNATIONAL CONFERENCE ON CONSERVATION AND MANAGEMENT OF MARINE MAMMALS, COLOMBO, SRI LANKA, FEBRUARY 1983

This meeting agreed a number of recommendations which related directly to certain of the proposals from the Zeist Workshop, and which were thought to be immediately feasible for many Indian Ocean coastal states. These included the creation of a network for reporting and evaluating strandings data (involving designating focal points, providing manuals and training, etc); arrangements for collaboration among local laboratories and specialists in the region; creation of small protected areas within the Sanctuary; recording of accidental and incidental catches; the extension of benign research that had started off in Sri Lanka and Oman, to other parts of the region. The conference also called upon the IWC to clarify which species of cetaceans were covered by its Sanctuary decision, and to reconsider the original proposal that the southern boundary be the Antarctic ice-edge on ecological grounds.

There appear to be no comments, either from the Scientific Committee or the Commission, on the report of this meeting.

SYMPOSIUM ON ENDANGERED MARINE ANIMALS AND MARINE PARKS, COCHIN, INDIA, 12–16 JANUARY 1985

Although this was formally a national symposium it had international scientific participation and took a regional perspective. The symposium did not make recommendations, but a number of papers relevant to scientific work in the Sanctuary were presented, discussed and subsequently published.

Appendix 1

PROJECTS IDENTIFIED AT THE ZEIST WORKSHOP

1. *Review of available data on the Indian Ocean cetaceans*
   Unfunded, but begun by Leatherwood, see (SC/F87/S15), assisted by Ross, Robineau and others.

2. *Study of historical materials relating to 19th C whaling in the western Indian Ocean*
   Not funded and not implemented.
3. *Analysis of logbook records from the eastern Indian Ocean*
   Bannister and an assistant. Partially implemented, only for right whales.
4. *To promote and co-ordinate use of platforms of opportunity*
   Not funded, but partially implemented on an *ad hoc* basis.
5. *Conduct a series of field trips to locate possible sites for long-term studies involving close encounters with whales*
   To be carried out principally by Darling and Ellis, with priority to: killer whales off South Africa; Bryde's whales off South Africa and S.E. Madagascar; humpback whales off Kenya, Mozambique, Oman, India; sperm whales off Mauritius. Although not implemented as envisaged in the proposal, clearly some relevant work has been carried out (e.g. see proposals 10 and 11).
6. *Investigate the presence of sperm whales in the waters around Mauritius*
   Will be carried out by Payne in the near future.
7. *Identify optimal sampling strategies for estimating the mean density of a given whale target in a given region over a given interval*
   To be carried out by Hiby. Partially implemented, with some field work off NE Sri Lanka, although most work carried out outside the Sanctuary.
8. *Sub-surface observation (diving and submersibles), particularly of sperm whales*
   Diving carried out during 'Tulip' project. Submersible technology is only now becoming available.
9. *To determine to what extent the blue whales seen in the Sanctuary are 'normal' blue, pygmy or both*
   Partially implemented.
10. *Conduct a long-term study of Bryde's whales in southwestern Indian Ocean*
    Not implemented. However, a sightings cruise for the South African inshore population was undertaken and some individual identification of Bryde's whales has been carried out in this area and elsewhere in the Sanctuary.
11. *To detail the existence of killer whale populations within the Sanctuary and the feasibility of conducting assessment studies by applying techniques of photographic and acoustic identification developed elsewhere*
    Not funded. However a programme of photo-identification of killer whales at the Prince Edward Islands has been initiated incidental to elephant seal research.
12. *Investigation of transequatorial links among humpback whales*
    Not yet implemented. Some song analysis begun in the Northern Hemisphere and recordings will be attempted in the Southern Hemisphere (Madagascar, Comoros and Aldabra) this year.
13. *Photo identification of humpbacks off Western Australia*
    Being partially implemented.
14. *Estimates of relative abundance of sperm whales off recently closed land stations*
    Not implemented.
15. *Survey of sperm whales and other cetaceans in the Seychelles area*
    One season aerial survey funded by IFAW and Seychelles government.
16. *Behaviour of sperm whales in the Indian Ocean*
    Funded by WWF for three years.
17. *Status of cetaceans in the waters of Oman*
    Partially accomplished in course of implementation of Project 16.
18. *Identification of minke whales*
    Not implemented.

19. *Photogrammetric aerial surveys of inshore delphinids off Natal and Transkei and offshore* Delphinus delphis *in the same area*
    Partially implemented.
20. *Aerial and shore inventory of cetacean species east and west of southern Madagascar*
    Will be begun in 1987 by P. Folkens, Oceanic Society.
21. *Placement of observers on R.V.* Marion Dufresne, *sailing between France and Terres Australes et Antartiques Françaises*
    Implemented.
22. *Obtain biological information and continuing statistics regarding subsistence whaling in Indonesia*
    Implemented and continuing.
23. *To study cetaceans in the Sanctuary*
    This very general title covered a variety of observations and studies to be made from SRV *Regina Maris*. Not implemented, as vessel did not visit Indian Ocean.
24. *Data collection and administration*
    This heading covered a project to establish a secretariat to assist in the collection and storing of data obtained under all projects, to facilitate the participation of Indian Ocean states, prepare manuals, organise training and exchanges, etc. Sri Lanka has established the Centre for Research in Indian Ocean Marine Mammals (CRIOMM) and has offered to serve such a purpose if funding becomes available.

Annex E

Full Texts of Recommendations of the Global Plan of Action, Referred to in this Report

Recommendation 2

The activities to be implemented after the first biennium of the Plan should contain a proposal as to the means by which a review of relevant information, concepts and alternatives for global objectives for the conservation of marine mammals would be undertaken. Part of this review should be the evaluation of the consequences these alternatives might have for the marine ecosystem and the rational utilisation of its other (non-mammal) resources.

Recommendation 5

Further to Recommendation 4, Governments should be requested to provide information on the past and present numbers and kinds of marine mammals killed incidentally to other activities in their waters or by their nationals, and to maintain these data for the future. FAO should be requested also to undertake this task, either directly or in association with the proposed Plan Secretariat.

In carrying out this and the previous task, FAO should consult closely with the countries concerned. In addition, it should seek the assistance of IWC, NPFSC, the Inter-American Tropical Tuna Commission (IATTC), the International North Pacific Fisheries Commission (INPFC), the Northwest Atlantic Fisheries Organisation (NAFO), the International Council for the Exploration of the Sea (ICES), IUCN, and other appropriate international bodies. In the first stage FAO, in consultation with ICES, should send inquiries to its field officers for collecting data which would provide some bases for a consultant study. This study might be followed by a small workshop to discuss the results.

Recommendation 8

UNEP and FAO: (a) commission a consultant study and review of what is known about the contamination of marine mammals; (b) arrange for the Inventory of Data on Contaminants to be kept up to date and improved in its coverage of studies of marine mammals and consider its expansion to include, where practicable, summaries of the data themselves as well as the locations of data; (c) invite ICES and IOC to cooperate in the preparation of a review of information on the occurrence of contaminants in the tissues of marine mammals, on the effects on the mammals and on the deaths or injuries to marine mammals presumed to be caused by contaminants.

Recommendation 9

UNEP and FAO arrange for a consultant study of the effects of man-induced environmental changes on marine mammal populations with the aims of:

(a) Identifying those populations at greatest risk from this cause;
(b) Assessing the nature and probably future trends of the most important causes of such risks.

Recommendation 11
FAO should examine the effects on marine mammal populations of recently expanding fisheries directed toward their food supplies, paying particular attention to the effects of the demersal fishery in the Bering Sea and the capelin fishery in the Northwest Atlantic.

Recommendation 12
(a) The *ad hoc* planning and coordinating committee, in consultation with the *ad hoc* advisory committee of scientists, seek to identify cases in which specific protective measures should be taken by individual Governments or groups of Governments to enhance the chance of survival of threatened marine mammal populations;
(b) UNEP and FAO, in consultation with IUCN and other appropriate bodies, provide upon request technical advice to such governments to take whatever legal or administrative steps may be necessary and, if required, seek sources for such technical and financial aid as may be needed.

Recommendation 14
UNEP, in cooperation with IUCN, IWC and FAO, support any initiatives taken by national Governments, individually or jointly, toward the development of objectives and practices of conservation area management at least in their own regions, and initiate any appropriate actions.

Recommendation 15
(a) IUCN, in association with UNEP, initiate actions based on the proposals of the IUCN/UNEP/WWF Workshop on Cetacean Sanctuaries held in Mexico in 1979, as they may be further developed by the competent organs of IUCN, including: (i) preparation of lists of proposed sanctuaries; (ii) public awareness activities.
(b) UNEP, IUCN and IWC explore the possibilities of including certain areas beyond national jurisdictions within conservation areas;
(c) UNEP make the necessary approaches to intergovernmental bodies, both within and outside the United Nations system, as will be called for in implementing the Plan of Action for marine areas outside national jurisdiction.

Recommendation 17
UNEP, FAO and the secretariat of CMSWA urge Governments concerned to identify the marine mammal resources which they share with other States and enter into bilateral or multilateral negotiations, as appropriate, to ensure that these resources are properly managed.

Recommendation 19
(a) FAO and UNEP examine the present and proposed coverage of existing information systems and make specific proposals for improving and coordinating them, or for a special new system if this seems desirable. In this task, account should be taken of the possibilities provided both by ASFIS and by INFOTERRA;
(b) Consultations be held with IOC (IODE/MEDI) as to whether the WDCs can participate usefully in the storage and retrieval of data relevant to the conservation of marine mammals.

Recommendation 20
(a) UNEP and UNESCO/IOC, in cooperation with non-governmental sources of funds, seek to make available a number of fellowships each year for tenure up to two years, for specialised training at designated institutions and on vessels;

(b) National research organisations, both public and private, arrange to accept fellows from their own and foreign countries under conditions to be determined;
(c) UNEP and UNESCO cooperate, with the assistance of FAO, in establishing a short list of research and educational institutes (including research vessels) prepared to accept fellows and to which assistance might be provided in dealing with the instructional load thereby imposed; NGOs with special interest in training facilities (eg IOI) be asked to assist in this task;
(d) International and regional organisations concerned assist in identifying specific training needs;
(e) Governments make provision for employment of those trained as marine mammal specialists through this programme in their service, or support their employment in universities or research institutions;
(f) National agencies and international organisations make available funds to permit experienced scientists to make advisory visits to localities in other countries where research activities are just beginning, and particularly to which fellows who have received initial training are returning.

Recommendation 21
(a) UNEP and IUCN, upon request, should provide assistance to any interested Government in setting up systems for public participation in marine mammal observations. This assistance could include advice concerning log-books, identifying charts, communication arrangements and so on;
(b) An appropriate body undertake to compile an inventory of existing arrangements;
(c) UNEP, in consultation with IUCN, arrange for a small group of experts nominated by Governments to be assigned the task of preparing proposals for the development of world and regional networks of such activities.

Recommendation 23
The United Nations and its specialised agencies, as appropriate:

(a) Urge Governments to seek to ensure that adequate provisions for the conservation of marine mammals are included in the instruments resulting from the adoption of the United Nations Convention on the Law of the Sea, and arrange that assistance is available to Governments and to international organisations, upon request, in their preparations to take action in this regard;
(b) Assist States, upon request, in preparing any actions which may be desirable and in accordance with existing international law and practice, for the conservation of marine mammals in waters under their jurisdictions or with respect to their nationals and to vessels flying their flags;
(c) Inform Governments of the advantages that their adherence to the relevant conventions would bring for the conservation of marine mammals, and encourage them to adhere to appropriate international agreements so as to bring them into effect or to make them more fully effective, as the case may be, and also encourage them to enact appropriate national legislation for implementing the commitments they thereby accept;
(d) Seek to ensure, through the organisations and secretariats concerned, that relevant marine mammals, especially threatened species, are included in lists annexed to the conventions or otherwise covered by them;
(e) Assist Governments, on their request, in the drafting of appropriate national legislation and regulations.

Recommendation 25
FAO and UNEP jointly seek to ensure that arrangements are made in the interim until the United Nations Convention on the Law of the Sea is in force so that as far as possible the requirements for marine mammal conservation are met by informal cooperation between Governments and through existing regional and specialised organisations.

Recommendation 26
UNEP draw the attention of Governments and organisations concerned to the need for coordination with respect to marine mammal conservation between international organisations having overlapping interests, and identify the specific problems in each ocean area.

Recommendation 28
(a) IUCN ensure, as follow-up to its project in cooperation with UNEP on cetacean sanctuaries, that the legal issues are explicitly considered, and that proposals for international agreement on these matters, through existing mechanisms or otherwise, are formulated and submitted to Governments for their consideration;
(b) IUCN, in cooperation with FAO, ensure that in any follow-up to its project on the incidental take of marine mammals in fisheries the legal issues are explicitly considered and proposals for international agreements, through existing mechanisms or otherwise, are formulated and submitted to Governments for their consideration;
(c) IUCN study legal problems relating to live capture and harassment, with a view to developing proposals for international agreements on these matters, through existing mechanisms or otherwise.

Recommendation 29
UNEP and IUCN, having supported the preparation of the Convention on the Conservation of Migratory Species of Wild Animals:

(a) Promote wide participation in and effective implementation of the convention;
(b) Arrange for the preparation of guidelines for the application of the Convention to marine mammals, taking into account the status that they as "highly migratory species" may be granted under the Convention on the Law of the Sea and under specific regional agreements, and make these guidelines available to interested Governments.

Recommendation 30
UNEP, in cooperation with UNESCO:

(a) Invite Governments concerned to consider the inclusion in their nominations for the World Heritage Lists of: (i) the breeding area of the southern right whale off the Valdez Peninsula, Argentina; (ii) areas of the Sea of Cortez, Mexico, which are important to the conservation of gray whales;
(b) Consult with the *ad hoc* planning and coordinating committee and the *ad hoc* advisory committee of scientists to identify further areas where inclusion in the World Heritage Lists would aid the conservation of threatened populations of marine mammals;
(c) Urge the Governments in whose jurisdictions such areas lie to nominate them for inclusion in the Lists;
(d) Encourage any relevant State which has not yet adhered to the World Heritage Convention to do so.

Recommendation 31
UNESCO and UNEP consult on ways in which the need to provide improvement in the establishment of protected areas for marine mammals can be associated with the Biosphere Reserves system under the Man and Biosphere Programme.

Recommendation 38
(a) UNEP, FAO and IUCN jointly convene a Review Meeting to be held towards the end of the first biennium of the Plan. The purpose of this meeting would be to review the progress which has been made and to consider and make recommendations on the draft proposals and budget for new activities. The meeting should consist of the planning and coordinating committee and the *ad hoc* advisory committee of scientists together with an approximately equal number of representatives of the Governments concerned.

Annex F

Establishment of Strandings and Sightings Networks

BACKGROUND

Proposals for establishment of stranding networks were made and recommended at the meeting in Zeist in 1981. Support for these proposals was reiterated at the meetings in Colombo, February 1983, and at the Workshop on strandings conducted at the IWC meeting in 1984 (IWC, 1985). The proposals considered, amongst other aspects, the need to locate and catalogue existing material, the likelihood of success in implementing stranding networks in the various Indian Ocean states, the minimum data to be collected from strandings (and incidental takes and live captures), the need for a practical handbook and poster campaigns and the establishment of central data and material storage in the Indian Ocean, together with alternative facilities. The value of strandings as a source of data was discussed, particularly in 1984. In general, participants agreed that potentially strandings could provide a considerable volume of valuable data on several biological aspects, though the 1984 meeting stressed that sampling had to be done as systematically as possible, so that the extent of biases inherent in samples obtained from stranded animals could be evaluated.

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Little implementation of the above proposals has taken place in the Sanctuary since 1981, with the exception of certain countries, particularly Sri Lanka, and some others such as Seychelles and Tanzania, whose activities indicate an active interest in such a network. [The present proposals differ from previous ones in the inclusion of sightings as part of the network.]

The initiation of a regional cooperative network in Argentina, Brazil, Chile and Uruguay to report on strandings and on sightings of selected cetacean species has suggested an approach to the problem of establishing networks in the Sanctuary area (SC/F87/S13). Many of the original proposals still stand – the need for identification guides, posters, training of observers and designation of regional data and material storage facilities. The South American approach, however, is designed to develop in steps, from a regional network on one or few species, to a broader regional and species base as enthusiastic personnel are identified and trained.

The group proposes that

(a) Efforts be made to establish one or more regional groups in the Sanctuary area, based on the structure and experience of the South American network. A regional coordinator should be designated to develop each of these groups. The coordinators should be preferably biologists actively involved in cetacean work. While not prescribing to the countries involved, we suggest that the following countries and persons may be appropriate nuclei for these networks:

   (1) Mr Tas'an of Indonesia, to coordinate Indonesia, Sumatra, Malaya, Burma and Thailand;
   (2) A NARA biologist (Sri Lanka) to coordinate Pakistan, India, Bangladesh, Sri Lanka, Maldives and Laccadives;

(3) A coordinator to be identified for the Gulf states, Oman, Yemen and South Yemen, states bordering the Red Sea, Djibouti and Somalia.
(4) Seychelles Fisheries biologist (Mahé) to coordinate Seychelles and other western Indian Ocean islands, and for the East African coastal states of Mozambique, Tanzania and Kenya.

(b) A simple illustrated identification guide requiring minimal text should be developed, to be of maximum value in various countries with different languages. Questionnaires should also be developed. Funding for production and distribution may be available through UNEP, possibly in association with the IWC.
(c) Participants should be selected on experience, where possible, and an enthusiasm for both the task and taking relevant training for it. Training of personnel in identification and other techniques should be undertaken under the direction of IWC and UNEP. Although initially networks are more likely to provide first order data (eg presence/absence of a species in an area), efforts should be made to recruit those in a position to provide some indication of sighting effort for sightings data, eg fisheries officers on coastal patrols. Appropriate methods for providing feedback to participants. Rights to publication of data need to be clarified.
(d) Although fisheries agencies or similar bodies are likely to be prime participants in such networks, it is important that data and material be lodged at a selected museum or similar institution, which can provide a long-term commitment to their care.

Records of the 'Blackfish' (Killer, False Killer, Pilot, Pygmy Killer and Melon-headed Whales) in the Indian Ocean, 1772–1986

Stephen Leatherwood[1], Donna McDonald[2], W. P. Prematunga[3], Phillip Girton[4], Anouk Ilangakoon[3] and Dennis McBrearty[5]

ABSTRACT

The status of knowledge about stock identity, distribution, movements and exploitation of the 'blackfish' in the Indian Ocean is reviewed. Sources include published accounts, museum and other institutional specimens and records and research of authors and colleagues. Killer whales may be found virtually anywhere in the Indian Ocean but have been seen most frequently around island groups, in both coastal and pelagic waters. Data from Soviet research cruises suggest that some Southern Hemisphere killer whales migrate northward, to as far as 20°S, in austral winter, then southward again in spring. However, some whales are present year-round in the central and northern Indian Ocean. Some killer whales are taken – deliberately by subsistence fishermen at Lamalera, Indonesia, and incidentally in gillnets in Sri Lanka. Killer whales reportedly helped 19th century whalers at Twofold Bay, Australia, catch baleen whales, but others interfered widely with longline fisheries for tuna from 1952 through 1963, 'attacking' fish on lines during up to 96% of the operations, destroying 55 to 100% of the catch per attack, and causing, in combination with sharks, loss of at least 4% of the annual catch. False killer whales are known from mass- and individual-strandings and occasional sightings and captures. For example, small numbers (less than 1% of the total catch of 810) were landed in northeastern Sri Lanka in 1984–6. False killer whales do not appear uncommon in the Northern Hemisphere waters of the Indian Ocean but are represented to date by only a handful of records from around the coastal margins of the Southern Hemisphere. Both long-finned and short-finned pilot whales have been identified from the Indian Ocean, the former from southern Australia, the latter from the Seychelles and Sri Lanka. Species identity has not been investigated in most of the estimated 125 records from the Indian Ocean. A few pilot whales are killed annually by Lamalera whalers; a few are taken in gillnets in Sri Lanka, mostly in February and May. Pygmy killer whales were first recorded off South Africa in 1969 and were only recently confirmed from the Indian Ocean Northern Hemisphere. Now, however, they appear frequently in Sri Lankan fish markets, harpooned and killed in gillnets, and are documented in sightings at sea in various locations. Measurements and reproductive information for 13 Sri Lankan specimens are comparable to those from elsewhere. Melon-headed whales are more widely known, usually above 10°S and usually in pelagic regions. Some are taken by whalers at Lamalera and harpooned or taken incidentally in gillnets off Sri Lanka.

Keywords: killer whale; false killer whale; pilot whale – long finned; pilot whale – short finned; pygmy killer whale; melon-headed whale; review; distribution; migration; strandings; sightings – incidental; whaling – aboriginal; whaling – modern; incidental capture.

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INTRODUCTION

In 1981, following the recommendations of the meeting in Zeist, the Netherlands, to plan a program of scientific research in the then newly formed Indian Ocean Sanctuary (Anonymous, 1981) (Fig. 1), the senior author began compiling information on marine mammals of the Indian Ocean. The principal purpose was to provide background for indepth investigations to be planned and conducted within the region by various workers. A preliminary catalogue of findings, without analysis, was completed in 1986 (Leatherwood, 1986). Data from that catalogue have since been incorporated into studies of Risso's dolphins, *Grampus griseus* (Kruse, Leatherwood, Prematunga, Mendes and Gamage, this volume), pygmy and dwarf sperm whales, *Kogia breviceps* and *K. simus* (Chantrapornsyl, Kinze, Leatherwood and Prematunga, this volume) and humpback whales, *Megaptera novaeangliae* (Reeves, Leatherwood and Papastavrou, this volume) and into a major program of research and conservation of marine mammals in Sri Lanka, 1985–6 (Leatherwood and Reeves, 1989).

Fig. 1. The Indian Ocean Sanctuary, showing coastal states bordering the Sanctuary and some of the place names referred to in the text and tables.

This paper reviews information available through 1986 on the distribution within the Indian Ocean of the five species of toothed cetaceans often referred to as 'blackfish': the killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), pilot whale (*Globicephala sp.*), pygmy killer whale (*Feresa attenuata*), and melon-headed whale (*Peponocephala electra*). It also summarizes data available on abundance, habitat preferences, available specimen materials and past and current exploitation.

MATERIALS AND METHODS

Published literature was assembled and reviewed. Colleagues were queried for unpublished information in their files. North American, Asian, African and European museums, research laboratories and academic institutions were canvassed for summaries of specimens and data in their collections (Leatherwood, 1986). All data from all sources were tabulated, plotted and examined for patterns in distribution, migration and abundance. Further data were collected during various activities of the authors as follows:

In 1975, the Dolphin Survey Project (DSP) was established to solicit and archive sightings of whales and dolphins made by observers aboard British ships and yachts. Like other programs of this kind (e.g. the U.S. National Marine Fisheries Service's Platforms of Opportunity Program and the U. S. Navy's Whale Watch Program, now defunct) the DSP was based on the knowledge that, provided they were given adequate aids to identification and their reports were subjected to careful scrutiny to verify species identity, opportunistic observers can be a valuable source of basic information on distribution of cetaceans worldwide. Information from such observers is of particular importance in remote regions not easily accessible to scientists. Based on successes during the period 1975–77 (e.g. McBrearty, 1981; 1986), the DSP was modified and put into operation in its present structure in 1978 (McBrearty, 1985).

From 1982 through 1986, the senior author conducted: vessel surveys from Singapore to Sri Lanka, and visits to fishing villages *en route*, April 1982; vessel, aircraft and land-based surveys off Sri Lanka, 22 February through 6 March 1983; vessel surveys from Djakarta to Mahe, Seychelles, and visits to various scientific institutions *en route*, April 1983 (Leatherwood *et al.*, 1984); and vessel surveys and visits to fish–landing sites and scientific institutions in Sri Lanka, 6–19 March 1984 (Leatherwood, 1985), 21 May–8 June 1985, 28 July–6 August 1985, 28 January–8 February 1986 and 27 February–3 March 1986 (Leatherwood and Reeves, 1989).

During 1985 and 1986, personnel of the Sri Lankan National Aquatic Resources Agency (NARA), under supervision of the senior author and fellow consultants Roger Payne and Abigail Alling, conducted a multi-faceted program of education, conservation and research activities focusing on marine mammals of Sri Lanka (Leatherwood and Reeves, 1989). Most pertinent to this paper, participants conducted vessel surveys and visited fish-landing sites to log cetaceans landed in fisheries and to collect biological data on cetaceans observed in the catch. Biological specimens were collected during this program, but as of this writing remain unanalyzed.

RESULTS AND DISCUSSION

Killer whale

Killer whales are cosmopolitan in distribution, although they are believed to be most prevalent in high latitudes of both hemispheres and to have centers of greatest abundance within about 800km of continents (Matkin and Leatherwood, 1986). Distribution is often patchy. Although apparently nowhere rare, threatened, or endangered, killer whales appear to exist in most areas in only moderate numbers, as one would expect of a top

Table 1

Published sightings and specimens of killer whales in the Indian Ocean, 1772 through 1986.

Code	Date	Location	Comments/Source
1	11 Dec 1772	51°51'S, 21°03'E	Sightings of 'Grampus...O. gladiator' (Forster,1772)
2	?? 1837	Algoa Bay, South Africa	Skull (A3209) at MNHN (coll. by Verreaux)
3	unreported	Nicobar Island	Skull w/o lower jaw (1-70)at BNHS (Pilleri and Gihr, 1973-74)
4	? Apr 1868	W.coast, Sri Lanka	Sighting(Blanford, 1891)
5	? ? ?	Seychelles	Skull (unnumb.) at BMNH (Blanford, 1891)
6	? ? ?	off Chilaw, Sri Lanka	Sighting (Holdsworth 1872, *fide* de Silva 1987) 7
7	? 1943	Armada, India	Stranding (Moses, 1948)
8	1960,6,7,8,9	Lamalera, Lembata, Indo.	3,1,2,1, and 1 killed (Hembree, 1980)
9	Mar-Nov '66	46°25'S, 51°45'E	Sightings (Voisin, 1972)
10	14 Nov 1966	46°25'S, 51°45'E	Young male killed (Voisin, 1972)
11	22 Aug 1969	Off Natal, So. Africa	3 animals seen from R/V *Edwin Cook**
12	24 Aug 1969	Off Natal, So. Africa	8 animals " "
13	31 Aug 1969	Off Natal, So. Africa	12 animals " "
14	? Jan 1971	Minicoy Is., Lacadives	6 animals seen (Morzer-Bruyns, 1971)
15	? ? 1972	Maldives	Tooth (Pilleri and Gihr, 1973-4)
16	9 Feb 1972	Off Natal, So. Africa	10 animals seen from R/V *G.G. Hovelmeier**
17	8 Feb 1973	Off Natal, So. Africa	2 animals seen from R/V *Pieter Molinaar**
18	10 Feb 1973	Off Natal, So. Africa	10 animals seen from R/V *Pieter Molinaar**
19	14 Feb 1973	Off Natal, So. Africa	5 animals seen from R/V *Pieter Molinaar**
20	Jan-Apr 1974	Hog Island, Crozet	38 sightings, incl. 27 adult males (Voisin, 1976)
21	20 Jan 1974	31°04'S, 58°50'E	5 animals seen (Gambell *et al.*, 1974); male collected, skull #36953 at SAM
22	25 Jan 1974	35°57'S, 23°53'E	11 seen, 3 marked (Lockyer, 1979)
23	27 Jan 1975	Off Natal, So. Africa	5-10 animals seen from R/V *Pieter Molinaar**
24	22 Oct 1976	Marion Island	3.8m male stranded (Conde *et al.*, 1978)
25	10 July 1979	10 km S. of Lamalera	2 pods (6,4) seen (Hembree, 1980)
26	19 July 1979	6 mi. S. of Lamalera	5.5m female harpooned (Hembree, 1980)
27	23 July 1979	off Lamalera	1 whale struck-and-lost (Hembree, 1980)
28	16 Aug 1980	6°6'S, 57°36'E	3 animals seen (Keller *et al.*, 1982)
29	? ? ?	Pakistan	stranding (F Ahmad, 1982, *fide* de Silva 1987)
30	17 Apr 1982	12°55'N, 96°48'E	7 animals seen (Leatherwood *et al.*, 1984)
31	? ? 1982	Kirinda, Sri Lanka	Specimen entangled in gillnet (Leatherwood and Reeves, 1989)
32	12 Apr 1983	NE. of Andaman Islands	Sighting (crew of M/S *World Discoverer*) (Leatherwood *et al.*, 1984)
33	20-6 May 1983	Dirk Hartog Is.,Austral.	Pods of 2-10 attacking dugongs (Anderson and Prince, 1985)
34	14 July 1983	Kottegoda, Sri Lanka	7-8m animal taken in gillnet (Leatherwood and Reeves, 1989)
35	1 Feb 1985	Beruwala, Sri Lanka	Animal possibly taken in gillnet (Alling, 1985)
36	11 Mar 1985	Beruwala, Sri Lanka	Animal possibly taken in gillnet (Alling, 1985)
37	22 Nov 1985	8°28.2'N, 50°21'E	2 animals seen (Small and Small, this volume)
38	12 Jan 1986	11°34.7'N, 49°57'E	3 animals seen (Small and Small, this volume)
39	6 Feb 1986	12°N, 51°1'E	7 animals seen (Small and Small, this volume)
40	8 Apr 1986	Pitipana, Negombo, Sri Lanka	111-in. female caught in gillnet (Leatherwood and Reeves, 1989: fig. 25)
41	? May, 1986	7mi.off Columbo, Sri Lanka	30 or more animals seen (Gunaratna, 1986)

Footnotes: MNHN=Muséum National d'Histoire Naturelle, Paris. Information provided to Leatherwood by Daniel Robineau; BNHS=Bombay Natural History Society, Bombay; BMNH=British Museum of Natural History, London; SAM = South African Museum, Durban.

*Unpublished reports from whale marking cruises off Natal, data courtesy R. Gambell, IWC

Table 2

Unpublished sightings of killer whales in the Indian Ocean, 1976 through 1986.

Date	Position	No.	Source
04 Sep 1976	05°43'N, 95°40'E	4-5	A. Collet, cited in Leatherwood and Clarke (1983, unpublished)
06 Dec 1978	13°20'S, 83°20'E	2	W.A. Murison to Dolphin Survey Project (DSP)
09 Sep 1979	34°31'S, 24°32'E	1	R.S. Wheeler to DSP
30 Jan 1980	21°06'N, 59°41'E	8	J.N. Duckworth to DSP
09 Feb 1980	21°45'N, 60°02'E	6	J.N. Duckworth to DSP
08 Mar 1980	27°30'N, 56°10'E	6	G.A. Lancaster to DSP
17 Apr 1980	11°27'N, 53°15'E	8	R.M. Hughes to DSP
25 Apr 1980	35°23'S, 118°23'E	6	R.A. Wilson to DSP
26 Sep 1980	10°00'N, 71°20'E	1	O.A. Howorth to DSP
24 Nov 1980	33°16'S, 80°47'E	25	J.R. Twiss to DSP
08 Dec 1980	46°05'S, 50°30'E	9	J.R. Twiss to DSP
12 Dec 1980	50°40'S, 29°22'E	1	J.R. Twiss to DSP
12 Sep 1981	34°10'S, 23°05'E	2	N. Rice to DSP
28 Nov 1981	22°38'N, 59°53'E	2	Capt. Lockwood to DSP
29 Apr 1982	Gulf of Aden, off Rashafun	1	J. Sullivan, pers. comm. to Leatherwood
14 Aug 1983	15°15'S, 87°21'E	1	Capt. M. Heron to DSP
17 Nov 1983	21°40'N, 59°40'E	5	O.J. Podmore to DSP
24 Nov 1983	04°55'N, 81°00'E	4	D.R. Norman to DSP
07 Jan 1984	36°23'S, 29°18'E	1	M.M. O'Keefe to DSP
22 Apr 1984	35°10'S, 21°40'E	16	A. Collet, pers. comm. to Leatherwood
02 Jun 1984	35°17'S, 115°57'E	8	O.J. Macaskie to DSP
19 Sep 1985	14°27'S, 40°6'E	2	O.A. Strangroom to DSP
20 May 1986	17°44'N, 68°07'E	4	Mrs. B. Maclean to DSP
24 Oct 1986	36°27'S, 123°34'E	2	T.A. Meharry to DSP
25 Oct 1986	35°50'S, 117°10'E	2	T.A. Meharry to DSP

predator (International Whaling Commission, 1982a; b). However, the combined population(s) in 4 of 6 statistical areas of the Antarctic, including some contiguous with the southern Indian Ocean Sanctuary, have been estimated, from sightings data, to number some 180,000 animals (Hammond, 1984). The Indian Ocean population has been casually estimated to contain 'a few thousand' animals (Nishiwaki, 1977; 1983), but abundance there has not really been studied.

The earliest published account of killer whales in the Indian Ocean apparently is that from 11 December 1772, when "Grampuses and some whales; Orca gladiator and Mystacoceti" were seen off South Africa (Forster, 1777 *In*: Hershkovitz, 1966). We are aware of an additional 40 records published since 1777 (Table 1), have assembled records of 25 unpublished sightings made from 1976 onwards (Table 2) and have reviewed published accounts of several survey programs covering large portions of the Indian Ocean. The 66 available records are from localities widely distributed around the entire Indian Ocean (Fig. 2), suggesting that the species is not absent from any major sector. The few concentrations of records as likely reflect human population centers and areas of scientific effort as they do areas of exceptional killer whale concentration. There are records for all months south of 30°S, records for most months and all quarters from 30°S to the Equator, and approximately uniform records for all months north of the Equator.

From 1952–63, tuna longline fishermen working widely in the Indian Ocean observed animals they identified as killer whales most commonly around the Maldives, Chagos, Greater Sunda and Lesser Sunda islands, and in the Banda and Timor seas

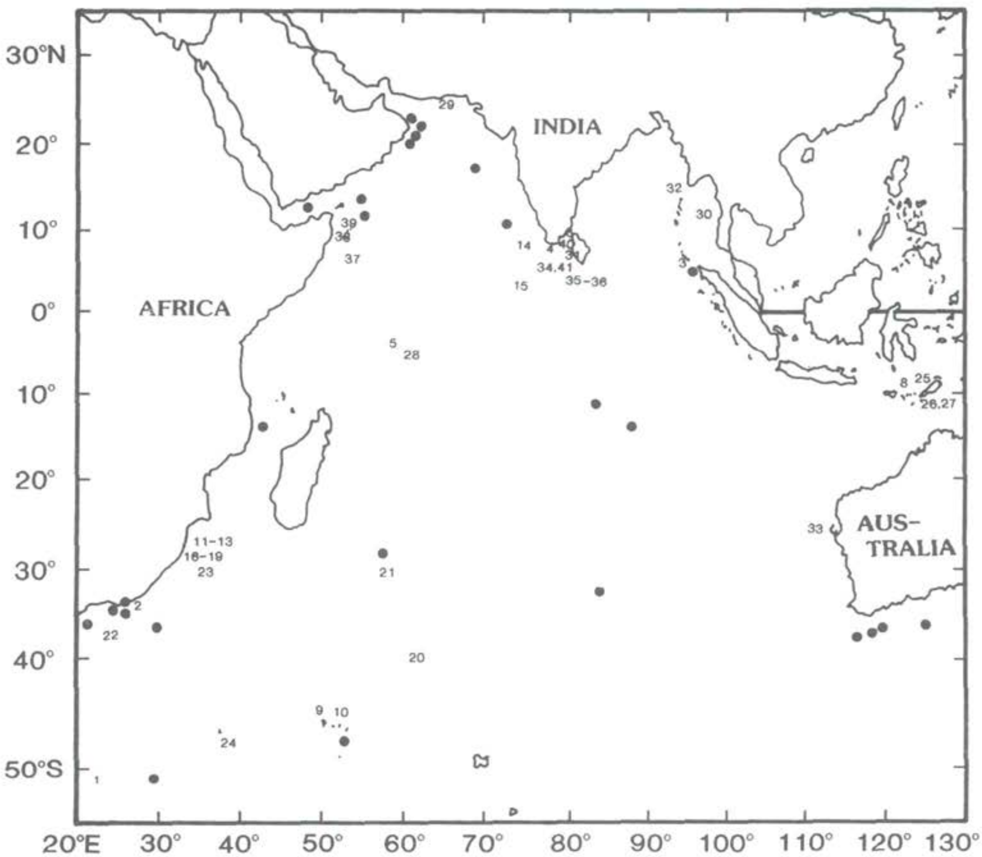

Fig. 2. Specific locations for records of killer whales in the Indian Ocean, 1772 through 1986.

(Sivasubramaniam, 1965). Records from Sri Lanka are from spring and summer, although fishermen working off the southwestern coast reported seeing killer whales in all seasons from 25 to 175 miles offshore (Leatherwood and Reeves, 1989; S. Senanayake, pers. comm.). Voisin (1972) reported that killer whales came very near the coast of Possession Island, in the southern Indian Ocean. In a later study, however, he observed that they tended to stay farther out to sea at nearby Hog Island. He suggested differences in surrounding submarine topography as the probable reason (Voisin, 1976). Killer whales tended to remain very near shore at Twofold Bay, Australia, during the whaling season, June through November (Wellings, 1964), but their whereabouts at other times of year were not reported.

Conde, van Aarde and Bester (1978) reported seasonal occurrence of killer whales off Marion Island, where the whales were most numerous from October to December. Voisin (1972) stated that observations were frequent near the coast of Possession Island from March through May and from September through November but that there were no sightings between 11 June and 11 August. Anderson and Prince (1985) noted reports of fishermen and other observers that killer whales are seen around Shark Bay, Western Australia, each winter.

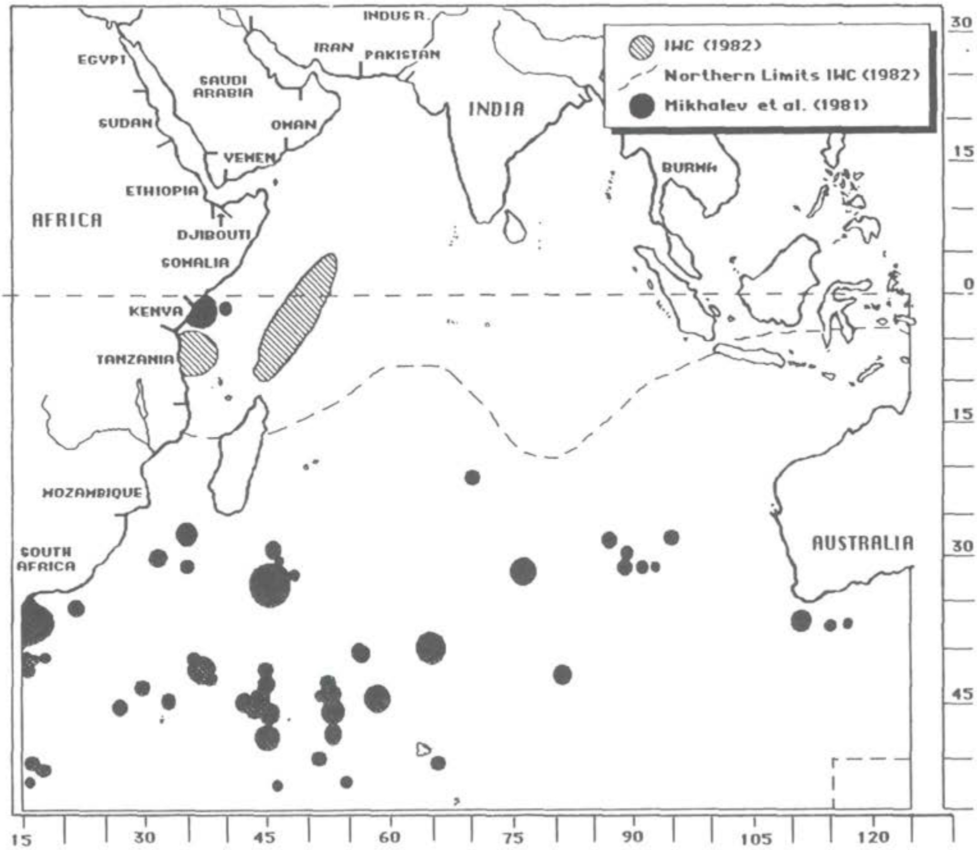

Fig. 3. General areas of the Indian Ocean in which killer whales reportedly are distributed. (From Mikhalev *et al.*, 1981; International Whaling Commission, 1982a)

Mikhalev, Ivashin, Suvasin and Zelanaya (1981), using data from logbooks of the Soviet whaling vessel *Sovietskaya Ukraina* from the years 1961/62 to 1978/79 and covering the waters of the Indian Ocean and adjacent Antarctic, presented information they interpreted as evidence of seasonal migrational trends of killer whales in the southern Indian Ocean. The majority of the data were obtained during the months November through May. They were interpreted to indicate the following (Fig. 3):

November: Most of the whales were seen near the west coast of Africa, about 25°-55°E and about 0°-55°S. There are no data for the eastern Indian Ocean.

December: Animals were moving to higher latitudes, with sightings about 20°-60°E and 75°-125°E and 30°-65°S.

January: Most sightings occurred south of 50°S; some animals were seen around Isles Crozet and Chatham Island.

February: Animals began northerly migration, in the Indian Ocean mainly 20°-52°E and 40°-55°S.

March: Many of the whales had left Antarctic waters; those in the Indian Ocean were mainly 20°-60°E and 40°-45°S.

Apr/May: All sightings from the Indian Ocean were north of 50°S; most were west of 75°E.

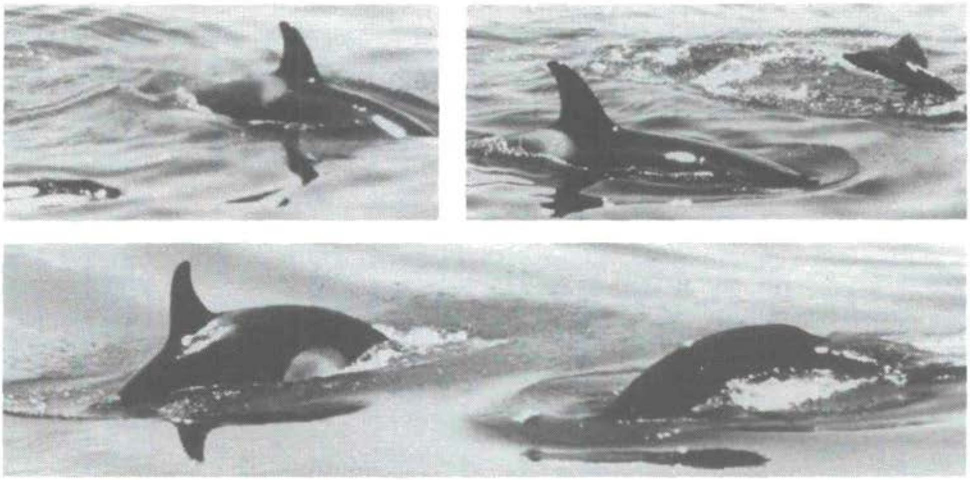

Fig. 4. Part of a pod of 7 killer whales encountered in the Andaman Sea in April 1983. (S. Leatherwood)

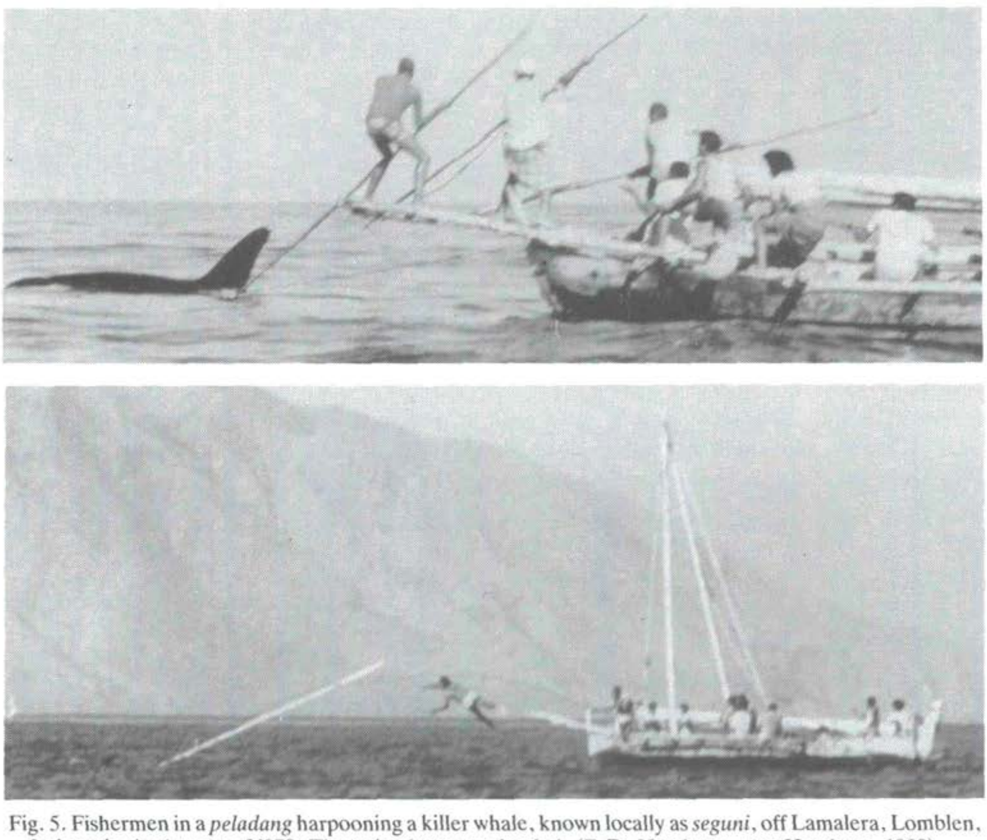

Fig. 5. Fishermen in a *peladang* harpooning a killer whale, known locally as *seguni*, off Lamalera, Lomblen, Indonesia, in August of 1979. The animal was not landed. (E.D. Hembree – see Hembree, 1980)

The authors linked these patterns of distribution to those of the rorquals, particularly the minke whale, *Balaenoptera acutorostrata*, on which killer whales occasionally feed (Mikhalev *et al.*, 1981). They postulated the existence of three migratory stocks: near the coast of Africa; on the west coast of Australia and in pelagic waters of the central Indian Ocean.

Elsewhere, killer whale movements appear to be related primarily to food supply. Conde *et al.* (1978) suggest that the presence of the migratory Macaroni (*Eudyptes chrysolophus*) and Rockhopper (*E. chrysocome*) penguins, and southern elephant seals, *Mirounga leonina*, may affect killer whale movements. They noted that killer whales were most abundant during the annual haul-out of young elephant seals on Marion Island. Sivasubramaniam (1965) surmised that killer whales which took tuna from the longlines of fishermen in the Indian Ocean followed the movements of the tuna boats or tunas.

There is some information suggesting the existence of local populations, at least seasonally. Certain groups of killer whales seen in Twofold Bay during June-November whaling seasons became well known to the whalers, who assigned them names and recognized some of them from year to year (Wellings, 1964). Conde *et al.* (1978) reported seeing the same adult male for three consecutive summers at Marion Island.

Perhaps some of the killer whales occurring in the Indian Ocean Sanctuary, particularly in higher latitudes of the Southern Hemisphere, are part of migratory population(s) moving northward from Antarctic waters during austral winter. However, some killer whales can be found in the Northern Hemisphere in all months (Fig. 2; Table 1).

Killer whales were ordinarily only secondary targets of whalers, so there have been relatively few commercial takes in the Indian Ocean. Mikhalev *et al.* (1981) reported that Soviet whalers took only 26 from Antarctic waters adjacent to the Sanctuary in the seasons 1969/70 through 1978/79. However, the geographical distribution of the exceptionally high catches by Soviet whalers in the Antarctic in the 1979/80 season (916) was reported only by expedition and not by area (International Whaling Commission, 1982a, p.621); so, the numbers taken from within or near the Sanctuary cannot be assessed. Catches by shore-based whalers operating from Durban, South Africa, amounted to only about 10 per year (Anonymous, 1978, p.107), but the fleet took a total of only 36 between 1971 and 1975 (Best and Ross, 1977). That fleet ceased operations in 1976.

Killer whales are sometimes taken by subsistence hunters at Lamalera, Indonesia. Hembree (1980) found records indicating takes of this species from as far back as 1960 and documented the strike and loss of one large male during his 2.5 month stay there in 1979 (Fig. 5).

Involvement of killer whales in net fisheries is demonstrated by the taking of five animals in gillnets on the Sri Lankan west and southwest coasts 1982–1986 (Table 1; Leatherwood and Reeves, 1989).

There are several noteworthy accounts of interactions between killer whales and humans in or near the Sanctuary. Wellings (1964) recounted well-documented tales of 19th century whalers at Twofold Bay, Australia, about killer whales routinely assisting them with the taking of baleen whales. According to accounts, the killer whales routinely drove the larger whales towards shore, where they could be reached by whalers. The killer whales ate the tongues and lips of the killed whales as the whalers retrieved the meat from them.

Sivasubramaniam (1965) reported that tuna longline fishermen in the Indian Ocean were plagued by killer whale predation on hooked fish. Reports of such predation apparently increased steadily from the opening of the fishery in 1952 through 1963, by which time it was thought to have been having a serious impact on the fishery. The percentage of operations during which killer whales were sighted on the fishing grounds increased from 0.4% in 1955 to 9.6% in 1963, suggesting that the whales may have learned to seek out tuna boats. During a given 'attack', 55 to 100% of the catch might be lost. Of the 80,000 tons of tuna and related species caught annually by these fisheries, at least 4% by weight was lost to killer whales and sharks. Hook-up rates were sometimes lowest when killer whales were present, presumably because the whales scared the fish. In some of the more important details, the interference by killer whales with the longline fishery for tuna was similar to that which exists in the blackcod fishery in the northeastern Pacific (Freeman, 1986), a phenomenon which has increased rapidly in geographical area and frequency of occurrence since it was first reported in 1984. On the other hand, the behavior described by Sivasubramaniam (1965) is typical of the behavior of false killer whales in many areas; so, one wonders if only killer whales were involved in the Indian Ocean interference.

False killer whale

The false killer whale, *Pseudorca crassidens*, is a monotypic, generally pelagic species with worldwide distribution (Davies, 1963; Leatherwood and Reeves, 1983). Deraniyagala (1945b) distinguishes a southern form occurring in the Indian Ocean as *Pseudorca crassidens meridionalis* Flower; however, Professor Flower himself abandoned the distinction after examining numerous skeletons (Hector, 1885), and subspecific names have been largely ignored by subsequent investigators (Rice, 1977). The majority of confirmed records of its occurrence are from tropical and warm temperate waters.

[*text continues on page 45*]

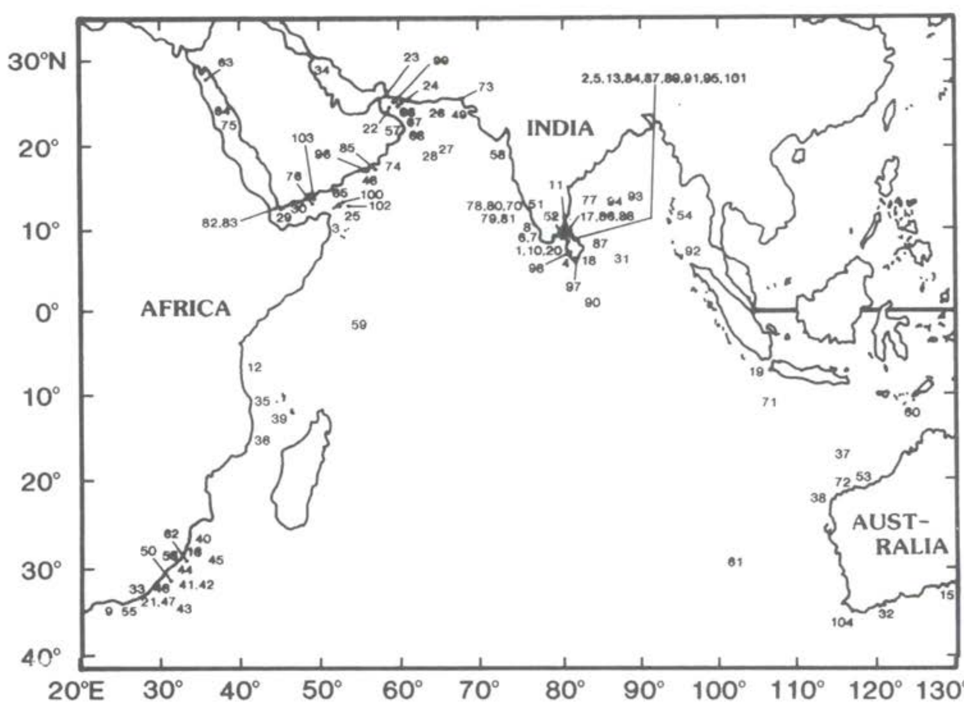

Fig. 6. Locations for records of false killer whales in the Indian Ocean, 1890 through 1984.

Table 3

Records of false killer whales in the Indian Ocean, 1890-1986

Code	Date	Location	Comments/Source
1	-	Pazhikara, N of Cape Comorin	stranding, (Silas and Pillay, 1960)
2	-	Ceylon	stranding, 3 schools, (Deraniyagala, 1945a)
3	-	Somali Coast	stranding, 1 skull, UFZM, (Puccetti, 1986)
4	Dec 1890 or 91	Moratuwa, Sri Lanka	Captured specimens, specimen 90A CMR (logged as 1980) (Leatherwood & Reeves, 1989) (Pearson; 1930, 1931)
5	1891	Sri Lanka	Specimen 90-B in CMR, (Leatherwood & Reeves 1989)
6	Feb 1902	Trivandrum, India	stranding, (Pillay, 1926)
7	Feb 1902-1925	Trivandrum, India	stranding, 2 animals (Pillay, 1926)
8	1903 or prior	08°41'N, 76°7'E, India	stranding, (Ferguson and Lydekker, 1903)
9	Apr 1910	Port Alfred	stranding, skull taken but missing, (Ross, 1984)
10	prior to 1911	Trivandrum, India	incidental capture, 2 animals, (Dawson, 1911); 201
11	3 Aug 1929	Velanai Is., (9°40'N, 79°54'E)	stranding, 167, 2 skeletons, 12 skulls recovered for CM, (Pearson, 1931)
12	2 Dec 1933	N of Zanzibar, Mtoni Bch	stranding, 54 animals, (Anonymous, 1934)
13	10 Nov 1934	Mutur, Sri Lanka (8°27'N, 81°15'E)	stranding, 97 animals, (Deraniyagala, 1965)
14	30 Sep 1939	Godavaya, Sri Lanka	stranding, skull recovered from CM (Deraniyagala, 1960)
15	5 Oct 1944	Port Prime, Australia	stranding, ca. 250 animals, skull and teeth to South Australia Mus. M2179 (Hale, 1944)
16	27 Aug 1947	Morgans Bay, So. Africa	stranding, 4 animals (US Nat. Mus., Str. Rec. 02131)
17	28 Jan 1954	Chempian Pattu (N.P.), Sri Lanka	stranding (Deraniyagala, 1960)
18	7 Mar 1954	07°02'N 82°02'E	sighting, 30 animals (Mörzer Bruyns, 1969)
19	1 Aug 1959	off Sunda Strait	sighting, 2 animals, tentative id (Mörzer Bruyns, 1969)
20	7 Nov 1960	Cape Comorin, India	stranding, 2 animals (1M, 1F) (Silas and Pillay, 1960)
21	1 Jun 1961	East London, So. Africa	stranding, skull in PEM (ELM 780) (Ross, 1984)
22	16 Jan 1961	23°05'N, 59°05'E	sighting, 30 animals (Mörzer Bruyns, 1969)
23	16 Jan 1961	24°05'N, 58°02'E	sighting, 20 animals (Mörzer Bruyns, 1969)
24	28 Feb 1961	23°07'N, 59°05'E	sighting, 2 animals (Mörzer Bruyns, 1969)
25	3 May 1961	10°02'N, 53°08'E	sighting, 3 animals (Mörzer Bruyns, 1969)
26	28 Feb 1961	23°01'N, 64°00'E	sighting, 40 animals (Mörzer Bruyns, 1969)
27	1 Mar 1961	19°07'N, 64°00'E	sighting, 10 animals (Mörzer Bruyns, 1969)
28	9 Mar 1961	09°00'N, 63°05'E	sighting, 6 animals (Mörzer Bruyns, 1969)
29	12 May 1961	11°08'N, 43°05'E	sighting, 4 animals (Mörzer Bruyns, 1969)
30	5 Mar 1961	12°05'N, 44°07'E	sighting, 1 animal (Mörzer Bruyns, 1969)
31	5 Mar 1961	06°00'N, 87°04'E	sighting, 5 animals (Mörzer Bruyns, 1969)
32	May 1964	34°22'S, 119°33'E	stranding, 34 animals (Mell, 1988)
33	13 Nov 1965	Kariega River Mouth	stranding, 1 animal, photograph, PEM (Ross, 1984)
34	4 Mar 1966	28°00'N, 49°06'E	sighting, over 40 animals (Mörzer Bruyns, 1969)
35	26 Mar 1966	11°08'S, 40°06'E	sighting, over 30 animals (Mörzer Bruyns, 1969)
36	26 Mar 1966	16°00'S, 40°00'E	sighting, over 100 animals (Mörzer Bruyns, 1969)
37	31 Jan 1967	18°05'S, 116°00'E	sighting, 35 animals (Mörzer Bruyns, 1969)
38	1 Feb 1967	21°07'S, 113°05'E	sighting, 10 animals (Mörzer Bruyns, 1969)
39	20 Oct 1967	11°07'S, 42°09'E	sighting, 1 animal (Mörzer Bruyns, 1969)
40	24 Oct 1967	29°02'S, 32°02'E	sighting, 6 animals (Mörzer Bruyns, 1969)
41	1969	Natal	sighting (Gambell, unpub. data)
42	1969	Natal	sighting, 30 animals, (Gambell, unpub. data)
43	8 Feb 1971	34°34'S, 31°43'E	sighting, 30 animals, 1 harpooned, (Ross, 1984)
44	12 Feb 1971	31°59'S, 31°21'E	sighting, 1 animal, (Ross, 1984)
45	2 Feb 1973	29°56'S, 32°00'E	sighting, 6 animals, (Ross, 1984)

Continued

Code	Date	Location	Comments/Source
46	9 Feb 1973	33°58'S, 28°07'E	sighting, 2 animals, (Ross, 1984)
47	10 Feb 1973	34°08'S, 27°21'E	sighting, 50 animals, (Ross, 1984)
48	1964	Dowha (40km S of Kuwait)	stranding, skeleton, NHMK, ESUC (Al-Robaae, 1974; Pilleri and Gihr, 1976; Wassif, 1956)
49	1974	Karachi, Pakistan	specimen, skull, lower jaw missing, Pilleri, #571, (Pilleri and Gihr, 1976)
50	9 Jan 1974	31°37'S, 31°05'E	sighting, 10 animals (Gambell *et al.*, 1974)
51	28 Jul 1975	Puthiappa, near Calicut	stranding, 1 animal, skeleton (25, LalMohan, 1984)
52	18 Oct 1975	Gulf of Mannar	stranding, 1 animal (25; Thiagarajan *et al.*)
53	Jun 1976	Fortescue Bay	stranding, skull retrieved
54	27 Jul 1976	Port Blair, Andamans	incidental capture, 2 animals, (Silas *et al.*, 1984)
55	pre 1977	Cape St. Francis	stranding, 1 animal, mandible, 5 teeth, PEM 1520/63, (Ross, 1984)
56	Jul 1977	Bushmans River Mouth*	stranding, 1 animal, skull, Port Elizabeth Museum, PEM 1520/76, (Ross, 1984)
57	1 Aug 1977	Masireh, Gulf of Oman	specimen, NHMO, BM 1980.795, (Gallagher, this vol.)
58	August 1978	Gulf of Cambay, India	specimen, Institute of Science (USNM #STRo2656) (collected by V.M. Raval - no reference)
59	Jun 79-May 80	Seychelles	sighting, 5 animals (IWC, 1981a)
60	31 Jul 1979	11km SE of Lamalera	sighting, ca. 70 animals (Hembree, 1980)
61	27 Aug 1979	29°39'S, 101°35'E	sighting, 6 animals (R.J. Clark to DSP)
62	17 Nov 1979	29°16'S, 32°07'E	sighting, 4 animals (R.S. Wheeler to DSP)
63	1980-1981	Gulf of Aquaba	sighting, 10 animals, 1 captured (Beadon, this vol.)
64	1980-1981	Red Sea	sighting, 11 animals (Alling *et al.*, 1982)
65	1 April 1980	14°51'N, 50°53'E	sighting, 20 animals (S.P. Weston to DSP)
66	2 June 1980	22°19'N, 60°65'E	sighting, 12 animals (C.J. Coxhead to DSP)
67	25 Oct 1980	22°32'N, 59°47'E	ZMA 21.168 (Gallagher, this vol.)
68	25 Oct 1980	22°32'N, 59°47'E	ZMA 21.186 (Gallagher, this vol.)
69	6 Dec 1980	-	sighting, appr. 5 animals (Harwood, 1980)
70	14 Dec 1980	12°N, 73°E	sighting, 5 animals (Harwood, 1980)
71	April 1981	10°30'S, 105°35'E	sighting, 4 animals (Capt. D.I. Jones to DSP)
72	Jul 1981	20°54'S, 115°22'E,	stranding, 40 animals (Mell, 1988)
73	17 Oct 1981	Phitti Creek, Pakistan	- (de Silva, 1983)
74	4 Nov 1981	16°56'N, 54°25'E	sighting, 6 animals (Al-Barwani, in litt. IWC, 30 Mar 82)
75	15 Dec 81	19°31'N, 38°53'E	sighting (Alling, 1986)
76	30 Dec 81	12°11'N, 44°09'E	sighting, possible id of 3 animals (Alling, 1986)
77	Apr 1982	NE of Sri Lanka	sighting, 35 animals (Leatherwood *et al.*, 1984)
78	8 Feb 1982	11°51'N, 72°56'E	sighting, 3 animals (Alling, 1986)
79	10 Feb 1982	10°25'N, 75°27'E	sighting, 3 animals (Alling, 1986)
80	2 Aug 82	11°51'N, 72°56'E	sighting, possible id, (Alling, 1986)
81	2 Oct 82	10°25'N, 75°27'E	sighting, possible id, (Alling, 1986)
82	11 Apr 1982	11°08'N, 43°01'E	fishery, 3 animals (Capt. M.J. Chambers to DSP)
83	11 Apr 1982	11°08'N, 43°08'E	fishery, 3 animals (Capt. M.J. Chambers to DSP)
84	18 Apr 1982	11°06'N, 53°05'E	fishery, 8 animals (Capt. M.J. Chambers to DSP)
85	1 Oct 1982	Kuria Muria, Oman	record, ONHM 64 (Gallagher, this vol.)
86	Jan-Apr 1983	Sri Lanka	sighting, 2 schools of 3-8 (Alling *et al.*, 1983)
87	6 Feb 83	07°38'N, 82°01'E	sighting, probable id (Alling, 1986)
88	16 Apr 1983	NE of Sri Lanka	sighting, 25-30 animals (Leatherwood *et al.*, 1984)
89	10 Oct 1983	Trincomalee	fishery kill, skull (Whitehead, in Leatherwood and Reeves, 1989)
90	4 Nov 83	09°28'N, 81°34'E	sighting (Alling, 1986)
91	Jan 84-Apr 85	Trincomalee	fishery bycatch, 7-8 animals (Alling, 1985 or 1983)
92	8 Mar 1984	06°05'N, 94°36'E	fishery, 10 animals (J. Pinder/S. Miller to DSP)
93	19 Mar 1984	11°03'N, 87°48'E)	fishery, 4 animals (J. Ayling to DSP)
94	19 Mar 1984	11°50'N, 87°30'E	fishery, 6 animals (J. Ayling to DSP)
95	4 Apr 1984	Trincomalee	fishery bycatch, 1 animal (Alling, 1986)

Continued

Code	Date	Location	Comments/Source
96	20 Jan 1985	1730.5605	ONHM 834 (Gallagher, this vol.)
97	9 July 1985	Galle, Sri Lanka	fishery bycatch
98	23 Oct 1985	Mirissa, Sri Lanka	fishery bycatch, 96cm male, (Leatherwood and Reeves, 1989)
99	21 Nov 1985	25°51'N, 59°51'E	sighting, 2 animals (M.A. Cook to DSP)
100	5 Mar 1986	11°47.7'N, 50°30.9'E	6 animals (Small and Small, this vol.)
101	10 Apr 1986	Trincomalee, Sri Lanka	L & R 1989; Fig 24(a) (SL table)
102	18 Apr 1986	11°16'N, 52°39'E	sighting, 1 animal (D. Harnett to DSP)
103	26 May 1986	11°23.0'N, 48°46.6'E	10 animals (Small and Small, this vol.)
104	30 Jul 1986	34°19'S, 115°10'E	stranding, 114 animals (Mell, 1988)

Notes: UFZM=University of Florence Zoology Museum; CMR=Colombo Museum Register; CM=Colombo Museum; PEM=Port Elizabeth Museum; NHMK=Natural History Museum of Kuwait; ESUC=Ein Shams University Cairo; NHMO=Natural History Museum of Oman; DSP=Dolphin Survey Project. *Bushman's River runs into the Tugela before reaching the Ocean at approx. 29°3'S, 31°5'E.

Bellision (1966) listed false killer whales as occurring commonly in Antarctic waters and Clark (1945) stated that it was found in the Bering Sea. However, given current knowledge about this species, it appears unlikely to occur, at least routinely, at such high latitudes.

Relatively little is known of the biology of this species. Most of the existing morphological and anatomical data were obtained opportunistically from strandings, including some mass strandings, and from incidental and intentional fishery takes. False killer whales are becoming increasingly common in zoological parks and oceanaria, where captive breeding programs are providing insight into reproduction and behavior (Brown *et al.*, 1966; Nishiwaki and Tobayama, 1982; Sylvestre and Tasaka, 1985; Anonymous, 1987), and some research programs are underway with captive specimens.

The tendency of the false killer whale, like other 'blackfish', to mass-strand has often provided opportunities to closely study anatomy and other aspects of its biology. At least seven of the ten reported strandings within the Indian Ocean Sanctuary (IOS) between 1925 and 1964 were of more than one animal (Table 3). The earliest of these, in which 167 animals swam onto the shore of Velanai Island, Sri Lanka, on 3 August 1929, enabled researchers to study reproductive condition, anatomy and external and skeletal morphology of different age/length groups within the same herd (Pearson, 1931; Purves and Pilleri, 1978).

According to Mörzer-Bruyns (1971), false killer whales were hunted for their ivory in the Arabian Sea in ancient times. Today they are normally not a target species for subsistance hunts in the IOS, but there are records of incidental catches, and specimens occassionally appear in local fish markets (Nishiwaki and Hung-Chia, 1961; Jones, 1976a; Leatherwood and Reeves, 1989) (Fig. 7). Of the 810 cetaceans landed in Trincomalee, northeastern Sri Lanka, 1984–86, eight (<1%) were false killer whales (Leatherwood and Reeves, 1989).

False killer whales are known to take tuna from longlines off Japan and Hawaii, and can do extensive damage to nets (Sivasubramaniam, 1965; Mizue *et al.*, 1969; Anonymous, 1980; International Whaling Commission, 1980; Klinowska, 1980; Kasuya, 1985). Mitchell (1975) stated that false killer whales damage tuna on long-lines worldwide, and one suspects that at least some of the reports of 'killer whales' taking fish from lines of Indian Ocean fishermen actually involved this species rather than killer whales.

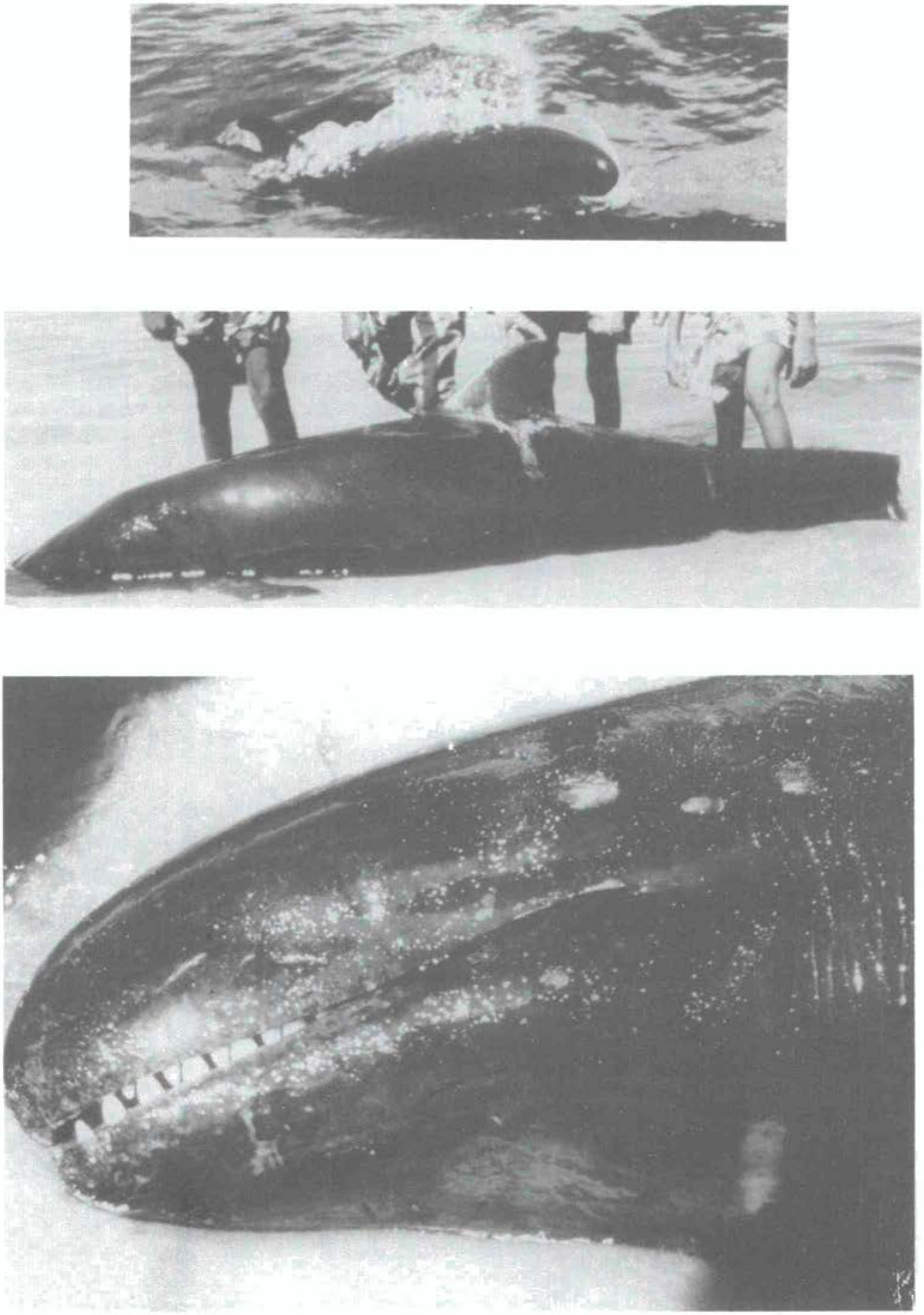

Fig. 7. False killer whales in the Red Sea, December 1982, and at Trincomalee, Sri Lanka, April 1984. (H. Whitehead, top, and A. Alling, middle and bottom, all courtesy WWF).

The earliest of the 104 records we located for the IOS (Table 3) are of strandings in 1890 and 1892 off Moratuwa, Sri Lanka, and Trivandrum, India (Pillay, 1926; Gunaratna, 1985) and a 'capture' in 1891 off Moratuwa (Pearson, 1931). The Indian and Sri Lankan locations are only a few hundred miles apart. Subsequent records also have been concentrated in the central, and more recently northeastern, Indian Ocean, around Sri Lanka and India, and in the northwestern Arabian Sea (Fig. 6). However, there are increasing numbers of sightings from the southern portions of the Indian Ocean, from South Africa and Tanzania, from traditional whaling grounds off Lamalera and in the open sea west of Australia. Bryden (1978) reported hearing frequent reports of sightings of false killer whales around Queensland, especially north Queensland.

In areas where they are best known, such as the northeastern Pacific, false killer whales are largely pelagic animals; we believe that they are likely far more common in some pelagic equatorial regions of the Indian Ocean than the scant reports indicate.

Pilot whale

Pilot whales, *Globicephala sp*., apparently were first identified in the Indian Ocean by Blythe (1852 *In*: Hershkovitz, 1966), who named a young specimen from the Hoogly River, 25 km north of Calcutta, *Globicephala indica*. (The type specimen is at the Museum of the Asiatic Society of Calcutta.) He distinguished the Indian pilot whale from the Atlantic pilot whale, which he called *G. deductor* (= *G. melaena*) because of the former's shorter and broader premaxillaries and 'considerably' stouter teeth.

Some confusion has been expressed in subsequent literature concerning the origin of Blythe's type specimen. Blanford (1891) and Alagarswami, Bensam, Rajapandian and Fernando (1973) wrote that it was part of a herd that stranded in the salt lakes near Calcutta in 1852. They may be referring in error to a stranding of twenty animals that did occur at that location in 1850 and was reported by Blythe (1851 *In*: Hershkovitz, 1966). However, Jones (1976b) noted that in the absence of Blythe's (1852 *In*: Hershkovitz, 1966) account of specifics on the date of the stranding or the date of the collection of the specimen it is difficult to ascertain with certainty whether the type specimen derived from the stranding in 1850 or from some isolated event in the subsequent two years.

Blanford (1891) found *G. indica* to be 'nearly allied with *G. melas* of the European seas'. Weber (1923) and van Bree (1971), on the other hand, synonomised *G. indica* with *G. macrorhynchus*. At present, two species of pilot whale are recognized (van Bree, 1971; Rice, 1977): *G. melaena* (Traill, 1809) and *G. macrorhynchus* (Gray, 1846). They are considered distinguishable by various aspects of morphology and coloration (Table 4). Specimens referred to by both names have been reported from the Indian Ocean (Table 5). A skull (CBL=582 cm) collected at Flinders Island, Australia, and deposited at the Museum of Natural History of Los Angeles County (No. 28256) is a *G. melaena* (J. Heyning, *in litt.*, 25 October 1986.) Skulls we have examined from farther north in the Indian Ocean, notably Sri Lanka and La Digue Island, Seychelles, (Fig. 8), are *G. macrorhynchus* (*fide* J. G. Mead, US National Museum, pers. comm.). Measurements of this latter specimen are presented in Table 6. The Seychelles and Sri Lankan skulls are, as far as we can determine, two of only seven pilot whale skulls collected from the northcentral and northwestern sectors of the Indian Ocean through 1986 (Table 5; Figs 9 and 10); we have not examined the five from Oman (Gallagher, this volume), but assume they, too, are *G. macrorhynchus*. Interestingly, pilot whales seen in the Seychelles (Keller *et al.*, 1982 see Fig. 11), appeared to have a ratio of flipper length to body length which is characteristic of short-finned pilot whales elsewhere.

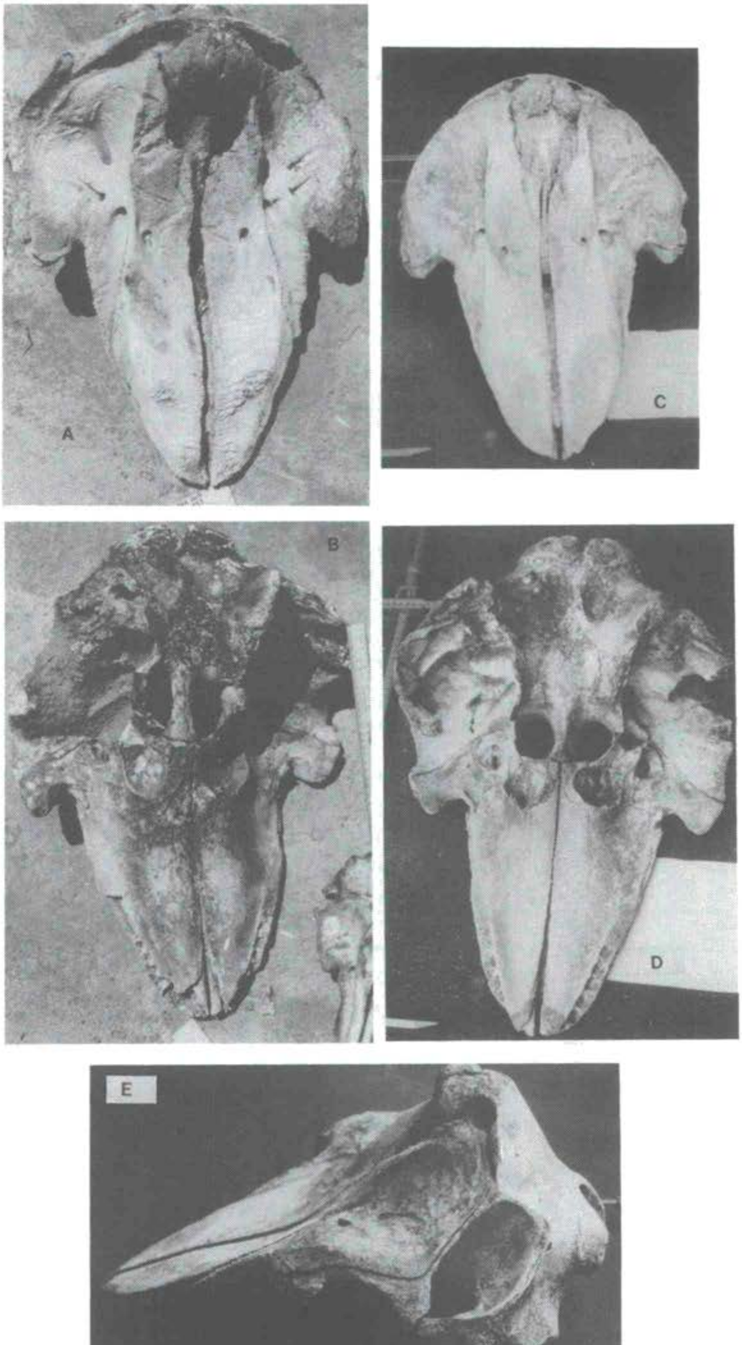

Fig. 8. Views of skulls of short-finned pilot whales from Negombo, Sri Lanka, (Specimen NARA009) (A and B) and La Digue Island, Seychelles, (C, D, and E). (S. Leatherwood)

In the northwestern Atlantic, the two pilot whale species overlap in areas of transition between tropical and cool temperate water masses, with the short-finned form/species continuing into tropical and the long-finned into colder temperate waters (Leatherwood *et al.*, 1976). In our opinion, there is sufficient material to support a meaningful investigation of pilot whales in the Indian Ocean. However, such an investigation was beyond the scope of this paper.

The nearly 125 records we located of pilot whales in the Indian Ocean are listed in Table 5 and their locations plotted in Figs 9 and 10. They include at least five mass strandings: 20 in the salt lakes near Calcutta in July 1850 (Blythe 1851; 1852 *In*: Hershkovitz, 1966; Jones, 1976b); 8 near Jeram, Salanger, on 20 March 1912 (Gibson-Hill, 1949); 27 on Weh Island, Sumatra, in the spring of 1914 (Weber, 1923; Gibson-Hill, 1949); 55 between Besuki and Situbondo, Java, on 2 January 1923 (Dammerman, 1924); and 145–160 at Manappadu, Madras, India, on 14 January 1973 (Alagarswami *et al.*, 1973; Jones, 1976b). Biological information from these strandings is limited to skeletal meristics and morphometrics, except for the Manappadu stranding, from which herd composition was determined and tissue samples were collected and analyzed (Alagarswami *et al.*, 1973).

The geographical spread of sightings and strandings suggests that pilot whales are distributed very widely in the Indian Ocean, in both coastal and oceanic zones. As with plots of records of other species discussed in this paper, the absence of records of pilot whales in the mid-ocean as likely reflects the distribution of searching effort as it does the actual distribution of the whales. The temporal distribution of the records does not suggest any clear pattern of migrations or seasonal changes in abundance in any region.

Pilot whales are gregarious and likely to be found in the company of cetaceans of other species. In the Indian Ocean, they have been reported with bottlenose dolphins, *Tursiops truncatus*, (Keller *et al.*, 1982), southern right whale dolphins, *Lissodelphis peronii* (Cruickshank and Brown, 1981) and sperm whales, *Physeter macrocephalus* (Alling, 1986).

Pilot whales have been, and probably still are, involved in fisheries in the Indian Ocean. In their review of whaling log books from the western Indian Ocean for the period 1800–1899, Wray and Martin (1983) found 29 separate references to the killing of 'blackfish', which they took to mean pilot whales. Dammerman (1924) found flesh on pilot whale specimens recently arrived at the Buitenzorg Museum in Java from Besuki, eastern Java, and concluded that they came from 'a place in the Indo-Australian Archipelago where people are hunting and eating these dolphins'. Jones (1976b) reported that there is no fishery for pilot whales in the Indian Ocean. On the contrary, pilot whales are taken deliberately and incidentally. Hembree (1980) reported that from four contacts involving an estimated 254 pilot whales off Lamalera, Indonesia, (actually in the Savu Sea) between 3 July and 18 September 1979, subsistence whalers killed two animals. Also, pilot whales are taken deliberately by harpooning and incidentally by gillnets in Sri Lanka. A total of 18 was landed at Trincomalee in 1984–6 (Leatherwood and Reeves, 1989).

[*Tables 4–6 and Figs 9–10 follow*
Text continues on page 55]

Table 4

Characterististics distiguishing long-finned from short-finned pilot whales

Long-finned pilot whale	Short-finned pilot whale
More elongated rostrum with rather narrow premaxillae uncovered a 1cm lateral margin of the maxillae	Rather short and broad with broad premaxillae completely covering the maxillae anteriorly or leaving uncovered a very small margin of the maxillae on one or both sides
Normally 9-12 teeth in each toothrow	Normally 7-9 teeth in each toothrow
Long pectoral fins (18-27% of total body length)	Short pectoral fins (14-19% of total body length)
Clear white blaze ventrally	Ventral blaze absent or indistinct

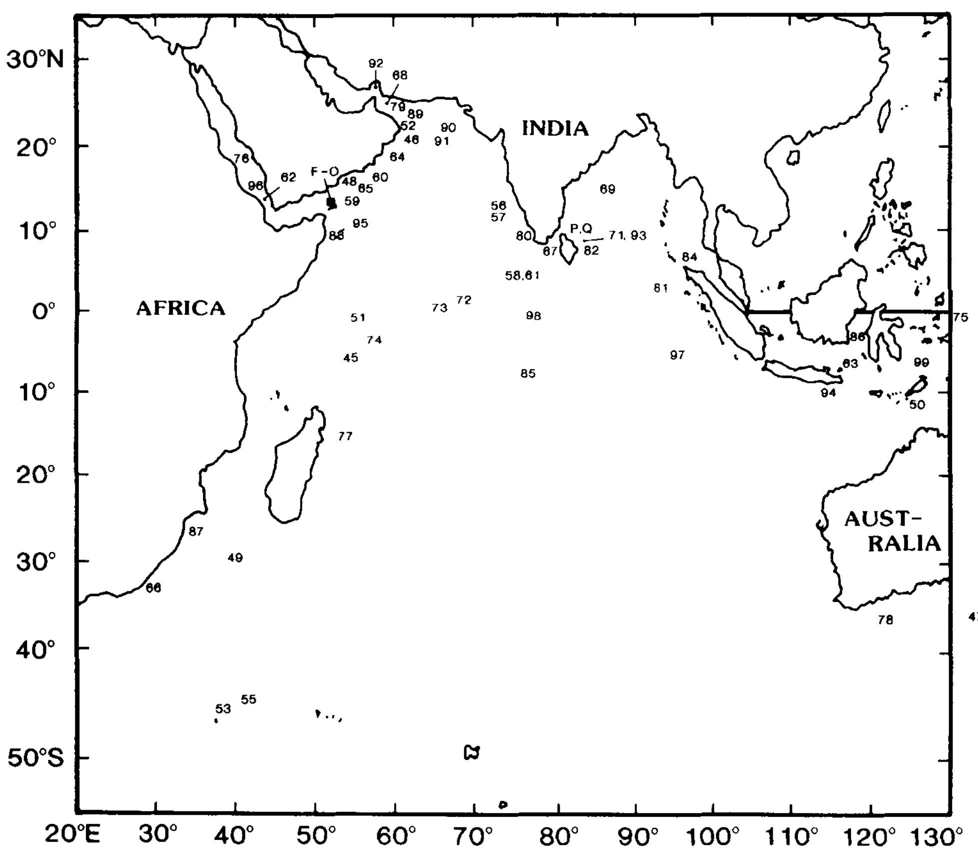

Fig. 9. Locations of sightings of pilot whales in the Indian Ocean, 1831 through 1986.

Table 5

Records of pilot whales in the Indian Ocean, 1831-1986.

Code	Date	Location	Comments/Source
1	Aug 1831	Slangkop, nr Cape Town	Skull (91176) at MHNB
2	before 1834	SE coast of South Africa	Skull and skin (56.9.18.26) at BMHM
3	July 1850	Salt Lakes, India (nr Cacutta)	Stranding of "several dozen"(Blyth, 1852)
4	July 1852	Hughli River, nr Scrampor, West Bengal	Skin and skeleton (unnumbered) at MASC collected by C.T. Lushington (Blyth, 1852)
5	- - -	Swain's Bay, Kerguelen Island	Skeleton (1876.1.28.80) at BMNH (Flower, 1879)
6	- - -	Alor Island, Indonesia	Skull (1897.10.13.1) at BMNH (Leatherwood and Clark, 1983)
7	- - -	- - - - -	Skull (1897.10.13.2) at BMNH
8	- - -	Malacca, Malasia	Skeleton (1912.10.27.1) at BMNH (Leatherwood and Clark, 1983)
9	29 Mar 1912	Jeram, Selangor	Stranded (Gibson-Hill, 1949)
10	Spring 1914	Village of Nias, Weh Island, Sabang, Sumatra	stranded (Weber, 1923)
11	1918	Coast of Saldanha Bay	Skeleton (14894) at SAM
12	2 Jan 1923	Java Sea (74° S, 113° E)	55 stranded, USNM/STR02087
13	2 Jan 1923	Besuki, East Java	Embryo (391) at BM (Dammerman, 1924)
14	" " "	" " "	Specimen (390) at BM " "
15	" " "	" " "	Skeleton (392) at BM " "
16	" " "	" " "	Specimen (394) at BM " "
17	" " "	" " "	Skull (393) at BM " "
18	26 Jan 1923	10 miles north of Bombay, India	3 photos, BMNH (H. Harmer inventory)
19	Feb 1923	Besuki, East Java	Skull (393) at MZB (Tas'an and Leatherwood, 1983; 1984)
20	" "	" " "	Skull (394) at MZB (Tas'an and Leatherwood, 1983; 1984)
21	- -	Indo-Australian Archipelago	Skull (395) at BM (Dammerman, 1924)
22	- -	" " "	Skull (516) at BM " "
23	- -	" " "	Skull (397) at BM " "
24	- -	" " "	Skull (396) at BM " "
25	- -	Australian Flag Staff Battery, Colombo, Sri Lanka	Vertabrae at CM (Deraniyagala, 1945)
26	10 July 1962	Sea View nr Port Elizabeth, S. Afr.	Skull (1496/68) at PEM
27	14 May 1963	Jeffrey's Bay, nr Port Elizabeth,	Skull (1496/69) at PEM
28	4 Dec 1966	Bass Strait, east side of Flinders Island, Australia	Skull (28256) at LACM
29	1968	Camtoos River mouth, South Africa	Skull (1513/108) at PEM
30	Oct 1969	3 miles west of Aniston, South Africa	Skull (35794) at SAM
31	9 Apr 1970	Sea View, nr Port Elizabeth	Skull (1515/30) at PEM
32	" " "	" " " " "	Skull (1515/36) at PEM
33	" " "	" " " " "	Skull (1515/37) at PEM
34	" " "	" " " " "	Skull (1515/38) at PEM
35	" " "	" " " " "	Skull (1515/39) at PEM
36	" " "	" " " " "	Skull (1515/40) at PEM
37	- - -	Crozet Islands	Skull (1971-235) at MHNM
38	8 Apr 1971	Port Alfred, South Africa	Skull (1516/87) at PEM
39	" " "	" " " "	Skull (1516/88) at PEM
40	" " "	" " " "	Skull (1516/89) at PEM
41	1971 or 1972	La Digue Island, Seychelles	Skull (unnumbered) at SNA (Leatherwood, 1986; *fide* J.G. Mead)

continued

Code	Date	Location	Comments/Source
42	Dec 1972	Algoa Bay, South Africa	Teeth (1518/22) at PEM
43	14 Jan 1973	Gulf of Mannar Manappadu, Madras India	147-160 stranded (Alagarswami, et al.,1973; Jones, 1976)
44	- - -	Ile aux Cochons	Skull (1974-315) at MNHM 1986)
45	Dec 1975	07°00'S, 52°41'E (Seychelles)	15-30 seen (photos USNM/STRO2547)
A	Aug 1977	20°31'N, 58°57'E	Specimen BM 1980.795 (Gallagher, this vol.)
46	3 July 1978	Mas al Hadd, Oman	4 seen (Ross, 1981)
47	8 Feb 1979	37°10'S, 131°25'E	2 seen (I. Anderson to DSP)
48	13 Mar 1979	15°20'N, 53°28'E	2 seen (M.S. Hydra to DSP)
49	20 June 1979	30°06'S, 39°35'E	10 seen (D.J. Ayling to DSP)
50	18 Sept 1979	Lamalera, Lomblen, Indonesia	Subsistence whaling, 4 contacts with 254 animals, 2 whales taken (Hembree, 1980)
51	16 Apr 1980	02°51'S, 55°12'E	4 seen with 90 *Tursiops* (Keller *et al.*, 1982)
52	16 May 1980	23°23'N, 59°19'E	3 seen (C.J. Coxhead to DSP)
53	28 May 1980	46°51'S, 38°02'E	20 seen with *Lissodelphis peronii* (Cruickshank and Brown, 1981)
54	1 July 1980	Treachery Head Beach, NSW, Aus.	58 stranded, USNM #SEAN5501
B	25 Oct 1980	22°32'N, 59°47'E	Specimen ZMA21.168 (Gallagher, this volume)
C	25 Oct 1980	22°32'N, 59°47'E	Specimen ZMA21.186 (Gallagher, this volume)
55	10 Dec 1980	46°38'S, 41°15'E	5 seen (J.R. Twiss to DSP)
56	14 Dec 1980	12°N, 73'E	2 groups seen (Harwood, 1980)
57	16 Dec 1980	11'N, 73'E	5 seen (Harwood, 1980)
58	18 Mar 1981	Felidu Chan., S Male Atoll, Maldives	6 seen (Leatherwood *et al.*, 1984)
59	8 Apr 1981	14°08'N, 52°09'E	2 seen (J.A. Condie to DSP)
60	9 Apr 1981	17°42'N, 56°53'E	1 seen " " " "
61	23 May 1981	Felidu Chan., S Male Atoll, Maldives	3-4 seen (Leatherwood *et al.*, 1984)
62	2 June 1981	14°57'N, 42°06'E	5 seen (D. Carpenter to DSP)
63	20 Oct 1981	7°07'S, 116°02'E	33 seen (K. Scott to DSP)
64	4 Nov 1981	19°02'N, 58°30'E	10-12 seen (A Collet in Leatherwood, 1986)
65	11 Nov 1981	16°40'N, 54°55'E	2 seen (Capt. G. Hepple to DSP)
66	28 Dec 1981	33°28'S, 28°08'E	1 seen (J.M. Rose to DSP)
67	30 Dec 1981	8°45'N, 78°17'E	1 seen (Capt. R. Knight to DSP)
68	8 Jan 1982	25°25'N, 57°23'E	8 seen " " " " "
P	5 Apr 1982	9°22'N, 81°03'E	1 seen (Alling, 1986)
69	14-16 Apr 82	Bay of Bengal	4 sightings of 37 animals (Leatherwood *et al.*, 1984)
D	1 Oct 1982	17°30'N, 55°58'E	Specimen ONHM 64 (Gallagher, this volume)
70	26 Feb 1983	Pitipana, Negombo, Sri Lanka	Skull (009) at NARA, collected by S.L. 23 Feb. 1983 (Leatherwood and Reeves, 1989)
71	15 Apr 1983	East coast of Sri Lanka	8 seen with 12 sperm whales (Alling, 1986)
72	21 Apr 1983	between Maldives and Seychelles	7 seen (Leatherwood *et al.*, 1984)
73	24 Apr 1983	" " " "	5 seen " " "
74	26 Apr 1983	west of Aride Island, Seychelles	3 seen " " "
75	8 Aug 1983	00°16'S, 132°10'E	8 seen (Capt. H. Barber to DSP)
76	29 Aug 1983	17°30'N, 40°25'E	2 seen (J.N. Balkwill to DSP)
77	29 Nov 1983	15°30'S, 57°51'E	12 seen (Capt. J.P. Briand to DSP)
78	18 Dec 1983	36°12'S, 123°07'E	12 seen (S. Miller to DSP)
79	9 Jan 1984	25°12'N, 57°02'E	4 seen (Capt. J. Spence to DSP)
80	31 Jan 1984	13°14'N, 73°33'E	2 seen (M.A. Cook to DSP)
81	17 Mar 1984	04°04'N, 91°50'E	46 seen (D.J. Aylins to DSP)
Q	11 Mar 1984	08°35'N, 81°31'E	2 seen (Alling, 1986)
82	25 Apr 1984	09°10'N, 81°07.2'E	Sighting (Alling, 1986)
83	May 1984	Trincomalee, Sri Lanka	2 males, 4 females taken this month (Leatherwood and Reeves, 1989)
84	3 May 1984	5°41'N, 96°55'E	50 seen (U. Ureel to DSP)
85	9 May 1984	07°23'S, 77°17'E	30 seen (A Collet, cited in Leatherwood, 1986)

continued

Code	Date	Location	Comments/Source
86	30 June 1984	01°36'S, 117°11'E	12 seen (Capt. Burley to DSP)
87	29 July 1984	26°32'S, 34°08'E	30 seen (Capt. C. Tingle to DSP)
88	26 Oct 1984	11°21'N, 51°34'E	8 seen (J. Podmore to DSP)
89	19 Nov 1984	23°18'N, 59°30'E	12 seen (A Collet, cited in Leatherwood, 1986)
90	20 Nov 1984	22°15'N, 62°37'E	25 seen (A Collet, cited in Leatherwood, 1986)
91	5 Jan 1985	20°30'N, 62°14'E	100 seen (A Collet, cited in Leatherwood, 1986)
92	18 Jan 1985	25°16'N, 57°17'E	10 seen (A. Pring to DSP)
E	20 Jan 1985	17°30'N, 56°05'E	Specimen ONHM 834 (Gallagher, this volume)
93	Feb 1985	Trincomalee, Sri Lanka	1 male, 2 females taken this month (Leatherwood and Reeves, 1989)
94	20 Mar 1985	8°08'S, 115°53'E	10 seen (S. Miller to DSP)
95	19 Dec 1985	11°57'N, 52°14'E	20 seen (Capt. R. Knight to DSP)
F	09 Feb 1986	10°18'N, 51°48'E	8 seen (Small and Small, this volume)
G	12 Mar 1986	11°21'N, 51°42'E	12 seen (Small and Small, this volume)
H	16 Mar 1986	10°24'N, 51°15'E	10 seen (Small and Small, this volume)
96	1 Apr 1986	15°12'N, 42°00'E	2 seen (T.S. Mosley to DSP)
97	4 Apr 1986	5°09'S, 95°10'E	10 seen (D. Harnett to DSP)
98	8 Apr 1986	00°04'N, 76°40'E	18 seen " " " "
I	11 Apr 1986	12°22'N, 50°39'E	12 seen (Small and Small, this volume)
J	13 Apr 1986	11°33'N, 51°13'E	1 seen (Small and Small, this volume)
K	18 Mar 1986	12°0'N, 51°23'E	2 seen (Small and Small, this volume)
L	18 May 1986	11°58'N, 51°32'E	25+ seen (Small and Small, this volume)
M	20 May 1986	11°49'N, 51°46'E	25 seen (Small and Small, this volume)
N	20 May 1986	11°57'N, 51°26'E	5°6 seen (Small and Small, this volume)
99	8 Oct 1986	08°12'S, 125°45'E	4 seen (T.A. Meharry to DSP
O	18 Nov 1986	11°42'N, 49°21'E	5 seen (Small and Small, this volume)
100	- - -	nr Mogadishu	Skull and skeleton, fragments, at ZM (Azzaroli and Puccatti, 1986)
101	- - -	Saldanha Bay area?	Skull (36809) at SAM
102	- - -	Mosselai area?	Skull (unnumbered) at MBM
103	- - -	Cape Hangklip, False Bay, S Afr.	Skull (3.27) at UCT
104	- - -	Bonza Bay, nr East London, S Afr.	Skull (27) at ELM
Q	11 Mar 1984	8°35'N, 81°31'E	2 seen (Alling, 1986)
R	1986	Trincomalee, Sri Lanka	9 taken in fisheries (Leatherwood and Reeves, 1989)

Footnotes: BM = Buitenzorg Museum, Java; BMNH = British Museum (Natural History), London; CM = Colombo Museum, Sri Lanka; DSP = Dolphin Survey Project; ELM = East London Museum, South Africa; LACM = Los Angeles County Museum, USA; MASC = Museum Asiatic Society of Calcutta, India; MBM = Mossel Bay Museum, South Africa; MHNB = Museum d'Histoire Naturelle, Bordeaux, France; MNHN = Museum National d'Histoire Naturelle, Laboratoire d'Anatomie, Paris, France; MZB = Museum Zoologicum Bogoriense, Java; PEM (in various institutional and private collections) = Port Elizabeth Museum, South Africa; SAM = South African Museum, South Africa; SCL = Sri Lankan Collections, Sri Lanka (in various institutional and private collections); SNA = Seychelles National Archives, Seychelles; UCT = University of Cape Town, Zoology Department Museum, South Africa; ZM = Zoology Museum, University of Florence, Italy

Table 6

Seychelles Island specimen measurements (in accordance with Perrin, 1975)

1	Condylobasal length	590mm
2	Rostrum length	280mm
3	Rostrum width at base	242mm
4	Rostrum width at 60	227mm
5	Rostrum width at midlength	191mm

continued

6	Premaxillary width at rostrum midlength	186mm
7	Rostrum width at 3/4 length	142mm
8	Rostrum tip to external nares	371mm
9	Rostrum tip to internal nares	N/A
10	Preorbital width	385mm
11	Least supraorbital width	N/A (broken off)
13	External nares width	76.2mm
14	Zygomatic width	97.8mm (left)
15	Greatest width of premaxillaries	152mm (near nares); 186mm (at 1/2 length)
16	Parietal width	249mm (parietals indented)
17	Braincase height	245mm
18	Braincase length	104mm
19	Posttemporal fossa length	144 (left)
20	Posttemporal fossa width	78 (left)
25	Orbit length	97 (left)
26	Antiorbital process length	54.2mm (left)
27	Internal nares length	116.5mm
28	Pterygoid length	N/A
30	Bulla length	N/A
31	Periotic length	N/A
32	Upper tooth row length	136mm (left); 127mm (right)
33-36	Number of teeth UL/UR:LL/LR	6(7)/6; N/A

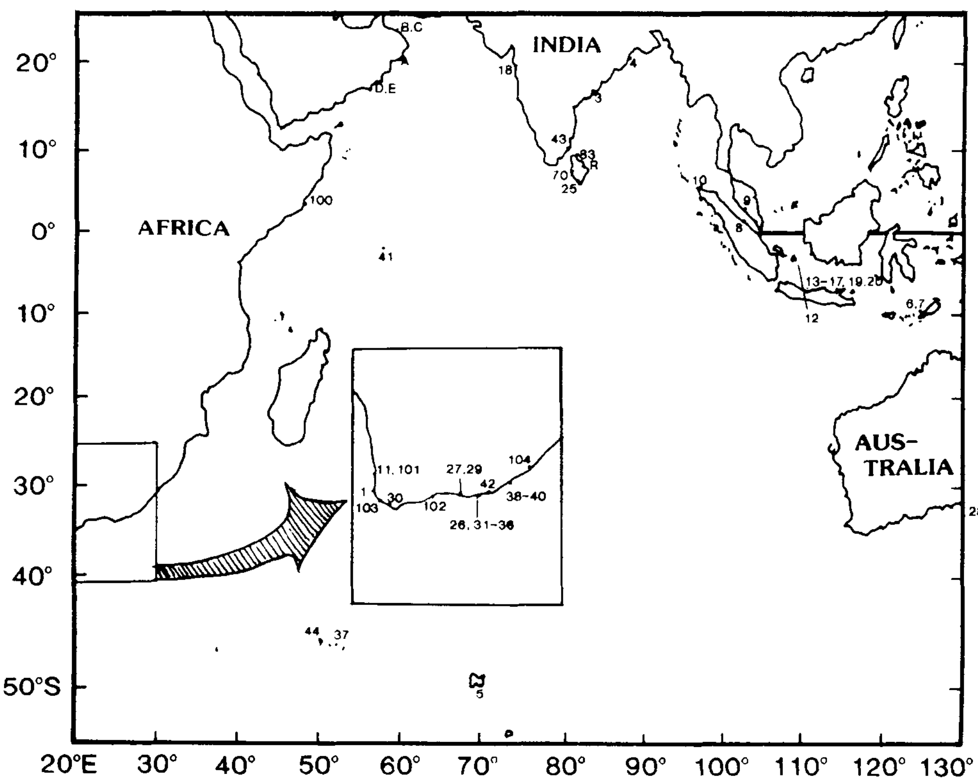

Fig. 10. Locations in the Indian Ocean where pilot whale specimens have been observed or collected.

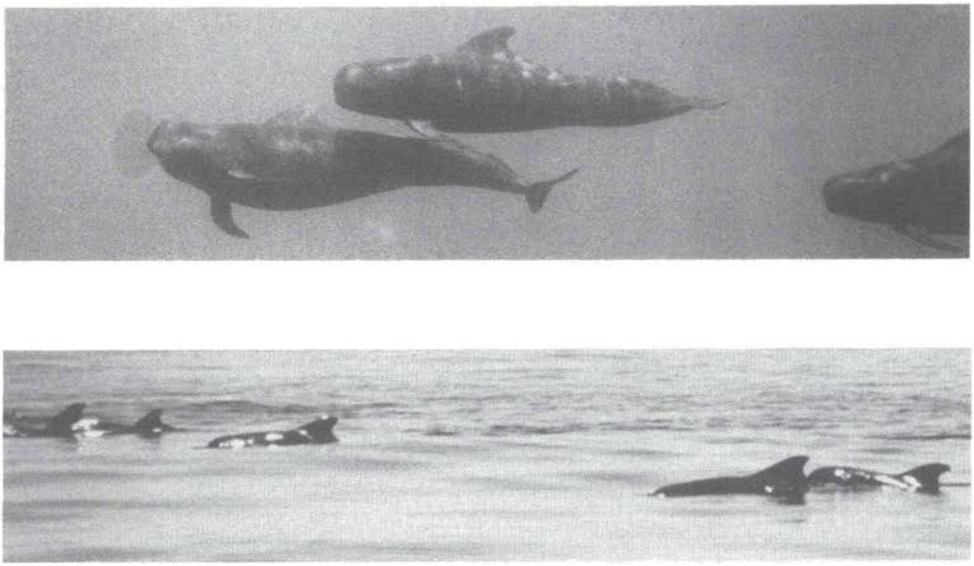

Fig. 11. Pilot whales off Alphonse Atoll, Seychelles, December 1975 (top) and off Northeastern Sri Lanka in April 1983 (bottom). [R. Salm, courtesy U. S. National Museum (top) and A. Alling, courtesy WWF (bottom)].

Pygmy killer whale

There is now general agreement that there is but a single species of pygmy killer whale, *Feresa attenuata*, which is widely distributed in tropical and warm subtropical waters worldwide (Ross and Leatherwood, in press). The species was first documented as occurring in the Indian Ocean, albeit very near the western boundaries of the Indian Ocean Sanctuary, in May 1968 based on a stranding at Richard's Bay, South Africa (Bass, 1969; Ross,G J B, 1979) (Table 7). That pygmy killer whales also occur alive off south Africa was confirmed by a sighting in August of the following year (Best, 1970). The only other Southern Hemisphere records in the Indian Ocean are those of an additional specimen from South Africa, at Port Elizabeth (Ross,WG, 1974), a sighting west of Seychelles Bank in 1987, reported second hand by Keller *et al.* (1982), and observations by subsistence whalers off Lamalera, Indonesia, in July and August 1979 of pods of small blackfish which were either pygmy killer whales or melon-headed whales (Hembree, 1980).

Confirmed evidence of occurrence of pygmy killer whales in the Northern Hemisphere of the Indian Ocean was, until very recently, equally sparse (Table 7, Fig. 12). It consisted of one sighting off Oman (Harwood, 1981) and two sightings in the Bay of Bengal, off northeastern Sri Lanka (Alling, 1983; Leatherwood *et al.*, 1984). However, observations of living animals at various locations during 1981–84 and the observation at Sri Lankan fish-landing sites of 22 specimens between February 1983 and October 1985 (Table 7; Fig. 13) demonstrates that the species is not rare in that region. The temporal distribution of these observations indicates that pygmy killer whales are present throughout the year in Sri Lankan waters.

Table 7

Records of pygmy killer whales in the Indian Ocean, 1968-1985

Code	Date	Location	Comments/Source
1	16 May 1968	28°50S, 32°05E	Stranding at Richards Bay (specimen 35601) at SAM (Bass, 1969; Ross, 1970)
2	2 Aug 1969	31°35S, 29°53E	11 seen (Best, 1970)
3	? May 1977	West of Seychelles Bank	12 seen (Keller et al., 1982)
4	9 Jul 1979	Off Lamalera, Indonesia	5 seen* (Hembree, 1980)
5	28 Aug 1979	Off Lamalera, Indonesia	2 pods seen (Hembree, 1980)
6	31 Mar 1980	16°16°N, 54°11E	38 seen (S.P. Weston to DSP)
7	24 Nov 1980	about 23°N, 59°E	Sighting (Harwood, 1980)
A	30 Dec 1981	12°13N, 44°15E	3 seen (Alling, 1986)
B	20 Jan 1981	19°17N, 58°11E	2 seen (Alling, 1986)
C	24 Jan 1982	23°24N, 58°59E	3 seen (Alling, 1986)
8	16 Apr 1982	Northeast of Sri Lanka	120 seen** (Leatherwood et al., 1984)
9	6 Feb 1983	07°53N, 81°54E	3 seen (Alling, 1986)
10	8 Feb 1983	Trincomalee, Sri Lanka	Gillnet bycatch (Alling, 1985)
11	3 Apr 1983	Trincomalee, Sri Lanka	Gillnet bycatch, 2 specimens, (Alling 1985)
D	3 Mar 1984	8°36N, 81°21E	3 seen (Alling, 1986)
12	19 Aug 1984	Negombo, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
13	7 Jan 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
14	24 Jan 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
15	12 Feb 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
16	15 Mar 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
17	19 Mar 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
18	7 Apr 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
19	19 May 1985	Beruwala, Sri Lanka	Gillnet bycatch (M. Vely, pers. comm. to SL)
20	20 Jun 1985	Trincomalee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
O	6 Jul 1985	20°15S, 39°0E	25-30 seen (J. Beadon to SL)
21	13 Jul 1985	20°15S, 39°0E	Gillnet bycatch (Leatherwood & Reeves, 1989)
E	27 Jul 1985	Trincomalee, Sri Lanka	Fisheries bycatch, 143.45cm male (Leatherwood & Reeves, 1989)
22	6 Aug 1985	Beruwala, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
23	7 Aug 1985	Trincomalee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
24	8 Aug 1985	Gallee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
25	9 Aug 1985	Trincomalee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
26	20 Aug 1985	Trincomalee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
27	14 Oct 1985	Trincomalee, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
28	25 Oct 1985	Kottegoda, Sri Lanka	Gillnet bycatch (Leatherwood & Reeves, 1989)
29	? ? ?	Port Elizabeth, South Africa	Specimen (Ross, 1984)

SAM=South African Museum; *possibly *Peponocephala electra* as a specimen of that species was taken there by subsistence fishermen during this period; **possibly *P. electra*.

Selected measurements for 13 of the Sri Lankan specimens are shown in Table 8. Although materials collected from those specimens have yet to be analyzed in any detail, lengths at sexual maturity in the Sri Lankan animals appears consistent with values in samples from elsewhere (Ross and Leatherwood, in press). Sperm was found in a 215.9-cm male but not in a 170.2 cm male. Females 207 and 221.6 cm, both caught in August, were lactating, and females 219.7 and 221.6 cm caught during the same month were carrying fetuses estimated to have been 70 cm long and near term.

Table 8

Selected external measurements (inches) of thirteen pygmy killer whales caught in gillnets off Sri Lanka 1983-85. Animals 1-5, 7-8, 10-12 caught at Trincomalee; animal 6 at Beruwala; animal 9 at Galle; and animal 13 at Kottegoda. The only information for animal 1 (specimen #AA1, head) is the tooth count: upper right=11; lower right=13; upperleft=11; lower left=13. Animals 7 and 8 were pregnant and carrying near-term fetuses, animal 9 had sperm in the testes and animal 12 had its flukes cut off.

Animal:	2	3	4	5	6	7	8	9	10	11	12	13
Specimen #	AA52483	AA52383	SL9785	SL4585	CA1885	SL13845	SL9585	AC8885	SL9485	*3185	*141085	**521055
Collected	3/4/85	3/4/85	29/6/85	13/7/85	6/8/85	7/8/85	7/8/85	8/8/85	9/8/85	20/8/85	14/10/85	25/10/85
Sex	Male	Female	Female	Male	Female	Female	Female	Male	Female	Female	Male	Female
Total length	47.5	82.5	53.0	67.0	48.5	87.25	86.5	85.0	81.5	81.0	-	70.0
Tip of snout												
to co eye	-	-	9.25	7.0	8.5	6.5	5.0	10.5	9.5	10.0	9.5	6.58.5
to ao mouth	-	7.0	6.0	7.0	5.5	4.25	8.5	7.5	7.5	7.5	8.04.75	7.0
to ear	-	11.0	8.25	10.25	9.0	7.0	13.0	-	11.5	11.0	7.25	11.0
to co blowhole	-	8.25	7.0	8.5	5.5	4.5	9.5	10.0	9.0	9.0	5.5	8.25
to flipper	-	16.5	11.0	15.5	11.0	8.5	17.5	15.0	16.0	17.0	11.0	14.0
to dorsal fin	-	49.5	-	-	22.0	-	-	-	-	-	-	30.0
to umbilicus	-	39.0	23.5	30.5	22.0	36.25	38.0	36.0	36.0	36.5	26.5	21.0
to gen. slit	-	52.0	33.5	38.0	36.0	23.5	56.0	48.0	52.5	50.5	28.5	43.5
to anus	-	56.0	35.5	43.25	-	24.75	58.5	54.0	54.5	54.0	33.0	45.5
Wo blowhole	-	1.5	-	-	-	-	-	-	-	-	-	-
Lo flipper												
Anterior	-	-	10.0	12.0	9.0	8.0	18.0	17.0	16.25	16.5	8.5	12.5
Posterior	-	11.0	7.25	9.5	7.0	6.0	13.0	12.0	12.0	12.25	6.5	9.75
Wo flipper	-	5.5	3.25	4.5	8.0	2.25	5.75	5.5	5.0	5.0	3.0	4.0
Ho dorsal fin	-	7.75	5.5	7.75	5.0	4.0	19.0	10.0	7.5	8.0	5.5	7.0
Lo dor. fin base	-	13.0	11.0	14.0	9.0	7.0	19.0	20.0	13.0	14.0	7.35	11.0
Wo fluke	-	22.0	25.0	32.0	27.5	27.5	22.5	22.0	22.0	19.0	-	14.0
Do fluke	-	14.0	3.2	4.5	3.5	2.75	6.5	7.0	5.75	5.5	-	5.5
Tooth count:												
Upper right/left	9/11	-	-	-	-	-	12/10	12/12	12/13	12/12	9/10	11/12
Lower right/left	11/11	10/12	11/12	12/9	9/10	-	12/9	12/12	12/13	12/12	9/10	11/12

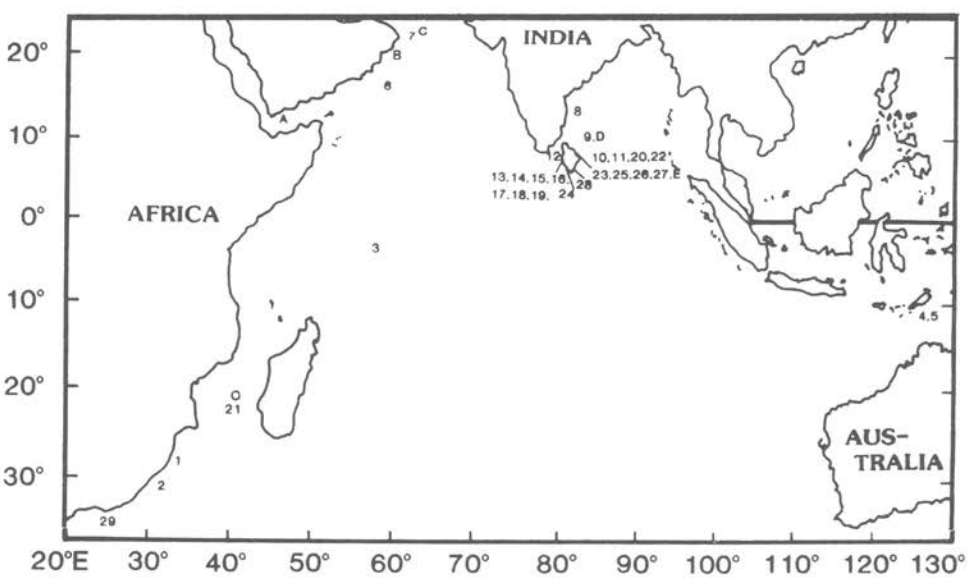

Fig. 12. Locations for records of pygmy killer whales in the Indian Ocean, 1968 through 1985.

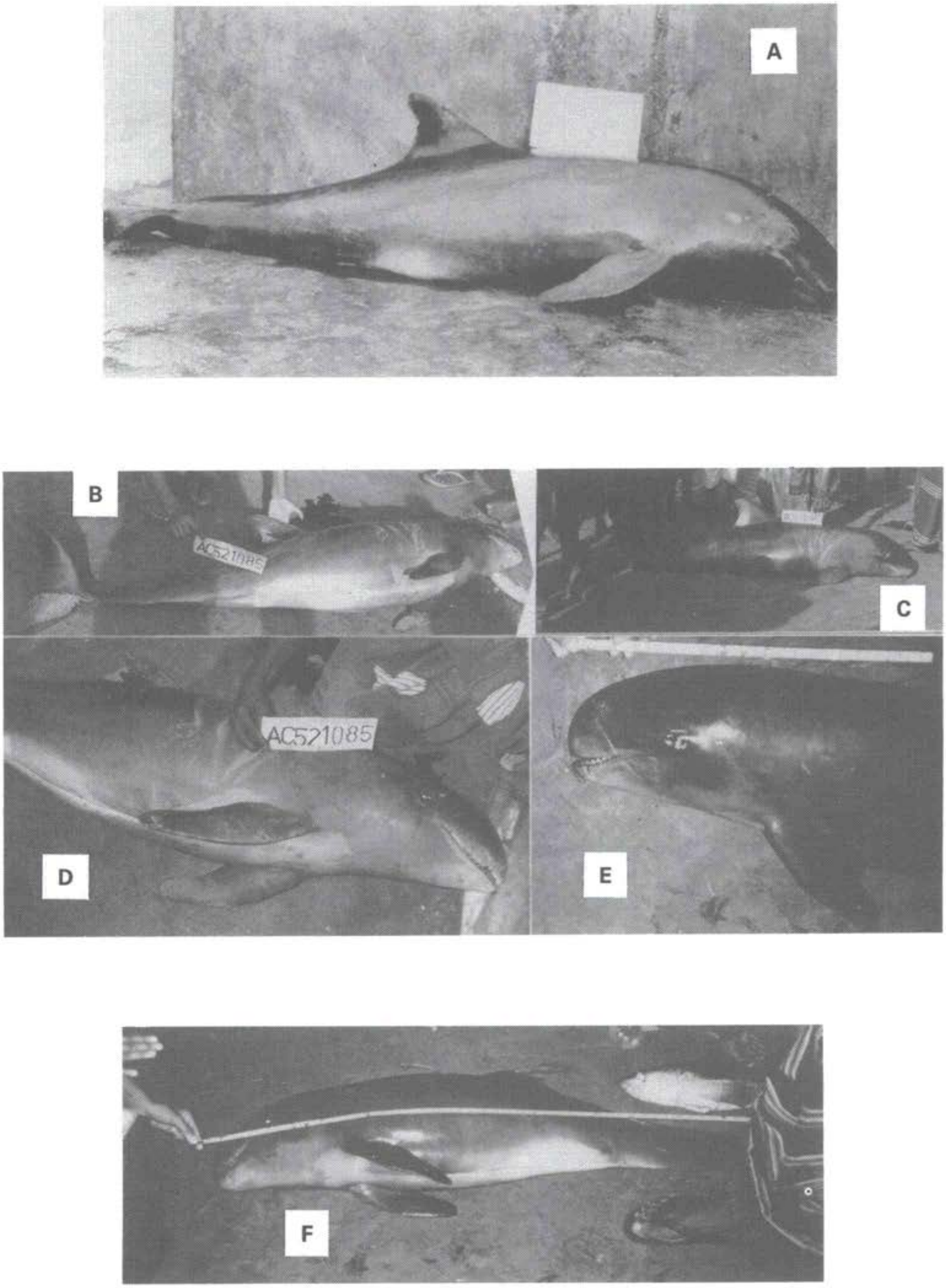

Fig. 13. Pygmy killer whales in the fish markets at Trincomalee (A), Kottegoda (B, C, and D), and Beruwala, Sri Lanka (E and F), 8 February 1983, 25 October 1985, and 6 August 1985, respectively. [A. Alling, courtesy WWF (A), C. Mendes, courtesy NARA (B, C, and D), and S. Leatherwood (E and F)]

Melon-headed whale

The melon-headed whale is known from sparse but widely distributed records to occur worldwide in tropical and subtropical seas (van Bree and Cadenat, 1968; Perrin, 1976). Currently, there is thought to be but a single species. Knowledge about its biology, including new distribution records for areas other than the Indian Ocean, is summarized by Perryman, Au and Leatherwood (in press).

Melon-headed whales are represented in the Indian Ocean by about two dozen specific records (Table 9) and a few summary allusions. The earliest published account refers to a skull collected 23 August 1853 at Madras, India, and deposited at the British Museum of Natural History in London (Owen, 1866). The most recent record is of a sighting off Somalia in February l986 (Small and Small, this volume). Most sightings for which precise positions were recorded occurred in pelagic waters.

Table 9

Records of melon-headed whales in the Indian Ocean, 1853-1986

Code	Date	Location	Comments/Source
1	23 Aug 1853	Madras, India	Skull (1866.2.5.1) at BMNH (Owen, 1866)
2	about 1888	Palk Strait, Sri Lanka	Stranding, skull at CM (Blanford, 1888;1891)
3	? ? 1888	Lamalera, Indonesia	4 calvaria and 2 mandibles (Weber, 1923)
4	? ? ?	Indian Ocean	Skull (398) at BM (Dammerman, 1924)
5	? ? ?	Vizagapatam,India	Sighting (Bierman and Slijper, 1947)
6	? ? 1959	Addu Atoll, Maldives	Skull and skeleton (1959.7.9.2) at BMNH, coll. by WA Phillips (cited in Dawbin et al., 1970)
7	before 1971	Car Nicobar Island	Specimen (Mörzer Bruyns, 1971)
8	before 1973	Sungkhula, Thailand	Stuffed skin at Fisheries Stn there (Pilleri & Gihr, 1973)
9	? Sept 1974	Aldabra, Seychelles	Stranding of 6 (Best and Shaughnessy, 1981)
10	Spring 1975	Aldabra, Seychelles	Stranding of 10 (Racey & Nicholl, in press cited in Keller et al., 1982)
11	9 July 1979	Lamalera, Indonesia	5 seen, possibly *Feresa* (Hembree, 1980)
12	28 Aug 1979	Lamalera, Indonesia	2 pods seen (Hembree, 1980)
13	29 Aug 1979	Lamalera, Indonesia	2.15m male harpooned (Hembree, 1980)
14	? ? 1980	Aldabra, Seychelles	Skull and skeleton (1980.147) at BMNH (collected by J.F. Peake)
15	? ? 1980	Aldabra, Seychelles	4 skulls (1980.148 & 150-152) at BMNH (collected by J.F. Peake)
16	13 Mar 1981	24°02'N, 58°46'E	36 seen (R.S. Combs, DSP)
17	14 Oct 1981	Cape Monze, Pakistan	Stranding (de Silva, 1987)
18	20 Mar 1982	Rehri Creek, Pakistan	Stranding (de Silva, 1987)
19	16 Apr 1982	Off NE Sri Lanka	about 120 seen (Leatherwood et al., 1984)
20	4 July 1985	Negombo, Sri Lanka	253.8cm female, harpooned while entangled in gillnet (Leatherwood & Reeves, 1989, fig 24c)
21	15 Oct 1985	Mirissa, Sri Lanka	262.5cm male harpooned
22	15 Oct 1985	Mirissa, Sri Lanka	245.8cm female harpooned
23	? ? ?	Western Java	Skull (399) at MZB (Tas'an & Leatherwood, 1984)
24	25 Sep 1985	Pemba Channel, Tanzania	Sighting (Peddemors & Ross, 1988)
25	1 Feb 1986	11°18.7'N, 48°52.8'E	3 seen in 397m water (Small & Small, this vol.)
26	? ? ?	? ? ?	Skull, Peradeniya Uni. (Leatherwood & Reeves, 1989*)

BMNH=British Museum of Natural History; CM=Calcutta Museum; BM=Buitzenzorg Museum; MZB=Museum Zoologicum Bogoriense. *(Appendix B1).

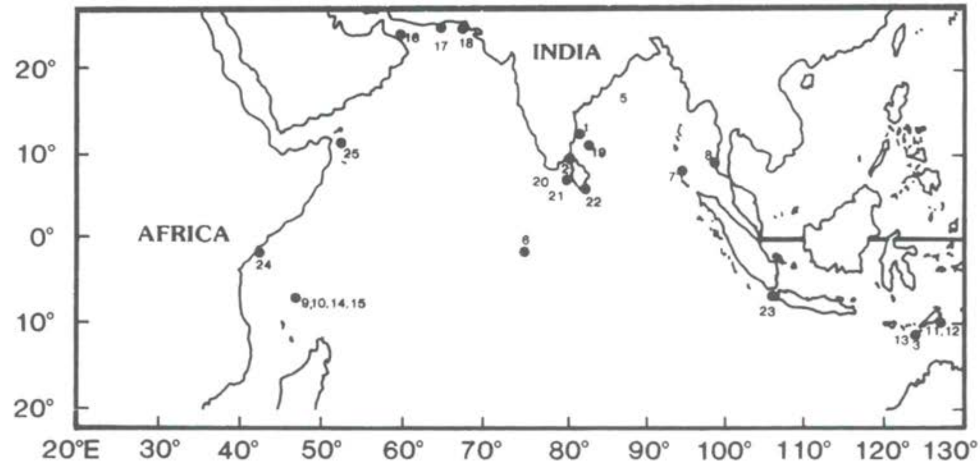

Fig. 14. Locations for records of melon-headed whales in the Indian Ocean, 1853 through 1985.

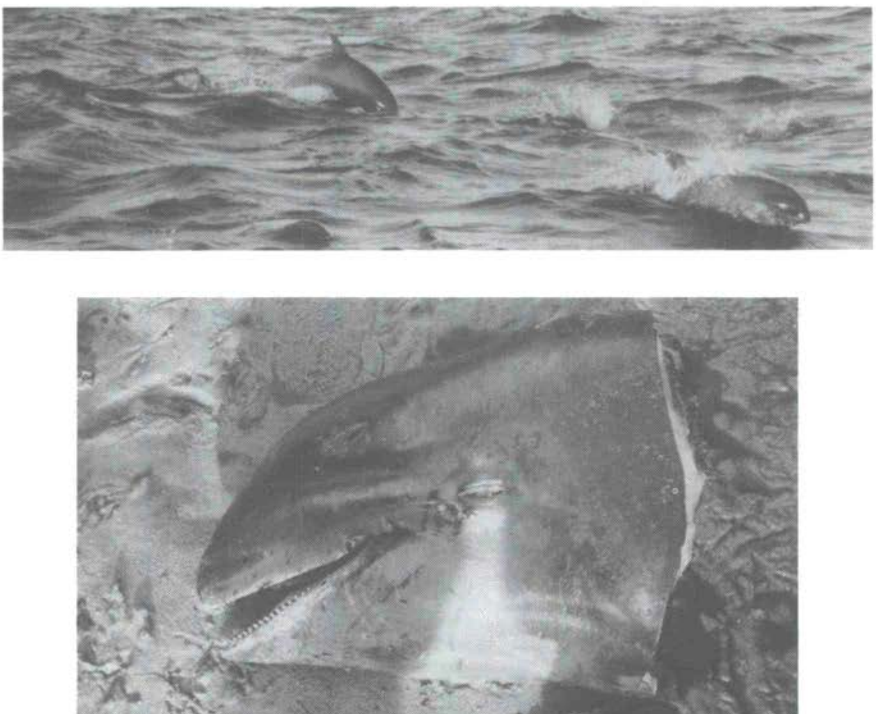

Fig. 15. Melon-headed whales in Pemba Channel, Tanzania, 25 September 1985 (top) and the head of a gillnetted specimen at Pitipana, Negombo, Sri Lanka, 4 July 1985. [V. Peddemors, from Peddemors and Ross (1988:Figure 1), top, and C. Mendes, bottom].

The vast majority of information is from the Northern Hemisphere, where these animals are present in virtually all areas studied (Fig. 14). They reportedly are common off Pakistan (Roberts, 1977), particularly off the Mekran coast after the monsoons and during winter, when fishing is best (Ranjha, cited in de Silva, 1987). Leatherwood and Reeves (1989) list three specimens observed at southwest Sri Lankan fish-landing sites in July and October 1985. One was killed incidental to gillnetting for tuna, sharks and billfish; the other two were harpooned for food or use as bait on longlines for sharks and tuna. Selected measurements of the three specimens are presented in Table 10. No materials are available from any of the three.

Melon-headed whales also are involved in fisheries in Southern Hemisphere portions of the Indian Ocean. Weber (1923) surmised that material from 1899 which he collected at Lamalera, Indonesia, probably derived from the long-lived and well-established harpoon fishery there for sperm whales and various smaller cetaceans (see Barnes, this volume). Melon-headed whales were still part of the catch at Lamalera in 1979, when a 2.15 m male was taken (Hembree, 1980), and, as the fishery continued virtually unchanged through the mid-1960s (Carey, 1986), they likely still are.

Table 10

Selected external measurements (inches) of three melon-headed whales from Sri Lanka.

Specimen Number	CA030785	CA031085	CA041085
Collected on	4 July 1985	15 October 1985	15 October 1985
Collected at	Negombo	Mirissa	Mirissa
Cause of death	Net entangled,harpooned	Harpooned	Harpooned
Sex	Female	Male	Female
Total length	96"	99"	93"
Snout to center of eye	13.5"	14"	13.5"
Snout to angle of mouth	10.5"	11"	10.75"
Snout to ear	15.5"	16"	16"
Snout to center of blowhole	14"	11.5"	13"
Snout to flipper	--	19"	20"
Snout to dorsal fin	--	37.5	42"
Snout to umbilicus	--	47"	45"
Snout to genital slit	--	57"	61"
Snout to anus	--	67.5"	64"
Blowhole width	--	--	1.75"
Flipper length, anterior	17.5"	20"	19"
Flipper length, posterior	12.5"	18"	13"
Flipper width	5.5"	5.5"	5"
Dorsal fin height	--	10.5"	8.5"
Length of dorsal fin base	--	15"	13.5"
Fluke width	21.5"	27"	23.5"
Fluke depth	6.75"	7"	6.75"
Tooth count upper left	23	22	20
Tooth count lower left	25	21	23

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REFERENCES

Alagarswami, N., Bensam, P., Rajapandian, M.E. and Fernando, A.B. 1973. Mass stranding of pilot whales in the Gulf of Mannar. *Indian J. Fish.* 20:269–79.

Alling, A. 1983. A preliminary report of marine mammal fisheries in Djibouti, Oman and Sri Lanka. Paper NARA/SMMIO/SP32 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished). 4pp.

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83:376–94.

Anderson, P.K. and Prince, R.I.T. 1985. Predation on dugongs; attack by killer whales. *J. Mammal.* 66:554–6.

Anonymous. 1978. *FAO Fisheries Series No. 5 [Mammals in the Seas]*. Vol. 1. *Report of the FAO ACMRR Working Party On Marine Mammals*. FAO, Rome. 264pp.

Anonymous. 1980. A report based on the workshop on stock assessment and incidental take of marine mammals involved in commercial fishing operations, Jan 30–31 and Feb 1, 1979. 99pp + 1app.

Anonymous. 1981. *Report of the Workshop to Plan a Programme of Scientific Research On Cetaceans in the Indian Ocean Sanctuary*. Ministry of Cultural Affairs, Recreation and Social Welfare, Netherlands. 105pp.

Anonymous. 1987. Sea Life Park's two most famous babies and a brief history of their interesting families. Sea Life Park, Hawaii.

Barnes, R.H. Indigenous whaling and porpoise hunting in Indonesia. (Published in this volume.)

Bass, J. 1969. A rare whale stranded in Zululand. *Bull. S. Afr. Assoc. Mar. Biol. Res.* 7:36.

Bellision, N.B. 1966. *Fauna Marina Antarctica*. Republica Argentina Secretaria de Marina, Servicio de Hidrografia Naval, Publico H.907, Buenos Aires. 91pp.

Best, P.B. 1970. Records of the pygmy killer whale, *Feresa attenuata*, from southern Africa, with notes on behaviour in captivity. *Ann. S. Afr. Mus.* 57:1–14.

Best, P.B. and Ross, G.J.B. 1977. Exploitation of small cetaceans off southern Africa. *Rep. int. Whal. Commn* 27:494–7.

Blanford, W.T. 1891. *The Fauna of British India, Including Ceylon and Burma*. Taylor and Francis, London. 617pp.

Brown, D.H., Caldwell, D.K. and Caldwell, M.C. 1966. Observations on the behaviour of wild and captive false killer whales, with notes on associated behaviour of other genera of captive delphinids. *Contrib. Sci. (Los Angel.)* 95:1–32.

Bryden, M.M. 1978. Whales and whaling in Queensland waters. *Proc. R. Soc. Queens.* 88:v-xviii. pls 1–3.

Carey, L. 1986. La luna protegga i cacchiaroti de mari. *Ligabue* 5:88–101.

Chantrapornsyl, S., Kinze, C.C., Leatherwood, S. and Prematunga, W.P. Notes on the Genus *Kogia* in the northern Indian Ocean. (Published in this volume).

Clark, A.H. 1945. Animal life in the Aleutian Islands. p. 131. *In:* H.B. Collins, A.H. Clark and E.H. Walker (eds.) *The Aleutian Islands: their people and natural history (with keys to the identification of the birds and plants*. Smithsonian War Background Studies 21, .

Conde, P.R., van Aarde, R.J. and Bester, M.N. 1978. The seasonal occurrence and behaviour of killer whales, *Orcinus orca*, at Marion Island. *J. Zool.* 184:449–64.

Cruickshank, R.A. and Brown, S.G. 1981. Recent observations and some historical records of southern right whale dolphins, *Lissodelphis peronii*. *Fish. Bull. Div. Sea Fish. S. Afr.* 15:109–21.

Dammerman, K.W. 1924. On *Globicephala* and some other delphinidae from the Indo-Australian Archipelago. *Treubia* 4:339–52.

Davies, J.L. 1963. The antitropical factor in cetacean speciation. *Evolution* 17:107–16.

Deraniyagala, P. 1945a. Some southern temperate zone snakes, birds and whales that enter the Ceylon area. *Spolia Zeylan.* 29:1–83.

Deraniyagala, P.E.P. 1945b. Some odontoceti from Ceylon. *Spolia Zeylan.* 24:113–20.

de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, and from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84:505–25.

Freeman, K. 1986. Fish of the month. Black cod. *Pac. Fishing* 7:34–41.

Gallagher, M.D. Collections of skulls of Cetacea: Odondoceti from Bahrain, United Arab Emirates and Oman, 1969–1990. (Published in this volume).

Gibson-Hill, C.A. 1949. The whales, porpoises and dolphins known in Malyan waters. *Malay. Nat. J.* 4:44–61.

Gray, J.E. 1846. On the cetaceous animals. No. 3. pp. 13–53. *In: Vol. I of The Zoology of the Voyage of H.M.S.* Erebus *and* Terror, *Under the Command of Captain Sir James Clark Ross during the years 1839 to 1843*. E.W. Janson, London. 30 pl.

Gunaratna, R. 1985. Record of marine mammal species in the Indian Ocean Whale Sanctuary with special reference to the waters around Sri Lanka. 15–20 July 1985. Unpublished manuscript.

Hammond, P.S. 1984. Abundance of killer whales in Antarctic Areas II, III, IV and V. *Rep. int. Whal. Commn* 34:543–7.

Harwood, J. 1981. Observations of cetaceans in the Arabian Sea, November – December 1980. Doc. 7 presented to the Workshop to Plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary, Zeist, Netherlands, 1981 (unpublished).

Hector, J. 1885. Notes on the dolphins of the New Zealand seas. *Trans. Proc. NZ Inst.* 1884:17.

Hembree, D. 1980. Biological aspects of the cetacean fishery at Lamalera. Report on World Wildlife Fund Project 1428 (unpublished). 55pp.+2 appendices.

Hershkovitz, P. 1966. Catalog of living whales. *Smithson. Bull.* 246:1–259.

International Whaling Commission. 1980. *Thirtieth Report of the International Whaling Commission*. International Whaling Commission, Cambridge. vii+584pp.

International Whaling Commission. 1982a. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn* 32:113–26.

International Whaling Commission. 1982b. Report of the workshop on the identity, structure and vital rates of killer whale populations. *Rep. int. Whal. Commn* 32:617–31.

Jones, S. 1976a. Dolphins and porpoises caught in seines along the coast of India. Paper ACMRR/MM/SC/17 presented to the FAO Scientific Consultation on the Conservation and Management of Marine Mammals and their Environment, Bergen 1976 (unpublished). 3pp.

Jones, S. 1976b. The short-finned pilot whale, *Globicephala macrocephalus* Gray, of the Indian Ocean. Paper ACMRR/MM/SC/31 presented to the FAO Scientific Consultation on the Conservation and Management of Marine Mammals and their Environment, Bergen 1976 (unpublished). 35pp.

Kasuya, T. 1985. Fishery-dolphin conflict in the Iki Island area of Japan. p. 354. *In:* J.R. Beddington, R.J.H. Beverton and D.M. Lavigne (eds.) *Marine Mammals and Fisheries*. George Allen and Unwin, London.

Keller, R.W., Leatherwood, S. and Holt, S.J. 1982. Indian Ocean cetacean survey, Seychelle Islands, April through June 1980. *Rep. int. Whal. Commn* 32:503–13.

Klinowska, M. 1980. *A World Review of the Cetacea*. Nature Conservancy Council Great Britain, London. 390pp.

Kruze, S., Leatherwood, S., Prematunga, W.P., Mendes, C. and Gamage, A. Records of Risso's dolphins, *Grampus griseus*, in the Indian Ocean, 1891–1986. (Published in this volume.)

Leatherwood, S. 1985. Further notes on cetaceans of Sri Lanka. *Cetology* 50:1–12.

Leatherwood, S. 1986. Whales, dolphins and porpoises of the Indian Ocean Sanctuary: a catalogue of available information. Hubbs Marine Research Center Technical Report 87–197. 206pp.

Leatherwood, S. and Reeves, R.R. (eds.). 1983. *The Sierra Club Handbook of Whales and Dolphins*. Sierra Club Books, San Francisco. xvii+302pp.

Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985–1986. *UNEP Mar. Mammal Tech. Rep.* 1:[vi], 1–138.

Leatherwood, S., Caldwell, D.K. and Winn, H.E. 1976. Whales, dolphins and porpoises of the western North Atlantic. A guide to their identification. *NOAA Tech. Rep., NMFS Circ.* 396:176.

Leatherwood, S., Peters, R., Santerre, R., Santerre, M. and Clark, J.C. 1984. Observations of cetaceans in the northern Indian Ocean Sanctuary, November 1980 – May 1983. *Rep. int. Whal. Commn* 34:509–20.

Matkin, C.O. and Leatherwood, S. 1986. General biology of the killer whale: a synopsis of knowledge. pp. 35–68. *In:* B.C. Kirkevold and J.S. Lockard (eds.) *Behavioral Biology of the Killer Whale*. Alan R. Liss, New York. 457pp.

McBrearty, D.A. 1981. A report on cetaceans observed on passage from Palma to Plymouth. *Mar. Obs.* 51:77–82.

McBrearty, D.A. 1985. Dolphin Survey Project: The use of professional seafarers in data collection on various marine species. *Proc. Symp. Endangered Mar. Anim. Mar. Parks* 1.

McBrearty, D.A. 1986. Observations on small cetaceans in the northeast Atlantic Ocean and the Mediterranean Sea: 1978–1982. pp. 225–50. *In:* M.M. Bryden and R. Harrison (eds.) *Research on dolphins*. Clarendon Press, Oxford.

Mikhalev, Y.A., Ivashin, M.V., Suvasin, V.P. and Zelanaya, F.W. 1981. The distribution and biology of killer whales in the Southern Hemisphere. *Rep. int. Whal. Commn* 31:551–66.

Mitchell, E. 1975. Report of the Meeting on Smaller Cetaceans, Montreal April 1–11, 1974, Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission. *J. Fish. Res. Board Can.* 32:889–983.

Mizue, K., Takemura, A. and Nakasai, K. 1969. Studies on the little toothed whales in the West Sea area of Kyushu – XVI. Underwater sound of the false killer whale. *Bull. Fac. Fish. Nagasaki Univ.* 28:19–29.

Mörzer-Bruyns, W.F. (ed.). 1971. *Field Guide of Whales and Dolphins*. C.A. Meese, Amsterdam. 258pp.

Nishiwaki, M. 1977. Distribution of toothed whales in the Antarctic Ocean. pp.783–91. Proc. Third SCAR Symposium Antarctic Biology.

Nishiwaki, M. 1983. Marine mammal species considered to be in the Indian Ocean. Paper NARA/SMMIO/SP12 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished). 11pp.

Nishiwaki, M. and Hung-Chia, Y. 1961. A curiously tailed dolphin caught in Formosa. *Norsk Hvalfangsttid.* 50(12):507–12.

Nishiwaki, M. and Tobayama, T. 1982. Hybrids between *Pseudorca crassidens* and *Tursiops truncatus gilli*. *Sci. Rep. Whales Res. Inst., Tokyo* 34:109–21.

Owen, R. 1866. On some Indian Cetacea collected by Walter Elliot, Esq. *Trans. Zool. Soc. Lond.* 6:17–47.

Papastavrou, V. and Salm, R. A note on recent sightings and strandings of Cetaceans in Oman: Ra's Sawadi to Rakhyut. (Published in this volume).

Pearson, J. 1931. A note on false killer whale, *Pseudorca crassidens*, (Owen). *Spolia Zeylan.* 16:199–203.

Peddemors, V.M. and Ross, G.J.B. 1988. First record of the melon-headed *Peponocophala electra* (Gray, 1846) for the East African coast. *Afr. J. Ecol.* 26:345–6.

Perrin, W.F. 1976. First record of the melon-headed whale, *Peponocophala electra*, in the eastern Pacific, with a summary of world distribution. *Fish. Bull., US* 74:457–8.

Perryman, W.L., Au, D. and Leatherwood, S. In press. Melon-headed whale *Peponocephala electra*. *In:* S.H. Ridgway and R.J. Harrison (eds). *Handbook of Marine Mammals.* Vol. 5. Academic Press, London.

Pillay, R.S.N. 1926. List of cetaceans taken in Travancore from 1902–1925. *J. Bombay Nat. Hist. Soc.* 31:815–7.

Purves, P.E. and Pilleri, G. 1978. The functional anatomy and general biology of *Pseudorca crassidens* (Owen) with a review of the hydrodynamics and acoustics in Cetacea. *Invest. Cetacea* 9:67–231.

Reeves, R.R., Leatherwood, S. and Papastavrou, V. Possible stock affinities of humpback whales in the northern Indian Ocean. (Published in this volume.)

Rice, D.W. 1977. A list of the marine mammals of the world. *NOAA (Nat. Oceanic Atmos. Adm.) Tech. Rep. NMFS (Nat. Mar. Fish. Serv.)* SSRF 711:1–75.

Roberts, T.J. (ed.). 1977. *The Mammals of Pakistan*. Ernest Benn Ltd., London. 393pp.

Ross, G.J.B. 1979. Records of pygmy and dwarf sperm whales, genus *Kogia*, from Southern Africa, with biological notes and some comparisons. *Ann. Cape Prov. Mus. (nat. Hist.)* 11:259–327.

Ross, G.J.B. and Leatherwood, S. In press. Pygmy killer whale, *Feresa attenuata. In:* S.H. Ridgway and R.J. Harrison (eds). *Handbook of Marine Mammals*. Vol. 5. Academic Press, London.

Ross, W.G. 1974. Distribution, migration, and depletion of bowhead whales in Hudson Bay, 1860 to 1915. *Arctic Alpine Res.* 6:85–98.

Sivasubramaniam, K. 1965. Predation of tuna longline catches in the Indian Ocean by killer whales and sharks. *Bull. Fish. Res. Stn., Ceylon* 17:93–6.

Small, J.A. and Small, G.J. Cetacean observations from the Somali Democratic Republic, September 1985 through May 1987. (Published in this volume.)

Sylvestre, J.-P. and Tasaka, S. 1985. On the intergeneric hybrids in cetaceans. *Aquat. Mamm.* 11.

Traill, T.S. 1809. Description of a new species of whale, *Delphinus melas*. *Nicholson's J. Nat. Philos. Chem. Arts* 22:81–3. + pl. iii.

van Bree, P.J.H. 1971. On *Globicephala sieboldii* Gray, 1846, and other species of pilot whales (Notes on Cetacea, Delphinoidea III). *Beaufortia* 19:79–87.
van Bree, P.J.H. and Cadenat, J. 1968. On a skull of *Peponocephala electra* (Gray, 1846) (Cetacea, Globicephaliae) from Senegal. *Beaufortia* 144:193–202.
Voisin, J.F. 1972. Notes on the behaviour of the killer whale, *Orcinus orca* L. *Norw. J. Zool.* 20:93–6.
Voisin, J.F. 1976. On the behaviour of the killer whale, *Orcinus orca* (L.). *Norw. J. Zool.* 24:69–71.
Weber, M. 1923. Die cetacean der Siboga Expedition. *Siboga Exped. Monogr.* 58:1–38.
Wellings, H.P. 1964. *Shore Whaling At Twofold Bay. Assisted By the Renowned Killer Whales. An Important Industry Now Defunct.* Printed at the Office of the *Magnet Voice*, Eden, Australia. i+15pp.
Wray, P. and Martin, K.R. 1983. Historical Whaling records from the western Indian Ocean. *Rep. Int. Whal. Commn* (special issue 5): 213–41.

Records of Risso's Dolphins, *Grampus griseus*, in the Indian Ocean, 1891–1986

Susan Kruse [1], Stephen Leatherwood [2], W.P. Prematunga [3], Chandana Mendes [3] and Asoka Gamage [3]

ABSTRACT

A review of records of Risso's dolphins from the Indian Ocean indicates that these animals are distributed throughout much of this broad region, particularly in deeper coastal waters, seaward of the continental shelf. During vessel surveys across the Arabian Sea and around Sri Lanka, groups of Risso's dolphins were the third most commonly seen small odontocete. Average group size was 17 individuals (n=36, SD=26.6). Between 1983 and 1986, 241 Risso's dolphins were reportedly landed in Sri Lanka, most caught in the drift gillnet fishery. Of 62 specimens measured, 55 (89%) were under 250cm long, and were judged, therefore, to be sexually immature. The reason for this apparent selection for small (young) animals is unknown, but it may well be having serious effects on the population(s) in this area. Systematic studies of the status and ecological relationships of Risso's dolphins in the Indian Ocean and of the impacts of sustained gillnet mortality on local populations are recommended. Because little is known about the biology of this species, detailed studies of the biology of specimens are advised.

Keywords: Risso's dolphin; distribution; Indian Ocean; survey-ship; sightings-incidental; incidental capture; social.

INTRODUCTION

Efforts to inventory the cetacean fauna of the Indian Ocean have focused on describing the distribution and abundance of the many cetacean species found in this region (e.g. Keller *et al.*, 1982; Leatherwood *et al.*, 1984; Leatherwood, 1985; Alling, 1986; Leatherwood and Reeves, 1989) and on the level of fisheries involvement of these animals (e.g. Alling, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). In this paper, we summarise information available on Risso's dolphins (*Grampus griseus*) in the Indian Ocean through December 1986, and examine this species' involvement in Sri Lanka's fisheries. Using the few data that exist, we estimate the apparent impact of these fisheries on the population status of Risso's dolphins in the Sri Lanka area.

Distribution and relative abundance

Sightings of Risso's dolphins have been clustered in the northern and western regions of the Indian Ocean, particularly around the coast of Sri Lanka (Figs 1 and 2). The absence of detailed records from the central and eastern Indian Ocean may well be an artifact of coverage rather than an actual hiatus in this species' distribution. Because of their cosmopolitan distribution elsewhere (Kruse *et al.*, in press), it is likely that Risso's dolphins are distributed also in Indian Ocean waters seaward of the continental shelf edge (waters > 180m), particularly where steep bathygraphic features occur.

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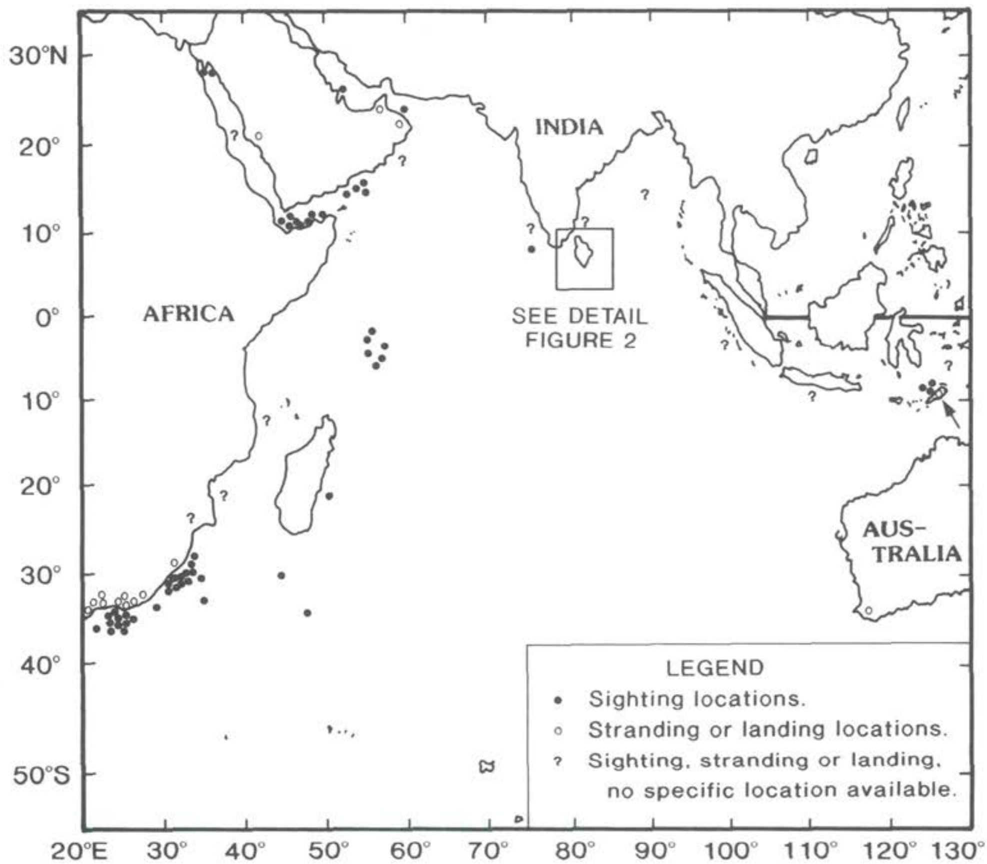

Fig. 1. Recorded distribution of Risso's dolphins in the Indian Ocean. Sources:

Sightings: Alling, 1986; Beadon, this volume; Weber, 1923; Dammerman, 1924; Mörzer-Bruyns, 1971; Gambell *et al.*, 1974; Hembree, 1980; Keller *et al.*, 1982; Leatherwood *et al.*, 1984b; Ross, 1984; Leatherwood, 1985; James and Lal Mohan, 1987; Leatherwood and Reeves, 1989.

Strandings/Landings: Alling, 1985; Gallagher, this volume; Iredale and Troughton, 1936; Hembree, 1980; Leatherwood *et al.*, 1984b; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989; Leatherwood *et al.*, this volume; Ross, 1984

Records of 36 groups of Risso's dolphins comprised an estimated total of 674 individuals. Groups reportedly consisted of two to 150 animals. The average group of Risso's dolphins contained 17 individuals (n=36, SD=26.6) – fewer than the estimated world-wide average of about 30 animals per group (Kruse *et al.*, in press) and somewhat more than the 11 animals per group reported for the eastern North Pacific (Leatherwood *et al.*, 1980).

Risso's dolphins were seen during surveys conducted for small cetaceans in the Indian Ocean between the months of November and June (Gambell *et al.*, 1974; Keller *et al.*, 1982; Leatherwood *et al.*, 1984b; Leatherwood, 1985; Alling, 1986; Leatherwood and Reeves, 1989). Indices of abundance ranged from 0.10 to 0.24 sightings/100 n.miles searched and from 1.4 to 7.18 animals/100 n.miles searched (Table 1). Alling (1986) reported that groups of Risso's dolphin were encountered more frequently than groups of other dolphin species, except bottlenose and spinner dolphins off the coasts of Oman,

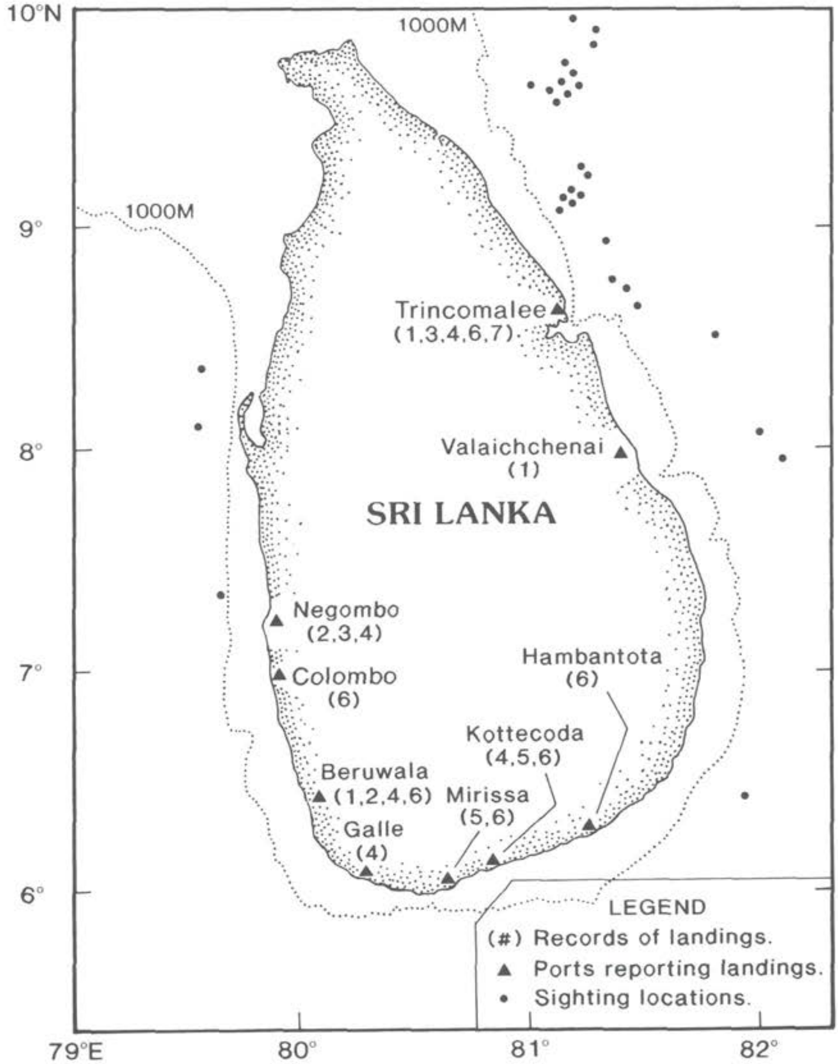

Fig. 2. Locations of sightings and landings of Risso's dolphins around Sri Lanka. Sources:
Sightings: Leatherwood *et al.*, 1984b; Alling, 1986; Leatherwood and Reeves, 1989.
Landings: Leatherwood *et al.*, 1984b; Alling, 1985; Joseph and Siddeek, 1985; Mendes and Gamage, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989; Leatherwood *et al.*, this volume.

India and Sri Lanka. Risso's dolphins were the sixth most abundant odontocete encountered (Alling, 1986). Leatherwood *et al.* (1984b) reported that Risso's dolphins were the 'most abundant' medium-sized whale encountered during their surveys of the northern areas of the Indian Ocean in April 1983. However, because details of sighting effort during the various surveys are not described, we cannot compare sighting frequencies among months or survey regions. Existing data are not sufficient to permit us to address questions about seasonal movements or shifts in abundance.

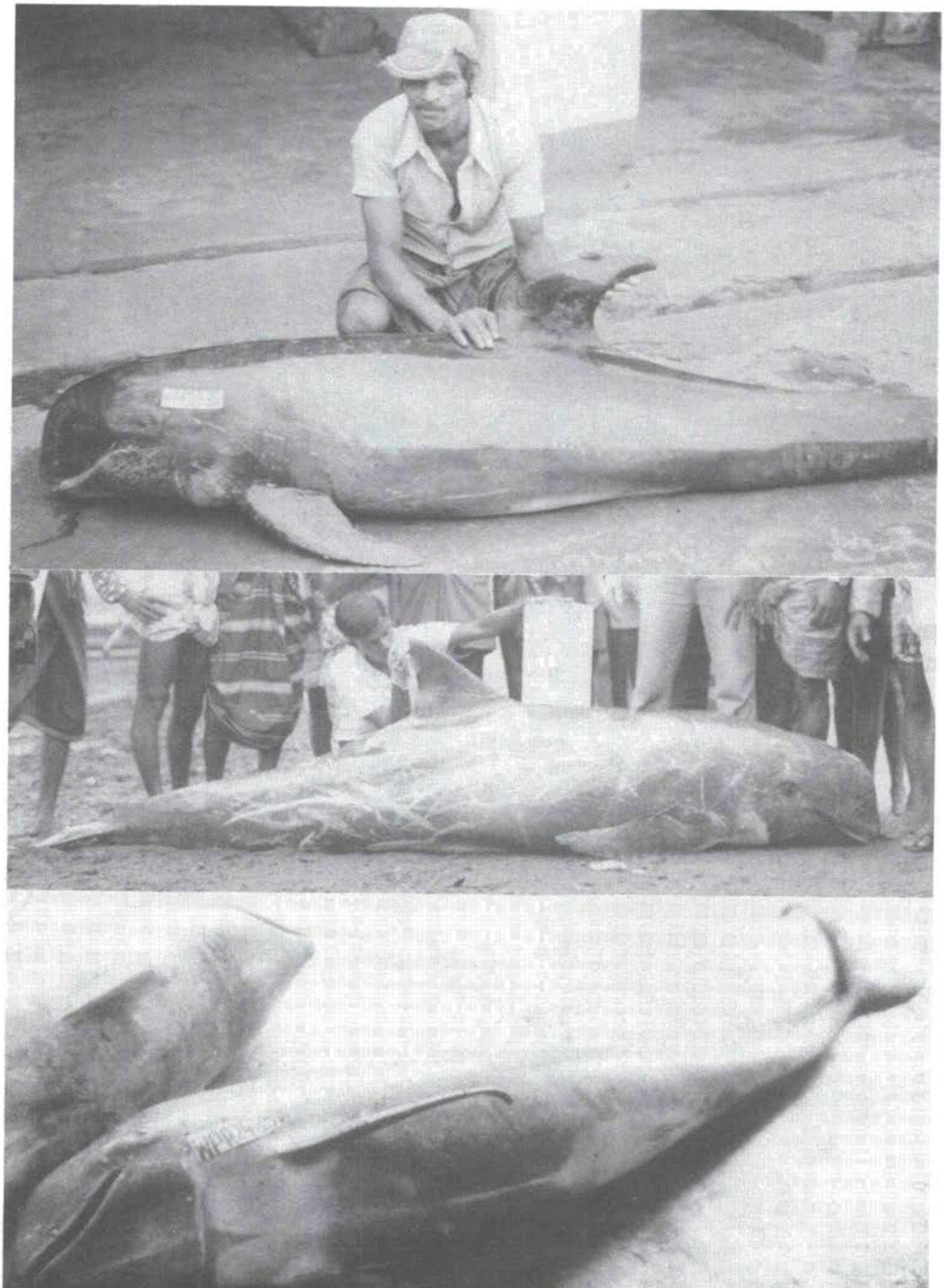

Fig. 3. Animals landed in Sri Lanka. Top: WPP0985, male, 214.5cm, Trincomalee, 15 August 1985; middle: A12785, adult, Beruwala, 19 July 1985; bottom: WPP2485, male, 165cm, Trincomalee, 15 August 1985.

Table 1

Published indices of abundance of Risso's dolphins in the Indian Ocean.
S = number of sightings, A = number of animals, S/100 = number of sightings per 100 n.mile, A/100 = number of animals per 100 n.miles, NM = n.miles surveyed.

Dates	Locations	S	A	S/100	A/100	NM	Sources
11.24.73 to 2.3.74	Southern Indian Ocean	6	86	0.10	1.40	6,225.8	Gambell *et al.* (1975)
4.16.80 to 6.28.80	Seychelle Islands	3	210	0.04	1.54	13,610.0	Keller *et al.* (1980)
4.83	Northern Indian Ocean	5	156	0.14	7.18	2,172.2	Leatherwood *et al.* (1984)
12.25.81 to 2.12.82	Northern Indian Ocean	8	101	0.24	3.10	3,300.0	Alling (1986)

Mörzer-Bruyns (1971) characterised Risso's dolphin as a species occuring primarily in deep coastal waters (>100m) and occasionally further offshore in oceanic waters. Kruse *et al.* (in press) note that where data are available, Risso's dolphins appear to frequent coastal areas characterised by steep bathygraphic features – presumably because of the high biological productivity associated with these areas. Almost all of the Risso's dolphins seen in the Indian Ocean were along or seaward of the continental shelf edge in waters ≥100m deep. The majority of the sightings occured in waters exceeding 1,000m in depth (Keller *et al.*, 1982; Leatherwood *et al.*, 1984b; Ross, 1984; Alling, 1986). Thus, Risso's dolphins in the Indian Ocean appear to inhabit environments similar to those reported for these animals elsewhere.

Gambell *et al.* (1974) reported that they observed Risso's dolphins in waters ranging from 19 to 28°C during 65 survey days between November 1973 and February 1984. Alling (1986) noted that between November 1981 and April 1984, all 37 of her sightings of Risso's dolphins were in waters ranging from 21.7 to 31.2°C. Beadon (this volume) reported seeing Risso's dolphins in the Gulf of Aquaba and the Gulf of Suez in waters as warm as 30°C. Elsewhere, Risso's dolphins have been reported to occur in waters ranging from 7.5 to 35°C, most commonly in tropical and temperate seas ranging in temperature from the mid teens to upper 20′s°C (Kruse *et al.*, in press). Thus, Risso's dolphins probably occur in the temperate and tropical areas of the Indian Ocean.

Involvement with the Sri Lankan drift gillnet fishery

Risso's dolphins are reportedly taken with harpoons and drift gillnets in aboriginal and commercial fishing ventures in several areas of the Indian Ocean (Lamalera and Lamakera, Indonesia – Weber, 1923 and Hembree, 1980; Oman – Alling, 1983; India – Lal Mohan, pers. comm.; Sri Lanka – Alling, 1983; 1985; Joseph and Siddeek, 1985; Leatherwood, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). To date, the most detailed studies of fishery-related mortality of Risso's dolphins concern Sri Lanka's drift gillnet fishery (Alling, 1983; 1985; Joseph and Siddeek, 1985; Leatherwood, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989).

Between February 1983 and March 1986, visits to Sri Lankan fish landing sites were made opportunistically to monitor the cetacean bycatch and collect biological data from animals landed (e.g. Alling, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). Body measurements, photographs, teeth, gonads and stomachs were collected from Risso's dolphins and other species brought to market (Fig. 3). Collected materials were deposited at Sri Lanka's National Aquatic Resources Agency (NARA), Colombo, NARA's Center for Research on Indian Ocean Marine Mammals (CRIOMM), Trincomalee, or at the Sri Lanka National Museum, Colombo (refer to Leatherwood and Reeves, 1989, for detailed account of specimen materials in Sri Lanka). To date, these materials remain unstudied.

Aspects of the fishery

Between January 1984 and November 1986, Risso's dolphins represented 15% of the observed landings of cetaceans at Trincomalee's main fish market – spinner dolphins, *Stenella longirostris*, accounted for 45% and spotted dolphins, *S. attenuata*, 17% (Leatherwood and Reeves, 1989). Alling (1985) reported that Risso's dolphins were the second most commonly landed cetacean (17% of the monitored catch; spinner dolphins accounted for 40% of the landings) during a 2.5 year sampling period (March 1982 – December 1984). Data were unavailable for either report on whether all animals caught were counted, or how many vessels were actually fishing each day. Numbers of Risso's dolphins landed were proportionately much higher than estimates of relative abundance (in terms of numbers of animals seen) presented by Alling (1986), suggesting that the Risso's dolphins are over-represented in the bycatch. Perhaps this species is more susceptible to net entanglement than other species of delphinids inhabiting Sri Lanka's coastal waters.

A total of 241 Risso's dolphins was recorded at fish-landing sites between 1983 and 1986. One hundred and twenty-four specimens were examined, 68 females and 56 males. Body lengths of 62 individuals measured ranged from 100 to 312.2cm (Fig. 4). Average total lengths were 198.4cm for females (n=33, SD=43.5cm) and 180.4cm for males

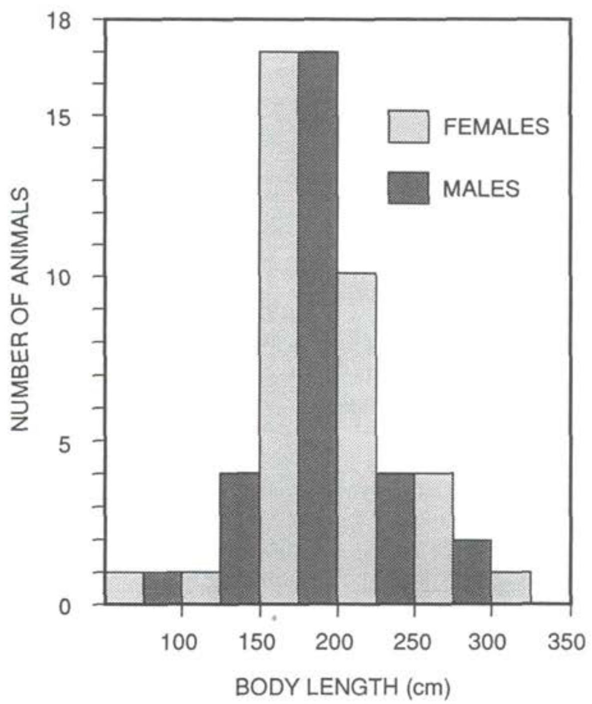

Fig. 4. Length distribution of Risso's dolphins measured in Sri Lankan fish markets.

(n=29, SD=47.6cm). From data summarised from all ocean regions, Perrin and Reilly (1984) reported that the smallest mature male of this species known was 262cm long and the smallest mature females ranged between 260 and 264cm. Based on a sample of five Risso's dolphins collected from southeastern Africa, Ross (1984) suggested that animals mature sexually at about 277cm. Assuming length at sexual maturity to be at least 250cm, only 8.2% (9.1% of the females and 7.1% of the males) of the animals measured in the Sri Lankan catch were 'possibly mature'. Thus, most Risso's dolphins being affected by the gillnet fishery were young, prereproductive members of the population(s).

It is unlikely that this bycatch of Risso's dolphins reflects accurately the overall population structure of free-ranging animals. Although information on demographics of Risso's dolphins apparently does not exist, studies of similar animals imply that a representative bycatch of Risso's dolphins should contain at least 50% adult-sized animals. Herds of pilot whales, *Globicephala macrorhynchus* and *G. melaena*, apparently contain 29–38% subadults (Sergeant, 1962; Kasuya and Marsh, 1984). Forty one percent of the bottlenose dolphins in the Sarasota Bay area of western Florida are immature (Wells *et al.*, 1987). Killer whale (*Orcinus orca*) populations in the Pacific Northwest of North America are typically composed of 50% juveniles (Olesiuk *et al.*, 1990).

The source of this bias towards small (young) animals killed in the fishery is unclear. The length distribution of Risso's dolphins caught in the gillnet fishery may reflect areal segregation by age/length, as has been reported for many odontocete species including sperm whales, *Physeter macrocephalus*, (Rice, 1989), Dall's porpoises, *Phocoenoides dalli*, in the western North Pacific (Kasuya, 1978), striped dolphins, *Stenella coeruleoalba*, in the western North Pacific (Kasuya, 1972; Miyazaki, 1984) and bottlenose dolphins, *Tursiops truncatus*, in Florida (Wells *et al.*, 1987).

Alternatively, the bias may indicate variable catchability of different age classes, as has been suggested for Hector's dolphins, *Cephalorhynchus hectori*, off New Zealand (Dawson, 1990), harbor porpoises, *Phocoena phocoena*, along the central California coast (Hohn and Brownell, 1990) and bottlenose dolphins (Wells and Scott, 1990). Young animals may be inexperienced in perceiving nets and may be entangled more frequently. Large (older) individuals may simply break through the net or learn to avoid entanglement. Observed catch biases probably do not reflect demographic/behavioural differences within this population, but rather the fishing practices employed off the Sri Lankan coast (i.e., fishermen may simply discard large animals at sea because they are too big to haul aboard their vessels, and/or would take up the boats' limited hold space which may be filled with more valuable catches).

As with the data on distribution and abundance, available catch statistics which might have been a useful measure of abundance are inconsistent and not comparable. Available catch rates (catch/boat/day) 'are highly variable and estimates for the same locality and approximately the same time period are substantially different' (Leatherwood and Reeves, 1989, p.46).

Potential impact of fisheries on Risso's dolphin population status

In an effort to appreciate the potential threat of gillnet entanglement to the Sri Lankan Risso's dolphin population, we estimate a range of animals killed per year and then estimate the population sizes necessary to sustain the population, given these kill rates and net population growth rates of 2% and 7% per year. Based on information collected by a variety of investigators during the period 1984 – 1985, catch rates (animals killed/boat/day) were estimated to be 0.0112 for northeastern Sri Lanka and 0.0163 for the west and southwest coasts (Leatherwood and Reeves, 1989; International Whaling Commission, 1990 – The IWC report contains corrections for errors in calculations published in Leatherwood and Reeves, 1989). By multiplying the estimated catch rates by the total number of boats registered to fish (classified as 'inboard' fishing boats and determined to be of the type 'likely' to take cetaceans) in these respective regions (1,385 vessels in northeastern Sri Lanka and 899 in the south and northwest – Joseph and Siddeek, 1985), multiplied by 274 (estimated minimum number of days fished) and adding the results from both regions, it is estimated that the total annual take of all species of small cetaceans in Sri Lanka ranged from 8,507 to 11,822 animals 1984–86 (IWC, 1990).

On average, Risso's dolphins represented 16% of the recorded small cetaceans taken in Sri Lanka fisheries (Alling, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). Based on estimated annual catch rates provided by the IWC (In press), at least 1,300 Risso's dolphins are probably landed each year. To sustain the Sri Lankan Risso's dolphin population with an annual kill of 1,300 animals, the population would have to include at least 65,000 animals if the population's net growth rate were 2% or 18,571 animals if the rate were 7%. In making these calculations it is necessary to assume that there are no age/sex biases in the take. We know that this is not the case. Therefore, these estimates of population size necessary to sustain the current rate of take should be considered preliminary.

Population growth rates are unknown for Risso's dolphins. Their longevity and comparatively large size and the observations of cow-calf bonds lasting longer than one year imply that populations of Risso's dolphins have relatively slow growth rates (Reilly and Barlow, 1986). Thus, the net annual population growth rate is probably nearer 2% annual net productivity than 7%. Accordingly, sustaining the current estimated annual take of 1,300 animals would require a Sri Lankan Risso's dolphin population in the tens of thousands.

There are no population estimates for Risso's dolphins in Sri Lankan waters. We generated an approximate population estimate by using indices of abundance presented by Alling (1986) and Leatherwood *et al.* (1984b) for the waters of the northern Indian Ocean. Both studies crossed large areas which are likely habitat for Risso's dolphins. Selecting an area of probable concentration (a 100km wide strip drawn around the island of Sri Lanka, seaward of the 1,000m contour), we estimated a habitat size of roughly 130,000km^2.

We selected this limited area because available survey data indicate that Risso's dolphins commonly occur in these waters, which are characterised by steep bathygraphic features (Fig. 2). Photographic identification studies conducted in Monterey Bay, California suggest that Risso's dolphins demonstrate some degree of site fidelity (Kruse, 1989). Although we cannot determine whether or not the animals off Sri Lanka belong to a distinct or closed population, available evidence suggests that they may repeatedly visit particular areas and may have extended ranges, as has been suggested for a number of odontocete species inhabiting continental shelf-edge habitats (e.g. Hawaiian spinner dolphins, *Stenella longirostris*, – Norris and Dohl, 1980; pilot whales, *Globicephala macrorhynchus*, – Shane and McSweeney, 1990 and Pacific white-sided dolphins, *Lagenorhynchus obliquidens*, – Kruse, pers. obs.). The suggested habitat size of 130,000km^2 may be an underestimate, especially if Indian Ocean Risso's dolphin populations are contiguous throughout the ocean basin. However, the area encompasses Sri Lanka's 'best' Risso's dolphin habitat and probably reflects closely the range of animals inhabiting the island's coastal waters. Thus, 130,000km^2 is a useful figure in estimating a minimum population size for Risso's dolphins inhabiting Sri Lankan coastal waters.

We estimated the effective strip width of the two surveys to be at least 200m. We suggest that, even under rough weather conditions, observers should have been able to detect all animals within 100m of either side of their survey platforms because Risso's dolphins are usually highly visible animals. They are large (up to 3.8m long), lightly coloured and often engaged in active surface behaviour. Based on the figures presented above, our minimum estimates of the Risso's dolphin population are (1) roughly 5,500 animals, according to Alling's (1986) index of abundance of 3.1 animals /100n.miles surveyed and (2) 13,000 animals derived from Leatherwood *et al.*'s (1984b) figure of 7.2 animals/100n.miles surveyed. These estimates are considerably smaller than the size of the population required to maintain 2% net annual growth in the face of an annual loss of 1,300 animals to the fishery.

Conclusions and implications

Risso's dolphins in the Indian Ocean appear to be similar in behaviour and ecology to those observed elsewhere. They have been seen in similar habitats, appear to be limited to the same temperature regimes and travel in groups of comparable size as Risso's dolphins from the Pacific and Atlantic Oceans. Although data are insufficient to characterise accurately their distribution and abundance in the Indian Ocean, these similarities with other areas suggest that Risso's dolphins are likely to be distributed throughout waters deeper than 100m in the Indian Ocean and are likely an important component of the cetacean fauna of at least the deep coastal waters of this broad region. Geographically broad cetacean surveys and long term studies of localised populations are needed to test these assumptions. Such studies would provide critically valuable data on abundance and seasonal movements of Risso's dolphins and on their ecological role in the Indian Ocean marine community.

The entanglement of Risso's dolphins in Sri Lanka's drift gillnet fishery warrants immediate detailed study. Data imply that as many as 1,300 animals may be killed annually in this gillnet fishery. Available data also suggest that as much as 89% of the catch monitored between 1983 and 1986 was composed of immature animals. The cause of this perceived bias toward small, and probably young dolphins is unclear, and its importance cannot be assessed with available data. Typically, a steady, biased take of immature animals has less impact on a population than if the fishery was killing mature animals with high reproductive potential. Unfortunately, the estimated annual take of Risso's dolphins is likely to be unsustainable at current levels, regardless of the demographics of the catch.

The estimated minimum annual take of 1,300 Risso's dolphins is affected by a number of biases which comprise its utility. Accurate levels of effort were impossible to calculate. We used the total number of boats large enough to potentially take marine mammals and registered with the Sri Lankan government as an estimate of effort. This overestimated effort and subsequently overestimated kill rates because (1) it is unlikely that all registered boasts fished each day of their 274 day season, and (2) not all boats large enough to take marine mammals were involved in fishing efforts which would result in marine mammal takes. Underestimates of animals landed occured because (1) fishermen did not land every dolphin they killed, (2) all fish landing sites were not monitored at any one time and (3) it is likely that observers were unable to account for every dolphin landed at the sites they were working. Thus, estimates were affected by factors which simultaneously led to overestimating and underestimating kill statistics. However, even if these estimates are off by as much as 50%, it is unlikely that there are enough Risso's dolphins to support the apparent mortality rate.

Survey data and population estimates indicate that, while groups Risso's dolphins are commonly seen in Sri Lanka's waters, these groups are small; the relative abundance of Risso's dolphins is rather low. Risso's dolphins are patchily distributed, occuring most commonly in areas characterised by steep bottom topography and relatively deep water. Low relative abundance and restricted habitat imply that limited numbers of Risso's dolphins inhabit coastal waters off Sir Lanka. A conservative interpretation of these data is that the current take of Risso's dolphin in the Sri Lankan drift gillnet fishery is not sustainable.

Concurrent studies of the life history of Risso's dolphins taken in Sri Lanka's gillnets and of the structure and movements of local populations of these animals would permit assessment of the real and potential impacts of the fishery on this species. Systematic collection and analyses of life history data from specimens taken in the fishery would contribute significantly to the understanding of the biology and population dynamics of this little-known delphinid.

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REFERENCES

Alling, A. 1983. A preliminary report of marine mammal fisheries in Dijibouti, Oman and Sri Lanka. Paper NARA/SMMIO/SP32 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished). 4pp.

Alling, A. 1985. Small cetacean entanglement: a case study of the incidental entrapment of cetaceans in Sri Lanka's gillnet fishery. Paper SC/37/SM5 presented to the IWC Scientific Committee, June 1985.

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83(2):376–94.

Beadon, J. A note on cetaceans seen and live-captured in the Gulf of Aquaba and the Gulf of Suez, 15 September 1980 through 1 September 1981. (Published in this volume.)

Dammerman, K.W. 1924. On *Globicephala* and some other delphinidae from the Indo-Australian Archipelago. *Treubia* 4(4):339–52.

Dawson, S.M. 1990. Sounds, acoustic behaviour and net entanglement of Hector's dolphins. Ph.D. Thesis, University of Canterbury, New Zealand. 134pp.

Gallagher, M. Collections of skulls of Cetacea: Odontoceti from Bahrain, United Arab Emirates and Oman, 1969–1990. (Published in this volume.)

Gambell, R., Best, P.B. and Rice, D.W. 1974. Report on the international Indian Ocean whale marking cruise, 24 November 1973 – 3 February 1974. *Rep. int. Whal. Commn* 25:240–52.

Hembree, D. 1980. Biological aspects of the cetacean fishery at Lamalera. Report on World Wildlife Fund Project 1428 (unpublished). 55pp.+2 appendices.

Hohn, A.A. and Brownell, R.L. 1990. Harbor porpoise in central Californian waters: life history and incidental catches. Paper SC/42/SM47 presented to the IWC Scientific Committee (unpublished).

International Whaling Commission. In press. Workshop on mortality of cetaceans in passive fishing nets and traps. *Rep. int. Whal. Commn* (special issue series).

Iredale, T. and Troughton, E.G. 1936. The correct and generic names for the grampus or killer whale, and the so-called grampus or Risso's dolphin. *Rec. S. Aust. Mus.* 19:28–36.

James, P.S.B.R. and Lal Mohan, R.S. 1987. The marine mammals of India. Mar. Fish. Info. Serv. Cent. Mar. Fish. Res. Inst., Cochin, India Tech. and Extens Series 71:1–13.

Joseph, L. and Siddeek, M.S.M. 1985. Threat to dolphins and small whales from commercial fisheries. Paper presented to the Annual Meeting of the Sri Lankan Association for the Advancement of Science, Colombo, Sri Lanka 1985 (unpublished). 18pp.

Kasuya, T. 1972. Growth and reproduction of *Stenella caeruleoalba* based on the age determination by means of dentinal growth layers. *Sci. Rep. Whales Res. Inst., Tokyo* 24:57–9.

Kasuya, T. 1978. The life history of Dall's porpoise with special reference to the stock off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst., Tokyo* 30:1–64.

Kasuya, T. and Marsh, H. 1984. Life history and reproductive biology of the short-finned pilot whale, *Globicephala macrorhynchus*, off the Pacific coast of Japan. *Rep. int. Whal. Commn* (special issue 6):259–310.

Keller, R.W., Leatherwood, S. and Holt, S.J. 1982. Indian Ocean cetacean survey, Seychelle Islands, April through June 1980. *Rep. int. Whal. Commn* 32:503–13.

Kruse, S. 1989. Aspects of the biology, ecology, and behaviour of Risso's dolphins (*Grampus griseus*) off the California coast. MS Thesis, University of California, Santa Cruz. 120pp.

Kruse, S., Caldwell, D.K. and Caldwell, M.C. In press. Risso's dolphin, *Grampus griseus*, (G. Cuvier, 1812). *In:* S. Ridgway and R. Harrison (eds.) *Handbook of Marine Mammals*. Vol. 5.

Leatherwood, S. 1985. Further notes on cetaceans of Sri Lanka. *Cetology* 50:1–12.

Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985–1986. *UNEP Mar. Mammal Tech. Rep.* 1:[vi], 1–138.

Leatherwood, S., Perrin, W.F., Kirby, V.L., Hubbs, C.L. and Dalheim, M. 1980. Distribution and movements of Risso's dolphin, *Grampus griseus* in the eastern North Pacific. *Fish. Bull., US* 77:951–63.

Leatherwood, S., Peters, R., Santerre, R., Santerre, M. and Clark, J.C. 1984. Observations of cetaceans in the northern Indian Ocean Sanctuary, November 1980 – May 1983. *Rep. int. Whal. Commn* 34:509–20.

Leatherwood, S., McDonald, D., Prematunga. W.P., Girton, P., Ilangakoon, A. and McBrearty, D. Records of the 'blackfish' (killer, false killer, pilot, pygmy killer and melon-headed whales) in the Indian Ocean. (Published in this volume.)

Mendes, C. and Gamage, A.C. 1985. Progress Report III: July/August, systematic and biological studies carried out in Sept. 1985. Report to NARA, Crow Island, Colombo, Sri Lanka (unpublished).

Miyazaki, N. 1984. Further analyses of reproduction in the striped dolphin, *Stenella coeruleoalba*, off the Pacific coast of Japan. *Rep. int. Whal. Commn* (special issue 6):343–53.

Mörzer-Bruyns, W.F. 1971. *Field Guide of Whales and Dolphins*. C.A. Meese, Amsterdam. 258pp.

Norris, K.S. and Dohl, T.P. 1980. Behavior of the Hawaiian spinner dolphin, *Stenella longirostris*. *Fish. Bull., US* 77(4):821–49.

Olesiuk, P., Bigg, M.A. and Ellis, G.M. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. *Rep. int. Whal. Commn* (special issue 12):209–43.

Perrin, W.F. and Reilly, S.B. 1984. Reproduction parameters of dolphins and small whales of the family Delphinidae. *Rep. int. Whal. Commn* (special issue 6):97–133.

Prematunga, W.P., Alling, A. and Leatherwood, S. 1985. Species composition of small cetacean bycatches in gillnets off Trincomalee, Sri Lanka, January 1984 through April 1985. Paper SC/37/SM9 presented to the IWC Scientific Committee, June 1985 (unpublished).

Reilly, S.B. and Barlow, J. 1986. Rates of increase in dolphin population size. *Fish. Bull., US* 84(3):527–33.

Rice, D.W. 1989. Sperm Whale – *Physeter macrocephalus* Linnaeus, 1758. pp. 177–234. *In:* S.H. Ridgway and R. Harrison (eds.) *Handbook of Marine Mammals*. Vol. 4. Academic Press, London, New York.

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. *Ann. Cape Prov. Mus. (Nat. Hist.)* 15(2):173–410.

Sergeant, D.E. 1962. The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. *Bull. Fish. Res. Board Can.* 132:1–184.

Shane, S.H. and McSweeney, D. 1990. Using photo-identification to study pilot whale social organization. *Rep. int. Whal. Commn* (special issue 12):259–63.

Weber, M. 1923. Siboga expeditie XXXVII. Cetaceen. p. 38pp. *In:* M. Weber and L.F. DeBeaufort (eds.) *Siboga Expeditie: Résultats des Explorations Zoologiques, Botaniques, Océanographiques et Géologiques, Entreprises auz Indes Orientales en 1899–1900*. T.J. Brill, Leiden, Amsterdam.

Wells, R.S. and Scott, M.D. 1990. Incidence of gear entanglement for resident inshore bottlenose dolphins near Sarasota, Florida. Presented at the Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps. October 20–21, 1990. La Jolla, CA.

Wells, R.S., Scott, M.D. and Irvine, A.B. 1987. The social structure of free-ranging bottlenose dolphins. pp. 247–306. *In:* H. Genoways (ed.) *Current Mammalogy*. Vol. 1. Plenum Press, New York.

Notes on the Genus *Kogia* in the Northern Indian Ocean

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ABSTRACT

This note reviews information on the distribution and biology of the two species of the genus *Kogia*, the pygmy sperm whale and the dwarf sperm whale, in the Indian Ocean, particularly the northern Indian Ocean, from a variety of published and unpublished sources.

Keywords: pygmy sperm whale; dwarf sperm whale; Indian Ocean; distribution; growth/length distributions; reproduction; prey/food.

INTRODUCTION AND METHODS

Only since 1966 have two species of *Kogia* been generally recognised: *Kogia breviceps* (Blainville, 1838), the pygmy sperm whale, and *Kogia simus* (Owen, 1866), the dwarf sperm whale. The two species differ in total length, body weight, size and position of the dorsal fin, and in certain skull characters (Handley, 1966; Ross, 1979). The type specimens of both species were collected in the Indian Ocean (for this paper identical with the Indian Ocean Sanctuary, IOS – International Whaling Commission, 1980), the former from the Cape of Good Hope (Blainville, 1838), the latter from Vizagapatum, India (Owen, 1866; 1867). Until 1980, only 6 records of *K. breviceps* and 5 records of *K. simus* existed from the IOS (Tables 2 and 3). An additional 30 specimens of *K. breviceps* and 32 of *K. simus* from South Africa were thoroughly treated by Ross (1979). Since 1980, there have been, to our knowledge, additional records only for Sri Lanka (Alling, 1983; Leatherwood, 1985; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). This paper reviews the status of knowledge about both species of *Kogia* in the IOS with emphasis on the northern Indian Ocean, and presents details of additional records from Sri Lanka and of the first record of *K. simus* from Thailand.

Records were assembled from published accounts, museum files, journals and field notes of colleagues and our own field work. For Sri Lanka, records were also obtained from government biologists monitoring by catches in fisheries at various landing sites. The most complete data are for Trincomalee, where records are more-or-less continuous for the period January 1984 through December 1986 (Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). Biological samples (e.g. skulls and skeletons, reproductive organs, stomachs, parasites) were collected from many of the Sri Lankan specimens. Regretably, most were lost during recent civil strife before they could be analysed. For detailed descriptions of the fishery see Alling (1983), Prematunga *et al.* (1985) and Leatherwood and Reeves (1989).

Kogia breviceps (Fig. 1A)

Distribution and abundance in the IOS

Knowledge on the distribution of this species still is sketchy and based mainly on specimens stranded or accidently caught in fishing nets. Except for the eastern tropical

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Pacific (Leatherwood *et al.*, 1988), there have been few confirmed sightings of either species of *Kogia* alive at sea. From available records (Table 1) it can reasonably be hypothesized that *K. breviceps* is distributed throughout the tropical and temperate waters of the IOS. Specimens have been recorded from the Cape of Good Hope (type specimen) and other South African locations, Sri Lanka (Trincomalee, Moratuwa, Gunapana, Negombo and Madduwa), and India (Trivandrum) (Fig. 1 and Table 1 for references).

Description
Pygmy sperm whales reach lengths of at least 3.7m and weights of over 400kg (Handley, 1966; Ross, 1979). The largest published specimens from the IOS are a 428cm (14ft) specimen of unknown sex and 305cm female (Pillay, 1926; Deraniyagala, 1964; Table 1). Measurements have been presented for a number of South African specimens (Ross, 1979) taken in the IOS. The extremely limited information from other areas of the IOS is presented in Table 1.

Seasonality
According to Ross (1979), *K. breviceps* occurs all year off the South African coast, suggesting a non-migratory habit. Records from other parts of the IOS are too few to deduce any migratory pattern. However, captures off Trincomalee Sri Lanka, occurred only in July (1), August (3) and October (6), in this last instance including 4 newborn or young calves and 1 adult. Collectively, the records from all of Sri Lanka and India included all months except January, April, May, June and September.

Reproduction and growth
Ross (1979) suggested a gestation period of over 11 months, and estimated the birth length to be approximately 1.2m based on South African material. A 3.05m female from Trivandrum, India, had a 23cm foetus (Pillay, 1926) and a 1.95m? specimen from Port Blair, Andaman Islands had an 80cm long, 8kg foetus (S. Acharya *in litt.* to M. Klinowska, 15 October 1988). Sexual maturity is reached when animals are approximately 2.75 and 2.85m long for females and males, respectively (Ross, 1979). The mating and calving season may last as long as seven months, from spring to autumn (Ross, 1979). As in most odontocetes, males grow larger than females. Ross (1979) provided information on body and skull growth.

Diet
The diet consists mainly of oceanic squids and crustaceans, prey items known to occur primarily seaward of the continental shelf (Ross, 1979). No detailed stomach examinations have been done for other parts of IOS, but fishermen interviewed in Negombo, Sri Lanka, in June 1985 and August 1986 said specimens of the two species of *Kogia* landed there had eaten 'cuttlefish' (Leatherwood, 1985; Leatherwood and Reeves, 1989) and squid beaks were found in the stomach of one specimen taken on 10 August 1985 off Trincomalee.

Kogia simus (Fig. 1B)

Distribution and abundance in the IOS
Knowledge on the distribution of this species, like that of *K. breviceps*, is based on specimens stranded or accidently caught in net fisheries. Sightings have been reported from Phitti Creek, Sind, Pakistan (de Silva, 1987), off Tromelin Island, Oman, (M.A. Al-Barwani *in litt.* to R. Gambell, 1982), and the east coast of Sri Lanka (Alling, 1983). Furthermore the species is known from India (Vizagapatam, type specimen), Indonesia

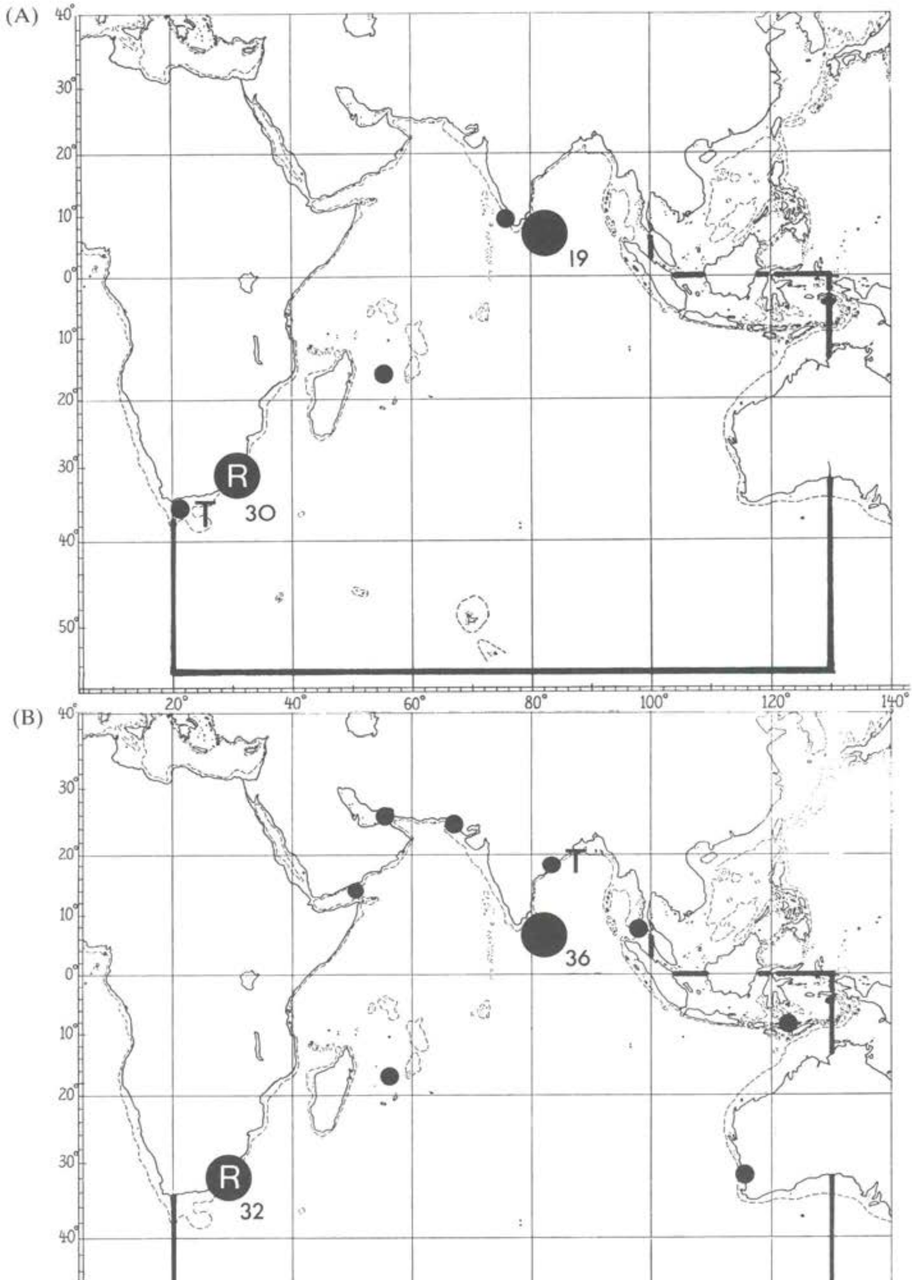

Fig. 1. The distribution of *K. breviceps* (A) and *K. simus* (B) within the Indian Ocean Sanctuary. 'T' indicates the type locality and 'R' the collecting area of South African specimens (see Ross, 1979 for further details). The total number of specimens is given for South Africa and Sri Lanka.

Table 1

Indian Ocean records of *Kogia breviceps*

TL=Total length in cm; W=Weight in Kg; BM(NH)=British Museum (Natural History); CRIOMM =Center for Research on Indian Ocean Marine Mammals. *References: A=Blainville (1838); B=Pearson (1920); C=Pillay (1926); D=Deraniyagala (1960); E=Deraniyagala (1961); F=M.A. Al-Barwai, *in litt.*; G=Whitehead *et al.*, (1983); H=Leatherwood (1985); I=Prematunga *et al.*, (1985) and/or Leatherwood (1986); J=Leatherwood (1986); Leatherwood and Reeves (1989).

Date	Locality	Sex	TL	W	Collection no.	Ref.*
1837	Cape of Good Hope, SA	U	-	-	MHNHParis1927-3	A
Pre-1891	Trincomalee, Sri Lanka	U	-	-	BM(NH)1891.10.13.1	B
30 Nov 1915	Moratuwa, Sri Lanka	U	-	-	SLNM-89	J
19 Dec 1924	Trivandrum, India	F	305	-	BM(NH)1952.8.28.2	C
19 Dec 1924	Trivandrum, India	U	Immature		-	C
9 Aug 1936	Gunapana, Sri Lanka'U		-	-	-	D
14 Aug 1960	Wadduwa	?	428	-	-	E
Feb 1982	16°54'N, 54°44'E, off Tromelin Is., Oman	U	-	-	-	F
9 Oct 1983	Trincomalee, Sri Lanka	M	-	-	-	G
15 Mar 1984	Back Bay, Trincomalee	U	-	-	CRIOMM 022T	J
16 Mar 1984	Negombo, Sri Lanka	U	-	-	-	H
17 Oct 1984	Trincomalee, Sri Lanka	F	-	100	-	I
21 Oct 1984	Trincomalee, Sri Lanka	M	-	125	-	I
22 Oct 1984	Trincomalee, Sri Lanka	F	-	100	-	I
23 Oct 1984	Trincomalee, Sri Lanka	F	-	225	-	I
26 Oct 1984	Trincomalee, Sri Lanka	M	-	100	-	I
7 Feb 1985	Negombo, Sri Lanka	U	-	-	A1B29	J
2 Jul 1985	Negombo, Sri Lanka	U	-	-	AIB29CRIOMM	I
7 July 1985	Trincomalee, Sri Lanka	M	143.5	-	JSL1024C5	J
8 Jul 1985	Trincomalee, Sri Lanka	U	-	-	WPP080785CRIOMM	I
9 Aug 1985	Trincomalee, Sri Lanka	U	-	-	WPP9885-2CRIOMM	I
10 Aug 1985	Trincomalee, Sri Lanka	U	-	-	WPP10885-1CRIOMM	I
11 Aug 1985	Trincomalee, Sri Lanka	U	-	-	WP110885-1CRIOMM	I

(Lomblon), Australia (Fremantle), the South African coast, Oman (Qurm Nature Reserve, Muscat), Sri Lanka (Negombo, Galle, Trincomalee, etc.) and Thailand (Patong Beach, Phuket Island, first record for Thailand) (Fig. 1B and Table 2 for references).

Given that there were only about 40 known records of both species of *Kogia* in 1966 (Handley, 1966) and that most of them were of *K. breviceps*, the number of takes of *K. simus* and the relative proportions of the 2 species off Sri Lanka and elsewhere in the Northern Indian Ocean are quite surprising. Combined with records from the poorly-covered coasts of Thailand and the Andamans, these occurrences suggest the Bay of Bengal is home to more than a few *K. simus*.

Description

Dwarf sperm whales range between 2.1 and 2.7m in total length and between 136 and 276kg in body weight (Handley, 1966; Ross, 1979). The largest published specimens from the IOS are 255cm for males and 236cm for females (Owen, 1867; Pearson, 1920). The few body measurements within the IOS consist mainly of total lengths. The type specimen was a 236cm female. Another female caught off Trincomalee, Sri Lanka, measured 183cm. The first specimen from Thailand was a 227cm male. Sets of detailed measurements exist only for specimens from South Africa (Ross, 1979) and Sri Lanka (this paper, Table 3).

Table 2

Indian Ocean records of *Kogia simus*.

PMBC=Pluket Marine Biological Center. Other abbreviations as in Table 1. *References A=Owen (1866; 1887); B=Weber (1923); C=Pearson (1920); D=Hale (1963); E=Gallagher & Van Bree (1980); F=de Silva (1987); G=Al-Barwani,*In litt*., (1972); H=Joseph *et al*. (1983); Leatherwood (1985); I=Alling (1983); J=Prematunga *et al*. (1985); Leatherwood (1986); K= this paper; Acharya, *In litt*., to M. Klinowska, 15 Oct. 1988; L=Gallagher (1990); M=Leatherwood and Reeves (1989).

Date	Locality	Sex	TL	W	Collection no.	Ref.*
?	?	-	-	-	SLNM89	J
28 Feb 1853	Vizagapatam, India	F	236	-	BM(NH) 1866.2.5.6	A
8 Mar 1990	Lamararap, Lomblon, Indonesia	U	-	-	ZMA5068	B
30 Nov 1915	Moratuwa, Sri Lanka	M	255	-	Colombo Mus., no. 89	C
19 Sep 1959	Leighton Bch, Fremantle	F	220	-	W. Aust. Mus., M4519	D
27 May 1979	Qurm Nat. Res. Oman	U	cf216	Z	20.712	E,L
17 Oct 1981	Phitti Creek, Sind, Pakistan	U	-	-	-	F
12 Dec 1981	17°22'N, 55°36'E,	U	-	-	-	G
18 Nov 1982	Negombo, Sri Lanka	U	175	-	-	H
9 Feb 1983	Trincomalee, Sri Lanka	U	-	-	Photograph	I
26 Feb 1983	Pitipana, Negombo	-	-	-	SLNM011C	M
1 Jun 1983	Trincomalee, Sri Lanka	U	-	-	Photograph	I
16 Mar 1984	Trincomalee, Sri Lanka	-	-	-	CRIOMM023T	M
16 Mar 1984	Trincomalee, Sri Lanka	-	-	-	CRIOMM024T	M
4 Apr 1984	Trincomalee, Sri Lanka	F	183	70	-	J
5 Apr 1984	Trincomalee, Sri Lanka	F	-	40	-	J
23 Apr 1984	Trincomalee, Sri Lanka	M	-	100	-	J
22 May 1984	Trincomalee, Sri Lanka	U	-	12	-	J
8 Aug 1984	Trincomalee, Sri Lanka	U	-	75	-	J
1 Oct 1984	Trincomalee, Sri Lanka	U	-	250	-	J
Mar 1985	Negombo, Sri Lanka	2F	-	-	-	J
23 Mar 1985	Trincomalee, Sri Lanka	F	-	100	-	J
26 Mar 1985	Trincomalee, Sri Lanka	F	-	110	-	J
26 Apr 1985	Trincomalee, Sri Lanka	M	-	150	-	J
29 Jun 1985	Trincomalee, Sri Lanka	M	113	-	WPP0785 CRIOMM	J
3 Jul 1985	Negombo, Sri Lanka	U	-	-	-	J
3 Jul 1985	Negombo, Sri Lanka	U	-	-	CA010785 CRIOMM	J
5 Jul 1985	Galle, Sri Lanka	M	183	-	CA050785 CRIOMM	J
5 Jul 1985	Trincomalee, Sri Lanka	F	193	-	JSL101485	J
7 Jul 1985	Trincomalee, Sri Lanka	F	122	-	-	J
7 Jul 1985	Trincomalee, Sri Lanka	M	144	-	-	J
8 Jul 1985	Trincomalee, Sri Lanka	F	184	-	WPP1585 CRIOMM	J
8 Jul 1985	Trincomalee, Sri Lanka	M	140	-	JSL02685 CRIOMM	J
12 Jul 1985	Trincomalee, Sri Lanka	M	109	-	-	J
20 Jul 1985	Trincomalee, Sri Lanka	F	216	-	-	J
23 Jul 1985	Trincomalee, Sri Lanka	F	211	-	-	J
24 Jul 1985	Trincomalee, Sri Lanka	M	149	-	-	J
9 Aug 1985	Trincomalee, Sri Lanka	F	165	-	-	J
9 Aug 1985	Trincomalee, Sri Lanka	M	158	-	WPP4085 CRIOMM	J
8 Sep 1985	Trincomalee, Sri Lanka	M	152	-	-	J
9 Sep 1985	Kottegoda, Sri Lanka	F	178	-	CA200985 CRIOMM	J
20 Oct 1985	Beruwala, Sri Lanka	M	166	-	CA050785 CRIOMM	J
Jul 1987	Patong Beach, Phuket Is., Thailand	M	227	-	PMBC	K
26 Apr 1988	Al Khaysa, Oman	F	1657	5445	ONHM1024(S)	L
8 Jul 1988	Port Blair, Andaman Is.	F	195	-		M
20 Sept 1988	Al Khaysa, Oman	F	1657	5445	ONHM1139(S)	L

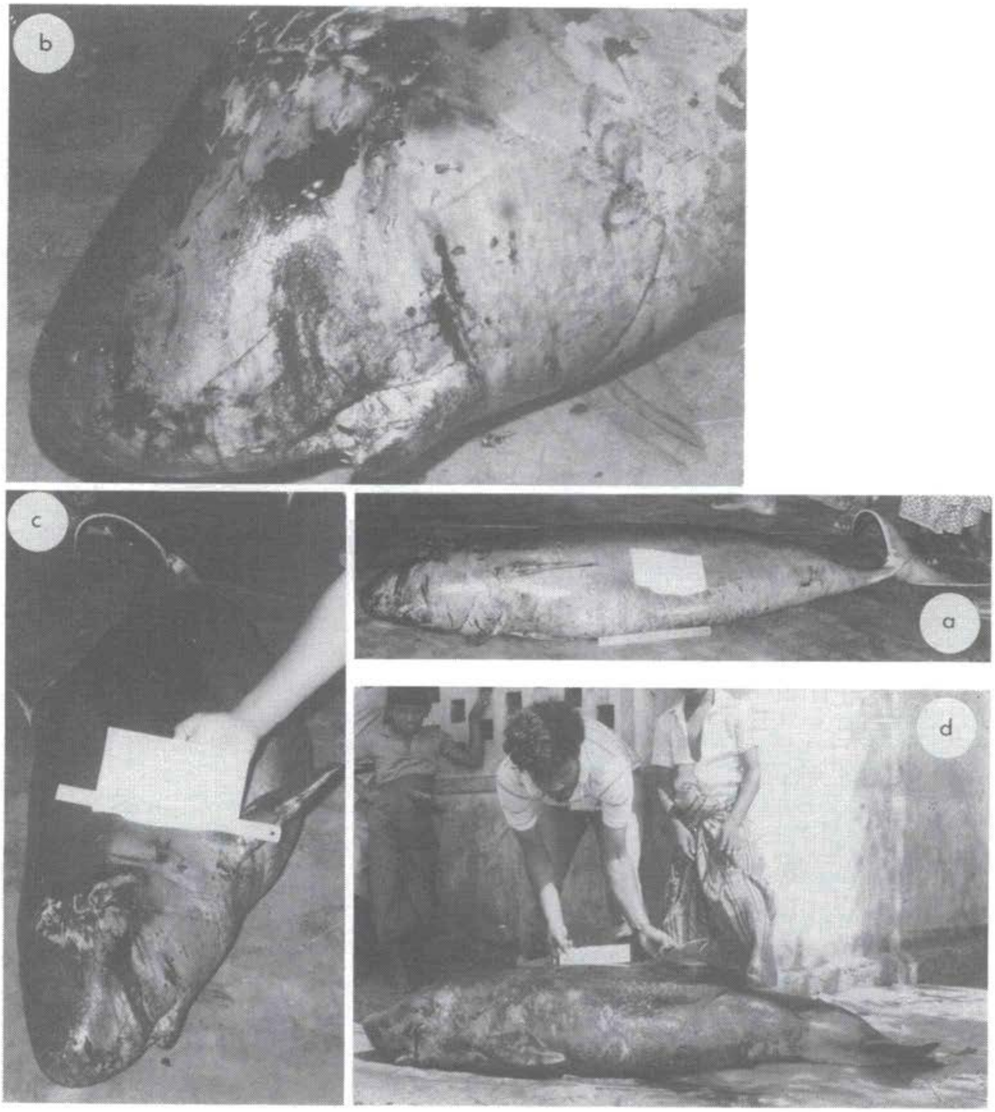

Fig. 2. *Kogia simus* specimens from Sri Lanka: a 183cm male at Galle, 5 July 1985 – specimen CA050785 (a-c) and a 178cm female at Kottegoda, 9 September 1985 – specimen CA200985(d). (Photos by Sujiva Senanayake, courtesy NARA).

With the possible exception of the gape length (measurement 4) measurements are in good agreement. The Sri Lankan sample consists solely of calves and subadults taken as by-catches in the gillnet fisheries. It has been suggested that similar absence or under-representation of larger adult specimens of Risso's dolphins, *Grampus griseus*, in the same fisheries can be explained by the tendency of the fishermen to generally bring home only specimens about 3m or less, discarding the others at sea because they are too heavy to bring aboard by hand and too bulky to tow (Leatherwood and Reeves, 1989; Kruse *et al.*, this volume). Weight data exist for a number of South African and Sri Lankan specimens

Table 3

Selected body measurements (in cm.) of *Kogia simus* from Sri Lanka and South Africa

	Sri Lanka (this study)			South Africa (Ross 1979)		
	Range	n	Mean	Range	n	Mean
Total length	1,092-2,159	16	1,613	136-264	21	2085
ToS to Co eye	9.7-14.3	17	12.2	8.7-13.3	20	11.0
Lo gape	4.6-11.9	15	9.2	2.0-8.3	18	4.3
ToS to external auditory meatus	10.2-17.1	14	14.6	11.5-19.5	7	15.1
ToS to blowhole	7.8-12.1	14	8.9	7.5-10.1	16	8.7
ToS to ant. insertion of flipper	19.5-26.1	16	21.9	16.7-23.3	20	19.6
ToS to dorsal fin tip	43.7-54.3	3	49.4	56.4-65.4	18	59.7
ToS to umbilicus	38.5-47.9	14	43.9	37.7-46.7	8	42.8
ToS to Co genital slit, male	47.2-56.7	9	51.5	44.5-51.6	6	47.3
ToS to Co genital slit, female	56.6-77.1	7	67.4	66.4-77.2	10	70.9
ToS to anus	63.7-80.2	15	71.6	67.3-75.1	9	71.7
Lo flipper, ant. insertion to tip	13.9-19.7	17	15.6	12.9-17.5	21	15.0
Lo flipper, axilla to tip	10.0-15.7	17	11.6	9.7-12.1	21	10.7
Max. Wo flipper	4.8-6.6	17	5.8	4.4-6.1	21	5.4
Ho dorsal fin	5.3-10.6	16	7.2	5.4-10.0	19	7.5
Lo dorsal fin	9.3-28.3	16	18.0	10.8-17.5	19	14.7
Wo fluke	19.7-30.6	14	26.2	21.2-32.4	21	26.1
Anterior border of flukes to notch	6.4-9.1	14	7.8	6.3-9.5	20	8.1

ToS=tip of snout; Lo=length of; Wo=width of; Ho=height; Co=to center of

(Table 3). Skull measurements from South Africa, Oman and Thailand are compared in Table 4 (Ross, 1979; Gallagher and van Bree, 1980).

Seasonality

Yamada (1954) found that specimens of *K. simus* off Japan were taken mainly during summer, suggesting a seasonal onshore offshore migration. Sri Lankan specimens also were taken in all months except November and December, with peaks in April (4) and July (9), during the summer months, although this may well reflect biassed fishing effort (Alling, 1983; Prematunga *et al.*, 1985; Leatherwood and Reeves, 1989). In contrast, Ross (1979) postulated a year round presence off the South African coast.

This August peak may well be significant as it occurs during a period characterised by a decline or cessation of fishing during one of the two monsoon seasons, about June-August and December-February.

Reproduction and growth

Gestation is believed to last well over nine months and length at birth has been estimated to be about 1m (Ross, 1979). The type specimen from Vizagapatam (Owen, 1866; 1867) was pregnant with a foetus of unreported sex and size. South African specimens smaller than 1.5m were found to be sucking, indicating a suckling period of at least 5 months

Table 4

Selected skull measurements (in mm.) for *Kogia simus*, after Pearson (1920), Ross (1979), Gallagher and Van Bree (1980) and this study

	Qurm nat.reserve	Moratuwa	Phuket I.	South Africa mean	range	n
Condylobasal length	282	286	270	270.0	201-323	25
Rostral length	39.0	33.2	40.7	36.2	28.5-41.4	25
Rostral width at base	46.4	44.4	50.0	45.4	39.6-53.5	24
Rostral width at ½ length	32.3	28.7	33.3	32.6	27.2-40.2	25
Preorbital width	88.6	80.4	83.3	81.8	79.6-91.1	25
Postorbital width	97.2	85.7	86.7	89.6	84.2-96.3	20
Zygomatic width	91.1	82.5	83.3	86.9	79.8-93.4	19
Lo upper tooth row	34.0	24.8	33.3	25.9	16.7-32.2	20
Lo lower tooth row	31.9	34.6	28.9	31.2	28.1-34.9	16
Lo mandible	85.8	80.4	80.7	83.1	78.2-88.3	16
Ho mandible	25.5	-	24.4	22.3	18.9-25.1	18

Lo=length of; Ho=height of

(Ross, 1979). Off Trincomalee, Sri Lanka, a 113cm male contained milk in the stomach, while a 140cm immature male had eaten solid food (29 June and 8 July 1985, Table 2). Sexual maturity is reached between 2.1 and 2.2m for both sexes (Ross, 1979). The male specimen from Phuket Island, Thailand, was 227cm long and sexually mature. Mating and calving seasons may last four to five months. Ross (1979) provided information on body and skull growth.

Diet

Stomach contents have only been systematically examined for South African specimens. In contrast to *K. breviceps*, the proportion of stomach contents containing squid species which occur in continental shelf waters is much higher in *K. simus*, indicating a more coastal habit (Ross, 1979). The stomach of a 140cm male taken 8 July 1985 off Trincomalee, Sri Lanka, contained 'cuttlefish' (Leatherwood, 1985; Leatherwood and Reeves, 1989 and Table 2).

The absence of records in pelagic areas of the IOS is most likely simply artifact of the poor coverage of those areas and the difficulty of detecting, let alone identifying, either species of *Kogia* at sea. From the frequency with which they strand or are taken in gillnets, neither species can be regarded as 'rare' in the IOS.

Both species were represented in the gillnet bycatch at Trincomalee and Negombo, Sri Lanka, prior to instigation of monitoring, as evidenced by the presence of weathered skulls on bonepiles and in a local museum and by local fishermen's ability to distinguish between the two species (Leatherwood, 1985).

The principal value in the Sri Lanka records, at least, is that they represent healthy animals and therefore offer insight into normal distribution; that distribution cannot be inferred confidently from strandings alone.

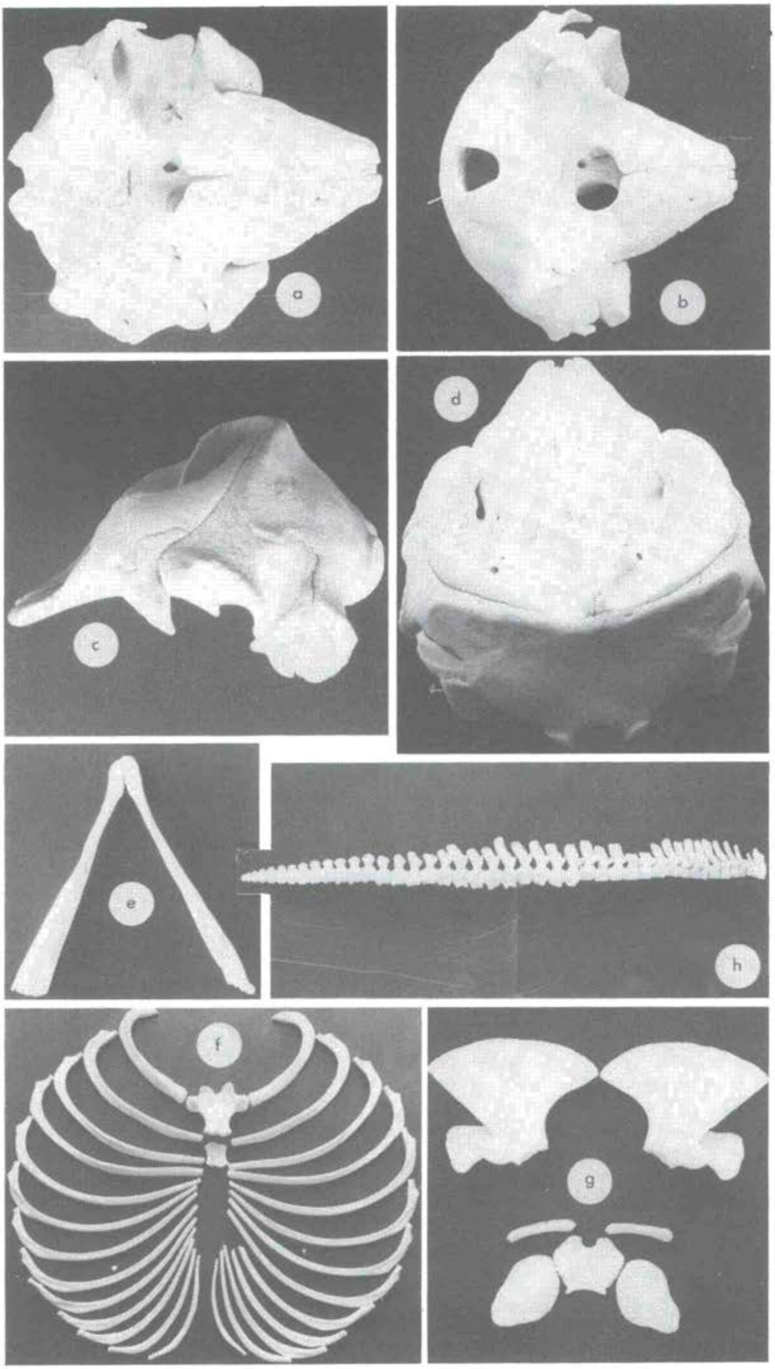

Fig. 3. For the first specimen of *Kogia simus* from Thailand: dorsal (a) ventral (b) lateral (c) and posterior – oblique (d) views of the skull; ventral view of the mandible (e); sternum and ribs (f); vertebral column (g) and scapulae (h).

REFERENCES

Alling, A. 1983. A preliminary report of marine mammal fisheries in Djibouti, Oman and Sri Lanka. Paper NARA/SMMIO/SP32 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished). 4pp.

Blainville, H.M.D. 1838. Sur les cachalots. *Ann. Fr. Étrangé Anat. Physiol.* 2:235–7.

Deraniyagala, P.E.P. 1960. Some southern temperate zone snakes, birds and whales that enter the Ceylon area. *Spolia Zeylan.* 29:79–85.

Deraniyagala, P.E.P. 1964. Some southern temperate zone fishes, birds and whales that enter the Ceylon area (Part II). *Spolia Zeylan.* 29:233–7.

de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, and from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84:505–25.

Gallagher, M.D. and van Bree, P.J.H. 1980. On a dwarf sperm whale *Kogia simus* (Owen, 1866), from the Sultanate of Oman. *Z. Säugetierkunde* 45:53–7.

Hale, H.M. 1963. Young female pygmy sperm whales from western and south Australia. *Rec. S. Aust. Mus.* 14:561–77.

Handley, C.O.J. 1966. A synopsis of the genus *Kogia* (pygmy sperm whales). pp. 62–9. *In:* K.S. Norris (ed.) *Whales, Dolphins, and Porpoises*. University of California Press, Berkeley and Los Angeles. xv+789pp.

International Whaling Commission. 1980. Chairman's report of the Thirty-First Meeting. *Rep. int. Whal. Commn* 30:25–41.

Joseph, L., Sideek, S.M. and Jayakody, D.S. 1983. Cetaceans landed by fishermen in Negombo, Sir Lanka. Paper NARA/SMMIO/SP3 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished).

Kruse, S., Leatherwood, S., Prematunga, W.P., Mendes, C. and Gamage, A. Records of Risso's dolphins, *Grampus griseus*, in the Indian Ocean, 1891–1986. (Published in this volume.)

Leatherwood, S. 1985. Further notes on cetaceans of Sri Lanka. *Cetology* 50:1–12.

Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985-1986. *UNEP Mar. Mammal Tech. Rep.* 1:[vi], 1–138.

Leatherwood, S., Reeves, R.R., Perrin, W.F. and Evans, W.E. 1988. *Whales, Dolphins and Porpoises of the Eastern North Pacific and Adjacent Arctic Waters*. Dover Publications, New York. 245pp.

Owen, R. 1866. On some Indian Cetacea collected by Walter Elliot, Esq. *Trans. Zool. Soc. Lond.* 6:17–47.

Owen, R. 1867. Note to memoir on the Indian Cetacea collected by Sir Walter Elliot. *Trans. Zool. Soc. Lond.* 6:171–4.

Pearson, J. 1920. A note on *Kogia breviceps*. *Spolia Zeylan.* 11:303–5.

Pillay, R.S.N. 1926. List of cetaceans taken in Travancore from 1902–1925. *J. Bombay Nat. Hist. Soc.* 31:815-7.

Prematunga, W.P., Alling, A. and Leatherwood, S. 1985. Species composition of small cetacean by catches in gillnets off Trincomalee, Sri Lanka, January 1984 through April 1985. Paper SC/37/SM9 presented to the IWC Scientific Committee, June 1985 (unpublished).

Ross, G.J.B. 1979. Records of pygmy and dwarf sperm whales, genus *Kogia*, from Southern Africa, with biological notes and some comparisons. *Ann. Cape Prov. Mus. (nat. Hist.)* 11:259–327.

Whitehead, H., Gilligan, P., Smyth, C., Weilgart, L. and Converse, C. 1983. WWF/IUCN Indian Ocean Whale Project. Interim Report, Oct-Dec. 1983. (Unpublished).

Yamada, M. 1954. Some remarks on the pygmy sperm whale, *Kogia*. *Sci. Rep. Whales Res. Inst., Tokyo* 9:37–61.

Collections of Skulls of Cetacea: Odondoceti from Bahrain, United Arab Emirates and Oman, 1969–1990

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ABSTRACT

This paper details the collections of odontocete cetacean skulls from Bahrain, the United Arab Emirates and Oman, 1969–90. Causes of death of specimens are unknown but the likelihood of natural strandings, incidental capture in fishing gear and mass mortality are discussed.

Keywords: morphology/anatomy; Indian Ocean; incidental capture; strandings; mortality; common dolphin; Risso's dolphin; spotted dolphin; striped dolphin; spinner dolphin; tropical dolphin; bottlenose dolphin; false killer whale; dwarf sperm whale; sperm whale; hump-backed dolphin; Cuvier's beaked whale.

INTRODUCTION

This is a report of 151 identified toothed whale and dolphin skulls, representing 14 species, collected from the southern shores of the Arabian (Persian) Gulf and from the shores of eastern Arabia during the period 1969 to 1990 (see map, Fig. 1 and Table 1). Most were collected by the author, to which have been added all identified specimens collected by others and passed to him. It includes two specimens in the Sultan Qaboos University, Oman. The list adds to and corrects earlier reports of these collections (e.g. in Leatherwood, 1986; de Silva, 1987).

COLLECTION, DISPOSAL AND DETERMINATION

Collections were made by the author as follows: Bahrain (Arabian Gulf), 1969–71 and April 1974; United Arab Emirates (UAE, Arabian Gulf), 1971–73; and Oman (Gulf of Oman and Arabian Sea), March 1973 and 1976–90.

As there was no suitable place at which to curate the specimens in the country of origin at the times of collection, the material was donated as follows: until 1977 to the British Museum (Natural History), London (BM), where identifications were provided by P.E. Purves; and from 1978 to June 1981 to the Institute for Taxonomic Zoology, Amsterdam, (ZMA), where P.J.H. van Bree undertook the identifications. Thereafter, collections in Oman by the author, and those others who have presented their finds to the national collection, have been accessioned to this collection in the Oman Natural History Museum (ONHM), identifications being provided by P.J.H. van Bree during a visit in March 1990.

In the list of these collections (Table 1), the nomenclature follows that adopted by IWC (1977, *et seq.*), except that *Tursiops aduncus* (Ehrenberg, 1832) and *Delphinus tropicalis* van Bree, 1971, are included as distinct species. The author is aware that various contributors to Leatherwood and Reeves (1990) have judged that there are, at present, no supportable species of bottlenose dolphin except *T. truncatus*. The status of *D. tropicalis* is reviewed by van Bree and Gallagher (1978).

[*Text continues on p. 95*]

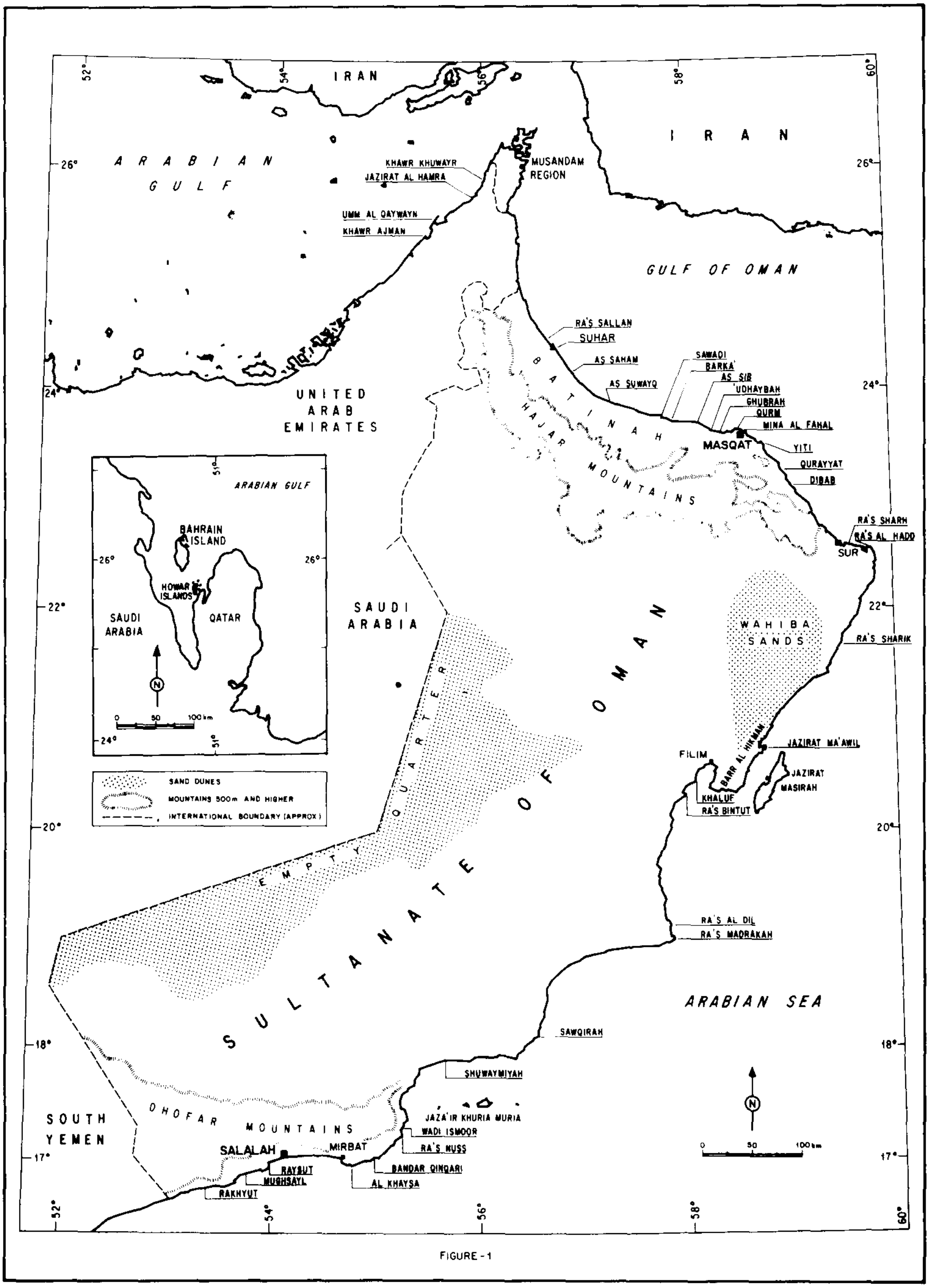

Fig. 1. Map to show the places of collections mentioned in the text. (Spellings are taken from the latest published gazetteer. United States Board on Geographic Names (USBGN), 1983; Birnie, 1986).

Table 1

Systematic List of Skulls of Cetacea: Odontoceti from Bahrain, United Arab Emirates and Oman 1969-1990. Sequence is alphabetical by family, etc. Nomenclature broadly follows IWC (1977), except for the use of *Tursiops aduncus* and *Delphinus tropicalis*.

Columns are: (1) Collector's number or initials (author where not stated); (2) Date and place of collection (in brief, with geographical co-ordinates in degrees, minutes North and East); (3) Museum accession number (BM = British Museum (Natural History); ONHM = Oman Natural History Museum; SQU = Sultan Qaboos University; ZMA = Zoological Museum Amsterdam.

Id = island(s); Jaz = jazirat (pl. jaza'ir, juzur) = island(s); Khawr = creek; nr = near; Ra's = headland; (S) = with partial or complete skeleton. The spelling of place names is subject to a continuing process of revision; the spellings used here are taken from the lastest published gazetteer (USBGN, 1983).

DELPHINIDAE Gray, 1821

Delphinus delphis Linnaeus, 1758, Common dolphin

OMAN			
5027	29 Aug 1978	Ra's al Hadd 2232.5947	ZMA 20.321
5028	29 Aug 1978	Ra's al Hadd 2232.5947	ZMA 20.322
5392	9 Oct 1979	Qurm 2337.5828	ZMA 20.898
6162	27 Mar 1981	Dibab 2305.5903	ONHM 873
6293	9 Oct 1981	nr Sur 2233.5936	ONHM 836
6352	29 Jan 1982	Ra's al Hadd 2232.5946	ONHM 496
6577	1 Oct 1982	Ra's al Hadd 2232.5947	ONHM 840
6578	1 Oct 1982	Ra's al Hadd 2232.5946	ONHM 863
6580	1 Oct 1982	Ra's al Hadd 2232.5946	ONHM 839
6617	2 Nov 1982	Jaz Khuria Muria 1731.5604	ONHM 428
6627	18 Nov 1982	Mina al Fahl 2338.5831	ONHM 429
JPR	Dec 1985	Ra's al Hadd 2232.5946	ONHM 471 (S)
7827	1 Jun 1986	Ra's al Madrakah 1900.5750	ONHM 564
7937	19 Feb 1988	As Sib 2341.5812	ONHM 659
GKDC	4 Nov 1988	Ra's al Hadd 2232.5947	ONHM1137
RVS	27 Aug 1988	nr Khawr Dirif 5720.1856	ONHM1140
8106	19 Jan 1989	nr Ru'ays 2212.5946	ONHM 1204
8175	26 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1386
8180	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1389 (S)
8181	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1390
8182	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1391
8183	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1392
8184	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1393
8185	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1394
8186	27 Oct 1989	Ra's al Hadd 2232.5947	ONHM 1395
ER	Oct 1989	nr Al Ashkara 2151.5934	ONHM 1479
8215	5 Mar 90	Al Bustan 2334.5836½	ONHM 1490
8230	23 Mar 90	Ra's al Hadd 2230.5949	ONHM 1499

Delphinus cf. *D.tropicalis* van Bree, 1971, Tropical dolphin

UAE			
2078	7 Apr 1972	Khawr Khuwayr 2556.5602	BM 1973.108
2301	26 Feb 1973	Khawr Ajman 2524.5527	BM 1973.1746
2498	12 Aug 1973	Umm al Qaywayn 2534.5536	ZMA 16.995
OMAN			
JPR	25 Oct 1980	Ra's al Hadd 2232.5947	ZMA 21.169

Delphinus sp.

OMAN			
5031	29 Aug 1978	nr Sur 2233.5930	ZMA 20.319
5032	29 Aug 1978	nr Sur 2233.5930	ZMA 20.318

Continued

Grampus griseus (G.Cuvier, 1812), Risso's dolphin			
OMAN			
4470	19 Mar 1977	Ra's Sallan 2424.5643	BM -
4782	11 Nov 1977	Qurm 2337.5828	BM 1980.794
5076	7 Oct 1978	Jaz Khuria Muria 1730.5551	ZMA 20.316
5306	24 May 1979	Jaz Masirah 2025.5845	ZMA 20.713
JKM	?	?	ONHM 15
JPR	25 Oct 1980	Ra's al Hadd 2232.5947	ZMA 21.185
8235	23 Mar 1990	Ra's al Hadd 2231.5947	ONHM 1503
SMH	Nov 1987	Ra's al Hadd 2230.5948	SQU
Stenella attenuata Gray, 1846, Spotted dolphin			
UAE			
2497	11 Aug 1973	Umm al Qaywayn 2535.5533	BM 1973.1750
OMAN			
2335	12 Mar 1973	nr Saham 2408.5655	BM 1973.1749
4590	18 Jul 1977	nr Sur 2233.5940	BM 1980.792
5942	Jan 1980	'Udhaybah 2336.5821	ZMA 21.005
Stenella coeruleoalba (Meyen, 1833), Striped dolphin			
OMAN			
4802	26 Nov 1977	nr As Suwayq 2352.5722	BM 1980.788
6076	1 Jan 1981	Ra's al Hadd 2232.5947	ZMA 21.440
Stenella longirostris (Gray, 1828), Spinner dolphin			
OMAN			
4588	18 Jul 1977	nr Sur 2233.5940	BM 1980.872
4589	18 Jul 1977	nr Sur 2233.5940	BM 1980.791
5037	29 Aug 1978	nr Sur 2233.5930	ZMA 20.320
5108	12 Nov 1978	Yiti 2332.5840	ZMA 20.317
5358	26 Jul 1979	Jaz Masirah 2035.5856	ZMA 20.724
6072	25 Dec 1980	'Udhaybah 2336.5821	ZMA 21.443
6092	27 Jan 1981	Jaz Masirah 2030.5847	ZMA 21.447
6161	27 Mar 1981	Dibab 2305.5963	ZMA 23.539
VP 23	8 May 1987	Barr al Hikman 2023.5816	ONHM 1021
GB	11 Nov 1989	Ra's al Hadd 2231.5948	ONHM 1410
VP	11 Nov 1987	Al Khuwayr c.2336.5826	SQU (S)
Stenella sp.			
OMAN			
6661	15 Feb 1983	Qurm 2337.5829	ONHM 762 (S)
Tursiops cf. *T.aduncus* (Ehrenberg, 1832), Bottlenose dolphin			
BAHRAIN			
189	10 Mar 1970	Bahrain Id	BM 1970.1511
197	27 Mar 1970	Bahrain Id	BM 1970.1512
UAE			
2496	7 Aug 1973	nr Jazirat al Hamra 2543.5550	BM 1973.1747
2503	23 Aug 1973	Khawr Khuwayr 2557.5603	BM 1973.1751
OMAN			
4626	1 Aug 1977	Jaz Masirah 2031.5857	BM 1980.793
5075	7 Oct 1978	Jaz Khuria Muria 1730.5551	ZMA 20.328
6073	31 Dec 1980	Ra's al Hadd 2232.5946	ZMA 21.434
VP15	16 Apr 1987	Ra's al Junayz 2226.5951	ONHM 1028
VP27	14 Apr 1988	Ra's Naws 1715.5515	ONHM 1046
VP29	14 Apr 1988	Wadi Ismoor 1718.5516	ONHM 1048
JPR	28 Sep 1988	Ra's al Hadd 2232.5947	ONHM 1106

Continued

Tursiops truncatus (Montagu, 1821),		Bottlenose dolphin	
BAHRAIN			
1003	11 Apr 1974	Howar Id 2543.5049	BM 1984.1756
1005	11 Apr 1974	Howar Id 2543.5049	BM 1984.1757
1019	15 Apr 1974	Howar Id 2540.5048	BM 1984.1760
1044	22 Apr 1974	Bahrain Id 2553.5031	BM 1984.1764
OMAN			
4585	18 Jul 1977	nr Sur 2233.5940	BM 1980.789
4586	18 Jul 1977	nr Sur 2233.5940	BM 1980.874
5930	16 Nov 1979	As Sib 2341.5810	ZMA 20.090
JPR	25 Oct 1980	Ra's al Hadd 2232.5947	ZMA 21.173
6160	27 Mar 1981	Dibab 2305.5903	ZMA 21.452
6351	29 Jan 1982	Ra's al Hadd 2232.5947	Univ. Tübingen DE-4 (S)
7432	28 Dec 1984	Sawadi al Batha 2346.5745	ONHM 183
DF	8 Feb 1988	'Udhaybah 2336.5820	ONHM 658 (S)
VP12	16 Apr 1987	Ra's Sharh 2233.5939	ONHM 1018
VP13	13 Jan 1987	Sawqirah 1809.5633	ONHM 1019
Tursiops sp.	Bottlenose dolphin		
OMAN			
5022	28 Aug 1978	nr Qurayyat 2307.5902	ZMA 20.329
5075	7 Oct 1978	Jaz Khuria Muria 1730.5551	ZMA 20.328
6615	1 Nov 1982	Jaz Khuria Muria 1731.5604	ONHM 835
7208	2 Oct 1984	Ra's al Madrakah 1900.5750	ONHM 880

GLOBICEPHALINAE Gray, 1866

Pseudorca crassidens (Owen, 1846),		False killer whale	
OMAN			
4619	1 Aug 1977	Jaz Masirah 2031.5857	BM 1980.795
JPR	25 Oct 1980	Ra's al Hadd 2232.5947	ZMA 21.168
JPR	25 Oct 1980	Ra's al Hadd 2232.5947	ZMA 21.186
JKD	1 Oct 1982	Jaz Khuria Muria 1730.5558	ONHM 64
7952	4 Apr 1987	Ghubrah 2336.5824	ONHM 689 (S)
JPR	20 Jun 1987	Jaz Masirah 2035.5855	ONHM 728.2
VP18	22 Mar 1987	Ra's ad Dil 1904.5749	ONHM 1044
VP25	21 May 1988	Shuwamiyah 1753.5540	ONHM 1023
?Globicepha macrorhynchus			
7446	20 Jan 1985	Jaz Khuria Muria 1730.5605	ONHM 834
VP2	18 Jun 1987	Qurayyat 2315.5856	ONHM 1014

PHYSETERIDAE Gray, 1821

Kogia simus (Owen, 1866),		Dwarf sperm whale	
OMAN			
5291	27 May 1979	Qurm 2337.5828	ZMA 20.712
VP	26 Apr 1988	Al Khaysa 1657.5445	ONHM 1024 (S)
RVS	20 Sep 1988	Al Khaysa 1657.5445	ONHM 1139 (S)
JKLM	26 Aug 1989	Nr Muscat 2336.5836	ONHM 1330 (S)
Physeter macrocephalus Linnaeus, 1758,		Sperm whale	
OMAN			
6169	7 Apr 1981	nr Suhar 2421.5646	ONHM 29 (S)
-	13 Sep 1986	Barka' 2342.5753	ONHM 866 (S)

Continued

STENINAE Fraser & Purves, 1960

Sousa chinensis (Osbeck, 1757) (=*S.plumbea* (G.Cuvier, 1829)), Indo-Pacific hump-backed dolphin

BAHRAIN			
48	30 Apr 1969	Bahrain Id	BM 1970.1505
56	10 May 1969	Bahrain Id	BM 1970.1510
171	18 Feb 1970	Bahrain Id	BM 1970.1509
229	27 Apr 1970	Bahrain Id	BM 1970.1506
230	Feb 1969	Bahrain Id	BM 1970.1508
231	Feb 1969	Bahrain Id	BM 1970.1507
JHC	Jan 1973	Howar Id	BM 1973.1748
1006	11 Apr 1974	Howar Id 2543.5049	BM 1984.1758
1011	14 Apr 1974	Howar Id 2545.5047	BM 1984.1759
1012	14 Apr 1974	Howar Id 2545.5047	BM 1984.1763
1024	16 Apr 1974	Howar Id 2540.5048	BM 1984.1761
1025	16 Apr 1974	Howar Id 2540.5048	BM 1984.1762
OMAN			
5337	17 Jul 1979	Jaz Masirah 2031.5847	ZMA 20.736
5338	17 Jul 1979	Jaz Masirah 2039.5852	ZMA 20.721
JPR	26 Jul 1979	Jaz Masirah 2035.5856	ZMA 20.737
5364	29 Jul 1979	Jaz Ma'awil 2042.5842	ZMA 20.726
5365	29 Jul 1979	Jaz Ma'awil 2042.5842	ZMA 20.738
5367	29 Jul 1979	Jaz Ma'awil 2042.5842	ZMA 20.725
5368	29 Jul 1979	Jaz Ma'awil 2042.5842	ZMA 20.727
5916	4 Nov 1979	Filim 2036.5811	ZMA 20.899
6093	27 Jan 1981	Jaz Masirah 2025.5844	ZMA 21.437
6172	13 Apr 1981	Khaluf 2028.5804	ZMA 21.451
6173	13 Apr 1981	Khaluf 2028.5804	ZMA 21.450
6174	13 Apr 1981	Khaluf 2028.5804	ZMA 21.431
PNM	Jan 1985	Wahiba coast	ONHM 439
7672	18 Feb 1986	Wahiba coast 2113.5900	ONHM 523
7688	20 Feb 1986	Wahiba coast 2112.5911	ONHM 525
7689	20 Feb 1986	Wahiba coast 2123.5915	ONHM 526
7950.1	27 Mar 1987	Ra's Sharik 2139.5927	ONHM 683
7950.2	27 Mar 1987	Ra's Sharik 2139.5927	ONHM 684
VP3	10 Nov 1986	Barr al Hikman 2023.5823	ONHM 1015
VP4	10 Nov 1986	Barr al Hikman 2023.5823	ONHM 1016
VP17	10 Nov 1986	Barr al Hikman 2023.5823	ONHM 1020
VP5	13 Sep 1987	Ra's Bintut 2021.5759	ONHM 1017
VP24	16 Mar 1987	Ra's Ruways 2057.5848	ONHM 1022
VP28	20 Apr 1988	Bandar Qinqari 1701.5500	ONHM 1047
VP30	4 May 1987	Barr al Hikman 2023.5823	ONHM 1049 (S)
VP31	7 May 1987	Barr al Hikman 2022.5823	ONHM 1050
VP20	21 Apr 1987	Ra's Bintut 2021.5758	ONHM 1045
DW	27 Dec 1988	Ra's Naqrair 1959.5749	ONHM 1022
8025	23 Feb 1990	nr Filim 2034.5816	ONHM 1438
RPW	17 Mar 1986	Qaysad 1817.5640	ONHM 1516

cf. *Sousa chinensis* (Osbeck, 1757)

OMAN			
5366	29 Jul 1979	Jaz Ma'awil 2042.5842	ZMA 20.728

ZIPHIIDAE Gray, 1865

Ziphius cavirostris G.Cuvier, 1823, Cuvier's beaked whale

OMAN			
PL	1982	Jaz Masirah	ONHM 344.14
VP	22 Jan 1988	Ra's al Hadd 2233.5946	ONHM 901 (S)
RVS	19 Sep 1988	Jaz Khuria Muria 1730.5555	ONHM 1141

The list does not include specimens collected and sent by others direct to other museums, or those held in private and other collections, such as at the Marine Science and Fisheries Centre, Ministry of Agriculture and Fisheries, Oman. However, it does include two specimens held by the Department of Biology, Sultan Qaboos University.

Of eight specimens sent to the British Museum (Natural History) and previously listed as *Tursiops aduncus*, four from Bahrain and two from UAE have been re-determined recently as *T. truncatus* (M.C. Sheldrick *in litt.*, 7 September 1988); these are included under the latter name in Table 1.

Some skulls were so damaged or beach-worn when found that they were either impossible to identify, or could be identified only to genus; these are omitted from the list.

It is of interest to note the absence from the list of the finless porpoise, *Neophocaena phocaenoides* (G. Cuvier, 1829) (Delphinidae). This neritic and estuarine species was seen, (as were *Sousa chinensis*, *T. aduncus*, *D. tropicalis* and *Balaenoptera* species), during a trip around Qishm Island, Iran, in the northern part of the Strait of Hormuz (Pilleri, 1973). The first Arabian Gulf specimen was a skull which came from Bahrain Island, where D. Herdson (*in litt.*, 21 October 1978) obtained three, of which one came from 26°12′N, 50°36′E, on 7 March 1976 (ZMA 20.292; van Bree, *in litt.*).

CAUSES OF DEATH

All skulls listed here were either already detached or were taken from the remains of animals found dead on the beaches; in some cases all or part of the skeleton was also collected (marked (S) in the Table). Some dolphins had clearly been dead for at least a year, but a few had died recently. Deaths are not uncommon in winter, but like others it is usually impossible for me to know whether deaths were from natural causes, strandings or fisheries.

Some casualties are certainly the result of strandings e.g. the four sperm whales reported in Gallagher (this volume). The four *Sousa chinensis* collected on 29 July 1979 had been stranded 200 to 300m inland from mean highwater mark, almost in the centre of the lowlying island; it is possible that a storm, such as the hurricane of June 1977 (Gallagher, 1977), had contributed to their deaths.

It is not uncommon to find whole dolphins or parts of dolphins in the vicinity of fishermen or their boats; these may be the result of drowning as incidental catches, particularly now that monofilament nets are in more general use. Evidence for involvement of cetaceans in fisheries in this region is increasing. A young humpback whale, *Megaptera novaeangliae*, found alive in a net off Muscat on 12 February 1990 and cut free, is the only direct proof (J.K.L. Mee, pers. comm.). However, there is additional circumstantial evidence, firstly, in that a small number either have the remains of netting around the tail stock or the flukes have been cut off (presumably to free the animal). A baleen whale about 16m long, found decomposing on the beach 3km north of Ra's Sidarah (19°53′N, 57°46′E), had the remains of a fishing net caught up around its tail (M. Kazi, J.A. Spalton, R.H. Daly, pers. comm.). Secondly, the number and distribution of cetaceans found dead would seem to include many that were not 'normal' strandings. For instance, on 27 April 1990, along about 60km of sandy beach examined between Ra's Bintut (20°21′N, 57°58′E), and Ra's Duqm (19°39′N, 57°43′E), more than 30 dolphins were found dead scattered along the tideline; most were only a few months dead and the tails were complete. The skulls of 15 were collected (seven *Delphinus delphis* and eight *Sousa chinensis*; none listed here); the remainder, examined and adandoned, were also of these two species. The cause of death could not be determined, and it may have been drowning or perhaps poisoning from eating fish affected by toxins produced by elements of the zooplankton such as those responsible for the 'red tides' (a known cause of fish death). There is clearly scope for a study of such mortality of cetaceans.

Only a few of the specimens found by the author had been butchered: a severed head of *Delphinus tropicalis* on the mud within Khawr Ajman, UAE, near large fishing craft on 26 February 1973; one *Kogia simus* at Qurm, near Muscat on 27 May 1979, filletted clean of flesh (Gallagher and van Bree, 1980); and one *Delphinus delphis* on Al Hallaniyah Island, Khuria Muria, on 2 November 1982, with all the flesh removed from the dorsum, and the tail cut off. The *Tursiops truncatus* of 18 February 1988 had been mutilated after death, perhaps by fishermen requiring bait. More instances of exploitation are cited by Papastavrou and Salm (this volume).

ACKNOWLEDGEMENTS

The author wishes to express his appreciation and thanks to everyone who has contributed in any way to this list. Particular thanks are due to P.E. Purves and P.J.H. van Bree for their encouragement and determinations; P.J.H. van Bree has also very kindly provided details of ZMA's holdings from Arabia, against which Table 1 has been checked; (the author accepts responsibility for any error in the list). P.J.H. van Bree, J.P. Ross and M.C. Sheldrick offered helpful improvements to this contribution. Support for collecting was given by Major-General (now Field Marshal Sir) R.C. Gibbs, 1970–71; Lt Col F.D. Carson, 1971–73; and R.H. Daly, 1976–81. HH Sayyed Faisal bin Ali Al-Said established the Oman Natural History Museum and gave support from 1982. The Sultan of Oman's Navy and Sultan of Oman's Air Force provided essential logistic support from 1976 to 1983. I.R. Bishop and M.C. Sheldrick provided British Museum (Natural History) accession data from 1984. Provisional identifications from photographs of some skulls in the Oman Natural History Museum were kindly provided by P.J.H. van Bree and James G. Mead (US National Museum). R.V. Salm and V. Papastavrou presented to the Oman Natural History Museum the skulls they collected during the Coastal Zone Management Survey of the Government of the Sultanate of Oman with the International Union for Conservation of Nature and Natural Resources (IUCN). Specimens or other helpful co-operation came from G. Barratt, S.M. Brogan, M.R. Brown, J.H. Clingly, Mrs G.K.D. Cummings, J.K. Drew, Mrs R. Dudley, C.J. Feare, D. Foster, D. Green, C. Hagstom, S.M. Head, A.E. Jones, P. Lagendyk, D.P. Mallon, J.K.L. Mee, J.K. Mottram, P.N. Munton, T. Pearson, E. Rook, J.P. Ross, M.P. Searle, H. Walter, R.P. Whitcombe and D. Willis. Mrs G.K.D. Cummings and V. Mohammad prepared many of the dolphin specimens in the Oman Natural History Museum collection. M.R. Brown prepared the map.

REFERENCES

de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, and from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84:505–25.

Gallagher, M.D. Stranding of sperm whales (*Physeter macrocephalus*) on the shores of Oman, Eastern Arabia. (Published in this volume.)

Gallagher, M.D. 1977. Cyclone hits Masirah. *RAF Ornith. Soc. Newsl.* 29:3–4.

Gallagher, M.D. and van Bree, P.J.H. 1980. On a dwarf sperm whale *Kogia simus* (Owen, 1866), from the Sultanate of Oman. *Z. Säugetierkunde* 45:53–7.

International Whaling Commission. 1977. Report of the sub-committee on small cetaceans – London 7–9 June 1976, Appendix C. List of smaller cetaceans recognised. *Rep. int. Whal. Commn* 27:483–4.

Leatherwood, S. 1986. Whales, dolphins and porpoises of the Indian Ocean Sanctuary: a catalogue of available information. Hubbs Marine Research Center Technical Report 87–197. 206pp.

Leatherwood, S. and Reeves, R.R. (eds.). 1990. *The Bottlenose Dolphin*. Academic Press, San Diego. 653pp.

Papastavrou, V. and Salm, R.V. A note on recent sightings and strandings of cetaceans in Oman: Ra's Sawadi to Rakhyut. (Published in this volume.)

Pilleri, G. 1973. *Cetologische Expedition Zum Indus Und Perzischen Golf Und Forschungsreise Nach Goa Und Thailand Im Jahre 1973*. Verlag Hirnanatomisches Institut, Waldau-Bern. 52pp. +27 pls [In German].

United States Board on Geographic Names (USBGN). 1983. *Gazetteer of Oman*. Defence Mapping Agency, Washington, D.C. 140pp.

van Bree, P.J.H. 1971. *Delphinus tropicalis*, a new name for *Delphinus longirostris* G. Cuvier, 1829. *Mammalia* 35:345–6.

van Bree, P.J.H. and Gallagher, M.D. 1978. On the taxonomic status of *Delphinus tropicalis* van Bree, 1971 (notes on Cetacea, Delphinoidea IX). *Beaufortia* 28:1–8.

Indigenous Whaling and Porpoise Hunting In Indonesia[1]

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ABSTRACT

When American and English ships began whaling on the Molucca grounds and near Timor in 1803, they were not the first whalers in this area. Lamalera, Lembata, and Lamakera, Solor, were hunting whales long before, and still do. Lamalera hunts various toothed whales, including sperm whales, while Lamakera hunts various baleen whales. Although the number of animals captured is small and currently declining, whale hunting remains economically and culturally important.

Only in two communities in maritime Southeast Asia are residents known regularly to hunt whales (Fig. 1). In Lamalera, Lembata (Lomblem on world maps), a village in the Province of Nusa Tenggara Timur, Indonesia, there are hunts for sperm whales, (*Physeter macrocephalus*), killer whales, (*Orcinus orca*), various dolphins and small toothed whales, manta rays, leatherback turtles and smaller sea turtles, sunfish (*Mola mola*), marlin, dorado, and several kinds of sharks. Villagers in Lamakera, Solor, hunt a similar range of fish, but, except for a very occasional Cuvier's beaked whale (*Ziphius cavirostris*), take no odontocetes, confining themselves instead to the baleen whales which enter the shallow Solor Strait. Broadly, therefore, the two closely situated villages distinguish themselves in that one hunts the larger toothed cetaceans, but not baleen whales, which are in general the only whales taken by the other. Neither village hunts blue whales (*Balaenoptera musculus*). Residents of Lewotobi, Flores, also hunt porpoises, but as yet no study of this village has been made and there is no further information about their fishery.

Although it may be assumed that the capture of porpoises and dugongs is more widespread, there are only ambiguous indications of indigenous whaling elsewhere. A rather self-contradictory report (Geurtjens, 1921, p.194) attributes communal hunting of large game – including dugongs, manta rays, turtles and sperm whales – to the inhabitants of the Kei Islands. The same source (p.280), however, relates that they approach sperm whales with diffidence and prefer the maxim, 'Do nothing to me, and I will do nothing to you.' A comment on food prohibitions in Portuguese colonies (de Almeida, 1945, pp.54–55) mentions in passing that the inhabitants of formerly Portuguese Timor would not hunt small whales without first carrying out propitiatory ceremonies to the spirits, although these rites were not required for porpoises.

In his *D'Amboinsche Rariteitkamer* (1705), Rumphius discusses at length the theories of the origin of ambergris and records a good deal of original information about strandings of whales in the eastern islands, but he makes *no* mention of indigenous whaling. However, hunting of whales by the islanders of Lewoleba, that is, Lembata, was mentioned as early as 1624 in an anonymous Portuguese document (*Fundação das Primeiras Cristanades nas*

[1] Further information may be found in Barnes (1974; 1980; 1984; 1986). Lamalera's fishery is depicted in a television film made in 1987, *The Whale Hunters of Lamalera, Indonesia* (John Blake, producer, David Watson, researcher, R.H. Barnes, anthropological adviser, London and Manchester: Granada Television).

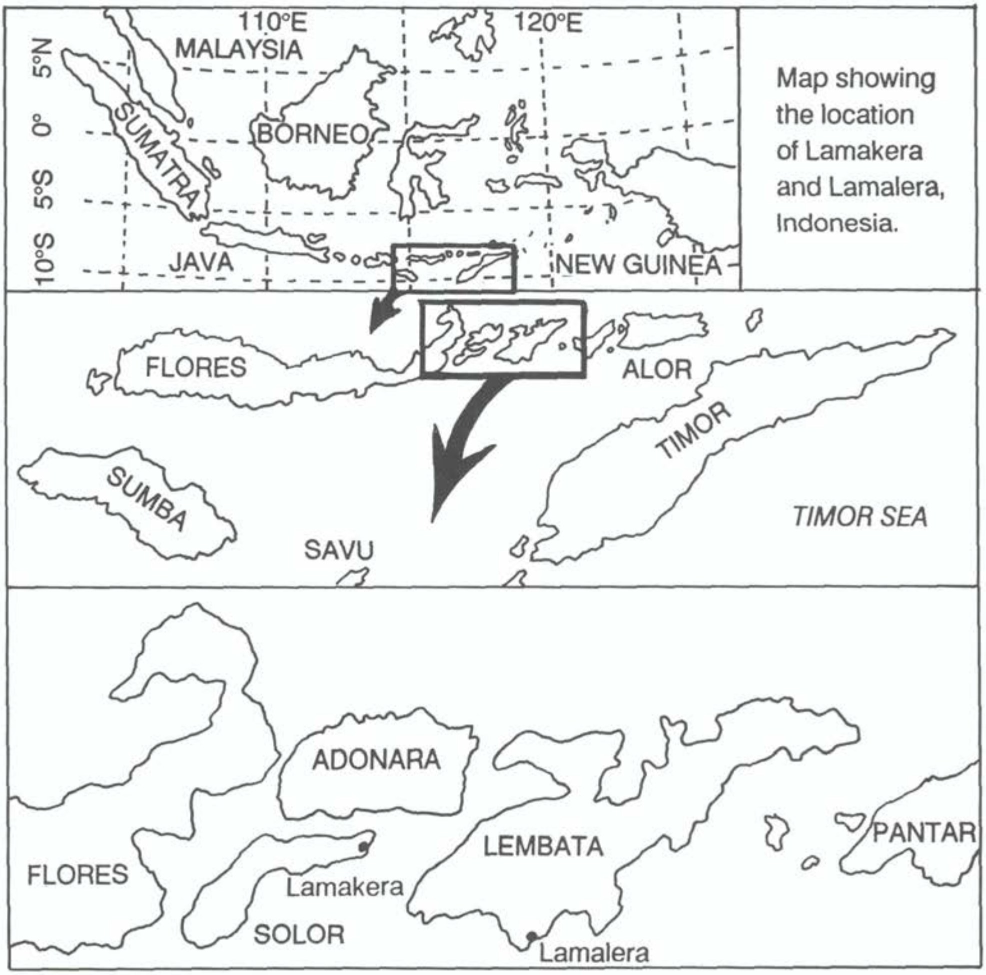

Fig. 1. Map of the area showing some places referred to in the text.

ilhas de Solor e Timor, 1956, p.487). The whales were hunted with harpoons for their oil, and the author implies that the islanders collected and sold ambergris at Larantuka, Flores. This early report confirms that indigenous whaling is ancient and that it antedates the appearance of American and British whalers in these waters by at least two centuries.

Near the end of the eighteenth century, Hogendorp (1779, pp.213–214; 1780, p.427) knew that the inhabitants of Solor and neighboring islands hunted a species of whale, which he, as did others subsequently, misidentified as the *Noordkaper* (*sensu stricta* the North Atlantic right whale). More substantial information was published by various authors in the 1830s and afterwards. From these we learn that the islanders sold whale oil at Kupang, Timor (Moor, 1837, p.10), which they have not done again since the middle of the nineteenth century. They also sold oil and other products to Bugis traders (Spangoghe, 1849, p.67; van Lynden, 1851, p.321). Hogendorp deserves the credit for first clearly identifying Lamakera, Solor, with whaling. Baron van Lynden (1851, p.321) first explicitly named Lamalera, Lembata, in this connection.

It is not widely recognised that the Savu Sea and the Ombai Strait, between Timor and Lembata, comprised one of the very earliest whaling grounds for American and English ships working westward from the Pacific. The whalers first worked on the Molucca ground in 1803 (Beale, 1839, p.149), which may well be the year of their first visit to Timor. When the British took over the Dutch East Indies following the Napoleonic wars, they placed Joseph Brown in Kupang as Resident of Timor. He wrote on 28 May 1813 that British whalers had long frequented Timor, whose coasts were the best ground for spermaceti whale. 'At one time these ships collected in such numbers in the straits of Timor that the fish for a length of time actually left the coasts and straits' (Brown, 1813).

Reports of Dutch residents of Timor, following the restoration of the islands to Dutch hands, showed that American and British whalers continued to frequent the region with as many as forty or fifty per year calling at Kupang in the late 1830s and early 1840s. By 1843 the number of whalers visiting Kupang began to decline, and after 1848 only a handful per year stopped there. The seamen told the Kupang authorities that their numbers had fallen because the whales had been overhunted and had moved on.

It was in the Ombai Strait south of Lembata that British and American whalers encountered Beale's legendary 'Timor Jack' (Beale, 1839, p.183) and Melville's 'Timor Tom', the scarred leviathan, 'who so long did'st lurk in the Oriental straits of that name, whose spout was oft seen from the palmy beach of Ombay' (Melville, 1851, Chapter 45). The National Library of Australia possesses in the Rex Nan Kivell collection (NK 828) a finely engraved whale bone plaque, dated 1858, depicting British whaling near Pulau Komba off the north coast of Lembata. Dr. Janet West has found the engraver to be the ship's surgeon William Lewis Roderick of the Barque *Adventure*, which was in the vicinity of Komba in July, 1855 (West and Barnes, 1990).

Despite the many indications of commercial whalers working near Solor and Lembata, there is absolutely *no* evidence of any direct contact with the fishermen of Lamalera and Lamakera. The whalers reprovisioned in ports along the north coast of Timor, but avoided the islands on the north side of the Ombai or Timor Strait, which among European sailors had a reputation for cannibalism and treachery. Although the whalers occasionally filled out a crew by taking islanders, they appear never to have shipped any of the seafaring peoples near Flores and Timor. According to van Musschenbroek (1877, p.507), whalers, mother-of-pearl fishers, and China-bound merchantmen hired make-up crew in the Talaud, Sangihe, Siau, Tahulandang and adjacent islands between Sulawesi and the Philippines. The most telling evidence of lack of contact is that the two villages have no memory of Western whalers and are unaware of any influence on their own fishery.

Today neither Lamakera nor Lamalera depends exclusively on their fishery. Lamalera has benefitted from over a century of exposure to modern schooling, and many offspring of the village now have successful careers in the professions, business and the Catholic clergy. Locally villagers today obtain cash income from trades such as carpentry and masonry, as well as from school teaching. Nevertheless, subsistence hunting and fishing remain a major part of their economic life.

The principal season for large scale fishing, during which the crews of nine to fifteen men put out to sea in ten metre long boats (*téna*) on most weekdays, is from around the beginning of May until, in most years, October. This period is called *léfa*. During the rainy season, from December through March, the large boats do not regularly go out, but if whales are sighted from land near the shore, villagers may *baléo*, that is hastily launch boats in hopes of harpooning the animals. Various kinds of individual small scale fishing take place through the year, either from shore, by swimming or floating in shallow water, or from small two-men boats called *berok* or *sapan*.

The large boats hunt sperm whales, locally known as *kote kelema*, killer whales or *seguni*, and Cuvier's beaked whales or *ika méã*. Other small whales and porpoises known to be hunted in Lamalera include false killer whales (*Pseudorca crassidens*) or *temu blã*, short-finned pilot whales (*Globicephala macrorhyncus*) or *temu bélã*, Risso's dolphins (*Grampus griseus*) or *temu bura*, melon-headed whales (*Peponocephala electra*) or *temu kebong*, and pygmy killer whales (*Feresa attenuata*) or *temu kebung*. Also taken are spotted dolphins (*Stenella attenuata*) and spinner dolphins (*Stenella longirostris*), both called *temu kirã*, Fraser's dolphins (*Lagenodelphis hosei*) or *temu notong*, and an unidentified small, soft-skinned dolphin named *fefa kumu*.

Whales known to be captured by villagers of Lamakera, Solor, include sei whales (*Balaenoptera borealis*), Bryde's whales (*B. edeni*), and minke whales (*B. acutorostrata*). These whales are all called *keraru* in Lamakera, which is the same as *kelaru* of Lamalera. Although not hunted because of its size, the blue whale is recognised by both villages when it appears and is known by the name *lelangaji*.

Although it is no longer the exclusive source of livelihood for the villages of Lamalera and Lamakera, the fishery, including the hunting of cetaceans, remains the principal source of sustenance for a large portion of their populations. Lamakera is able to dispose of its produce for cash in the market at Waiwerang, Adonara. Lamalera, however, must barter fish and meat in non-cash transactions for agricultural foods, which until recently they did not grow themselves.

The Lamalera boats are built to an ancient 'lashed-lug' design (Barnes, 1985), a technique which can be traced to pre-Viking and early Viking boats and which was developed during the Bronze Age. They are propelled by oars and paddles and by the use of rectangular sails woven from the leaves of the gebang palm (*Corypha elata* Roxb.), which are suspended from bipod masts. The harpooner stands on a platform which extends about a metre in front of the boat. Iron harpoons are manufactured locally in various sizes for different kinds of game, to a non-Western design. The snub-nosed blade continues as a flange past the shaft to which it stands at an angle. To the shaft is fastened a leader of thin cotton rope. The shaft is fitted, but not fastened, to a bamboo harpoon pole, which becomes detached once the harpoon strikes. The gear of each boat contains a variety of harpoons, poles and ropes, a different combination of which is used for each species hunted.

Each boat is made and maintained by a corporation centering on a patrilineal descent group. This group is responsible for organising a crew and for performing the many rituals (in Lamalera now given a Catholic form) necessary for harmony and success. Rights in the catch are complex, and each animal is carefully divided to insure that those holding rights receive their due.

Little research has been done on the cetaceans in these waters (see Hembree, 1980). The steep downward slope of the sea bottom permits many different whales to come very close to the south shore of Lembata, but the shallow Solor Strait, between Solor and Adonara, is a suitable habitat for fewer species. In the absence of any research on cetacean populations and movements, it is difficult to determine the relative effects of natural and social factors on the annual success of hunting for cetaceans or fishing for such large game fish as manta ray. The numbers of whales and porpoises taken annually are not deemed sufficient to have ever affected their conservation, and in any case have dropped dramatically since the 1960s.

There are no records of the Lamakera fishery, but Lamakera seems to take only a small number of whales and porpoises per year. Records available for Lamalera are haphazard and intermittent. They derive mostly from a retired local school teacher and begin in 1959, when 35 sperm whales were captured. The numbers of sperm whale taken dropped to 15 in 1966 and then rose to 56 in 1969, the largest number recorded, although it is thought that a

Table 1

Annual catch of sperm whales and large rays, 1959-87

	1959	1960	1961	1965	1966	1967	1968	1969	1970	1971
Sperm whale	35	26	31	34	15	25	43	56	37	43
Large ray	249	29	87	97	195	269	186	360	188	*
	1972	1973	1974	1975	1977	1978	1979	1982	1983	1987
Sperm whale	36	23	26	21	21	15	15	8	2	7
Large ray	*	*	*	*	*	*	148 [a]	79	*	*

*no record; [a] record incomplete

great many whales were taken during World War II. There was an average annual catch of 37 sperm whales in Lamalera from 1959 through 1970. During the decade of the 1970s, the average annual capture declined to just over 20. During the 1980s the average has declined to under 8. In 1983, only 2 were taken; in 1987 the number rose to 7. The annual take of manta rays is now well under 100, in comparison with the peak of 360 harvested in 1969 (for discussion see Barnes, 1986, pp.308–9; Table 1). During 1969, 25 whaling boats were in regular employment. In 1987, there were still 15 in use, but on average they were not taken out for as many days per year as they would have been in earlier decades. It is difficult to estimate precisely the impact of the different factors which may account for the decline of whaling and large scale fishing. Schooling and alternative occupations have reduced the pool of potential crew members. In years when there are poor results, the large boats are taken out less often, further reducing the catch. Natural conditions, such as the disruption caused by a new undersea volcano some miles from Lamalera or the presence and amount of other food sources, may affect the movement and numbers of cetaceans and rays. In any case it is probable that the number of whales visiting these waters varies among years, and we do know that at least twice during the first half of the nineteenth century few if any showed up on the hunting grounds.

Villagers are aware of the pressures their fishery is under and are concerned that it does not disappear. It is an ancient tradition, the importance of which for community identity is felt and valued even by those who have moved away and taken on modern occupations. Whaling remains a vital part of village economic life, and villagers do not expect to stop. Even under present circumstances, boats continue to be rebuilt and to attract crews.

REFERENCES

Barnes, R.H. 1974. Lamalera: a whaling village in eastern Indonesia. *Indonesia* 17:137–59.

Barnes, R.H. 1980. Cetaceans and Cetacean Hunting: Lamalera, Indonesia. Report on World Wildlife Fund Project 1428 (unpublished). 82pp. [Available from WWF].

Barnes, R.H. 1984. Whaling off Lembata: the effects of a development project on an Indonesian community. Document 48 presented to the International Work Group for Indigenous Affairs, Copenhagen (unpublished). 32pp.

Barnes, R.H. 1985. Whaling vessels of Indonesia. pp. 345–66. *In:* S. McGrail and E. Kentley (eds.) *Archaeological Series*. 10. *Sewn Plank Boats: Archaeological and Ethnographic Papers Based On Those Presented to a Conference At Greenwich in November 1984*. B.A.R., Oxford. National Maritime Museum, Greenwich. 399pp.

Barnes, R.H. 1986. Educated Fishermen: Social consequences of development in an Indonesian whaling community. *Bull. Éc. Fr. Extrême-Orient* 75:295–314.

Beale, T. 1839. *The Natural History of the Sperm Whale*. 2nd Edn. van Voorst, London. 393pp. [Reprinted in 1973 by The Holland Press, London].

Brown, J. 1813. Report of the resident of Timor, Joseph Brown, 28th May 1813. Raffles Collection, India Office Library (unpublished).

de Almeido, A. 1945. Carne de mamiferos aquaticos – tabu alimentar dos nativos dos colonias Portuguesas. *Bol. Ger. Colon.* 21:48–58. [In Portuguese].

Fundacao das Primeiras Cristanades nas ilhas de Solor e Timor. 1956. Transcrito do Códice 465, existente no Fundo Geral da Biblioteca Nacional de Lisboa. pp. 475–553. *In:* A. Basilio de Sa (ed.) *Documentaçao para a História das Missoes do Padroado Portugês do Oriente, Insulíndia*. Vol. 4. Agencia Geral do Ultramar, Lisboa. 553pp. [In Portuguese].

Geurtjens, H. 1921. *Uit Een Vreemde Wereld, of Het Leven En Steven Der Inlanders Op De Kei-Eilanden*. Teulings, Hertogenbosch. 398pp. [In Dutch].

Hembree, D. 1980. Biological aspects of the cetacean fishery at Lamalera, Lembata. Report on World Wildlife Fund Project 1428 (unpublished). 55pp.+2 appendices.

Melville, H. 1851. *Moby Dick or the White Whale*. Harper and Brothers, New York. 634pp.

Moor, J.H. 1837. *Notices of the Indian Archipelago and Adjacent Countries.*, Singapore. 410pp.

Rumphius, G.E. 1705. *D'Ambonische Rariteitkamer*. Halma, Amsterdam. 340pp. [In Dutch].

[Spangoghe, J.B. 1849.] Walvischvangst der Solorezen. *Tijdschr. Ned. Indië* 11(2):66–7. [In Dutch].

van Hogenndorp, W. 1780. Vervolg der Beschrijving van het Eiland Timor. *Verh. Bat. Genootschap Kunsten Wet.* 2:405–31. [In Dutch].

van Hogenndorp, W. 1779. Beschrijving van het Eiland Timor voorzoover het tot nog toe Bekend is. *Verh. Bat. Genootschap Kunsten Wet.* 1:192–214. [In Dutch].

van Lynden, D.W.C. 1851. Bijdrage tot de kennis can Solor, Allor, Rotti, Savoe en omliggende eilanden, getrokken uit een verslag van de residentir Timore. *Natuur. Tijdschr. Ned-Indië* 2:317–36, 388–414. [In Dutch].

van Musschenbroek, S.C.J.W. 1877. Cachelot-visscherij van de Amerikanen in den Ned. Indischen Archipel. *Tijdschr. Ned. Maatschappij Bevordering Nijverheid* 40(1):473–532. [In Dutch].

West, J. and Barnes, R.H. 1990. Scrimshaw by William Lewis Roderick: a whale bone plaque dated 1858 showing the barque *Adventure* of London whaling off Flores and Putau Komba in the Indian Ocean. *Mariner's Mirror* 76(2):135–48.

Plate I: Harpooner and Crew of a Whaling Boat of Lamalera, Lembata, Indonesia.

Plate II: Flensing a Sperm Whale on the Shore of Lamalera, Lembata, Indonesia.

Plate III: A Woman Preparing to Carry Sheets of Whale Blubber on the Shore of Lamalera, Lembata, Indonesia.

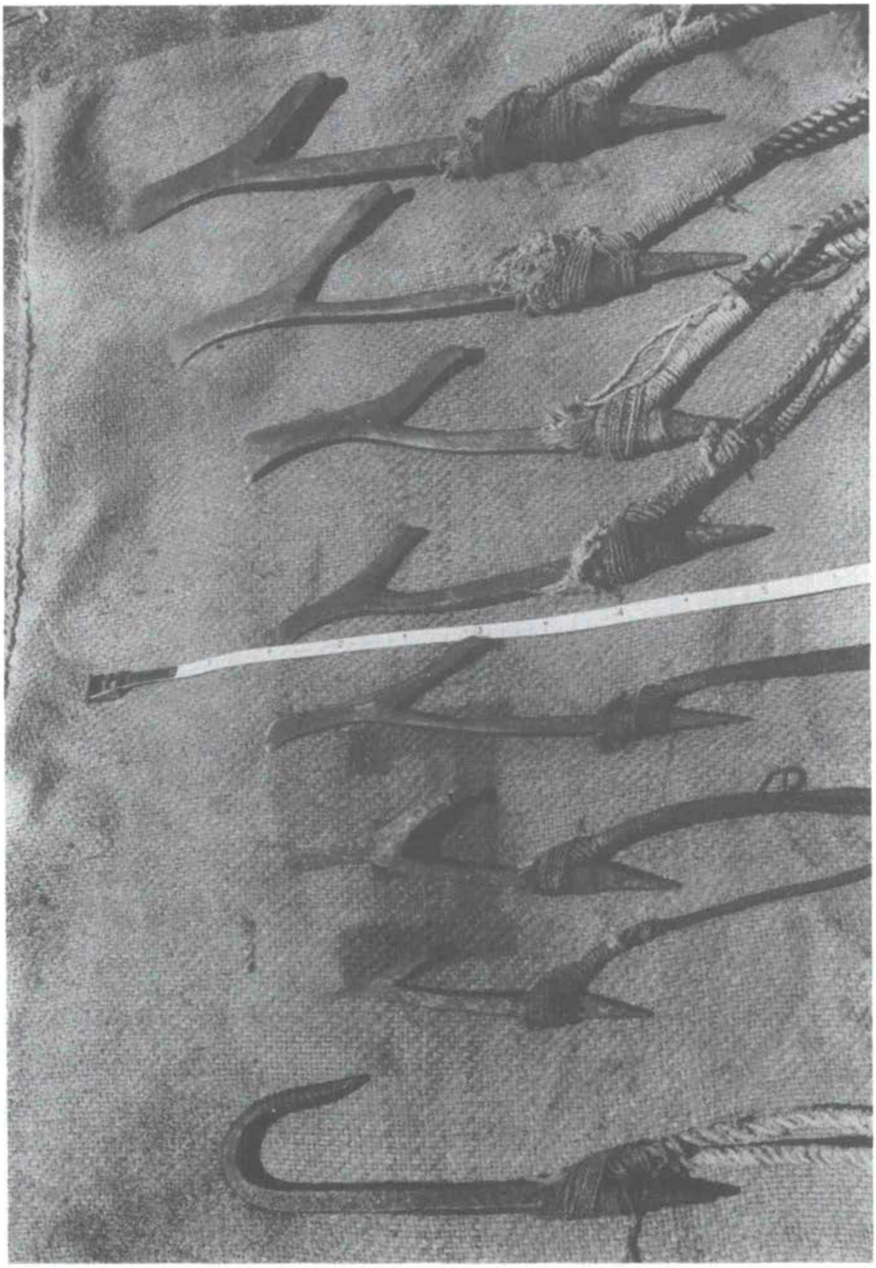

Plate IV: A Gaff and Harpoons Used in Fishing and Cetacean Hunting in Lamalera, Lembata, Indonesia.

A Note on the Capture of the Smaller Cetaceans for Food in the Laccadive Islands*

M. Ali Manikfan

Muraduganduvar, Minicoy, Laccadives, India[1]

ABSTRACT

Dolphins and porpoises often are found in large numbers close to the islands in the Laccadive Archipelago. The people of Minicoy, the southernmost island, who are Hahl-speaking, like the people of the Maldives, do not catch dolphins but treat them as companions and friends. On the other hand, residents of the other inhabited islands, Malayalam-speaking like the inhabitants of Kerala, have long caught dolphins whenever possible for food. They do so by harpooning individuals or driving herds into lagoons and slaughtering them. The meat is cooked fresh with spices and coconut and made into curries. Any excess meat available is salted and dried in the sun and stored for later use.

Keywords: whaling-aboriginal; small cetaceans; Indian Ocean.

INTRODUCTION

The Laccadive Islands group (approximately 8°00′N to 12°30′N, 72°00′E to 74°00E) consists of ten inhabited islands and about a dozen uninhabited islands and reefs (Fig. 1). Minicoy, the southernmost island, is the largest and most populated; it is separated from the rest by the Eight Degree Channel. Although the inhabitants of all the islands are Muslims, those of Minicoy are ethnically related to the Maldivians and differ from inhabitants of the northern islands in language, customs and culture. Minicoy's residents have ancient seafaring and fishing roots. They do not generally kill or eat cetaceans, as the meat is forbidden to them by tradition. Furthermore, cetaceans, particularly the dolphins and porpoises, are regarded as companions or fellow travellers in the sea. Sailors enjoy watching them swimming on the bow of their ships or coming close during the night. Tuna fishermen, particularly those after the oceanic skipjack *Katsuomus pelamis*, regard dolphins as harbingers of good fishing, believing they help to drive the shoals of small fishes into the lagoon, where the islanders can collect them for use as live bait. Dolphins and porpoises are known in Minicoy as *'Komas'*, presumably from the roots *'ko'*, which derives from *'ho'* (meaning hole, signifying the blow hole) and *'mas'* (a common name for fishes in the Mahl language).

DOLPHIN FISHERY

Residents of the northern islands, formerly ignorant of the current mechanised methods of catching skipjack, once regularly caught dolphins and porpoises near the islands, either by harpooning individuals or by driving large schools into the shallow lagoons.

Harpoon fishery

The harpoon is a barbed steel rod with a cup-shaped cavity for affixing it to the end of a coconut pole. A length of rope, used to attach the harpoon head to the shaft, is made of

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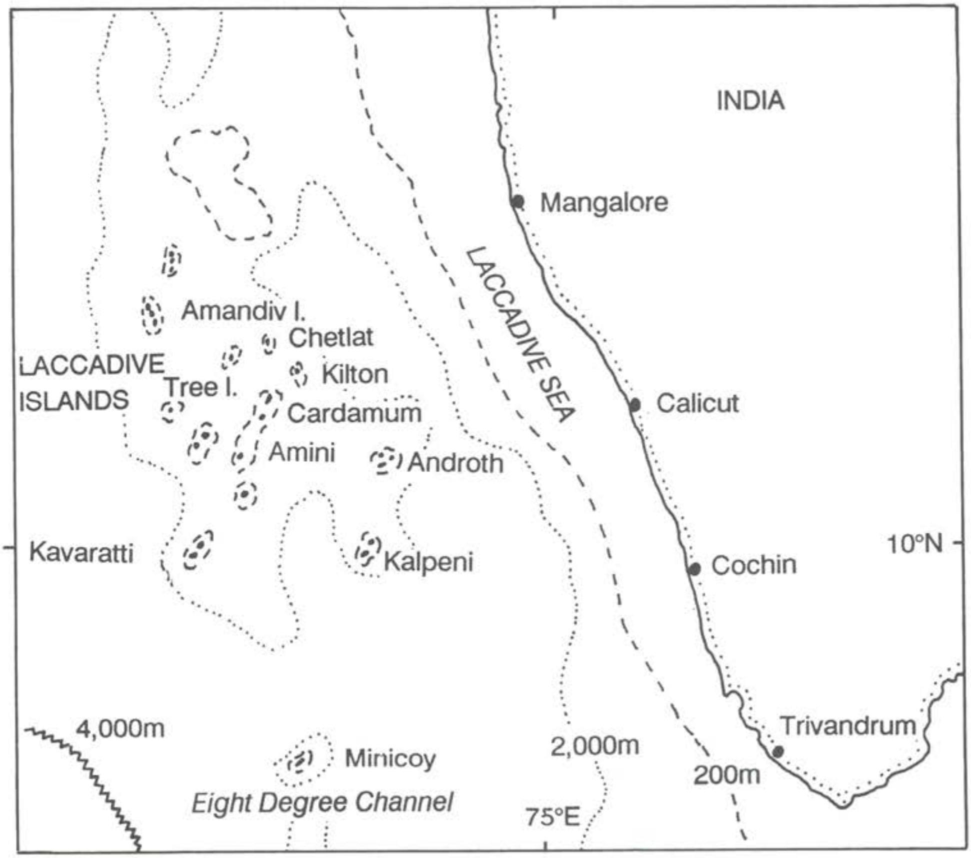

Fig. 1. The Laccadive Islands are located on narrow 200m platforms and have ready access to pelagic waters.

specially twisted coconut fibre to make it strong enough to withstand the struggle and pull of the harpooned animal. The harpoon and the pole are tied in such a manner that after the dolphin is struck the pole becomes detached and serves as a float. Harpooning is carried out from small 3–5m boats, with two or three men on board. The harpooners rarely miss. If a harpooned animal does escape, its entire herd disappears; on the other hand, when a successfully harpooned animal is hauled into the boat, the herd might reappear. There have been instances in which boats have been pulled by a harpooned dolphin for long distances. In some such instances, without any navigational aids, water and food, the sailors have lost their sense of direction, drifted and become lost at sea. Some have landed on other islands after days of suffering from thirst and hunger. Formerly, the northern islanders also often harpooned smaller cetaceans during voyages to the mainland in their boats, known as a *'odam'*s.

Drive fishery

Occasionally, when the sea is calm and smaller cetaceans come in large schools close to the islands, the northern islanders organise dolphin drives. These operations involve large numbers of small boats and the cooperative efforts of hundreds of people. Those engaged in the drive appear to be in a festive mood; those watching from shore urge and encourage the drivers with their shouts. The boats form a semi-circle around the animals and drive them towards the reef by beating the water with sticks or oars to make noise to frighten them. On reaching the gaps or channels in the reef, the animals enter the lagoon, where they ultimately are stranded or caught in the shallows and then slaughtered. Rarely, dolphins are stranded or caught after they naturally stray into the lagoon while feeding. Some drives formerly resulted in catches of over two hundred dolphins, or more. Such drives are very rare now.

Utilisation

The meat of dolphins (known as *'irachi'*, meaning 'flesh' in Malayan) is made into a spiced curry dish, called *biriyani*, much as with beef, mutton or chicken, and eaten with rice. When large quantities of dolphins were available, their meat was boiled and dried in the sun for later use. Dolphin *'biriyani'* was formerly highly relished. However, fishing for smaller cetaceans has reportedly declined with the general improvement in the area's economy, introduction of skipjack fishing from mechanised boats and provisioning by modern ships. Neither the species involved nor the status of their stocks around the Laccadives are known.

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A Note on Cetaceans Seen and Live-captured in the Gulf of Aquaba and the Gulf of Suez, 15 September 1980 through 1 September 1981

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ABSTRACT

This note summarises sightings of cetaceans made during operations to live-capture cetaceans for Tel Aviv Dolphinarium from 15 September 1980 to 1 September 1981. Searching took place in the Gulf of Aquaba and the Gulf of Suez. Spotted dolphins were most abundant, followed by Risso's dolphin. Two kinds of bottlenose dolphin were seen and caught: a smaller form and a larger form. Hump-backed dolphins and one false killer whale were also seen.

Keywords: incidental capture; sightings – incidental; spotted dolphin; Risso's dolphin; bottlenose dolphin; hump-backed dolphin; false killer whale; Indian Ocean; Northern Hemisphere.

INTRODUCTION

In 1980 and 1981, a crew of five searched for and captured cetaceans for the Tel Aviv Dolphinarium, which opened in September 1981 and closed in December 1983. Search and capture operations were conducted from a base at Na'ama (Sharm al Moya) Bay from 1 September 1980 through 1 June 1981. Occasional searches also were made from the base between 2 June 1981 and 1 September 1981. As a routine, searches were made from two small craft cruising along parallel search patterns from 0.5 to 3.0 n.miles apart: a 38 ft twin engine inboard-powered 'Princess' and a 17ft cathedral-hulled outboard-powered skiff, operating in radio contact. There were two distinct areas and periods of operation:

GULF OF AQUABA

From about 15 September through 15 November 1980, searches were made daily, weather permitting, in the portion of the mouth of the Gulf of Aquaba within 40 n.miles of shore between Nabq and Ras Muhammad, the point separating the Gulf of Aquaba from the Gulf of Suez (Fig. 1). This area is characterised by a very narrow coral shelf, outside which the bottom drops precipitously to oceanic depths (over 500m) very near shore. Searches targeted the different portions of this region more-or-less equally, with the obvious exception that coverage was greatest near the base, by virtue of the comings and goings.

GULF OF SUEZ

From about 15 November 1980 through 1 September 1981, the boats were taken on about twenty 4- or 5-day excursions into the Gulf of Suez, where they operated within about 10 n.miles of shore, mostly around Sha Ab Ali Mahmud, but extending as far into the Gulf as Ras Shukheir (Fig. 1). This area is shallow, to 20m or less, and has a relatively flat bottom. Offshore, there are numerous raised coral platforms which reach near or above the surface. Because of routes to and from this target area, additional coverage resulted in the southern Gulf of Aquaba and in the southern Gulf of Suez.

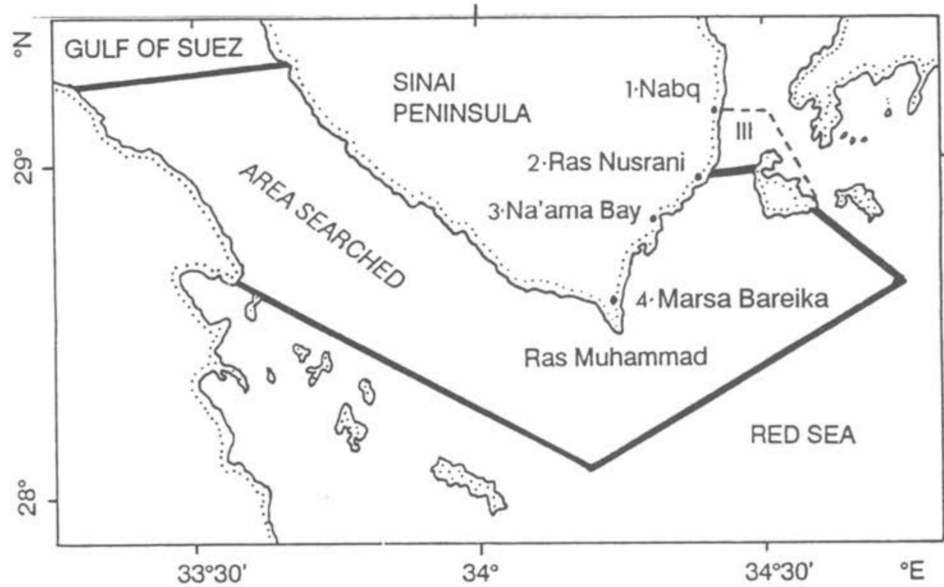

Fig. 1. The Gulf of Aquaba and Gulf of the Suez, highlighting areas of search and capture and indicating other place names referred to in the text. The author thanks Ronnie Zilber for assistance with this note. 1 = Nabq – northermost point of searches; 2 = Ras Nusrani – the base camp and holding pools; 3 = Nauma Bay – the boat base; 4 = Marsa Bareika; III = the additional area searched.

RESULTS

All sightings of cetaceans were logged. Captures of desired species were attempted when appropriate sex and size classes were located and holding facilities permitted. Records of all activities were filed with the 'Slemurot-Ateva' (Israeli Parks Board). As those records were not available for this report, I simply summarise here observations and collections by species and area.

Spotted dolphins, *Stenella attenuata*, were by far the most abundant and frequently encountered cetaceans, even though we saw them only in pelagic regions of the Gulf of Aquaba. We encountered spotted dolphins almost daily when at sea in the Gulf of Aquaba with calm waters and good visibility. They were found in herds of 300 or more and were eager bow riders. Early in the capture operations, September through November 1980, eight specimens were removed (Fig. 2A). All were released within six days, however, because they were not eating and were, therefore, considered to be at high risk.

Risso's dolphins, *Grampus griseus*, also restricted to pelagic waters of the Gulf of Aquaba, were the second most abundant and frequently seen species. They were encountered once or twice per week in the Straits of Tiran and daily when operating around Tiran Island. Herds contained up to about 100 animals, but averaged about 30–40. As they did not come to the vessels' bow waves, we attempted no captures.

Two types of bottlenose dolphin, *Tursiops truncatus*, were seen and caught. One was small (to no more than about 2.2m) and relatively slender, with a gentle slope from the melon onto a relatively elongated snout. They were pale gray on the back and sides, lighter on the ventrum, and frequently had spotting, particularly on the throat (Fig. 2B). These smaller bottlenose dolphins were not seen at all in the Gulf of Aquaba but were the third most abundant and frequently seen species overall; they were common in the Gulf of

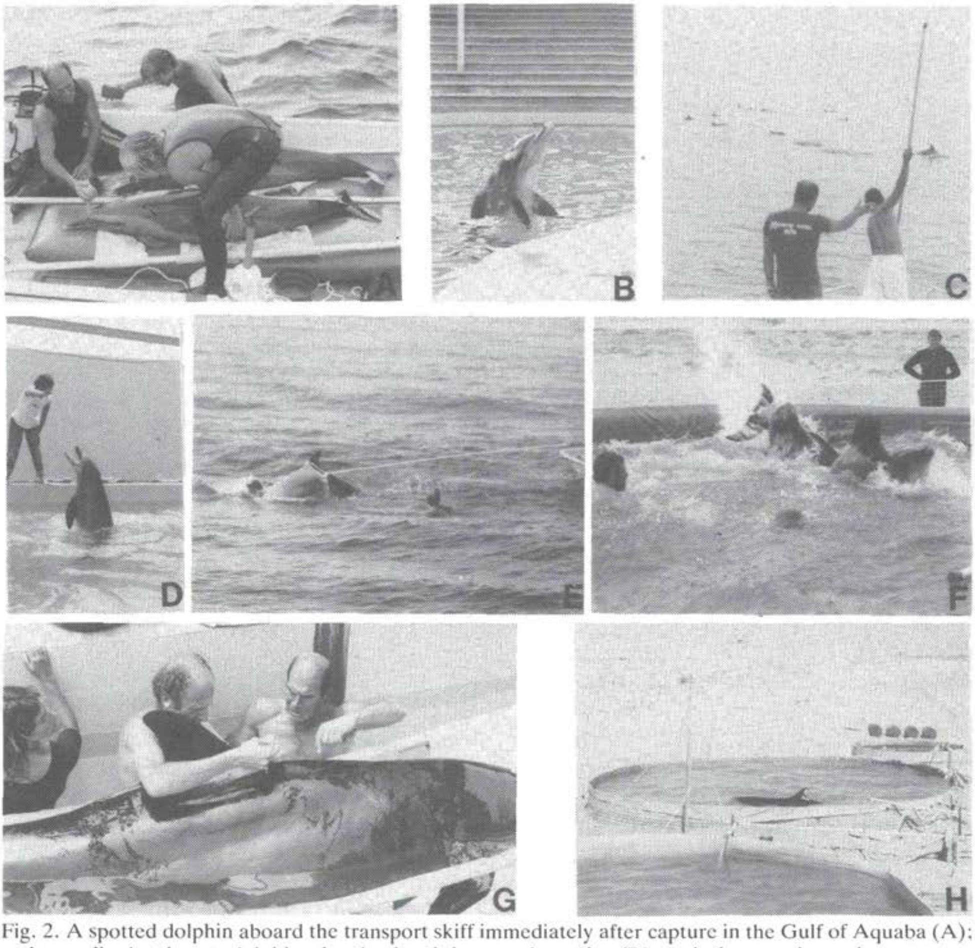

Fig. 2. A spotted dolphin aboard the transport skiff immediately after capture in the Gulf of Aquaba (A); the smaller bottlenose dolphin, showing head shape and spotting (B); typical group size and appearance at sea (C); one of the animals sent to Tel Aviv (D); the larger bottlenose dolphin, with swimmers, just after capture off Ras Muhammad (E); and during handling in the holding facilities (F); the false killer whale, on the stretcher during transport (G); and in the holding pool at "Ras Nusrani" (H).

Suez, both in channels among and along seaward sides of coastal coral reefs and around or inside the offshore coral complexes. They were also seen in the Narrows of the Suez Canal, itself. There appeared to be 'resident' groups of up to about 20 individuals of this type (Fig. 2C), each associated with a given reef system, as recognisable individuals were seen visit after visit. We did, however, encounter larger groups, up to 200, away from the reefs. We took these to be short-term feeding aggregations of many local groups. One male and one female were caught and sent to the oceanarium (Fig. 2D).

These small bottlenose dolphins have at times been assigned to *Tursiops abusalam*. In Arabic, the word 'abusalam' means 'father of peace'. These dolphins are respected, if not revered, locally and neither they nor any other species are deliberately exploited in any of the areas in which we operated.

The second type of bottlenose dolphin was large (to 4m or more) and robust with a comparatively steeper melon, shorter, boarder snout, and apparent lack of ventral spotting. Individuals of this type were seen three times (1, 6 and 10 individuals), always at the southern end of 'Marsa-Bareika'. It was our impression that these larger animals were travellers, as we frequently passed Ras Muhammad but saw them only three times. In October 1980, a 3.9m male was caught and removed from a group of 6 (Fig. 2E and F). It was the smallest member of its group.

Hump-backed dolphins, *Sousa* sp., were seen not infrequently in the Gulf of Suez, including Port Said and Port Suez, usually as singles or in groups of up to 12. They were the fourth most frequently encountered species, but it was our impression we were seeing the same few animals repeatedly, either in groups or as scattered individuals. They were usually over the offshore coral platforms. In January 1981, one was captured by purse seine at En Nigh. It was released, as hump-backed dolphins were not a target species for the dolphinarium.

In February 1981, as we were leaving the coastal areas of the Gulf of Suez, we encountered a single false killer whale, *Pseudorca crassidens*, over an approximately 5m deep sand flat in an offshore reef. The animal moved beside us until we were off the deep shelf, where it joined a second individual. We then followed the two animals into the southern end of the Gulf of Aquaba, where they joined with 10 others and continued northward. We caught one animal, a 3.9m male, and removed him to Tel Aviv. No other false killer whales were seen. Neither were any other species of cetaceans.

Bottlenose Dolphins in Natal Shark Nets, 1980 through 1987: Catch Rates and Associated Contributing Factors

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ABSTRACT

A minimum of 212 bottlenose dolphins, *Tursiops truncatus*, was caught in anti-shark nets off Natal, South Africa, between January 1980 and December 1987. Catches from January 1982 onwards showed significant interannual and seasonal variations in numbers and mass/sex composition. Sexually mature males and females constituted 16.7% and 23% of the total catch, respectively. Of the latter, 63% were lactating and a further 12% were pregnant. Adolescents, 90kg-130kg in mass and ≤8 GLGs in the dentine, comprised 14.8% of the catch. Almost 45% of the catch consisted of calves of less than 90kg mass and less than two GLGs. Of these, 69.5% were either weaned or weaning at capture. Analysis of the biological, environmental and physiographic data for each capture suggests a number of reasons for the catch of bottlenose dolphins. The longshore distribution of catches was random, but catch rates were proportional to the number of nets. The stomachs of most dolphins were more than 63% full at the time of capture, suggesting that enmeshing occurred either during or shortly after feeding. Most captures were of single animals, but lactating females with calves constituted more than 20% of catches. The direction of the prevailing current was significantly related to captures. These data are examined in relation to existing knowledge of bottlenose dolphins in this area and possible methods of reducing captures are proposed.

Keywords: incidental capture; bottlenose dolphin; Indian Ocean; Southern Hemisphere; shark; oceanography feeding; distribution; mortality.

INTRODUCTION

The incidental death of marine mammals in fishing gear is a recurring problem wherever marine mammals and fisheries interact. These interactions are diverse (Beddington *et al.*, 1985; Gulland, 1986) and involve a variety of marine mammals, including large whales (Whitehead and Carscadden, 1985), sea lions and fur seals (Shaughnessy and Payne, 1979; Fowler, 1982; Loughlin and Nelson, 1986), freshwater dolphins in both South America and Asia (Pei-Xun, 1981; Best and da Silva, 1984; Northridge and Pilleri, 1986) and inshore and oceanic small cetaceans (Perrin, 1970; Bannister, 1977; Best and Ross, 1977).

The mortality of marine mammals associated with fishing operations is recognised as a major threat to many of their populations (Beverton, 1985; Northridge and Pilleri, 1986). Currently, fishing activities have become so widespread and in many areas so intensive, that they probably account for the major portion of small cetaceans killed (Meith, 1984). Mitchell (1975) reviewed fisheries for and incidental catches of small cetaceans in a species by species account. More recently, the interactions of small cetaceans with fishing enterprises has been reviewed by Northridge and Pilleri (1986) and Meith (1984).

On the east coast of southern Africa, numbers of small cetaceans are caught incidentally in non-commercial gillnets set off those Natal beaches frequented by tourists. These nets are set to catch and reduce the population of sharks, reducing the probability of contact

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between bathers and sharks. Although nets were first installed off Durban in 1952 and subsequently at other localities, most were maintained and serviced by private tenders until the mid 1970s. Little regulation of these contractors made the assessment of numbers and identity of cetacean catches difficult. Since early in the 1980s the entire shark netting operation has been administered by a parastatal body, the Natal Sharks Board, which maintains these nets using trained staff. Cooperation with these staff and an increased effort in collecting meshed cetaceans has enabled a better assessment of catch rates since this time, particularly since January 1982 when collection procedures were defined.

Incidental catches of cetaceans in the shark nets include individuals of three dolphin species, the common dolphin, *Delphinus delphis*, the hump-backed dolphin, *Sousa plumbea* and the bottlenose dolphin, *Tursiops truncatus* (Cockcroft, 1990). Recent concern over the level of the catches of bottlenose and hump-back dolphins has prompted assessments of the population numbers of these two species in Natal (Ross, 1982; Ross *et al.*, 1989). The results of the latter work suggest that the continuing mortality of bottlenose dolphins in the nets may lead to a decline in their numbers in the Natal region. This, and the apparent similar plight of the hump-back dolphin in Natal, lead to the initiation of an experimental programme to test the effect of various net attached deterrents on captures of these two species (Peddemors, Cockcroft and Wilson, this volume).

STUDY AREA, MATERIALS AND METHODS

Nets are installed at 44 beaches along the southern half of the Natal coast, between Richards Bay and Mzamba (Peddemors *et al.*, this volume). In all, some 416 nets are set along this coastline. At most installations, nets are approximately 110m long by 10m deep. The number of nets positioned at each beach (2 to 63) is dependent on the extent of beach use by bathers. Nets are set in constant fixed positions, in a staggered fashion, 400–500m offshore and approximately 100m seaward of the surf. Weather permitting, the nets are examined daily and any catch, shark or dolphin, is removed and taken to shore where it is frozen to await processing. The beach, net number and date of all catches are recorded.

Routine necropsies were performed on all dolphins retrieved from the nets between January 1980 and December 1987. Biological and morphological parameters (*sensu* Ross, 1984), including length, mass, sex and reproductive state, were recorded. Age was determined from the number of growth layer groups (GLGs; *sensu* Perrin and Myrick, 1980) counted in thin sections of the dentine of teeth. For data interpretation, dolphins were divided into the following mass classes: juveniles (<90kg) (Cockcroft and Ross, 1990a), adolescent males and females (between 90kg and 130kg) and adult males and females (>130kg); adult females were further divided into lactating, pregnant or quiescent (neither lactating nor pregnant females). We partitioned adolescents and adults at 130kg as that corresponds to the approximate mass at which females first appear to ovulate (Cockcroft and Ross, 1990b).

Statistical analyses were performed on biological parameters and one derived biological parameter for each dolphin, and on environmental factors and physiographic characteristics of the capture site/s (Table 1). The derived biological character was the 'proportional fullness of the stomach'; this was estimated from the mass of the remains in the stomach as a percentage of the stomach's estimated maximum volume (*sensu* Cockcroft and Ross, 1990a). Environmental factors were taken from daily records of sea temperature, water visibility, wave height and current direction routinely made by officers while meshing the nets. The physiography of each net installation was obtained from underwater surveys undertaken by staff of the Natal Sharks Board.

Table 1

Variables included in the matrix of biological, environmental and physiographic parameters examined to determine factors contributing to the catch of bottlenose dolphins off Natal.

1. Locality of capture
2. Year of capture
3. Month of capture
4. Day of capture
5. Sex (male or female)
6. Sex/mass class (1=<90kg, 2=males >90kg <130kg, 3=females >90kg <130kg, 4=quiescent females >130kg, 5=lactating females, 6=pregnant females, 7=mature males >130kg)
7. Mass (kg)
8. Length (cm)
9. Age (GLGs)
10. Net in which caught (locality specific)
11. Number of animals caught simultaneously
12. Percentage fullness of stomach
13. State of the tide (two days either side of spring tide=1, 2 days either side of neap tide=2, mid tide=3)
14. Water visibility on day of capture (m)
15. Water visibility on day after day of capture (m)
16. Difference between 14 and 15
17. Temperature on the day of capture (C)
18. Temperature on the day after day of capture (C)
19. Difference between 17 and 18
20. Current direction (northerly=1, southerly=2, offshore=3)
21. Swell height (m)
22. Channel at the net (yes=1, no=2)
23. Reef under the net (yes=1, no=2)
24. Reef in the net area other than under net (yes=1, no=2)
25. Type of reef (bare rock=1, flora covered=2)
26. Substratum type (rock=1, rock+algae=2, rock+sand=3, sand=4, mud=5)
27. Distance of net from shore (m)
28. Depth of water at net (m).

The biological, environmental and physiographic matrix resulting from all captures was, by definition, a serial matrix containing data from captured animals only. Additionally, the matrix consisted of both ordinal and nominal data, of different measurements and scales, and was therefore unsuitable for multivariate analysis.

Bottlenose dolphin catches and data gathered between January 1980 and December 1987 are examined in this paper. However, the data on catches for 1980 and 1981 reflect only those dolphins which were studied after having been retrieved and frozen and not the total catch. In some circumstances during these two years, dolphins were not retrieved from nets or were retrieved in a condition too decayed to warrant transport ashore. Analysis of annual catch statistics has, therefore, been limited to those between January 1982 and December 1987, when all dolphins known to have been captured were recovered. All other analyses include dolphins throughout the study period for which the relevant information was available.

RESULTS AND DISCUSSION

Characteristics of the catch

Between January 1980 and December 1987, 212 bottlenose dolphins were recovered from the shark nets. Thirteen were recovered in 1980 and 13 in 1981. There was significant interannual variation between catches for the years 1982 through 1987 (χ^2=14.1, df=5,

Table 2

The numbers of each bottlenosed dolphin mass/sex class caught between January 1980 and December 1987. The total catch for each year and the total catch of each mass/sex class is also given.

Maturity class	1980	1981	1982	1983	1984	1985	1986	1987	Total
Males >130kg	1	1	4	13	3	7	2	4	35
Males >90kg<130kg	0	2	1	1	3	0	0	6	13
Females >130kg	0	1	1	4	1	2	1	2	12
Females >90kg<130g	2	4	2	2	0	5	3	2	20
Calves <90kg	9	4	7	7	22	23	8	15	95
Lactating females	1	1	5	4	5	4	3	8	31
Pregnant females	0	0	0	0	0	1	3	2	6
Total catch	13	13	20	31	34	42	20	39	212

$P<0.05$) (Table 2). There were no differences between years if catches for either 1982 or 1986 were excluded from the analyses.

Mass/sexual state classes

There was also significant interannual variation in the proportions of each of the seven mass/sexual state classes (juveniles, adolescent males and females, adult females, lactating females, pregnant females and adult males) caught (Fig. 1:$\chi^2=56.2$, df=30, $P<0.01$). If the entire catch for 1983 was excluded, the interannual variations were not significant ($\chi^2=32{,}44$, df=24, $P>0.05$). Similarly, if the males captured during 1983 were excluded from analyses, the differences between the mass/sex class composition of the annual catches were no longer significant ($\chi^2=43.3$, df=30, $p>0.05$).

Overall, similar numbers of female and male bottlenose dolphins were caught ($\chi^2=2.14$, $P>0.05$). Capture rates of mature males and females and adolescent males and females, respectively, were also similar ($\chi^2=2.01$, $P>0.05$ and $\chi^2=0.3$, $P>0.05$, respectively). However, fewer adolescent dolphins (n=31) were caught than either adults (n=84, $\chi^2=24.6$, $P<0.01$) or calves (n=95, $\chi^2=32.8$, $P<0.01$) if sexes were combined in each category. Mature males constituted 16.7% of the total catch, mature females 23% of the catch. Of the sexually mature females, 63% were lactating and a further 12% were pregnant. Some 14.8% of the catch was comprised by adolescents with eight or fewer GLGs in the dentine (Fig. 2). The major portion of the catch consisted of calves, which were probably still sucking or were just weaned (Cockcroft and Ross, 1990a). The stomachs of 30.5% of these calves contained milk only, another 8.5% milk plus solids while the remaining 61% had no traces of milk, only solids.

The catch was clearly seasonal, showing a clumped, non-random distribution (mean square successive difference test, C=0.58, $P<0.05$); the majority of captures (74%) occurred between May and October (Fig. 3). No significant variation was found among the combined monthly captures of the seven mass/sexual state classes ($\chi^2=60.27$, df=66, $P>0.05$). This seasonal capture pattern was significantly correlated with mean monthly temperatures ($r=-0.776$, n=12, $p>0.01$) (Fig. 3). In contrast, monthly catches were not significantly correlated with mean monthly water visibility ($r=0.205$, n=12, $p>0.05$) (Fig. 3) and catches occurred over the entire range of water visibility from 0m to 10m.

Geographic and environmental

No bottlenose dolphins were captured in the northernmost installation, at Richards Bay where the mean annual water visibility was less than 1m but the mean annual water

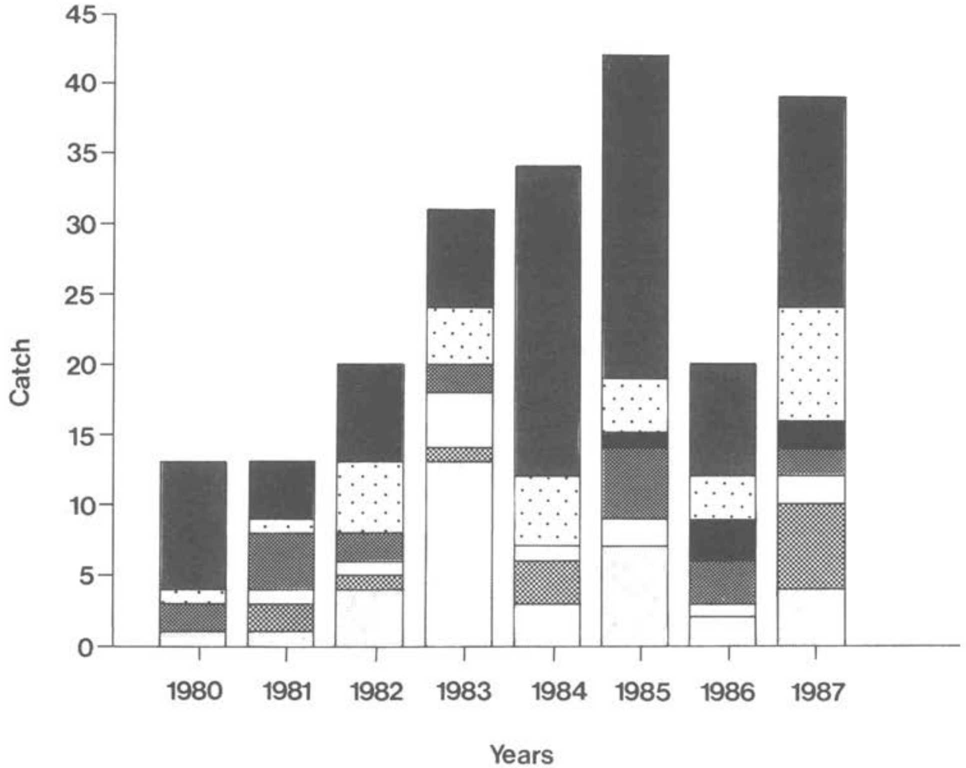

Fig. 1. The mass/sex composition of the annual catch of bottlenose dolphins from the Natal shark nets between January 1980 and December 1987. (– sexually mature males > 130kg, – adolescent males > 90kg < 130kg, – adolescent females > 90kg < 130kg, – quiescent sexually mature females > 130kg, – pregnant females, – lactating females, – calves < 90kg).

temperature was similar to that of other installations. The muddy substrate at this installation was also unlike any other along the coast. Catches per net occurred at random along the remainder of the Natal coast (runs test, n1=25, n2=20, u=24), although there was a strong relationship between the number of nets in an installation and the number of dolphins caught (r=0.774), with dolphin catches increasing with the number of nets set (Spearman's rank order correlation, p=0.97, P<0.01). There was no significant difference among the proportions of any of the seven mass/sex classes caught on the north Natal coast (Zinkwazi – Durban), upper south Natal coast (Amanzimtoti – Ifafa) and lower south Natal coast (Mtwalumi – Mzamba) (χ^2=15.15, df=12, P>0.05).

Of the environmental and physiographic variables, only the distribution of current direction in the capture matrix differed significantly from its expected frequency of occurrence (χ^2=34.006, df=2, P<0.01). The majority of captures occurred when the current direction was northerly (59.3%), while lesser proportions occurred when the current was flowing south (39.3%) or offshore (1.5%). The proportions of these current flow directions in the environmental data were 35.7%, 63.5% and 0.8% respectively.

The frequency distribution of the number of animals in the net in any instance was significantly non normal (Kolmogorov-Smirnov test, D=0.4618, n=212, p<0.01). One hundred and fifty seven captures were single events. On 27 occasions, two animals were

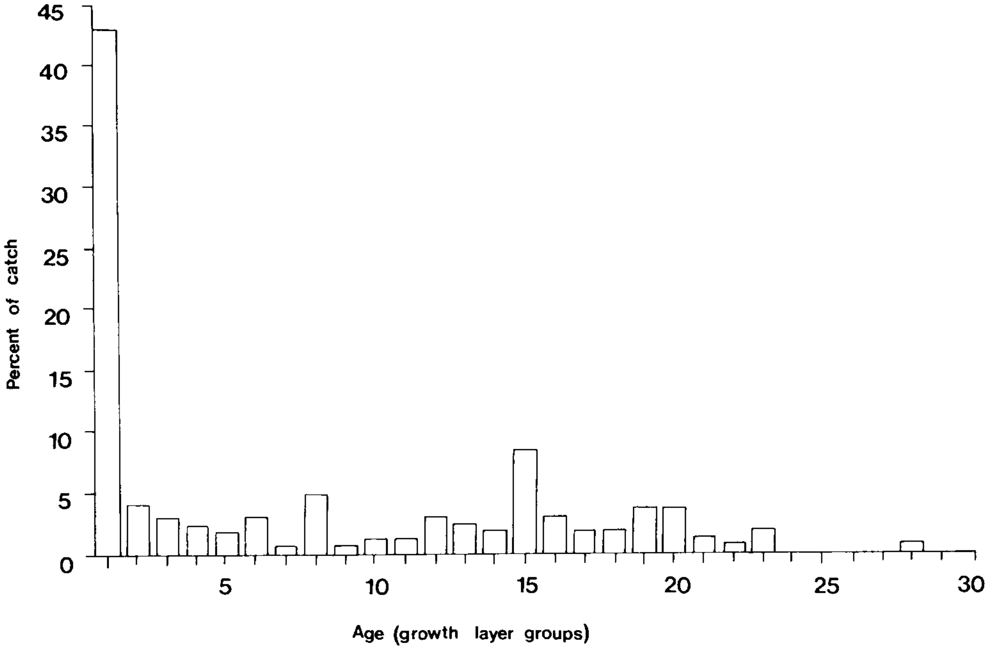

Fig. 2. The age (number of growth layer groups in dentine) composition of the bottlenose dolphin catch in the Natal shark nets between January 1982 and December 1987.

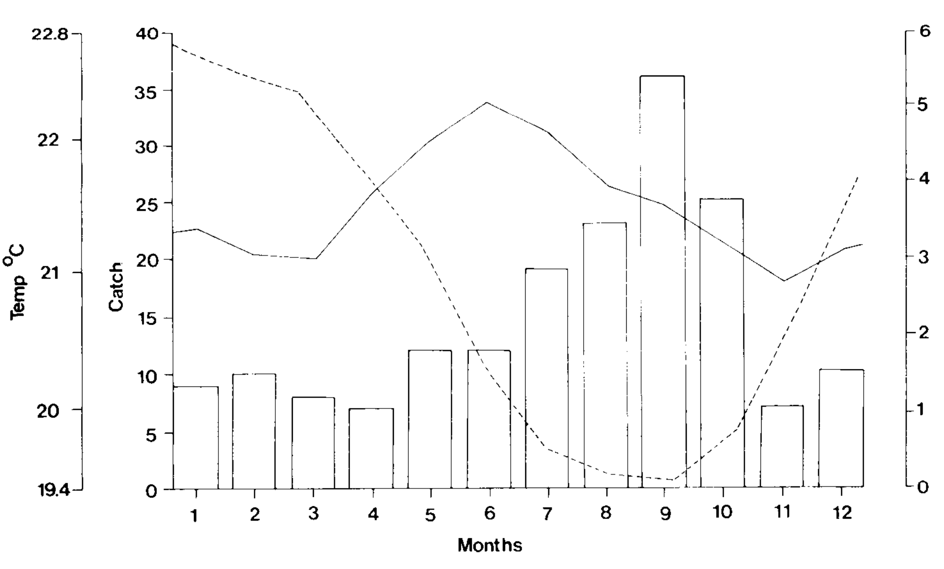

Fig. 3. Monthly catch of bottlenose dolphins, monthly mean water visibility (———) and monthly mean water temperature (– – – –) on the Natal coast between January 1982 and December 1987.

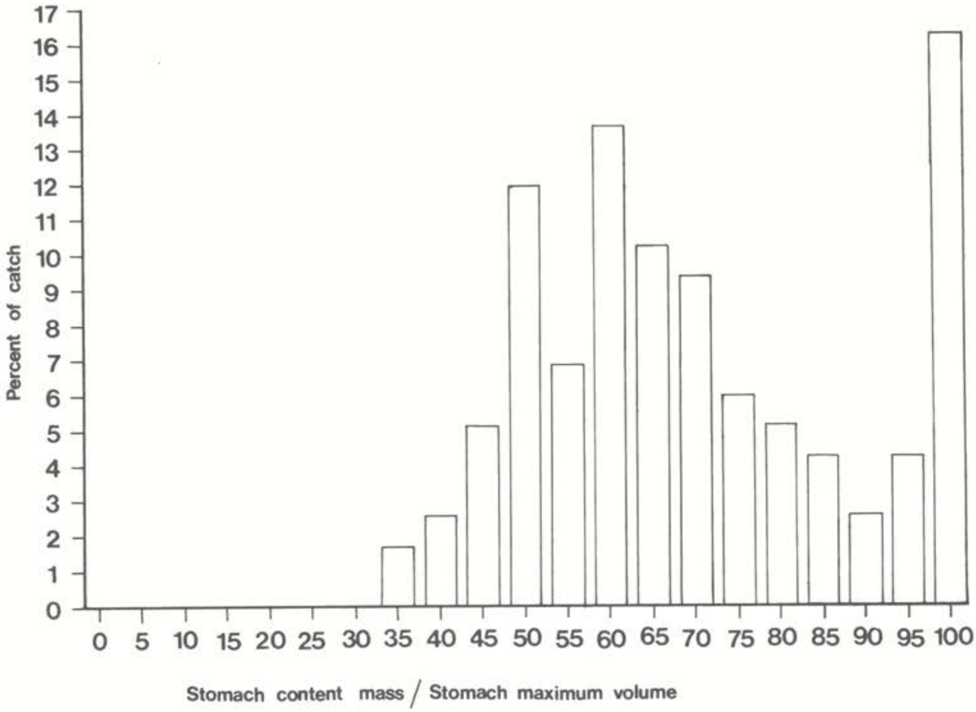

Fig. 4. Frequency distribution of the proportional fullness (stomach content mass/estimated stomach maximum volume) of the stomach of bottlenose dolphins caught in the Natal shark nets.

caught together – 20 lactating females, each accompanied by a calf and seven calves caught with either adult males, non lactating females or juveniles.

The average fullness of stomachs was 63.9% and the distribution of proportional fullness of stomachs was significantly skewed from the normal ($D=0.1821$, $n=117$, $p>0.01$) (Fig. 4).

At only three localities, Umhlanga Rocks, Durban and North Amanzimtoti, were catches sufficient (more than 10) to allow statistical analyses by locality. One locality specific variable, the net in which the animals were caught, was included in these analyses. Examination showed that animals were randomly caught in nets at each locality (runs test, Durban: $Z=-1.01905$, $n=18$, Umhlanga: $Z=0.13815$, $n=11$, North Amanzimtoti: $Z=0.138$, $n=12$).

An analysis of length distribution shows only four catches of dolphins less than 140cm in length (Fig. 5). Estimates from regressions of length on maximum body height ($X=aY+b$, $a=0.271805$, $b=0.50425$, $r=0.973$) suggest that lengths of 130cm and 140cm correspond with maximum body heights of 34.8cm and 37.6cm, respectively.

Probable causes of capture

An examination of the catch statistics for bottlenose dolphins taken off Natal provides some clues to the reasons for their capture. In an analysis of bottlenose dolphins killed during a drive fishery at Iki Island, Japan, Kasuya (1985) found that 42.7% of the dolphins

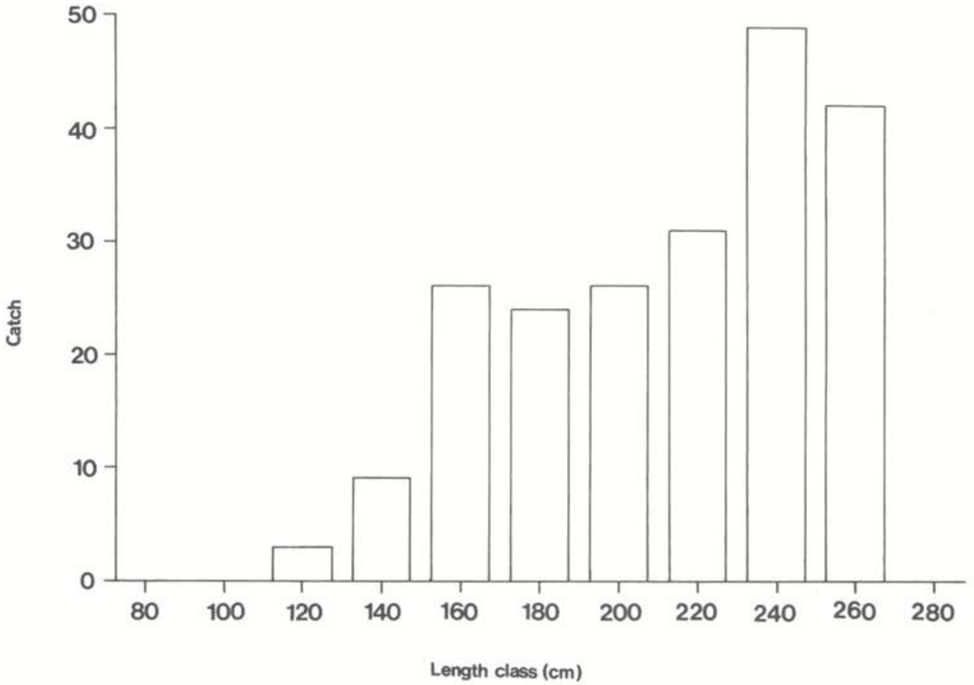

Fig. 5. The length composition of bottlenose dolphins caught in the Natal shark nets between January 1982 and December 1987.

caught were males. Of females caught, 40.1% were immature, 20.6% pregnant, 3.6% pregnant and lactating and 28.6% lactating. If similar proportions of sexes and size/sex classes are assumed to characterise the Natal bottlenose dolphin population, one would surmise from the Natal catch data that the overall proportions of the sexes in the two catches are similar. However, the proportions of immatures (60% of catch) are over represented, while pregnant females (5% of females) are under represented in the Natal catch.

Skewed catches of different age– or size-classes of marine mammals in commercial fishing nets are not unusual. Ferrero and Jones (1986) reported on the predominance of immature Dall's porpoise caught during salmon fishing in the western North Pacific Ocean. Loughlin and Nelson (1986) reported that mature females constituted the majority of northern sea lions caught during walleye pollock fishing off Alaska. Read (1987) has suggested that reproductive female harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada, are caught preferentially in groundfish gillnets. Smith *et al.* (1983) found that 52% of harbour porpoises trapped in herring wiers in the Bay of Fundy, were one year old.

Cockcroft and Ross (1990a; b) have suggested that different mass/sex of bottlenose dolphins off Natal feed in different areas of the inshore zone, on differing sizes and types of prey. Mature males feed farther from shore, on larger prey and on a different prey spectrum than do other classes. Lactating females and calves feed close inshore, where the former take a wider variety of prey than other subgroups while the latter, feeding with their mothers, take a limited variety of small prey. Segregation of sex- and size-classes of small cetaceans over limited (Wells *et al.*, 1980) and large areas (Ferrero and Jones, 1986) is well documented and may directly influence the catch of these animals (Kasuya and Jones, 1984).

Distributional segregation of bottlenose dolphins along the Natal coast may contribute to the apparent selectivity of the shark nets. The majority of captured calves had less than two GLGs in their teeth; so, they were probably still subject to maternal care (Cockcroft and Ross, 1990a). Evidence from stomach contents indicates that most were either weaned or weaning at capture; Cockcroft and Ross (1990b) showed that prey species found in the stomachs of calves had also been taken by their mothers. These data suggest that feeding plays an important role in predisposing calves to capture and may explain why calves constitute the majority of captures. Although the ontogeny of sound production and sound use, particularly in echolocation, is not well known in this species, it is probable that calves are not adept at perceiving the nets, either visually or acoustically, and are caught as a consequence. The slow attainment and perfection of behavioural and social skills apparent during the long period of maternal care of bottlenose dolphin calves (Cockcroft and Ross, 1990a) supports this hypothesis. Feeding behaviour in the inshore area with calves might also be expected to predispose lactating females to capture; it is unclear why fewer lactating females than calves are caught.

Mature males and adolescents, which appear to feed in different areas than lactating females and calves, may enter the near shore area and therefore be subject to capture only occasionally. Bottlenose dolphins along the Natal coast appeared to frequent 'preferred areas', each some 33–40km long (Cockcroft, Ross and Peddemors, 1990). This was the case even though captures along the coast occurred at random and were proportional to the number of nets only. They suggested that as captures did not coincide with 'preferred areas' of occurrence, they may result from unfamiliarity of the captured dolphins with a given area. Personal observations (VGC) and those of Natal Sharks Board staff suggest that bottlenose dolphins are aware of the presence of nets and often feed in their vicinity. That the majority of dolphins had almost full stomachs further indicates that they were feeding just prior to capture and may not have perceived the nets because of a preoccupation with feeding. Similar conclusions were suggested by Goodson *et al.* (1988) who proposed that if bottlenose dolphins suppress sound echoes which do not match those of their targets this may lead to their entanglement in nets. Detailed behavioural studies of free ranging dolphins are required, however, to provide answers to these questions.

Seasonal variations in the distribution and catch of bottlenose dolphins may result from environmental fluctuations and associated differences in prey abundance and distribution which affect feeding. Locally, bottlenose dolphins are known to avoid turbid water (Ross, 1977), and Cockcroft *et al.* (1990a) linked seasonal decreases in sighting rates of bottlenose dolphins on the Natal coast to seasonal increases in inshore turbidity. This suggests that increased inshore turbidity from the high river runoff in summer may reduce the presence of dolphins in the inshore region, thus decreasing the probability of their capture at that season. Although no direct link between captures and water visibility was evident from this study, the relationship between captures and seasonal temperature variations was clear. These data suggest a strong seasonal component in the lives of Natal bottlenose dolphins which may be related to prey movement and availability. Although there appeared to be no seasonal change in the abundance of the major prey of bottlenose dolphins in Natal (Cockcroft and Ross, 1990b), the spawning and distribution inshore of many of these prey is known to occur during peak times of dolphin capture (Joubert, 1981). Prey related seasonal distribution patterns have been suggested for bottlenose dolphins off Sarasota, Florida (Irvine *et al.*, 1981) and for the harbour porpoise (*Phocoena phocoena*) and common dolphin (*D. delphis*) in British waters (Evans, 1980) and are well documented for pilot whales off Newfoundland (*Globicephala melaena*, Sergeant, 1962) and southern California (*G. macrocephalus*, Leatherwood *et al.*, 1988).

Alternative reasons for seasonal distribution patterns of dolphins, such as changes in the abundance of sharks, have also been proposed (Wells *et al.*, 1980). However, in Natal shark and bottlenose dolphin peak capture periods coincide (Cockcroft *et al.*, 1989). Also, despite the relatively high level of shark predation on bottlenose dolphins in both Australian (Corkeron *et al.*, 1987) and South African waters there was no indication that sharks in any way influence dolphin capture in Natal (Cockcroft *et al.*, 1989).

Factors contributing to the seasonality of the bottlenose dolphin catch off Natal may also be implicated in the interannual variation of catches. The annual catch varied markedly even though the number of nets remained constant. The mass/sex class composition of the catch also varied annually, although this was probably caused by the catch of mature males only at certain times. Annual variations in the capture of cetaceans are not unusual. Paterson (1979) showed annual variations in catches of dolphins in shark nets off southern Queensland. Although the reasons for such variations are unknown, studies of hump-back whale (*Megaptera novaeangliae*) incidental mortality off Newfoundland suggest that increased captures in the late 1970s resulted from changes in the status of the food resource (Whitehead and Carscadden, 1985). It seems likely that annual fluctuations in environmental conditions off Natal result in differences in the local distribution and abundance of particular prey. This, in turn, may influence the inshore distribution of bottlenose dolphins, particularly that of mature males, and be reflected in the total annual catch rate and the catch rates of various mass/sex classes.

The similarity of the physical conditions at each of the netted beaches and the fact that sightings (Cockcroft *et al.*, 1990) and captures occur along most of this coast suggest that the Natal coast provides a habitat suitable for bottlenose dolphins. The exception is Richards Bay, where there were no captures or sightings, which is probably unsuitable because of low mean annual water visibility and muddy substrate. However, three factors suggest that small variations in physiographic conditions do not contribute to the capture of dolphins: the randomness of the catches along the Natal coast, the indication that catch rates are dependent only on the number of nets present and the similarity of the mass/sex composition of catches throughout. This is further supported by the evidence that bottlenose dolphins off Natal appear not to follow typical travel routes and are captured apparently at random within an installation, their movements dictated by factors other than physiography.

In contrast, a number of environmental factors appear directly linked to the capture of bottlenose dolphins in Natal. Seasonal variations in temperature show a correlation with peak capture times during the year. Although no connection was apparent in this study, Cockcroft *et al.* (1990a) linked the onshore occurrence and distribution of bottlenose dolphins to water clarity. In addition, dolphins were caught under significantly different current regimes than would have been predicted from the daily environmental data collected. Although no relationship was found between capture and state of the tide, a number of authors have suggested that bottlenose dolphin movements occur in relation to tidal flow (Würsig and Würsig, 1979). It is possible that the prevailing current may reflect tidal flow and, as suggested earlier, that there are relationships between tidal current (flow), other environmental fluctuations and the short term movements of prey species of bottlenose dolphins along the Natal coast. However, Irvine *et al.* (1981) found that the movement and activity patterns of bottlenose dolphins off Florida were not influenced by environmental conditions, other than tide, in any recognisable way.

A number of biological factors also showed biases suggesting that they are directly related to the causes of capture. The assessment that the stomachs of most animals were relatively full at time of capture implies they were feeding shortly before. Weaned calves, and to a lesser degree lactating females, are at greater risk of capture than other size/sex classes. The majority of captures were single events, but when double captures did occur they were usually of calves and lactating females.

Continuing mortality in shark nets may have severe implications for the Natal population of the bottlenose dolphin. Ross *et al.* (1989) estimated that the population of these dolphins in the shark-netting areas of Natal totalled approximately 900 animals. The capture and death of 212 animals in the nets between 1980 and 1987 represents a 3.5% mean annual mortality. The impact of this mortality cannot be assessed without unbiased data of the sex and age structure of bottlenose dolphins in this population. However, the high proportion of reproductively active females caught is of concern (19% of catch between 1980 and 1987 and 0.7% of the estimated total population annually), as a shortage of such females might impair the replacement potential. Dolphin populations are particularly sensitive to depletion through exploitation and recover only very slowly once exploitation has ceased (Estes, 1979). Recovery is more difficult for populations which continue to be exploited, particularly if exploitation involves reproductive females. Pressure on bottlenose dolphins in Natal continues; dolphins die in shark nets and may suffer deleterious effects from the accumulation of comparatively high levels of chlorinated hydrocarbons (Cockcroft *et al.*, 1989).

The results of this suggest some potential methods for reducing or preventing dolphin captures in the shark nets. The obvious approach would be to remove some or all nets, at least for the period of peak captures, between May and November. Unfortunately, peak shark captures coincide with peak dolphin captures (Cockcroft *et al.*, 1989); consequently the tourist industry on the Natal coast might suffer huge losses from this approach. An alternative would be to increase the mesh size of the shark nets. The existing mesh has a 25cm bar, resulting in a triangular height and width mesh dimension of 35.4cm when the net is set and taut. This measurement coincides almost exactly with the minimum size of dolphin caught (34.8cm maximum height and 130cm length) even though birth occurs at a length ranging between 838cm and 1120cm (Cockcroft and Ross, 1990b). Although there are a number of possible reasons for this coincidence, including mothers' protecting their neonates from coming into contact with nets, the coincidence of mesh size and minimum size of dolphins caught nevertheless implies that an increase in the bar size may increase the minimum size of dolphin captured and possibly reduce the catch. Experimental evaluation of this and other methods of reducing bottlenose dolphin mortality in the nets is urgently needed.

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REFERENCES

Bannister, J.L. 1977. Incidental catches of small cetacea off Australia. *Rep. int. Whal. Commn* 27:506.

Beddington, J.R., Beverton, R.J.H. and Lavigne, D.M. (eds.). 1985. *Marine Mammals and Fisheries*. George Allen & Unwin, London. 354pp.

Best, P.B. and Ross, G.J.B. 1977. Exploitation of small cetaceans off southern Africa. *Rep. int. Whal. Commn* 27:494–7.

Best, R.C. and da Silva, V.M.F. 1984. Preliminary analysis of reproductive parameters of the boutu, *Inia geoffrensis*, and the tucuxi, *Sotalia fluviatilis*, in the Amazon River system. *Rep. int. Whal. Commn* (special issue 6):361–9.

Beverton, R.J.H. 1985. Analysis of marine mammal-fisheries interactions. p. 354. *In:* J.R. Beddington, R.J.H. Beverton and D.M. Lavigne (eds.) *Marine Mammals and Fisheries*. George Allen and Unwin, London.

Cockcroft, V.G. 1990. Catches of dolphins in the Natal shark nets, 1980 to 1988. *S. Afr. J. Wildl. Res.* 20:44–51.

Cockcroft, V.G. and Ross, G.J.B. 1990a. Age, growth and reproduction of bottlenose dolphins from the east coast of southern Africa. *Fish. Bull., US* 88:289–302.

Cockcroft, V.G. and Ross, G.J.B. 1990b. Food and feeding of the Indian Ocean bottlenose dolphin off southern Natal, South Africa. p. 653pp. *In:* S. Leatherwood and R. Reeves (eds.) *The Bottlenose Dolphin*. Academic Press, New York.

Cockcroft, V.G., Cliff, G. and Ross, G.J.B. 1989. Shark predation on Indian Ocean bottlenose dolphins (*Tursiops truncatus*) off Natal, South Africa. *S. Afr. J. Zool.* 24(4): 305–10.

Cockcroft, V.G., Ross, G.J.B. and Peddemors, V.M. 1990. Bottlenose dolphin distribution in Natal's coastal waters. *S. Afr. J. Mar. Sci.* 9:1–9.

Cockcroft, V.G., DeKock, A.C., Lord, D.A. and Ross, G.J.B. 1989. Organochlorines in bottlenose dolphins from the east coast of southern Africa. *S. Afr. J. Mar. Sci.* 8:207–218.

Corkeron, P.J., Morris, R.J. and Bryden, M.M. 1987. Interactions between bottlenose dolphins and sharks in Moreton Bay, Queensland. *Aquat. Mamm.* 13:109–13.

Estes, J.A. 1979. Exploitation of marine mammals: r-selection of K-strategists? *J. Fish. Res. Board Can.* 36:1009–17.

Evans, P.G.H. 1980. Cetaceans in British Waters. *Mammal Rev.* 10:1–52.

Ferrero, R.C. and Jones, L.L. 1986. Distribution and movement patterns of Dall's porpoise (*Phocoenoides dalli*) in the western north Pacific Ocean during June and July 1981–1984. Document submitted to the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission. 24pp.

Fowler, C.W. 1982. Interactions of northern fur seals and commercial fisheries. pp.278–92. Transactions of the 47th North American Wildlife and Natural Resources Conference, 1982.

Goodson, A.D., Klinowska, M. and Morris, R. 1988. Interpreting the acoustic pulse emissions of wild bottlenose dolphin (*Tursiops truncatus*). *Aquat. Mamm.* 14:7–12.

Gulland, J.A. 1986. Marine mammal-fisheries interactions. *Ambio* 15:152–4.

Irvine, A.B., Scott, M.D., Wells, R.S. and Kaufmann, J.S. 1981. Movements and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, near Sarasota, Florida. *Fish. Bull., US* 79:671–88.

Joubert, C.S.W. 1981. Aspects of the biology of five species of inshore reef fishes on the Natal coast, South Africa. *Invest. Rep. Oceanogr. Res. Inst., Durban* 51:1–16.

Kasuya, T. 1985. Fishery-dolphin conflict in the Iki Island area of Japan. p. 354. *In:* J.R. Beddington, R.J.H. Beverton and D.M. Lavigne (eds.) *Marine Mammals and Fisheries*. George Allen and Unwin, London.

Kasuya, T. and Jones, L.L. 1984. Behaviour and segregation of the Dall's porpoise in the northwestern North Pacific. *Sci. Rep. Whales Res. Inst., Tokyo* 35:107–28.

Leatherwood, S., Reeves, R.R., Perrin, W.F. and Evans, W.E. 1988. *Whales, Dolphins and Porpoises of the Eastern North Pacific and Adjacent Arctic Waters*. Dover Publications, New York. 245pp.

Loughlin, T.R. and Nelson, R. 1986. Incidental mortality of northern sea lions in Shelikof Strait, Alaska. *Mar. Mammal Sci.* 2:14–33.

Meith, N. 1984. Saving the small cetaceans. *Ambio* 13:2–13.

Mitchell, E. 1975. *Porpoise, Dolphin and Small Whale Fisheries of the World: Status and Problems*. Unwin Brothers, Surrey. 129pp. International Union for Conservation of Nature and Natural Resources Monograph No. 3.

Northridge, S. and Pilleri, G. 1986. A review of human impact on small cetaceans. *Invest. Cetacea* 18:221–61.

Paterson, R. 1979. Shark meshing takes a heavy toll of harmless marine animals. *Aus. Fish.* October 1979:17–23.

Peddemors, V.M., Cockcroft, V.G. and Wilson, R.B. Incidental dolphin mortality in the natal shark nets: A preliminary report on prevention measures. (Published in this volume.)

Pei-Xun, C. 1981. Lipotes research in the Peoples Republic of China. *Rep. int. Whal. Commn* 31:575–7.

Perrin, W.F. 1970. Color pattern of the eastern Pacific spotted porpoise *Stenella graffmani* Lonnberg (Cetacea, Delphinidae). *Zoologica, N.Y.* 54:135–42.

Perrin, W.F. and Myrick, A.C. (eds.). 1980. *Age Determination of Toothed Whales and Sirenians*. International Whaling Commission, Cambridge. 229pp.

Read, A.J. 1987. Incidental catch of harbour porpoises in the Bay of Fundy groundfish gillnets. Abstracts of the Seventh Biennial Conference on the Biology of Marine Mammals, Miami, December 1987.

Ross, G.J.B. 1977. The taxonomy of bottlenosed dolphins *Tursiops* species in South African waters, with notes on their biology. *Ann. Cape Prov. Mus. (nat. Hist.)* 11:135–94.

Ross, G.J.B. 1982. A preliminary survey of bottlenosed dolphin *Tursiops aduncus* and humpback dolphin *Sousa plumbea* populations on the south-east coast of southern Africa. Internal report to South African Nature Foundation, 25pp.

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. *Ann. Cape Prov. Mus. (nat. Hist.)* 15:173–410.

Ross, G.J.B., Cockcroft, V.G., Melton, D.A. and Butterworth, D.S. 1989. Population estimates for bottlenose dolphins *Tursiops truncatus* in Natal and Transkei waters. *S. Afr. J. Sci.* 8:119–30.

Sergeant, D.E. 1962. The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. *Bull. Fish. Res. Board Can.* 132:1–184.

Shaughnessy, P.D. and Payne, A.I.L. 1979. Incidental mortality of cape fur seals during trawl fishing activities in South African waters. *Fish. Bull. Div. Sea Fish. S. Afr.* 12:20–5.

Smith, G.J.D., Read, A.J. and Gaskin, D.E. 1983. Incidental catch of harbor porpoises, *Phocoena phocoena* (L.), in herring wiers in Charlotte county, New Brunswick, Canada. *Fish. Bull., US* 81:660–2.

Wells, R.S., Irvine, A.B. and Scott, M.D. 1980. The social ecology of inshore odontocetes. pp. 211–62. *In:* L.M. Herman (ed.) *Cetacean Behaviour: Mechanisms and Functions*. John Wiley & Sons, New York.

Whitehead, H. and Carscadden, J.E. 1985. Predicting inshore whale abundance – whales and capelin off the Newfoundland coast. *Can. J. Fish. Aquat. Sci.* 42:976–81.

Würsig, B. and Würsig, M. 1979. Behavior and ecology of the bottlenose dolphin *Tursiops truncatus*, in the south Atlantic. *Fish. Bull., US* 77:399–412.

Incidental Dolphin Mortality in the Natal Shark Nets: A Preliminary Report on Prevention Measures

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ABSTRACT

Concern for the effect of incidental shark-net captures on populations of bottlenose dolphins, *Tursiops truncatus*, and hump-backed dolphins, *Sousa plumbea*, off Natal led to experiments with dolphin deterrent devices in the nets. Passive devices included plasticised aluminium foil, aluminium discs and stainless steel wire; active devices included clangers, rattles and bells. Operational problems and an extremely low CPUE for dolphins led to the discontinuation of these experiments.

Keywords: Hump-backed dolphin; bottlenose dolphin; Indian Ocean; Southern Hemisphere; incidental capture; sharks; acoustics.

INTRODUCTION

Incidental catches of marine mammals usually involve interactions with commercial fishing gear (Northridge, 1984). Exceptions are operations that fish for sharks solely as a means of protecting bathers, as occurs off New South Wales and Queensland, Australia (Bannister, 1977), and Natal, South Africa (Cliff *et al.*, 1988). The Natal shark nets are extremely effective in shark capture, catching some 1,400 sharks annually. The inshore population of these large predators has decreased about fourfold since the introduction of nets (Cliff *et al.*, 1988). Only 3 shark attacks (1 lost limb; 2 minor scratches) have occurred while the nets were operational. However, where shark nets are used, a substantial catch of harmless animals, including various delphinid species, occurs (Bannister, 1977; Best and Ross, 1977; Paterson, 1979; Ross, 1982).

Individuals of three delphinid species are caught incidentally in the Natal Shark nets: common dolphins (*Delphinus delphis*), Indo-Pacific hump-backed dolphins (*Sousa plumbea*) and Indian Ocean bottlenose dolphins (*Tursiops truncatus*). The latter two species appear to be resident along the Natal Coast and possibly represent discrete populations (Ross, 1977), although both species extend well beyond this area. By contrast, the common dolphin is apparently a seasonal visitor to Natal accompanying large schools of the pelagic fish, *Sardinops ocellatus*, which migrate up the east coast of southern Africa between March and August (Heydorn *et al.*, 1978).

Although the population size of the common dolphin is unknown, it probably exceeds several thousand and the mean annual capture rate of 50 animals is probably of little consequence to the population. There is, however, clear reason for concern about the level of hump-backed and bottlenose dolphin catches in the Natal shark nets. Recent aerial census surveys estimated that the bottlenose dolphin population on the Natal coast are approximately 900 animals (Ross *et al.*, 1989). The mean annual catch for this species is 31 animals (Cockcroft and Ross, this volume), which represents 3.5% of the estimated population along this area of coast (Cockcroft and Ross, this volume; Ross *et al.*, 1989). The cryptic behaviour exhibited by hump-backed dolphins hampers accurate aerial censusing. The population is estimated at 200 animals, based on extremely limited information, and no variance estimate is available (Ross, 1982). The mean annual catch of

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this species is about 8 animals (unpubl. data), possibly representing some 4% of the estimated number along this coast.

The preliminary investigations reported here were prompted by concern over the possible impact of incidental captures on the populations of hump-backed and bottlenose dolphins in Natal waters. In 1985 a project was initiated to determine the reasons for dolphin capture and assess the effectiveness of various methods in reducing such capture. An analysis of biological and environmental data indicated that the inshore distribution of bottlenose dolphins is related to water clarity, although capture events appear unrelated to water clarity (Cockcroft and Ross, this volume). Feeding behaviour and age appear to be major factors affecting capture (Cockcroft and Ross, this volume). The significance of environmental and behavioural factors in hump-backed dolphin captures is as yet unknown, but it appears to be similar to that in captures of the bottlenose dolphins.

The effectiveness of various methods used in attempts to prevent incidental dolphin captures is reported here. The shark nets provide an ideal opportunity for this type of experimental research as they are a non-commercial operation which allows trained officers to record dolphin occurrence and behaviour, catches and environmental parameters. A number of constraints were, however, placed on this programme. It was required that any device used should not influence the efficiency of the nets in catching sharks or net maintenance operations.

METHODS AND MATERIALS

The Natal Sharks Board (NSB) has 410 nets installed at 44 beaches along the Natal coast (Fig. 1). The nets are made of 3mm multifilament black polyethylene braid (breaking strain = 160 kg). Each net is 107m long by 6.3m deep and has a mesh size of 25cm (Fig. 2). The nets are anchored in water ranging in depth from 10m to 14m, and are placed parallel to the beach between 500m and 900m from the shore. Initially the head-rope floats, but after approximately eight days the weight of fouling organisms causes the net to sink so that the foot-rope is on the bottom. At this stage the nets are changed for cleaning. The nets are inspected daily at daybreak, weather permitting, and all catches transported to the NSB headquarters at Umhlanga Rocks, where they are used for research purposes.

The annual bottlenose dolphin catch per net (catch per unit effort – CPUE) was calculated for each beach for the period 1978–1985 (Table 1). Various dolphin deterrents, both active and passive devices, were manufactured and tested at beaches with the highest CPUE. Captures of both hump-backed and bottlenose dolphins are highly seasonal (Cockcroft and Ross, 1990), and the installation of the various deterrent devices was timed to coincide with high dolphin capture rates and increased dolphin sighting rates by meshing officers. No bottlenose dolphins are caught at Richards Bay, so deterrents installed at this beach were specifically aimed at hump-backed dolphins. Any dolphin presence and movement around the experimental nets was recorded during daily inspections.

Active devices emitted sounds and were of three types: clangers; rattles; and bell buoys.

Clangers consisted of hollow copper cylinders each with an internal pendulum which was set in motion through wave action (Fig. 3). The cylinders were cut to different lengths (70mm, 140mm, and 210mm) in an attempt to determine which frequencies produced a deterrent effect on the dolphins. Clangers were tested at Ramsgate and were attached to the 7th and 8th nets of this installation, as all previous dolphin captures had occurred in these two nets. The clangers were suspended from the net marker buoys at a depth of 20cm to 30cm below the water surface and left in place for 15 days.

Rattles consisted of loose metal balls inside the net floats (Fig. 3). Wave action caused

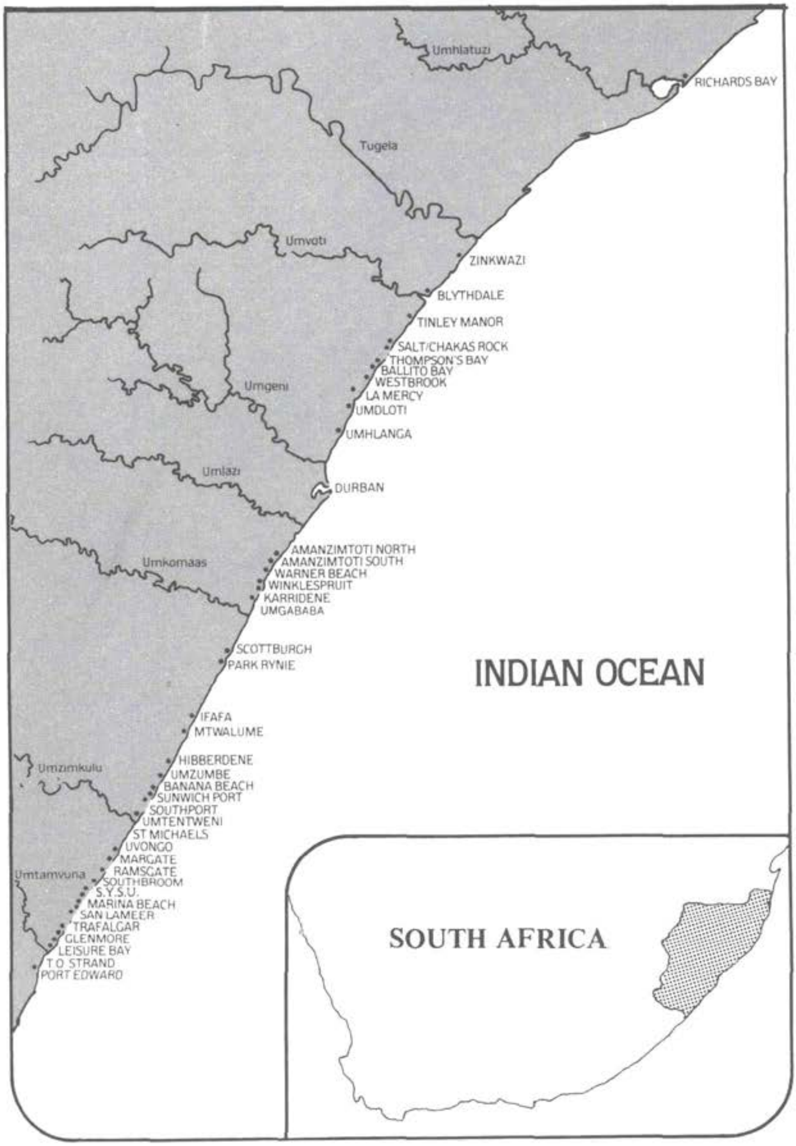

Fig. 1. Map of the study area showing location of nets.

rolling of these balls inside the floats, thereby emitting a continuous low pitched grind. A 220m length of net head rope with rattles at 4m intervals, was suspended above net 8 at the Umhlanga installation for 48 days.

A bell buoy was constructed of a 7kg gas bottle with a pendulum suspended within the sealed cavity (Fig. 3). This deterrent was anchored at the Richards Bay installation at the northern end of net 8 for 42 days.

Passive devices did not produce audible signals and consisted of three types: plasticised

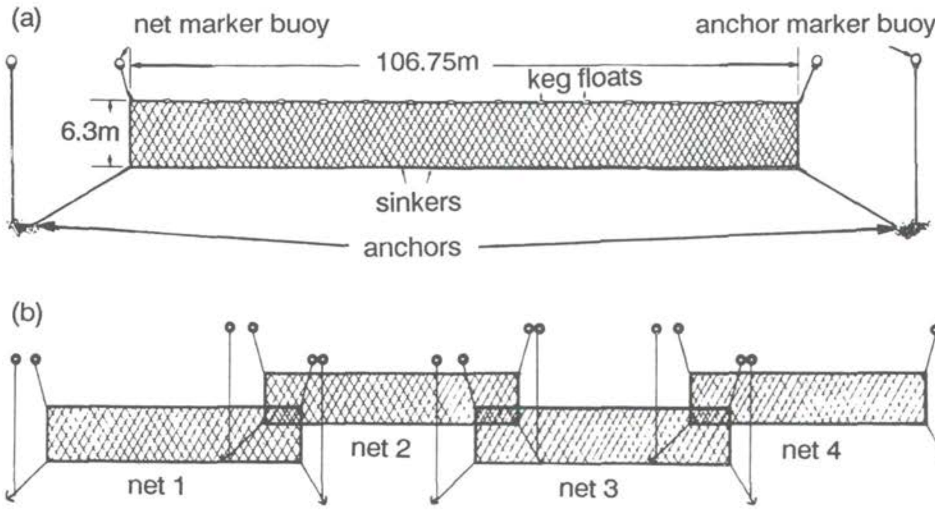

Fig. 2. Nets used by the Natal Sharks Board (see text).

Table 1

Indian Ocean bottlenose dolphin catches in the NSB shark nets for the period 1981-1987.
A = No. of nets; B = Total nets; CPUE1 = CPUE all nets; CPUE2 = CPUE capture nets only.

Beach	Catch	A	B	CPUE1	CPUE2	Beach	Catch	A	B	CPUE1	CPUE2
ZIN	2	1	8	0.036	0.286	MTW	5	2	8	0.089	0.357
BLY	1	1	6	0.024	0.143	HIB	11	5	6	0.262	0.314
TIN	5	3	6	0.119	0.238	UMZ	5	3	6	0.119	0.238
SAL	7	5	10	0.100	0.200	BAN	1	1	6	0.024	0.143
T.B	3	3	6	0.071	0.143	SUN	1	1	7	0.024	0.143
BAL	7	4	10	0.100	0.250	S.P	3	3	4	0.107	0.143
TON	2	1	6	0.048	0.286	UMT	6	4	6	0.143	0.214
L.M	2	1	6	0.048	0.286	ST.	3	3	6	0.071	0.143
UMD	2	2	6	0.048	0.143	RAM	4	4	10	0.057	0.143
UMH	15	10	18	0.119	0.214	UVO	4	4	6	0.095	0.143
DUR	21	12	63	0.048	0.250	MAR	5	4	14	0.051	0.179
ANS	1	1	6	0.024	0.143	SOB	8	3	6	0.190	0.381
BRI	4	3	6	0.095	0.190	SYS	2	2	6	0.048	0.143
N.A	10	7	18	0.079	0.204	MAR	0	0	2	0	0
S.A	3	3	16	0.027	0.143	SAN	6	4	8	0.107	0.214
WAR	6	5	8	0.107	0.171	TRA	3	2	5	0.086	0.214
WIN	5	5	6	0.119	0.143	GLN	1	1	4	0.036	0.143
KAR	1	1	6	0.024	0.143	LEB	3	3	6	0.071	0.143
UMG	0	0	8	0	0	T.O	2	2	6	0.048	0.143
SCO	2	2	12	0.024	0.143	P.E	4	3	6	0.095	0.190
PAR	5	2	8	0.089	0.357	MZA	12	9	14	0.122	0.190
IFA	1	1	6	0.024	0.143	Total	194	136	387	0.072	0.20

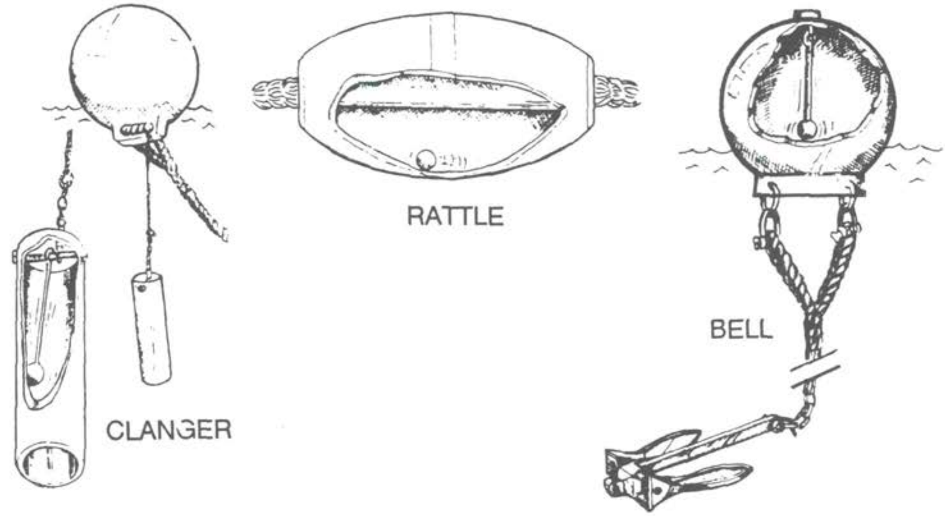

Fig. 3. Active devices used to deter dolphins from nets (see text).

aluminium foil; aluminium discs; and a stainless steel braid. The first two were to act as possible stimuli for vision and echolocating whereas the braid was to act only as a stimulus for echolocation.

Twenty-six plasticised aluminium foil squares (250mm x 250mm and 0.11mm thick) were heat sealed and attached at 4m intervals along the centre of a net. The net was positioned 600m south of the Umhlanga installation, because of concern that the reflective panels might attract sharks into the normal bathing area. This net was monitored daily for a period of 18 days.

A 235mm diameter flat (0.5mm thick) aluminium disc was attached to a net in a preliminary test to determine whether such a device would attract sharks and/or cause tangling when the net was serviced.

In July 1987, a new braid was developed which included a double strand of 0.16mm diameter stainless steel twine, added in an attempt to make the nets more acoustically detectable to the dolphins. The strength of the stainless steel braid was tested during net washing prior to the construction and deployment of new nets.

RESULTS

Active devices

Sound emitted from the clangers were clearly audible from a small boat near the nets; however the underwater noise levels are unknown due to a lack of suitable recording equipment. Within two weeks, electrolytic action caused corrosion of the pendulums and necessitated the removal of the clangers. During this time, no visible changes in dolphin movement patterns around the installation were observed. Shark capture rates increased in comparison to other years (Table 2); but further tests need to be conducted before the effect of the clangers can be determined.

Hydrophone recordings made around the installation containing the rattles indicated this deterrent made very little noise in calm sea conditions. The experimental net was,

Table 2

Total shark catches for the month during dolphin deterrent experiments

Year	Experiment				
	Clangers	Rattles	Bell	Foil	Disc
1978	0	1		4	5
1979	0	2		6	1
1980	1	10	4	5	2
1981	2	1	11	8	0
1982	2	3	6	0	0
1983	1	3	17	6	1
1984	1	0	12	2	1
1985	11 *	2 *	6 *	9	1
1986	6	1	19	8 *	0 *
1987	6	2	12	0	0
Mean	3.0	2.5	10.9	4.8	1.1
SD	3.4	2.7	5.0	3.1	1.5

* = period of experimentation.

however, kept in place because when the swell exceeded 1m the rattles were audible from a distance of 8m. During the first two weeks of this experiment, bottlenose dolphins were twice seen moving past the nets within 20m of the rattle deterrent. No reaction to the deterrent was noticed. On the fifteenth day a juvenile female bottlenose dolphin (179cm) was caught on the inside of net 8. At the position of capture, the deterrent had bowed offshore by approximately 10m because of prevailing surface currents. Subsequently, the lead rope was attached to the centre of the net, using a 3m length of twine to decrease the bowing effect. Unfortunately, this caused minor entanglements of the net on 14 of the remaining 33 days that the deterrent was in position. However, rattling was still audible at the surface for a distance of approximately 4 metres. During this period, dolphins were seen passing the deterrent on five occasions. Although they swam within 15m of the deterrent, no visible reactions were exhibited. No change in shark capture rate occurred whilst the deterrent was in position (Table 2).

Noise generated by the bell was audible from a boat for approximately 18m; however, it only rang effectively during periods of strong wind or heavy swell. These conditions were created by northeasterly winds which increased turbidity in the netted area. Hump-backed dolphins only move into the netted area when water turbidity is low (unpubl. data); thus, during periods when dolphins were in the netted area the bell buoy was not functioning. Three weeks after installation of the bell buoy a juvenile female hump–backed dolphin (171cm) was caught in a net 300m from the buoy. The bell was functional for six weeks, after which it was washed away during a period of heavy (7m) swell. There was no increase in the shark catch rate during this experiment (Table 2).

Passive devices

A reaction with the salt water dissolved the aluminium layer on all panels where the plastic seal had been broken. No dolphin movements were observed around the net and no captures occurred during the time of this experiment. There were no shark catches in this net during the test period, and no increase in shark capture rate occurred in the adjacent Umhlanga installation (Table 2).

The aluminium discs corroded rapidly and caused minor entanglements when the net was being serviced. No dolphin or shark captures occurred in this net during experimentation (Table 2).

The stainless steel strand within the net braid was not affected by corrosion; however, three breaks per 5m length found in the stainless steel twine after a single washing in the shore-surf made these nets unmanageable.

DISCUSSION

Of the three active devices used, two (bell and rattle) were in operation when a dolphin capture occurred. This suggests that such devices have a minimal effect in preventing captures and may even encourage investigation of the sounds. The clangers were not functional for long enough to determine their effect as dolphin deterrents. The active devices tested were, however, not designed to radiate loud, harsh sounds in the 16–32 kHz range, as perhaps they should have been. In addition, all active devices tested required wave action to produce sound and were therefore of limited use during calm weather periods. Although Cockcroft and Ross (this volume) suggested no difference in capture rates during rough or calm weather, observations by V.M.P. suggest that bottlenose dolphins move further offshore during bad weather and may therefore not have been in netted areas when the active deterrents were most efficient.

The apparent limitations of the active devices tested suggest that electronically activated deterrents which function under all weather conditions may prove more efficient. Such devices, known as 'pingers', have been used in a number of marine mammal – fisheries interactive experiments (Anderson and Hawkins, 1978; Perkins and Beamish, 1979; Miller, 1983; Hanan and Scholl, 1985), but have shown little effectiveness against cetaceans. These pingers emit a sound of constant frequency at set intervals; however, cetaceans may habituate to these 'pings' and not react to them. It is therefore suggested that a system be developed which would randomly transmit variable frequencies at irregular pulses.

Although Cockcroft and Ross (this volume) found no increased capture rate for any particular nets within an installation, dolphins appear to use 'preferred routes' during their daily movements up and down the coast (VMP unpubl. data). In the Umhlanga area, this would have led to their not encountering the more southerly placed experimentation net containing the reflective panels. This underscores the need to incorporate observational studies, both surface and subsurface, when evaluating this type of experiment.

The stainless steel strand inserted in the net braid was too brittle to withstand constant use and breakages soon made it hazardous to handle. Its usefulness as a deterrent is also questionable. Hembree and Harwood (1987) using trained bottlenosed dolphins found 1mm diameter galvanised wire difficult to detect. Busnel and Dziedzic (1967) showed that a blindfolded harbour porpoise (*Phocoena phocoena*) could easily avoid wires made of copper, iron and steel 0.5mm in diameter but frequently swam into wires 0.2mm in diameter. If *Tursiops* and *S. plumbea* have similar echolocatory abilities to *Phocoena* as suggested by Wood and Evans (1980) and Purves and Pilleri (1983) respectively, a 0.16mm strand within a braid is probably of little functional use. Sea trials using 4mm chrome plated nickel bead chain looped through 15cm mesh multifilament nylon net indicated no significant difference in dolphin capture rate between modified and unmodified nets (Hembree and Harwood, 1987), even though they appeared readily detectable in captive conditions.

Additionally, it appears that metallic objects may not be entirely suitable as high frequencies are needed to produce their optimum reflective properties (Howell, pers.

comm.). Although Bel'kovich and Dubrovskiy (1976) report a higher maximum range of detection for lead targets than for steel targets, air has the highest underwater acoustic reflective properties and should be further investigated for incorporation into net material in the form of glass microspheres or crushed slag typical of most smelting operations. Hembree and Harwood (1987) experienced operational problems when using air-filled plastic tubing. Another alternative is to attach reflector corners made of high density foam to nets. These methods may prove to be the most appropriate in making nets visible to odontocete echolocation as this would incorporate the most 'reflective' materials and offer reflective angles.

Net detection calculations using two trained bottlenose dolphins predict a detection range of 130m for 11.4cm mesh twisted net (TS = 26dB at 120 kHz) and 310m for a 5.1cm mesh knotless net joined in the middle to a 5.1cm braided net (TS = 4dB at 120 kHz) (Murchison, 1980). These tests were conducted in near perfect acoustic conditions (i.e. minimal white noise). It is improbable that these detection ratios would stand for open sea conditions, particularly where nets are set close to a high energy surf zone, such as is the case in Natal. McBride (1956) found that dolphins charged a net of 24cm mesh, whereas they did not do so if the mesh size was reduced. This further supports the view that dolphins, even under ideal open sea conditions, are probably unable to detect a 25cm mesh net from any significant distance. Unfortunately, smaller mesh sizes can not be used for the shark nets as this would reduce their efficiency at capturing sharks while increasing the incidental catch of other animals.

The low overall rates of catching both bottlenose and hump-back dolphins in the Natal shark nets results in an exceptionally low CPUE, even for the nets with the highest catch rates. This low CPUE is probably the most significant feature influencing any experimentation in the use of dolphin deterrents, as any such devices would have to remain in the nets for long periods before statistically significant results were obtained. At a depletion rate of 3.5%, it is unlikely that either population could survive long periods of experimentation. This suggests that other avenues should be explored. The results of Cockcroft and Ross (this volume), which suggest that behavioural and biological factors are important in the capture of bottlenose dolphins, and the preliminary work on deterrents indicate that experimental work should be accompanied by detailed observations of movements and behaviour of dolphins around the nets. Only in this way will it be possible to establish the behavioural factors influencing capture, and to characterise any behavioural effects produced by the deterrent devices.

The authors have initiated a research programme which will monitor environmental and physical parameters, such as turbidity, noise and slope profiles, at those net installations with the highest CPUE and those with the lowest. This programme will be accompanied by underwater and surface observations of behaviour and movements of dolphins at these sites and continued experimentation with deterrent devices. A comparison of areas with low and high catch rates should lead to a better understanding of the factors involved in dolphin capture and the design of methods helpful in preventing these captures.

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REFERENCES

Anderson, S.S. and Hawkins, A.D. 1978. Scaring seals by sound. *Mammal Rev.* 8:19–24.

Bannister, J.L. 1977. Incidental catches of small cetacea off Australia. *Rep. int. Whal. Commn* 27:506.

Bel'kovich, V.M. and Dubrovskiy, N.A. 1976. *Sensory Bases of Cetacean Orientation*. Nauka, Leningrad. [Translated into English by the Israel Program for Scientific Translations, Jerusalem].

Best, P.B. and Ross, G.J.B. 1977. Exploitation of small cetaceans off southern Africa. *Rep. int. Whal. Commn* 27:494–7.

Busnel, R.-G. and Dziedzic, A. 1967. Resultats metrologiques experimentaux de l'echolocation chez le *Phocoena phocoena* et leur comparison avec ceux de certaines chauves-souris. pp. 307–35. *In:* R.-G. Busnel (ed.) *Animal Sonar Systems, Biology and Bionics*. Laboratoire de Physiologie Acoustique, Jouy-en-Josas, France.

Cliff, G., Dudley, S.F.J. and Davis, B. 1988. An overview of shark catches in Natal shark nets: 1966–86. pp. 84–90. *In:* I.A.W. McDonald and R.J.M. Crawford (eds.) *Long-Term Data Series Relating to Southern Africa's Renewable Natural Resources*. South African National Science Programme Report, 157, CSIR, Pretoria. 497pp.

Cockcroft, V.G. and Ross, G.J.B. Bottlenose dolphins in Natal shark nets, 1980 through 1987: catch rates and associated contributing factors. (Published in this volume.)

Hanan, D.A. and Scholl, J. 1985. Acoustic harassment testing in the San Francisco Bay Pacific herring, *Clupea harengus*, gill net and purse seine fisheries. pp. 36–39. *In:* D.A. Hanan (ed.) California Department of Fish and Game, Coastal Marine Mammal Study, Annual Report for the period July 1, 1982 – June 30, 1983. [US] NMFS Report LJ-85-10C (unpublished).

Hembree, D. and Harwood, M.B. 1987. Pelagic gillnet modification trials in northern Australian seas. *Rep. int. Whal. Commn* 37:369-73.

Heydorn, A.E.F., Bang, N.D., Bass, A.J., Berry, P.F., Carter, R., Crawford, R.J.M.F., B.W., Hughes, G.R., Pearce, A.F., Schleyer, M., Shelton, P.A., Van der Else, R.P. and Wallace, J.H. 1978. Ecology of the Agulhas current region – an assessment of biological responses to environmental parameters in the south-west Indian Ocean. *Trans. R. Soc. S. Afr.* 43:151–90.

McBride, A.F. 1956. Evidence for echolocation in cetaceans. *Deep-Sea Res.* 3:153–4.

Miller, D.J. 1983. Acoustic harassment experiments on harbour seals in the Klamath River, 1981. pp. 52–6. *In:* Coastal marine mammal study, annual report for the period of July 1, 1981 – June 30, 1982. [US] NMFS Report LJ-83-21C (unpublished).

Murchison, A.E. 1980. Detection range and range resolution of echolocating bottlenose porpoise (*Tursiops truncatus*). pp. 43–70. *In:* R.G. Busnel and J.F. Fish (eds.) *Animal Sonar Systems*. Plenum Press, New York. 1,135pp.

Northridge, S.P. 1984. World review of interactions between marine mammals and fisheries. *FAO Fish. Rep.* 251:1–190.

Paterson, R. 1979. Shark meshing takes a heavy toll of harmless marine animals. *Aus. Fish.* October 1979:17–23.

Perkins, J.S. and Beamish, P.C. 1979. Net entanglements of baleen whales in the inshore fishery of Newfoundland. *J. Fish. Res. Board Can.* 36:521–8.

Purves, P.E. and Pilleri, G.E. 1983. Dolphin sounds (*Sousa plumbea*). pp. 97–110. *In:* P.E. Purves and G.E. Pilleri (eds.) *Echolocation in Whales and Dolphins*. Academic Press, London. 261pp.

Ross, G.J.B. 1977. The taxonomy of bottlenosed dolphins *Tursiops* species in South African waters, with notes on their biology. *Ann. Cape Prov. Mus. (nat. Hist.)* 11:135–94.

Ross, G.J.B. 1982. A preliminary survey of bottlenosed dolphin *Tursiops aduncus* and hump-back dolphin *Sousa plumbea* populations on the south-east coast of southern Africa. Internal report to South African Nature Foundation, 25pp.

Ross, G.J.B., Cockcroft, V.G., Melton, D.A. and Butterworth, D.S. 1989. Population estimates for bottlenose dolphins *Tursiops truncatus* in Natal and Transkei waters. *S. Afr. J. Sci.* 8:119–30.

Wood, F.G. and Evans, W.E. 1980. Adaptiveness and ecology of echolocation in toothed whales. pp. 381–426. *In:* R.G. Busnel and J.F. Fish (eds.) *Animal Sonar Systems*. Plenum Press, New York. 1,135pp.

Distribution of Large Cetaceans in the Indian Ocean: Data From Japanese Sighting Records, November–March

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ABSTRACT

Records of large cetaceans observed in summer from Japanese sighting vessels in the Southern Hemisphere of the Indian Ocean are presented, with a brief analysis of the distribution patterns they reveal. The most frequently observed species was the minke whale, followed by sperm, killer, fin, sei, Bryde's and blue whales; right and humpback whales were rarely seen. Some species showed a bimodal latitudinal concentration on either side of the Antarctic Convergence, probably reflecting either segregation between different components of the population (sperm whales) or different stocks (blue and killer whales). 'Normal' blue, humpback and minke whales summer in the highest latitudes, while the other baleen whales (i.e. fin, sei, right, pygmy blue and Bryde's whales, from south to north) use lower latitudes. Those summering in similar latitudes are potential competitors for food resources. Sperm and killer whales frequent similar geographical areas in the Indian Ocean. Blue, Bryde's and sperm whales and possibly humpbacks are represented by stocks in the Bay of Bengal and Arabian Sea which are isolated from conspecifics in the rest of the Indian Ocean.

Keywords: survey-ship; Indian Ocean; distribution; minke whale; sperm whale; killer whale; fin whale; sei whale; Bryde's whale; pygmy blue whale; blue whale; right whale; humpback whale; Southern Hemisphere; stock identity; competition; prey/food.

INTRODUCTION

Since the 1965/66 Antarctic whaling season, the Far Seas Fisheries Research Laboratory has collected records of cetacean sightings made by the scouting vessels attached to the Japanese whaling fleets and research vessels chartered by the Fisheries Agency of Japan (Ohsumi and Yamamura, 1982). These data are presented here with a level of analysis sufficient to elucidate the recent general distribution of large cetaceans in the International Whaling Commission's Indian Ocean Sanctuary. Although the sanctuary itself is at present limited to the area north of 55°S (i.e. approximately the Antarctic Convergence northward), we present here the data from the equator to the ice edge in order to provide a better understanding of whale distribution in the Indian Ocean. Sightings results from north of the equator are also briefly discussed.

MATERIALS AND METHODS

This study is based on sighting records obtained by scouting vessels attached to the Japanese factory ships and by some other vessels used for whale research. Data were obtained before, during and after Antarctic whaling, and during the experimental catches of Bryde's whales in the Indian Ocean (Ohsumi, 1980). Also included are records obtained by the research vessels chartered by the Fisheries Agency of Japan for the IWC/IDCR whale sighting cruises in 1978/79 (*Toshimaru No. 16* and *No. 18*), 1979/80

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(*Toshimaru No. 11* and *Kyomaru No. 27*), 1981/82 (*Shonanmaru* and *Shonanmaru No. 2*), 1982/83 (*Kyomaru No. 27*) and 1984/85 (*Shonanmaru, Shonanmaru No. 2* and *Kyomaru No. 27*).

The data cover the Antarctic whaling seasons from 1965/66 to 1984/85 for right, humpback, blue, fin, sperm and killer whales (Figs 1 to 4). As sei whales were not separated from Bryde's whales in the earlier years, data presented for these species cover only the seasons from 1974/75 to 1984/85 and 1972/73 to 1984/85, respectively. Minke whale sightings have been recorded since the 1966/67 season. Searches were maintained during all daylight cruising time (except during bad weather) and all large cetacean sightings were recorded. The data include both primary and secondary sightings. The former represent whales sighted during ordinary searching activity, and the latter those sighted during other activities, including the time spent confirming (i.e. determining species and numbers) primary sightings. The positions of sightings are represented by the daily noon positions of the sighting vessels. Sighting effort is represented as the distance steamed when searching, including that spent confirming schools. The daily sighting effort is allocated to the noon position of each vessel. The total number of whales of each species sighted by the cruises in the Indian Ocean sector north of the Antarctic ice edge is shown in Table 1.

The data were first grouped by month and 5° blocks, and the two dimensional distribution of whales was expressed as encounter rates (number of whales per 10,000 n.miles sighting effort) for each block (Figs 5 to 40). In the computer program used to analyse these data, the two 5° blocks between the equator and 10°S have been combined. In addition, the records have not been separated into the Java Sea and Indian Ocean areas. Results from a total of 22 days of sightings effort in the Indian Ocean to the north of Equator are summarised in Table 12.

The arithmetic means of the encounter rates in 5° blocks have been used to indicate east/west variations in encounter rates (Table 2) or seasonal north/south shifts (Tables 3 to 11). We have not calculated encounter rates for each longitudinal sector or latitudinal stratum, by dividing the total number of whales by the total corresponding sighting effort, because this would positively bias the density indices. Distribution of sighting effort was not random, as there was possibly more effort in high density areas. Although the method used here, i.e. averaging the indices for 5° blocks, will decrease the bias, it will increase the variance due to the possible small sample sizes in some squares. In addition, the method does not take into account the decrease in area of 5° blocks from the equator poleward, if absolute numbers are considered.

Exploitation continued on some of the species considered in this paper for various periods of time during the collection of the sightings data, i.e. one year for blue whales (until 1965/66), 11 years for fin whales (until 1975/76), three years for sei whales (until 1977/78) and 17 years for minke whales (1968/69 to the present). Their abundance may thus have changed over the period, in some cases quite considerably; consequently, these data allow only a limited comparison of the current relative abundance.

RESULTS

Right whale, *Eubalaena australis* (Desmoulins, 1822)

A total of 864 right whales was seen between 1965/66 and 1984/85 (Table 1). There were no sightings of this species south of 60°S.

The data reveal three areas of relatively high density: west of 30°E; 45°-75°E; and east of 90°E. Although these first two areas are only 15° latitude apart, they do appear to be distinct (Table 2, Figs 5–8). The three areas agree approximately with the concentrations of catches of this species in the 19th century (Townsend, 1935), and presumably correspond to the three breeding grounds: off South Africa; off Madagascar and the islands in the western Indian Ocean; and off Australia, respectively.

The species' southern limit shifts seasonally from 40°-45°S in November to 55°-60°S in February and March. The density near the southern limits increases some in January, but densities are always highest between 40° and 45°S from November to February (Table 3), which overlaps with the sei whale distribution (see below). This suggests that the majority of right whales remain in lower latitudes during austral summer and supports the view that there may be a potential competitor with the sei whale for food resources (e.g. see review by Horwood, 1987).

Humpback whale, *Megaptera novaeangliae* (Borowski, 1781)

A total of 469 humpback whales was seen over a 20 year period, about half the number of right whales seen over the same period (Table 1). However, the ratio of the mean encounter rates for the two species over the entire Indian Ocean sector is 3:7 in favour of humpback whales (Table 2).

The data suggest two concentrations of this species in the Indian Ocean: one between 60°E and the coasts of Madagascar and east Africa; and the other from 80°E to the coast of western Australia. The density appears to be relatively low in the middle Indian Ocean region from 60°-80°E (Table 2). This agrees well with the distribution proposed in earlier studies (e.g. see review in Mackintosh, 1965).

Densities are highest south of 60°S during the five months from November to March. No significant latitudinal movement is apparent during this period. However, the northern distribution varies considerably, with the northern limit probably between 10°-15°S in November and 40°-45°N in February (Table 4). This reflects the fact that the humpback whale migration is protracted by differences in the timing of migration of different age and reproductive classes (Dawbin, 1956).

Blue whale, *Balaenoptera musculus* (Linnaeus, 1758)

The records of sightings of 2,199 blue whales over the 20 years do not distinguish 'normal' from pygmy blue whales. The latter is known to segregate in the lower latitudes (Gambell, 1964; Ichihara, 1966; Omura *et al.*, 1970). During those months with adequate sightings coverage, the data reveal two latitudinal concentrations of blue whales, one on either side of the Antarctic Convergence (Table 5 and Figs 13 to 16). One shifts from 10°-15°S in October to 30°-55°S (with a peak from 40°-50°S) in February, while the other appears to move from about 60°-65°S in November and December to 65°-70°S in January and February. The former latitudes agree with those where pygmy blue whales had been caught (Ichihara, 1966). Most of these sightings at lower latitudes, which in turn represent most of the blue whale sightings, were probably of pygmy blue whales. The more southerly concentrations were probably 'normal' blue whales.

Eight blue whales were seen in the northern equatorial Indian Ocean in March (Table 12). They were isolated from the concentrations of the above putative pygmy blue whales (Fig. 16), and suggest the presence of separate stock in the Arabian Sea.

These data suggest that there are three longitudinal concentrations of pygmy blue whales: at 30°-55°E; 70°-100°E; and east of 115°E (Table 2 and Figs 14 to 16). The longitudinal distribution of the 'normal' blue whale is difficult to determine from the rather limited data available but the density appears greatest in the western sector (40°-80°E) (Table 2).

The total number of blue whales (including pygmy blue whales) seen was about 2.5 times the number of right whales seen (Table 1). From the mean encounter rates, the relative density of blue whales to right whales in the entire Indian Ocean sector is about 4:1 (Table 2). Since the exploitation of blue whales ceased after the 1965/66 season, this ratio will approximate the current relative abundances of these species.

Fin whale, *B. physalus* (Linnaeus, 1758)

A total of 13,398 fin whales was recorded over the 20 years. This is over six times the number of blue whales seen over the same period (Table 1). From the encounter rates, however, the density of fin whales in the entire Indian Ocean sector is just over three times that of blue whales (Table 2). Even this figure may overestimate the current relative abundance of fin whales as their exploitation continued until 1975/76.

The fin whale sightings are concentrated in two longitudinal areas, one to the west of 50°E and the other in the area from 70°-100°E. Fin whale sightings were uncommon east of 100°E (Table 2). This pattern of distribution is similar to that reported by Mackintosh (1942) based on sightings from 1933 to 1939.

The northern limits of the fin whale's range were about 20°-25°S in November/December, 40°-45°S in March. The southern limits were around 50°-55°S in November, and 55°-60°S from December to March (Table 6, Figs 17–20).

Sei whale, *B. borealis* Lesson, 1868

A total of 1,735 sei whales, was seen in the Indian Ocean sector during the 11 Antarctic seasons from 1974/75 to 1984/85 (Table 1). Although the mean encounter rate for sei whales in the entire Indian Ocean lies between those of the fin and Bryde's whales (Table 2), the current relative densities of the three may be different due to differing histories of exploitation during the sampling period (see 'Materials and Methods').

The latitudes of high sei whale density are 30°-45°S in November, around 40°-50°S in December, 40°-55°S in January, and between 40°-50°S in February. Few animals appear to migrate to waters south of 55°S, and none were recorded south of 65°S (Table 7). The northern limit of sei whales in the Indian Ocean sector is, with few exceptions, around 25°-30°S in November and December and 35°-40°S from January to March. The sei whale's range does not usually overlap with that of the Bryde's whale (see below), which is found in lower latitudes, but, as already noted, it does overlap considerably with the major summer distribution of the right whale (Table 3).

Sei whales are found in all longitudinal sectors of the Indian Ocean between 40°S and 50°S, but four concentrations may exist: off South Africa; in the western Indian Ocean; in the eastern Indian Ocean; and south of Australia (Figs 21–24). The apparent higher densities west of 30°E and east of 120°E are exaggerated due to the non-random distribution of sighting effort.

Bryde's whale, *B. edeni* Anderson, 1878

A total of 482 Bryde's whales was seen from the survey vessels during the 13 Antarctic whaling seasons from 1972/73 to 1984/85 (Table 1). The encounter rate for the total area appears to be between those of the sei and blue whales (Table 2).

Ohsumi (1980) compared the length distributions of Bryde's whales taken off Donkergat (inshore and offshore), Natal, Madagascar and Java. He concluded that the length frequencies in the latter three areas were similar, although intermediate between the two forms shown to be taken from Donkergat (Best, 1977). Recently Wada (1987) concluded from an isoenzyme analysis that the Bryde's whales off Madagascar and those off Java belong to separate stocks. Best, Butterworth and Rickett (1984) showed the distribution of the inshore form of Bryde's whales in the Indian Ocean off the coast of South Africa. Collectively, these studies indicate that there are at least four Bryde's whale stocks in the Indian Ocean.

The present data show four, albeit indistinct, areas of Bryde's whale concentration in the southern latitudes of the Indian Ocean: south of Java to the west coast of Australia (east of 90°E); in central Indian Ocean (65–90°E); off Madagascar (35–65°E); and off South Africa (east of 35°E). This last area includes both inshore and offshore forms (Table 2, Figs 25–28). North of the equator, there were concentrations in the southern Arabian Sea and southern Bay of Bengal in March (Table 12). Although it is unclear whether the former is separate from the Madagascar group, the latter seems to be isolated from the rest of the stocks in the Indian Ocean (Fig. 28).

The southern limit of Bryde's whales in the Indian Ocean shifts from 15°-20°S in October to 35°-40°S from December to February (Table 8), changes in northern limits were not detected from the present data.

Minke whale, *B. acutorostrata* Lacépède, 1804

A total of 30,117 minke whales was seen during the 19 years from 1966/67 to 1984/85 (Table 1). This species seems to be the most abundant in the surveyed area. The diminutive form of minke whale (Best, 1985; Arnold *et al.*, 1987) was not identified or recorded during the cruises. Four sightings of this form were reported in November and December at 7°-35°S off western Australia outside of 200 n.mile zone (Kasamatsu, 1989), and another one individual was collected at 58°S, 111°E in late March (Kato *et al.*, 1989). These two forms were sympatric in at least some areas and seasons. Many of the minke whales seen in lower latitudes of the Indian Ocean may have been the diminutive form.

Minke whale density is high in the eastern and western sectors of the Indian Ocean and low in the central sectors (70–110°E). This pattern of distribution is similar to that observed for the pygmy blue and sei whales (Table 2), although these latter species inhabit much more northerly waters and have summer distributions which do not significantly overlap with those of the minke whale.

The latitudes of the highest minke whale densities are south of 60°S from November to March, although there are considerable sightings to the north of 55°S in the austral summer. This suggests that in summer not all individuals migrate to waters south of the Antarctic Convergence. The latitudes of high minke whale density overlap with those of the humpback and 'normal' blue whales.

The northern limit of the minke whale (Table 9) appears to begin to shift south in October, reaching 40-45°S by January, and then shifts back northwards to 15–20°S in February, indicating the seasonal migration of the species. The apparent lack of sightings between 30°-40°S in January may be partly due to limited sighting effort (Fig. 3). There were no minke whale sightings in the equatorial Indian Ocean north of 5°S.

Sperm whale, *Physeter macrocephalus* Linnaeus, 1758

A total of 17,950 sperm whales was seen in the Indian Ocean north of 70°S from 1965/66 to 1984/85 (Table 1).

There were two latitudinal concentrations, with a hiatus in density which shifted from 50–55°S in November to 55–60°S in December, then from 50–55°S in January to 40–45°S in March (Table 10). We believe that this seasonal change is related to expansions/contractions of the Antarctic Convergence, and that the northern concentration represents mainly breeding (mixed) schools and the southern one the segregating adult bulls (Kato, 1984). Best (1979) linked the southern limit of mixed schools to the subtropical convergence. Table 2 shows that the sperm whale encounter rate to the north of the Antarctic Convergence (150 whales per 10,000 n.miles survey) is about twice that to the south (78 whales per 10,000 n.miles). The difference in the estimated absolute number of individuals between these strata is even more pronounced if the extreme difference in the size of the areas is taken into consideration.

North of 55°S, sperm whales are distributed almost evenly throughout the Indian Ocean (Table 12), with no obvious local concentrations, although the encounter rate tends to be slightly higher between 25–40°S in many of the months. Longitudinally, (Table 2, Figs 33–36) the encounter rates are higher in the middle and eastern sectors (40–80°E and 110–120°E). Similar longitudinal concentrations are found south of 55°S.

We found high densities of sperm whales in the northern latitudes of the tropical Indian Ocean. This area is separated from the concentrations in the southern subtropical and temperate waters of the ocean by a hiatus of low density, suggesting the presence of isolated populations in the Arabian Sea and Bay of Bengal.

Killer whale, *Orcinus orca* (Linnaeus, 1758)
A total of 5,198 killer whales was seen in the Indian Ocean from 1965/66 to 1984/85 (Table 1). As with the sperm whale, there were two latitudinal concentrations (20°-45°S; south of 60°S) with a hiatus around 50°–55°S, i.e. the Antarctic Convergence (Table 11). The data do not indicate clear seasonal shifts in the concentrations. Berzin and Vladimirov (1983) reported two morphologically distinct geographical forms of killer whales, which they designated as different species, in the Indian Ocean sector of the Antarctic Ocean (*O. orca* away from the ice and *O. glacialis* close to the ice). Although the latitudinal ranges of these two forms have yet to be clarified (Berzin and Vladimirov, 1983), it is possible that the two latitudinal concentrations represent the two forms. From Table 2, the encounter rate of killer whales south of 55°S (231 individuals per 10,000 n.miles) can be seen to be almost 13 times that at the lower latitudes (18 individuals per 10,000 n.miles).

Killer whale density is high in the central Indian Ocean sector (40–80°E) on both sides of the Antarctic Convergence. Another concentration is found to the east of 100°E and south of 55°S (Table 2). The mean encounter rate of this species in the entire Indian Ocean was similar to that of sperm whales, but the actual abundance was probably lower because the density of killer whales was greater in higher latitudes where size of area was smaller.

DISCUSSION

These data indicate that each baleen whale species has particular latitudes of concentration in summer, and detectable monthly north/south shifts. The latitudes of the highest encounter rates in January (when the whales have reached their southernmost distribution and the sighting effort is greatest) are as follows (from north to south): Bryde's whale <30–40°S; pygmy blue whale 35–50°S; black right whale 40–45°S; sei whale 40–55°S; fin whale 45–60°S; minke whale 60–70°S; humpback whale 60–70°S; 'normal' blue whale 65-70°S.

These data have been collected over many years, and thus include annual fluctuations in oceanographic conditions and resultant variations in the distribution of baleen whales. This means that overlaps in the latitudinal ranges shown above will exaggerate the actual degree of the overlap which might be present between two species in a particular month of a particular year. Thus, any slight overlap in range (e.g. 5°) cannot be taken as showing a real overlap of the ranges. In addition, the precision of the latitudinal density gradient is only 5°.

Even taking this into account, we consider evidence of latitudinal overlap in the summer distributions to be clear for: (1) right and sei whales; and (2) minke, 'normal' blue and humpback whales. The summer range of the species in the first group probably overlaps to some degree with that of pygmy blue and fin whales, in the north and south, respectively. Additionally, the longitudinal summer distributions of many species within the two groups overlap. Although further information on the food items and feeding behaviour are required to confirm inter-specific competition for food resources (see review in Horwood, 1987), our data suggest the potential for competition between some baleen whale species, especially within the above two groups.

In January, both sperm and killer whales concentrate in two similar latitudinal ranges on either side of the Antarctic Convergence. Their longitudinal distributions are also similar i.e. in the western (40–80°E) and eastern (east of 110°E) Indian Ocean. This may perhaps reflect the availability of food resources, although it is doubtful if they share any major food items.

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REFERENCES

Arnold, P., Marsh, H. and Heinsohn, G. 1987. The occurrence of two forms of minke whales in east Australian waters with a description of external characters and skeleton of the diminutive or dwarf form. *Sci. Rep. Whales Res. Inst., Tokyo* 38:1–46.

Berzin, A.A. and Vladimirov, V.L. 1983. A new species of killer whale (Cetacea: Delphinidae) from the Antarctic waters. *Zool. Zh.* 62:287–95. [In Russian with English summary].

Best, P.B. 1977. Two allopatric forms of Bryde's whale off South Africa. *Rep. int. Whal. Commn* (special issue 1):10–38.

Best, P.B. 1979. Social organization in sperm whales, *Physeter macrocephalus*. pp. 277–89. *In:* H.E. Winn and B.L. Olla (eds.) *Behavior of Marine Animals*. Vol. 3. *Cetaceans*. Plenum Press, New York and London. i-xix+438pp.

Best, P.B. 1985. External characters of southern minke whales and the existence of a diminutive form. *Sci. Rep. Whales Res. Inst., Tokyo* 36:1–33.

Best, P.B., Butterworth, D.S. and Rickett, L.H. 1984. An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*). *Rep. int. Whal. Commn* 34:403–23.

Dawbin, W.H. 1956. The migration of humpback whales which pass New Zealand. *Trans. Roy. Soc. NZ* 84:147–96.

Gambell, R.G. 1964. A pygmy blue whale at Durban. *Norsk Hvalfangsttid.* 53:85–142.

Horwood, J. 1987. *The Sei Whale: Population Biology, Ecology and Management*. Croom Helm, London, New York, Sidney. 375pp.

Ichihara, T. 1966. The pigmy blue whale, *Balaenoptera musculus brevicauda*, a new subspecies from the Antarctic. pp. 79–113. *In:* K.S. Norris (ed.) *Whales, Dolphins and Porpoises*. University of California Press, Berkeley.

Kasamatsu, F. 1989. Preliminary report of the second minke whale surveys in low and middle latitudinal waters in the southern hemisphere in 1988/89. Paper SC/41/SHMi15 presented to the IWC Scientific Committee, June 1989. 15pp. (Unpublished).

Kato, H. 1984. Observation of tooth scars on the head of male sperm whale, as an indication of intra-sexual fightings. *Sci. Rep. Whales Res. Inst.* 35:39–46.

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whale. *Rep. int. Whal. Commn* 39:235–48.

Mackintosh, N.A. 1942. The southern stocks of whalebone whales. *Discovery Rep.* 22:197–300.

Mackintosh, N.A. 1965. *The Stocks of Whales*. Fishing News (Books) Ltd, London. 232pp.

Ohsumi, S. 1980. Population study of the Bryde's whale in the Southern Hemisphere under scientific permit in the three seasons, 1976/77–1978/79. *Rep. int. Whal. Commn* 30:319–31.

Ohsumi, S. and Yamamura, K. 1982. A review of the Japanese whale sightings system. *Rep. int. Whal. Commn* 32:581–6.

Omura, H., Ichihara, T. and Kasuya, T. 1970. Osteology of pygmy blue whale with additional information on external characteristics. *Sci. Rep. Whales Res. Inst., Tokyo* 22:1–27.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, N.Y.* 19:1–50+6maps.

Wada, S. 1987. Biochemical analyses of genetic differentiation among the populations and species in *Balaenoptera*. Doctoral Thesis, Faculty of Agriculture, University of Tokyo. 145pp.

Table 1

Monthly number of large cetaceans sighted in the Indian Ocean between the equator and 70°S

Species Period	Right '65/66 -84/85	Humpback '65/66 -84/85	Blue '65/66 -84/85	Fin '65/66 -84/85	Sei '74/75 -84/85	Bryde's '72/73 -84/85	Minke '66/67 -84/85	Sperm '65/66 -84/85	Killer '65/66 -84/85
November	213	51	59	166	274	146	2,860	4,985	681
December	328	73	262	822	364	81	3,815	3,853	547
January	280	211	517	3,976	923	107	15,013	4,379	1,966
February	35	112	1,038	5,933	136	63	7,671	2,929	1,742
March	8	19	319	2,494	36	58	722	1,277	257
April	-	0	2	1	0	-	0	3	-
Total	864	469	2,199	13,398	1,735	482	30,117	17,950	5,198

Table 2

Longitudinal distribution of large cetaceans in the Indian Ocean between October and April calculated as the arithmetic mean of densities for the 5° squares in Figs 5-40, expressed as number of whales sighted per 100,000 n.miles. Latitudes: A = 0°-55°S; B = 55°S to ice edge; C = 0° to ice edge. Species: B = blue; Br = Bryde's; F = fin; H = humpback; K = killer; M = minke; R = black right; S = sei; Sp = sperm.

Species	R	H	B		F	S	Br	M	Sp		K	
Latitudes	C	C	A	B	C	C	C	C	A	B	A	B
20°-30°E	0.5	11.9	2.7	0	86	95	84	519	132	3	12	69
30°-40°E	0	8.9	26.6	0	66	21	4	561	131	56	11	123
40°-50°E	0.4	8.5	36.9	116	36	13	32	959	215	10	22	215
50°-60°E	0.3	14.0	8.2	0	21	11	16	679	207	12	26	283
60°-70°E	0.1	1.6	2.5	19	26	8	5	3,188	195	284	39	486
70°-80°E	0.1	2.0	5.5	14	74	10	11	439	174	72	25	417
80°-90°E	0.0	5.3	6.8	6	90	8	7	417	132	51	12	141
90°-100°E	3.1	6.4	5.4	3	16	40	10	175	102	25	12	26
100°-110°E	2.5	3.0	1.1	4	5	8	15	233	136	51	25	180
110°-120°E	3.3	8.8	6.2	1	4	20	18	555	151	104	14	200
120°-130°E	22.8	6.7	14.3	2	13	82	0	1,213	72	185	4	399
Mean	3.0	7.0	10.6	15	40	29	18	812	150	78	18	231

Table 3

Longitudinal distribution of black right whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 5-8, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	0	-	-	0	0	-	40°-45°S	-	13.1	6.9	14.1	30.5	0	0
10°-15°S	0	0	0	-	0	0	-	45°-50°S	-	0	3.2	9.1	0.1	0.7	0
15°-20°S	0	0	0	-	0	0	-	50°-55°S	-	0	0	5.5	0.1	0	-
20°-25°S	-	0	0	-	0	0	-	55°-60°S	-	0	0	0	0.1	0.3	-
25°-30°S	0	0.7	0	-	0	0	-	60°-65°S	-	0	0	0	0	0	-
30°-35°S	0	0.1	0	0	0	0	-	65°-70°S	-	-	0	0	0	-	-
35°-40°S	0	3.1	0.6	0	0	0	-								

Table 4

Longitudinal distribution of humpback whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 9-12, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	0	-	-	0	0		40°-45°S	-	1.1	1.4	0.5	0.1	0.2	0
10°-15°S	0	0.8	0	-	0	0	-	45°-50°S	-	0	0.5	2.6	0.9	1.3	0
15°-20°S	0	0	0	-	0	0	-	50°-55°S	-	0	1.9	1.5	1.8	0.1	-
20°-25°S	-	0	0	-	0	0	-	55°-60°S	-	2.3	5.3	5.2	3.1	0.3	-
25°-30°S	0	1.0	3.9	-	0	0	-	60°-65°S	-	6.7	27.1	47.9	36.3	48.7	-
30°-35°S	4.4	3.6	10.1	0	0	16.1	-	65°-70°S	-	-	14.0	47.4	79.7	-	-
35°-40°S	0	1.1	2.6	2.0	0	1.0	-								

Table 5

Longitudinal distribution of blue whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 13-16, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	0	-	-	0	0	-	40°-45°S	-	1.6	4.3	13.9	29.2	14.3	0
10°-15°S	3.4	0	0	-	0	0	-	45°-50°S	-	0.6	9.7	23.7	34.0	34.3	7.0
15°-20°S	0	0	0	-	0	0	-	50°-55°S	-	0	13.9	1.0	4.5	7.7	-
20°-25°S	-	10.3	0	-	0	0	-	55°-60°S	-	0	0	1.4	0.1	2.4	-
25°-30°S	0	0	68.1	-	1.8	2.7	-	60°-65°S	-	4	3.2	7.4	0	0	-
30°-35°S	0	2.7	20.3	0	0	8.0	-	65°-70°S	-	-	0	67.3	22.5	-	-
35°-40°S	0	1.8	3.0	50.3	4.0	0	-								

Table 6

Longitudinal distribution of fin whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 17-20, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	0	-	-	0	0	-	40°-45°S	-	11	18	33	87	43	0
10°-15°S	0	0	0	-	0	0	-	45°-50°S	-	2	28	107	127	62	4
15°-20°S	0	0	0	-	0	0	-	50°-55°S	-	16	147	98	118	170	-
20°-25°S	-	0	8	-	0	0	-	55°-60°S	-	3	186	153	108	168	-
25°-30°S	0	0	4	-	0	0	-	60°-65°S	-	2	9	2	4	0	-
30°-35°S	10	3	21	0	0	0	-	65°-70°S	-	-	0	0	0	-	-
35°-40°S	0	9	6	45	6	0	-								

Table 7

Longitudinal distribution of sei whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 21-24, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	1	-	-	0	0	-	40°-45°S	-	57	44	121	58	1	0
10°-15°S	0	5	0	-	0	0	-	45°-50°S	-	14	518	76	81	15	0
15°-20°S	0	0	0	-	0	0	-	50°-55°S	-	0	5	54	17	24	-
20°-25°S	-	3	0	-	0	0	-	55°-60°S	-	0	3	6	1	3	-
25°-30°S	-	8	7	-	2	0	-	60°-65°S	-	0	0	2	3	0	-
30°-35°S	19	40	21	0	0	0	-	65°-70°S	-	-	0	0	0	-	-
35°-40°S	-	37	33	13	19	20	-								

Table 8

Longitudinal distribution of Bryde's whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 25-28, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	63	-	-	0	53	-	40°-45°S	-	0	0	0	0	0	0
10°-15°S	46	65	68	-	0	47	-	45°-50°S	-	0	0	0	0	0	0
15°-20°S	36	70	37	-	36	0	-	50°-55°S	-	0	0	0	0	0	-
20°-25°S	-	61	40	-	9	6	-	55°-60°S	-	0	0	0	0	0	-
25°-30°S	0	13	102	-	49	50	-	60°-65°S	-	0	0	0	0	0	-
30°-35°S	0	0	60	562	41	10	-	65°-70°S	-	-	0	0	0	-	-
35°-40°S	0	0	3	71	2	0	-								

Table 9

Longitudinal distribution of minke whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 29-32, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	28	0	-	-	0	0	-	40°-45°S	-	28	51	19	27	8	0
10°-15°S	33	7	0	-	0	0	-	45°-50°S	-	6	21	17	16	14	0
15°-20°S	46	14	0	-	13	0	-	50°-55°S	-	28	34	63	32	31	-
20°-25°S	-	36	39	-	8	0	-	55°-60°S	-	103	228	442	166	93	-
25°-30°S	27	26	33	-	10	19	-	60°-65°S	-	1,461	2,479	12,379	2,102	226	-
30°-35°S	34	35	32	0	11	17	-	65°-70°S	-	-	2,726	8,991	6,054	-	-
35°-40°S	0	21	25	0	9	22	-								

Table 10

Longitudinal distribution of sperm whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 33-36, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	73	146	-	-	825	50	-	40°-45°S	-	175	117	164	79	31	2
10°-15°S	151	141	0	-	558	156	-	45°-50°S	-	27	134	49	63	54	7
15°-20°S	36	43	0	-	70	132	-	50°-55°S	-	3	14	7	15	31	-
20°-25°S	-	148	108	-	145	98	-	55°-60°S	-	9	7	25	20	23	-
25°-30°S	282	183	201	-	327	380	-	60°-65°S	-	43	99	390	78	0	-
30°-35°S	1,203	304	254	189	275	171	-	65°-70°S	-	-	22	128	27	-	-
35°-40°S	26	189	144	133	525	424	-								

Table 11

Longitudinal distribution of killer whales in the Indian Ocean (20°-130°E) calculated as the arithmetic mean of densities for the 5° squares as shown in Figs 37-40, expressed as number of whales sighted per 100,000 n.miles surveyed

Month:	O	N	D	J	F	M	A	Month:	O	N	D	J	F	M	A
0°-10°S	0	4	-	-	0	53	-	40°-45°S	-	24	10	28	8	16	0
10°-15°S	0	9	0	-	0	6	-	45°-50°S	-	6	0	10	51	18	0
15°-20°S	0	9	0	-	0	29	-	50°-55°S	-	0	16	6	11	9	-
20°-25°S	-	38	0	-	0	39	-	55°-60°S	-	7	72	23	24	23	-
25°-30°S	10	11	0	-	125	31	-	60°-65°S	-	50	18	389	337	0	-
30°-35°S	17	64	43	0	3	51	-	65°-70°S	-	-	40	742	954	-	-
35°-40°S	0	22	8	0	80	0	-								

Table 12

Result of two sightings cruises in the Indian Ocean north of the equator in 1982. Sightings in the Southern Hemisphere during the cruises are included in Figs 1-40.

Date	Noon position	Distance surveyed (n.miles)	No. whales sighted			
			Blue	Bryde's	Sperm	Killer
Shonanmaru						
3 March	00°07'N, 61°30'E	110	-	-	1	-
4 March	00°28'N, 65°27'E	113	1	1	-	-
5 March	01°01'N, 69°26'E	113	-	-	5	-
6 March	02°06'N, 73°26'E	124	-	-	-	-
7 March	02°47'N, 77°54'E	140	-	-	-	-
8 March	03°22'N, 81°27'E	107	-	-	24	-
9 March	04°07'N, 86°06'E	137	-	-	-	-
10 March	04°57'N, 90°37'E	67	-	3	-	-
11 March	05°19'N, 92°30'E	110	-	-	8	-
12 March	06°01'N, 94°57'E	59	-	2	34	-
13 March	04°04'N, 99°23'E	0	-	-	-	-
Shonanmaru No.2						
1 March	00°22'N, 50°31'E	73	7	6	-	-
2 March	02°13'N, 53°59'E	64	-	1	28	-
3 March	03°49'N, 57°23'E	78	-	2	13	2
4 March	05°23'N, 61°32'E	126	-	-	-	-
5 March	04°57'N, 66°13'E	106	-	3	-	-
6 March	04°43'N, 70°18'E	107	-	2	-	-
7 March	05°06'N, 74°17'E	118	-	-	-	-
8 March	05°12'N, 78°58'E	101	-	-	12	-
9 March	05°22'N, 83°28'E	109	-	-	1	-
10 March	05°42'N, 87°59'E	120	-	1	-	-
11 March	05°52'N, 92°29'E	108	-	-	6	-
12 March	06°00'N, 94°59'E	129	-	-	21	-
13 March	03°51'N, 99°42'E	0	-	-	-	-

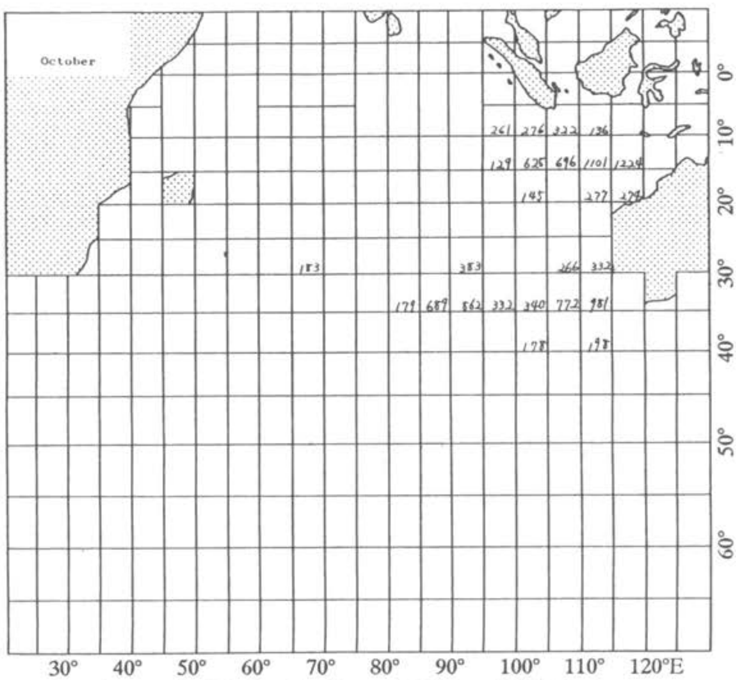

Fig. 1. Sighting effort (in n. miles) in October from 1965/66 to 1984/85 by Japanese research vessels or scouting boats attached to factory ship whaling fleets. Sightings and the corresponding effort data for minke, Bryde's and sei whales cover seasons since 1966/67, 1972/73 and 1974/75 inclusive, respectively.

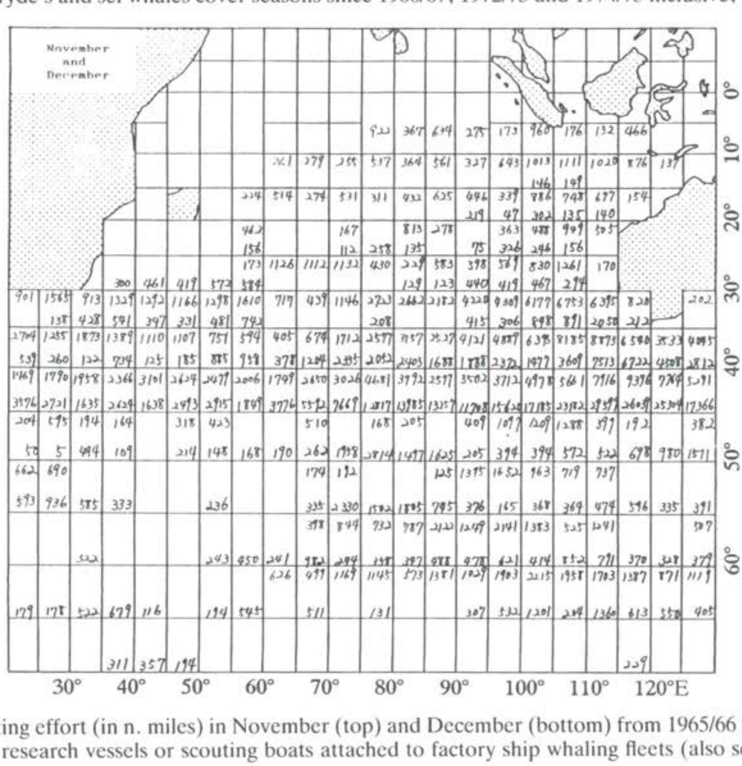

Fig. 2. Sighting effort (in n. miles) in November (top) and December (bottom) from 1965/66 to 1984/85 by Japanese research vessels or scouting boats attached to factory ship whaling fleets (also see Fig. 1).

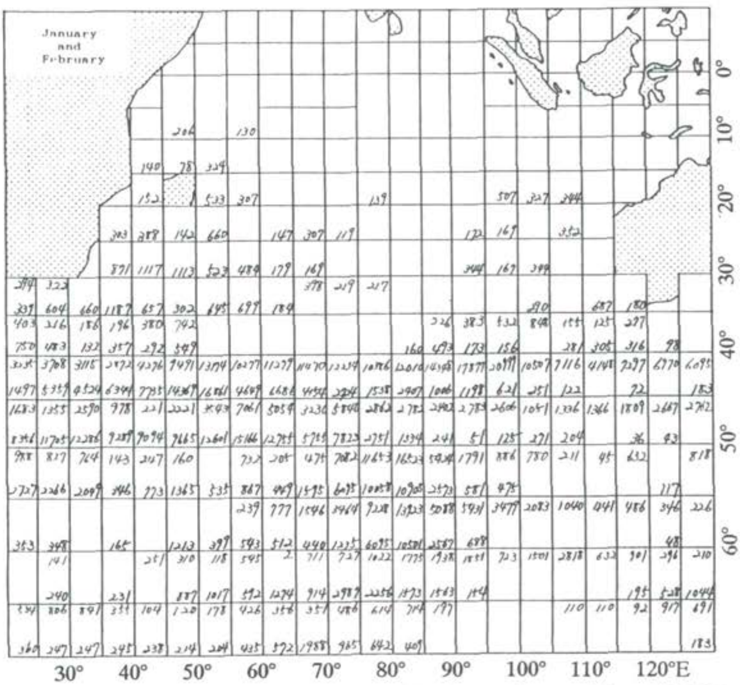

Fig. 3. Sighting effort (in n. miles) in January (top) and February (bottom) from 1965/66 to 1984/85 by Japanese research vessels or scouting boats attached to factory ship whaling fleets (also see Fig. 1).

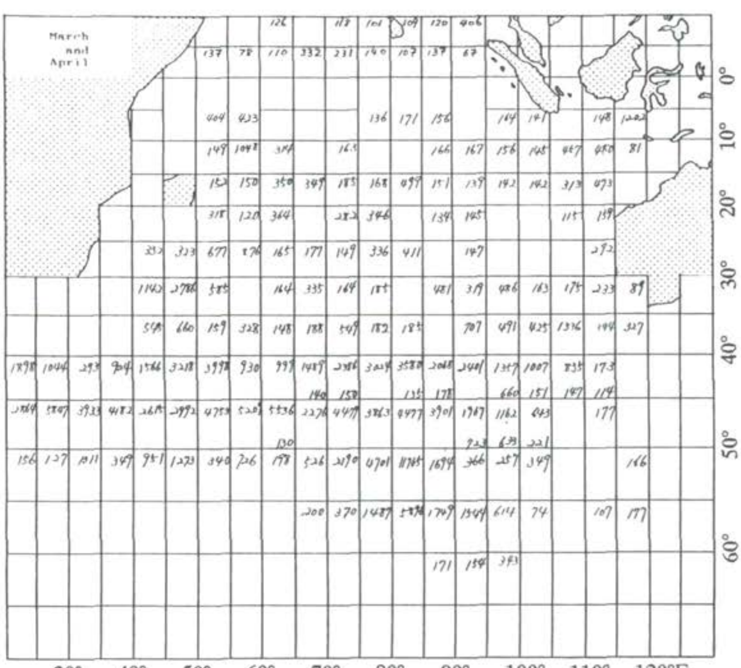

Fig. 4. Sighting effort (in nautical miles) in March (top) and April (bottom) during 1965/66 to 1984/85 by Japanese research vessels or scouting boats attached to Japanese factory ship whaling fleets (also see Fig. 1).

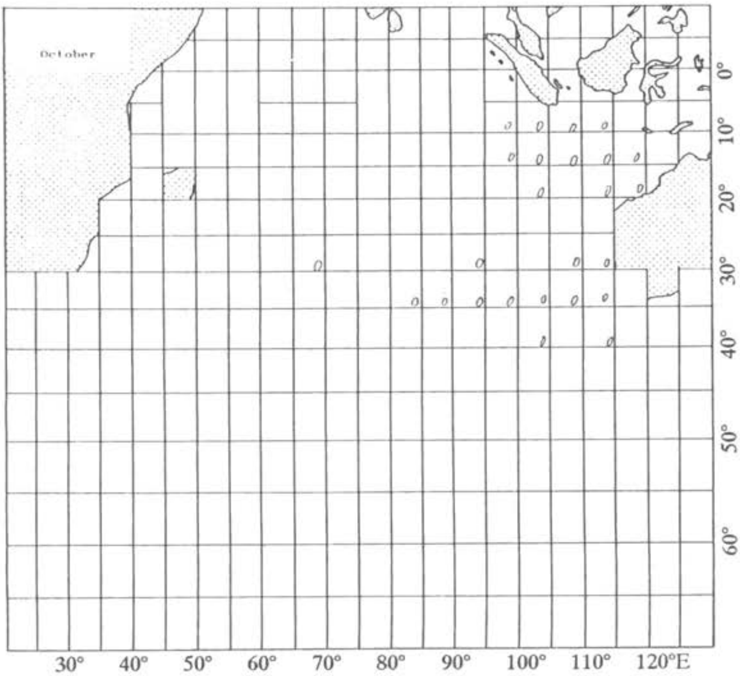

Fig. 5. Black right whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

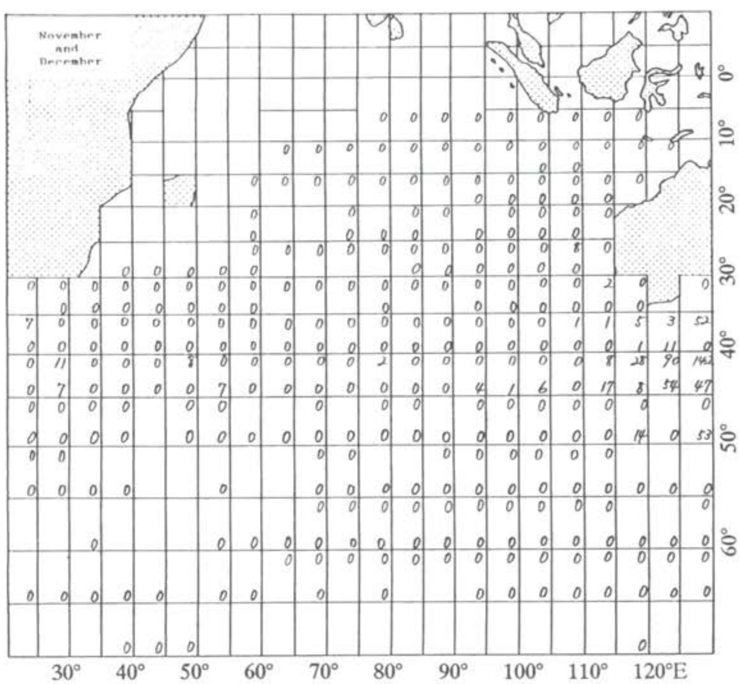

Fig. 6. Black right whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

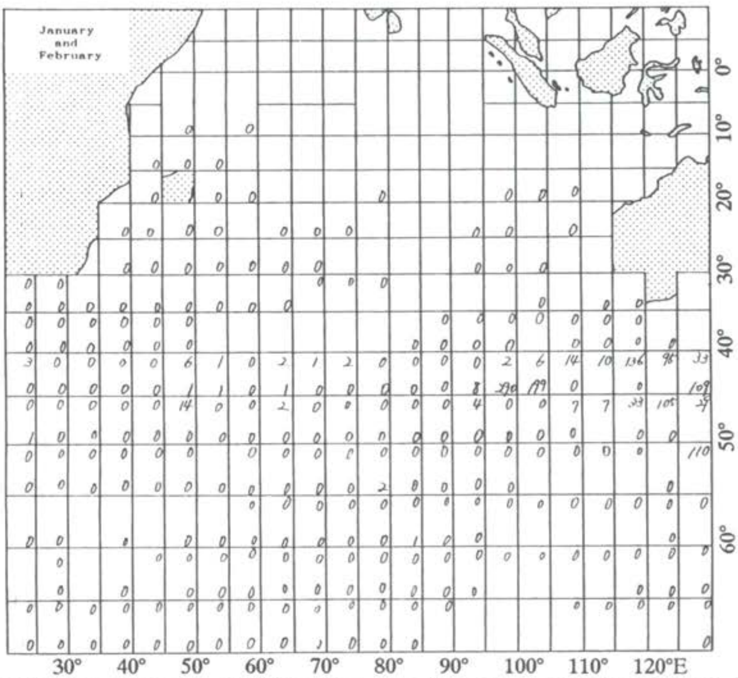

Fig. 7. Black right whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

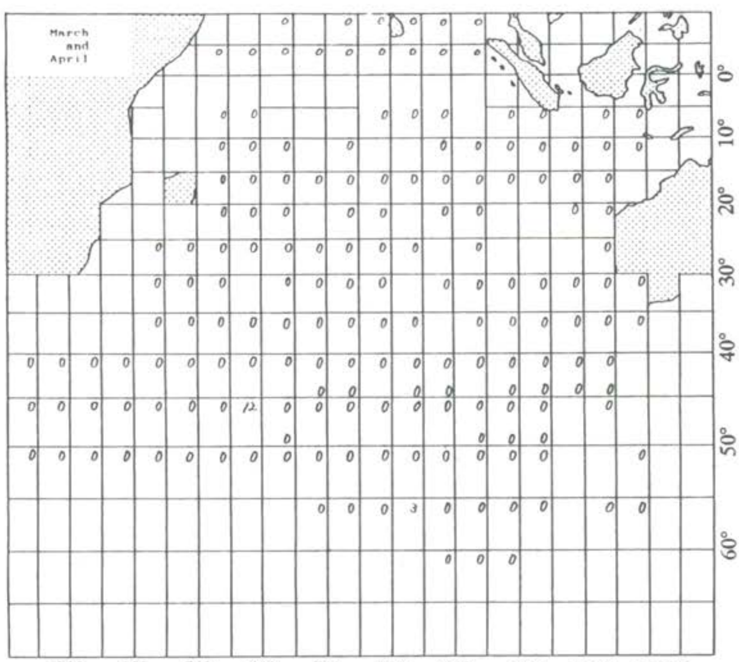

Fig. 8. Black right whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

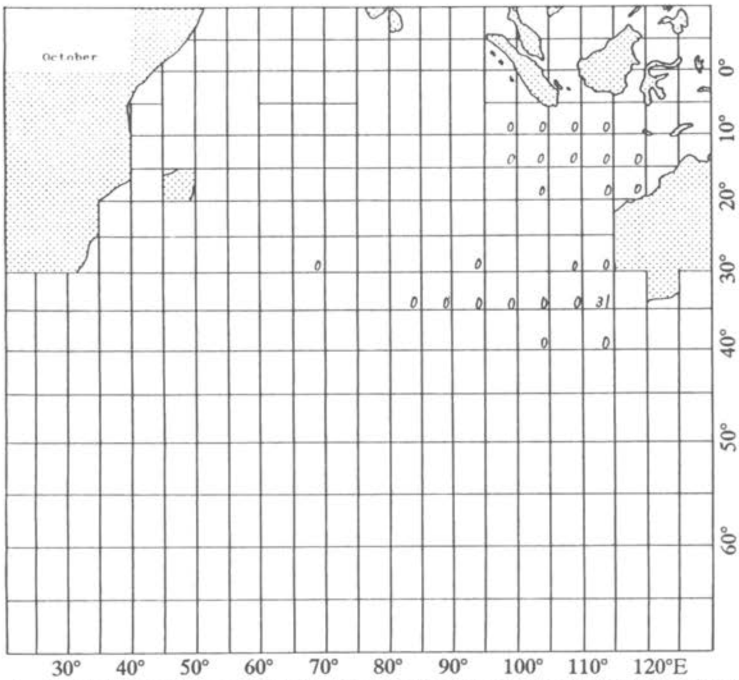

Fig. 9. Humpback whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

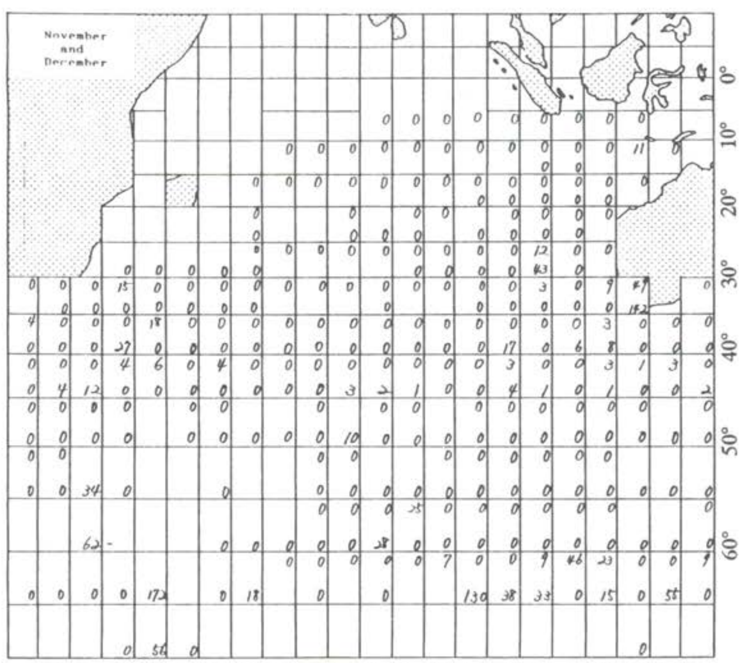

Fig. 10. Humpback whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

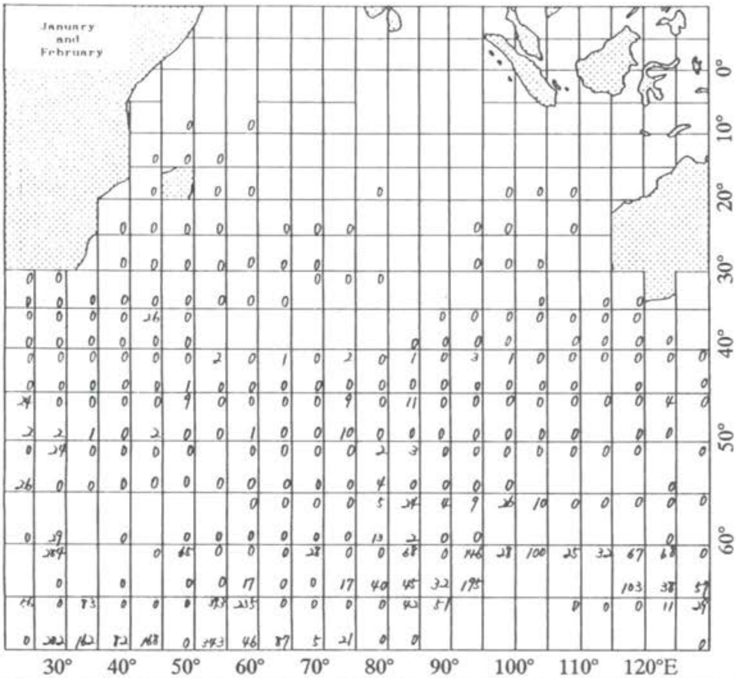

Fig. 11. Humpback whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

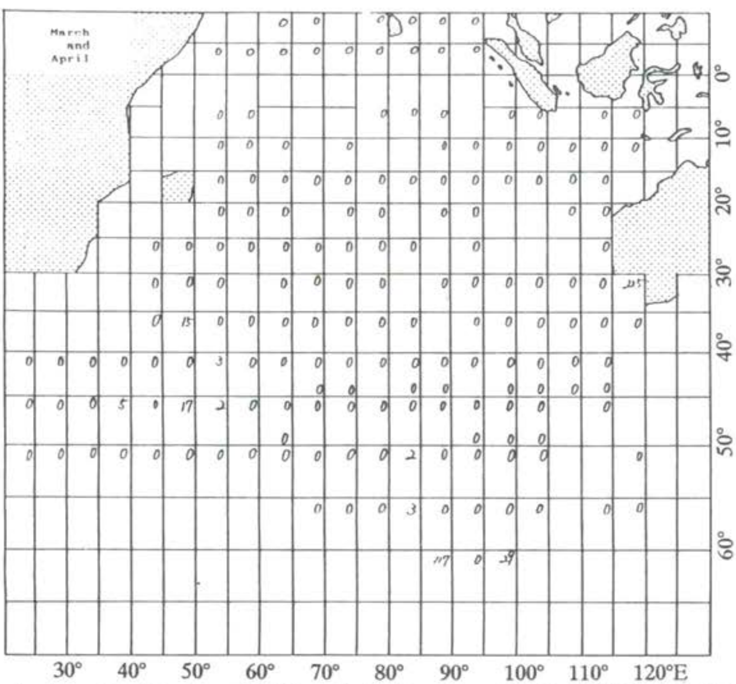

Fig. 12. Humpback whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

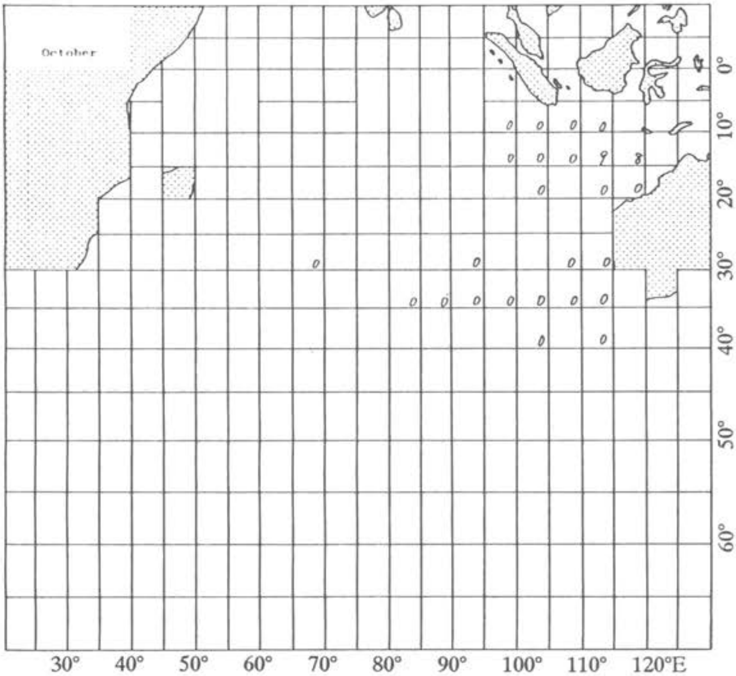

Fig. 13. Blue whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

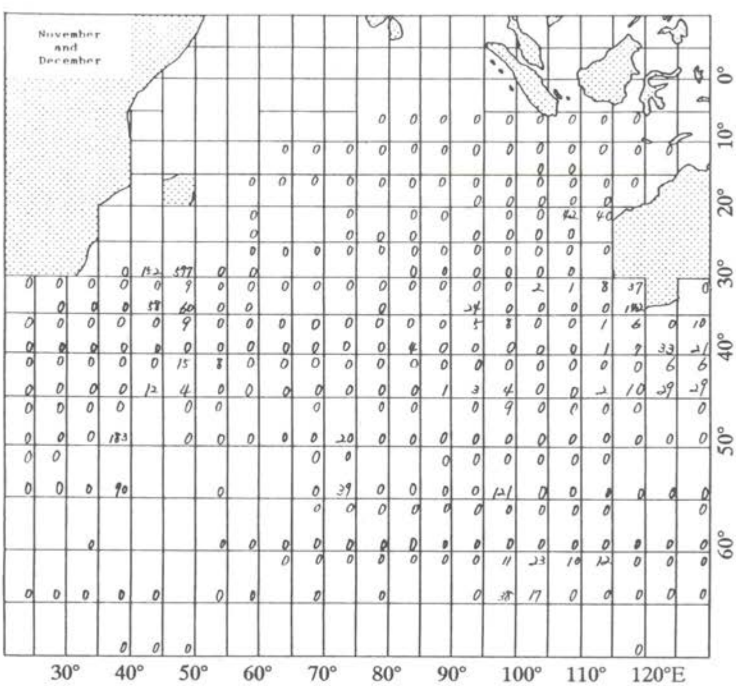

Fig. 14. Blue whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

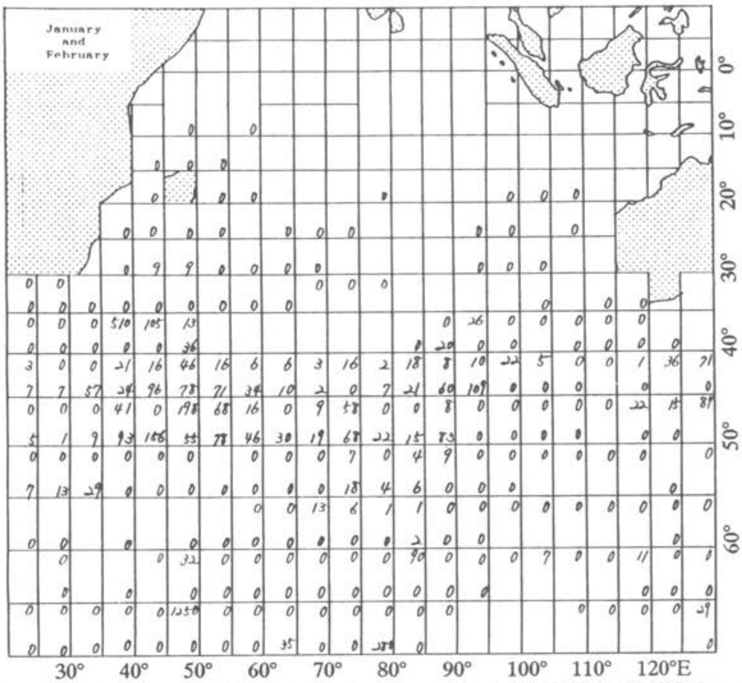

Fig. 15. Blue whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

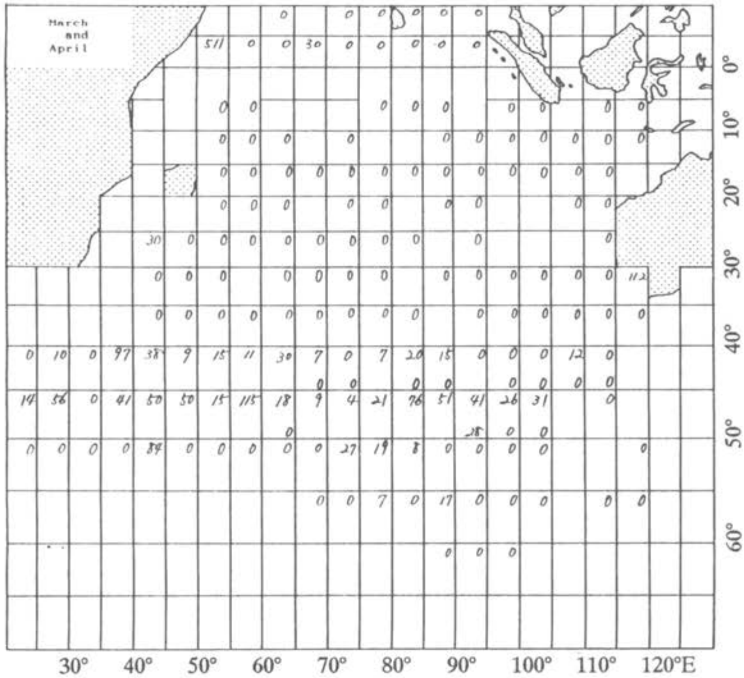

Fig. 16. Blue whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

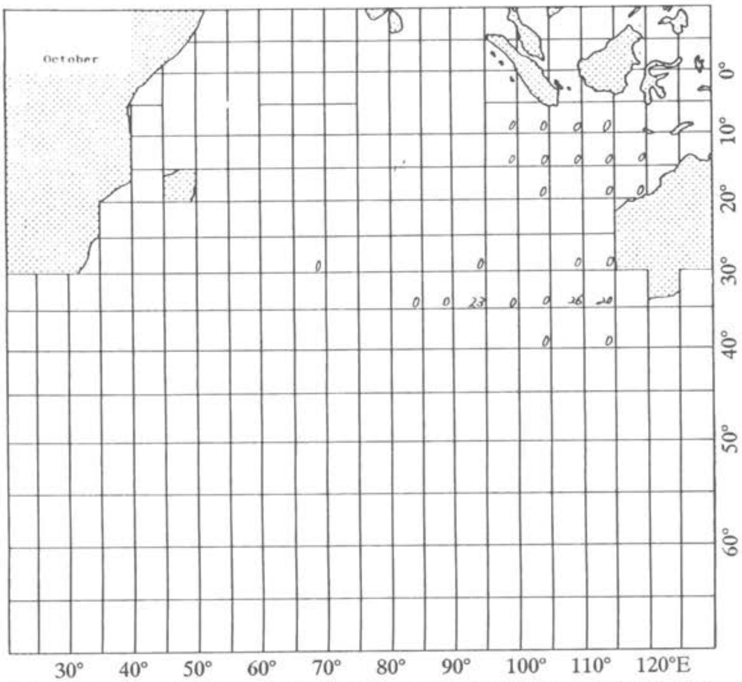

Fig. 17. Fin whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

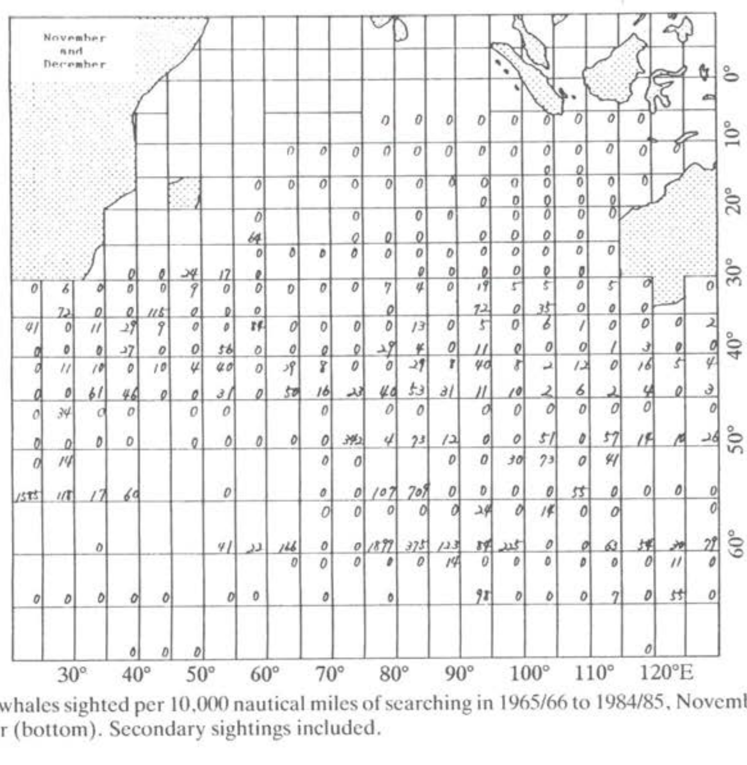

Fig. 18. Fin whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

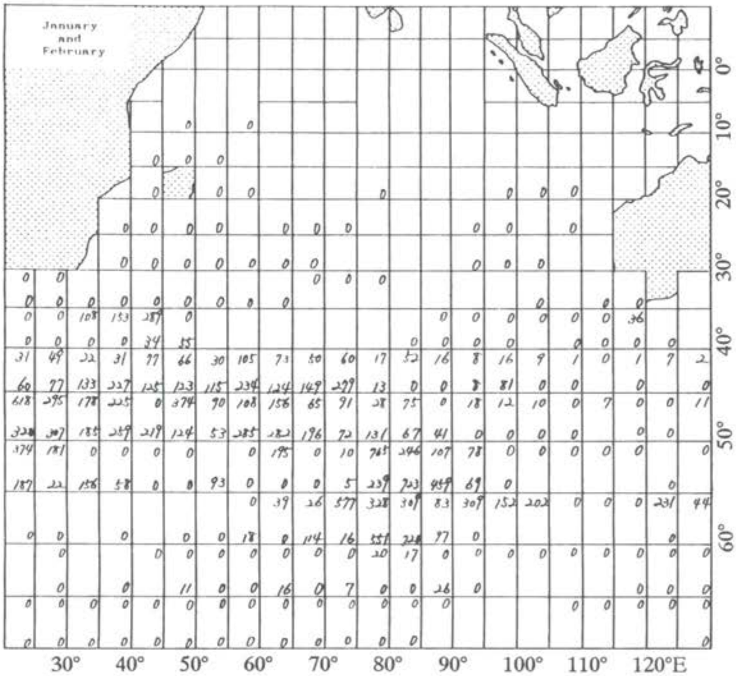

Fig. 19. Fin whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

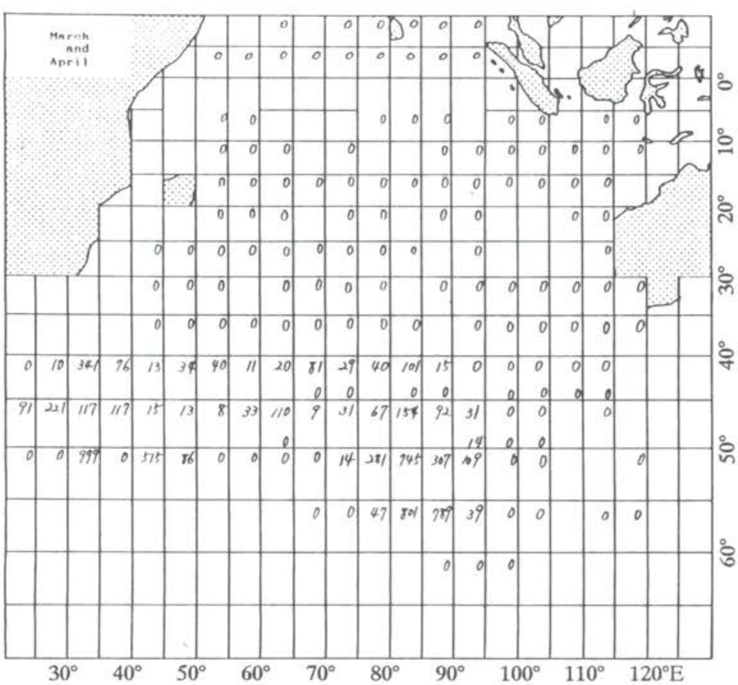

Fig. 20. Fin whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

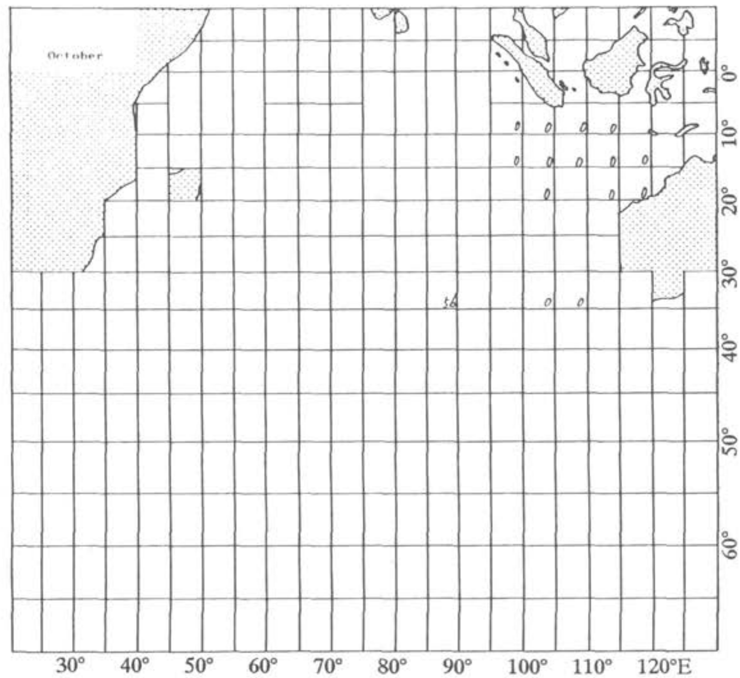

Fig. 21. Sei whales sighted per 10,000 nautical miles of searching in 1974/75 to 1984/85, October. Secondary sightings included.

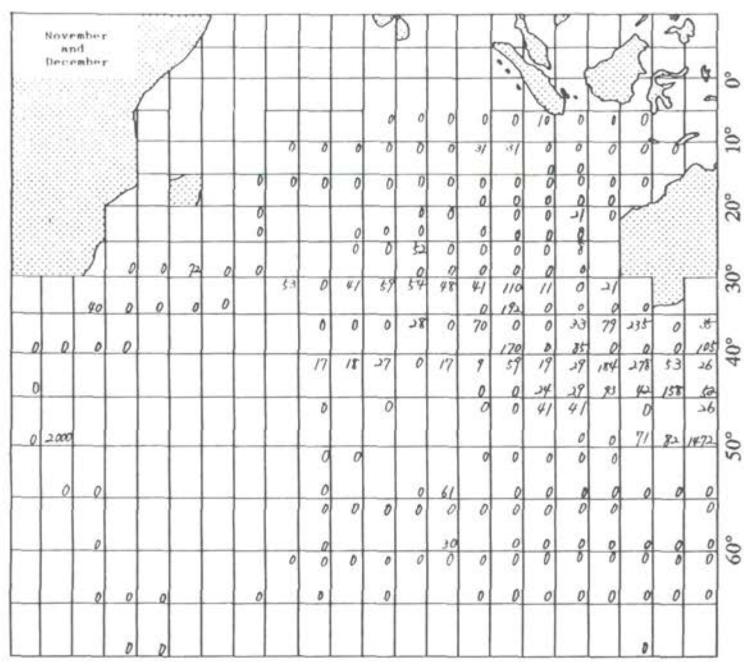

Fig. 22. Sei whales sighted per 10,000 nautical miles of searching in 1974/75 to 1984/85, November (top) and December (bottom). Secondary sightings included.

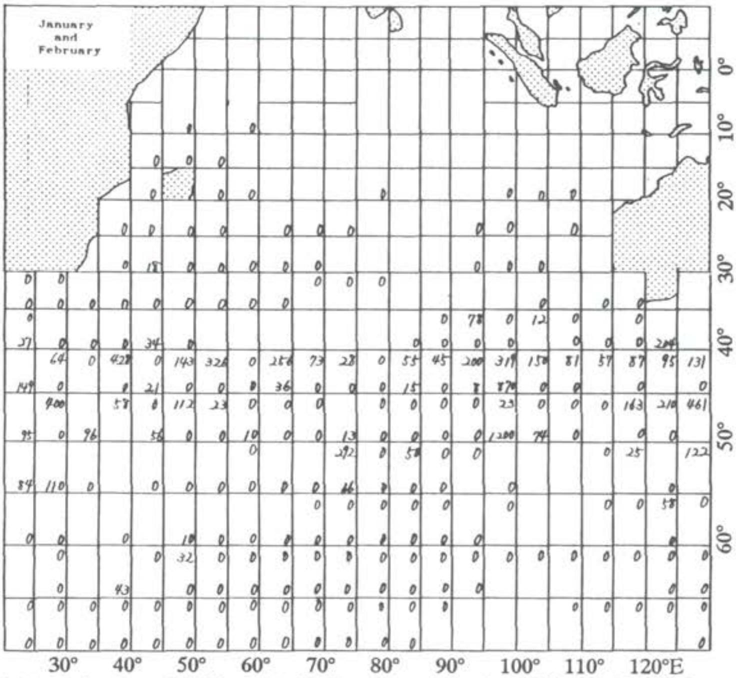

Fig. 23. Sei whales sighted per 10,000 nautical miles of searching in 1974/75 to 1984/85, January (top) and February (bottom). Secondary sightings included.

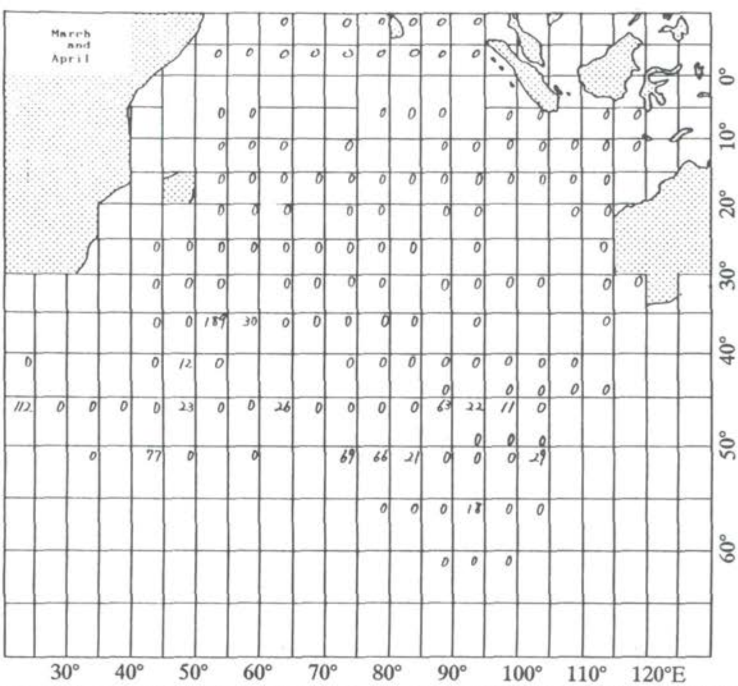

Fig. 24. Sei whales sighted per 10,000 nautical miles of searching in 1974/75 to 1984/85, March (top) and April (bottom). Secondary sightings included.

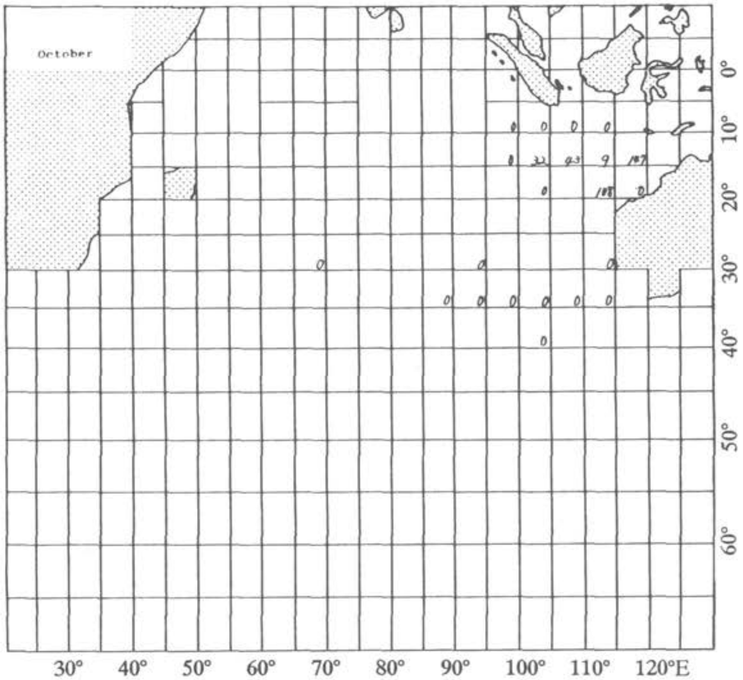

Fig. 25. Bryde's whales sighted per 10,000 nautical miles of searching in 1972/73 to 1984/85, October. Secondary sightings included.

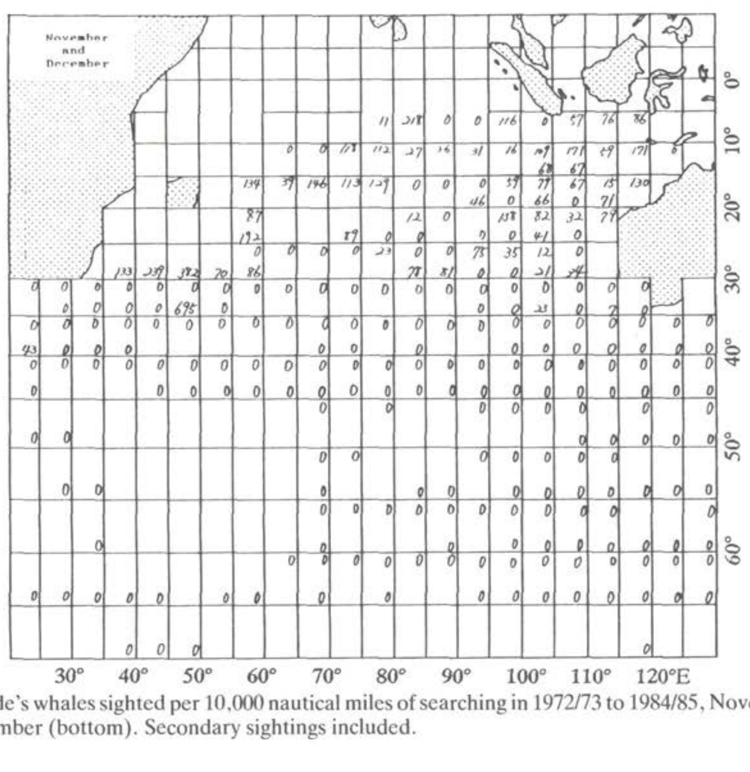

Fig. 26. Bryde's whales sighted per 10,000 nautical miles of searching in 1972/73 to 1984/85, November (top) and December (bottom). Secondary sightings included.

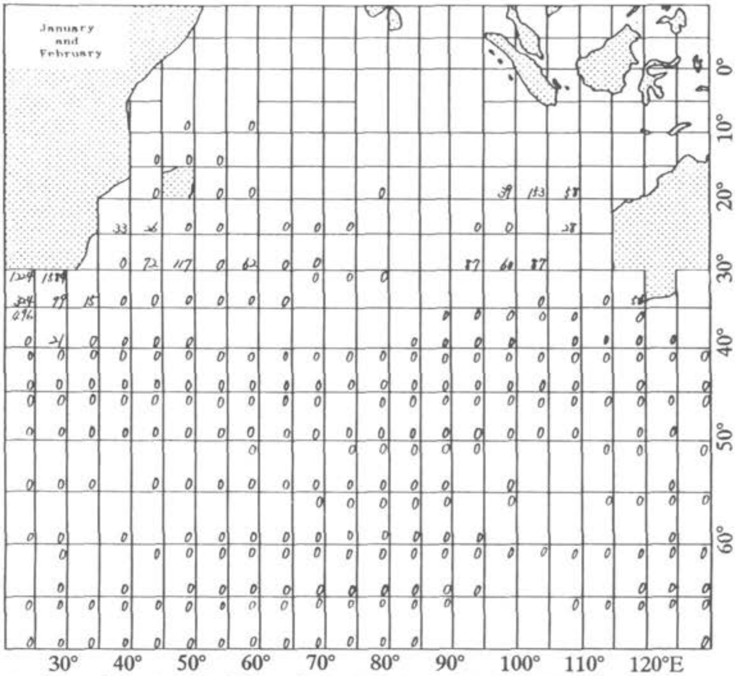

Fig. 27. Bryde's whales sighted per 10,000 nautical miles of searching in 1972/73 to 1984/85, January (top) and February (bottom). Secondary sightings included.

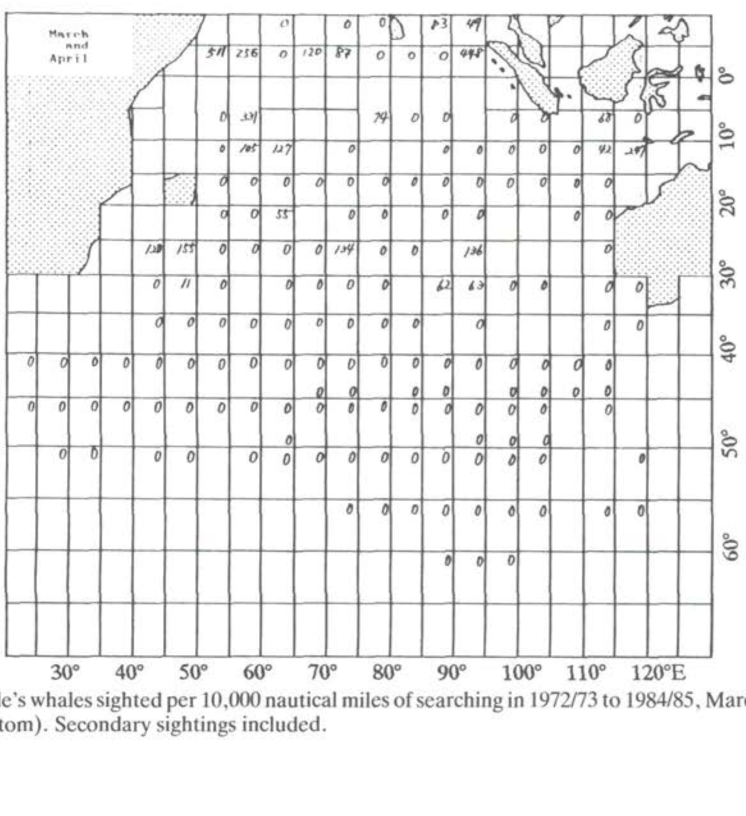

Fig. 28. Bryde's whales sighted per 10,000 nautical miles of searching in 1972/73 to 1984/85, March (top) and April (bottom). Secondary sightings included.

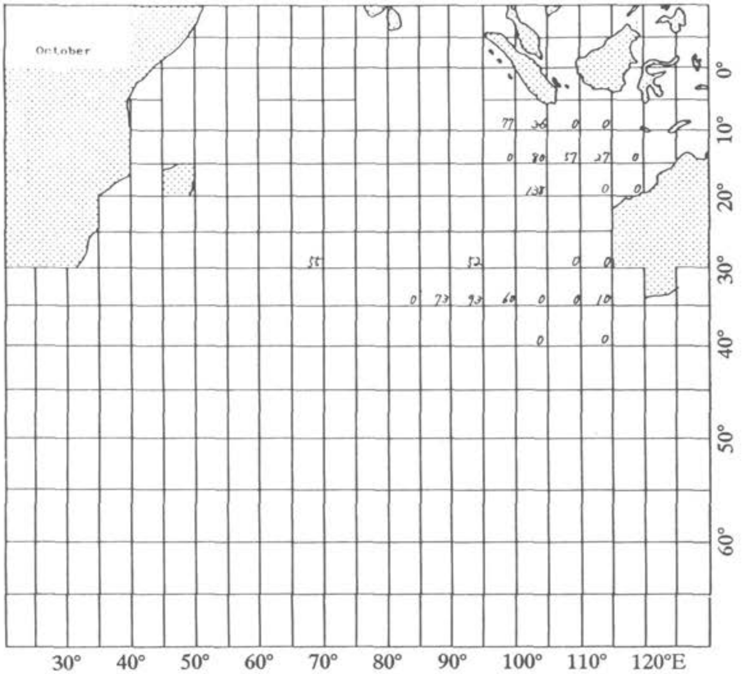

Fig. 29. Minke whales sighted per 10,000 nautical miles of searching in 1966/67 to 1984/85, October. Secondary sightings included.

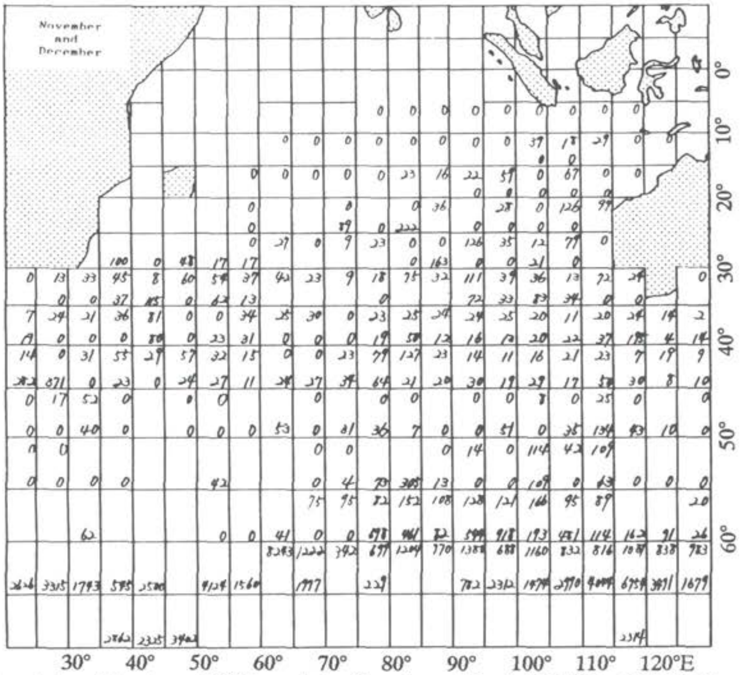

Fig. 30. Minke whales sighted per 10,000 nautical miles of searching in 1966/67 to 1984/85, November (top) and December (bottom). Secondary sightings included.

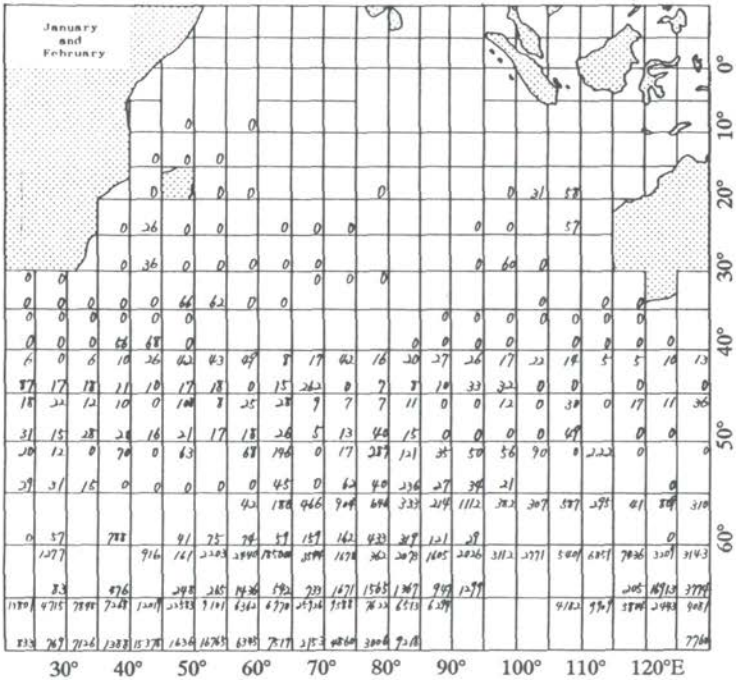

Fig. 31. Minke whales sighted per 10,000 nautical miles of searching in 1966/67 to 1984/85, January (top) and February (bottom). Secondary sightings included.

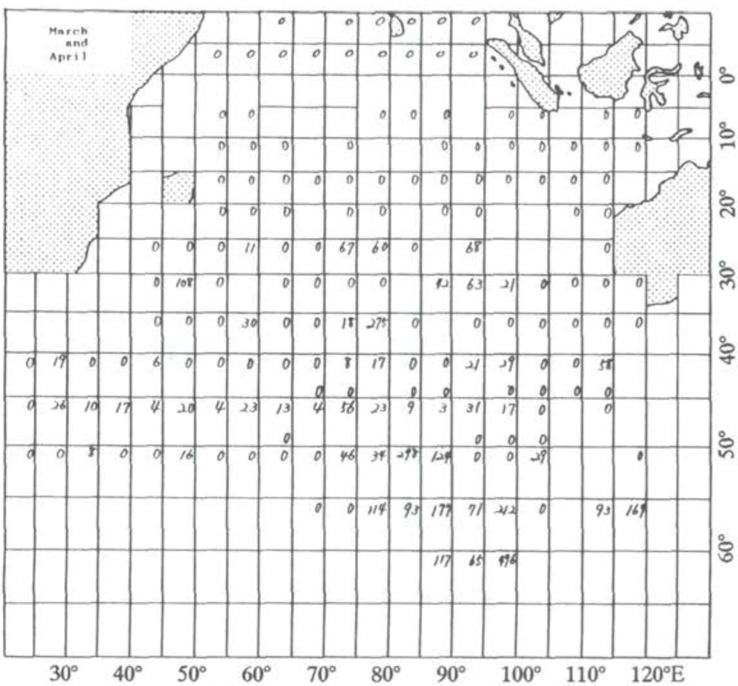

Fig. 32. Minke whales sighted per 10,000 nautical miles of searching in 1966/67 to 1984/85, March (top) and April (bottom). Secondary sightings included.

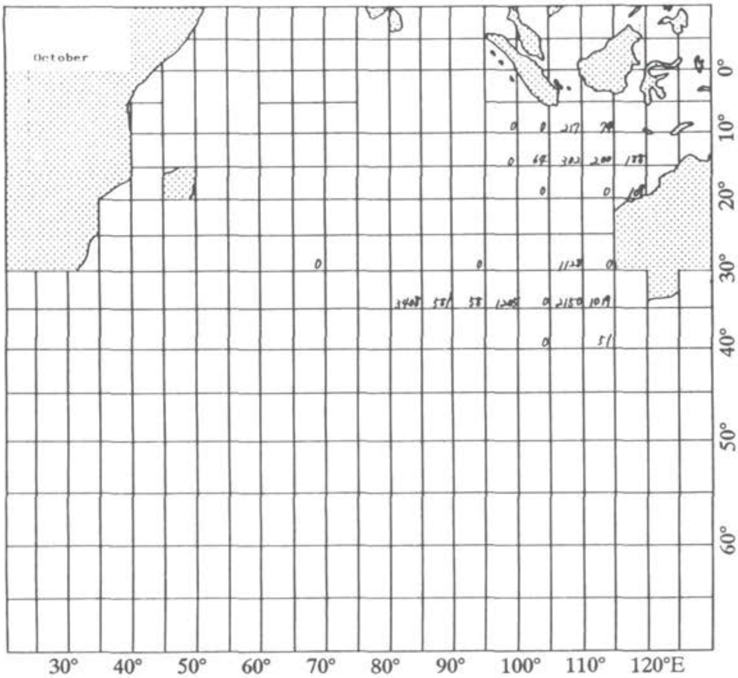

Fig. 33. Sperm whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

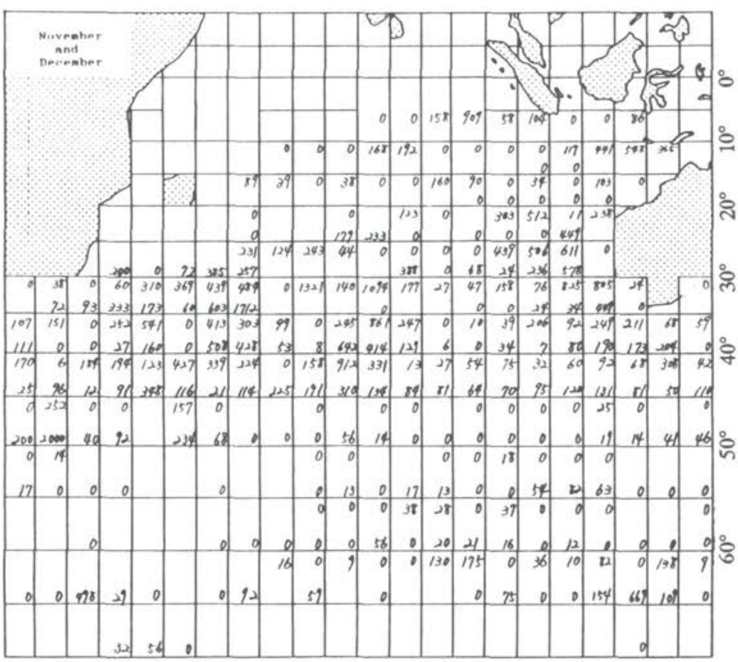

Fig. 34. Sperm whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

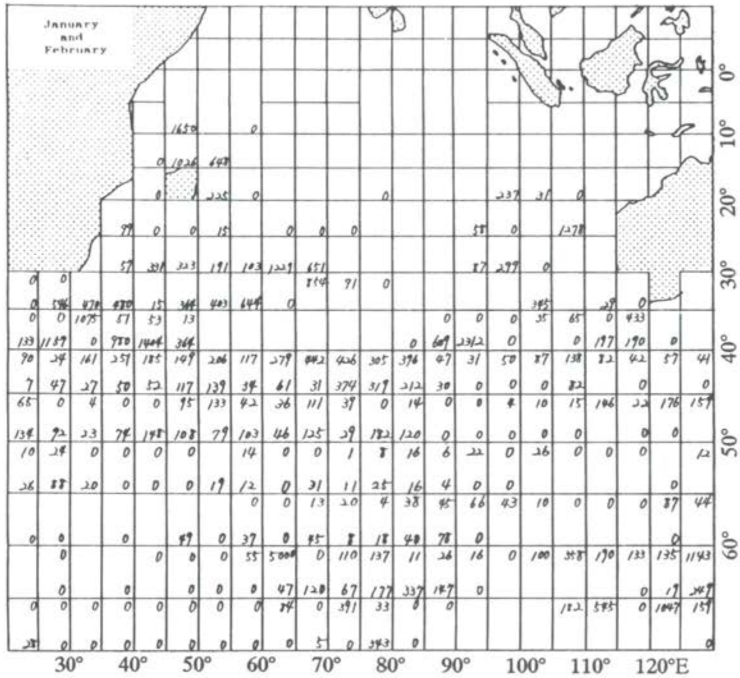

Fig. 35. Sperm whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

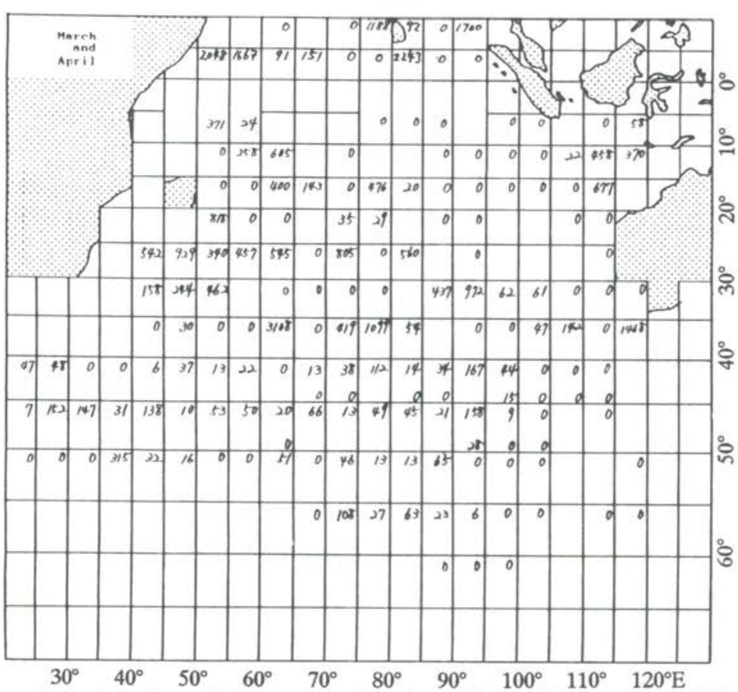

Fig. 36. Sperm whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

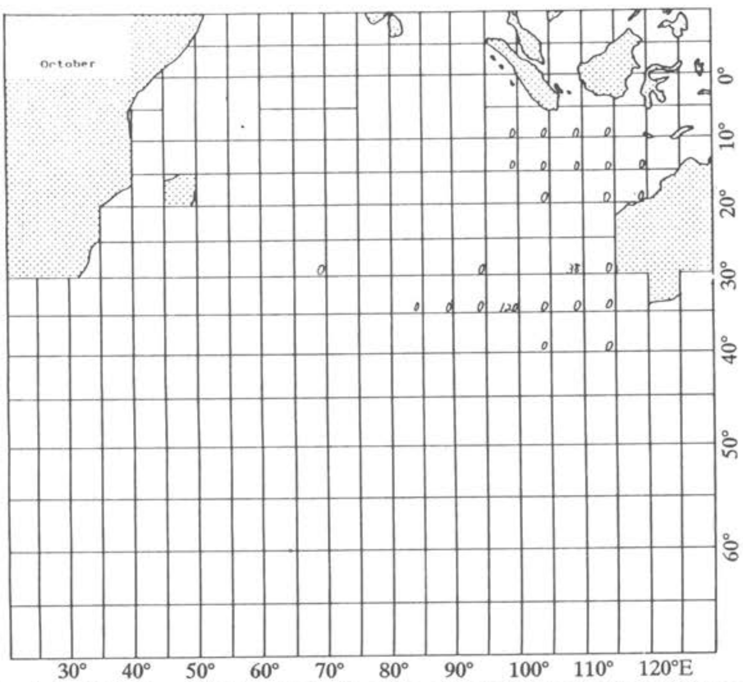

Fig. 37. Killer whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, October. Secondary sightings included.

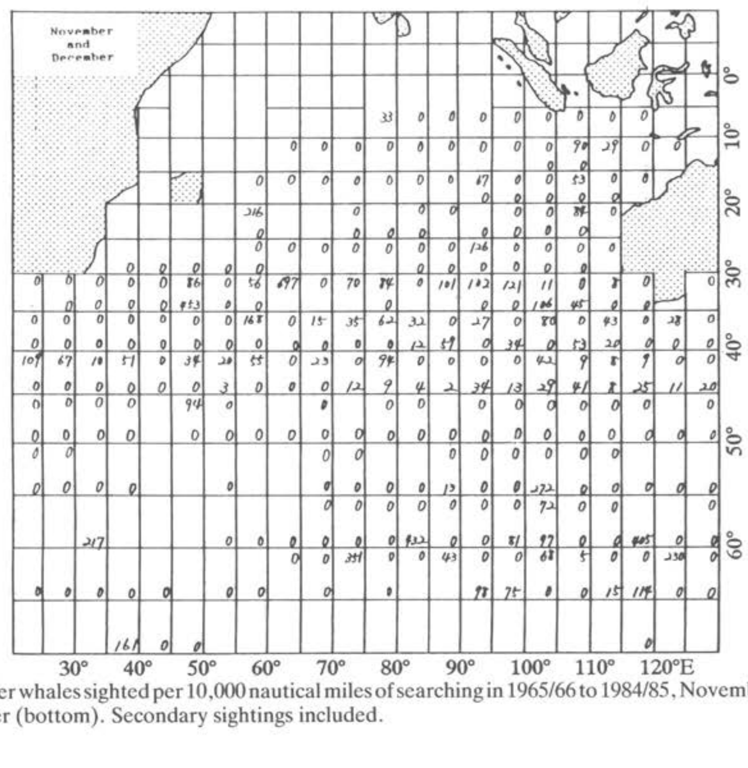

Fig. 38. Killer whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, November (top) and December (bottom). Secondary sightings included.

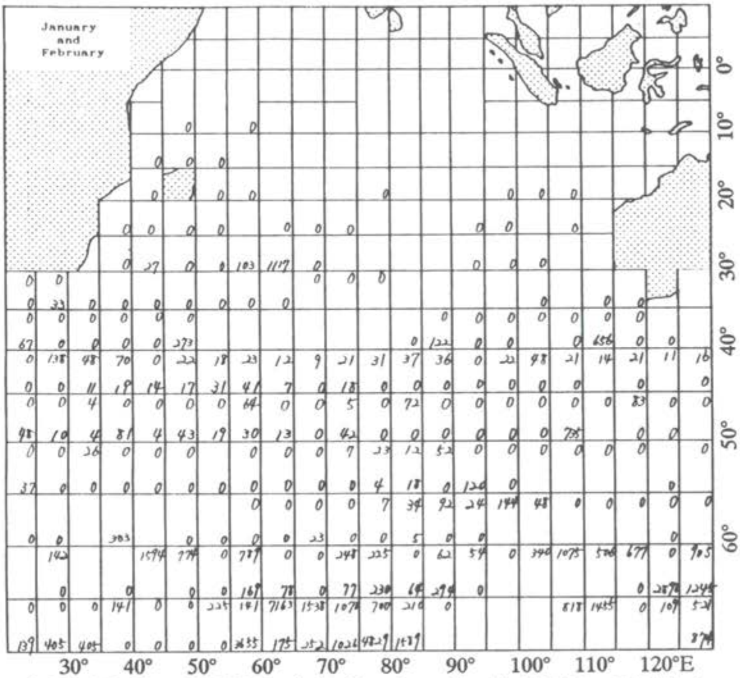

Fig. 39. Killer whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, January (top) and February (bottom). Secondary sightings included.

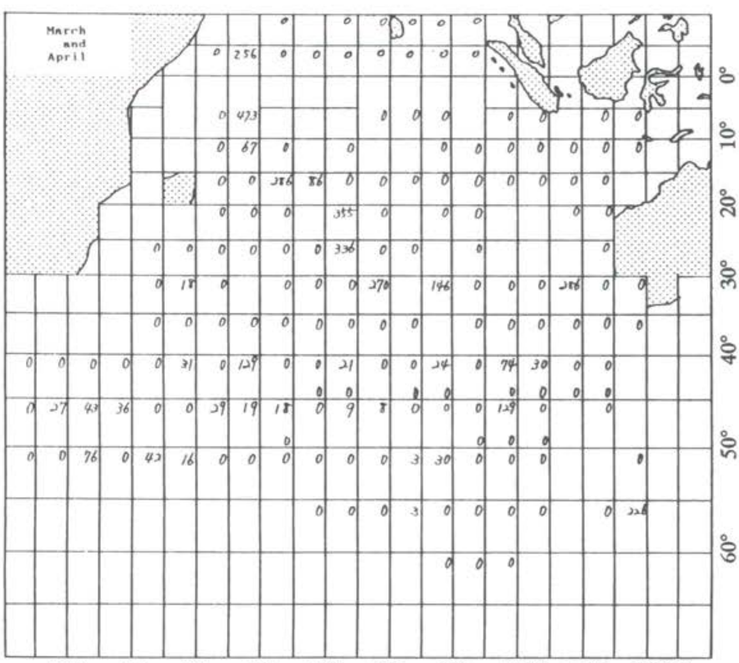

Fig. 40. Killer whales sighted per 10,000 nautical miles of searching in 1965/66 to 1984/85, March (top) and April (bottom). Secondary sightings included.

Balaenopterid Sightings in the Western Tropical Indian Ocean (Seychelles Area), 1982–1986

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ABSTRACT

From 1982 to 1986, 964 balaenopterid sightings were recorded by French tuna-seiners fishing around the Seychelles islands. An area of concentration was identified in the eastern part of the archipelago, at about 5°S and between 55° and 65°E. The number of sightings is particularly high from November to March, during the North West monsoon when the equatorial counter-current is established in the area. By contrast, sightings are rare during the South East monsoon. Because the period with most sightings roughly corresponds to the austral summer, it seems unlikely that the balaenopterids recorded in the area at this time of the year belong to the migratory species of the Southern Hemisphere.

Keywords: sightings-incidental; baleen whales; fisheries; fish; distribution; oceanography; migration; sperm whale; Bryde's whale; fin whale.

INTRODUCTION

Following two exploratory cruises (December 1980 to March 1981 and November 1981 to July 1982), the French tuna fleet expanded its operations into the western tropical Indian Ocean. Today an average of some twenty tuna seiners, based in the Seychelles (Mahé), fish year round, mainly between 5°N and 15°S and 45° and 75°E. During daylight hours a permanent look-out on each vessel searches for signs (including whales) which may indicate the presence of tuna (Stequert and Marsac, 1983). Since 1982, whale sightings have been reported on forms completed each day by captains. The information is stored on computer in the tuna data base of the Seychelles' 'Antenne ORSTOM' (Institut Français de Recherche Scientifique pour les Développements en Coopération) in Victoria (Mahé).

Thanks to the co-operation of F. Marsac during a recent visit to Victoria these data were extracted and compiled for the five years (1982–86). The present work is the result of a programme of research co-operation (established in 1982) between the Centre National d'Étude des Mammifères Marins and the Seychelles' Antenne ORSTOM. The results are interesting as there is little information on the mysticetes in this area (for recent summaries see Keller *et al.*, 1982; Robineau, 1982; Leatherwood, 1986).

MATERIALS AND METHODS

The fishing form comprises a table where each line represents either a seine trial or a sighting day (if no sets have been made). In the former case, the position plotted precisely indicates the locality of sighting. In the latter case, the position indicates the vessel's position at midday. Entries in the 'appearances' section of the form indicate the signs seen which suggested the presence of tuna: wrecks, birds, whale sharks (*Rhincodon typus*), and whales. The presence of one (or more) whale(s) is noted, but the number of individuals in 'groups' is not recorded. Discussions with the captains revealed that the whales are usually solitary, although small groups of 2 or 3 individuals may be observed occasionally. It is possible, of course, that the same animal (or group) may be encountered several times by the same vessel or be reported by different vessels.

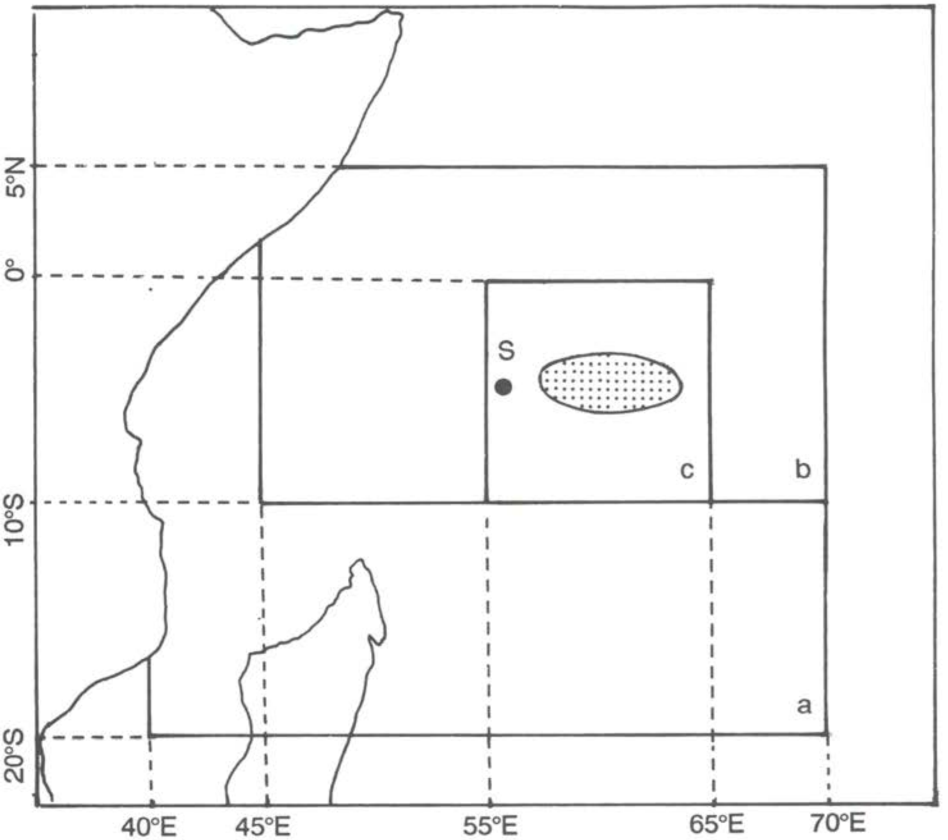

Fig. 1: Western tropical Indian Ocean: (a) area where all sightings were made; (b) area where 97% of the sightings were made; (c) area in which sightings were most numerous, especially in the hatched area located east of the Seychelles (S).

The species is not determined. However, the fishermen can clearly recognise sperm whales, *Physeter macrocephalus*, which, as they are never seen in association with tuna schools unless it is a carcase floating on the surface, are either not recorded or are specifically noted. Further, as southern right, *Eubalaena australis*, whales do not usually come as far north as 25°S (Townsend, 1935; Keller *et al.*, 1982), the whales observed in this region are probably all or mostly balaenopterids.

RESULTS

From 1982 to 1986, 964 sightings of whales were recorded. When plotted by 5° square, all fall within an area bounded by 5°N – 20°S and 40° – 70°E (Fig. 1 a); 97% of them are within the area bounded by 5°N – 10°S and 45° – 70°E (Figs 1b and 2). Sightings were particularly dense in an area east of the Seychelles islands (Fig. 1c hatched area).

An examination of the data by month shows that in January and February, when they were most numerous, sightings were concentrated to the east of the Seychelles, around 5°S and 60°E. This concentration began to disperse in March, had disappeared by May and

(a) 45°E – 70°E, 5°N – 10°S

1 1 264	2 18 1263	3 3 891	4 0 119	5 0 26
6 43 897	7 32 1606	8 182 2725	9 233 2948	10 10 768
11 11 724	12 34 1517	13 181 1900	14 160 1684	15 29 522

(b) 45°E – 70°E, 5°N – 10°S

1 0.379 264	2 1.425 70	3 0.337 297	4 0 -	5 0 -
6 4.794 21	7 1.992 50	8 6.679 15	9 7.904 12	10 1.302 77
11 0.152 66	12 2.241 45	13 9.526 10	14 9.501 10	15 5.555 18

Fig. 2: (a) numbers of sightings of balaenopterids (above) and total numbers of fishing days (below) from 1982 to 1986 [in 5° squares numbered from 1 to 15 in the upper right corner, between 5°N and 10°S, 45°E and 70°E]. (b) Balaenopterid sighting index (number of fishing days/number of balaenopterids sightings) by 5° square.

returned again in November. This monthly variation is illustrated in Fig. 3 for the area shown in Fig. 1b. These variations may be linked to annual climatic cycles in the area (see discussion). Sightings were most numerous during the North West monsoon (November to March), diminished considerably during the inter-monsoon period (April) and were rare during the South East monsoon (May to October).

From Fig. 4 it can be seen that the monthly fishing effort ('sighting effort') was reasonably high throughout the year, although it was slightly lower during much of the South East monsoon period. However, to confirm that monthly variation was not artifact of fishing effort, a monthly rarity index was calculated and plotted (Fig. 5). Index values confirm that sightings were more common during the North West monsoon. The general pattern for the area also applied in the more limited area defined as 0°-10°S and 55°-65°E.

The Index indices for this latter area also confirms that the areas apparently most visited by whales were squares 8, 9, 13 and 14 followed by squares 15 (Southwest Chagos) and 6 (West-Northwest Seychelles) (Fig. 2b).

DISCUSSION

Seasonality and distribution

The presence of the balaenopterids seems to mirror the well-characterised annual climatic cycle of the area. As noted above sightings in the eastern Seychelles, were particularly numerous during the North West monsoon along 5°S. This area corresponds precisely to the convergence separating the North Equatorial current (CNE) from the Equatorial Countercurrent (ECC) (Fig. 6a). During the South West monsoon, when sightings were rare, the convergence (and the more southerly divergence) disappears and a eddy system invades the area (Fig. 6b). In terms of the current system, then, the presence of balaenopterids coincided with the ECC, from November to March-April. The animals apparently left the area when the current changed.

Distribution

The presence of balaenopterids in areas where tuna are abundant is probably explained by a common feeding base. Convergences are high productivity areas which support large concentrations of small fish (Stequert and Marsac, 1986). In the Seychelles area, the tuna appear to feed on small fishes which can also be eaten by some balaenopterid species (in

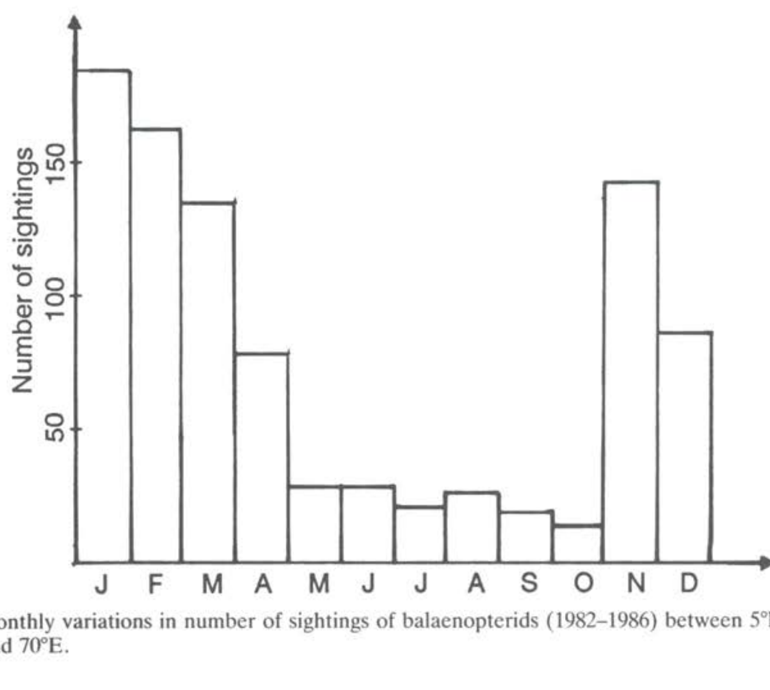

Fig. 3: Monthly variations in number of sightings of balaenopterids (1982–1986) between 5°N and 10°S, 45°E and 70°E.

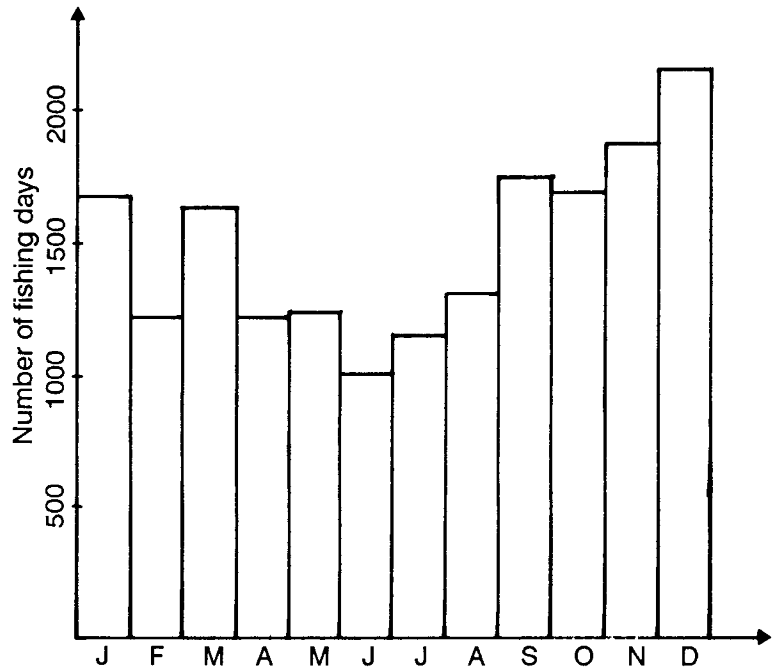

Fig. 4: Monthly variations in fishing effort (1982 to 1986) between 5°N and 10°S, 45°E and 70°E.

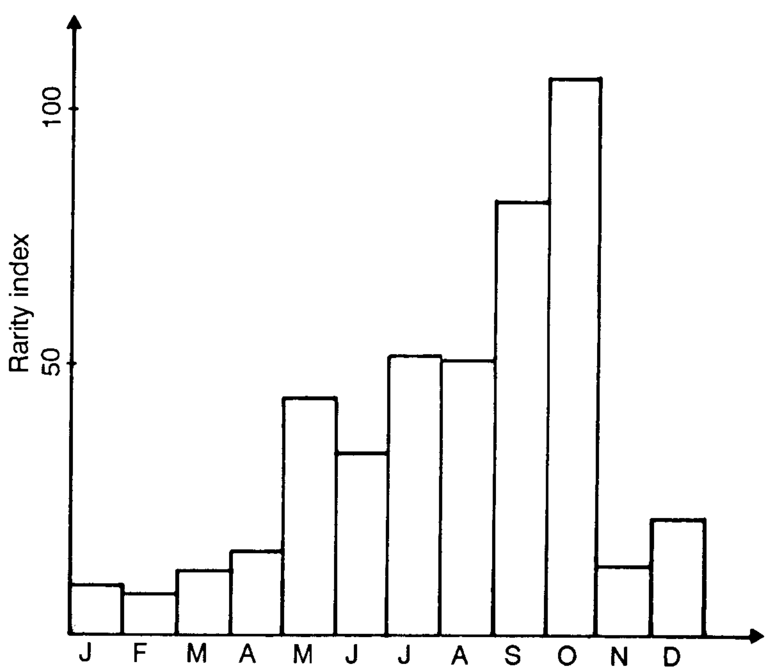

Fig. 5: Monthly variations in 'rarity index' of balaenopterids (number of fishing days required to make one sighting) from 1982 to 1986, between 5°N and 10°S, 45°E and 70°E.

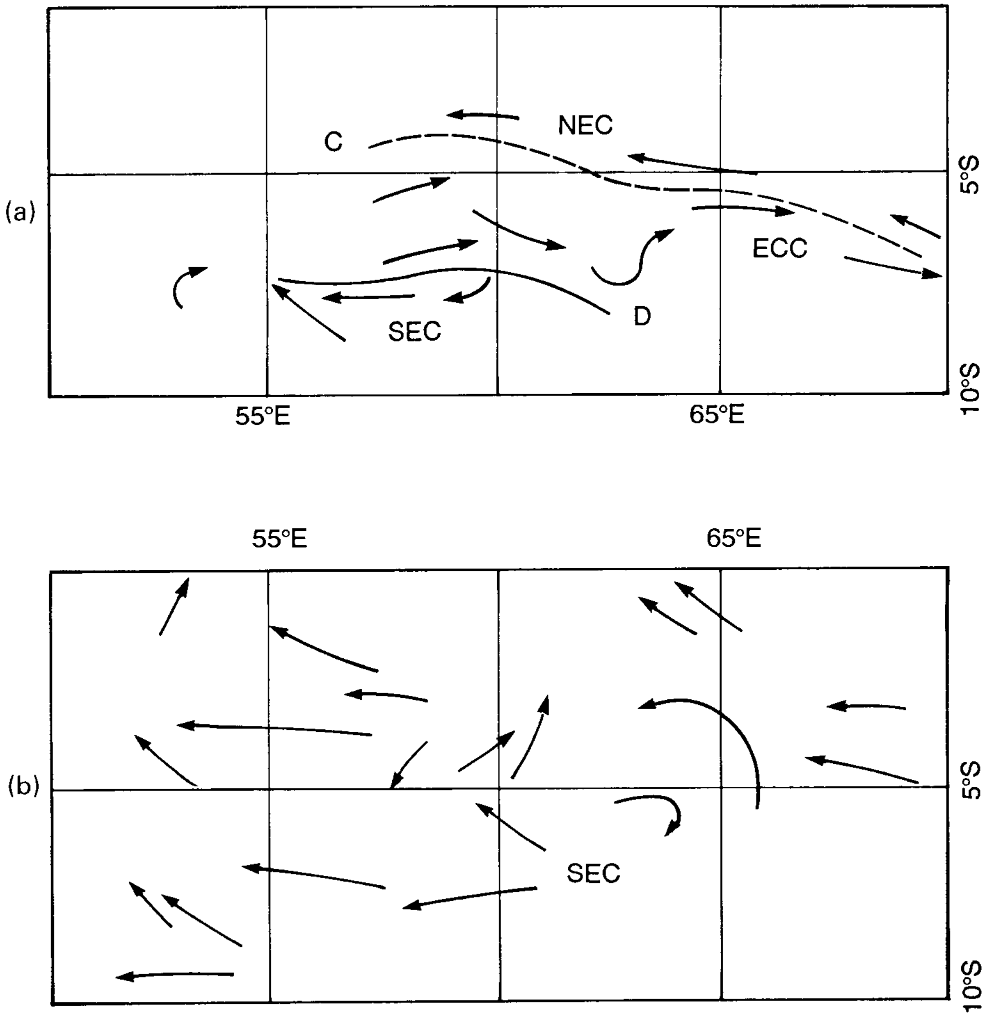

Fig. 6: (a) Northwest monsoon – general direction of currents between 0° and 10°S, 50°E and 70°E: C=convergence, D=divergence, ECC=equatorial counter-current, NEC=North equatorial current, CSE=South equatorial current. (b) Southeast monsoon – general direction of currents between 0° and 10°S, 50°E and 70°E. (Same abbreviations as in Fig. 6a.)

particular Bryde's whales *Balaenoptera edeni* and fin whales, *B. physalus*). This view is supported by several observations of balaenopterids feeding with tuna on the same school of small fish (Le Lay, an observer for almost five years on the plane used by the French tuna fleet, pers. comm.).

Species identification

Information provided by P. Le Lay gives some insight into the species reported by the tuna fishermen. From his observations in the area, sperm whales are the most frequently encountered species (in small groups of 4 to 10 individuals). The next most common are balaenopterids of a similar size to the sperm whales. Of these, the humpback whale, easily recognisable by its large white flippers, is rare (only ten or so observations within five years). Also rare are very large whales, about twice as large as sperm whales and with a light colour, (about ten sightings within five years); these are probably blue whales (*Balaenoptera musculus*). It appears that the balaenopterids reported by the tuna fishermen are principally individuals of about 15m in length and thus are probably sei whales (*B.borealis*) or Bryde's whales (*B.edeni*), although the much larger fin whale (*B.physalus*), cannot be totally discounted.

The seasonal appearance of the balaenopterids discussed above may also provide insight into the identity of the species most often seen by the tuna vessels.

Most balaenopterid species follow a seasonal north-south migration pattern. In summer they are found in the productive cold waters where they feed intensely, building up energy reserves for the autumn migration to the winter breeding grounds, where little or no feeding occurs. Only a small number of individuals of such species/stocks appear not to migrate. Thus, the populations from each hemisphere remain separate (Brown and Lockyer, 1981). However, Bryde's whales appear to undertake relatively local migrations, remaining in warm waters throughout the year.

Waters in the Seychelles area are warm year-round. The peak presence of balaenopterids near the Seychelles corresponds to the austral summer; i.e. the period when the migratory Southern Hemisphere species are on the Antarctic feeding grounds. Thus, at the very most, these species are probably represented near the Seychelles by only a few non-migratory individuals. The small number of sightings reported during the austral winter suggests that whales from these Antarctic populations do not visit this area during their reproductive periods either.

The migratory patterns of balaenopterids in the Northern Indian Ocean are not known. Balaenopterid whales are encountered during the boreal winter in the Gulf of Aden, the Arabian Sea and the Bay of Bengal (Brown, 1957; Slijper *et al.*, 1964; Leatherwood, 1986; Leatherwood and Reeves, 1989). Their abundance seems to diminish during the boreal summer, which suggests that most are not part of the Southern Hemisphere migratory species (Slijper *et al.*, 1964). Slijper *et al.* (1964) put forward two hypotheses to explain this pattern:

(i) the arrival in the North Indian Ocean, during the boreal winter, of rorquals coming from the North Pacific Ocean;
(ii) the existence within the North Indian Ocean of local non-migratory stocks.

The second hypothesis appears the more plausible; it assumes that these 'local' populations undertake less extensive migrations, to other areas of the tropical Indian Ocean.

From the above discussion, therefore, it seems likely that the most common species seen in the studied area is the Bryde's whale, although field studies should be undertaken to confirm this.

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REFERENCES

Brown, S.G. 1957. Whales observed in the Indian Ocean. Notes on their distribution. *Mar. Obs.* 27:157–65.

Brown, S.G. and Lockyer, C.H. 1981. The migration of whales. pp. 165–237. *In:* D.J. Aidley (ed.) *Society for Experimental Biology Seminar Series.* 13. *Animal Migration.* Cambridge University Press, Cambridge.

Keller, R.W., Leatherwood, S. and Holt, S.J. 1982. Indian Ocean cetacean survey, Seychelle Islands, April through June 1980. *Rep. int. Whal. Commn* 32:503–13.

Leatherwood, S. 1986. Whales, dolphins and porpoises of the Indian Ocean Sanctuary: a catalogue of available information. Hubbs Marine Research Center Technical Report 87–197. 206pp.

Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985–1986. *UNEP Mar. Mammal Tech. Rep.* 1:[vi], 1–138.

Robineau, D. 1982. Distribution des grands cétacés de l'Océan Indien occidental. *Ann. Soc. Sci. Nat. Charente-Marit.* Suppl. Decembre 1982:17–23.

Slijper, E.J., Van Utrecht, W.L. and Naaktgeboren, C. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. *Bijdr. Dierkd.* 34:3–93.

Stequert, B. and Marsac, F. 1983. *Péche thonière à la senne: experience dans l'océan Indien.* ORSTOM, Paris. 30pp. [In French].

Stequert, B. and Marsac, F. 1986. La pêche de surface des thonides tropicaux dans l'ocean Indien. *FAO Fish. Tech. Pap.* 282:1–213. [In French].

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, N.Y.* 19:1–50+6maps.

Cetacean Observations from the Somali Democratic Republic, September 1985 through May 1987

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ABSTRACT

Two vessels, the M/V *Bastesen* and the M/V *Beinta*, operated along the Gulf of Aden and northern Indian Ocean coasts of the Somali Democratic Republic from August 1985 through May 1987. Their fishing activities carried them on a routine basis from Djibouti, Republique de Djibouti, to the Horn of Africa and, on many cruises, into the Indian Ocean as far south as 8°N. The frequent and regular presence of these vessels afforded a unique research opportunity since the few previous surveys along the Somalian coast were transitory and/or of short duration. There were 398 sightings of cetaceans representing at least 14 species: blue whale (*Balaenoptera musculus*), Bryde's whale (*Balaenoptera edeni*), Sperm whale (*Physeter macrocephalus*), melon-headed whale (*Peponocephala electra*), false killer whale (*Pseudorca crassidens*), killer whale (*Orcinus orca*), short-finned pilot whale (*Globicephala macrorhynchus*), Indo-Pacific hump-backed dolphin (*Sousa chinensis*), common dolphin (*Delphinus* sp.), bottlenose dolphin (*Tursiops* sp.), Risso's dolphin (*Grampus griseus*), spotted dolphin (*Stenella* sp.), striped dolphin (*Stenella coeruleoalba*) and spinner dolphin (*Stenella* sp.). Sighting locations and related environmental data are discussed. Some trends between years were seen in the occurrence and location of blue, killer and short-finned pilot whales.

INTRODUCTION

Two vessels, the M/V *Bastesen* and the M/V *Beinta*, operated along the Gulf of Aden and northern Indian Ocean coasts of the Somali Democratic Republic from August 1985 through May 1987. Their fishing activities and movements were determined by requirements of their participation in a fishery exploration/pilot project funded by the World Bank and overseen by the North East Coast Fisheries Enterprise (NECFISH), an autonomous agency of the Somali government. The project consisted of an inshore component, to work with the artisanal fishery for production of product for local consumption, and an offshore component, to produce product for commercial exportation. Searches for marine mammals were carried out during the offshore component of the NECFISH project, but as a personal undertaking, not an official part of the project.

The frequent and regular presence of these vessels afforded a unique research opportunity since the few previous surveys along the Somalian coast were transitory and/ or of short duration. As a result, workers had been able to verify the presence of many fish and turtle species in the Indian Ocean and Red Sea, but not in the Gulf of Aden and the western Indian Ocean (e.g. Fischer and Bianchi, 1984). The apparent gaps in distribution also are reflected in a lack of representative specimens in museum collections from these latter areas.

The NECFISH exploratory fishing area extended from about Berbera, Somalia, (approximately 45°E) east to approximately 52°E and north to approximately 13°N in the Gulf of Aden, with a southern boundary in the Indian Ocean of approximately 8°N (Fig. 1). Records of environmental data, fish activity and location, vessel activity and fish catch statistics were collected on a routine basis on board both fishing vessels. The two biologists assigned to the offshore project transferred back and forth between the two vessels during the project.

Searches for marine mammals were made by GJS and at times JAS during all daylight travel (0600–1800hrs) including the area as far west as the Republique de Djibouti, where the offshore project was based. We have been granted permission by the Ministry of Fisheries of the Somali Democratic Republic to analyze and report here on the environmental and marine mammal sighting data collected during the NECFISH project. We hope that further data releases from the Somali Democratic Republic will allow correlation of the fish catch- and sightings-data with marine mammal sightings and specimens from the NECFISH project.

GEOGRAPHICAL AND ENVIRONMENTAL CONDITIONS

The coastline of Somalia extends for approximately 3,300km, bounded along the Gulf of Aden on the north and the Indian Ocean on the east, making it one of the longest coastlines in Africa (Fig. 1). The Gulf of Aden portion stretches for approximately 925km (500nm) and consists of extensive sand beaches, rocky promontories and mountains dropping directly into the sea. The subocean topography is an extension of the terrestrial topography overlain with coral, rocks and intermittent flat sandy areas. Mangrove swamps exist near the Horn of Africa in the Gulf of Aden. Seamounts are located in both the eastern and western Gulf of Aden. The Indian Ocean portion has high vertical cliffs from the Horn south to near 4°N. Coastal dunes appear south of Eil (approximately 8°N) and continue uninterrupted to near the Kenyan border where mangrove swamps are frequent.

In both areas there is generally a very narrow subocean shelf, the 100fm contour, extending less than 6nm from shore. However, in one area of the Somalian northeast coast between the Horn of Africa (Cape Guardafui, 11°50′N, 51°17′E) and Ras Hafun (10°25′N, 51°20′E) the shelf is up to 27nm wide.

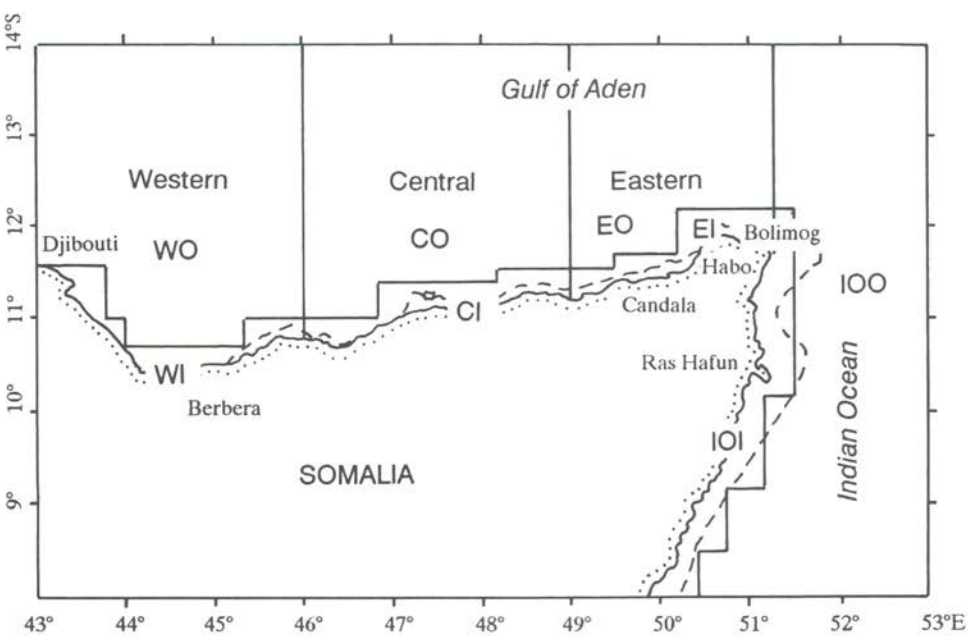


Fig. 1. Map showing boundaries of each project region, 100fm contour and key villages on the coast of Somalia.

Somalia's coastline is distinguished by strong, monsoon-driven upwelling, especially in the region of the wide shelf between the Horn of Africa and Ras Hafun (Wyrtki, 1973). This upwelling is the main factor affecting primary production along Somalia's north coast and in the entire Indian Ocean. The southwest monsoon current begins with the decay of the northeast monsoon in late April, reaches it's greatest strength in July and tapers off into October when it is gradually replaced by the northeast monsoon circulation. During the southwest monsoon, water from the South Equatorial Current forms the northward flowing Somali Current beginning at approximately 10°S (Fig. 2a).

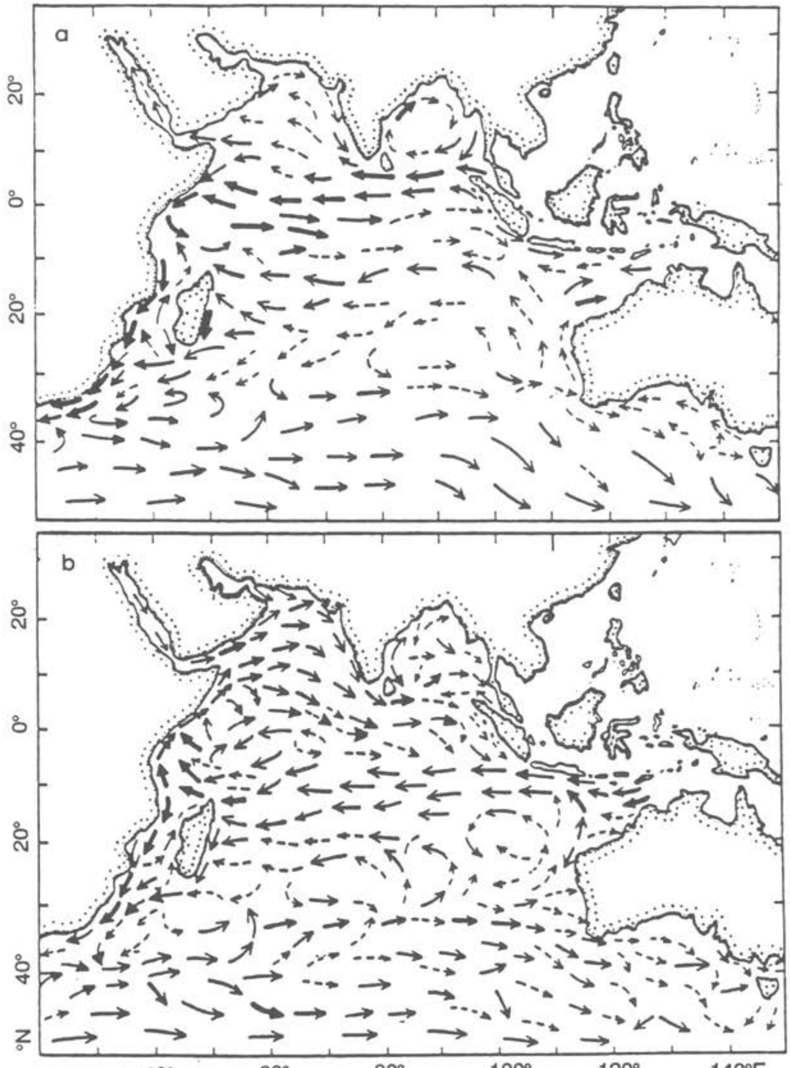


Fig. 2. Maps of the Indian Ocean current system during the southwest monsoon (a) and the northeast monsoon (b) (after Wyrtki, 1973).

Prevailing strong winds from the southwest, with speeds of over 600cm/s, impel the Somali Current, moving at roughly 300cm/s and transporting 50–65 million m^3/s of water, to continue its northerly flow along the Somali coast (Anonymous, 1987). The current turns eastward from the coast near the Horn of Africa, between 11° and 12°N, and flows towards the Arabian Sea. During the southwest monsoon, upwelling occurs east of Somalia in the Indian Ocean, especially in the region of Ras Hafun, between 5° and 11°N (Wyrtki, 1973). The turbulence associated with upwelling brings nutrient-rich (1.115–3.384gC/m^2 per day (Smith, 1984)), cold (<20°C) subsurface waters to the surface. The average surface water temperature during this period is about 24°C, the average salinity, 35.0ppt (Anonymous, 1987). Evans and Brown (1981) showed that the pattern of movement of the Somali Current during the southwest monsoon is variable between years, producing a pattern of gyres and eddies along the Somalian Indian Ocean coast. Cox (1979) hypothesized that these circulation patterns are dependent upon the intensity and directional shifts of the southwest monsoon wind as it interacts with the coastline of Somalia.

During the northeast monsoon (November to April), the surface current flow changes from clockwise to counter-clockwise in the northern Indian Ocean (Fig. 2b). The northeast winds are weak, as is the Somali Current with speeds less than 10cm/s, resulting in little surface turbulence. There are no striking upwelling areas during this time. The surface water drift is generally southward along the Somali Indian Ocean coast where it crosses the equator, then moves westward, forming part of the Equatorial Countercurrent (Wyrtki, 1973). During this period, inshore surface waters off Somalia's Indian Ocean coast have uniform temperatures (about 28–30°C) and an average salinity of 34.5ppt (Anonymous, 1987).

Northern Somalia has very little rainfall (90–450mm annually (Technical Unit of the State Planning Commission, Somali Democratic Republic, 1976)) and no continuously flowing rivers or streams. As a result, there are negligible quantities of nutrients entering the sea from terrestrial sources. In the absence of rivers, wind driven upwelling is the chief contributor to primary productivity, bringing nutrient rich waters to the surface. Satellite imagery during the months of February, March and April 1984 revealed extensive eddies of plankton in the area of the Horn of Africa (Wittenberg-Fay, 1987). The correlation of satellite imagery with fish, and secondarily cetacean, concentration in the area is beyond the scope of this report.

SURVEY METHODS

From September 1985 through May 1987 GJS participated in 20 cruises varying in length from 3 to 33 days (averaging 18.6 days) and totalling 371 days at sea aboard the M/V *Bastesen* and the M/V *Beinta* (Table 1). Visual observations were carried out on 289 days (2,615hrs) and over a distance of 17,313nm (32,029km) (Table 2).

The M/V *Bastesen* is 32.4m (106.3ft) overall length with a cruising speed of eleven knots. It was equipped with two ELAC, SIMRAD SA4 sonars, Wesmar sonar, SCANMAR sonde, SIMRAD ordinary and color scopes, two radars and satellite navigation. The *Bastesen* is of Norwegian registry and was built in Norway in 1979 (Natural Resources Consultants, 1987).

The M/V *Beinta* is 32.72m (107.4ft) overall length with a cruising speed of eleven knots. Electronics included two Furuno scanning sonars, a Furuno color scope, Furuno ESD, Furuno Fish Scope, two Furuno radar units, a Scanmarsone, Furuno satellite navigation and Shipmate Decca. The *Beinta* is of Danish registry and was built in Scotland in 1981 (Natural Resources Consultants, 1987).

Table 1

Duration and dates of NECFISH offshore project cruises in which GJS participated.
Cruise duration (Total days at sea = 371)

Vsl/Cruise	Date	Number of days	Vsl/Cruise	Date	Number of days
Beinta/3	23 - 30 Sept 85	8	*Beinta*/13	18 - 20 Aug 86	3
Beinta/4	7 - 30 Oct 85	24	*Bastesen*/12	5 Sep - 7 Oct 86	33
Beinta/5	16 Nov - 1 Dec 85	16	*Beinta*/15	11 - 30 Oct 86	20
Beinta/6	3 - 18 Dec 85	16	*Beinta*/16	4 - 20 Nov 86	17
Beinta/8	28 Jan - 23 Feb 86	27	*Beinta*/17	1 - 17 Dec 86	17
Bastesen/7	28 Feb - 25 Mar 86	26	*Beinta*/18	3 - 21 Jan 87	19
Bastesen/8	6 - 25 Apr 86	20	*Beinta*/19	29 Jan - 21 Feb 87	24
Bastesen/9	12 - 31 May 86	20	*Beinta*/20	27 Feb - 17 Mar 87	19
Bastesen/10	7 - 18 Jun 86	12	*Beinta*/21	22 Mar - 8 Apr 87	18
Bastesen/11	8 - 18 Aug 86	11	*Beinta*/22	17 Apr - 7 May 87	21

Vessel operations were directed primarily by the project manager in Djibouti and secondarily by the biologists and captains on board each vessel. There was no regular or systematic search course or transect set for the vast majority of these monthly surveys. Both vessels operated as commercial fishing vessels, searching out areas of prime fishing; marine mammal surveys were not an officially recognized component of the project. As a result, the vessels did not always divert from their cruise tracks or fishing activities to permit observers to more closely observe marine mammals or confirm identifications. Photographs were taken of animals whenever practical. Only sightings of marine mammals made and noted by GJS and JAS were included in this analysis, as those noted by others were incidental and could not be associated with visual search effort.

The following environmental data and vessel position and activity were recorded every two hours of a 24 hour day and entered into a computer data base: vessel name and cruise number; date; time; observer name; latitude and longitude; vessel course; wind direction and speed; swell direction and height; cloud cover; sea state; air and sea surface temperature; vessel movement codes; searching method codes; and vessel activity codes. Except for sea surface temperature, all environmental data included in this report was collected by GJS. All sea surface temperatures from the M/V *Bastesen* are included here because this vessel had a direct readout of sea surface temperatures in the wheel house. Sea surface temperatures from the M/V *Beinta* are included here only when GJS was aboard as they were obtained by manual bucket dipping while the vessel was underway.

Marine mammal sightings were recorded onto a standardized form immediately following the observation. Each sighting was given a unique number and entered into a separate computer data base. Recorded at the time of the sighting were: observation number; observer name; date; time; common name; general locality (relationship to the nearest landmark); latitude and longitude; sea surface temperature (Celsius); sea state; number of animals; mixed school (Y,N); distance from vessel; photos (Y,N); depth (m); and remarks. The reliability of the identification of sightings is indicated in the common name: 1) an unidentified whale or dolphin denotes a sighting where a name could not be reliably assigned; 2) a name followed by a ? denotes a sighting where there was confidence in the identification but some doubt remained; and 3) the presence of a name with no ? denotes a sighting where there was full confidence in the identification. Field identification was aided by reference to Leatherwood and Reeves (Leatherwood and Reeves, 1983). When available, photographs were later examined to aid in species identification.

Table 2

Time spent searching (hrs), distance searching (nm) and percent of total time spent searching summarised for each project region, each month and for all regions combined.

Vessel/Cruise	Project month	Time	Dist.	%	Time	Dist.	%
			WI			*WO*	
Beinta/03	Sep. 1985	2.13	15.68	4.1%	14.00	105.41	27.2%
Beinta/04	Oct. 1985	12.80	103.78	6.4%	8.75	61.08	4.4%
Beinta/05	Nov. 1985	11.54	87.19	7.4%	13.37	103.55	8.6%
Beinta/06	Dec. 1985	9.70	72.92	7.4%	7.63	57.56	5.8%
Beinta/08	Jan. 1986	4.00	24.00	9.2%	17.00	99.78	39.3%
Beinta/08	Feb. 1986				15.00	94.05	7.1%
Bastesen/07							
Bastesen/07	Mar. 1986	14.04	98.66	6.1%	9.96	74.03	4.4%
Bastesen/08	Apr. 1986	13.50	92.30	7.4%	6.46	42.51	3.5%
Bastesen/09	May 1986	7.92	52.44	4.3%	18.36	131.59	9.9%
Bastesen/10	Jun. 1986	6.38	43.38	34.5%	12.13	82.03	65.5%
	Jul. 1986						
Bastesen/11	Aug. 1986	2.04	18.01	3.8%	9.96	87.94	18.4%
Beinta/13							
Bastesen/12	Sep. 1986	19.75	180.81	28.2%	8.00	69.19	11.4%
Beinta/15	Oct. 1986	4.50	31.35	2.5%	14.04	106.63	7.9%
Beinta/16	Nov. 1986	33.54	176.93	27.8%	29.93	200.30	24.8%
Beinta/17	Dec. 1986				13.46	107.51	9.4%
Beinta/18	Jan. 1987	6.75	53.92	5.0%	19.54	155.00	14.6%
Beinta/19							
Beinta/19	Feb. 1987	5.25	26.22	3.6%	21.25	133.24	14.8%
Beinta/20							
Beinta 20	Mar. 1987				18.68	119.97	9.0%
Beinta/21							
Beinta/21	Apr. 1987	7.27	51.14	8.2%	20.40	133.51	22.9%
Beinta/22							
Beinta/22	May 1987				7.00	56.22	10.2%
	Totals	161.0	1128.73		284.8	2021.1	
			CI			*CO*	
Beinta/03	Sep. 1985	35.38	264.86	68.7%			
Beinta/04	Oct. 1985	14.05	98.20	7.1%	8.21	57.48	4.1%
Beinta/05	Nov. 1985	23.61	177.31	15.2%	4.04	30.32	2.6%
Beinta/06	Dec. 1985	69.90	525.51	53.3%			
Beinta/08	Jan. 1986	20.34	119.86	47.0%			
Beinta/08	Feb. 1986	55.89	334.03	26.4%	31.70	167.67	15.0%
Bastesen/07							
Bastesen/07	Mar. 1986	25.96	181.34	11.3%	2.04	15.16	0.9%
Bastesen/08	Apr. 1986	25.34	174.38	13.8%			
Bastesen/09	May 1986	27.34	190.10	14.8%	9.38	64.78	5.1%
Bastesen/10	Jun. 1986						
	Jul. 1986						
Bastesen/11	Aug. 1986	14.00	98.38	25.9%	6.00	47.03	11.1%
Beinta/13							
Bastesen/12	Sep. 1986	23.28	203.05	33.3%			
Beinta/15	Oct. 1986	27.00	180.54	15.2%	3.96	31.75	2.2%
Beinta/16	Nov. 1986	34.74	254.08	28.8%	3.80	31.99	3.1%
Beinta/17	Dec. 1986				26.80	202.76	18.7%
Beinta/18	Jan. 1987	61.65	443.05	45.9%	14.62	84.87	10.9%
Beinta/19							
Beinta/19	Feb. 1987	12.50	62.49	8.7%			
Beinta/20							
Beinta 20	Mar. 1987	18.30	120.14	8.9%	16.03	101.51	7.8%
Beinta/21							
Beinta/21	Apr. 1987	13.29	93.04	14.9%	15.80	109.12	17.8%
Beinta/22							
Beinta/22	May 1987				11.00	82.70	16.1%
	Totals	502.5	3520.36		153.3	1027.08	

Table 2 continued.

Vessel/Cruise	Project month	Time	Dist.	%	Time	Dist.	%
			EI			*EO*	
Beinta/03	Sep. 1985						
Beinta/04	Oct. 1985	50.10	372.86	25.2%	28.68	201.63	14.4%
Beinta/05	Nov. 1985	13.90	104.43	8.9%	4.20	31.57	2.7%
Beinta/06	Dec. 1985	44.02	331.03	33.5%			
Beinta/08	Jan. 1986	1.91	11.49	4.4%			
Beinta/08	Feb. 1986	38.92	236.95	18.4%			
Bastesen/07							
Bastesen/07	Mar. 1986	30.50	217.80	13.3%	6.35	46.45	2.8%
Bastesen/08	Apr. 1986	57.03	377.55	31.1%	8.38	52.88	4.6%
Bastesen/09	May 1986	63.25	421.89	34.2%	26.34	182.60	14.3%
Bastesen/10	Jun. 1986						
	Jul. 1986						
Bastesen/11	Aug. 1986	14.80	55.24	27.4%	7.20	56.11	13.3%
Beinta/13							
Bastesen/12	Sep. 1986	18.97	182.62	27.1%			
Beinta/15	Oct. 1986	33.16	182.41	18.6%			
Beinta/16	Nov. 1986	7.00	49.19	5.8%	11.50	80.54	9.5%
Beinta/17	Dec. 1986	7.73	34.87	5.4%	13.32	99.18	9.3%
Beinta/18	Jan. 1987	28.28	183.91	21.1%	3.47	20.87	2.6%
Beinta/19							
Beinta/19	Feb. 1987	27.00	113.95	18.8%	2.00	10.05	1.4%
Beinta/20							
Beinta 20	Mar. 1987	76.83	385.93	37.2%	36.51	217.69	17.7%
Beinta/21							
Beinta/21	Apr. 1987	3.29	22.23	3.7%	15.08	105.75	17.0%
Beinta/22							
Beinta/22	May 1987	22.50	117.70	32.8%	6.00	45.00	8.8%
	Totals	539.1	3402.05		169.0	1150.32	
			IOI			*IOO*	
Beinta/03	Sep. 1985						
Beinta/04	Oct. 1985	60.94	430.77	30.7%	15.28	107.18	7.7%
Beinta/05	Nov. 1985	79.24	595.74	50.9%	5.91	44.48	3.8%
Beinta/06	Dec. 1985						
Beinta/08	Jan. 1986						
Beinta/08	Feb. 1986	43.55	261.57	20.6%	26.46	158.70	12.5%
Bastesen/07							
Bastesen/07	Mar. 1986	79.04	530.17	34.5%	60.93	429.36	26.6%
Bastesen/08	Apr. 1986	72.40	490.65	39.5%			
Bastesen/09	May 1986	16.08	105.03	8.7%	16.08	105.03	8.7%
Bastesen/10	Jun. 1986						
	Jul. 1986						
Bastesen/11	Aug. 1986						
Beinta/13							
Bastesen/12	Sep. 1986						
Beinta/15	Oct. 1986	72.88	352.91	40.9%	22.67	113.33	12.7%
Beinta/16	Nov. 1986						
Beinta/17	Dec. 1986	82.00	488.65	57.2%			
Beinta/18	Jan. 1987						
Beinta/19							
Beinta/19	Feb. 1987	72.02	412.08	50.0%	3.98	19.81	2.8%
Beinta/20							
Beinta 20	Mar. 1987	19.19	97.36	9.3%	20.98	127.67	10.2%
Beinta/21							
Beinta/21	Apr. 1987	12.27	72.24	13.8%	1.53	9.92	1.7%
Beinta/22							
Beinta/22	May 1987	22.00	110.27	32.1%			
	Totals	631.5	3947.44		173.8	1115.48	

Table 2 continued.

Vessel/Cruise	Project month	Number of days	Total - All regions	
			Time	Dist.
Beinta/03	Sep. 1985	7	51.50	385.95
Beinta/04	Oct. 1985	23	198.80	1432.97
Beinta/05	Nov. 1985	15	155.80	1174.59
Beinta/06	Dec. 1985	14	131.25	987.03
Beinta/08	Jan. 1986	4	43.25	255.14
Beinta/08	Feb. 1986	23	211.50	1252.97
Bastesen/07				
Bastesen/07	Mar. 1986	22	228.80	1592.97
Bastesen/08	Apr. 1986	18	183.10	1230.27
Bastesen/09	May 1986	18	184.74	1253.46
Bastesen/10	Jun. 1986	2	18.50	125.41
	Jul. 1986			
Bastesen/11	Aug. 1986	8	54.00	362.70
Beinta/13				
Bastesen/12	Sep. 1986	14	70.00	635.68
Beinta/15	Oct. 1986	18	178.20	998.92
Beinta/16	Nov. 1986	13	120.50	792.97
Beinta/17	Dec. 1986	13	143.30	932.97
Beinta/18	Jan. 1987	17	134.30	941.62
Beinta/19				
Beinta/19	Feb. 1987	19	144.00	777.84
Beinta/20				
Beinta 20	Mar. 1987	23	206.50	1170.27
Beinta/21				
Beinta/21	Apr. 1987	11	88.91	596.95
Beinta/22				
Beinta/22	May 1987	7	68.50	411.89
		Totals 287	2615.417	17,312.57

Effort was calculated by means of a visual search data base and characterized as the total numbers of daylight hours and distances searched for each vessel each day. Distance traveled was estimated from the average speed of the vessel during daylight hours, calculated from the Furuno satellite navigation fixes. It must be noted that visual search effort was carried out even at times when the vessel was not underway. The visual search data base was used to: track fish sighting locations; note their relationship to the presence of birds, marine mammals and debris; note the estimated school weight and depth; and note the bottom depth and distance from shore.

A tracing from a hand held *Sippican* expendable bathythermograph (XBT) was used to measure temperature at the sea surface and the thermocline at depths. XBT stations were chosen randomly by both vessels throughout the survey area and sometimes corresponded to fishing operations.

The study area was divided into four geographical sections, each of which was subdivided into an inshore (average within 15nm of shore) and offshore (average 15nm or more from shore) (Fig. 1) subsection. This distinction between inshore and offshore was determined by fishing vessel operations and is related to sea bottom topography. British Admiralty navigational charts were used.

The project regions of the Somali coast are designated: Western Gulf of Aden Inshore (WI); Western Gulf of Aden Offshore (WO); Central Gulf of Aden Inshore (CI); Central Gulf of Aden Offshore (CO); Eastern Gulf of Aden Inshore (EI); Eastern Gulf of Aden Offshore (EO); Indian Ocean Inshore (IOI); and Indian Ocean Offshore (IOO) (Fig. 1). This convention is followed in this report so that marine mammal sightings can be related with fish distribution at a later date.

RESULTS

A total of 398 marine mammal sightings, representing at least 14 species, was recorded (Table 3). The areas most commonly visited were the central (CI), eastern (EI) and Indian Ocean (IOI) inshore areas, which collectively accounted for 62.78% of the total distance searched (Table 4). As might be expected, these three areas produced the highest numbers of marine mammal sightings, 86, 109 and 118, respectively, and the highest number of sightings per 100nm searched, 2.44, 3.20 and 2.99, respectively (Table 4); these areas also collectively accounted for 77.86% of the total project sightings. The relatively high frequency of sightings per unit effort encountered in the area of the Horn of Africa, both in the Gulf of Aden and in the Indian Ocean, correlates with an area of known high productivity where seasonal monsoons create intense upwelling.

Because of fish availability and weather conditions, the vessels traveled and carried out visual searches primarily in the inshore areas (Table 4) and did not search all the project regions on each cruise (Table 3). For example, monsoons, especially the southwest monsoon, created sea conditions which made it difficult, if not impossible, to operate the fishing vessels in the Indian Ocean areas.

There was considerable variation in environmental conditions among the project regions as well as between years (Table 5, Fig. 3). Onset of wind direction shifts between monsoon periods varied between project regions (Table 5). Wind speed, as judged from Beaufort sea state observations, was highest (force 5 or greater) in the EI, EO, IOI and IOO areas during the end of the southwest monsoon in 1985, the onset and end of the northeast monsoon and beginning of southwest monsoon of 1986, the end of the southwest monsoon in 1986 and the onset of the northeast monsoon in 1987 (Table 5).

On the Indian Ocean coast the upwelling impinged upon the shallow shelf area and came into direct contact with the warmer waters flowing out of the Red Sea and Gulf of Aden. With light wind conditions, a distinct line of turbulence could be seen running parallel to the coast at the north east tip of Somalia. The interaction of these two major water bodies resulted in widely variable sea temperatures in all seasons. For example, sea surface temperatures ranged from lows of 20°C in December 1985 and 1986, to a high of 37°C in October 1985 (Fig. 3). The highest average temperatures in all areas occurred in May and June and from August through October at the onset and termination of the southwest monsoon (Fig. 3). Unfortunately, no data were collected during July of any year. The coldest average temperatures were recorded in the western and central Gulf of Aden from December through March in both years (Fig. 3). The eastern Gulf of Aden and Indian Ocean followed a similar pattern except for the unusually cold October 1986 (Fig. 3). Mean sea surface temperatures in the EI and IOI were 4.7 and 3.3°C warmer, respectively, in October 1985 than those in October 1986 (Fig. 3e-g).

In the Indian Ocean, upwelling, as indicated by stable water masses at the top of the thermocline, was at a minimum in January of both years (100m and 70m respectively) and February 1987 (72m) (Fig. 4d). Conversely, shallow stable water, indicating upwelling activity, was recorded by XBT recordings in April of both years (7m and 11m) (Fig. 4d).

Table 3

List of species observed and the number of sightings per species (probable but not confirmed sightings are shown in parentheses).

Identification	Number of sightings	(?)
Blue whale (*Balaenoptera musculus*)	6	(3)
Bryde's whale (*Balaenoptera edeni*)	13	(6)
Sperm whale (*Physeter macrocephalus*)	23	
Unidentified small whale	1	
Unidentified whale	36	
Melon-headed whale (*Peponocephala electra*)	1	
False killer whale (*Pseudorca crassidens*)	1	(1)
Killer whale (*Orcinus orca*)	3	
Short-finned pilot whale (*Globicephala macrorhynchus*)	10	
Indo-Pacific humpbacked dolphin (*Sousa chinensis*)	7	
Common dolphin (*Delphinus* sp.)	29	(2)
Bottlenose dolphin (*Tursiops* sp.)	76	(8)
Risso's dolphin (*Grampus griseus*)	5	(1)
Spotted dolphin (*Stenella* sp.)	41	(4)
Striped dolphin? (*Stenella coeruleoalba*)		(1)
Spinner dolphin (*Stenella* sp.)	38	(4)
Unidentified dolphin	78	

Table 4

Number of sightings, percent of total project distance searched, number of sightings per 100nm searched and sightings per hour searched for each project region.

Project region	Number of sightings	Percent of total project distance searched	Sightings per 100nm searched	Sightings per hour searched
WI	17	6.52%	1.51	0.11
WO	23	11.67%	1.13	0.08
CI	86	20.33%	2.44	0.17
CO	1	5.93%	0.10	0.01
EI	109	19.65%	3.20	0.20
EO	15	6.64%	1.30	0.09
IOI	118	22.80%	2.99	0.19
IOO	28	6.44%	2.51	0.16

The effect of the monsoon in the Gulf of Aden was less defined because of the influence of other water masses and too few XBT readings for the large area covered. From available thermocline data, little upwelling was seen from January to March in 1986, and January 1987 in the western region (Fig. 4a) and only during January 1986 and in 1987 in the eastern area (Fig. 4c). The shallowest thermoclines occurred in the Gulf of Aden in December 1985, April 1986 and 1987 and August 1987 (Fig. 4a-c). The top of the thermocline was shallowest, indicating upwelled waters, in the central and eastern Gulf of Aden in October, November 1985, and March, September, and October 1986 and April 1987 (Fig. 4b, 4c).

[*Text continues on p. 194*]

Table 5

Wind direction and Beaufort sea state as percent of total observations for each project region each month.

		Wind direction (% observations)								Beaufort sea state (% observations)							
Month	n	N	NE	E	SE	S	SW	W	NW	0	1	2	3	4	5	6	7+
Western Inshore Gulf of Aden (WI)																	
Aug 85	0																
Sep	3			100							100						
Oct	13		31	54	15						23	23	31	23			
Nov	6		80	20								50	50				
Dec	5		20	80								60	40				
Jan 86	2			100										100			
Feb	0																
Mar	8	13	88							38		13		50			
Apr	8		38	63							38	25		38			
May	5		100									60	40				
Jun	18	6				28	39	28		6	11	33	33	17			
Jul	0																
Aug	1						100					100					
Sep	27			11			15	74			4	30	30	37			
Oct	19	32	32	37							37	26	5	32			
Nov	21	5	29	67						10	5	24	52	10			
Dec	0																
Jan 87	5		60	40									20	20	60		
Feb	3		100									100					
Mar	0																
Apr	9	11	78	11							56		22	22			
May	0																
Jun	0																
Western Offshore Gulf of Aden (WO)																	
Aug 85	0																
Sep	9			100							33	56	11				
Oct	5			80	20						20	40	40				
Nov	8		38	63								88	13				
Dec	11			100								9	73	18			
Jan 86	10		70	30									40	50	10		
Feb	6		83	17										17	17	67	
Mar	9		33	67						11		22		67			
Apr	10		10	80	10						20		30	30	20		
May	14	14	29	57						13		64	14	7			
Jun	10		10	50		40						50	30		10		10
Jul	0																
Aug	11						100					18		64	18		
Sep	4			100								100					
Oct	18	6		83		11					50	33	11	6			
Nov	21		29	62	10					10	10	38	43				
Dec	13		15	85								8	85	8			
Jan 87	16		53	47						6	31	50		13			
Feb	14		21	79								7	79	14			
Mar	19		37	63								16	42	37	5		
Apr	20	10	30	55				5			15	40	25	20			
May	6		100								83	17					
June	0																

Continued

Table 5 continued.

		Wind direction (% observations)								Beaufort sea state (% observations)							
Month	n	N	NE	E	SE	S	SW	W	NW	0	1	2	3	4	5	6	7+
Central Inshore Gulf of Aden (CI)																	
Aug 85	0																
Sep	27	19	22	48				11			67	33					
Oct	12		67	33						8	58	33					
Nov	12		50	50							17	50	17	17			
Dec	51	17	79	4						6	16	20	29	18	12		
Jan 86	11		64	36							18	36	45				
Feb	37		91						9	3	41	11	22	11	5	3	5
Mar	26	28	68	4							12	4	46	31	8		
Apr	17		11	88								71	18	12			
May	18	28	56	17							22	56	17	6			
Jun	43	7					53	16	23		9	21	14	28	12	9	7
Jul	0																
Aug	47		15			32	26	15	13		11	57	9	21	2		
Sep	81	12	46	20		4	10	5	4	7	35	21	17	5	12	2	
Oct	40	23	8	70						23	10	20	33	15			
Nov	22	14	64	18	5					18	45	5	27	5			
Dec	0																
Jan 87	52		48	52							10	29	29	29	4		
Feb	8		75	25							38	50	13				
Mar	14		57					14	29			43	14	21	21		
Apr	8			13			50	38		13	63	25					
May	0																
Jun	0																
Central Offshore Gulf of Aden (CO)																	
Aug 85	0																
Sep	0																
Oct	6	50		50							50	50					
Nov	3		33	67								67	33				
Dec	0																
Jan 86	0																
Feb	17		75	25							29	6	41		12		12
Mar	1		100										100				
Apr	0																
May	5	20	20	20			20		20				40	40	20		
Jun	5						80	20				20	20	40	20		
Jul	0																
Aug	5					60		40					40			60	
Sep	0																
Oct	2			100									100				
Nov	2				100					50	50						
Dec	16		25	75								75	25				
Jan 87	8			100								13	25		13	50	
Feb	0																
Mar	9		44	56									22	44	33		
Apr	8		50	50							25	25	25	25			
May	6			100							83	17					
Jun	0																

Table 5 continued.

Month	n	Wind direction (% observations)								Beaufort sea state (% observations)							
		N	NE	E	SE	S	SW	W	NW	0	1	2	3	4	5	6	7+
Eastern Inshore Gulf of Aden (EI)																	
Aug 85	0																
Sep	0																
Oct	40	20	43	25				3	10	15	65	8	8	3	3		
Nov	8	50	50								75	13	13				
Dec	23	35	61	4						9	17	26	43	4			
Jan 86	1	100								100							
Feb	24		71	4	8		13		4		4	17	29	29	17	4	
Mar	25		61	28	6	6						28	16	32	12	12	
Apr	36		33	47	17	3					22	39	25	8	6		
May	48	38	58		2	2				15	19	23	27	10	6		
Jun	0																
Jul	0																
Aug	13		23			38		38				38	38	23			
Sep	59	15	14	25		2			44	3	29	25	39	3			
Oct	21	10		90						29	29		19	10	14		
Nov	19		95			5					26	53	21				
Dec	33	18	82								30	15	36	18			
Jan 87	51	22	67	12							8	22	43	16	12		
Feb	42	2	76	19		2				2	10	45	43				
Mar	69	9	39	36	10			6		4	10	30	19	29	4	3	
Apr	13	46	46		8					23	23	8	46				
May	11	9	64		18				9	64	9		18	9			
Jun	0																
Eastern Offshore Gulf of Aden (EO)																	
Aug 85	0																
Sep	0																
Oct	17		59	18	24					29	71						
Nov	2		100								50	50					
Dec	0																
Jan 86	0																
Feb	0																
Mar	3		67	33									33	33	33		
Apr	5			60	40							20	20	20	20	20	
May	17	18	29	41		12				12	6	35	24	18	6		
Jun	0																
Jul	0																
Aug	3		33			66							33		33	33	
Sep	0																
Oct	2	100											100				
Nov	6		100								17	17	17	50			
Dec	7		100									14	86				
Jan 87	2		100											100			
Feb	1			100							100						
Mar	22		27	68	5						18	36	32	14			
Apr	8		50		50							25	63	13			
May	3	100										100					
Jun	0																

Continued

Table 5 continued.

Month	n	Wind direction (% observations)								Beaufort sea state (% observations)							
		N	NE	E	SE	S	SW	W	NW	0	1	2	3	4	5	6	7+
Indian Ocean Inshore (IOI)																	
Aug 85	0																
Sep	0																
Oct	29	3		3	10	62	14	3	3		31	55	10	3			
Nov	43	52	20	2				16	9	9	30	30	30				
Dec	0																
Jan 86	0																
Feb	21		52	10	38					5	38		33	24			
Mar	45		48	7	30	16				27	24	11	27	7	2	2	
Apr	56	13	38	4	9	34	2			13	14	32	27	14			
May	7					100				14			43	43			
Jun	0																
Jul	0																
Aug	0																
Sep	0																
Oct	51	6	6	86	2					37	59	4					
Nov	0																
Dec	36	8	83	8								14	47	39			
Jan 87	0																
Feb	64	8	41	52						2	19	17	36	11	16		
Mar	12				42	42	17					33	58	8			
Apr	13		31	69						15	54	23	8				
May	14					100					71	29					
Jun	0																
Indian Ocean Offshore (IOO)																	
Aug 85																	
Sep	0																
Oct	17					76	18	6			12	59	18	12			
Nov	2	100										50	50				
Dec	0																
Jan 86	0																
Feb	20		55	35	10					5	30	15	30	20			
Mar	37		27	14	46	14				16	57	24	3	5			
Apr	0																
May	10					100						10	80			10	
Jun	0																
Jul	0																
Aug	0																
Sep	0																
Oct	6			33	67					83	17						
Nov	0																
Dec	1		100									100					
Jan 87	0																
Feb	3			100								33			66		
Mar	12			50	42	8					17		33	50			
Apr	1			100								100					
May	0																
Jun	0																

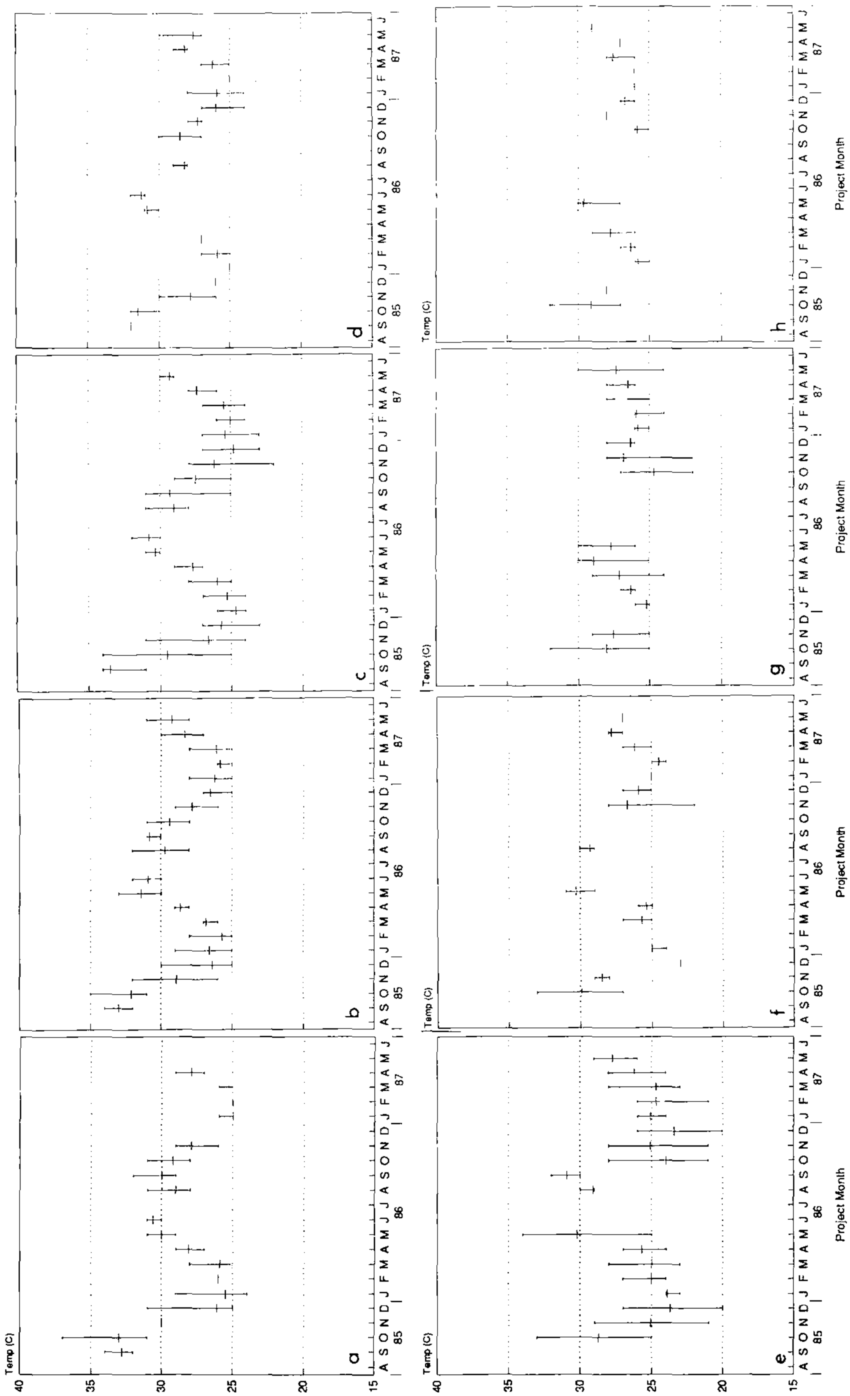


Fig. 3. Sea surface temperatures (minimum, maximum and mean) in the WI (a), WO (b), CI (c), CO (d), EI (e), EO (f), IOI (g) and IOO (h) for each project month.

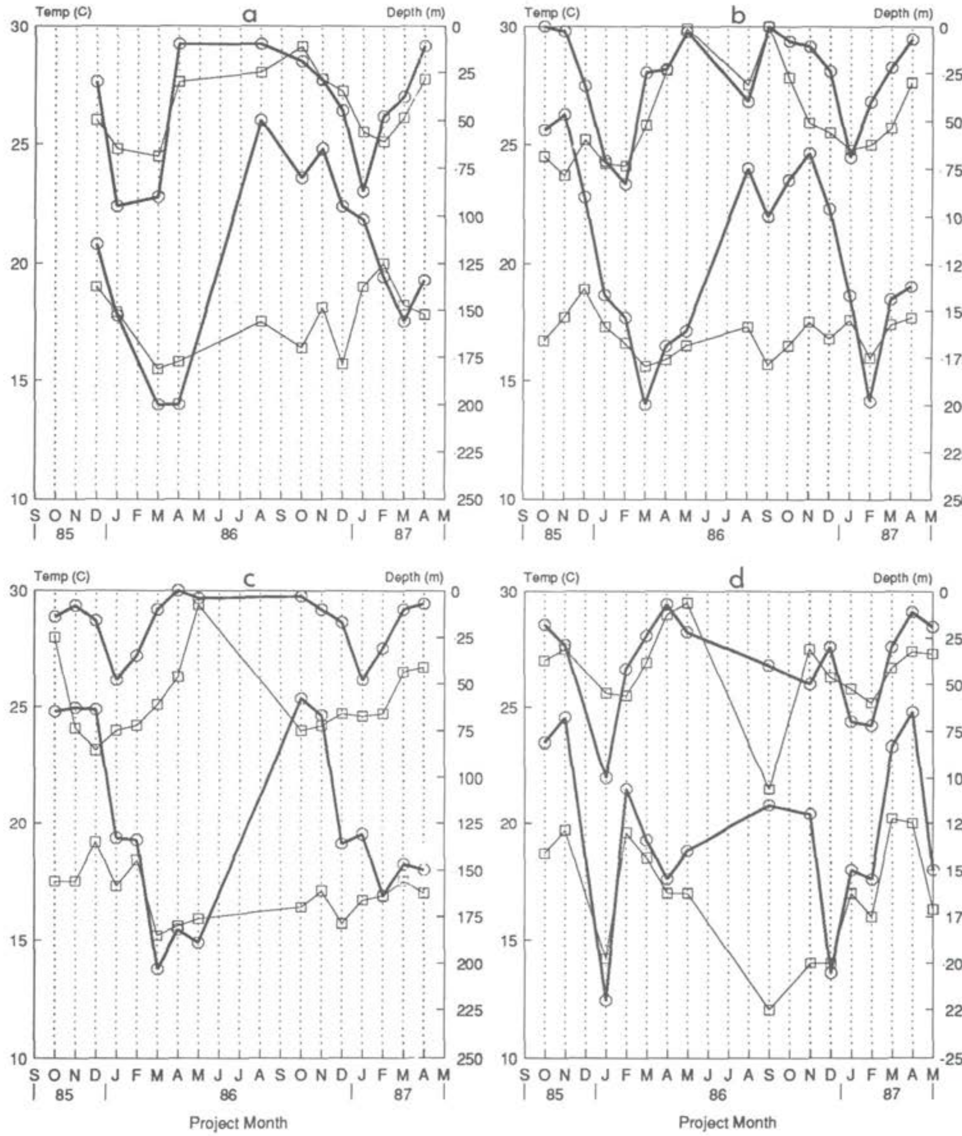


Fig. 4. Temperature at top and bottom of thermocline and depth of top and bottom of thermocline where bottom depth was greater than 100m in the western Gulf of Aden (a), central Gulf of Aden (b), eastern Gulf of Aden (c) and Indian Ocean (d).

Red pelagic crabs seemed more abundant in the pre-northeast monsoon period of 1985, as the purse seining gear was severely clogged with crabs on several occasions. Because purse seining was replaced by other fishing methods in 1986, it is difficult to accurately compare the abundance of red pelagic crabs between the two years. However, at times during 1985 red pelagic crabs were so plentiful that it was estimated by GJS that there was one crab for every three square meters of sea surface. Red pelagic crabs were not so abundant during 1986. Pelagic crabs have been observed in the stomachs of dolphinfish

(*Coryphaena hippurus*) in the Gulf of Oman and skipjack tuna (*Katsuwonus pelamis*) in the eastern Atlantic (Scott McEntire, pers. comm.). Red pelagic crabs (*Lupa pelagica*) were found in the stomachs of 58% of the yellowfin tuna (*Thunnus albacares*) examined during the project (Natural Resources Consultants, 1987). Also, *L. pelagica* was noted in the stomachs of bigeye tuna (*Thunnus obesus*), common dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*) and Spanish mackerel (*Scomberomorus commerson*).

Artisanal fishing along the northeast coast of Somalia is carried out using drift nets and hook and line techniques. Both fisheries target sharks along the entire coast, tuna near the Habo (11°47′N, 50°32′E) and Candala (11°28.5′N, 49°53′E) canneries and bottom fish in the western Gulf of Aden near Berbera (10°36′N, 45°02′E). Sharks and large pelagic fish are caught for local consumption by trolling with sail powered canoes at the convergence of the Gulf of Aden and the Indian Ocean. The fishermen report that their numbers (estimated to be 365 people involved throughout the year between Habo and Bandar Beila (09°27.5′N, 50°50.5′E) (Natural Resources Consultants, 1987)) and activity levels are very low; thus, they have little impact on the marine mammals of the area.

The artisanal drift net fishermen acknowledge catching dolphins infrequently, but the frequency of these catches is unknown. Dolphins are not used for food by the inhabitants of the northeast coast. The fishermen consider the tangling of dolphins in their nets a nuisance. The gillnets and tangle nets most commonly used on the coast are constructed of heavy dacron, nylon or cotton. In theory these should be easier for dolphins to detect and avoid than the monofilament nets used by the project vessels. Local fishermen do not differentiate between the various dolphin species, making it impossible to determine the species mix of the catch or to ascertain a difference in catch frequency by season. Hook and line fishermen apparently do not interact with dolphins during their fishing activities.

'A great number' of factory trawlers were operating in the project area (Natural Resources Consultants, 1987). Italian and Egyptian vessels and Asian vessels of unknown nationality trawl for lobster, shrimp and bottomfish in the northern Somalian coastal area. The Italian vessels are reportedly catching dolphins in their trawls at the rate of one or two a month and the dolphins are said to be eaten by the vessel crews (crew member, pers. comm.). The exact number and the species of the dolphins are unknown. There is no information on marine mammals taken by Asian pair trawlers as these vessels are fishing in Somalian waters with no government observers on board.

We present below accounts by species of all marine mammal observations. Individual sighting records are presented in Appendix 1. Note that there are no effort figures for small cetaceans for the months of September, October, November, and December 1985, as GJS was not systematically recording small cetacean sightings during those months.

Species Accounts

Blue Whale (Balaenoptera musculus)

Blue whales were identified positively six times, and tentatively three times. A total of 18 animals was seen, as singles or in groups of up to 6 (Appendix 1). Blue whales were observed only during October, November and December 1985 and possibly in October 1986. All the 1985 sightings were in the EI and IOI areas (Table 6, Fig. 5a). One group of whales was observed near 'schools of small tuna' and a second was 'associated with *Sardinella* sp.'. A note of 'birds over whales' may have indicated feeding activity. Other whales were seen 'rolling and splashing at surface'. A 'young' animal was seen on 11 December 1985.

Yukhov (1969) identified pygmy blue whales southeast of Cape Guardifui and along the Oman coast based on the fact that they raised their flukes clear of the surface upon diving while blue whales in the Antarctic do not.

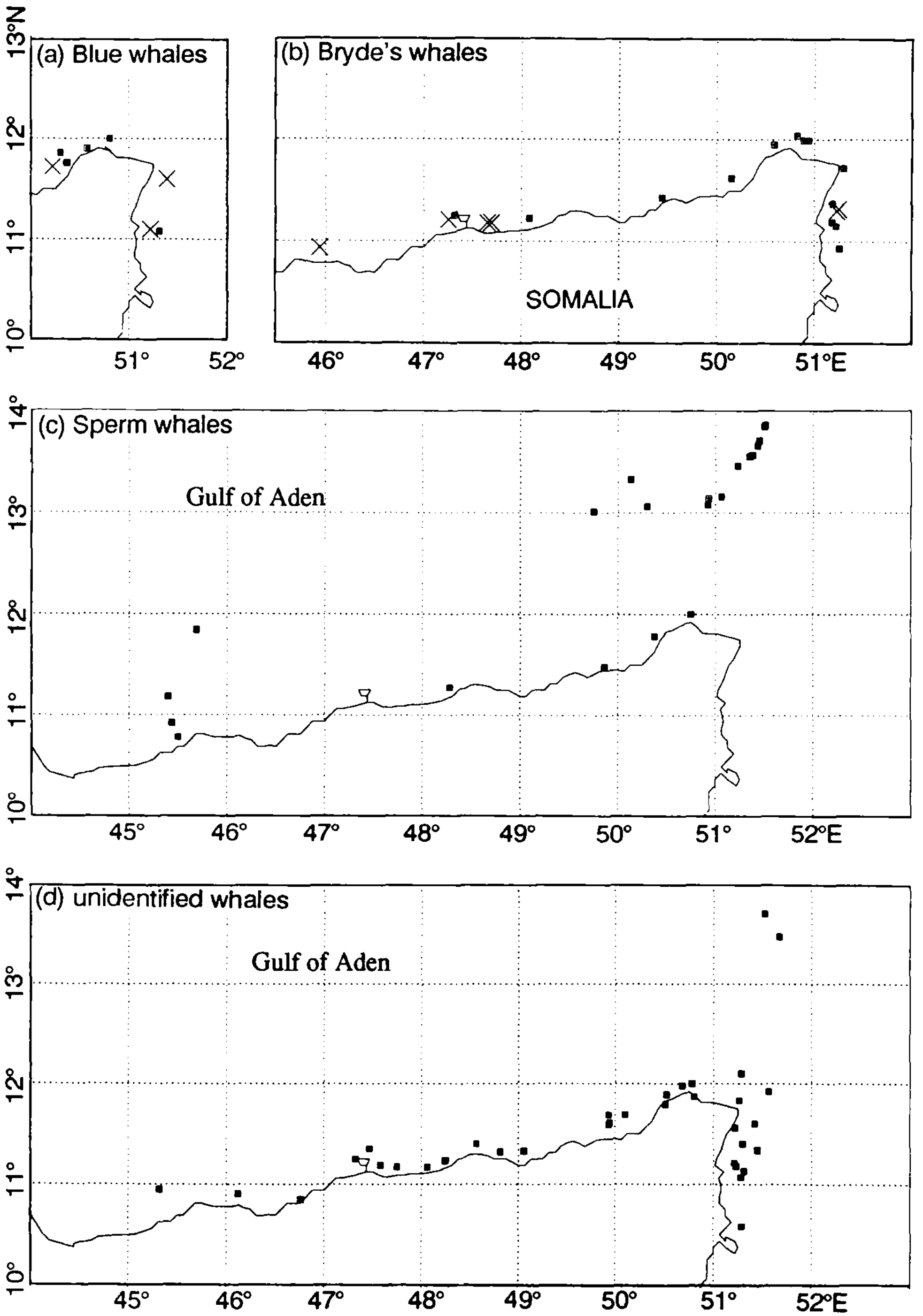


Fig. 5(a-d). Maps showing locations of sightings (solid dot – confident identifications, x – tentative identifications) of each species.

Bryde's Whale (Balaenoptera edeni)
There were 13 positive identifications of Bryde's whales and six tentative. A total of at least 29 animals was seen, as singles and groups of up to 3 or more. (Appendix 1)

Positive identifications of Bryde's whales occurred in the CI, EI and IOI areas (Table 6, Fig. 5b, Appendix 1). All sightings of this species logged were observed during February, April, September and October over the two field seasons (Table 6, Appendix 1).

Bryde's whales were observed breaching. They also approached the vessel, affording a good opportunity for observation. Whales were noted to have been associated with the following fish species: 'Jacks and mackerel', 'Indian oil sardines', 'Indian oil sardines' and 'wahoo', 'yellowfin tuna' and 'common dolphinfish and longtail tuna'. A group of whales observed 'rolling and splashing near Indian oil sardines' may well have been feeding. Depths at sighting locations ranged from 10 to 300m (averaging 75m). Some whales were observed as close as 5km from shore.

One Bryde's whale, which was photographed, (Fig. 6a) had a clearly visible chevron pointing posteriorly above the flippers.

Sperm Whale (Physeter macrocephalus)
Sperm whales were the most common large cetacean in the Gulf of Aden. They were seen and positively identified 23 times. Animals were observed as singles and in groups of up to 5 (or 7) individuals, totaling 59 to 62 animals (Appendix 1).

Six of the sightings were in inshore areas in water 17 to 550m deep; 17 sightings were in deep waters at or near seamounts in both WO and EO areas (Table 6, Fig. 5c). A series of 10 sightings was made on 8 March 1987 as the boat travelled over a series of seamounts in the eastern Gulf of Aden. On that day, there were 1.84 and 6.27 sightings per 100nm in the EO and IOO project regions, respectively, most in water deeper than 2,000m (Table 6, Appendix 1). Apparently, the whales were foraging; they rose steeply to the surface, emitting an explosive blow, stayed on the surface for some minutes and then dived vertically, exposing flukes and tail stock. Dive times were logged twice at 8 and 10 minutes each. The echo sounder displayed a scattering layer at 168fm.

Sperm whales were seen associated with 'longtail tuna', 'jumping manta rays', and 'unidentified tuna and small pelagic fish and bill fish'.

Young sperm whales were noted on 17 May 1986 (Fig. 6b) and 8 March 1987.

Somalis living along the coast report finding ambergris washed up on the beaches. It is prized by the locals for its high resale value. There was also a large sperm whale mandible mounted on the wall of the tuna cannery office in Habo.

Unidentified whales
There were 37 sightings of unidentified great whales, as singles and in groups of up to 4 (Appendix 1). Sightings were scattered through the Gulf of Aden and Indian Ocean areas (Table 6, Fig. 5d). The inability to positively identify animals in these sightings is attributable to poor visibility, distance or the inability to divert the vessel to get a better look or to wait for animals to resurface.

Melon-headed Whale (Peponocephala electra)
Melon-headed whales were positively identified only once, three individuals in the CI (Table 6, Fig. 5e, Appendix 1).

False Killer Whale (Pseudorca crassidens)
False killer whales were identified positively once (6 animals) and tentatively once (10 animals) in the EI and CI. Both sightings were in inshore areas, one near shore and the other in water 562m in depth. (Table 6, Fig. 5e, Appendix 1).

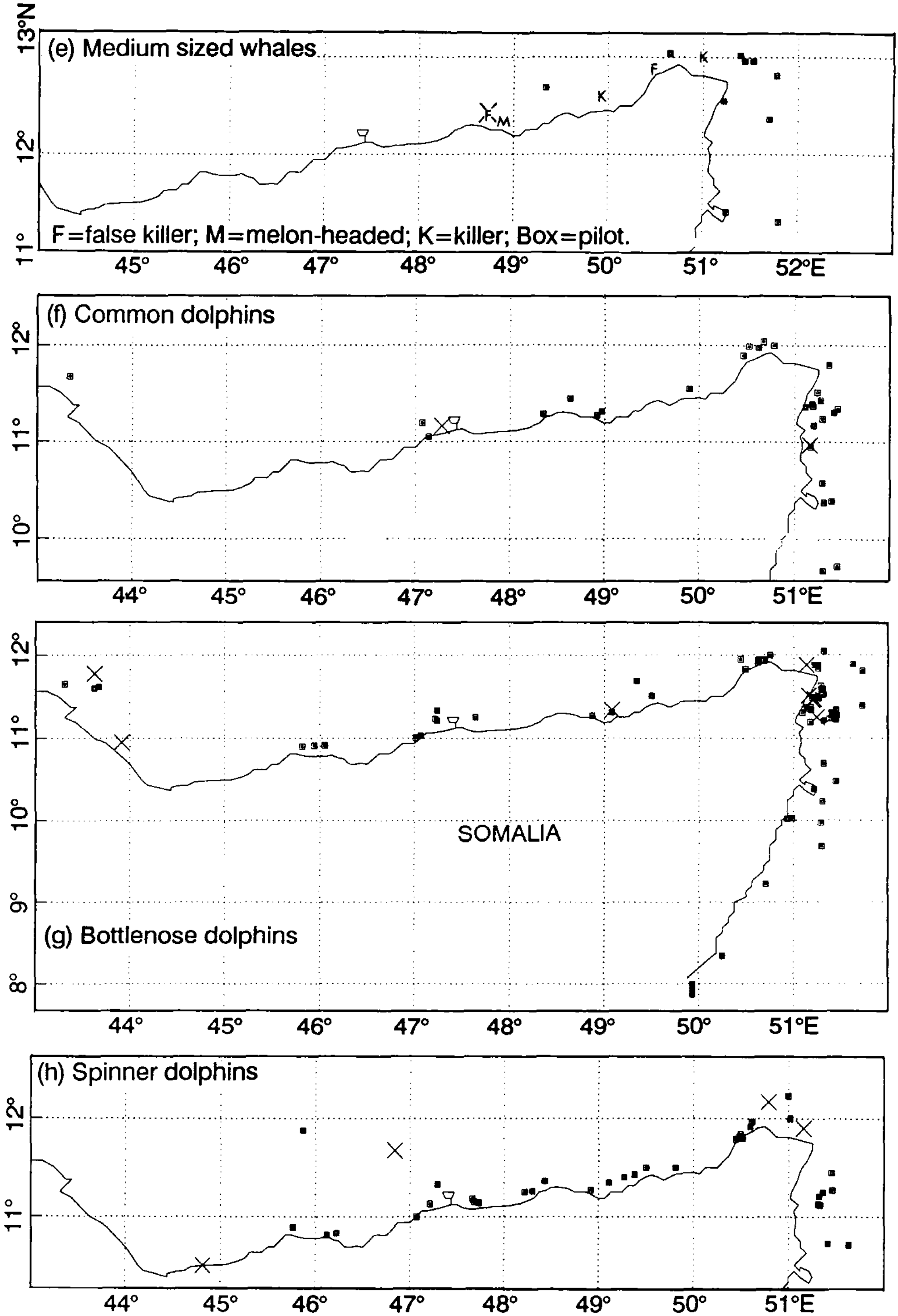


Fig. 5(e-h). Maps showing locations of sightings (solid dot – confident identifications, X – tentative identifications) of each species.

Killer Whale (Orcinus orca)
There were three observations of killer whales, between November 1985 and February 1986. Groups contained 2 to 7 individuals. Two of these were in the EI area and the other in the southern extreme of the project area in the Indian Ocean, where project vessels rarely visited. (Table 6, Fig. 5e, Appendix 1).

The pod of seven seen 7nm from shore on 6 February 1986 consisted of one adult male, three adult females/subadult males and three juveniles or calves (Fig. 6c). They were heading west in a close group and remained near the boat for 45 minutes.

Few sightings of killer whales have been recorded for the Somali coast. Robineau and Rose (1984) reported two sightings, 27 November 1978 and 7 January 1979, in the Gulf of Tadjoura, Republique de Djibouti. Yukhov (1969) reported killer whales 'in all areas of the Gulf' in October through December 1964, but does not present his cruise track or give the number of sightings. Leatherwood (1986) lists one sighting, 29 April 1982, off of Ras Hafun; erroneously referred to as being in the Gulf of Aden. For the Somali coast, Leatherwood and Dahlheim (1978) reported 'no published information, status unknown'.

Short-finned Pilot Whale (Globicephala macrorhynchus)
Pilot whales were seen ten times, as singles and in groups of up to 25 or more (Appendix 1). Young animals 'slightly larger than half size of largest animals' were seen 9 February 1986.

Pilot whales were never seen west of the EO area (Table 6, Fig. 5e). Their primary occurrence was in the area in the Indian Ocean near the Horn of Africa in the area where the warm Gulf of Aden waters and Indian Ocean upwelling converge. Water depths at sighting locations were 457–1,500m. The two sightings in shallower water, 11 and 34m, were in an area of low productivity and a sandy bottom. Pilot whales were only seen during February, March, April and May 1986 and once in November 1986. (Fig. 6d, Table 6, Fig. 5e, Appendix 1).

Common Dolphin (Delphinus sp.)
Common dolphins were identified positively 29 times and tentatively twice. The number of animals per sighting varied from 3 to 100–200 (Appendix 1). Most sightings were near the Horn of Africa, mostly in the Indian Ocean. Sightings in the wide shelf area between the Horn of Africa and Ras Hafun, in water ranging from 16–148m deep, represented 48% of the total common dolphin sightings. (Table 6, Fig. 5f, Appendix 1).

'Lots of small calves' were noted on 15 March 1987 in the central Gulf of Aden inshore area.

A common dolphin taken incidental to the surface gillnet fishery was identified as *D. tropicalis* (Fig. 6e).

Common dolphins were noted in association with *Sardinella* sp. and little tuna. During some sightings, jellyfish and swimming crabs, unidentified tuna, *Sardinella* sp., Spanish mackerel, *Decapterus russeli* [Indian scad] and Pompano feeding on baitfish were also seen in the area. On one occasion, common dolphins came to the vessel as it was drifting at night with deck lights on. Red/blue pelagic crabs were at the surface in the light ring. An unknown number of common dolphins was seen one at a time to enter the light ring. They never surfaced within the light ring but could be seen and heard surfacing just outside the ring. The dolphins were not observed actually taking any food items.

Bottlenose Dolphin (Tursiops sp.)
Bottlenose dolphins were identified positively 78 times and tentatively 8 times in groups of from 3–100 or more (Appendix 1). Observations were concentrated in the wide shelf area

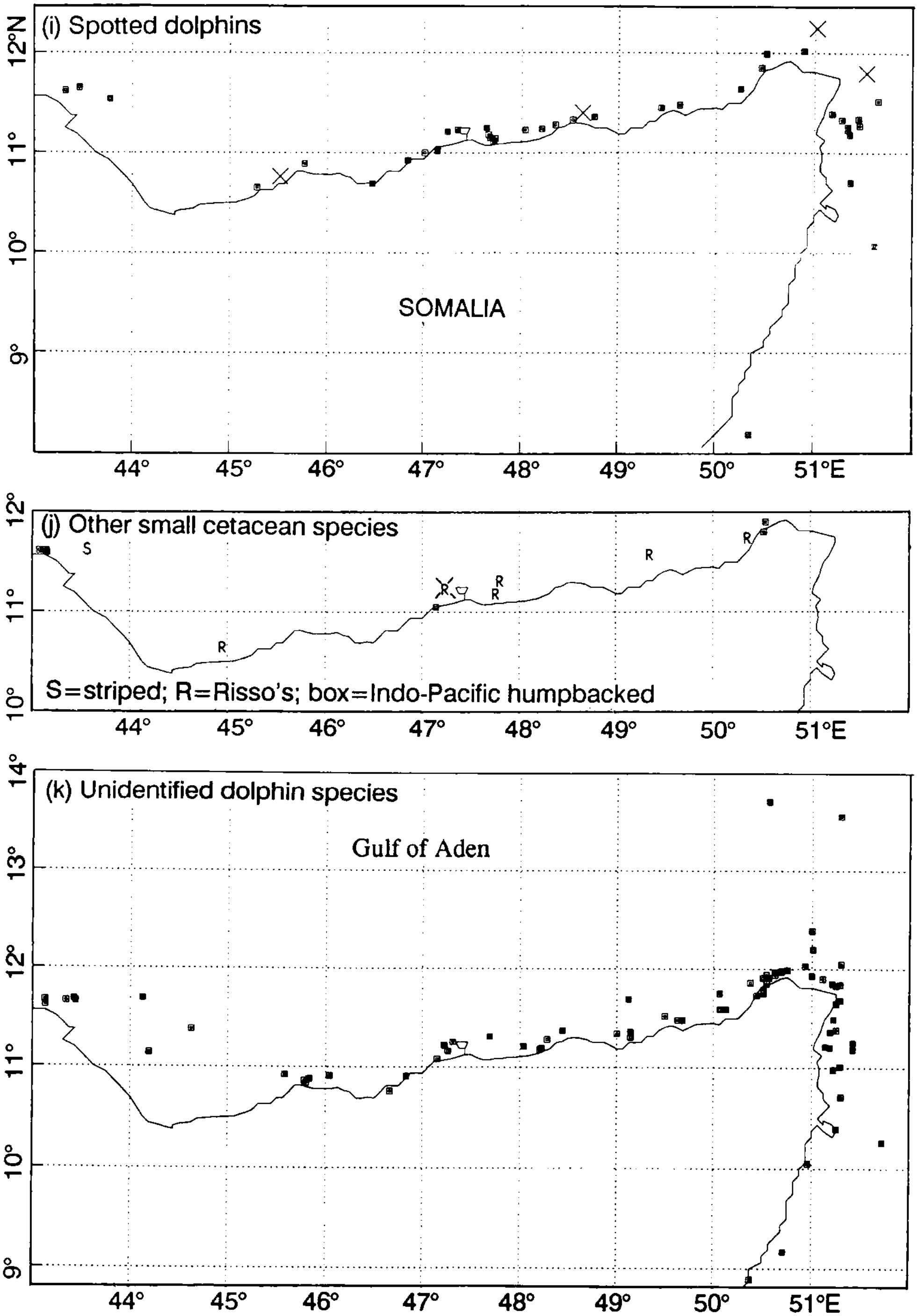


Fig. 5(i-k). Maps showing locations of sightings (solid dot – confident identifications, X – tentative identifications) of each species.

in the Indian Ocean around the Horn of Africa and south to Ras Hafun, but bottlenose were also seen scattered near shore the length of the Somali Gulf of Aden coast (Table 6, Fig. 5g, 6f).

Bottlenose were seen nearly daily from the settlement at Bolimog, very close to shore and in water as shallow as 2m. Bolimog affords an anchorage somewhat protected on the east by Cape Elephante, a high promontory rising from the water, which would offer an ideal perch from which to carry out bottlenose behavior studies.

From 10–13 February 1987 in the Indian Ocean just south of 8°N bottlenose dolphins approached and followed the fishing vessel when the bottom trawl was being set and retrieved. Upon net retrieval, the animals dived around and under the net. We assume the attraction was the small fish and invertebrates bursting through the codend of the net. On 12 February 1987 (0°53.4′ N, 49°53.5′ E) one dolphin so associated was killed when he was swept into the bottom trawl while the net was in operation (M/V *Beinta*, cruise 19, haul 20). The net had been fishing at a depth of 14fms and the bottlenose was dead when the net came to the surface. He was a male, 226cm in length and weighed approximately 190kg. His forestomach contained one 30cm mullidae, numerous small mullidae, 11 – 25cm balistidae, squid beaks and a few otoliths. The complete skeleton, stomach contents and measurements are deposited in the Division of Mammals, U.S. National Museum (USNM 550969). Bottlenose dolphins found in the Indian Ocean between 11°17.8′N and 11°22′N also were attracted to the trawl nets during March and May 1987. Only twice did bottlenose in the Gulf of Aden seem attracted to such fishing operations.

Spinner Dolphin (Stenella sp.)

Spinner dolphins were identified positively 38 times and tentatively four times. Their distribution was throughout the Gulf of Aden and Indian Ocean inshore areas. These inshore area sightings were in water from 10–491m deep. Only on three occasions were spinner dolphins identified in an offshore area. These offshore sightings occurred in water depths of 475, 116 and 78m respectively and took place in March 1986 and 1987. (Table 6, Fig. 5h, 6i, Appendix 1).

Young animals were observed on 10 April 1986 and on 15 March 1987.

Spotted Dolphin (Stenella sp.)

Spotted dolphins were identified positively 41 times, and tentatively 4 times in groups ranging in size from 2 to approximately 2,000 individuals. Sightings occurred at bottom depths from 3–800m. On only four occasions were spotted dolphins positively identified in an offshore area. (Table 6, Fig. 5i, 6h, Appendix 1).

Young animals were noted on 8 February 1986, 20 September 1986 and on 4 January 1987.

Striped Dolphin (Stenella coeruleoalba)

Striped dolphins were identified tentatively only once, in the western inshore Gulf of Aden (Table 6, Fig. 5j, Appendix 1). The seas were rough (Beaufort 4) and the animals were surfacing out of the tops of the waves; they showed no interest in the vessel as they crossed it's bow.

Risso's Dolphin (Grampus griseus)

Risso's dolphin were identified positively five times and tentatively once. All sightings were within the Gulf of Aden. Group size varied from 3 to 30 individuals. Positive identifications were located where bottom depths were 300–512m. (Table 6, Fig. 5j, Appendix 1).

The observation logged on 2 February 1986 (Fig. 6g) was recorded as six animals. However, in the remarks accompanying the sighting it is noted that 50–100 animals were traveling together but that only these six parted from the group and came close enough to permit identification.

Indo-Pacific Hump-backed Dolphin (Sousa chinensis)
Hump-backed dolphins were seen seven times as solitary animals and in groups of up to 25 (Appendix 1).

Five of the sightings were in Djiboutian waters. In addition to the sightings logged during cruises, it was common to see hump-backed dolphins in the Djibouti harbour swimming among the boats, very close to the docks and in the shoals in the entrance to the harbour, as noted by Burton (1964). Hump-backed dolphins are readily identifiable in this area from the hump; in addition, they swim with a jerky, snapping motion, obviously different from the more fluid motions of the bottlenose dolphin.

There were only three sightings of hump-backed dolphins along the Gulf of Aden coast (Table 6, Fig. 5j). This may have resulted from the tendency of the project vessels to spend very little time traveling close to shore since the water there was not deep enough to set a net. In fact, the three sightings logged were all taken before 11:00 am, while the boat was on the preceding night's anchorage. It was not routine for the vessels to anchor inshore at night.

The inshore component of the NECFISH project had a permanent settlement at Bolimog (11°56.3′ N, 50°37.3′ E), near the Horn of Africa. GJS was onboard vessels anchored at Bolimog quite regularly throughout the project but never saw hump-backed dolphins there.

Unidentified dolphins
There were 78 sightings in which dolphins could not be identified. These sightings involved 1 to thousands of animals and occurred throughout the project areas (Table 6, Fig. 5k, Appendix 1). As with the great whales, the inability to identify to species was attributable to poor visibility, distance or the inability to divert the vessel to get a better look or wait for animals to resurface.

A group of six animals seen on 5 September 1986 in the WO most closely resembled hourglass dolphins, *Lagenorhynchus crueiger*, based on head colour patterns and morphology; there were no photographs taken. Sea conditions (Beaufort 2), time of day (1600hrs) and proximity to the school (20m) were optimum for a clear view of these animals. This locality is far north of the known range of this species and in waters much warmer (32°C) than they are expected to enter (Leatherwood and Reeves, 1983). However, the sighting clearly was of unusual dolphins, observed only this once. It occurred where few marine mammals were observed and where the vessels visited irregularly during the course of the NECFISH project.

Mixed groups
Groups of dolphins composed of more than one species were recognized on 23 occasions. Species combinations were: bottlenose and spinner dolphins (2), bottlenose and spotted dolphins (3), bottlenose and common dolphins (3), bottlenose and pilot whales (3), bottlenose, spinner and spotted dolphins (1), bottlenose, common and spinner dolphins (1), common and spotted dolphins (4), common and spinner dolphins (1) and spinner and spotted dolphins (5).

[*Text continues on p. 209*]

Table 6

Number of sightings per 100nm (D) and per hour searched (T) for each species observed. Project vessels were not searching in all eight regions in all months and all species were not observed in all months - see Table 2.

	WI		WO		CI		CO		EI		EO		IOI		IOO	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Blue whale																
Oct 1985									0.27	0.02						
Nov 1985									0.96	0.07			0.17	0.01		
Dec 1985									0.91	0.07						
Blue whale?																
Oct 1985									0.27	0.02						
Oct 1986													0.57	0.05		
Bryde's whale																
Apr 1986					0.57	0.04			0.26	0.02			0.61	0.04		
Sep 1986					0.99	0.09			0.55	0.05						
Oct 1986									1.64	0.09			0.57	0.03		
Feb 1987									0.88	0.03						
Bryde's whale?																
Apr 1986					1.15	0.08										
Sep 1986					0.49	0.04										
Oct 1986	3.19	0.22											0.28	0.01		
Feb 1987													0.24	0.01		
Sperm whale																
Dec 1985					0.19	0.01			0.60	0.05						
May 1986											1.64	0.11				
Jun 1986	2.31	0.16														
Jan 1987					0.23	0.02			0.54	0.04						
Feb 1987			0.75	0.05												
Mar 1987											1.84	0.11			6.27	0.38
Apr 1987			0.75	0.05												
Unidentified great whales																
Sep 1985					0.76	0.06										
Oct									1.34	0.10			0.23	0.02		
Nov									0.96	0.07			0.50	0.04		
Dec					0.19	0.01										
Feb 1986					0.90	0.05			0.42	0.03						
Mar													0.38	0.03		
Apr			2.35	0.15	2.29	0.16							0.20	0.01		
May									0.24	0.02			1.90	0.12		
Sep									0.55	0.05						
Oct					0.55	0.04							0.57	0.03		
Dec									2.87	0.13						
Jan 1987					0.23	0.02										
Feb									0.88	0.04						
Mar															2.05	0.10
Apr			0.75	0.05												
May									0.85	0.04			1.81	0.10		

Continued

Table 6 continued.

	WI		WO		CI		CO		EI		EO		IOI		IOO	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Melon-headed whale																
Feb 1986					0.30	0.02										
False killer whale																
Mar 1986									0.46	0.03						
False killer whale?																
May 1986					0.53	0.04										
Killer whale																
Nov 1985													0.17	0.01		
Jan 1986									8.70	0.52						
Feb 1986									0.42	0.03						
Short-finned pilot whale																
Feb 1986															0.63	0.04
Mar 1986													0.19	0.01	0.23	0.02
Apr 1986									0.26	0.02			0.20	0.01		
May 1986													1.90	0.12	1.90	0.12
Nov 1986											1.24	0.09				
Indo-pacific hump-backed dolphin																
Feb 1986					0.30	0.02										
Mar 1986									0.46	0.03						
Apr 1986			2.35	0.15												
May 1986			0.76	0.05												
Sep 1986									0.55	0.05						
Jan 1987			0.65	0.05												
Mar 1987			0.83	0.05												
Common dolphin																
Feb 1986					0.30	0.02									0.63	0.04
Mar															0.23	0.02
Apr									0.26	0.02			1.02	0.07		
Aug					3.05	0.21										
Sep									0.55	0.03						
Oct			0.94	0.07					0.55	0.03			1.42	0.07		
Jan 1987					0.23	0.02			0.54	0.04						
Feb													0.24	0.01		
Mar					1.66	0.11			0.26	0.01			1.03	0.05		
Apr													1.38	0.08		
Common dolphin?																
Feb 1987													0.24	0.01		
Mar 1987									0.26	0.01						

Table 6 continued.

	WI		WO		CI		CO		EI		EO		IOI		IOO	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Bottlenose dolphin																
Jan 1986									8.70	0.52						
Feb					0.30	0.02							1.15	0.07		
Mar									0.46	0.03			1.32	0.09	0.70	0.05
Apr									0.53	0.04			1.22	0.08		
May					0.53	0.04							1.90	0.12	1.90	0.12
Jun			1.22	0.08												
Aug					1.02	0.07										
Oct					0.55	0.04							1.42	0.07		
Nov	0.57	0.03			0.39	0.03					1.24	0.09				
Dec													0.41	0.02		
Jan 1987					0.23	0.02			1.09	0.07						
Feb	3.81	0.19							3.51	0.15			2.18	0.13		
Mar			0.83	0.05	0.83	0.05			0.78	0.04			2.05	0.10		
Apr			0.75	0.05	1.07	0.08			13.50	0.91						
May									2.55	0.13			2.72	0.14		
Bottlenose dolphin?																
Feb 1986									0.42	0.03						
Oct													0.85	0.04		
Nov	0.57	0.03														
Feb 1987													0.24	0.01		
May			1.78	0.14					0.85	0.04						
Risso's dolphin																
Feb 1986					0.90	0.05										
Nov	0.57	0.03							2.03	0.14						
Feb 1987											9.95	0.50				
Mar					0.83	0.05										
Risso's dolphin?																
Sep 1986					0.49	0.04										
Spotted dolphin																
Jan 1986			1.00	0.06												
Feb					2.40	0.14							1.15	0.07	0.63	0.04
Apr					1.15	0.08			0.26	0.02						
May					0.53	0.04			0.24	0.02			1.90	0.12	0.95	0.06
Jun	4.61	0.31														
Aug					1.02	0.07										
Sep	0.55	0.05			0.49	0.04			1.10	0.11						
Oct													1.13	0.05		
Nov					0.79	0.06										
Jan 1987	1.85	0.15	0.65	0.05	0.68	0.05			1.09	0.07						

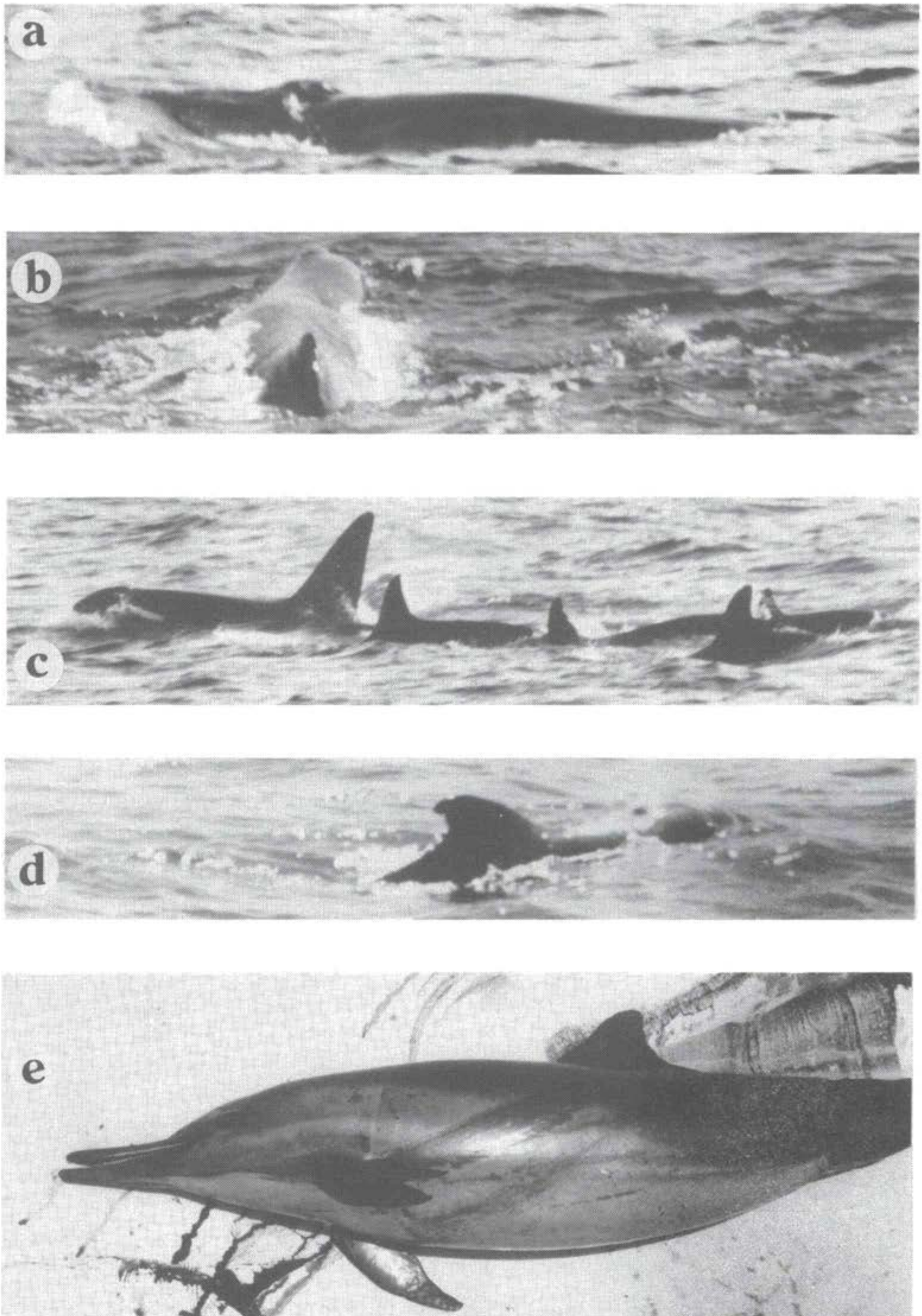
Continued

Table 6 continued.

	WI		WO		CI		CO		EI		EO		IOI		IOO	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Spotted dolphin?																
Jan 1986						0.83	0.05									
Apr											1.89	0.12				
May						0.53	0.04									
Sep	0.55	0.05														
Oct															0.88	0.04
Striped dolphin?																
Jan 1986	4.17	0.25														
Spinner dolphin																
Jan 1986					0.83	0.05										
Feb					1.20	0.07			0.42	0.03			0.76	0.05		
Mar			1.35	0.10	1.65	0.07			0.46	0.03			0.38	0.03	0.23	0.02
Apr					1.72	0.12			1.32	0.09			0.20	0.01		
May					1.05	0.07			0.24	0.02						
Jun	2.31	0.16														
Sep									0.55	0.05						
Jan 1987									0.54	0.04						
Feb									2.63	0.11			0.24	0.01		
Mar					0.83	0.55					0.46	0.03				
Spinner dolphin?																
Feb 1986							0.60	0.03								
Mar	1.01	0.07														
Apr									0.53	0.04						
Unidentified dolphin																
Jan 1986					2.50	0.15										
Feb					0.30	0.02			0.84	0.05			0.76	0.05	0.63	0.04
Mar	1.01	0.07			0.55	0.04							0.19	0.01		
Apr					0.57	0.04			1.06	0.07			1.02	0.07		
May					0.53	0.04			0.95	0.06			0.95	0.06		
Aug					1.02	0.07										
Sep	0.55	0.05			1.48	0.13										
Oct													0.28	0.01		
Nov					0.39	0.03					1.24	0.09				
Dec									8.60	0.39						
Jan 1987			2.58	0.20	0.23	0.02										
Feb									3.51	0.15			0.49	0.03		
Mar									3.11	0.16	0.92	0.05	3.08	0.16	1.57	0.10
Apr			0.75	0.05									2.77	0.16		
May			1.78	0.14												

On the following two pages:

Fig. 6. Photographs of Bryde's whale, 20 April 1986 (a); sperm whale, 17 May 1986 (b); killer whale, 6 February 1986 (c); short-finned pilot whale, 8 November 1986 (d); common dolphin, GJS 047 14 August 1986 (e); bottlenose dolphin, 19 May 1986 (f); Risso's dolphin, 2 February 1986 (g); spotted dolphin, 23 April 1986 (h); spinner dolphin, 24 May 1986 (i).


a
b
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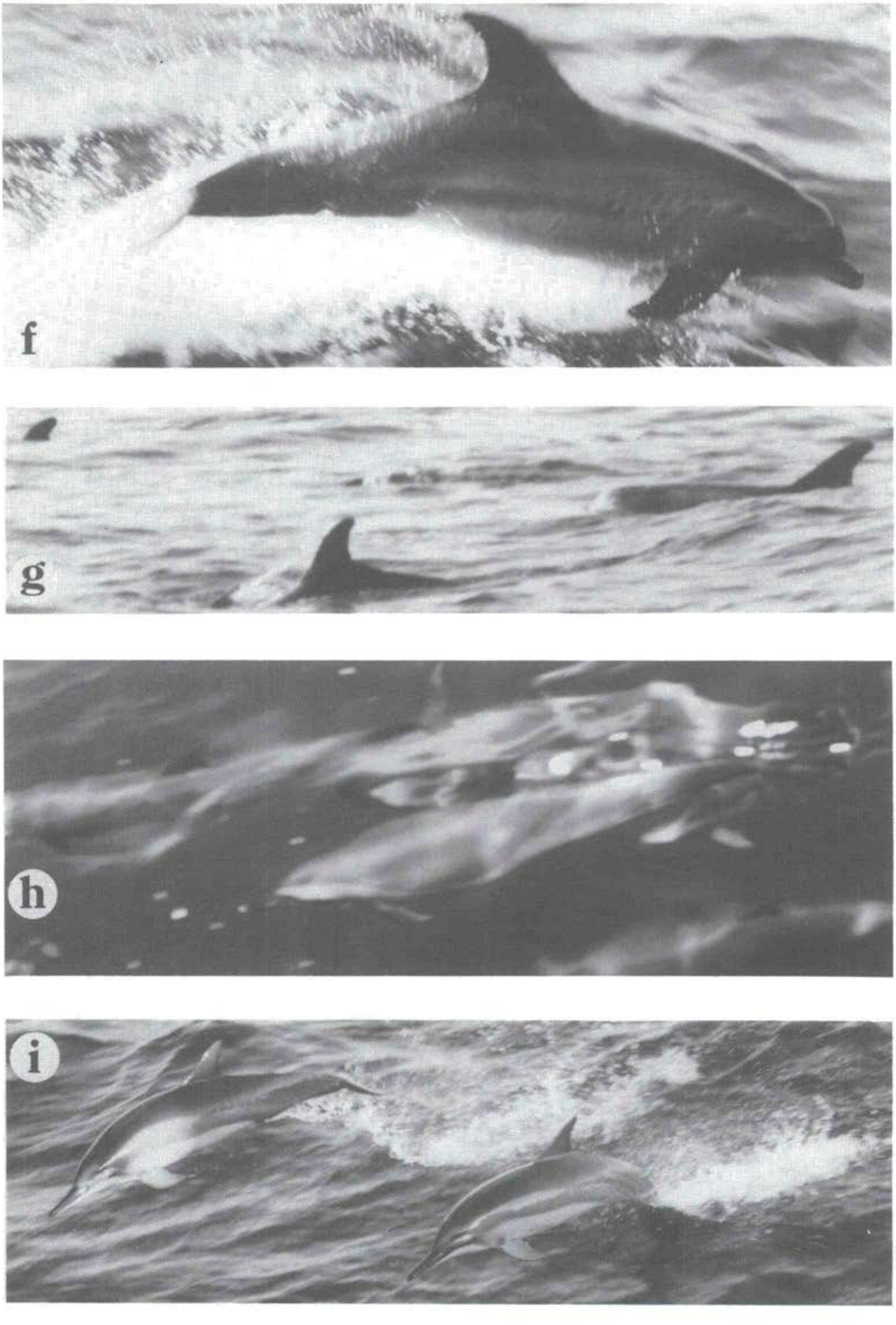
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DISCUSSION

To our knowledge, the offshore NECFISH project represents the first time marine mammal observations have been noted in the area off Somalia and Djibouti over an extended period of time (August 1985 through May 1987) and on a routine basis. Therefore, it provides some insight into distribution, relative abundance, habitats and seasonality of cetaceans of this little studied region.

The most common large cetacean was the sperm whale (23 sightings). Yukhov (1969) noted that sperm whales were 'the most frequently encountered whale' in the Gulf of Aden and the Arabian Sea. Tomilin (1957) indicates that one of the major whaling grounds for sperm whales was located 'in the Arabian Sea (between the mainland of Arabia and Socotra I.)'. Just west of this area is a group of seamounts where 15 of our 23 sightings were located. Humpback whales were not sighted during the project. Yukhov (1969) reported seeing small groups of humpback whales only east of Cape Ras Fartak (15°38′N, 52°13.5′E). Bryde's whales were seen not uncommonly in coastal waters. Most sightings were in the area of the Horn of Africa in the Gulf of Aden and in the Indian Ocean.

Records of occurrence of blue and killer whales show a common trend in the project area, as they were observed only during the pre-northeast and northeast monsoon period of 1985–86. Blue whales were observed only during October, November and December 1985, killer whales only during November 1985 and January and February 1986. Both species were observed only in the EI and IOI areas. The fishing vessel which GJS was aboard did not enter the EI or the Indian Ocean in September 1985; and in January 1986 it spent only 1.9 hours searching in the EI, none in the Indian Ocean. The distance and time searched in 1986 in the Gulf of Aden and Indian Ocean inshore areas from October through December was 42% and 18%, respectively, less than the distance and time searched during the same period in 1985. The differences in the number of sightings between the two years could be explained by the fact that there was less effort expended searching in the areas in 1986. However, October 1985 through February 1986 differ from the same period in 1986–87 in some environmental aspects as well as the presence/absence of red pelagic crabs. Perhaps, due to favorable conditions, there was a favorite food source which was abundant in the area during the 1985–86 period but not in 1986–87. Examination of the NECFISH fisheries statistics would perhaps shed more light on the subject.

Pilot whales were found only in the EI, EO, IOI and IOO areas in the months from February through May 1986 and November 1986. Four of the sightings were in the area off the Horn of Africa where waters from the Gulf of Aden and the Somali Current converge during the months of the southwest monsoon.

Common and bottlenose dolphins were observed mostly in the area of the Horn of Africa in the Gulf of Aden and Indian Ocean north of Ras Hafun. Spotted and spinner dolphins were seen scattered throughout the Gulf of Aden and Indian Ocean.

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Steiner Bastesen, then Chairman of the Norwegian Whaling Commission and owner of the M/V *Bastesen*, was always enthusiastic and willing whenever possible to divert the vessel for that 'extra look' to confirm an identification. Captains Atle Magne Nekkoy and Willy Pedersen, M/V *Beinta*, were also helpful with their ever watchful eyes and interest in our endeavors. Special thank you to Willy too for allowing us to necropsy marine mammals and embalm fish specimens on the deck of the M/V *Beinta*.

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REFERENCES

Anonymous. 1987. ESCWA/FAO/UNESCO/IMO/IAEA/IUCN/UNEP: Coastal and Marine Environmental Problems of Somalia. Part 1. Consolidated Report and Action Plan. *UNEP Reg. Seas Rep. Stud.*

Burton, J. 1964. The grey dolphins of Djibouti harbour. *Animals (Lond)* 3(15):414–6.

Cox, M.D. 1979. A numerical study of Somali current eddies. *J. Phys. Oceanogr.* 9:311–26.

Evans, R.H. and Brown, O.B. 1981. Propagation of thermal fronts in the Somali Current system. *Deep-Sea Res.* 28A(5):521–7.

Fischer, W. and Bianchi, G. 1984. *FAO species identification sheets for fishery purposes, western Indian Ocean*. FAO, Rome. Vol. 1–5.

Leatherwood, S. 1986. Whales, dolphins and porpoises of the Indian Ocean Cetacean Sanctuary: a catalogue of available information. Hubbs Marine Research Center Technical Report 87–197. vi + 207pp.

Leatherwood, S. and Dahlheim, M.E. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, San Diego, Calif., Technical Note 443. iii+39pp.

Leatherwood, S. and Reeves, R.R. (eds.) 1983. *The Sierra Club Handbook of Whales and Dolphins*. Sierra Club Books, San Francisco. xviii + 302pp.

Natural Resources Consultants. 1987. Report on the Northeast coast exploration/pilot fisheries project – offshore component in the Somali Democratic Republic, August 1985 through June 1987. Submitted to the North East Coast Fisheries Enterprise, Somali Democratic Republic, December 1987. 2 vol.: 148pp + Tables and Figs.

Robineau, D. and Rose, J.M. 1984. Les cétacés de Djibouti. Bilan des connaissances actuelles sur la faune cétologique de la mer Rouge et du golfe d'Aden. *Bull. Mus. Natn. Hist. Nat., Paris* (4)6(1): 219–49.

Smith, S.L. 1984. Biological indications of active upwelling in the North Western Indian Ocean in 1964 and 1979, and a comparison with Peru and North West Africa. *Deep-Sea Res.* 31:951–67.

Technical Unit of the State Planning Commission, Somali Democratic Republic. 1976. *Feasibility Study on the Fisheries Resettlement Programme, Eil, Adale, Brava, Kulmis/Kismayo*. TUSPC, Mogadiscio. iii+221pp.

Tomilin, A.G. 1957. Zveri SSSR i Prilezhasfchikh Stran. Zveri Vostochnoi Evropy i Severnoi Azii. Vol. IX. Kitoobraznye. Izdatel'stvo Akademi Nauk SSSR, Moscow. 756pp. [Translated in 1967 as *Mammals of the USSR and Adjacent Countries. Mammals of Eastern Europe and Adjacent Countries. Vol. IX. Cetacea* by the Israel Program for Scientific Translations, Jerusalem, 717pp.].

Wittenberg-Fay, R. 1987. Processing of satellite data to supplement an oceanography survey of the northern Somali coast. Prepared for the Food and Agriculture Organization of the United Nations. June 1987. 7pp.+8 illus.

Wyrtki, K. 1973. Physical oceanography of the Indian Ocean. pp. 18–36. *In:* B. Zeitschel and A. Gerlach (eds.) *The Biology of the Indian Ocean*. Springer-Verlag, Berlin.

Yukhov, V.L. 1969. Observations of cetaceans in the Gulf of Aden and the northwestern part of the Arabian Sea. pp. 327–8. *In:* V.A. Arsenev, B.A. Zenkovich and K.K. Chapskii (eds.) *Marine Mammals*. Akad. Nausk., Moscow. [Original in Russian, this article translated by S. Pearson, National Marine Mammal Lab., Seattle, USA].

A Note on Recent Sightings and Strandings of Cetaceans in Oman: Ra's Sawadi to Rakhyut

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ABSTRACT

This paper lists cetacean strandings and sightings off the coast of Oman from October 1984-July 1985. Sightings were incidental and most occurred close to shore. A brief summary of other published information for the area is given. Marine mammals are utilised in the region but it is unclear if there are directed takes as opposed to incidentally caught animals.

Keywords: Indian Ocean; sightings – incidental; hump-backed dolphin; bottlenose dolphin; false killer whale; incidental capture; whaling-modern; strandings; cetaceans – general.

INTRODUCTION

This brief note lists cetacean sightings and strandings made over a period of 34 months (October 1984 – July 1988) along the coast of the Sultanate of Oman. The cetacean observations were made during the course of routine coastal studies of the Coastal Zone Management Project undertaken by the International Union for the Conservation of Nature (IUCN) for the Ministry of Commerce and Industry in Oman. The area covered extends approximately 1,500km from Ra's Sawadi, in the Gulf of Oman, south to Rakhyut, near the border with the People's Democratic Republic of Yemen (Fig. 1). Cetacean sightings were made from the shore and from boats and helicopters operating in nearshore seas (Table 1). Information on sightings of humpback whales (collected during this project) is tabulated separately in Reeves *et al.* (this volume).

STRANDINGS

Cetacean remains in varying stages of decomposition, from complete animals to bleached bones, were located and recorded (Table 2, Fig. 2). Where possible, specimens were collected, measured and photographed. These are deposited in the national cetacean collection in the Oman Natural History Museum (ONHM). Those marked 'det. van Bree' were identified provisionally by P.J.H. van Bree (Instituut Voor Taxonomische Zoölogie, Netherlands) from photographs. However, in some cases, it was impossible either to collect the specimen or to identify it to species, *in situ*.

SIGHTINGS

All the sightings were of animals close to shore. This accounts for the large proportion of Indo-pacific hump-backed dolphins (*Sousa chinensis*) in the sightings. This dolphin, a member of the family Stenidae, feeds exclusively in shallow water on fish, molluscs and crustaceans. Off southern Africa they are rarely seen more than 1km offshore (Ross, 1984, p. 378). No sightings or strandings of this species were recorded in the Gulf of Oman. Also, all 16 specimens of hump-backed dolphins in the Oman Natural History Museum

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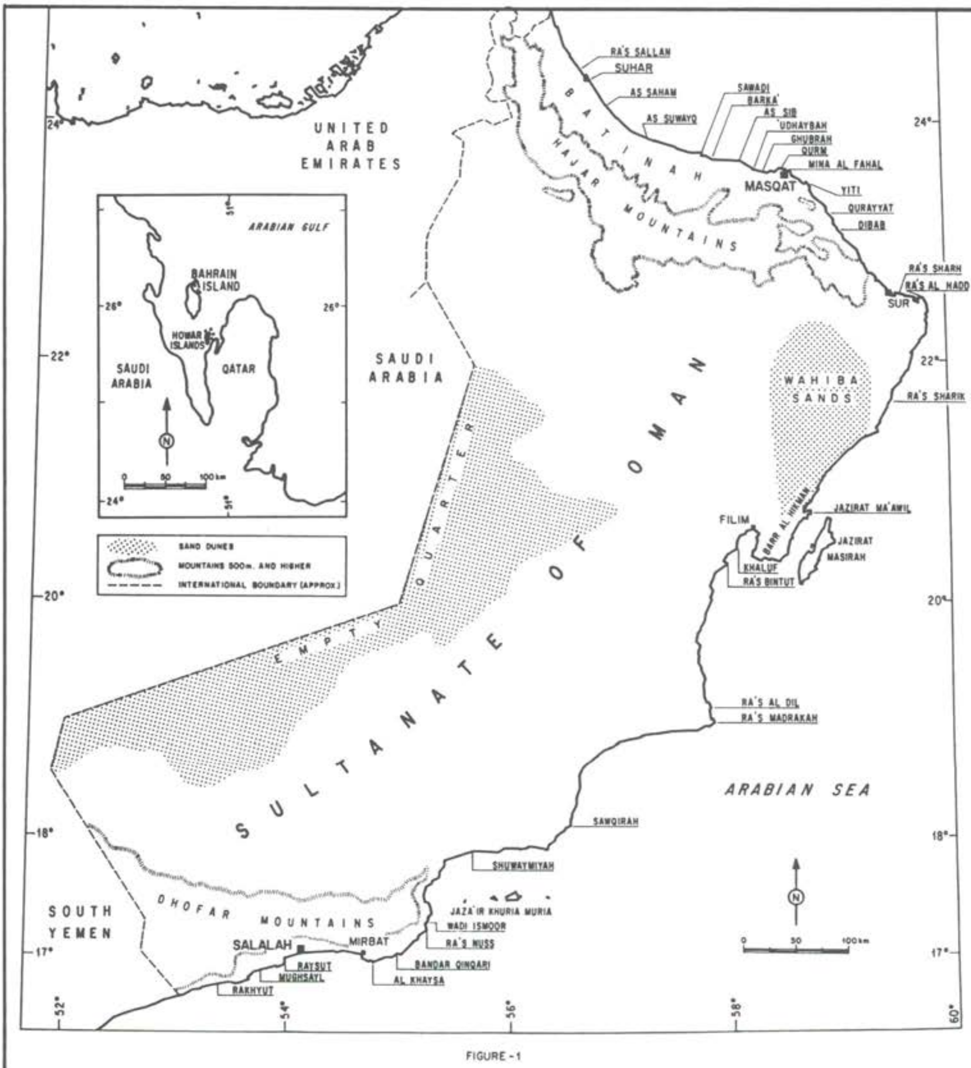

Fig. 1. Map to show the places of sightings and strandings mentioned in the text. (Spellings are taken from the latest published gazetteer, USBGN, 1983).

were collected South of Ra's al Hadd, the southern boundary of the Gulf of Oman (Gallagher, this volume, a). It is possible that the headland at Ra's al Hadd marks a natural barrier affecting the local distribution of these animals. However, Gallagher has also collected specimens of *Sousa chinensis* at Bahrain in the Arabian Gulf (Gallagher, pers. comm.). The possibility that these may represent discrete populations warrants examination. The remains of 28 bottlenosed dolphins found on the beach at Ra's Nuss invite speculation, as mass strandings are not known for this species (S. Leatherwood, pers. comm.).

Table 1

Cetacean sightings: Ra's Sawadi to Rakhyut.

Date	Place	Position	Notes
27/11/84	Yiti	23°32'N, 58°41'E	10 bottlenose dolphins close inshore.
22/01/85	Daymaniyat Is.	23°52'N, 58°06'E	30-50 common dolphins moving west. Mixed group including adults with small young (length approx. 75cm).
26/04/85	Daymaniyat Is.	23°52'N 58°07'E	Less than 10 small dolphins (black beak, back and dorsal fin, dark grey stripe separating black back from pale belly, pale of belly up flank in hourglass pattern ?pink-red patch below, *Stenella* or *Delphinus* spp.
29/08/85	Between Fahl& Daymaniyat Is.	23°45'N, 58°17'E	40 common and 2 bottlenose dolphins, 10-15km offshore.
02/04/86	Daymaniyat Is.6	23°51'N, 58°01'E	2 groups <50 & 60 common dolphins, 1.8-2.0m long, with young, heading west
09/11/86	An Nuqdah	20°52'N, 58°45'E	100 hump-backed dolphins, close to shore, north of village.
09/11/86	Ra's Aubaq	20°23'N, 58°29'E	20 hump-backed dolphins, over reef close to headland.
11/11/86	Wadi Salutiyat	20°15'N, 57°52'E	>50 hump-backed dolphins, close to shore off wadi.
20/11/86	Sharbithat	17°55'N, 56°17'E	10 hump-backed dolphins.
07/01/87	Ra's ar Ruays	22°11'N, 59°46'E	1 hump-backed dolphin, seen from helicopter
07/01/87	Khuwaymah S	20°07'N, 58°09'E	2 large whales, grey. Tall straight spout. Whale 1 flukes in air, serrated trailing edge, indistinct dorsal fin - fleshy ridge. Whale 2: distinct dorsal fin.
12/01/87	Barr al Hikman	20°20'N, 58°27'E	2 hump-backed dolphins.
15/03/87	Ra's Sagalah	21°31'N, 59°23'E	5 hump-backed dolphins travelling at 2kts, 50m off Ra's,
16/03/87	Ra's ar Ruays	21°01'N, 58°50'E	30 hump-backed dolphins off cliffs, 8km north of Ra's ar Ruays, moving north.
4/04/87	Ra's Sagalah	21°31'N, 59°23'E	More than 10 hump-backed dolphins.
16/04/87	Ra's Sagalah	21°31'N, 59°23'E	Approx. 5 hump-backed dolphins.
04/05/87	Barr al Hikman	20°21'N, 58°27'E	5 hump-backed dolphins.
04/08/87	Ra's al Hadd	22°28'N, 59°49'E	5 hump-backed dolphins, off small beach.
13/04/88	Bandar Nuss	17°16'N, 55°15'E	>100 common dolphins, 1.5-1.8m long, breaching.
13/04/88	Hasik	17°27'N, 55°15'E	Less than 100 common dolphins.
13/04/88	Wadi Sunayk	17°36'N, 55°16'E	2 groups hump-backed dolphins (5 and 10) in bay.
13/04/88	3km NW Hadbaram	17°27'N, 55°15'E	10 bottlenose dolphins heading northwest. One had dorsal fin bitten off.
14/04/88	Wadi Thakaut	17°17'N, 55°15'E	15 bottlenose dolphins milling around.
14/04/88	Bandar Nuss	17°16'N, 55°15'E	5 groups of bottlenose dolphins, 10 in each group with young, milling around over sand in 2-4m depth.
16/04/88	Khawr Hadbin	17°11'N, 55°13'E	10 bottlenose dolphins.
17/04/88	Jabal Musayrah	17°09'N, 55°12'N	2 groups bottlenose dolphins milling around (6 and 20).
17/04/88	Khawr Murir	17°06'N, 55°03'E	5 bottlenose dolphins.
25/04/88	Al Khaysa	16°57'N, 54°46'E	4 (+1 calf) hump-backed dolphins, between isl. & shore
26/04/88	Sanur	17°01'N, 54°32'E	80-100 common dolphins, heading west.
26/04/88	Khawr Rawri	17°01'N, 54°27'E	5 hump-backed dolphins, feeding.
13/05/88	Wadi Afl	16°52'N, 59°45'E	2 groups hump-backed dolphins, feeding (10 and 5).
14/05/88	W of Ra's Sajir	16°46'N, 53°32'E	7 hump-backed dolphins.
15/05/88	Mughsayl	16°52'N, 53°46'E	3 (+2 calves, 1<1m) hump-backed dolphins, off blow-hole
17/05/88	Mughsayl	16°52'N, 53°49'E	3 hump-backed dolphins, heading E just outside breakers.
20/05/88	Yiti	23°34'N, 58°41'E	6 dolphins, 3-4m long, about 3km offshore (R. Thompson, (pers comm). From photos and description most likely false killer whales (S. Leatherwood pers. comm.).
21/05/88	Shuwaymiyah Beach	18°54'N, 53°42'E	3 or 4 hump-backed dolphins in surf.
27/07/88	Grindstone Cove	16°57'N, 54°49'E	2 dolphins milling around behind breakers in bay. Light grey, ?hump-backed dolphins.
27/07/88	Marbat	16°58'N, 54°43'E	9 bottlenose dolphins, feeding in surf, breaching.

Table 2

Cetacean strandings: Ra's Sawadi to Rakhyut. Specimens deposited in the Oman Natural History Museum are numbered with prefix ONHM.

Date	Place	Position	Notes
08/11/86	Between Nuqdah & Ra's ar Ruays	20°54'N, 58°45'E	Dead hump-backed dolphin on beach.
10/11/86	Barr al Hikman	20°23'N, 58°23'E	3 dolphin skulls: 2 hump-backed dolphin; 1 bottlenose (approx.) ONHM1015, ONHM1020, ONHM1016.
10/11/86	Al Minjal al Film	20°35'N, 58°08'E	6 hump-backed dolphins on mudflats.
1986/ 1987	Ra's al Junayz	22°25'N, 59°50'E	Cetacean materials found 1987 during archaeological dig (4,000 years old): right and left dolphin mandibles, 47 teeth LR; 8 dolphin vertebrae (5 of which compressed); various large spongy bone fragments; vertebral disc of whale. In Ministry of National Heritage & Culture, specimens: RJ2 Room 3 level 750 nos 4,5,11; RJ2 Room 16 level 701 no.5; RJ2 Room 4 level 12 no.116.
07/01/87	Al Minjal al Film	20°35'N, 58°08'E	Less than 5 dolphins seen from helicopter on beach.
17/03/87	Ra's Tamtim	20°27'N, 58°03'E	Humpbacked dolphin.
17/03/87	Between Ra's Tamtin and Jawarah	20°26'N, 58°01'E	Humpbacked dolphin at high water level, bloated.
17/03/87	3.4km NE of Jawarah	20°27'N, 58°02'E	Bottlenose dolphin (2m, teeth: 24LL, 24UL).
17/03/87	NE of Jawarah	20°26'N, 58°00'E	?Bottlenose dolphin.
17/03/87	Jawarah	20°25'N, 57°59'E	Remains small humpback whale (large flipper, approx. 5m of whale visible, also throat grooves and skin, 2 vertebrae and mandible collected). Est. length 15-17m.
17/03/87	N Ghadaw	20°25'N, 57°58'E	Humpbacked dolphin on beach.
17/03/87	S Ghadaw	20°25'N, 57°58'E	Humpbacked dolphin on beach.
17/03/87	1km S Ghadaw	20°24'N, 57°57'E	Baleen whale, skull cranium only.
17/03/87	1.7km S Ghadaw	20°24'N, 57°57'E	Dolphin.
17/03/87	4km S Ghadaw	20°23'N, 57°57'E	Dolphin skull and vertebrae on dune.
17/03/87	Bandar Martub	20°20'N, 57°58'E	Dolphin skull. S side Ra's, 2m wide baleen whale skull. buried in beach.
17/03/87	Bandar Martub	20°19'N, 57°58'E	Baleen whale skull and 1 vertebra collected (now at Marine Science and Fisheries Centre).
17/03/87	Bandar Martub	20°20'N, 57°58'E	Humpbacked dolphin on beach.
17/03/87	Bandar Martub S	20°18'N, 58°56'E	Baleen whale skull.
17/03/87	Bandar Martub S	20°17'N, 57°54'E	Dolphin.
17/03/87	Bandar Martub S	20°17'N, 57°54'E	Dolphin.
18/03/87	Ra's Bu Firak	20°09'N, 57°49'E	Male bottlenose dolphin, 2m, teeth very worn.
18/03/87	Ra's Hadud NE	20°08'N, 57°50'E	Dolphin skull.
18/03/87	Ra's al Aqit S	20°02'N, 57°49'E	Large whale vertebrae, dolphin skull.
22/03/87	Ra's Khushayyim	18°59'N, 57°49'E	Ribs and 3 vertebrae collected from small whale, thought to be pygmy killer whale from previous tooth count (by R. Salm) ONHM1043.
22/03/87	Ra's ad Dil	19°01'N, 57°58'E	Skull of false killer whale (det. van Bree). ONHM1044.
22/03/87	Ra's Madrakah	19°00'N, 57°58'E	Maxillae of baleen whale used to construct hut. Also dolphin skull and part of false killer whale skull.
08/05/87	Ra's Ghabirty	20°21'N, 58°27'E	Vertebrae, skull (145cm wide), ribs, maxillae, scapula, digits and jaw of large baleen whale piled above dunes. Baleen collected ONHM716.
08/05/87	Barr al Hikman Khawr Milh	20°23'N, 58°18'E	2 whale vertebrae and discs collected.
18/06/87	Quriyat	23°15'N, 58°56'E	Skull of false killer whale (det. Van Bree) ONHM1014.
30/08/87	Muscat	22°36'N, 58°36'E	New born ?false killer whale. Stranded alive, now in freezer at Marine Science and Fisheries Centre (length: 1,600mm; weight 35kg).

Continued

Date	Place	Position	Notes
12/09/87	Sahil al Jazir	18°47'N, 56°50'E	2 vertebrae and jawbone from baleen whale.
13/09/87	Ra's Bintawt	20°21'N, 57°59'E	Humpbacked dolphin (det. Van Bree) skull and left mandible ONHM1017.
22/01/88	Ra's al Hadd	22°32'N, 59°47'E	Complete mature male Cuvier's breaked whale (length 5m; vertebrate: 6 cervical, 10 thoracic, 10 lumbar, 12 caudal; bottom jaw 78cm long). ONHM901 (det. Van Bree).
30/03/88	Mughsayl	16°53'N, 53°48'E	Humpbacked dolphin on beach.
14/04/88	Wadi Ismoor	17°18'N, 55°16'E	Bottlenose dolphin skull ONHM1048.
14/04/88	Ra's Nuss	17°15'N, 55°15'E	28 bottlenose dolphin skulls and other remains on beach. Possibly mass stranding. One skull collected, ONHM1046.
19/04/88	South of Sadh	17°02'N, 55°03'E	Sperm whale remains on beach. Identification from tooth sockets in piece of lower jaw.
20/04/88	Bandar Qinqari	17°01'N, 55°00'E	Dolphin skull, ONHM1047.
21/04/88	East of Al Khaysa	16°57'N, 54°50'E	Remains of large baleen whale on beach (mandible 2.4m).
26/04/88	Al Khaysa	16°57'N, 54°45'E	Skull and some bones, dwarf sperm whale, ONHM1024.
21/05/88	Shuwaymiyah	17°53'N, 55°40'E	False killer whale, skull collected, ONHM1023.
21/05/88	Shuwaymiyah	17°53'N, 55°35'E	1 hump-backed dolphin eaten by sharks (photos taken).
26/05/88	E of Madrakah	18°56'N, 57°31'E	1 hump-backed dolphin.
27/05/88	Al Khaluf N	20°27'N, 58°05'E	1 hump-backed dolphin, lower jaw broken in two pieces but healed (see photo).

The number of records of all cetaceans was considerably higher south of Ra's al Hadd than in the Gulf of Oman. However, bottlenose dolphins, *Tursiops truncatus*, and common dolphins, *Delphinus delphis*, were seen in the Gulf of Oman. The former generally occurred in small groups, about 10 or fewer, close to shore; the latter were seen farther offshore, in groups of adults and young sometimes containing over 100 animals.

Other published information on the cetaceans off Oman includes van Bree (1971) and van Bree and Gallagher (1978) on the taxonomic status of *Delphinus tropicalis*; Ross (1981) on cetacean sightings and in particular humpback whale sightings off Oman; Gallagher and van Bree (Gallagher and van Bree, 1980) on a dwarf sperm whale; Whitehead (1985) on humpback whale songs heard off the south coast of Oman; Alling, Gordon, Rotton and Whitehead (1982) and Alling (1986) on cetaceans seen during the 'Tulip' cruise between Muscat and Salalah. In this volume, Reeves *et al*. (1990) discuss records of humpback whales and the possible relationship of northern Indian Ocean humpbacks to stocks elsewhere. Also, Gallagher (this volume, a) provides a list of cetacean material in the Oman Natural History Museum and Gallagher (this volume, b) notes the stranding of four sperm whales. Cetacean sightings are also being collected by the Marine Science and Fisheries Centre in Oman; these are as yet unpublished.

The sightings and strandings described in this paper were collected as a by-product of coastal zone management studies. No rigorous sighting surveys were conducted; consequently, it is not possible to quantify effort. Even so, it appears to the authors that the waters off Oman are rich in cetaceans and merit further study.

MARINE MAMMAL FISHERY

Butchered dolphins were found at five locations (Table 3). It is unclear whether they were actively hunted or caught incidentally in gillnets set for sharks. It was only possible to determine whether a dolphin had been butchered if remains still had flesh attached. Therefore, some of the other skulls and skeletons found along the coast may also have been from butchered animals.

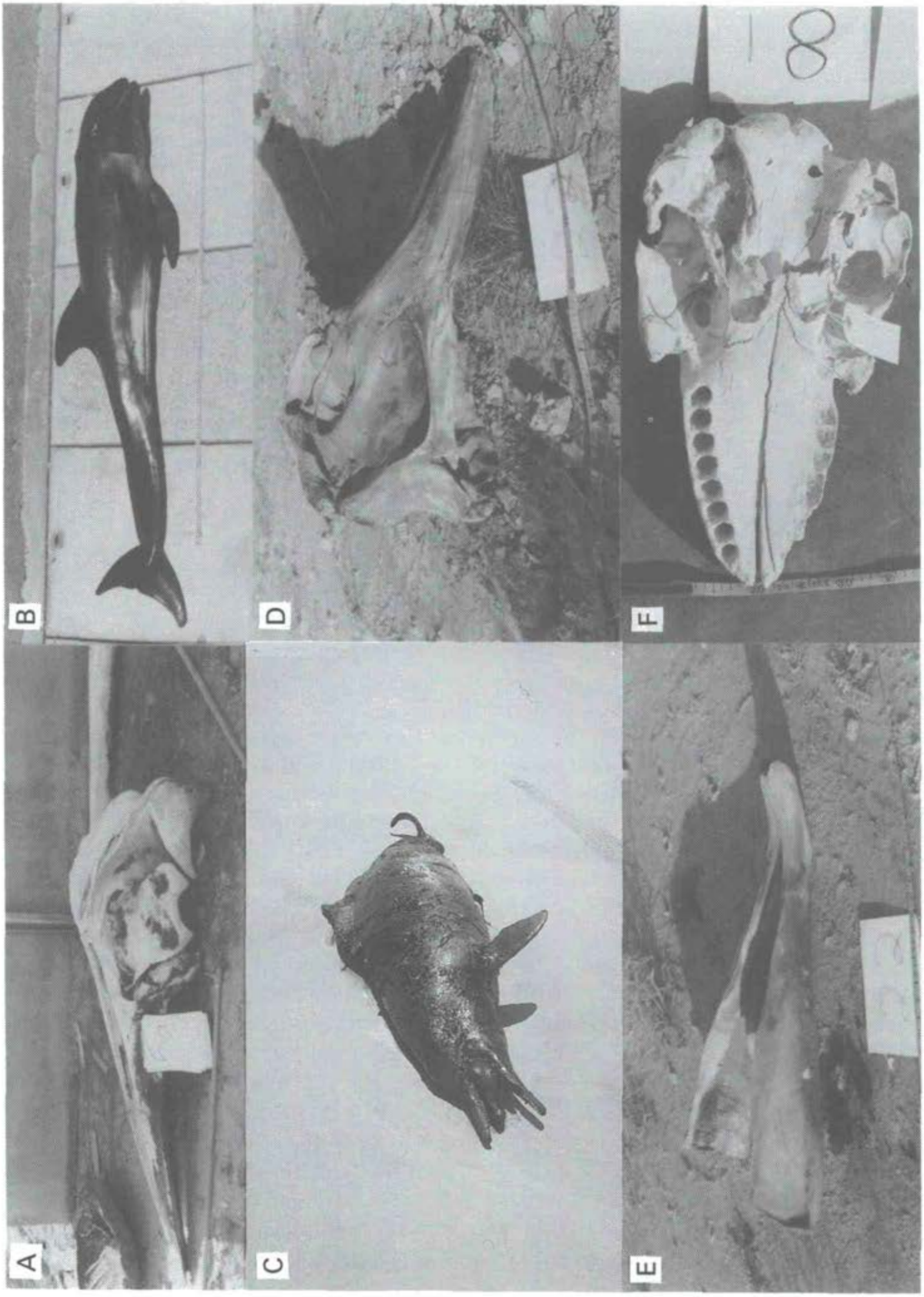

Fig. 2. Some cetacean specimens from Oman: baleen whale skull, collected 17 March 1987 and now at the Marine Science and Fisheries Center (A); calf false killer whale stranded near Muscat 30 August 1987 (B); hump-backed dolphin near Al Khaluf 27 May 1988 (C); mature male Cuvier's beaked whale at Ras al Hadd 22 January 1988 (D,E); and skull of a false killer whale (ONHM 1044) collected at Ras al Dil 22 March 1989 (F) (V. Papastavrou).

Table 3

Probable exploitation of Cetacea: Ra's Sawadi to Rakhyut.

Date	Place	Position	Notes
13/01/87	Wadi Haytam on Jazir coast	18°50'N, 56°55'E	3 butchered dolphins; tails removed.
13/01/87	Sawqirah	18°09'N, 56°33'E	1 butchered bottlenose dolphin (det. Van Bree) ONHM1019.
16/03/87	Ar Ruays	20°57'N, 58°48'E	Skull of butchered dolphin, 34 teeth, UR ONHM1022.
24/04/87	Ra's Khushayyim	18°58'N, 57°48'E	Butchered bottlenose dolphin (photos taken).
07/05/87	Barr al Hikmana	20°22'N, 58°23'E	Freshly butchered dolphin (photos taken), less than 34 teeth, LR ONHM1050.
08/05/87	Barr al Hikman	20°23'N, 58°16'E	Small butchered dolphin (skeleton collected, ONHM1021).
02/02/87	Barr al Hikman	20°22'N, 58°23'E	Freshly filleted dolphin on beach: tail, skull and all meat removed, vertebrae, ribs and entrails left on beach.

The dolphin carcasses found in the Jazir region, at Sawqirah and at Ra's Khushayyim had been cut in half behind the flippers and the head, thorax and internal organs discarded. The dolphin carcasses found on Barr al Hikman had virtually all the muscle removed, with knife cuts behind the head. At Ar Ruays, only the head of a butchered dolphin was found; it was not possible to determine how long before it had been butchered. Fishermen interviewed at Barr al Hikman claim to eat dolphin meat fresh and to dry it, along with shark meat, for sale to the bedouins. This practise was more common in the past (Mohammed al Barwani, pers. comm.).

Alling (1983) and Alling *et al.* (1982) mention a small dolphin fishery off Masirah, information which she received from Mohammed al Barwani. The island of Masirah was outside our study area. Gallagher and van Bree (1980) describe a dwarf sperm whale found near Muscat, which appeared to have been deliberately filleted. It appears from these accounts and the evidence presented in Table 3 that few animals are caught.

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REFERENCES

Alling, A. 1983. A preliminary report of marine mammal fisheries in Djibouti, Oman and Sri Lanka. Paper NARA/SMMIO/SP32 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished). 4pp.

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83:376–94.

Alling, G., Gordon, J., Rotton, N. and Whitehead, H. 1982. WWF-Netherlands Indian Ocean sperm whale study, 1981–1982 interim report. Paper SC/34/Sp9 presented to the IWC Scientific Committee, June 1982 (unpublished). 46pp.

Gallagher, M.D. a. Collections of skulls of Cetacea: Odontoceti, from Bahrain, United Arab Emirates and Oman, 1969–1988. (Published in this volume.)

Gallagher, M.D. b. Strandings of sperm whales (*Physeter macrocephalus*) on the shores of Oman, Eastern Arabia. (Published in this volume.)

Gallagher, M.D. and van Bree, P.J.H. 1980. On a dwarf sperm whale *Kogia simus* (Owen, 1866), from the Sultanate of Oman. *Z. Säugetierkunde* 45:53–7.

Reeves, R.R., Leatherwood, S. and Papastavrou, V. Possible stock affinities of humpback whales in the northern Indian Ocean. (Published in this volume.)

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. *Ann. Cape Prov. Mus. (nat. Hist.)* 15:173–410.

Ross, J.P. 1981. Recent marine mammal sightings in the Sultanate of Oman (1980/1981). Document 23 presented at Workshop to Plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary, Zeist, Netherlands, 28 September – 1 October.

van Bree, P.J.H. 1971. *Delphinus tropicalis*, a new name for *Delphinus longirostris* G. Cuvier, 1829. *Mammalia* 35:345–6.

van Bree, P.J.H. and Gallagher, M.D. 1978. On the taxonomic status of *Delphinus tropicalis* van Bree, 1971 (notes on Cetacea, Delphinoidea IX). *Beaufortia* 28:1–8.

Whitehead, H. 1985. Humpback whale songs from the North Indian Ocean. *Invest. Cetacea* 17:157–62.

The World Wildlife Fund's Indian Ocean Sperm Whale Project: An Example of Cetacean Research Within The Indian Ocean Sanctuary

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ABSTRACT

The World Wildlife Fund's Indian Ocean Sperm Whale Project was initiated in response to the formation of the Indian Ocean Sanctuary. The methods used and some of the findings of the project are briefly reviewed. The extent to which the project achieved some previously agreed objectives for scientific research in the sanctuary is discussed, and it is concluded that it did address all these objectives. Appropriate benign research can provide the information required for the conservation and management of cetacean populations within reserves. The experience of this project shows that scientific research and cetacean sanctuaries may interact constructively. Each can benefit from the other in a number of ways.

Keywords: sanctuary; Indian Ocean; sperm whale; social; behaviour; acoustics; survey-general; photo-id; photogrammetry; growth/length distributions; echolocation; feeding; communication; management; reproduction; education.

INTRODUCTION AND BACKGROUND

Scientific research has always been integral to concepts of cetacean sanctuaries. For example, one of the criteria for a cetacean sanctuary proposed by the workshop on cetacean sanctuaries convened in Mexico by the International Union for the Conservation of Nature (IUCN) and the United Nations Environmental Program (UNEP) was to provide an area where benign research and public observations should be conducted appropriately. Other criteria were: that cetaceans would be protected from being killed or harassed; that their environment should not be impaired by human activities; and that public awareness of the significance of cetaceans in the natural environment should be enhanced (Anonymous, 1979).

Most interactions between scientific research and a cetacean sanctuary are positive (Table 1). A sanctuary provides a particularly favourable research location and may encourage financial support, while scientific research contributes information necessary for the effective management of the sanctuary and also enhances its interest. The possible negative effects concern the extent to which the existence of a sanctuary might inhibit disruptive or consumptive scientific research and conversely the degree to which such research would violate the effectiveness of a sanctuary.

When the Seychelles proposed that the International Whaling Commission (IWC) should declare the Indian Ocean a whale sanctuary, it prompted much debate along these lines in the Scientific Committee of the IWC (International Whaling Commission, 1980b). While some members welcomed the sanctuary as an area of minimal disturbance with a stable management regime which would thus be an ideal location for long term population studies, others believed that scientific research would suffer from a lack of specimens and

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Table 1

Interactions between research projects and cetacean sanctuaries

Positive	Negative
Consequences for sanctuary of research	
Provide necessary information on: the distribution of different species within the sanctuary, the size and status of specific stocks, the conservation and management of populations. Contribute to the sanctuary's role in promoting awareness of cetaceans.	Some research may harm or disturb cetaceans
Consequences for research of sanctuary	
Provides a unique study location where: studies will not be disrupted by human interference, subjects may be particularly approachable, recovery of populations after exploitation can be investigated, populations at "initial levels" or carrying capacity may become available for study, comparative studies with non-protected stocks can be performed. Sanctuaries may promote interest in the support for relevant research both inside and outside the sanctuary.	Certain kinds of research may be precluded

financial interest from commercial whaling. It was further argued that the information necessary for management could be provided only if scientific catches were allowed within the sanctuary. Other scientists argued that whaling material had already proved inadequate for providing such information, but that it was possible that studies of live cetaceans within the sanctuary might succeed in providing it. Essentially, the argument reflected different views within the committee of the shortcomings of data derived from whaling operations and on the potential of benign research techniques to provide information required for effective conservation and management.

At its annual meeting in July 1979 the IWC accepted a revised version of the Seychelles' proposal and declared all of the Indian Ocean north of 55°S to be a whale sanctuary (International Whaling Commission, 1980a). The Commission also approved a resolution asking the Scientific Committee to investigate the types and levels of research necessary to obtain adequate information on the status of the stocks within the sanctuary.

Following the success of their sanctuary initiative, the Seychelles hosted a meeting of Indian Ocean states in April 1980 and proposed an Indian Ocean Alliance for Conservation. Amongst their recommendations was one that a meeting should be convened to plan a co-operative program of monitoring and research in the new sanctuary, with emphasis on the study of the living animals by benign methods, that is methods which neither harm nor substantially change the behaviour of the subjects (Anonymous, 1980).

Such a meeting was held in Zeist, Netherlands, in 1981, and was sponsored by governments of the Seychelles and the Netherlands with the support of IWC, World Wildlife Fund (WWF) and the League for the Protection of Cetaceans. Participants included scientists from Indian Ocean States and scientists working in other parts of the world who had developed and were using field techniques which were likely to be appropriate for work in the sanctuary. The meeting thus reviewed available methods and made proposals for new research projects in the sanctuary. At this meeting the following objectives for a research program in the sanctuary were agreed:

(1) to satisfy the needs of the IWC Scientific Committee particularly in obtaining adequate information about the distribution and abundance of whales, their reproductive behaviour and related matters relevant to assessment of stocks;
(2) to obtain scientific information pertinent to assessing and realising the economic, cultural and scientific value of living cetaceans;
(3) to enhance understanding of the ecological role of cetaceans in marine biological systems, and to permit assessment of the impact of human activities on recovering and unexploited populations;
(4) to focus attention on the development and application of benign research techniques;
(5) to foster investigations on the frontiers of research on living cetaceans, such as communication, navigation, behaviour and physiology of diving;
(6) to ensure the establishment of centres of research on cetaceans in the Indian Ocean, and to further communication about cetacean research among Indian Ocean coastal states and between them and others involved in such research (Anonymous, 1981).

In November of 1980, WWF and whales were chosen as the beneficiaries of a televised opening of a new flower market in the Hague. WWF Netherlands decided to use the proceeds to fund a study of live cetaceans within the new sanctuary, and accepted a proposal from Hal Whitehead and myself to conduct a three year shipboard investigation of the social behaviour of sperm whales. The social behaviour of sperm whales was recognised as being of crucial management importance but was very poorly known. Social behaviour is the interaction of live individuals, and such a dynamic system is difficult, if not impossible, to investigate using the corpses made available by commercial whaling operations. Sperm whales are a largely oceanic species, rarely coming into shallow waters. They make long deep dives which can last over an hour and spend much of their lives underwater. They were believed to be a particularly intractable species for behavioural study and would thus provide a severe test, and we hoped a proof, of the efficacy of benign research techniques. The project was lead by Hal Whitehead, I was a principal scientist with special responsibility for sperm whales and project co-leader in the final year. Abigail Alling was involved with the project throughout and took responsibility for dolphin and blue whale studies. The research vessel was renamed *Tulip* at the beginning of the project in recognition of the source of sponsorship and the whole project soon became known as the 'Tulip' project.

This was the first and most extensive behavioural project to take place within the sanctuary. *Tulip* operated in the Indian Ocean for four field seasons (and research during transit from and to home port) spread over three years (Table 2). Preliminary reports were presented after each field season. Analysis of these materials is being published as a series of papers. Much of the sperm whale analysis is presented by Gordon (1987a).

In this paper I aim to give an impression of the scope of the project by briefly describing the techniques used, and by giving examples and a summary of our findings. I will limit myself to discussion of the sperm whale research. (Research conducted on blue whales, is

Table 2

Time and location of field seasons

Spring 1982	Jan-April	Red Sea. Gulf of Aden. S. Coast of Oman. Laccadives, S. Coast of India, Gulf of Mannar Sri Lanka.
Spring 1983	Jan-April	Gulf of Mannar, W. Coast of Sri Lanka, E. Coast of Sri Lanka.
Autumn 1983	Oct-Dec	E. and S.W. coasts of Sri Lanka, Maldives
Spring 1984	Feb-April	Maldives. E. Coast of Sri Lanka.
Summer 1984	May-June	Seychelles, Red Sea.

presented in other parts of this volume). Incidental sightings of small cetaceans are presented by Alling (1986), work on the dolphin by-catch was summarised by Alling (1985) and some humpback research has been published by Whitehead (1985). I will also consider the extent to which the project has managed to address the Zeist objectives and discuss what this experience tells us about the way that scientific research projects and sanctuaries interact.

FIELD TECHNIQUES

The techniques used and developed on the project are described by Whitehead and Gordon (1986), and also Gordon (1987a). Our basic approach was to use a small offshore sailing yacht with auxiliary power, crewed by a small team of field workers who combined a scientific training with a knowledge of the sea and sailing.

Research vessel

The research vessel *Tulip* was a 10m sloop (Gladiateur/Waquiez), with a small (25hp) diesel engine. In reasonable conditions she could manage 5–6 knots under sail and 4–5 knots under power. Such a vessel had a number of advantages for this kind of research.

Being small she had modest operating and maintenance costs. She was relatively simple to run and maintain, obviating the need for a specialised crew and allowing a fair degree of independence, even in remote locations. Small size also made her highly manoeuvrable, an important feature when working around whales. She represents a minimal disruptive presence. At 10m *Tulip* was about the same length and considerably lighter than most of the cetaceans being studied.

The vessel's sailing ability was important in allowing such a small boat to be an effective research vessel. It gave her an extended range, reduced the fuel bill and (in combination with the engine) provided a double element of safety. Sails also helped to steady the boat in a seaway making it a relatively comfortable working platform. The ability to heave-to quickly to stop the boat, was also very useful. Mono-hull sailing boats, like *Tulip*, have deep keels which hold them in the water and prevent them being blown quickly downwind as tends to happen with motorboats or multihulls.

The mast also provided a necessary elevated viewpoint. In this case a viewing position was provided by suspending a canvas bosun's chair at the cross-trees (height *ca* 9m). The mast was climbed with the help of folding mast steps. Under sail alone such a vessel can be manoeuvred almost silently. This can be crucially important, especially when working acoustically with such an acoustically aware animal.

The vessel was not without shortcomings. It was cramped, hot and at times uncomfortable. Inevitably it was slightly less able to operate in rough weather conditions than a larger boat would have been. In addition, the boat's limited power supply precluded the use of equipment with large energy requirements. On the whole the benefits far outweighed the disadvantages, and in most cases the overwhelming economic advantages of using a boat like this would overshadow most other considerations.

Working procedures

At most times we had a crew of four or five. At night, or when not close to whales during the day, one person was able to handle the boat and keep track of the whales. During close encounters with whales there would usually be one observer at the cross trees who sighted whales, guided the helmsman to them and took photographs for length measurement. One or two others would take identification photographs from the deck. Another kept notes on the behaviour and movements of the whales and on all photographs taken. The final worker was responsible for sailing and steering the boat.

Each crew member had an interest in, and an involvement with, the research. Consequently they were willing and able to work conscientiously for long hours in difficult conditions.

Finding and following sperm whales

Sound proved to be the key to finding and following sperm whales. Sperm whales make very loud and regular click vocalisations while they are underwater. By using a passive directional hydrophone we were able to obtain a bearing on these sounds. Having done this we would sail in the direction of the sounds for about 5 to 10 minutes, then stop the boat and listen again. With practice we became better able to judge the range of whales from the loudness and quality of their vocalisations, and thus to determine how far to go before listening again. Clicks from closer whales were louder. They also sounded 'sharper' due to an increased high frequency component and reduced reverberation. When whales were very close their sounds became non-directional in the horizontal plane. A whale's clicking typically became irregular and then ceased completely some minutes before it surfaced. This was taken as a cue to intensify our visual search for surfacing whales.

Acoustic tracking allowed whales to be followed for extended periods and even through the night. However whales sometimes fell silent for long periods and at such times groups might be lost. Confusion could also arise when two groups moved close together at night. When the groups separated again one had no means of knowing which sounds to follow. On several occasions later analysis of identification photographs revealed that we had inadvertently switched groups while tracking whales acoustically, although at the time we believed we were following the same individuals. Even so, we were able to follow one group over a period of 12 days (although not continuously).

The directional hydrophone that we used during this study was fairly unsophisticated and consisted of a single hydrophone at the focus of a reflective cone, which was mounted in a streamlined fairing about 1.5m below the surface at the stern of the boat. High-pass filters (up to 10KHz) were used to cut out low-frequency background and water noise. The estimated range of this system (determined by steaming rapidly away from a clicking whale) was 3–5 n.miles. A slightly different hydrophone being used in the Azores appears to have better performance and with more sophisticated designs greater ranges should be achieved.

A second method of following whales acoustically was used for precise tracking at short range. This involved using a simple three hydrophone array towed behind the boat. Two hydrophones were towed at the same distance behind the boat and approximately 4m apart. Their output was displayed simultaneously on a dual-trace oscilloscope. If a vocalising whale was to the right its clicks would reach the starboard hydrophone first and this would be seen on the oscilloscope traces. If the boat was now steered to starboard the time difference at the two hydrophones would decrease. When sound was arriving at exactly the same time at both hydrophones the whale would be either directly ahead or directly behind. This ambiguity could be simply resolved by comparing the time of a sound's arrival at one of the pairs hydrophones and at a third hydrophone streamed some way behind it.

Identification of individuals

Individual sperm whales were identified from high quality photographs of distinctively marked fins and flukes. Photographs were taken with 35mm cameras with 200–300mm lenses. Both colour-transparency and black and white films were used. Photographs of dorsal fins were easy to obtain as they were usually exposed by whales at the surface. Dorsal fins varied in shape, in the presence and shape of calluses, and were occasionally scarred. Photographs of flukes were more difficult to obtain as whales revealed these features to a surface observer for only a brief period, usually as they began deep dives. Sperm whale flukes may have marks, scars, nicks and more major deformities along their trailing edges. 57% of all the flukes photographed during this study had potentially useful identification features.

Some whales had other distinctive features such as white markings or a mottled pattern of small spots on their flanks.

Photographs of dorsal fins were difficult to analyse because distinctive marks were often subtle and photographs could be ambiguous. They were useful for distinguishing between a limited number of individuals over a short period of time; between the members of a group which was being followed for example. I have not used them for making long term identifications.

Fluke markings were much more distinctive and easy to recognise. Flukes showing several clear marks have been used to make longer term reidentifications both within and between years.

Identified whales were organised in catalogues. A total of 320 identification numbers was assigned during the two spring field seasons, and 106 of these whales had potentially useful fluke marks.

The same identification methods have recently been used during a study of sperm whales off the Galapagos (Whitehead and Arnbom, 1987). The flukes of the whales photographed off the Galapagos were more extensively scarred than those from Sri Lanka increasing the scope of the research which can be attempted in this species using individual identification.

Determinations

Adult males can be readily distinguished by their greater size and by their relatively larger head size; however immature males are difficult to distinguish from females. Kasuya and Ohsumi (1966) have shown that calluses are far more common on the dorsal fins of mature females than on the fins of other members of the population. The correlation is not perfect, but over 82% of the 98 female and immature male whales in their sample would have been correctly classified on the basis of dorsal fin calluses. Photographs taken for identification allowed the presence of calluses to be observed and an individual could be assigned to a sex on this basis.

Whales could also be sexed by visual inspection of the genital region by underwater observers. However, it was difficult to correlate these observations with identification photographs taken above the surface.

Measuring body length

A technique was developed which allowed the length of a whale to be estimated from a single photograph, taken at a known height and showing the horizon and the whale at the surface with its dorsal fin and blow hole visible. Details of this technique were given in Gordon (1985; 1987a). Accuracy under field conditions proved acceptable (95% confidence limits for a single photograph of 10%). The technique can also be used to measure the length of other species. It has been used to measure minke and fin whales and adapted to allow the measurement of blue whales (Gordon *et al.*, 1986).

An acoustic length estimation technique first suggested by Norris and Harvey (1972) has been investigated and will be discussed further in a later section.

Depth sounder traces

A dry-paper recording depth sounder (*Simrad, Skipper* 603) was used to track diving sperm whales. To achieve this the research vessel was manoeuvred into the slick left by a diving whale. As the initial part of a sperm whale's dive is steep, whales could often by tracked down to about 500m in this way. Longer traces, and tracks of whale movements while underwater, could be obtained by using the three hydrophone array tracking technique outlined above.

Underwater observations
Sperm whales had rarely been encountered by swimmers previously, but we found that we were able to observe sperm whales underwater routinely. Observers with snorkelling equipment were usually towed by the boat so that they could maintain proximity with whales. Observations were made and memorised, and still and movie film was taken. It was important to note down observations as soon as possible after leaving the water.

Underwater sound recordings
The use of a small quiet vessel which could be easily hove-to facilitated the collection of good quality underwater sound recordings. Omnidirectional hydrophones with preamplifiers (*Benthos* AQ17 and *KSP* HS-107/22) and reel to reel tape recorders (*Uher* and *Nagra*) were used. Very long sequences were occasionally recorded from groups while sailing the boat slowly to keep up with them. During several periods of the study short recordings were made in a standard way on a regular schedule to allow patterns and cycles of vocalisations to be investigated.

Behavioural observations
Whale behaviour could be noted by observers on the deck, from a viewing position at the cross trees and while swimming. General surface activities and observational effort were recorded on prepared data sheets. Commentaries recorded on tape, video recordings and super-8 film were useful for making detailed records of behavioural events.

RESULTS

My intention here is to give a brief overview of our findings. For a more detailed presentation of this work see Gordon (1987a).

Geographical coverage
Our principal research aim, to study sperm whale social behaviour, required us to make a careful study in one particular area for as long as possible. This was not conducive to achieving an extensive geographical coverage. However *Tulip* had to be brought from Europe at the beginning of the project and returned there at the end and in the first year several different areas were visited and assessed as study locations. Fig. 1 shows the vessel's approximate path and Table 2 indicates the areas visited during different study periods. Fig. 2 shows the vessel's track off the east coast of Sri Lanka (our main study area) in the springs of 1983 and 1984.

SURVEYS

All sightings of cetaceans made during passages and while conducting fieldwork were noted. Incidental sightings of small cetaceans made on the project have been reported by Alling (1986) and sightings and behavioural observations of blue whales are presented elsewhere in this volume.

Two acoustic surveys were conducted in the Gulf of Mannar (March 1982 and January 1983) by sailing along a predetermined course and monitoring hydrophones at stations 10

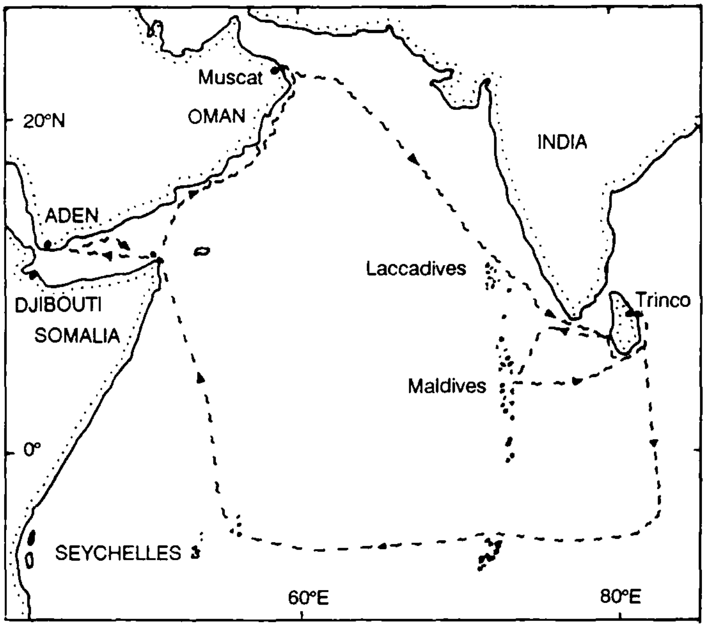

Fig. 1. Approximate track of the research vessel 'Tulip' in the Indian Ocean, 1982–1983.

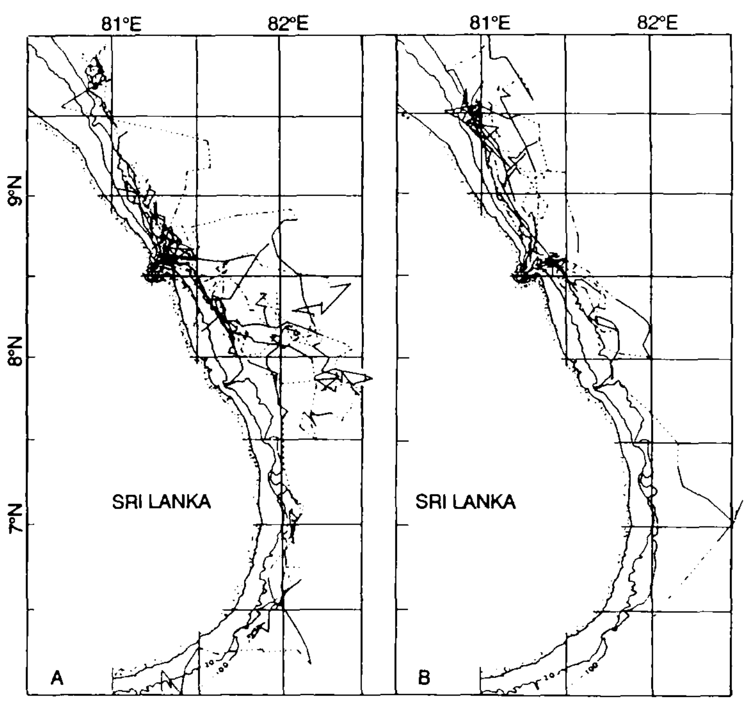

Fig. 2. Vessel's track off eastern coast of Sri Lanka during 1983 (A) and 1984 (B). Broken line indicates track during the hours of darkness. Dotted lines show the 20 and 100 fathom contours.

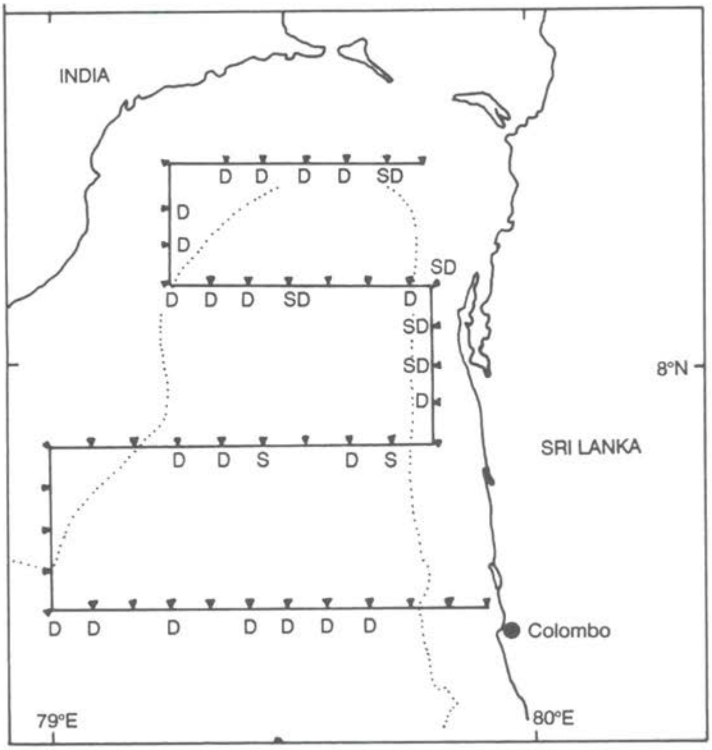

Fig. 3. Vessel's track and monitoring positions during an acoustic survey of the Gulf of Mannar, January 1983. Key: ▼ = monitoring station; S = sperm whales heard; D = dolphins heard.

miles apart. The survey in March 1982 had to be abandoned due to bad weather. Fig. 3 summarises the second survey, completed in January 1983. Sperm whales were most often heard near the edge of the continental shelf on the Sri Lankan side of the Gulf. This is also where we encountered most whales when not conducting surveys. Dolphins were heard at most listening stations.

A census trackline must be unbiased relative to the objects being censused. We spent much of our time at sea in areas where we expected to find sperm whales, and often followed them. Our movements were thus highly biased, particularly with respect to sperm whales.

Fig. 4 shows the position of all encounters with sperm whales on the NE coast of Sri Lanka during the spring field seasons in 1983 and 1984. Sperm whales were distributed offshore from the continental shelf and along most of the northeast coast. Two locations, one to the north (9°30′N, 81°0′E approx) and another outside Trincomalee Bay (approx 8°40′N, 81°20′E) appear to be areas of high concentration.

During the 1984 field season the vessel was hove-to every two hours and the hydrophones were monitored for three minutes. Various data were recorded including the number of sperm whales which could be heard clicking. These data have been analysed by 10 n.mile squares (Fig. 5). Sperm whales were heard all along the coast, usually along the edge of the continental shelf, with particularly high occurrences to the north and outside Trincomalee Bay.

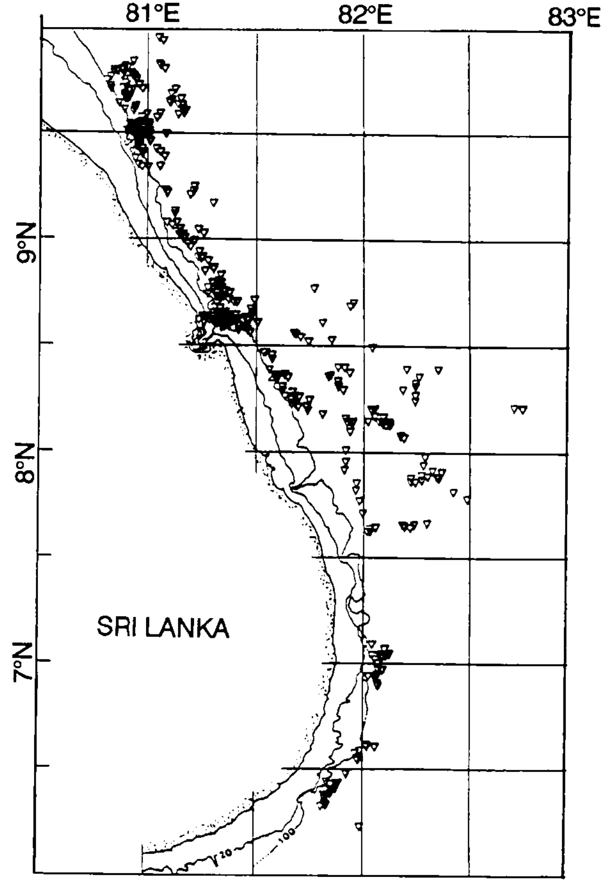

Fig. 4. Positions of all encounters with sperm whales off the eastern coast of Sri Lanka during 1983 and 1984. Dotted lines show 20 and 100 fathom contours.

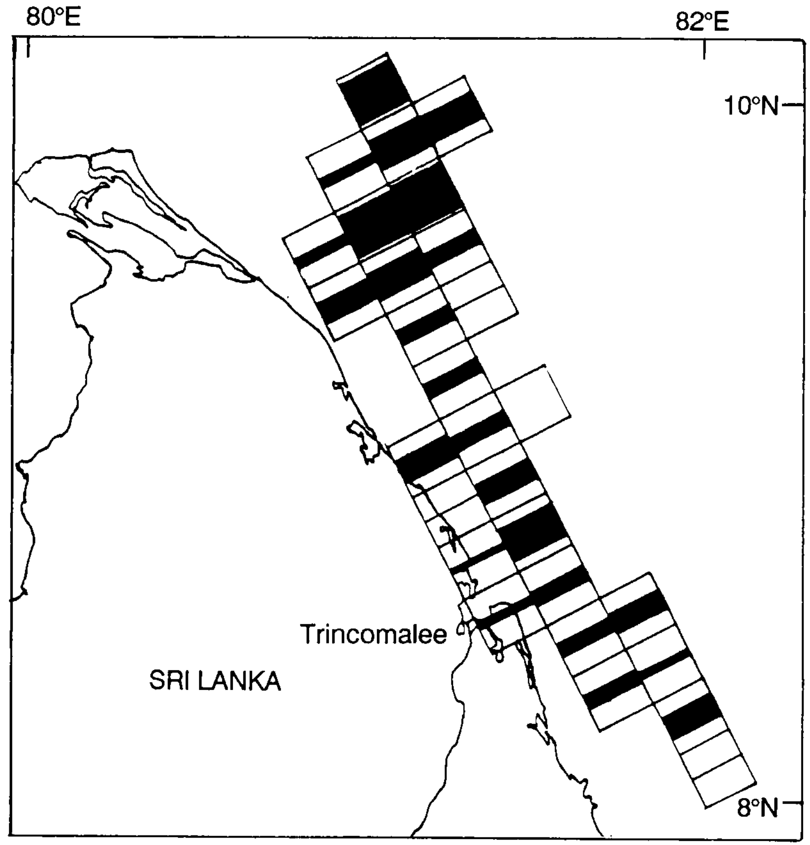

Fig. 5. Distribution of sperm whales during the months of March and April 1984 as indicated by acoustic monitoring. The average number of sperm whales heard per monitoring is indicated by the width of the shaded bar in each square (1.7mm represents one whale). Squares are 10 by 10 nautical miles, only squares in which 5 or more monitoring sessions were conducted are shown.

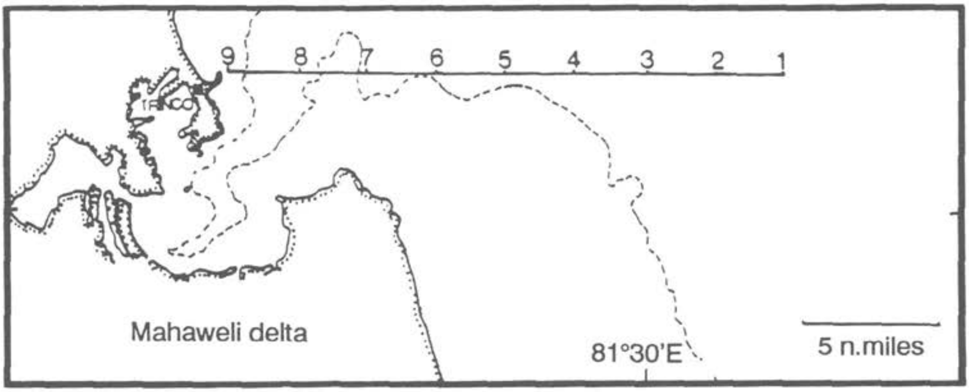

Fig. 6. Transect and position of monitoring stations off Trincomalee, northeast coast of Sri Lanka. 100 fathom contour is shown.

On seven occasions during the spring field seasons of 1983 and 1984 a standard transect was sailed. Two of these attempts could not be completed due to poor weather conditions. The transect started 20 miles east of Swami Rock (near Trincomalee) and followed the course shown in Fig. 6. A watch was kept from the cross-trees as the boat sailed in toward Trincomalee, and the boat's position when any cetacean passed abeam and its estimated range were noted. Every 2.5 miles the boat was hove to and the hydrophones were monitored while environmental data were recorded. The number of sperm whales seen on each leg, and the number of occasions on which sperm whales were heard at each station, are shown in Table 3. Sperm whales were heard at all but the most inshore and the most offshore stations; however, they were only seen between stations 5 and 9. Data from these transects support earlier suggestions that sperm whales are most abundant close to the edge of the continental shelf, although the underwater topography in this region is complicated.

Our success with using simple acoustic methods to locate sperm whales, and our experience with attempting acoustic surveys, emphasises the likely value of acoustic censusing for sperm whales. I believe that for this species an acoustic approach would offer many advantages over visual surveys. Further research will be needed and some of this work is already being conducted.

Table 3

Number of sperm whales heard and seen on transects

Stations	Legs	Heard	Seen	Stations	Legs	Heard	Seen	Stations	Legs	Heard	Seen
1		0		4		2		7		3	
	1-2		0		4-5		0		7-8		2
2		2		5		2		8		3	
	2-3		0		5-6		1		8-9		4
3		2		6		3		9		0	
	3-4		0		6-7		2				

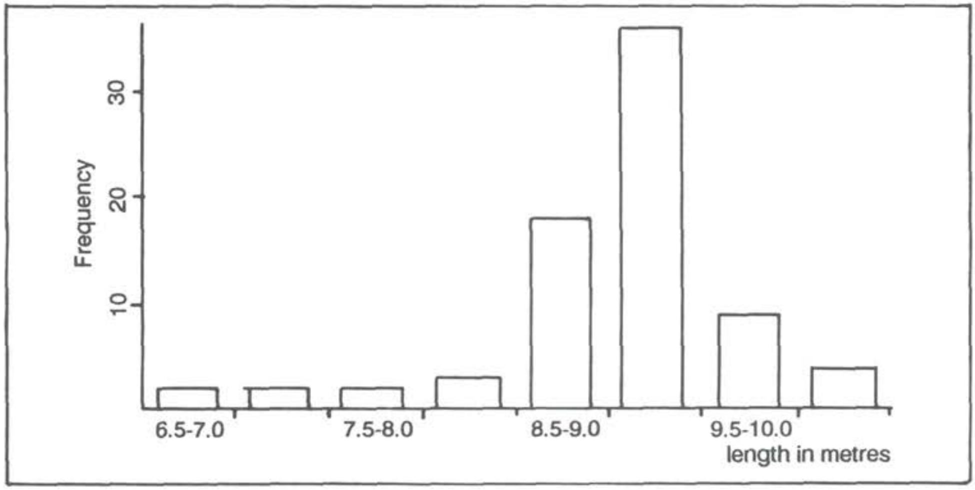

Fig. 7. Histogram showing distribution of average values of photographic length estimates of individuals encountered off Sri Lanka.

Population composition

During the two spring field seasons only female and immature male whales were encountered, with a single possible exception. One large sperm whale, believed to have been a mature male, was encountered briefly on 24 April 1984, the last day of fieldwork. Mature males were encountered off the southwest coast of Sri Lanka on two occasions during cruises in the autumn of 1983. Even at this time mature males were uncommon (Whitehead *et al.*, 1983). The distribution of photographic length estimates for whales encountered off Sri Lanka in the Springs of 1983 and 1984 revealed that most individuals were between 8 and 10 metres, and none were longer than 12 metres (Fig. 7). This is the size distribution one would expect to find for a population of females and immature males. The ratio of encounters with individuals with dorsal fin calluses to those with no calluses during the two spring field seasons was very close to the ratio which would be expected for a tropical population (assuming that all whales with calluses were mature females and various life history parameters suggested by Best (1979) apply (Gordon, 1987b).

Social behaviour

An animal's social behaviour is its interactions with other individuals of the same species. Hence extensive observations of live animals are required to study it adequately. In his excellent review of sperm whale social behaviour, based mainly on information obtained from whaling operations, Best (1979) refers to his conclusions as, "a skeleton…that needs 'fleshing out' with direct field observations of social behaviour". Making these much needed observations was our major research aim. Findings relevant to social behaviour were presented by Gordon (1987a; b).

Sperm whales which were within 100m of each other at the surface and which showed coordinated movements and behaviour, were considered to belong to the same pod. The distribution of individuals in some typical pods is shown in Fig. 8. Sperm whales were most frequently encountered as singles off Sri Lanka. However most whales spent their time in pods of size six. The largest pod size observed was ten. Pods could include individuals with calluses (presumed mature females), individuals with no calluses (presumed immatures) and calves. Whales with calluses were observed in slightly larger pods than calves, which in

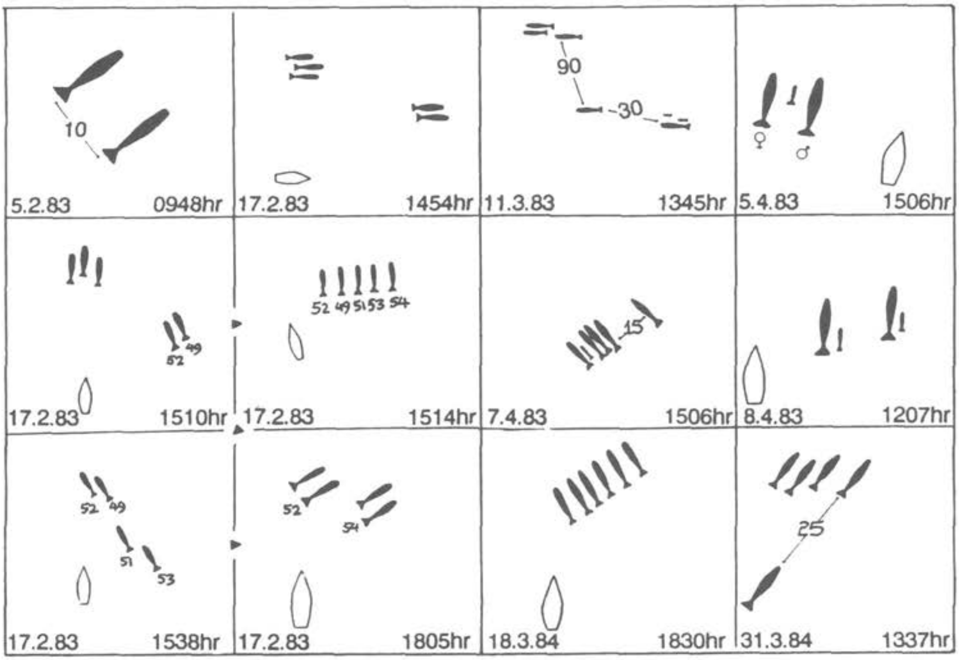

Fig. 8. Spatial distribution of whales in some typical pods encountered on the dates and times shown. Vessel's position is also shown. Arrows indicate sequential views. Identification numbers and sexes of individuals are shown where appropriate. Views are based on field sketches and are not to scale. When shown, distances are in metres.

turn tended to be in larger pods than whales with no calluses. There were some indications that whales with no calluses tended to associate together in all no-callus pods. The composition of pods was very labile, with the associations of individuals changing between sightings. However longer term observations revealed the existence of larger groupings, of about 20 individuals (termed schools in this study). Schools appeared to be closed groups with stable membership. A substantial number of the members of a school first encountered in 1983 were recognised associating together in pods in 1984 this indicates long-term stability of schools (Fig. 9).

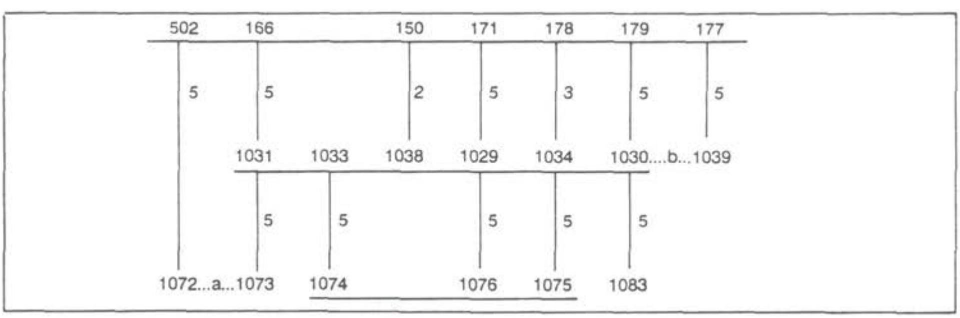

Fig. 9. Numbers in the body of the table are identification numbers assigned to whales. Horizontal lines link individuals seen in groups together; vertical lines indicate photographic matches and numbers in the lines indicate the reliability of these matches. (5=exact correspondence of reliable features, 0=no match).

Identified calves were often seen escorted by different adults, on some occassions calves were seen alone at the surface with adults which could not have been their mothers. On at least one of these occasions the escort was an immature male (as determined by genital inspection). These escort whales may have been performing a baby-sitting role while the calf's mother was absent, possibly engaging in deep feeding dives. (Such observations indicate the futility of attempting to avoid taking nursing mothers by not catching adults accompanied by calves). Some of our findings suggested that communal suckling might occur in this species (Gordon, 1987b), but more extensive observations will be required to confirm this. This work certainly suggests that the care and rearing of calves may be an important function of social groups in the sperm whale. If this is the case, intact social units are likely to be necessary for optimal reproduction.

Different behavioural activities were observed at different rates in pods of different sizes. For example, various activities and vocalisations which we believed to have a social function occurred at a higher rate in larger pods, while activities and sounds associated with feeding were observed at a higher rates in smaller pods. It seems likely that feeding competition and interference would be lower in smaller pods. Larger pods may break into smaller units for feeding. Thus changes in pod size may well be adaptive, facilitating the performance of different activities at different times.

The best studied school in 1983 was tracked over a period of 12 days. During this time it moved first northwest then southeast along the Sri Lankan coast, retracing its path almost exactly. On two occasions in 1984, seven individuals from this school were encountered within a few miles of their position in 1983 (Fig. 10). The degree of site fidelity which these observations suggest is most unexpected in a free-swimming oceanic species.

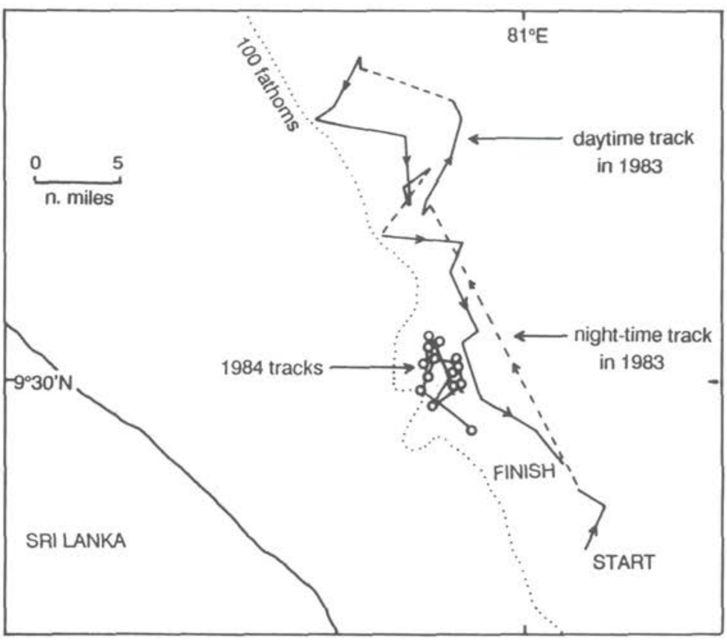

Fig. 10. Vessel's track during part of the 'long follow' (27 March-8 April 1983). Solid line is track through the day, broken line is track through the night. Circles show vessel's position and movements on occasions when whales from the 'long follow school' were re-encountered during 1984. 100 fathom contour is also shown.

These observations and a later study, which used the same techniques, in the Galapagos (Whitehead and Arnbom, 1987), indicate the subtlety and intricacy of sperm whale social behaviour. Simple fixed groupings may not exist. Social behaviour may be better described in terms of continuum of inter–individual associations, with different associations being more important at different times and for different activities.

The labile and dispersed nature of mixed schools indicted by these data suggests that the harem-defence breeding system assumed in the IWC sperm whale model might not represent the most economic breeding strategy for males. A searching strategy could be more profitable and is also suggested by observations of mature males associating with mixed schools off Sri Lanka and in the Galapagos (Whitehead and Arnbom, 1987).

Considerations of social behaviour greatly complicate the conservation and management of this species. We still have little basis for predicting how exploitation or other human activities would affect social behaviour, and how this would affect population productivity or the species' survival potential. Social behaviour is clearly important for the survival and success of individual sperm whales and I suggest that the disruption of the social system would also be deleterious for the population as a whole.

Above-water behavioural observations

The tendency for different activities to occur at different rates in groups of different sizes has already been mentioned. There were also indications of activities occurring at different rates in different locations. Feeding related activities occurred at higher rates and group sizes were smaller when whales were over the continental slope in waters between 500 and 1000m in depth. Larger group sizes and higher rates of 'social' activities were observed from whales in deeper waters.

There was little diurnal variation in activity rates. This may reflect the fact that sperm whales feed at depths to which little sunlight penetrates, where food availability may not vary diurnally, and where passive acoustics and echolocation may be more important than vision for finding food. A most surprising finding was significant variation in both fluking up rate and swimming direction on a tidal cycle. The significance of tides to an animal living well offshore in an area with a tidal range of less than one metre is not obvious.

Vocalisations

Sperm whales are highly vocal animals living in an environment which greatly favours the propagation of sound in comparison to light. The most commonly heard pattern of vocalisation was 'regular clicking': long sequences of clicks produced at a regular rate (ca.2 per sound). This was interspersed with pauses and another vocalisation: 'creaks'. Sperm whales appear to engage in regular clicking for most of the time that they are away from the surface on deep dives. 'Creaks' are short sequences of clicks produced at an increasing repetition rates (usually up to 50–100 clicks per second). I believe them to be equivalent to the echolocation runs made by bats and dolphins as they close in on targets. Interclick intervals and rate of increase of click rate during creaks are consistent with this view. Whales which creaked while being tracked by a depth sounder often showed a marked change in dive profile during a creak, as though they had made a diversion during their descent to catch prey (Fig. 11). If creaks do occur during feeding then rates of creaking may be indicative of feeding rates. Whales were found to creak at rates which would allow them to achieve their daily dietary requirements in 11 hours, if one food item was caught each time the whale creaked.

Sperm whales should be able to monitor the feeding activities of other whales by attending to their creak rates. This provides considerable scope for the evolution of co-operative feeding associations in this species.

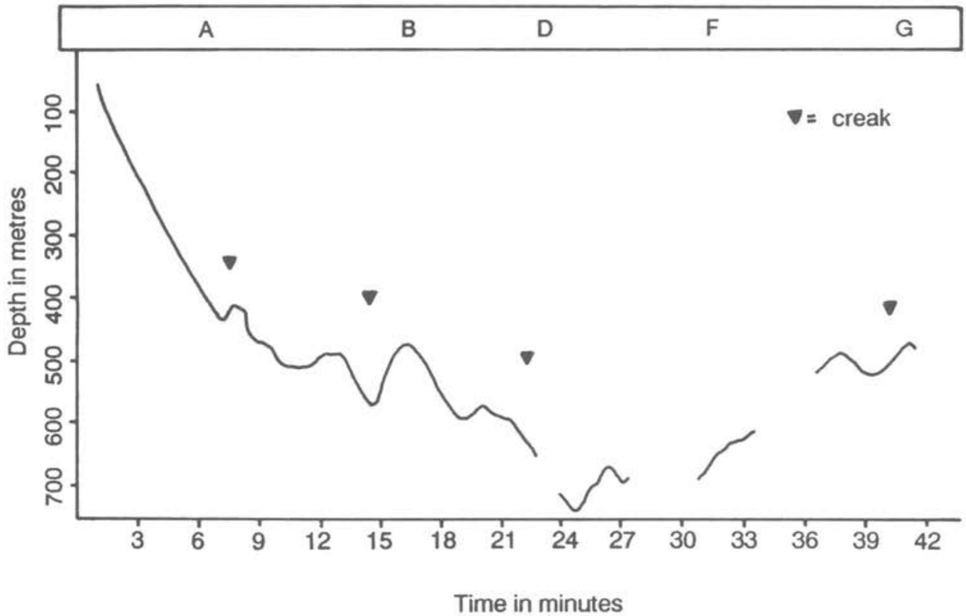

Fig. 11. Traces of sperm whales dives obtained by keeping the boat directly above diving whales.

Evidence was collected supporting the view (contrary to that proposed by Watkins, 1980) that sperm whales do make sounds suitable for echolocation. In particular they make creaks during long dives and rapid click sequences when at the surface. Rapid clicks recorded at the surface were found to be directional and to show systematic changes in frequency emphasis which would facilitate fine scale discrimination of objects. Observations made during this project lead me to propose that sperm whales can operate in two echolocatory modes. Loud 'regular clicks' could represent a very wide-beam, low acuity sonar, useful for searching large volumes of the ocean for substantial features such as the bottom, the surface, other whales, and prey schools. Creaks and rapid click trains could represent a narrow-beam, short range, high acuity sonar similar to that employed by dolphins and used for fine-scale discrimination of proximate objects.

Various patterned sequences of clicks, including stereotyped patterns called codas, were heard from socialising groups. They are believed to represent a form of communication. Watkins (1980) suggested that codas are individual identification calls; however, preliminary analysis of our material does not fully support this contention.

Another vocalisation often recorded was the 'clang': loud resonant clicks with a narrow band of frequency emphasis repeated at a very slow (*ca* 1 per 7secs) and regular rate. These qualities make 'clangs' ideal for long range transmission and reception and I suggest that they may be used for long-range communication or echolocation.

Extremely loud impulsive reports, termed 'gunshots', were occasionally recorded. 'Gunshots' are likely candidates for the prey-stunning sounds proposed by Norris and Mohl (1983). However they were recorded too rarely for them to be considered a normal adjunct to feeding events.

Vocalisations were monitored regularly both through the day and through the night giving some insights into nocturnal behaviour. Sperm whales were highly vocal at all times. Average click rates were remarkably constant at about two per second; however rates were slightly, but significantly, elevated during the daylight hours. Social sounds were heard more often during the day but this result might have been confounded by our enhanced ability to stay close to socialising groups during the day. Overall there was remarkable little diurnal variation in vocalisation rates.

We were able to conduct the first test of an acoustic length measuring technique. The waveform of a typical sperm whale click often shows two or more discrete sound pulses. Norris and Harvey (1972) suggested that the time interval between such pulses was equal to the travel time for sound between two air sacs, at either end of the sperm whale's head, which act as sound mirrors. Interpulse interval (IPI) would thus be related to head length and also to overall body length. Mohl, Larsen and Amundin (1981) extended this idea further providing a general equation relating IPI to body length and suggesting that this should be a useful method for measuring body length at sea.

I have been able to test these ideas by measuring interpulse intervals in the clicks of identified whales and comparing these with photographic measurement of body length. Variability in IPI was relatively high (CV *ca* 10%) but confidence limits can easily be tightened by analysing a large number of clicks. IPI did not vary consistently with whale depth or with time since leaving the surface however there was a significant tendency for IPIs to occur in runs of high and low values. IPIs did increase with body length but not according to the formula given by Mohl *et al.* (1981). It appears that these authors had used a speed of sound in spermaceti which was twice as large as it should be, and incorporated an erroneous relationship between spermaceti sac length and total length in their equation. When correct values are used, IPIs do give an accurate indication of total length. This does represent a useful field technique for measuring body length that has many advantages in certain situations. However more work needs to be done to better determine the relationship between IPI and total length and to refine analysis procedures.

Underwater observations

Our underwater observations provided little quantative data but they have given us unique insights into the animal's habits and the physical environment in which it lives. Observations made underwater can also be useful in interpreting the fleeting glimpses of whales one sees at the surface. Sperm whales were revealed to be highly manoeuvreable and graceful swimmers, belying their clumsy log-like appearance at the surface. They would readily assume a variety of orientations when swimming underwater. They sometimes swam on their sides and more commonly on their backs, ventral surface uppermost. It often seemed that sperm whales would turn their ventral surface towards objects which they wished to observe visually. It was also common to see sperm whales hanging more or less vertically in the water.

Suckling was observed on several occasions. Calves were completely submerged while they sucked, and appeared to be grasping the nipple in the corner of their mouths. Some particularly interesting observations, made underwater soon after the birth of a sperm whale calf, have been described by Weilgart and Whitehead (1986).

Sperm whales often touched and rubbed their bodies against each other as they milled together near the surface. Underwater, groups were often seen to assume a three dimensional 'star-like' formation, with all heads pointing in towards the centre, reminiscent perhaps of the 'marguerita flower' formation described by Nishiwaki (1962). On two occasions whales were observed swimming belly to belly with their jaws slightly agape and touching. The significance of these observations is not fully understood but they do reinforce the view that sperm whales have an advanced and complex social organisation.

Faecal analysis

Squid beaks collected from faeces samples were identified, to the level of genus, by Dr Malcom Clarke (Marine Biological Association, Plymouth, U.K.). Only lower beaks can be identified at present. The total sample of (47 lower beaks, collected on 13 different occasions) is dominated by *Histiotuthid* squids which accounted for over 72% of the total. This is broadly in line with collections from the stomachs of sperm whales caught in warm water areas (Clarke, 1980).

The presence of hormones in faeces was investigated with monoclonal antibodies by Charles Bishop (Department of Zoology, University off Bristol, U.K.). His preliminary results were encouraging in that hormones were found in the relative proportions expected for a mammal.

Diving

Dive times are difficult to measure accurately due to the difficulty of spotting whales as soon as they reach the surface and the likelihood of getting individual whales confused. These problems are confounded when whales are in groups and individuals perform long dives. The average dive time for 72 well recorded dives for which the diver was identified photographically at each end of the dive, was 35.5 minutes with a surface time of 9.6 minutes. It might be noted that these were all small whales (<12m) and larger individuals might be expected to dive for longer.

Depth sounder dive traces have been analysed for 163 dives. Whales began dives with descent rates of 1.94m sec^{-1} (3.77 knots) but rates of descent decreased with depth, presumably because dive angle also decreased. Typically dives leveled off at around 400 to 700m and whales would tend to remain at about these depths until they returned to the surface. The greatest depth at which a sperm whale was recorded was 800m. While at depth, whales often moved considerable distances horizontally and sometimes also made rapid small scale vertical movements. Extended depth sounder traces allowed whale depth and horizontal movements to be recorded for almost complete dives (Fig. 11).

These observations have also prompted some theoretical work on the economics of diving to great depths to forage.

CONTRIBUTIONS BY THE PROJECT TO RAISING PUBLIC AWARENESS OF CETACEAN AND OF THE INDIAN OCEAN WHALE SANCTUARY

Members of the project wrote popular articles and gave talks in schools and to the public. More significantly perhaps, the research project and its scientific work provided material and acted as a focus for the educative work of others, such as WWF, the National Aquatic Resources Agency (NARA), journalists and film makers.

The effect was seen most dramatically in Sri Lanka. When we first arrived there in 1982 there was little evidence of public awareness of local cetaceans. Members of the public that we spoke to knew what whales were, they had seen them on television or read about them in books, but believed that they were to be found only in polar waters, not in the tropical Indian Ocean. Some useful scientific work had been published on the Cetacea of the area, notably by Deraniyagala, and mainly based on stranded material. However another author had stated that 'the waters of the Indian Ocean are not their [whales'] natural habitat' (De Bruin, 1972).

During 1983 a revolution in public awareness took place, thanks mainly to an international conference organised by NARA, lectures, films, television programs and newspaper articles. Our project acted as a useful catalyst for this, but most of the credit must go to NARA and their understanding of the local media. In 1983 and 1984 it seemed that any man in the street could tell us more about the animals we were studying then we knew ourselves. A telling testament to the Sri Lankan public's new awareness of cetaceans was the appearance of whales in political cartoons. NARA also instigated whale watching trips during 1983 and 1984. Based at Trincomalee on the east coast of these Sri Lanka, these trips have given VIPs, local people, and foreign tourists the chance to experience whales first hand in the Indian Ocean Whale Sanctuary.

Two films were made, featuring the work of the project, the Indian Ocean whale sanctuary and the whales of Sri Lanka. These films included some of the first good underwater footage to be taken of sperm, blue and Bryde's whales. The project provided a focus of interest for the film. The techniques we had developed allowed cameramen to get close to the whales to film them and we also assisted them in finding and following the subjects in the field.

National Geographic magazine published an article (written by Hal Whitehead) in its December 1984 issue which described the sanctuary and the project's work within it. Most of Flip Nicklin's excellent photographs which accompanied the article were taken with the assistance of the project.

ENCOURAGING THE ESTABLISHMENT OF CENTRES OF RESEARCH IN THE INDIAN OCEAN

Scientists from Oman and Sri Lanka joined the vessel for offshore research cruises to observe cetaceans at sea and learn appropriate benign techniques. I believe that the work of the project also drew the attention of local scientists to some of the possibilities for studying cetacea in their waters. Some projects, such as the investigation of the problem of small cetacean by-catch in drift nets, initiated by Abigail Alling, and the studies of blue whales, have been continued by Sri Lankan scientists. NARA, in collaboration with R. Payne and S. Leatherwood and with financial assistance from UNEP, established the Centre for Research on Indian Ocean Marine Mammals (CRIOM) and initiated a National Marine Mammal Program (NMMP) which to some extent continues and extends the work of the 'Tulip' project.

DISCUSSION AND CONCLUSION

It should be remembered that the 'Tulip' project was a modest study. It consisted of a small boat, operated far from home, by a team of four young scientists without the logistic backing of any major institution. Even so, I believe that the project has managed to address all of the Ziest objectives, some of them fairly comprehensively. It also demonstrates many of the constructive ways in which a scientific research project and a cetacean sanctuary can interact.

The sanctuary provided the project with a unique study location where long term behavioural investigations, which would not be disrupted by human interference, could be initiated. The existence of the sanctuary also encouraged conservation organisations to raise funds to support benign cetacean research.

The project has provided basic information on the occurrence and distribution of cetaceans in part of the sanctuary as well as a more detailed understanding of the status and behaviour of sperm whales. Important populations of rare cetaceans, such as the blue whales off Trincomalee, were found and attention has been drawn to potentially serious conservation problems, such as the by-catch of small cetaceans. At the same time the work of the project and the attention it has attracted has widened the public's awareness of the sanctuary. The project has also been instrumental in fostering continuing research projects within the sanctuary.

This study has also contributed to some of the sanctuary's wider aims. Much of the information collected on sperm whale behaviour is of more general significance. It has provided many new, and some unexpected, insights into the biology of one of the world's least known animals and it may prompt reevaluation of the management of the species. Two new sperm whale research projects, one in the Galapagos and one in the Azores, have developed out of this work. The suite of benign techniques developed and used on the project are proving useful both in other areas and with other species.

This project has demonstrated that it is possible to study cetaceans effectively, and to obtain information necessary to manage stocks, using benign methods inside a sanctuary. The research methods described here represent a viable new approach to studying sperm (and some other) whales. I would envisage that new research techniques will continue to be developed increasing the scope of non-lethal research. For example, genetic fingerprinting and hormonal analysis using biopsy samples; and radio and satellite tracking, all show much promise for future research in sanctuaries.

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REFERENCES

Alling, A. 1985. Small cetacean entanglement: a case study of the incidental entrapment of cetaceans in Sri Lanka's gillnet fishery. Paper SC/37/SM5 presented to the IWC Scientific Committee, June 1985.

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83:376–94.

Anonymous. 1979. Report of the Workshop on Cetacean Sanctuaries. Unpublished report of the workshop held at Tijuana and Guerrero Negro, Baja California, Mexico, 4–9 Feb. 1979.

Anonymous. 1980. Report of the meeting of the Indian Ocean Coastal States on a proposed Indian Ocean Alliance for Conservation. Mahé, Seychelles, April 14–15 1980.

Anonymous. 1981. *Report of the Workshop to Plan a Programme of Scientific Research On Cetaceans in the Indian Ocean Sanctuary*. Ministry of Cultural Affairs, Recreation and Social Welfare, Netherlands. 105pp.

Best, P.B. 1979. Social organization in sperm whales, *Physeter macrocephalus*. pp. 277–89. *In:* H.E. Winn and B.L. Olla (eds.) *Behavior of Marine Animals*. Vol. 3. *Cetaceans*. Plenum Press, New York and London. i-xix+438pp.

Clarke, M.R. 1980. Cephalopoda in the diet of sperm whales of the Southern Hemisphere and their bearing on sperm whale biology. *Discovery Rep.* 37:324pp.

De Bruin, G.H.P. 1972. Stranded whales. *Loris* 12:247–8.

Gordon, J. 1985. Report on results from minke whale length measuring experiment. Paper SC/J85/S12 presented to the IWC Scientific Committee, June 1985 (unpublished).

Gordon, J.C.D. 1987a. The behaviour and ecology of sperm whales off Sri Lanka. Ph.D Thesis, University of Cambridge. 347pp.

Gordon, J.C.D. 1987b. Sperm whale groups and social behaviour observed off Sri Lanka. *Rep. int. Whal. Commn* 37:205–17.

Gordon, J.C.D., Papastavrou, V. and Alling, A. 1986. Measuring blue whales: a photogrammetric technique. *Cetus* 6:5–8.

International Whaling Commission. 1980a. Chairman's report of the Thirty-First Meeting. *Rep. int. Whal. Commn* 30:25–41.

International Whaling Commission. 1980b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 30:42–137.

Kasuya, T. and Ohsumi, S. 1966. A secondary sexual character of the sperm whale. *Sci. Rep. Whales Res. Inst., Tokyo* 20:89–94.

Mohl, B., Larsen, E. and Amundin, M. 1981. Sperm whale size determination: outline of an acoustic approach. *FAO Fish. Ser. (5) [Mammals in the Seas]* 3:327–32.

Nishiwaki, M. 1962. Aerial photographs showing sperm whales interesting habits. *Norsk Hvalfangsttid.* 51:395–8.

Norris, K.S. and Harvey, G.W. 1972. A theory of the function of the spermaceti organ of the sperm whale (*Physeter catodon*). pp. 397-417. *In:* S.R. Galler, K. Schmidt-Koering, G.J. Jacobs and R.E. Belleville (eds.) *Animal Orientation and Navigation*. NASA, Washington DC. Special Publication 262.

Norris, K.S. and Mohl, B. 1983. Can odontocetes debilitate prey with sound? *Am. Nat.* 122:85–104.

Watkins, W.A. 1980. Acoustics and the behavior of sperm whales. pp. 238–90. *In:* R.G. Busnel and J.F. Fish (eds.) *Animal Sonar Systems*. Plenum Press, New York. [NATO Advanced Study Institute Series. Ser. A, Life Sciences 28.]

Weilgart, L.S. and Whitehead, H. 1986. Observations of a sperm whale (*Physeter catodon*) birth. *J. Mammal.* 67:399–401.

Whitehead, H. 1985. Humpback whale songs from the North Indian Ocean. *Invest. Cetacea* 17:157–62.

Whitehead, H. and Arnbom, T. 1987. Social organization of sperm whales off the Galapagos Islands, February – April 1985. *Can. J. Zool.* 65:913–9.

Whitehead, H. and Gordon, J. 1986. Methods of obtaining data for assessing and modelling sperm whale populations which do not depend on catches. *Rep. int. Whal. Commn* (special issue 8):149–65.

Whitehead, H., Gilligan, P., Smyth, C., Weilgart, L. and Converse, C. 1983. WWF/IUCN Indian Ocean Whale Project. Interim Report, Oct-Dec. 1983. (Unpublished.).

Strandings of Sperm Whales (*Physeter macrocephalus*) on the Shores of Oman, Eastern Arabia

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ABSTRACT

Four recent single strandings of sperm whales, *Physeter macrocephalus* Linnaeus, 1758 (Cetacea: Odontoceti), are reported from the shores of Oman, eastern Arabia, two of them young males from the Gulf of Oman. Reports of catches and sightings from the literature together with more recent sightings are given, and suggestions are made for the recovery of cetacean skeletal material.

Keywords: sperm whale; Indian Ocean; Northern Hemisphere; strandings; whaling-modern; whaling-historical; sightings-incidental.

INTRODUCTION

There are few recent published reports of sperm whales (*Physeter macrocephalus*) in the seas of the Sultanate of Oman, eastern Arabia. It is therefore appropriate to report four recent strandings, and to examine the literature and recent sightings data as further evidence of occurrence. Suggestions for the recovery of cetacean skeletal material are offered. Oman, never a whaling nation, has been a member of the International Whaling Commission since July 1980, and supports the retention of the Indian Ocean as a sanctuary for whales.

STRANDINGS

Suhar, April 1981

On the ebbing tide on the evening of 7 April 1981, two large whales became stranded on the sandy Batinah coast of northern Oman, Gulf of Oman. One struggled free, but the other died next day in front of the houses of Hillat al Shaikh (24°21′N,56°46′), 2.5km south-east of Suhar (*Times of Oman*, 16 April 1981; *Oman Daily Observer*, 24 April 1981).

This event was reported to me on 10 April, after which I examined and photographed the animal. It was an all-black male sperm whale, and had already begun to decompose; the measurements were: tail notch to:– tip of nose 10.56m, penis 4.64m, rear of flipper 6.67m, tip of lower jaw 9.28m; width of tail flukes 2.93m; and visible teeth – 18 (left) and 15 (right).

The Suhar Municipality insisted that the whale be buried in a concave pit already dug into the sandy shore just above high-water mark. In May 1982, I and six helpers retrieved the bones over a period of six days. The skeleton was accessioned into the national cetacean collection at the Oman Natural History Museum (ONHM 29). The age of the whale was about three years (G. Behrmann, pers. comm., after examination of the skeleton in October 1988).

During recovery I was told that winter storms had partially exposed the remains, and that these had been bulldozed into the sand again. Villagers kindly gave me some bones and teeth that had ‘escaped’, but several were lost, or damaged by the bulldozer.

Barka, September 1986

On 13 September 1986 I was taken to see a sperm whale which had been cast up on 10 September on the beach of the Baluch quarter of Barka (23°24′N, 57°53′E), also on the Batinah coast. It appeared all–black, and was lying in shallow water red with blood from the many incisions made during an apparently vain search by local fishermen for ambergris (*'anbr*). It lay head out to sea and could not be closely examined or measured. Despite requests that it should be towed to rot in the open desert nearby, the Municipality had it buried in a deep concave trench, already dug 300m from the houses and just above high-water mark; the base of the trench later proved to be below the level of spring highs. I learned later that it took the combined efforts of three large mechanical shovels to move the whale.

In December 1987, with a team of five men, I uncovered the remains (to the protestations of the local inhabitants). It measured approximately 14m in total length. In one week all the bones were recovered except for a few which could not be found in the knee-deep mud and ooze. Some bones were found to be broken within the skin (which had not fully rotted), presumably from pressure from the mechanical equipment used during burial; the bones most affected were the occipital crest, the ribs on the upper (right) side and the dorsal tips of some lumbar vertebrae. The largest teeth had been sawn and broken off in apparent attempts to remove them from the freshly-dead animal. The skeleton was accessioned into the national collection at the Oman Natural History Museum (ONHM 866), where it is now exhibited. Its age is about 4 years (G. Behrmann, in pers. comm.).

Mughsayl, December 1987

On 7 December 1987, Keith W. Cox (Fisheries Adviser to the Department of Fisheries, Ministry of Agriculture and Fisheries) found and photographed part of the decomposing carcass of a sperm whale at the eastern end of the beach at Mughsayl (Dhofar, southern Oman, 16°53′N, 53°47′E). Although distorted and incomplete, he estimated its total length to be 45–50ft (13.7–15.2m). Nearby was the clean (and therefore older) skull of a baleen whale. Both were removed or buried by the local municipality. The photographs show the large bulbous head of a sperm whale, on which some features are sufficiently distinct to allow positive identification (G. Behrmann, V. Papastavrou, pers. comm.). The proximity of the skull of another species is considered to be coincidental.

The remains of another sperm whale, found south of Sadh (17°02′N, 55°03′E) on 19 April 1988, is reported by Papastavrou and Salm (this volume).

DISCUSSION

Occurrence

It is very probable that sperm whales occur all the year in the Arabian Sea, the northernmost extension of the western Indian Ocean; the prime attraction being the biological richness of the seas off southeastern Arabia caused by upwelling during the southwest monsoon from June through September (see, for instance, Cushing, 1971; Thiel, 1978; and the many publications of the results of the International Indian Ocean Expedition 1963–64). Poor visibility, heavy seas and variable but usually very strong winds have deterred any recent observation off southeast Arabia during summer, so that we are dependent upon the literature and upon observations made in other seasons for an assessment of the status of the whales in Oman's waters.

Sperm whales are occasionally reported off the coast of southern Oman, and I have seen pods of small sperm whales off Ra's Raysut (16°55′N, 54°00′E) in autumn. During the investigations for sperm whales off southern Oman in January 1981, J.C.D. Gordon encountered small groups in Khuria Muria bay, west of the Khuria Muria islands, on three occasions between 14 and 16 January and once on 18 January 70 n.miles ENE of the Khuria Murias; all were small animals, *ca* 30–35ft (9–10.7m), which would indicate that they were females or immature males (Gordon, 1982; Gordon, pers.comm.).

On 29 November 1988, R.V. Salm (pers. comm.) saw a total of four live sperm whales 1–5km off shore near Ra's Mirbat, southern Oman (16°59′N, 54°41′E) where the edge of the continental shelf or shelfbreak comes very close to the shore.

Two 'medium-sized' sperm whales were seen from a ship passing close by, apparently asleep on the surface, off Salalah at 15°37′N, 53°10′E on 14 February 1988 (W.R.P. Bourne, pers. comm.).

In the latter half of the 19th century, the Arabian coast was popular as a whaling ground; mostly small sperm whales were taken. Wray and Martin (1983) provide important evidence of this industry, mostly from American sources. It apparently developed as an extension from the whaling activities along the Somali coast, which took place most of the year, but peaked from May to September, the period of the southwest monsoon. Moving eastward before the onset of the northeast monsoon, the available records show that ships worked the coast from September to January with a peak in October, the most favoured places being Ra's Fartak (South Yemen, 15°38′N, 52°16′E), Ra's Mirbat (Oman, 16°59′N, 54°41′E) and over the continental shelf in Khuria Muria Bay, all places of intense seasonal upwelling and biological productivity. Townsend (1931) gives records of whalers during the period 1821 to 1899 which show sperm whales off Dhofar (the southern region of Oman) and off the Khuria Muria islands, from September to January, but none north of Ra's al Madrakah (19°N).

Brown (1957) discussed sightings made from merchant vessels in the Indian Ocean between 1952 and 1956. Sperm whales were reported off the coasts of Yemen, Oman and Somalia from March to May and September to November. He noted that the overall distribution agreed largely with the catch distribution shown by Townsend (1935), apart from the occurrence of whales in the 'Arabian' region in spring. Slijper, Utrecht and Naaktgeboren (1964) examining Dutch merchant shipping records reported sightings in the Gulf of Oman for all months except January, March, June and October. From the literature and recent records, therefore, it appears that sperm whales occur in the region throughout the year.

Earlier, writing of a visit to Masirah island in January 1824, Owen (Owen, 1857, p. 187) says

> In the bay between Alif and Ya is a place called Hastelleagh, where they fish for whale. The tooth of the sperm species is in great request for sword handles, it being supposed to have a peculiar charm.

Ambergris was collected by the poor inhabitants of Al Hallaniyah island, Khuria Muria, according to several visitors (e.g. Haines, 1845, p.137). How they obtained it is not stated, but as the inhabitants had no boats it was presumably obtained as flotsam, and not by hunting the sperm whale as described by Marco Polo for the people of Socotra, in the Gulf of Aden 370 miles to the southwest (Latham, 1958, pp. 296–7).

Ambergris from the sea shore of the Suhar region of the Batinah coast is mentioned as one of Oman's commodities which played a significant role in traditional Asian trade in historical times (Huart, 1912 *in:* Williamson, 1973). As no such trade is known now, ambergris and the sperm whale must have been more abundant then.

Ambergris is still found on the beaches of South Yemen, Gulf of Aden. Shami and Walczac (Shami and Walczak, 1977) wrote

> Today along the Yemen coast local people still search the beaches for this gift from the sea, especially along the southern coast between Khauka and Bab-el-Mandeb, during the winter monsoon referred to as the Aziab. During this time quantities of ambergris are washed ashore by the heavy winds. The local people search for it quietly almost like spies. Occasionally when a group of fishermen find a clump of amber together a fight results over the ownership and the problem has to be settled in the court room. A small piece of amber according to John Crompton in his book *The Living Sea* can sell for as much as the equivalent of 5,000 Y.Riyals.

The most recent commercial sperm whale catches in the Indian Ocean off the Arabian peninsula were catches of 65 whales by a Norwegian expedition in 1962/63 and 87 whales by a Soviet expedition in 1966/67 (Holt, 1979). Russian sightings in the northwest Arabian Sea are mentioned by Berzin (1971); mixed schools of nursing female and young sperm whales, but no large males, were seen during October-December 1964–5 and 1965–6. The stranding of the male sperm whale at Suhar, reported above, adds April to the known months of occurrence.

There are few reported strandings of sperm whales in the western Indian Ocean. In a summary of five recent strandings on the Indian coast (James, 1983) only two were on the west coast – at Karwar (14°50′N, 74°09′E) on 23 June 1972 (Antony Raja and Vasudev Pai, 1973), and a small female near Quilon on 25 November 1980.

Two earlier unidentified strandings on the shores of northern Oman, which may have been sperm whales, have been reported. In 1955 a 'huge whale' was stranded at Qurm (23°37′N, 58°28′E) (Sadiq Mohammed Said, pers.comm.), and in 1965 the remains of the 'most giant fish ever created' was found nearby (Sadiq, *Times of Oman*, 23 April 1981). Subsequent discussions with Sadiq and his companions have not allowed me to identify the whales to species.

Recovery of skeletal material

The need for the rapid disposal of cetacean carcases when stranded near habitation cannot be denied. In Oman, the responsible municipalities evidently find that burying *in situ* is an effective and economical method for the disposal of large and heavy animals, whereas those of more manageable proportions are lifted or towed to the municipal rubbish dump. However, burying, particularly in beach sand subject to flooding, creates enormous problems for the later recovery of the skeleton. In addition the bones will be damaged by the inevitable use of mechanical equipment, and the smaller bones and teeth may be lost in the ground. It is therefore worth noting two alternative methods, whilst remembering that the skull is usually the most important part for identification.

Small carcases left in the intertidal zone are soon lost due to rapid disintegration, scattering and burying by the combined action of the waves, putrefaction and scavengers (e.g. cats, dogs, foxes, hyaenas, birds, crabs and beetles). The mandible is usually the first to go. Goats and other domestic animals are still commonly disposed of in this way, even near habitation. Collectors of cetacean material should therefore either quickly flense small cetaceans *in situ* and remove the fresh bones, or remove the complete carcase to a convenient site for flensing above high-water mark.

If recovery of the skull or skeleton is not possible immediately, an alternative is to tow the carcase to deserted ground well above the reach of storm seas and spring high tides and away from habitation. Here the carcase may be left to rot. In less than a year in dry tropical conditions, I have found that the flesh and fat will have degraded, and the skin hardened to provide natural protection to most of the bones, which may then be collected at leisure. This method works well for small cetaceans, but it may have been impossible in the case of the large whales reported here because of their weight, their proximity to habitation and the need for more concerted action between the various agencies involved than has been achieved so far. Drawbacks include deterioration by over-exposure to ultra-violet light, differential staining and hardening of the oil which makes cleaning difficult, and the depradations by souvenir-hunters and by scavenging wild and domestic animals; animals often gnaw dry bones, particularly the beaks of dolphins, apparently to obtain trace elements.

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REFERENCES

Antony Raja, B.T. and Vasudev Pai, M. 1973. On a record of a stranded sperm whale *Physeter catodon* Linnaeus at Karwar. *Indian J. Fish.* 20(2):641–5.

Berzin, A.A. 1971. *Kashalot*. Izdatel'stvo 'Pishchevaya Promyshlennost', Moscow. 324pp. (+Appendices and Indices). [Translated in 1972 as *The Sperm Whale* by the Israel Program for Scientific Translations, Jerusalem. i-v + 394pp.].

Brown, S.G. 1957. Whales observed in the Indian Ocean. Notes on their distribution. *Mar. Obs.* 27:157–65.

Cushing, D.H. 1971. Upwelling and the production of fish. *Adv. Mar. Biol.* 9:255–334.

Gordon, J. 1982. Sperm whales. WWF/IUCN Indian Ocean Sperm Whale Study, 1981–82 Interim Report (unpublished). 43pp.+10 figs.

Haines, S.B. 1845. Memoir of the South and East Coasts of Arabia, Part II. *J. R. Geogr. Soc.* 15:104–60.

Holt, S. 1979. Modern whaling in the Indian Ocean, particularly in the temperate-tropical zone and the subdivision of stocks. Paper SC/31/2 presented to the IWC Scientific Committee, June 1979 (unpublished).

Huart, C. 1912. *Histoire Des Arabes*. Paris.

James, P.S.B.R. 1983. On the stranding of whales along the Indian coast with special reference to recent incursions of sperm whales into the coastal waters of India. Paper NARA/SMMIO/SP2 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished).

Latham, R. 1958. *The Travels of Marco Polo*. Penguin, London. 380pp.

Owen, W.F.W. 1857. The coast of Arabia Felix – from the journal of Capt. W.F.W. Owen of H.M.S. *Leven*. *Naut. Mag.* April 1857:180–91.

Papastavrou, V. and Salm, R.V. A note on recent cetacean sightings and strandings in Oman: Ra's Sawadi to Rakhyut. (Published in this volume.)

Shami, A. and Walczak, P. 1977. Ambergris search along the Yemen coast. *J. Saudi Arabian Nat. Hist. Soc.* 20:19.

Slijper, E.J., van Utrecht, W.L. and Naaktgeboren, C. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. *Bijdr. Dierkd.* 34:3–93.

Thiel, H. 1978. Benthos in upwelling regions. pp. 124–38. *In:* B. Boje and M. Tomczak (eds.) *Upwelling Systems*. Springer-Verlag, Berlin.

Townsend, C.H. 1931. Where the 19th Century whaler made his catch. *Bull. NY Zool. Soc.* 34(6):173–9.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, N.Y.* 19(1–2):1–50+6maps.

Williamson, A. 1973. *Sohar and Omani Seafaring in the Indian Ocean*. Petroleum Development Oman Ltd., Muscat. 36pp.

Wray, P. and Martin, K.R. 1983. Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Commn* (special issue 5):218–42.

Blue Whales (*Balaenoptera musculus*) off the Northeast Coast of Sri Lanka: Distribution, Feeding and Individual Identification

Abigail Alling[1], Eleanor M. Dorsey[2], and Jonathan C.D. Gordon[3]

ABSTRACT

Blue whales were studied in the Bay of Bengal off the northeast coast of Sri Lanka from a 10m sloop in late winter and spring of 1983 and 1984. Their distribution was determined by acoustic censuses and by sightings, and underwater dives were tracked with a depth sounder. Feeding was indicated by dives through dense scattering layers at 160–260m depth and by defecations at the surface. At least one fecal sample contained mysidaceans. Mother-calf pairs were seen on at least two occasions. Individual animals were recognised from close-up photographs of the tail flukes, the pigmentation pattern on the body and miscellaneous scars. 35 individuals were identified in 49 sightings; the maximum time between sightings within a year was 31 days, and one whale was seen in both years.

INTRODUCTION

In response to the establishment of the IWC Indian Ocean Sanctuary, the World Wildlife Fund sponsored a study of sperm whales, *Physeter macrocephalus*, in the northern Indian Ocean from January 1982 to April 1984 (Whitehead and Gordon, 1986; Gordon, 1987a; b). During this study, blue whales, *Balaenoptera musculus*, also were encountered and studied off the northeast coast of Sri Lanka. Gordon *et al.* (1986) report on a photogrammetric technique for measuring these blue whales, and Alling and Payne (1987) present analyses of their vocalisations. This paper describes the distribution and feeding of blue whales off northeastern Sri Lanka in 1983 and 1984 and the recognition of individual animals from close-up photographs.

METHODS

The area of study was along the northeast coast of Sri Lanka, mostly near the edge of the continental shelf (Fig. 1). The field season extended from 20 January to 24 April in 1983 and from 22 February to 25 April in 1984. The major focus of the study in both years was sperm whales, which were actively tracked most of the time at sea. Blue whale observations were made opportunistically except for 10 days in 1984 which were devoted exclusively to the study of blue whales. All sightings of blue whales during both years were noted. The number of daylight hours spent at sea in 1983 and 1984 were 553 and 337, respectively.

The research vessel *Elendil/Tulip* is a 10m sloop (Gladiateur/-Wauquiez) with a 25hp diesel engine, which allows excursions at sea of up to 14 days. The mast of the sloop

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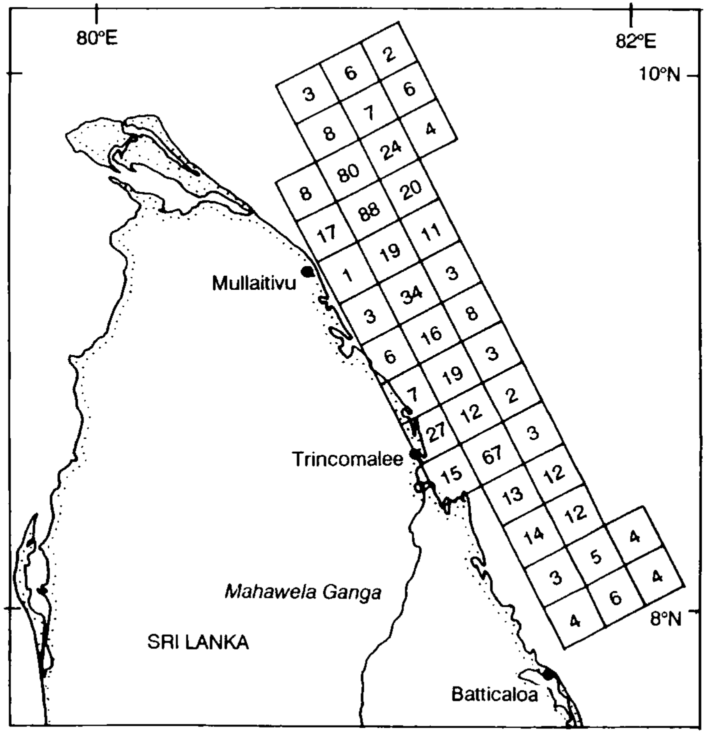

Fig. 1. The study area off the northeast coast of Sri Lanka, showing the grid of 10 n mi x 10 n mi squares used to analyse the acoustic census conducted in 1984. The number inside each square is the number of monitoring sessions conducted in that square.

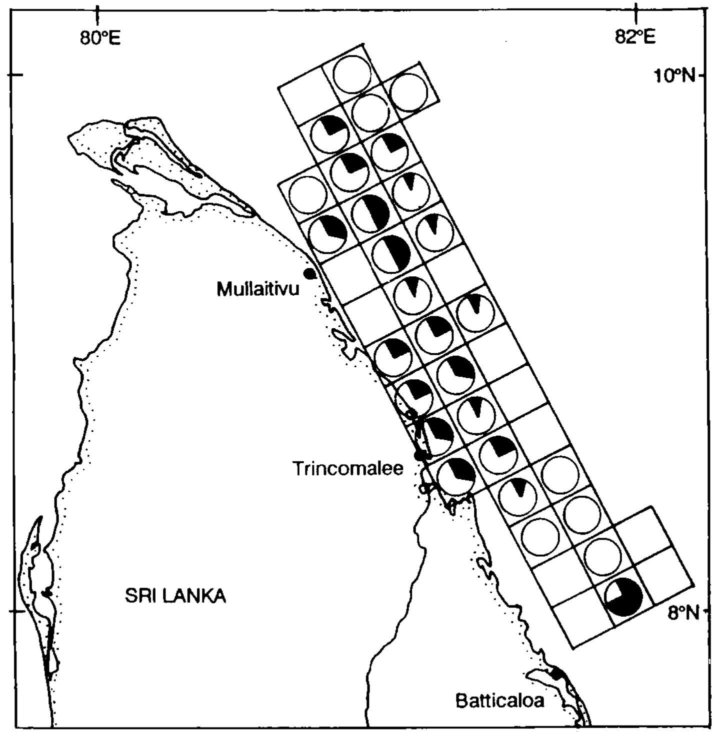

Fig. 2. Distribution of blue whales in 1984, as shown by acoustic monitoring. The proportion of each circle that is blackened indicates the proportion of monitoring sessions in that square during which at least one blue whale sound was heard. See Fig. 1 for the number of monitoring sessions in each square. Squares with fewer than five monitoring sessions were not analysed.

provided an elevated vantage point for spotting and observing whales. Locations at sea were determined with a *Tracor* Transtar Satellite Navigator, which provided fixes that were accurate to 0.4km every 1.5h on average and permitted estimation of positions by dead reckoning between fixes. Inshore positions were determined from bearings to landmarks taken with a hand sightings compass. A *Simrad* Skipper 603 recording depth sounder with a receptive beam of around 33° was used in 1983 but not in 1984.

During 1984, an acoustic census was made by lowering hydrophones every 2 hours, listening for 3 minutes for cetacean vocalisations and noting the presence or absence of sounds of identifiable species. The acoustic monitoring equipment consisted of either (1) *Benthos* AQ17 hydrophones with built in pre-amplifiers and a *Uher* 4200 or *Uher* 4400 tape recorder, or (2) *KSP* hydrophones (HS-107/222) and a *Nagra* IV S tape recorder with pre-amplifier. Blue whale sounds were recognised as a characteristic, unmodulated, pure frequency call at about 110hz lasting for about 30s. This call was the loudest segment of a four-segment pattern that was repeated by blue whales recorded in the study area at close range. Alling and Payne (1987) call this segment phase 3 of the blue whale 'song'. A monitoring session was scored positive for blue whale sounds if this call was clearly recognisable whether loud or faint. It is possible, but unlikely, that another species of whale in the area makes an identical call and that some calls were incorrectly attributed to blue whales.

A standardised single transect was run from Flagstaff Point due east 20 n.miles (36km) on three days in 1983 and two days in 1984. The observer was 8m above the water surface, and all marine mammal sightings along the transect line were noted (only the blue whale sightings are reported here). Hydrophones were lowered every 5km to listen for cetacean vocalisations. These stations were not included in the 1984 acoustic census described above.

Close-up photographs for identification of individual animals were taken with a variety of SLR cameras with telephoto lenses, usually with Kodachrome 64 or Ektachrome 200 film. The slides were converted to black and white prints for most analyses. A few photographs were contributed by other scientists working in the study area.

RESULTS

Distribution

A total of 606 acoustic monitoring sessions were conducted in 1984, and a grid with squares 10x10 n.miles was constructed after the fact with its axis parallel to the 200 fathom contour (indicative of the edge of the continental shelf). Fig. 1 presents the number of monitorings made in each square of the grid; Fig. 2 presents, for all squares with five or more monitorings, the proportion of monitorings in which blue whales were heard. Some blue whale sounds were heard in 20 of those 28 squares. The densest concentrations of blue whales, as indicated by sounds, were in three areas: in and near Trincomalee Bay; 10–30km off Mullaitivu; and about 20km off Batticaloa. Because distant whales heard may have been in a different square of the grid from the research vessel, the distribution shown in Fig. 2 may be approximate.

Visual search effort and sightings are plotted for each year (Figs 3a-d). In 1983, blue whales were seen on 36 occasions between 5 Feb and 6 April (Fig. 3c); sightings were of 1–4 animals. In 1984, blue whales were seen on 51 occasions between 3 March and 23 April (Fig. 3d), with 1–6 animals per sighting. There were a few additional sightings each year for which locations were not recorded. In both years, effort and sightings were especially concentrated in the Trincomalee Bay area and in 1983, few blue whales were sighted

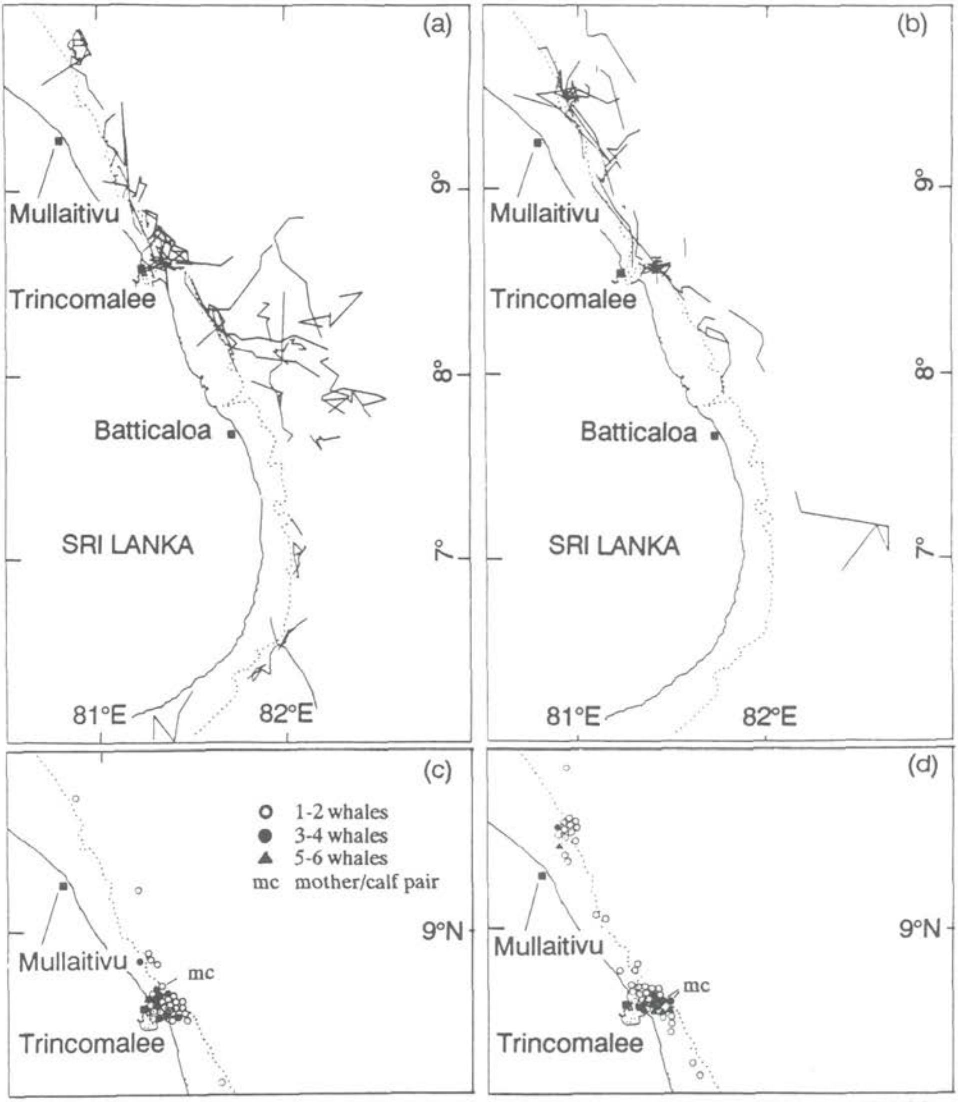

Fig. 3. Research vessel's track during daylight hours off the eastern coast of Sri Lanka during 1983 (a) and 1984 (b) and sightings of blue whales in 1983 (c) and 1984 (d). The dotted line indicates the 100fm contour.

anywhere else. In 1984, however, effort and sightings increased further north, off Mullaitivu. For 1984, patterns of distribution surmised from the acoustic census (Fig. 2) and the sightings (Fig. 3d) were similar, except that there were no blue whales seen in the southernmost portion of the acoustic census areas (at about 8°10′N, 82°E), where blue whale sounds were frequently heard.

On transect (Fig. 4) there were generally fewer blue whales seen in 1984 than in 1983. In both years, the whales seen were clustered near the 100 fathom contour and none were seen in the deepest water, at the easternmost third of the transect. In 1983, blue whales apparently had moved out of Trincomalee Bay by 24 April, as none were seen on that day.

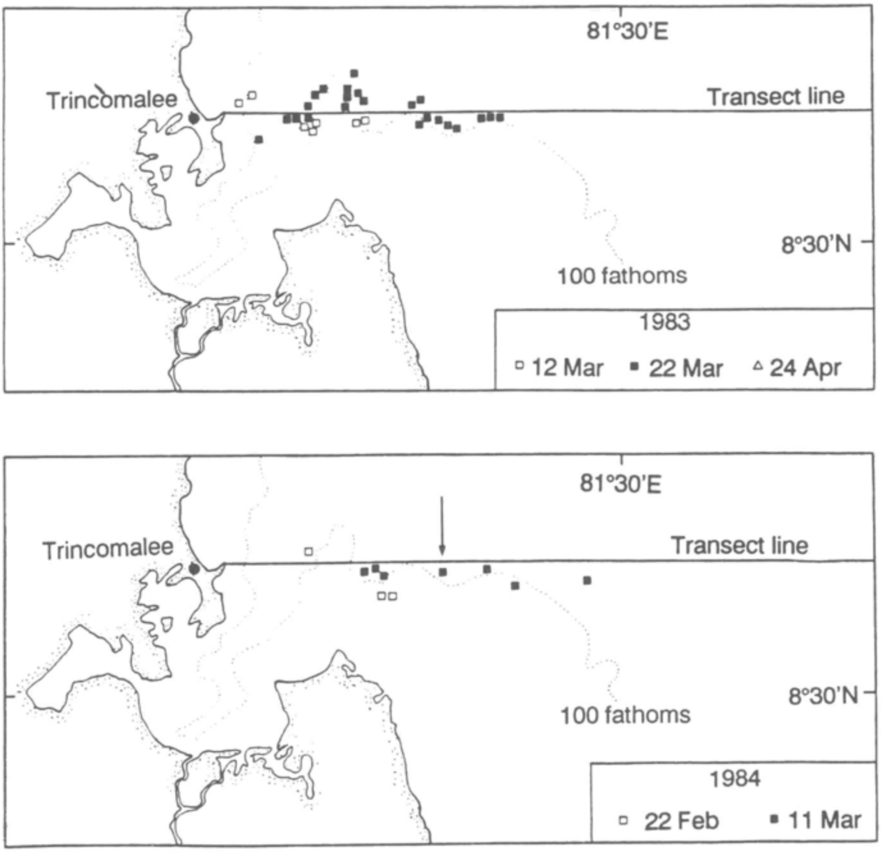

Fig. 4. Blue whale sightings along standardised transect off Trincomalee in 1983 and 1984. The transect line is along the 8°35′N parallel. No blue whales were seen on 24 April 1983.

As the research vessel moved away from shore, a very sharp boundary was evident between the turbid fresh water effluent of the Mahaweli Ganga, the largest river in Sri Lanka, and the clearer oceanic water. At the boundary, the distinct edge extended 2–4m below the surface and was defined by flotsam, foam and large numbers of small crabs on the surface. The location of this boundary on 11 March 1984 is indicated on Fig. 4; an equal number of blue whales was seen that day inside and beyond the river plume.

In 1983, a possible mother-calf pair was seen on 13 February, and in 1984 two mother-calf pairs were seen, one each on 6 March and 7 March (see Figs 3c and d). The latter instance might have involved the same pair because the observations were on adjacent days in approximately the same location but no photographs were taken at either sighting. Also in 1984, one lone blue whale observed at close range was estimated to be shorter than the 10m research vessel.

The direction blue whales were headed at the surface was recorded on 222 occasions in 1984. These headings were quite evenly distributed around the compass, with a slight southward tendency (Fig. 5).

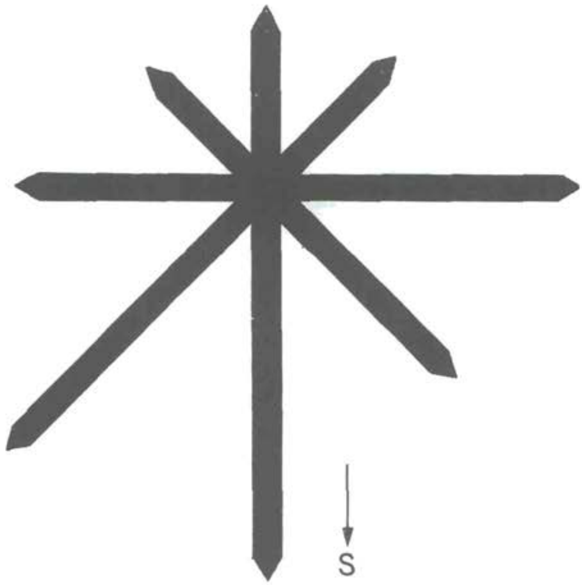

Fig. 5. Observed headings of individual blue whales. The length of each arrow is proportional to the number of headings within that octant (n=222 headings).

Feeding

Blue whales were tracked underwater with the depth sounder on 3 days in 1983 (Fig. 6). Dive traces were made by maneuvering the boat onto the slick produced by a diving whale. The boat continued forward slowly in the direction the whale had last been seen swimming. The whales usually raised their flukes above water before diving and sometimes appeared to be braking their forward movement with their flukes before doing so. This, considered with the fact that we could readily keep the descending animals on the depth sounder, suggests that the dives were steep. For analysis of the tracings from the depth sounder, the whale was assumed to be at the depth of the trace, in spite of the small ambiguity in depth readings due to the width of the receptive beam (33°). For the purposes of this paper we do not consider the error introduced by this ambiguity to be important (but see Gordon (1987a) for a discussion of its magnitude).

Fig. 6 presents four typical dive traces with notes explaining them. Usually, there was a continuous light Deep Scattering Layer (DSL) about 25m thick near the surface and a heavier, more patchy DSL at around 160–260m. Blue whales often were seen diving into and through the deeper patches, which usually were so dense that the whales could not be distinguished inside them. We presume that these deeper, denser patches represent the whales' prey but were unable to test this assumption (e.g. with deep trawls). On several occasions the whales appeared to pass straight down through a patch and then ascend through it. Almost all traces of whales showed them descending or ascending rather than swimming at a constant depth. Whales sometimes appeared to continue their descents to the bottom (Fig. 6b), but this may be an artifact of the wide beam of the depth sounder.

Whales were seen diving together, in pairs, on a majority of the traces on 5 February and 17 March and on a few of the traces on 28 February. The pairs appeared to stay together for the entire descent down to the patches and sometimes were together on the ascents.

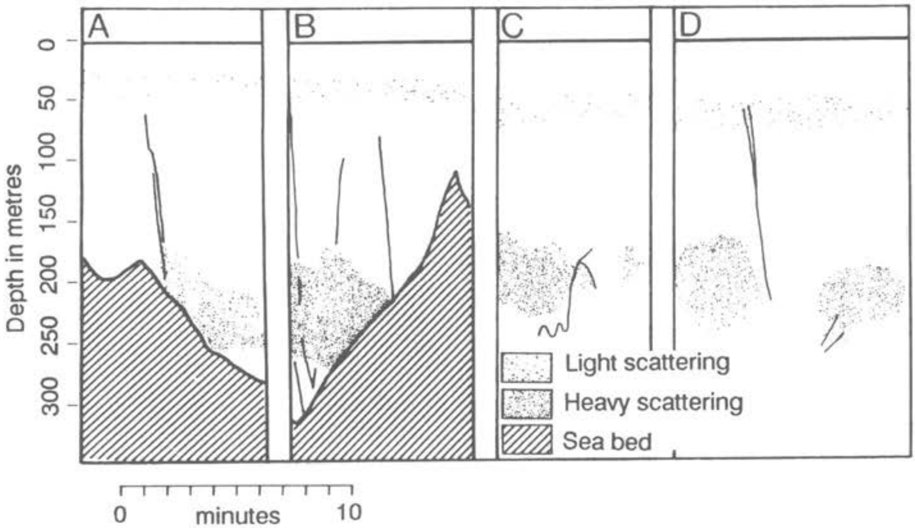

Fig. 6. Four typical traces of blue whale diving. A. 28 February 1983 (08:15 hours). Two whales dive into a heavy scattering layer located between 160 and 230 m, very close to the bottom. B. 28 February 1983 (10:04 hours). One whale can be seen diving into and through a heavy scattering layer extending from 180 to 270 m. The whale reaches 270 m, very close to the bottom, then appears to come up through the school of prey again and continue toward the surface. Near the start, the trace of a second whale is seen briefly descending close to the bottom, at 308 m. A third descending trace extends down close to the bottom at 215 m near the edge of the heavy scattering layer. C. 5 February 1983 (14:41 hours). The trace shows a blue whale apparently changing depth repeatedly near the bottom of a heavy scattering layer at around 240 m. Towards the end of the trace, two whales can be seen to diverge, one ascending, the other diving deeper. No bottom is visible here, indicating that the water was at least 500 m deep. D. 5 February 1983 (15:24 hours). Two whales descend together, apparently going below the level of the heavy scattering layer (from 165–240 m) then ascending together into it.

Such pairs also were close together at the surface and surfaced and dived again within a few seconds of each other. All pairs consisted of large whales of similar size. Feeding whales spent little time at the surface, presumably to return to feeding as soon as possible. The observed surface behaviour of whales tracked into the deep, dense DSL was similar to that of whales for which dive traces were not made on many other days, suggesting that feeding was common throughout the study periods.

Rates of diving were obtained on 17 March 1983 for nine descents and three ascents by measuring depths from the traces and counting depth sounder marks between beginning and ending points of a dive to determine the elapsed time (Table 1); tracings on the other two days were not suitable for such measurements. Descent rates (1.0 – 2.1 m/sec; mean = 1.51 m/sec), were significantly slower than ascent rates (2.0 – 2.8 m/sec; mean = 2.36 m/sec) ($p<0.02$, Mann-Whitney U test).

Blue whales at the surface often defecated copious amounts, some of which could be collected. Defecations appeared to be composed largely of the exoskeletons of red-coloured crustaceans. Body parts from one sample from 1983 were identified as those of mysidaceans, not identifiable to species. Seven apparently similar samples from 1984 were not analysed.

Table 1.

Data on rates of ascent and descent by diving blue whales, calculated from echo sounder tracings made on 17 March 1983. Brackets indicate pairs of animals that were swimming together. In all cases except ascent 1, the deepest trace discernible was at the top of heavy scattering layer.

		Shallowest depth trace (m)	Deepest depth trace (m)	Mean depth (m)	Rate of change (m/sec)
Descent	1	57.0	150.4	103.7	1.80
	2	85.9	152.2	119.1	1.33
	3	53.7	136.0	94.9	1.70
	4	107.4	136.0	121.7	1.03
	5	82.4	146.8	114.6	1.49
	6	57.3	153.9	105.6	1.90
	7	43.0	150.4	96.7	2.10
	8	71.6	118.1	94.9	1.20
	9	84.1	125.3	104.7	1.10
Ascent	1	82.3	39.4	60.8	1.98
	2	146.8	32.2	89.5	2.80
	3	150.4	37.6	94.0	2.30

Recognition of individual animals

These blue whales often lifted their flukes above water before a dive; flukes observed contained a variety of individually distinctive markings. Many had small nicks (Figs 7a-e) and/or larger 'scallops' (Figs 7e-j) along the trailing edge. Several had pale-coloured circular depressions (Figs 7a-d) or small spots or irregular areas coloured white, pink or orange (Figs 7f-h, j). The fluke-tips of one whale were curled ventrally (Fig. 7j).

There was also considerable variation in two other features: the shape of the fluke notch, which ranged from wide (Fig. 7i) to narrow (Fig. 7e) (in one whale the sides of the notch appeared to overlap), and from shallow to deep; and degree of curvature of the sides of the notch, which varied from one whale to another and, in one case, from one side of the notch to the other side. Although not codified or quantified for this study, these variations could be used to facilitate sorting of photographs and checking for newly acquired nicks or scars. The trailing edge of the flukes was either a smoothly curving line or a slightly wavy line, with the pattern of waves distinctive in some individuals.

Photographs of the sides of whales revealed variation in dorsal fin shape and patterns of pigmentation useful for individual recognition (Figs 8a,b). A few whales had unusual scars on their bodies (Figs 8c,d), some of which were visible at considerable distances. In practice, many whales were photographed from one side only, making the flukes most useful for individual recognition. All individual identifications were supported by good fluke photographs; most had side photographs as well.

A total of 35 individuals was identified, 16 in 22 sightings in 1983 and 20 in 27 sightings in 1984. One whale (#3) was seen in both years. There was no change in the appearance of the ventral surface of the flukes of this whale in 1984 (Figs 7a,b); the small nick on the left leading edge and the fairly subtle markings near the middle all remained visible. Table 2 presents the dates and locations of all sightings of the whales identified more than once. Most resightings occurred within two weeks and within a few miles of the Trincomalee Bay

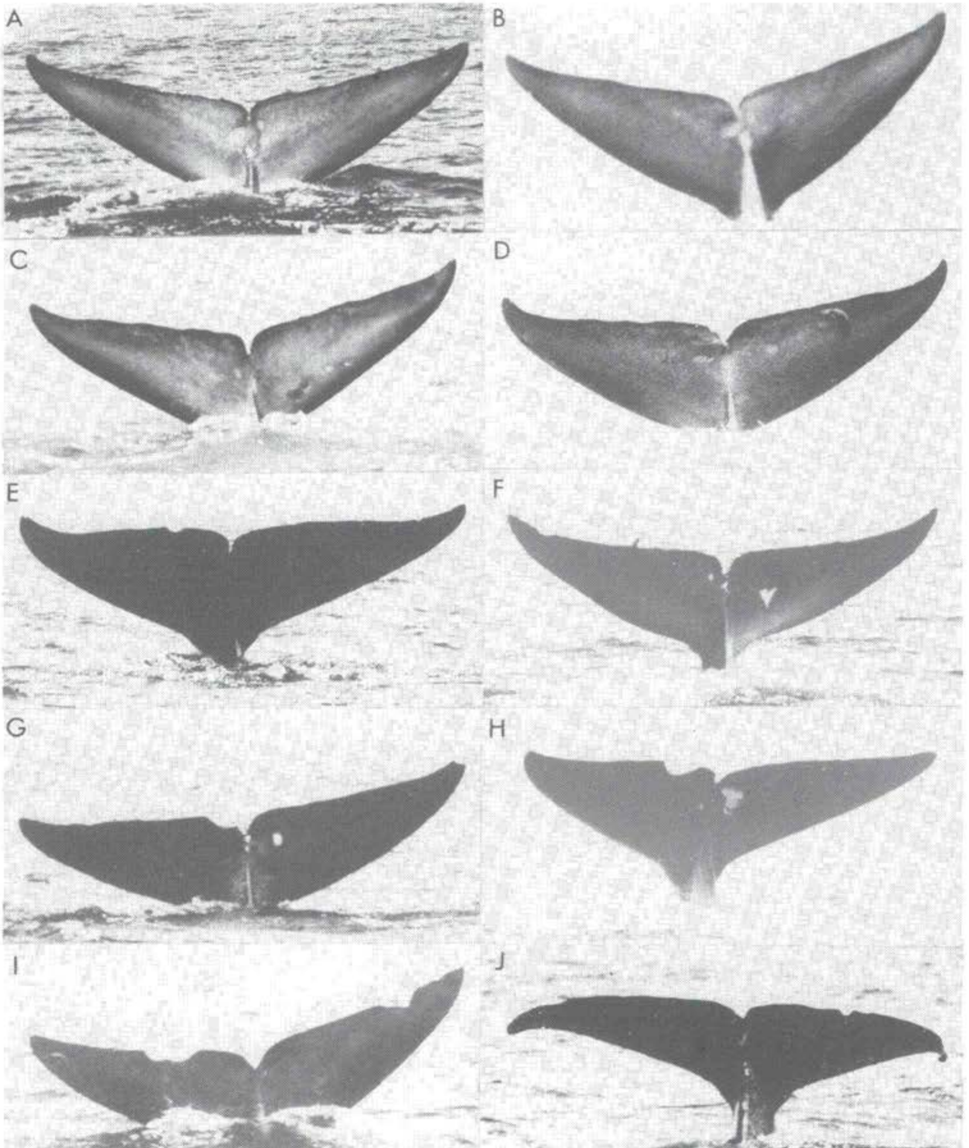

Fig. 7. A sample of ventral sides of blue whale tail flukes. Whale 3 on 8 March 1984 (A) and 28 February 1983 (B). C. Whale 22. D. Whale 2. (Note the small remora near the right trailing edge). E. Whale 25. F. Whale 24. G. Whale 27. H. Whale 14. I. Whale 29. J. Whale 30.

area. The longest movement observed, that of whale #27, was about 100km in 18 days, from offshore of Mullaitivu to near Trincomalee. The longest time between sightings within a year was 31 days for whale #14. All three sightings of whale #14 in 1983 and the three sightings of whale #3 in 1983–84 were near the Trincomalee area.

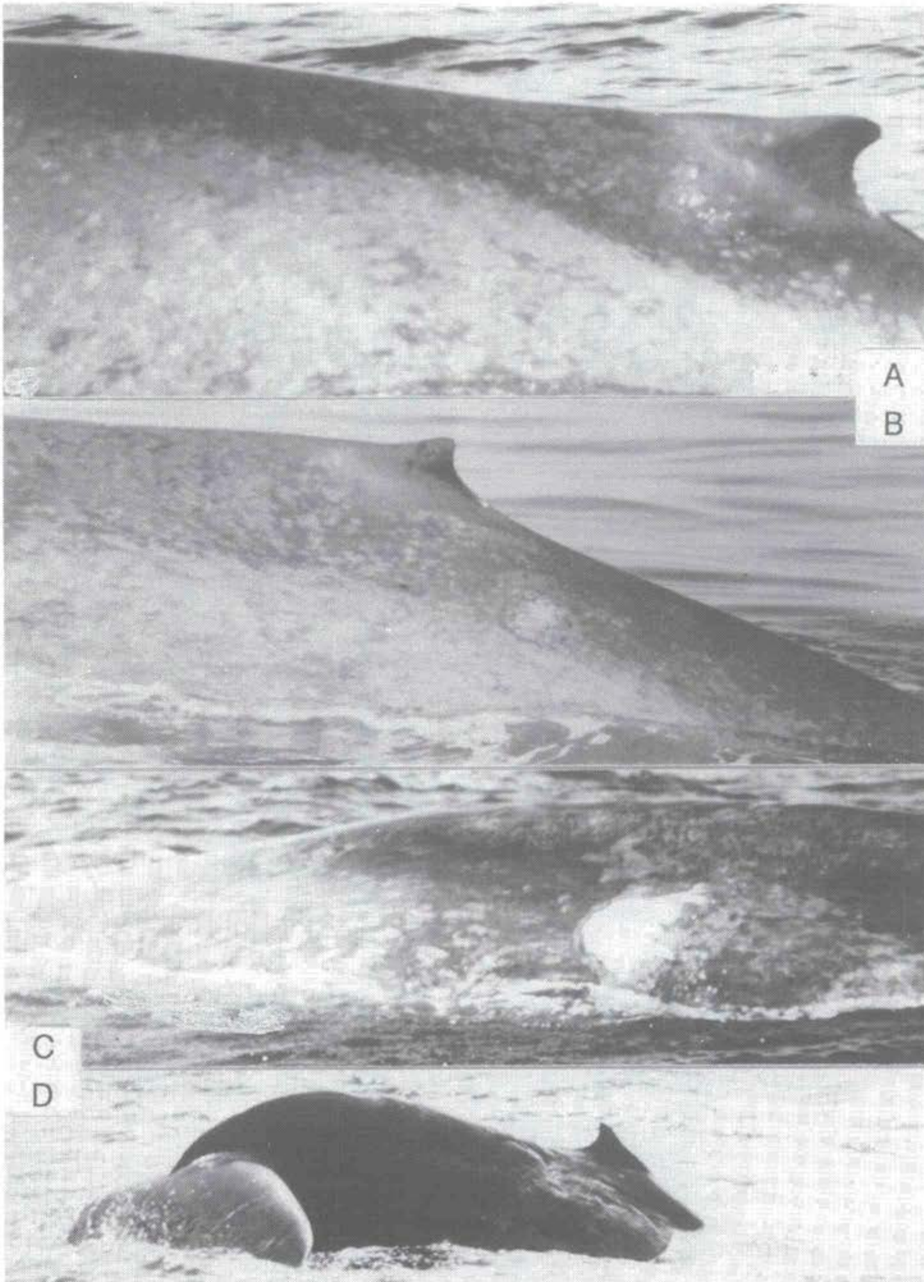

Fig. 8. Individually distinctive natural markings on the body. A. Body pigmentation on whale 13. B. Body pigmentation on an unnumbered whale photographed on 16 April 1984. C. White scar on whale 18. D. Irregular puckering, probably an old scar, near dorsal fin of whale 18.

Table 2.

Dates and locations of all sightings of repeatedly recognised whales.

ID	First sighting			Second sighting			Third sighting		
	Date	°N	°E	Date	°N	°E	Date	°N	°E
1	02.03.83	8°34.0';	81°18.7'	05.03.83	8°34.3';	81°15.8'			
3	28.02.83	*;	81°24.8'	08.03.84	8°34.5';	81°28.2'	19.03.84	8°34.4';	81°28.2'
5	03.03.83	8°37.2';	81°16.2'	17.03.83	8°34.7';	81°20.8'			
11	28.02.83	8°34.1';	81°19.5'	03.03.83	8°37.2';	81°16.2'	05.03.83	8°34.3';	81°15.8'
14	28.02.83	8°36.2';	81°19.3'	03.03.83	8°37.4';	81°15.9'	31.03.83	8°36.5';	81°17.0'
19	06.03.84	8°35.9';	81°26.6'	07.03.84	8°35.5';	81°25.4'			
23	07.03.84	8°35.6';	81°27.1'	08.03.84	8°36.0';	81°25.5'	19.03.84	8°36.5';	81°24.3'
24	06.03.84	8°35.4';	81°22.7'	08.03.84	8°34.5';	81°24.8'			
25	16.04.84	8°35.9';	81°26.0'	17.04.84	8°35.7';	81°20.8'			
27	30.03.84	9°25.3';	80°54.6'	17.04.84	8°35.7';	81°20.8'			

* Identified just outside Trincomalee Harbor, precise coordinates not known. The same animal was re-identified by Leatherwood in approximately the same location 19 Mar 84 (from Leatherwood, 1985-Table 1).

DISCUSSION

Before this study, blue whales were known from Sri Lankan waters only from occasional sightings and strandings, often poorly documented. After a preliminary review in early 1983 of the evidence for the existence of blue whales in Sri Lankan waters, Santerre and Santerre (1983) concluded 'we are hesitant to add this species to the list of marine mammals that we feel definitely have occurred here'. More recently, other expeditions to the study area in 1983, 1984 and 1985 have reported blue whales (Leatherwood *et al.*, 1984; Leatherwood, 1985; Leatherwood and Reeves, 1989) in late winter and spring. Leatherwood (1985) reported finding the same blue whale, identified from photographs by distinctive markings, off Trincomalee in February 1983 and March 1984. Blue whales also were sighted near Trincomalee, in spring of 1986 (R. Gunaratne, pers. comm.), and in April of 1987 (W.P. Mahendra, pers. comm.). Thus, it appears that blue whales have been regularly found off the northeast coast of Sri Lanka, at least since 1983, and that some individuals have returned in successive years.

The occurrence of blue whales in these waters may be only seasonal, however. The *Elendil/Tulip* surveyed the study area in October-December 1983, saw only one small blue whale on 16 October near Trincomalee, and concluded that baleen whales were less abundant off the east coast in October and November than in February-April (Whitehead *et al.*, 1983). If blue whales from the study area regularly migrate elsewhere, there is no information on where that might be.

These blue whales, even the larger animals accompanied by calves, appeared to be relatively small, raising the possibility that they are of the subspecies *Balaenoptera musculus brevicauda*, or pygmy blue whales. A few photogrammetric length and proportion estimates made on animals seen in March 1984 did not resolve this question (Gordon *et al.*, 1986).

Based upon our depth sounder tracings of repeated dives into dense patches of presumed prey, frequent observations of defecation at the surface and a residence time of over four weeks for a recognised individual, Sri Lanka waters appear to be important to these blue whales as a feeding area.

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REFERENCES

Alling, A. and Payne, R. 1987. Songs of Indian Ocean blue whales, *Balaenoptera musculus*. Paper presented to the Scientific Meeting to review the Indian Ocean Sanctuary, Seychelles, February 1987 (unpublished).

Gordon, J.C.D. 1987a. The behaviour and ecology of sperm whales off Sri Lanka. Ph.D Thesis, University of Cambridge. 347pp.

Gordon, J.C.D. 1987b. Sperm whale groups and social behaviour observed off Sri Lanka. *Rep. int. Whal. Commn* 37:205–17.

Gordon, J.C.D., Papastavrou, V. and Alling, A. 1986. Measuring blue whales: a photogrammetric technique. *Cetus* 6(2):5–8.

Leatherwood, S. 1985. Further notes on cetaceans of Sri Lanka. *Cetology* 50:1–12.

Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985–1986. *UNEP Mar. Mammal Tech. Rep.* 1:[vi], 1–138.

Leatherwood, S., Peters, C.B., Santerre, R., Santerre, M. and Clarke, J.T. 1984. Observations of cetaceans in the northern Indian Ocean Sactuary, November 1980-May 1983. *Rep. int. Whal. Commn* 34:509–20.

Santerre, M.T. and Santerre, R.M. 1983. The occurrence and distribution of marine mammals in Sri Lanka. Paper NARA/SMMIO/SP14 presented to the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished).

Whitehead, H. and Gordon, J. 1986. Methods of obtaining data for assessing and modelling sperm whale populations which do not depend on catches. *Rep. int. Whal. Commn* (special issue 8):149–65.

Whitehead, H., Gilligan, P., Smyth, C., Weilgart, L. and Converse, C. 1983. WWF/IUCN Indian Ocean Whale Project. Interim Report, Oct-Dec. 1983. (Unpublished.).

Possible Stock Affinities of Humpback Whales in the Northern Indian Ocean

R.R. Reeves[1], S. Leatherwood[2] and V. Papastavrou[3]

ABSTRACT

Records of humpback whales, *Megaptera novaeangliae*, in the northern Indian Ocean are compiled and evaluated to test various hypotheses concerning stock relationships. The conventional view that all humpbacks in this region are migrants from the Southern Hemisphere or, less likely, from the Pacific Ocean has been challenged recently by other authors. There is no reason to doubt that some Antarctic humpbacks cross the Equator during their winter breeding migration northward. However, sightings in the northern Indian Ocean during the austral spring, summer and fall are sufficiently frequent and widespread to support the hypothesis that some whales remain north of the Equator in the Indian Ocean year-round. Humpbacks appear to be present off Oman throughout the year, including relatively large concentrations, apparently feeding, during boreal summer/fall. We postulate that areas of cool, highly productive upwelling near the coast of Oman create conditions suitable for humpback feeding. The northern Indian Ocean is characterised by a virtual absence of modern commercial whaling and a paucity of cetacean research. As a result, evidence is insufficient to determine the relationships between stocks of humpbacks in the northern Indian Ocean and stocks of humpbacks elsewhere.

INTRODUCTION

The humpback whale, *Megaptera novaeangliae*, has a cosmopolitan distribution. All well-studied populations (or stocks) of humpbacks are known to make annual long-distance migrations, from high-latitude (50–65°) summer feeding grounds to low-latitude (10–30°) winter calving/breeding grounds (Kellogg, 1929; Tomilin, 1957). For the most part, these migrations are thought not to involve movement across the Equator, and most humpback stocks probably remain within either the Northern or Southern Hemisphere year-round. Two exceptions are: (a) the populations that summer in Antarctic Areas II and III and winter (at least to some extent) in the Gulf of Guinea, astride the Equator off west Africa; and (b) the population that summers in Antarctic Area I and winters off northern Peru, Ecuador, Colombia and Panama (Townsend, 1935; Mackintosh, 1965, p.83, figure 11; Tomilin, 1957, p.274*, figure 50; Mackintosh and Brown, 1974, plate 2; Aguilar, 1985; Winn and Reichley, 1985, p. 251, figure 7). In both these cases, calving occurs during austral winter (principally June-July), in synchrony with the calving of other Southern Hemisphere populations. The annual cycles of Northern and Southern Hemisphere humpback populations are about six months out of synchrony (Lockyer, 1984), and populations from contiguous ocean basins of the two hemispheres have not been documented to occupy the same tropical grounds.

At least two stocks of humpbacks have long been known to occur in the Indian Ocean south of the Equator. One moves from Antarctic Area III to Madagascar and the east coast of Africa at least as far north as Kenya (perhaps crossing the Equator; see below). The other migrates between Antarctic Area IV and northwestern Australia (Mackintosh, 1965, p.83, figure 11; Mackintosh and Brown, 1974, plate 2; Winn and Winn, 1985,

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*Here and throughout the paper, page numbers refer to the English translation of 1967.

p.20, figure 7). Tomilin (1957, p.272) stated that a few animals, apparently from the Area III stock, migrate north of Madagascar, reaching 'the coasts of Arabia and Baluchistan, even penetrating the Persian Gulf.' He also referred to the Seychelles as a 'breeding' ground and to observations of females and calves in the Bay of Bengal during August through October. Van Beneden (1887) referred to sightings at Réunion, the Comoros and Oman.

Recent records of humpbacks in various parts of the northern Indian Ocean permit re-evaluation of hypotheses about stock divisions in this region. As noted by Winn and Winn (1985, p.21), 'the humpbacks in the Arabian Sea and the northern Indian Ocean are something of a mystery.' Brown (1957) considered humpbacks seen in the northern Indian Ocean during austral winter to be 'almost certainly members of the same population as is found in the Antarctic in the southern summer.' Although he did not comment on stock affinities of those whales found in the northern Indian Ocean during seasons outside austral winter, Brown concluded from the opportunistic sightings that he analysed that humpbacks and other rorquals 'are found unexpectedly far north, on the supposition that they all belong to the Southern Hemisphere populations.' Slijper *et al.* (1964, p.27) questioned Brown's supposition. Although they agreed that the humpbacks observed in the northern Indian Ocean during winter probably belong to a Southern Hemisphere stock, Slijper *et al.* assumed that those seen north of the Equator during austral summer belong to a North Pacific population. Neither Brown (1957) nor Slijper *et al.* (1964) seem to have entertained the possibility of a resident stock of humpbacks in the northern Indian Ocean, as proposed by Winn and Winn (1985, p.21), who noted: ' Not only does the area offer a vast supply of food, but for part of the year its temperatures are satisfactory for calving; indeed, calves have been sighted throughout the year.'

Whitehead (1982; 1985) presented new evidence, both visual and acoustic, of the humpback's occurrence in the northwestern Indian Ocean. He found that the content of their underwater songs was different from that of Atlantic and Pacific humpback songs but that the songs recorded off Oman and west of Sri Lanka had 'virtually the same content.' Whitehead concluded that some humpbacks remain in the northern Indian Ocean year-round, probably making only short migrations between their feeding and breeding grounds.

RESULTS AND DISCUSSION

Records of occurrence

In Fig. 1, we have plotted records of humpbacks in the Indian Ocean north of the Equator (also see Brown, 1957, p.163, figure 4; Slijper *et al.*, 1964, chart 5; Whitehead, 1985). The records of Brown (1957) and Slijper *et al.* (1964) are mainly sightings by merchant seamen, and the species identifications are unconfirmed. Only the sound recordings from Whitehead (1985) and the records supported by documentary photographs (e.g. Fig. 2) or a specimen (Table 1) can be considered entirely reliable. In some instances where we knew enough about the observer's capabilities and training, we accepted sight records as valid even though no photographs were examined.

In their study of American whaling in the western Indian Ocean, Wray and Martin (1983, p.223) referred to the whaling grounds 'off the Ceylonese coast between Colombo and Galle' as being 'full of sperm, humpbacks and finbacks,' apparently during September-November 1847. However, the same authors indicated elsewhere (p.228) that only one sighting of a humpback was reported for 'the Ceylon grounds' in the sample of logbooks and journals that they examined; this was during 'the [probably northern] winter of 1846'.

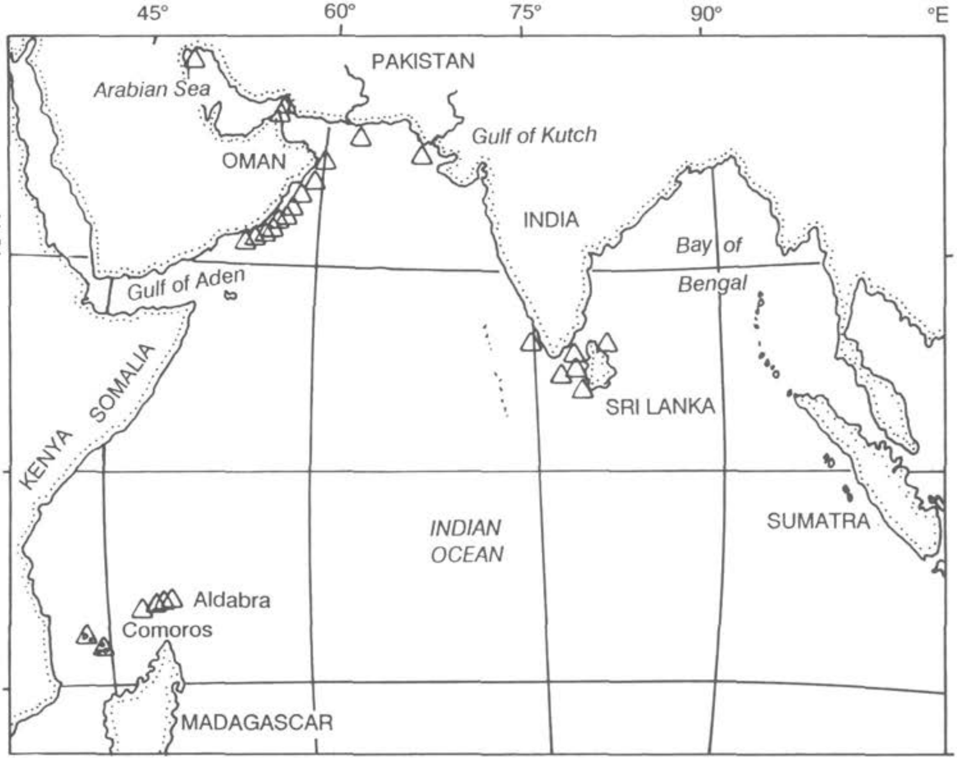

Fig. 1. Records of humpback whales in the Indian Ocean north of the Equator not included in Brown (1957) and Slijper *et al.* (1964). Also shown are recent sightings near the Seychelles and Comoros pertinent to discussions in this paper.

Blanford (1891, p.568–9) had no definite evidence of humpbacks in 'the Indian seas' but was convinced that they occurred there. He referred to a skull of *Megaptera boops* (= *novaeangliae*) from Java in the Leyden Museum. [However, according to Van Beneden and Gervais (1880, p.118) this specimen was identified by W.H. Flower as a *Balaenoptera*. Van Beneden and Gervais did note that a 45ft whale stranded at Pekalongan, north coast of Java, on 12 April 1863 (Anonymous, 1864) was a humpback. Blanford rejected Gray's (1866, p.131) diagnosis that a partial skull in the Asiatic Society's collection in Calcutta belonged to the genus *Megaptera*; this was probably the same specimen mentioned by Van Beneden and Gervais (1880, p.131).] The Pekalongan specimen may have been the basis for Tomilin's (1957, p.272) inclusion of Java in the list of winter breeding grounds. We are unaware of other published records from Indonesia.

Presence or absence of calves

The presence of young calves can be interpreted as evidence that a calving ground is nearby. However, since calves accompany their mothers to high-latitude feeding grounds where they continue at least for several months to be recognisable as calves (e.g. Baker *et al.*, 1985; Clapham and Mayo, 1987), records of calf sightings should not be assumed automatically to indicate proximity to a calving ground. Brown (1957) provided no information about the sizes of humpbacks seen in the northern Indian Ocean. However,

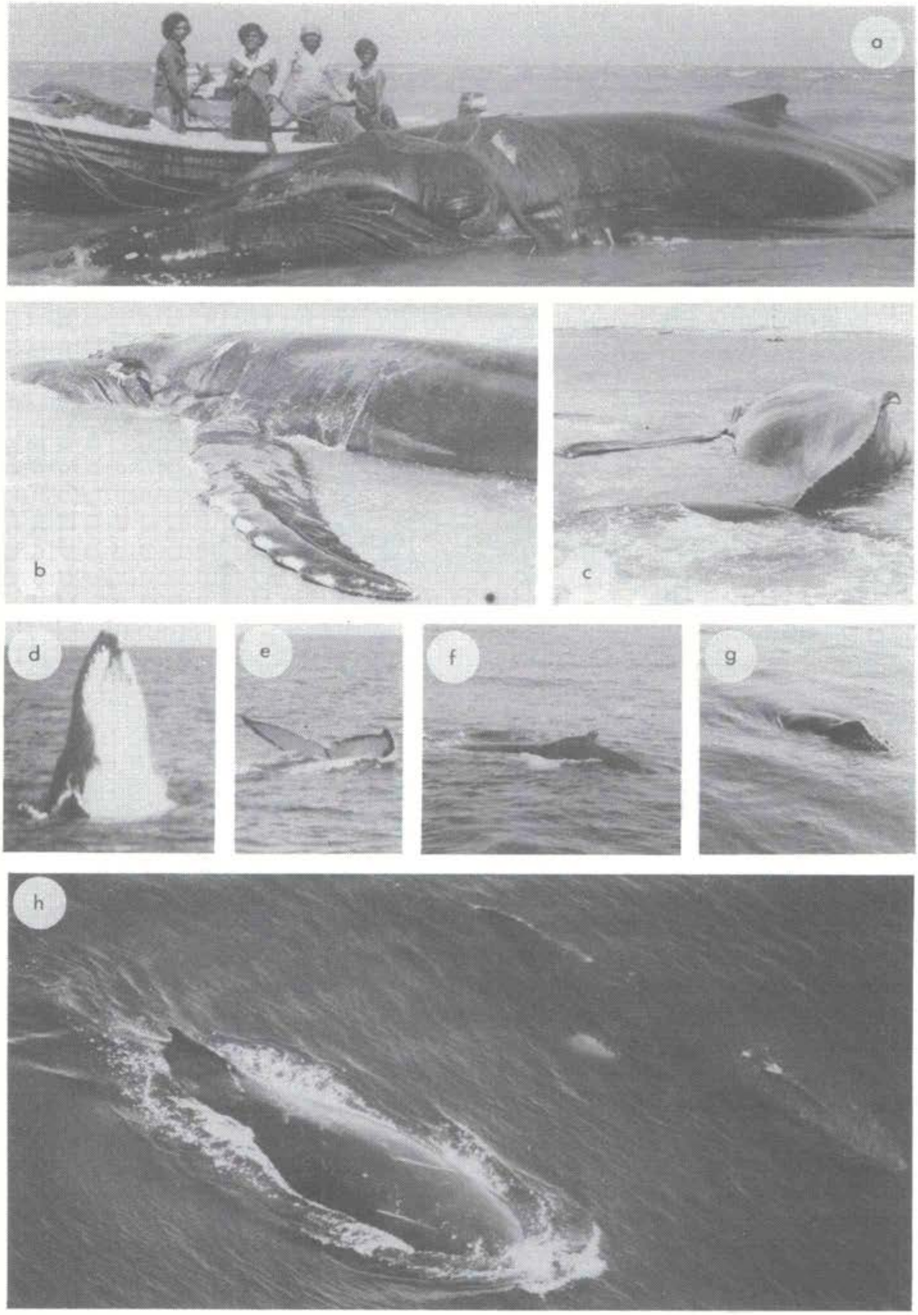

Fig. 2. Views of humpback whales in the Indian Ocean: (a-c) Chilaw, Sri Lanka, 22 January 1981; (d,e) Kuria Muria Islands, Oman, 20 January 1985; (f,g) adult and calf off Ile de Mayotte, Comoros, September/October 1986; and (h) 1 mile south of Taqah, Oman, 14 October 1987. (Photos courtesy of Sri Lankan National Aquatic Resources Agency (a), Colombo Museum (b,c), Michael Gallagher (d,e), John Beadon (f,g) and John Nowell (h)).

Table 1

Records of humpback whales in the Indian Ocean north of the equator. For additional records see Brown (1957) and Slijper *et al.* (1964). ID: A = Definitely *M. novaeangliae*; B = probably.

Date	Location	Observations/specimens	ID	Source
325 B.C.	N shore of Arabian Gulf E of mouth of Khisht	Stranded, observed by Nearchus, said to have been covered with barnacles	B	1,2
July 1873	Off the Baluchistan coast of Pakistan	Decomposed carcass entangled in marine telegraph cable	A(?)	3
ca 1883	Arabian Gulf <100 mi from mouth of Khisht	1 stranded; skeleton in Academy of Sciences Paris	A	1,2
23 Jan 1943	Anjengo coast nr Quilon, Travancore, India	15m specimen entangled in seine net	A	4
Feb 1947	Bambalapitiya, Sri Lanka	Adult and calf, 300m offshore	A	5
22 Feb 1949	Colombo harbor, Sri Lanka	Adult + calf photographed; 'second record of the the humpback from Ceylon'	A	6,7
21 Sept 1953	0-10°N, 70-80°E	One sighted (not plotted on Fig. 1)	B	8
26 Sept 1953	10-20°N, 40-50°E	±50 sighted (not plotted on Fig. 1)	B	8
1950s-1960s	Mulatiwu NE Sri Lanka	Frequent sightings by fishermen	B	9
Sept-Oct	Off Masirah, Oman	In 1980, fishermen report seeing whales, probably humpbacks, each year	B	10
22 Jan 1981	Chilaw, Sri Lanka	12-13m stranded specimen	A	11,12
12 Nov 1981	16°55'N 54°36'E, Oman	8 incl. juvenile seen from Omani naval vessels	B	13,14
15-17 Jan 1982	Kuria Muria Bay, Oman	Songs recorded	A	15
19 Feb-10 Mar 1982	Gulf of Mannar, Sri Lanka	Songs recorded	A	15
24 May 1984	Nr Karachi, Pakistan	950cm carcass found entangled in gillnet	A	16,17
4 Aug 1984	Near Qalhat, Oman,	Decomposed carcass; flippers 8ft long; dead for at least 2 weeks	A	18
20 Jan 1985	*ca* 17°36'N 56°00'E Oman	2 animals photo'd between Ra's al Hallaniyah and Ghurzout, Kuria Muria Islands	A	19
Mar 1986	17°31'N 56°06'E Oman	1 animal seen & swum with NE of Al Hallaniyah	A	20
Sep/Oct '86	17°N 55°04'N Oman	3 photographed from helicopter 3 mi. S of Sudh	A	21
17 Mar 1987	20°25'N, 57°59'E	Remains of small whale stranded	B	22
May 1987	20°42'N 58°58'E Oman	20-30 whales in subgroupsof 2-3; remained	A	23
last week		off N tip Masirah Island several days	A	23
14 Oct 1987	17°01'N 54°24'E Oman	2 animals photographed 1 mi. S of Taqah	A	21
Unknown	*ca* 19°N 57°52'E Oman	Video taped off Ra's Madrakah	?	24
July	Gulf of Mannar		B	25
Unknown	Shatt-al-Arab, Iraq	1 shot by Turkish gunboat	B	26

Sources: 1 = Pouchet, 1892a; 2 = Pouchet, 1892b; 3 = Van Beneden, 1889; 4 = Mathew, 1948; 5 = R. Jonklass, pers. comm. 23 Feb 1983; 6 = Deraniyagala, 1960; 7 = Deraniyagala, 1965; 8 = Slijper *et al.*, 1964, p. 55; 9 = G.H.P. DeBruin pers. comm. 1985; 10 = Ross, 1981; 11 = de Silva, 1983, Figs 2a-c; 12 = de Silva, 1987; 13 = M.A. Al-Barwani *in litt.* to IWC, 30 June 1982; 14 = IWC, 1983, p.149; 15 = Whitehead, 1985; 16 = Ahmed, 1985; 17 = Ali, 1984; 18 = B. McClure & S. McEntyre, Ministry of Agriculture and Fisheries, pers. comm.; 19 = M.D. Gallagher *in litt.*, 7 Oct 1988; Fig. 2 d-e; 20 = C. McNeily pers. comm.; 21 = J. Nowell pers. comm.; (Fig. 2h; 22 = Papastavrou & Salm , this vol.; 23 = P. Jonathan & D. Bridge, J.P. Ross *in litt.*, 1 Dec 1988); 24 = S. McEntyre pers. comm.; 25 = Rex de Silva, pers. comm. *in* 15; 26 = Al-Robbae, 1974 *in* 11.

Slijper *et al.* (1964, p.27–28) plotted sightings of calves in the Arabian Gulf and off Oman in November, in the Gulf of Kutch in December and January, west of Sri Lanka in January, in the open Arabian Sea in November and in and just outside the Gulf of Aden in September and November. Depending on the actual ages of the calves in these sightings, their presence may or may not suggest something about the timing and location of calving.

Seasonality of records

Brown's (1957) records of humpbacks in the Indian Ocean north of the Equator spanned all four seasons, with sighting frequencies ('numbers of sightings of individual species per 1,000 miles steaming') varying from 0.015 (June-August) to 0.073 (March-May). The larger sample of records presented by Slijper *et al.* (1964, chart 5) gives high sighting frequencies (numbers of animals sighted per 1,000 hours steamed in daylight) for humpbacks in the Gulf of Oman and Arabian Sea during January (61–70), February (81–90), March (161–180), August (121–140), October (251–300) and December (101–120), and indicates small numbers of humpbacks (1–20 per 1,000 hours) in the Arabian Gulf or near Oman during April, May, August and October. Recent observations (Table 1) make it possible to add September and November to the months when humpbacks have been seen off Oman. The combined records thus suggest strongly that humpbacks are present in this region year-round.

Given the timing of humpbacks' passing through whaling grounds off Madagascar (Slijper *et al.*, 1964) and Mozambique (Rørvik, 1980), one would expect to find whales from Southern Hemisphere stocks in the Northern Hemisphere only from about June through August or September. There are no areas of the northern Indian Ocean where records are confined to these months (Table 2). For most areas, records at other times of year are sufficiently numerous that they cannot be dismissed as involving only stragglers. The more-or-less year-round presence of humpbacks in the northern Indian Ocean supports the hypothesis expressed by Winn and Winn (1985) and Whitehead (1985), that some humpbacks remain within the northern Indian Ocean. It is not possible to determine from available data whether there is more than one resident stock in the northern Indian Ocean, or to describe details of movements by individual whales within this broad area.

Geographic spread of sightings

Humpbacks occur over much of the northern Indian Ocean. Brown (1957) and Slijper *et al.* (1964) quantified sighting effort and interpreted their sighting records accordingly. Brown's humpback sightings generally were in areas of high effort (off southwestern India and around the mouth of the Gulf of Aden). Although Slijper *et al.* (1964, p.26) stated that many of their sightings were from the Arabian Sea, Gulf of Aden and Bay of Bengal, their Chart 5 shows no sightings at all in the Bay of Bengal. We find these authors' reference, as well as that of Tomilin (1957, p.272) concerning the presence of humpbacks with calves in the Bay of Bengal during August through October, puzzling. Perhaps Slijper *et al.* considered their few records from southeast of Sri Lanka and off the northwestern tip of Sumatra to be in the Bay of Bengal (thus the question marks in Table 2). We found no

Table 2

Monthly occurrence of humpback whales in various parts of the northern Indian Ocean. x=definite record(s); +=probable record(s); ?=uncertain basis - see text

Area	J	F	M	A	M	J	J	A	S	O	N	D
Gulf of Aden	+	+	+	+			+	+	+	+	+	+
Oman	x		x	+	x			x	x	x	+	
Arabian Gulf					+		x?	+			+	
North Arabian Sea	+		+		x		x	+		+		+
South India/Sri Lanka	x	x	x	+	+	+	+	+	+		+	
Bay of Bengal		?					?	?	?	?	?	
Somalia North of 0°			+	+					+		x	
Central/South Arabian Sea		+		+	+		+	+			+	

certain evidence, historical or recent, of humpbacks in this large bay, although one observer reported that whales, possibly humpbacks, were seen frequently by fishermen off Mulatiwu, northeastern Sri Lanka, during the 1950's and 1960's (G.H.P. DeBruin, pers. comm. 1985).

Do Antarctic Area III humpbacks migrate to the northern Indian Ocean?
How far north does the Area III humpback stock migrate in winter? Recent observations have been made during September and October near Aldabra and the Comoro Islands, at the southwestern extremity of the Seychelles archipelago and west of the northern tip of Madagascar (Table 3; Fig. 1 and 2). These and other observations of humpbacks (with young calves) near Ile Sainte-Marie off the northeast coast of Madagascar in August and September 1987 (Pieter Folkens, pers. comm. 1988) are consistent with the timing of humpback catches at Madagascar (June-October; peak in July-August – Slijper *et al.*, 1964, Table 3) and Mozambique (Rørvik, 1980). Slijper *et al.* (1964, p.27) took the large number of sightings in the Seychelles area (0–10°S, 50–70°E) during April and August to mean that humpbacks were migrating through the Seychelles northbound from and again southbound toward the Antarctic.

Table 3

Unpublished records of humpback whales in the western Indian Ocean.

Date	Location	Seen	Source
Sep/Oct 1986	Ile de Mayotte, Comoro Islands	2[1]	J. Beadon, *1987; Fig. 2f,g
17 Sep 1986	Nr reef off Malabar, Aldabra	?	Aldabra library, K. Kangas, *1987
9-10 Sep 1988	Aldabra	1	R. Woodroffe, WCRU, *in litt.* 16.1.90
20 Oct 1988	09°18.31'S, 46°19.36'E, nr Aldabra	1a	Leatherwood
20 Oct 1988	1.7 n.miles off East Channel, Aldabra	2a	Leatherwood
25 Oct 1988	400m outside reef at Moroni, Comoro Is	1	W. Carlson, US Embassy Moroni, *1987

[1] adult and neonate; *=pers. comm.; a=underwater listening through hydrophone revealed no humpback songs. WCRU=Wildlife Conservation Research Unit, Aldabra.

R.R. Harger (letter of 9 April 1927 in S.F. Harmer papers, British Museum [Natural History]) wrote of his observations and those of a Norwegian whaling captain concerning the movements of humpbacks along the east coast of Africa. According to Harger, humpbacks unaccompanied by calves were seen and taken from May through July as they traveled northward some 10–20 miles offshore, 'as depth of water allowed.' The whaling station was on the Mozambique coast at about 16°S (see Rørvik, 1980). During September and October, 'schools' were traveling south without exception and adult females were in most cases accompanied by calves. The timing is consistent with these animals' being southern-ocean humpbacks, having given birth in austral winter (June-July) and moving south toward higher latitudes in austral spring (September-October). The whaling captain told Harger that he had been 'right up the north coast seeking suitable locality and had traced the Humpbacks to entrance to the Persian Gulf,' noting that whales were 'not approachable or so concentrated when calving among the shallow inlets and sandy banks.' The implication seems to be that this captain considered the whales in the Arabian Gulf to have been from the same population as those migrating along the coast of Mozambique.

Wray and Martin (1983, p.228) noted observations of humpbacks on the 'coast of Arabia,' a Northern Hemisphere whaling ground that 'evolved as an extension of activities along the Somali coast' (Wray and Martin, 1983, p.224). The positions for these humpback sightings were from 4°S to just north of the Equator and between about 41° and 48°E; the dates, from July to the end of December.

The presence of humpbacks at other times of year (including 'singing' whales in January [Whitehead, 1985]) in the Gulf of Aden, Arabian Gulf, Gulf of Oman and various parts of the Arabian Sea (Slijper *et al.*, 1964; Tables 1 and 2) offers the possibility that the calving whales mentioned by Harmer's informant were from a different stock than he supposed. With evidence available at present, it is impossible to judge how far north Antarctic Area III humpbacks migrate and whether or not two different stocks calve (or calved formerly) in the same parts of the northwestern Indian Ocean some six months out of synchrony.

Is there a humpback feeding ground near Oman?

Most of the confirmed observations of humpbacks off Oman (Table 1) were made during the boreal winter, and songs heard in January (Whitehead, 1985) imply that breeding behaviour occurs near Oman during this season. Given the well-known summer productivity of Omani waters noted by Winn and Winn (1985) and Whitehead (1985), we suspect that humpbacks also feed off Oman.

Highly productive and seasonal (May through September) marine upwellings occur at intervals along the coast of Oman, especially along the southern coast (Dhofar). Steep gradients in the bottom topography in combination with seasonal currents, wind-driven by the southwest monsoon, cause deep upwelled water to reach the surface, sometimes cooling the sea surface to temperatures as low as 16°C (Smith, 1968; Bottero, 1969; Currie *et al.*, 1973). In this broad upwelling, water arrives at the surface from much greater depths than is usual in many other upwelling systems (Barratt, 1984).

The upwellings off Oman are sufficiently productive to support a seasonal sardine (*Sardinella longiceps*) fishery. They also support a unique assemblage of normally temperate-region algae and coral communities. The kelp beds are dominated by *Eklonia radiata*, a kelp otherwise found in temperate areas off New Zealand, Australia and southern Africa (Barratt, 1984). The 'temperate' nature of this sublittoral ecosystem may indicate that Dhofar also functions as a 'temperate' feeding area for some humpbacks. The records in Table 1 from near Sudh and the Kuria Muria Islands are from areas of the most intense upwelling (Barratt, 1984). The sighting at Ra's Madrakah is also from an area noted for its upwelling. The 20–30 whales seen for several days off Masirah Island in late May 1987 (Table 1) were reported to have been blowing large masses of bubbles underwater and surfacing through the bubble clouds with mouths open (J.P. Ross, *in litt.*, 1 Dec. 1988). Such behaviour is associated with feeding in other areas (Ingebrigtsen, 1929; Hain *et al.*, 1982).

Seas are usually sufficiently rough during the southwest monsoon to prevent small vessels from embarking. The only consistent contact between the Kuria Muria Islands and the mainland during this season is by air (M. Gallagher, pers. comm.). Thus, feeding humpback whales may be present but go largely unnoticed and unreported during the months of May through September (Papastavrou, 1990). The large number of humpback sightings by merchant seamen reported by Slijper *et al.* (1964, chart 5) for the northern Arabian Sea during August and October may represent a feeding assemblage of Northern Hemisphere humpbacks.

CONCLUSIONS

The scarcity of confirmed records from the South China Sea and the Indonesian archipelago did not deter Slijper *et al.* (1964) from concluding that the humpbacks in the northern Indian Ocean during boreal winter (December-March) are North Pacific migrants. The fact that humpback songs have been recorded near Oman in January and near Sri Lanka in February and March can be taken to mean that at least some whales in the northern Indian Ocean consider this period 'the breeding season and therefore presumably winter' (Whitehead, 1985). However, as Whitehead (1985) noted, the distance between Oman and the nearest summer feeding grounds in the North Pacific is sufficiently long to make an annual feeding-breeding migration between the North Pacific and the Arabian Sea improbable. Productivity in certain areas of the northern Indian Ocean during boreal summer/fall may be adequate to supply the energy requirements of a humpback population. A parsimonious conclusion from the available data is that some humpbacks are 'resident' in the northern Indian Ocean, finding suitable habitats for both feeding and breeding between the Equator and the south Asian/northeast African land masses.

The question of whether humpbacks from Antarctic feeding grounds (Areas III and IV) migrate as far north as the Gulf of Aden, Gulf of Oman and/or Gulf of Kutch during the calving/breeding season remains moot. However, given the sparseness of reliable data on humpbacks in the northern Indian Ocean, no hypothesis can be ruled out. Even the possibility of a connection between humpbacks in the Arabian Sea (and Bay of Bengal?) with those in the Pacific and southwestern Indian oceans remains open. Mörzer-Bruyns (1971, chart 15) proposed a migration linking humpbacks in the northern Arabian Sea and Lesser Sunda Islands of southern Indonesia. Durant Hembree told Leatherwood (pers. comm., January 1987) that although he obtained no definite evidence of the humpback's occurrence during his research at Lamalera in the Lesser Sunda Islands in June-September 1979 (Hembree, 1980), he was convinced that they do occur near both Lamalera and Lamakera and believed that they are taken in the latter area. Dolar *et al.* (in prep.) present reports by traditional whalers at Pamilican Island, Philippines, that they see humpbacks in Spring and took at least one specimen in the 1980s. Japanese scouting and research vessels reported sighting 11 humpbacks per 10,000 nautical miles of searching in an area just south of the Lesser Sunda Islands during austral summer, November-March (Kasuya and Wada, this volume; also see Slijper *et al.* [1964, chart 5, December]). Similar out-of-season occurrences of humpbacks have been reported from the Torres Strait region (Anonymous, 1985).

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REFERENCES

Aguilar, A. 1985. Aboriginal whaling off Pagalu (Equatorial Guinea). *Rep. int. Whal. Commn* 35:385–6.

Ahmed, M.F. 1985. Stranding of a humpback whale (*Megaptera novaeangliae*, Borowski 1781) on the Sind coast. *Rec. Zool. Surv. Pak.* 10(1, 2):111–2.

Ali, M.H. 1984. Humpback whale – first record in Sind coastal waters. *WWF Pak. Newsl.* 3(2):5–6.

Anonymous. 1864. Bestuursvergadering, gehouden den 9en mei 1863, in het gebouw der vereeniging. *Natuur. Tijdschr. Ned.-Indie* 26:422–30. [In Dutch.].

Anonymous. 1985. Australia. Progress report on cetacean research, June 1983 to April 1984. *Rep. int. Whal. Commn* 35:158–61.

Baker, C.S., Herman, L.M., Perry, A., Lawton, W.S., Straley, J.M. and Straley, J.H. 1985. Population characteristics and migration of summer and late-season humpback whales (*Megaptera novaeangliae*) in southeastern Alaska. *Mar. Mammal Sci.* 1:304–23.

Barratt, L. 1984. *Ecological Study of Rocky Shores on the South Coast of Oman*. IUCN report to the UNEP Regional Seas Programme (unpublished). 104pp.

Blanford, W.T. 1891. *The Fauna of British India, Including Ceylon and Burma*. Taylor and Francis, London. 617pp.

Bottero, J.S. 1969. An analysis of upwelling off the South East Arabian coast during the summer monsoon. MSc. Thesis, Oregon State University.

Brown, S.G. 1957. Whales observed in the Indian Ocean. Notes on their distribution. *Mar. Obs.* 27:157–65.

Clapham, P.J. and Mayo, C.A. 1987. The attainment of sexual maturity in two female humpback whales. *Mar. Mammal Sci.* 3:279-83.

Currie, R.I., Fisher, A.E. and Hargreaves, P.M. 1973. Arabian Sea upwelling. The biology of the Indian Ocean. *Ecol. Stud.* 3:475–86.

Deraniyagala, P.E.P. 1960. Some southern temperate zone snakes, birds and whales that enter the Ceylon area. *Spolia Zeylan.* 29(1):79–85.

Deraniyagala, P.E.P. 1965. A sanctuary for turtles, the dugong, whales and dolphins in the Indian and Southern Oceans. *Loris* 10(4):246–50.

de Silva, P.H.D.H. 1983. Taxonomy of the Cetacea of the Indian Ocean. Paper NARA/SMMIO/SP31 presented to the Symposium on marine mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished).

de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84(3):505–25.

Dolar, M.L.L., Leatherwood, S., Anagones, L.V. and Hill, C.L. In prep. Directed fisheries for cetaceans in Palarvan, the Southern Visayas and the Mindenas Sea, Philippines.

Gray, J.E. 1866. *Catalogue of Seals and Whales in the British Museum*. British Museum, London. 402pp.

Hain, J.H.W., Carter, G.R., Kraus, S.D., Mayo, C.A. and Winn, H.E. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. *Fish. Bull., US* 80:259–68.

Hembree, D. 1980. Biological aspects of the cetacean fishery at Lamalera. Report on World Wildlife Fund Project 1428 (unpublished). 55pp.+2 appendices.

Ingebrigtsen, A. 1929. Whales caught in the North Atlantic and other seas. *Rapp. P.-V. Réun. CIEM* 56(2):1–26.

International Whaling Commission. 1983. Report of the sub-committee on protected species and aboriginal whaling. *Rep. int. Whal. Commn* 33:142–51.

Kasuya, T. and Wada, S. Distribution of large cetaceans in the Indian Ocean: Data from Japanese sighting records, November-March. (Published in this volume).

Kellogg, R. 1929. What is known of the migrations of some of the whalebone whales. *Rep. Smithson. Inst.* 1928:467–94+2pls.

Lockyer, C. 1984. Review of baleen whale (Mysticeti) reproduction and implications for management. *Rep. int. Whal. Commn* (special issue 6):27–50.

Mackintosh, N.A. 1965. *The Stocks of Whales*. Fishing News (Books) Ltd, London. 232pp.

Mackintosh, N.A. and Brown, S.G. 1974. Whales and whaling. pp.2–4 + pl. 2 *In*: Antarctic Mammals. *Antarct. Map Folio Ser.* 18. American Geographical Soc., New York.

Mathew, A.P. 1948. Stranding of a whale (*Megaptera nodosa*) on the Travancore coast in 1943. *J. Bombay Nat. Hist. Soc.* 47:732–3.

Mörzer-Bruyns, W.F.J. 1971. *Field Guide of Whales and Dolphins*. C.A. Meese, Amsterdam. 258pp.

Papastavrou, V. 1990. Oman's desert whale song. *Sonar* 3:18.

Papastavrou, V. and Salm, R.V. A note on recent sightings and strandings of cetaceans in Oman: Ra's Sawadi to Rakhyut. (Published in this volume.)

Pouchet, G. 1892a. Note sur la baleine observée par Néarque. *C. R. Soc. Biol., Paris* 4:422–3. [In French].

Pouchet, G. 1892b. Sur un échouement de cétacé de la 133e olympiade. *C. R. Acad. Sci., Paris* 114:1077–9. [In French].

Rørvik, C.J. 1980. Whales and whaling off Mozambique. *Rep. int. Whal. Commn* 30:223–5.

Ross, J.P. 1981. Recent marine mammal sightings in the Sultanate of Oman (1980/1981). Document 23 presented at Workshop to Plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary, Zeist, Netherlands, 28 September – 1 October (unpublished).

Slijper, E.J., Van Utrecht, W.L. and Naaktgeboren, C. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. *Bijdr. Dierkd.* 34:3–93.

Smith, R.L. 1968. Upwelling. *Oceanogr. Mar. Biol. Ann. Rev.* 6:11–46.

Tomilin, A.G. 1957. Zveri SSSR I Prilezhasfchikh Stran. Zveri Vostochnoi Evropy I Severnoi Azii. Vol. IX. Kitoobraznye. Izdatel'stvo Akademi Nauk SSSR, Moscow. 756pp. [Translated in 1967 as *Mammals of the USSR and Adjacent Countries. Mammals of Eastern Europe and Adjacent Countries. Vol. IX. Cetacea* by the Israel Program for Scientific Translations, Jerusalem, 717pp.].

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, N.Y.* 19(1–2):1–50+6maps.

Van Beneden, P.J. 1887. Histoire naturelle de la baleine à bosse (*Megaptera boops*). *Mém. couronnés Acad. R. Belg.* 40:1–42. [In French].

Van Beneden, P.J. 1889. *Histoire Naturelles Des Cétacés Des Mers D'Europe*. Brussels. 664pp. [Not seen, cited in Slijper *et al.*, 1964].

Van Beneden, P. and Gervais, P. 1880. *Ostéographie Des Cétacés Vivants Et Fossiles*. A. Bertrand, Paris. 634pp. [In French].

Whitehead, H. 1982. Humpback whale songs from the North Indian Ocean. Paper SC/34/PS2 presented to the IWC Scientific Committee, June 1982 (unpublished).

Whitehead, H. 1985. Humpback whale songs from the North Indian Ocean. *Invest. Cetacea* 17:157–62.

Winn, H.E. and Reichley, N.E. 1985. Humpback whale *Megaptera novaeangliae* (Borowski, 1781). pp. 241–7. *In:* S.H. Ridgway and R. Harrison (eds.) *Handbook of Marine Mammals. Vol. 3. The Sirenians and Baleen Whales*. Academic Press, London. 362pp.

Winn, L.K. and Winn, H.E. 1985. *Wings in the Sea. The Humpback Whale*. University Press of New England, Hanover and London, . 151pp.

Wray, P. and Martin, K.R. 1983. Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Commn* (special issue 5): 218–42.

Occurrence of Organochlorines in Stranded Cetaceans and Seals from the East Coast of Southern Africa

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ABSTRACT

This paper reports on a study to assess organochlorine occurrence in marine mammals from southeastern South Africa. Samples were taken from 43 odontocete cetaceans and 11 seals found stranded along the coast between 1976 and 1981. Large variation was found in residue levels between and within species. The results suggest that coastal waters are more contaminated with both PCBs and DDT than pelagic waters. Levels of PCBs and DDT in the blubber of some animals, especially male spotted and bottlenose dolphins gives cause for concern. Lindane was almost absent from most animals but about half the sampled animals contained detectable levels of Dieldrin. The importance of continued monitoring and assessment of likely impact is stressed.

Keywords: pollution; Indian Ocean; Southern Hemisphere; strandings; seals; Risso's dolphin; spotted dolphin; bottlenose dolphin; striped dolphin; bottlenose whale; common dolphin sperm whale; beaked whale – Blainville's; dwarf sperm whale.

INTRODUCTION

The synthetic chlorinated hydrocarbons reported most frequently in aquatic ecosystems are the polychlorinated biphenyls (PCBs), DDT and its metabolites DDE and DDD, Dieldrin and the chlordane group. The large lipid reserves and longevity of marine mammals make them ideal repositories for these highly lipophilic compounds. The chlorinated hydrocarbons are geographically wide spread and literature reviews indicate a global contamination of marine mammals with these compounds (Risebrough, 1978; Gaskin, 1982; Wageman and Muir, 1984).

There are few published data on the occurrence of PCBs, the DDT group of compounds and other chlorinated hydrocarbon residues in cetaceans inhabiting the coastal waters of the south east coast of southern Africa (Ross, 1979; Gardner *et al.*, 1983). The intense agricultural use of land along the coastal zone, particularly in Natal, means that large quantities of DDT probably entered the marine ecosystem prior to the discontinuance of the agricultural use of this compound in 1976. The continued use of DDT in state-managed malaria control procedures in northern Natal (van Dyk *et al.*, 1982) suggest that quantities of DDT are still entering the marine system. PCBs are not manufactured in South Africa, and their input is probably limited to the dumping of products containing PCBs in the four industrialised areas of Richards Bay, Durban, East London and Port Elizabeth. The use of Dieldrin in South Africa was completely banned in 1982 (van Dyk *et al.*, 1982).

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MATERIALS AND METHODS

Stranded animals were routinely dissected to evaluate biological characteristics. For cetaceans, blubber samples of approximately 30g were removed from the flank, in the neck region anterodorsal to the flipper insertion, where the greatest blubber thickness was consistently found. For seals, most blubber samples were removed from the dorsal, neck region. Liver samples, approximately 30g, were removed from either lobe of the liver. Samples were immediately wrapped in aluminium foil and frozen to await analysis.

Sample extraction, clean up and analysis were done using the methods detailed by (Watling, 1981). Lipid from thawed samples (5–10g) was extracted by ultrasonic maceration with hexane. During clean up using a silica gel and sodium sulphate column, two fractions were obtained: the first containing the PCBs and DDTs; and the second Dieldrin and most of the Lindane. Samples were analysed using a PYE gas liquid chromatograph (GLC) with an electron capture detector. The sensitivity of this instrument was tuned to approximately 250 $g^{*10}{}_{-12}/\mu l$. Compounds were quantified by frequent calibration of the GLC with external standards obtained from the Environmental Protection Agency (USA). Occasionally, further confirmation was done by ultraviolet photolysis.

RESULTS AND DISCUSSION

During the period between 1976 and 1981, blubber and/or liver samples from 54 strandings on the south east coast of southern Africa were collected and assessed for the presence of chlorinated hydrocarbons. The concentrations of PCBs, DDT, DDE, TDE, Dieldrin and Lindane found in blubber and liver of each of the 43 cetaceans and 11 seals are given in Tables 1 and 2, respectively. The ratio of DDE to total DDT concentration is also given. Liver concentrations of both PCBs and total DDT (T-DDT) were generally five to ten times lower than levels in the blubber. This is not unexpected. Aguilar (1985) has suggested that organs with a metabolic function, such as the liver, may contain higher proportions of degraded pollutants than non metabolically active tissues. As the liver is metabolically active its lipid levels will fluctuate. Consequently, residue concentrations may vary with lipid level and reflect the time lapse since the animal last fed and the constituents of the meal rather than the residue 'load' of the animal, which is more likely to be represented by the stored residues in the blubber.

There was a moderate correlation ($r=0.59$) between cetacean blubber levels of PCB's and t-DDT, suggesting that in this region these compounds commonly, but not necessarily, occur together.

There were large variations in residue levels between species and also within single species. The low numbers within species precluded the establishment of any sex– or size-related patterns. Similarly, low numbers of strandings from Natal and the diverse sex ratio of all strandings precluded any investigation of geographic differences. However, cetaceans which inhabit inshore waters of this area (bottlenose dolphins, *Tursiops truncatus* and common dolphins, *Delphinus delphis*) and those known to spend periods in inshore waters (spotted dolphins, *Stenella attenuata*) (Ross *et al.*, 1987) contained significantly higher mean blubber concentrations of PCBs and t-DDT ($t=2.6$, $P<0.05$ and $t=2.7$, $P<0.01$, $df=40$) than cetaceans inhabiting pelagic waters. These differences are also evident in the liver residue concentrations of cape fur seals, *Arctocephalus pusillus* and sub-Antarctic fur seals, *A.tropicalis*, where *A.pusillus* from southern Africa generally contained higher levels of both PCBs and t-DDT than the sub-Antarctic *A.tropicalis*. The sample sizes for these two species were too small, however, to warrant statistical

Table 1
Chlorinated hydrocarbon residue concentrations (μg/g wet mass) and DDE to total DDT ratio with length (mm), sex, mass (kg) and locality of blubber (bl.) and liver (li.) tissue of cetaceans stranded on the east coast of southern Africa.
N.D = not detectable; t-DDT=DDT+DDE+TDE; ratio = DDE/t-DDT

PEM#	date	length	mass	sex	tissue	PCB	DDE	TDE	DDT	Diel	Lind	t-DDT	ratio
							Eastern Cape						
Grampus griseus													
325	09.77	2120	84.8	F	bl.	N.D	0.86	0.54	1.79	N.D	-	1.4	0.61
					li.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
319	09.77	2540	-	F	bl.	N.D	0.61	0.37	1.07	N.D	-	0.98	0.62
					li.	N.D	0.037	0.021	N.D	N.D	-	0.058	0.64
449	04.80	2980	304.0	M	bl.	N.D	4.37	0.0748	0.4	N.D	N.D	4.4448	0.98
14	01.80	2640	185.0	M	bl.	N.D	1.93	N.D	N.D	N.D	N.D	1.93	1.00
Tursiops truncatus													
9	12.79	1075	14.5	F	bl.	N.D	0.422	0.0195	0.113	0.0292	N.D	0.4415	0.96
					li.	N.D	0.029	0.0013	0.0008	N.D	0.0012	0.0303	0.96
383	01.79	1160	46.5	F	bl.	4.23	5.37	N.D	1.27	0.062	-	9.6	0.56
					li.	0.11	0.3	N.D	0.03	N.D	-	0.41	0.73
290	11.76	950	9.5	F	bl.	N.D	0.32	0.59	N.D	0.038	-	0.91	0.35
415	08.79	2250	-	M	bl.	10.02	2.4	N.D	0.97	2.95	-	12.42	0.19
					li.	0.39	0.296	N.D	0.096	N.D	-	0.686	0.43
392	02.79	1050	17.7	M	bl.	2.57	23.68	N.D	0.5	0.03	-	26.25	0.90
					li.	0.18	0.64	N.D	0.04	0.004	-	0.82	0.78
340	12.77	1040	30.3	M	bl.	N.D	6.86	N.D	N.D	0.09	-	6.86	1.00
					li.	N.D	0.81	N.D	N.D	0.035	-	0.81	1.00
270	02.76	-	-	M	bl.	N.D	0.87	1.16	1	0.089	-	2.03	0.43
					li.	N.D	0.068	0.01	0.044	0.001	-	0.078	0.87
Stenella coeruleoalba													
-	07.78	-	-	-	bl.	N.D	1.21	N.D	N.D	N.D	-	1.21	1.00
349	04.78	-	-	-	bl.	N.D	2.49	0.82	1.74	0.042	-	3.31	0.75
					li.	N.D	0.19	0.044	N.D	N.D	-	0.234	0.81
448	07.80	2280	128.0	F	bl.	N.D	6.54	N.D	N.D	N.D	-	6.54	1.00
					li.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
349	04.78	2150	78.5	M	bl.	N.D	1.82	N.D	N.D	0.16	-	1.82	1.00
					li.	N.D	0.37	N.D	N.D	N.D	-	0.37	1.00
Orcinus orca													
301	01.77	6050	3067.0	M	bl.	N.D	7.84	3.7	8.45	0.036	-	11.54	0.68
					li.	N.D	0.452	0.269	N.D	N.D	-	0.721	0.63
Mesoplodon densirostris													
683	04.81	2300	157.0	F	bl.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
369	08.78	3510	468.0	F	bl.	1.71	2.79	N.D	0.43	0.014	-	4.5	0.62
17	02.80	4500	-	F	bl.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
					li.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
370	08.78	4650	-	M	bl.	0.45	1.71	N.D	0.32	0.019	-	2.16	0.79
Delphinus delphis													
12	01.80	2280	107.0	M	bl.	N.D	5.61	N.D	1.04	0.43	N.D	5.61	1.00
					li.	N.D	0.138	0.0185	0.0418	0.0568	N.D	0.1565	0.88
312	04.77	2210	112.4	M	bl.	N.D	N.D	0.17	0.34	0.015	-	0.17	0.00
					li.	N.D	0.007	0.014	0.01	N.D	-	0.021	0.33
13	01.80	1385	27.5	M	bl.	N.D	0.481	0.0051	0.0124	0.0055	N.D	0.4861	0.99
					li.	N.D	0.0344	0.0019	0.004	N.D	N.D	0.0363	0.95
388	01.79	1210	37.5	M	bl.	4.33	10.77	N.D	1.88	0.076	-	15.1	0.71
					li.	2.17	6.81	N.D	0.79	0.04	-	8.98	0.76
420	11.79	2280	112.0	M	bl.	6.82	12.9	0.0024	0.51	N.D	0.0114	19.7224	0.65
					li.	0.465	1.85	0.0235	0.183	N.D	N.D	2.3385	0.79
Kogia simus													
682	03.81	2650	-	-	bl.	N.D	0.614	N.D	N.D	N.D	N.D	0.614	1.00
679	03.81	-	-	-	bl.	N.D	0.0667	N.D	N.D	N.D	N.D	0.0667	1.00
					li.	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-
678	03.81	-	-	-	bl.	N.D	0.189	N.D	0.331	N.D	N.D	0.189	1.00
					li.	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-
317	07.77	2200	156.0	F	bl.	N.D	0.316	0.136	0.44	N.D	-	0.452	0.70
					li.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
318	07.77	1470	61.5	F	bl.	N.D	0.036	N.D	0.073	N.D	-	0.036	1.00
					li.	N.D	N.D	N.D	N.D	N.D	-	N.D	-
338	11.77	1710	98.5	M	li.	N.D	0.789	N.D	N.D	N.D	-	0.789	1.00
392	02.79	-	-	M	bl.	1.77	3.09	N.D	0.25	0.005	N.D	4.86	0.64

continued

Table 1 continued

PEM#	date	length	mass	sex	tissue	PCB	DDE	TDE	DDT	Diel	Lind	t-DDT'	ratio
Kogia breviceps													
342	02.78	2560	176.5	M	bl.	N.D	1.01	N.D	N.D	0.038	-	1.01	1.00
					li.	N.D	0.66	N.D	N.D	N.D	-	0.66	1.00
Physeter macrocephalus													
324	09.77	3720	-	F	bl.	N.D	0.087	0.04	0.076	N.D	-	0.127	0.69
					li.	N.D	0.011	0.003	N.D	N.D	-	0.014	0.79
444	03.80	4080	-	M	bl.	N.D	0.204	N.D	N.D	N.D	N.D	0.204	1.00
					li.	N.D	N.D	N.D	N.D	N.D	N.D	N.D	-
							Natal						
Grampus griseus													
530	04.80	2033	81.5	M	bl.	N.D	N.D	N.D	N.D	0.105	N.D	N.D	-
Stenella attenuata													
7	10.79	1880	51.4	F	bl.	30.6	32.0	1.27	0.522	0.0445	N.D	63.87	0.50
					li.	1.93	1.44	0.08	0.0949	N.D	N.D	3.45	0.42
489	??.80	1740	45.5	M	bl.	48.3	16.9	N.D	3.45	0.0695	N.D	65.2	0.26
					li.	N.D	0.399	N.D	N.D	N.D	N.D	0.399	1.00
334	10.77	1820	55.5	M	bl.	8.733	8.83	1.6	3.37	N.D	-	19.163	0.46
					li.	0.51	0.5	0.025	N.D	N.D	-	1.035	0.48
335	09.77	2200	84.1	M	bl.	4.775	2.65	0.17	N.D	N.D	-	7.595	0.35
					li.	0.888	0.69	0.15	0.07	N.D	-	1.728	0.40
Tursiops truncatus													
8	09.79	1020	-	M	bl.	22.9	13.6	0.712	4.95	0.19	0.026	37.212	0.37
Stenella coeruleoalba													
363	05.78	1860	76	M	bl.	N.D	2.3	1.17	2.85	N.D	-	3.47	0.66
					li.	N.D	0.303	0.24	N.D	N.D	-	0.543	0.56
Hyperodon planifrons													
292	11.76	2910	228.2	M	bl.	N.D	1.2	0.4	2.99	0.07	-	1.6	0.75

Table 2

Chlorinated hydrocarbon residue concentrations ($\mu g/g$ wet mass) and DDE to total DDT ratio with length (mm), sex, mass (kg) and locality of seals beached on the east coast of southern Africa.
N.D = not detectable; t-DDT=DDT+DDE+TDE; ratio = DDE/t-DDT

PEM#	date	length	mass	sex	tissue	PCB	DDE	TDE	DDT	Diel	Lind	t-DDT	ratio
							Eastern Cape						
Arctocephalus pusillus													
-	08.78	-	-	-	bl.	N.D	1.02	N.D	N.D	0.11		1.02	1.00
					li.	N.D	0.236	N.D	N.D	N.D		0.236	1.00
606	04.79	1500	64.8	F	bl.	0.58	2.23	N.D	0.166	0.01		2.81	0.79
604	02.79	1520	69	F	bl.	0.39	2.25	N.D	0.09	0.006		-2.64	0.85
					li.	0.19	0.4	N.D	0.11	N.D		0.59	0.68
609	11.79	1292	-	F	bl.	20.2	9.05	N.D	N.D	N.D	N.D	29.25	0.31
					li.	N.D	0.101	N.D	N.D	0.0111	N.D	0.101	1.00
663	10.78	920	19	F	bl.	1.73	14.53	N.D	3.465	0.072		16.26	0.89
					li.	0.53	0.8	N.D	0.11	N.D		1.33	0.60
607	09.79	910	10	M	bl.	N.D	0.472	0.0688	N.D	0.0388	N.D	0.5408	0.87
603	08.78	1500	75	M	bl.	3.49	23.03	N.D	7.9	0.01		26.52	0.87
					li.	1.3	2.21	N.D	0.26	N.D		3.51	0.63
605	04.79	1530	73.6	M	bl.	2.93	10.4	N.D	1.52	0.023		13.33	0.78
							Southern Ocean						
Arctocephalus tropicalis													
-	-	-	-	-	li.	0.874	0.355	0.159	0.037	N.D		1.388	0.26
-	-	-	-	-	bl.	N.D	0.492	N.D	N.D	N.D		0.492	1.00
					li.	N.D	2.99	N.D	N.D	N.D		2.99	1.00
-	-	-	-	-	li.	N.D	0.898	0.0781	N.D	N.D		0.9761	0.92

comparison. These results suggest that coastal waters have a greater contamination of PCBs and DDT than pelagic waters.

PCB concentrations in the blubber of between 50 µg/g and 200 µg/g may be deleterious to the health of a dolphin (Alzieu and Duguy, 1979). In general the levels of organochlorines in stranded animals on the southeast coast of southern Africa were low. However, some animals displayed disturbingly high levels of PCBs and DDT in the blubber, particularly male spotted and bottlenose dolphins, which, in some instances, had considerable blubber concentrations of these residues. A recent study of Dall's porpoise, *Phocoenoides dalli*, in the northwestern N orth Pacific has shown a correlation between blubber PCB and DDE concentrations of between 15 µg/g and 20 µg/g and decreased testosterone levels in males (Subramanian *et al.*, 1987). Some of the animals assessed in this study, particularly those from Natal, as well as hump-backed dolphins, *Sousa plumbea*, from Natal (Gardner *et al.*, 1983), showed levels as high or higher than those in the Dall's porpoises studied. This suggests that males of some Natal dolphin species may be at risk of reduced reproductive capacity. In Natal, the bottlenose and hump-backed dolphin are both subject to incidental mortality in anti-shark nets, to a degree which may endanger their survival (Cockcroft and Ross, this volume). A reduced reproductive efficiency of males may exacerbate pressures on these species; thus, the monitoring of contamination in these dolphins is a priority.

It has been suggested that a blubber DDE to t-DDT ratio higher than 0.6 suggests a decrease or cessation of DDT input into the system (Aguilar, 1984; Borrell and Aguilar, 1987). Although the DDE/t-DDT ratios from the present study varied considerably, the majority (69%) were in excess of 0.6. There was no significant difference ($t=0.1$, $P>0.05$, $df=43$) between mean DDE/t-DDT ratios of cetaceans stranded in Natal (0.72) and those from the eastern Cape (0.70). This suggests that there has been very little recent input in either area. However, only a few strandings were available from Natal and analysis of further samples from this area may well reveal differences between the two regions.

Only two of the 43 cetaceans and none of the seals sampled showed any signs of Lindane contamination. In contrast approximately half of all the animals sampled (56%) contained detectable levels of Dieldrin. This is almost certainly attributable to the differences in environmental persistance of the two substances. Dieldrin was used primarily as a stock remedy, a moth proofing agent and for tsetse fly and harvester termite control until 1979 (van Dyk *et al.*, 1982); thus, its presence and persistance in the marine environment at the time of this study is not unexpected.

The assessment of what levels of stored organochlorines may be deleterious of marine mammals is complex. None of the organochlorine pollutant concentrations recorded in this study appear to be sufficiently high to warrant concern. However, the transfer of a maternal load of pollutants to a neonate calf or pup, during lactation, poses unknown problems. Carstens *et al.* (1979) have suggested that the human foetus and neonate are particularly susceptible to PCB intoxication. Further, Blus (Blus, 1982) considers that most organochlorines exert some adverse effect. It is therefore imperative that the monitoring of pollutant levels in stranded marine mammals continues.

REFERENCES

Aguilar, A. 1984. Relationship of DDE/DDT in marine mammals to the chronology of DDT input into the ecosystem. *Can. J. Fish. Aquat. Sci.* 41:840–4.

Aguilar, A. 1985. Compartmentation and reliability of sampling procedures in organochlorine pollution surveys of cetaceans. *Residue Rev.* 95:91–114.

Alzieu, C. and Duguy, R. 1979. Teneurs en composés organochlorés chez les cétacés et pinnipèdes frequentant les côtes françaises. *Oceanol. Acta.* 2(1):107–20.

Blus, L.J. 1982. Further interpretation of the relation of organochlorine residues in brown pelican eggs to reproductive success. *Environ. Pollut.* 28A:15–33.

Borrell, A. and Aguilar, A. 1987. Variations in DDE percentage correlated with total DDT burden in the blubber of fin and sei whales. *Mar. Pollut. Bull.* 18:70–4.

Carstens, L.A., Barsotti, D.A. and Allen, J.R. 1979. Exposure of infant rhesus macaques (*Macaca mulatta*) to polychlorinated biphenyl (PCB). pp. 339–45. *In: Animals as Monitors of Environmental Pollutants*. National Academy of Sciences, Washington D.C.

Cockcroft, V.G. and Ross, G.J.B. Bottlenose dolphins in Natal shark nets, 1980 through 1987: catch rates and associated contributing factors. (Published in this volume.)

Gardner, B.D., Cornell, A.D., Eagle, G.A., Molden, A.G.S., Oliff, W.D., Orren, M.J. and Watling, R.J. 1983. South African marine pollution survey report 1976–1979. *S. Afr. Natl Sci. Programmes Rep.* 73.

Gaskin, D.E. 1982. *The Ecology of Whales and Dolphins*. Heinemann, London. 459pp.

Risebrough, R.W. 1978. Pollutants in marine mammals – a literature review and recommendations for research. Report NTIS PB 290728 presented to the US Marine Mammal Commission (unpublished).

Ross, G.J.B. 1979. The smaller cetaceans of the southeast coast of southern Africa. Ph.D. Thesis, University of Port Elizabeth, South Africa. 415pp.

Ross, G.J.B., Cockcroft, V.G. and Butterworth, D.S. 1987. Offshore distribution of bottlenosed dolphins in Natal coastal waters and Algoa Bay, Eastern Cape. *S. Afr. J. Zool.* 18:643–6.

Subramanian, A.N., Tanabe, S., Tatsukawa, R., Saito, S. and Miyazaki, N. 1987. Reduction in the testosterone levels by PCBs and DDE in Dall's porpoises of the northwestern North Pacific. *Mar. Pollut. Bull.* 18:643–6.

van Dyk, L.P., Wiese, I.H. and Mullen, J.E.C. 1982. Management and determination of pesticide residues in South Africa. *Residue Rev.* 82:37–124.

Wageman, R. and Muir, D.C.G. 1984. Concentrations of heavy metals and organochlorides in marine mammals of northern waters: Overview and evaluation. *Can. Tech. Rep. Fish. Aquat. Sci.* 1279.

Watling, R.J. 1981. A manual of methods for use in the South African marine pollution monitoring programme. *S. Afr. Natl Sci. Programmes Rep.* 44.

Incidence of Shark Bites on Indian Ocean Hump-backed Dolphins (*Sousa plumbea*) off Natal, South Africa

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ABSTRACT

The incidence of shark-induced wounds or scars on 36 hump-backed dolphins (*Sousa plumbea*) incidentally captured in shark nets off Natal, South Africa, is examined. Only two dolphins showed recent wounds, while a further eight showed either single or multiple scars, consistent with previous shark attack. Only two of these hump-backed dolphins were smaller than 200cm in length, suggesting that either younger animals somehow avoid attack or are killed outright by such attack. Shark predation on hump-backed dolphins is discussed in light of the current knowledge of the latter's natural history.

Keywords: hump-backed dolphin; Indian Ocean; Southern Hemisphere; sharks; predator-prey; incidental capture; scars; mortality.

INTRODUCTION

Shark predation on seals is well documented. It has been suggested that mortality resulting from shark predation may be significant in the population dynamics of certain seal populations, such as the Hawaiian monk seal (Kenyon, 1981) and the grey seal in eastern Canada (Brodie and Beck, 1983). Furthermore, Ainley *et al.* (1985) postulate that the abnormal timing of the breeding season of the northern elephant seal on the Farallon Islands may, to some degree, be a response to predation pressure by white sharks on newly weaned pups. They speculate that the timing of breeding seasons of other seals also may be, in part, an evolutionary response to shark predation.

There is no doubt that sharks also prey on dolphins. Wood *et al.* (1970) reviewed the literature and the types of interactions between these animals. Subsequent to this review, interactions between dolphins and sharks have been observed on a number of occasions (Leatherwood *et al.*, 1972; Saayman and Tayler, 1979). Other authors have inferred shark attack on dolphins either by observing shark induced scars and wounds on dolphins (Ross and Bass, 1971; Ross, 1977; Norris and Dohl, 1980a; Corkeron *et al.*, 1987) or by noting the presence of dolphin remains in sharks (Arnold, 1972; Stevens, 1984; Patterson, 1986). Despite these observations and studies, however, nothing is known of the extent or effect of shark predation on the dolphin populations concerned.

Norris and Dohl (1980a) reported that spinner dolphins off Hawaii were apparently attacked frequently. Corkeron *et al.* (1987) found that 36.6% of 334 identified bottlenose dolphins in Moreton Bay, Queensland, Australia, showed definite evidence of shark attack. Ross (1977) noted that although the level of shark predation on bottlenose dolphins in South African waters was unknown, the number of animals displaying shark bite scars suggested it was low.

Ross (1982) has suggested that the Natal population of hump-back dolphins (*Sousa plumbea*) numbers between 150 and 220 animals. The Natal shark nets, set to capture large sharks and therefore protect bathing beaches, capture, on average, eight hump–back dolphins per year (Cockcroft, 1990). This number represents a minimum of 4% of the

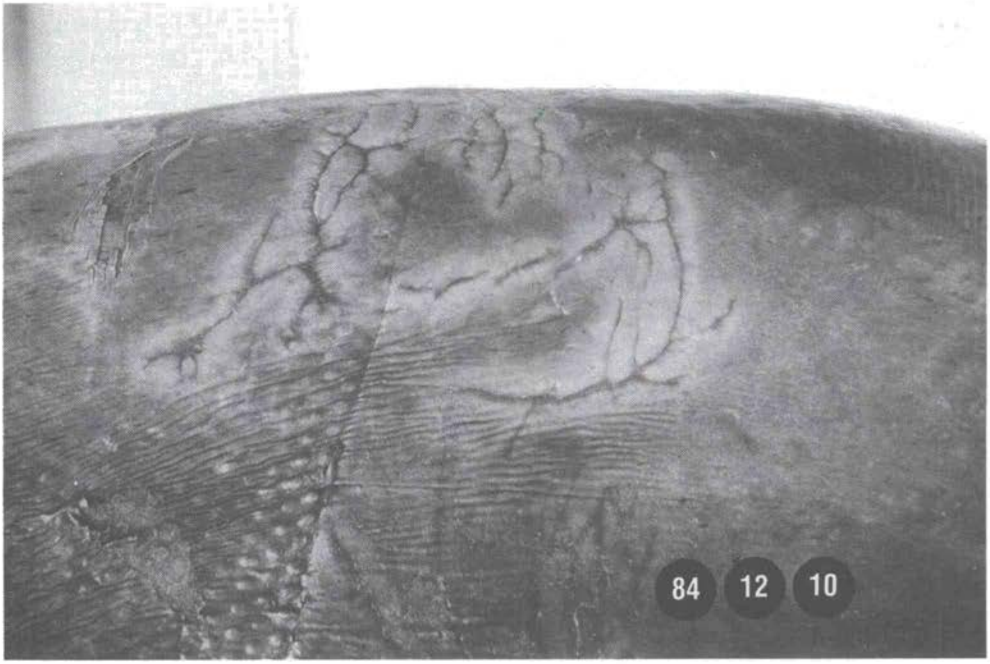

Plate 1. Mature male *Sousa plumbea* (PEM N1121) 267cm in length showing multiple shark bite scars on the ventral surface just anterior to the genital area.

estimated population. This study was undertaken as a result of observations that many of the hump-backed dolphins incidentally captured in the shark nets exhibited single or multiple scars and recent wounds which were apparently a result of shark attack.

MATERIALS AND METHODS

A total of 36 hump-backed dolphins caught in anti-shark nets between November 1980 and March 1987 was examined for evidence of shark attack. All specimens were kept frozen until a thorough dissection could be undertaken. The condition of decay of some dolphins made it difficult to determine the presence of scars and because of time constraints not all animals were examined with equal diligence.

At the time of dissection, all specimens were inspected for the presence of old scars or recent wounds. Scars or wounds forming single or double arcs on the body were noted as apparent shark bites (Plates 1 & 2). Thus, only scars and wounds which by their shape and appearance were consistent with shark bites were considered in this study. Fresh wounds which were consistent with shark bites and showed some healing were also noted and considered. Finally, flukes or dorsal fins that showed evidence of damage congruous with shark bites, and large missing parts or pieces were also included. Any fresh wounds which were obviously inflicted subsequent to capture in the nets were excluded.

The number and position of scars or recent wounds were noted and photographs taken. Measurements were taken of both axes of recent wounds.

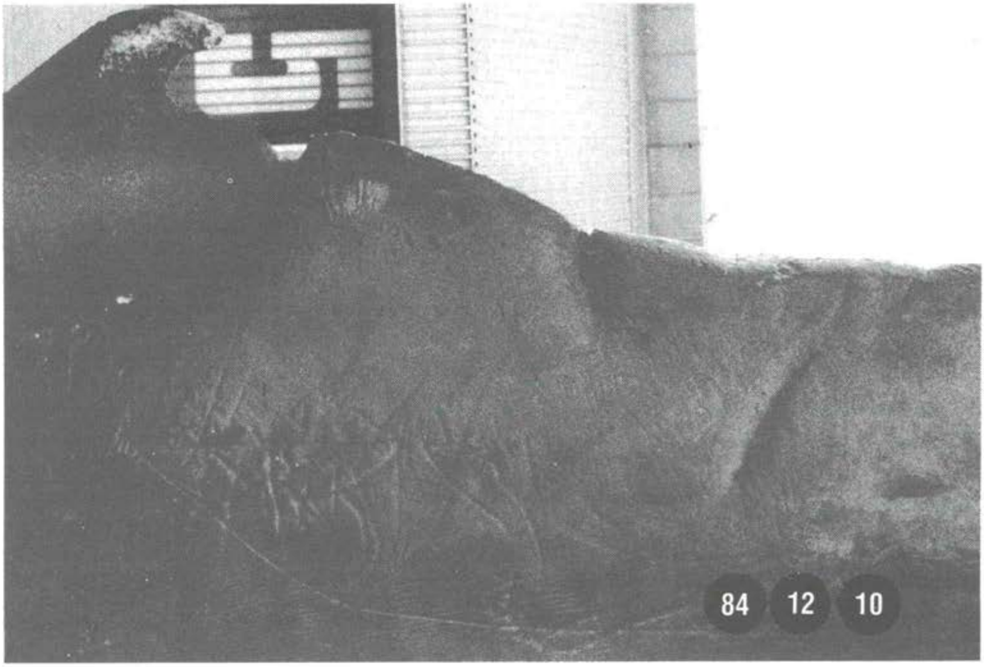

Plate 2. Mature male *Sousa plumbea* (PEM N1121) 267cm in length showing multiple shark bite scars on its posterior, dorsal surface.

RESULTS

The low number of animals caught permitted only a simple analysis of the results. Some patterns are nevertheless obvious.

Of the 36 hump-backed dolphins caught: one showed scars of unidentifiable cause; three (8%) displayed fluke or dorsal fin notching which could possibly have resulted from shark bite but, according to the above criteria, could not be attributed to sharks with certainty; and 22 (72%) showed no evidence of shark attack. Ten (28%) exhibited scars or recent wounds probably inflicted by shark bite. Two (5.6%) of the 10 displayed recent, healing wounds almost certainly caused by sharks. These dolphins were 225cm and 267cm in total length and were caught in August 1985 and December 1984, respectively. The bites measured 27cm and 30cm, respectively, at their widest axes.

The remaining eight (22%) showed single or multiple scars almost certainly caused by shark bite. Five (50%) of these 10 animals had multiple scarring; one of them (PEM N1121, a mature male 267cm in length), which in addition to recent bite punctures, showed scarring which suggested that it had been subject to at least seven previous bites (Plates 1 & 2). Only two of the ten animals showing evidence of attack were less than 200cm in length; the rest were longer than 220cm. Six of the ten were males and four were females.

On most animals, scars were on the paler, ventral portions of the body, slightly anterior to the genital area (Plate 1). On animals that exhibited multiple scarring, some bite scars also occurred in other areas, particularly on the caudal peduncle and on other posterior areas (Plate 2).

Animals displaying scars were caught in widely separated geographical areas suggesting that throughout Natal, hump-backed dolphins are subject to attack by sharks. During the study period no hump-backed dolphins were caught on the same day or in the same net as any shark. Similarly, no hump-backed dolphins showed any signs of having been scavenged in the nets subsequent to capture.

DISCUSSION

It is almost impossible to identify the species of shark from healed scars of unknown age (Compagno, pers. comm.), and it was not possible to do so in this study. The relatively large elliptical axes of both recent bites (27cm and 30cm) measured in this study, however, suggest that the sharks involved were a minimum 220cm and 240cm standard length, respectively (Bass *et al.*, 1973; Bass *et al.*, 1975a; b).

Four species of shark captured in the Natal shark nets – great white (*Carcharodon carcharius*), tiger (*Galaeocerdo cuvieri*), Zambezi (*Carcharhinus leucas*) and dusky (*Carcharhinus obscurus*) – sometimes contain flukes of small cetaceans (Cockcroft *et al.*, 1989) and all have previously been implicated in marine mammal predation (Wood *et al.*, 1970; Compagno, 1984; McCosker, 1985; Stewart and Yochem, 1985; Alcorn and Kam, 1986; Corkeron *et al.*, 1987).

A higher percentage of hump-backed dolphins (28%) incidentally caught in Natal showed evidence of shark bite than did bottlenose dolphins (10%) caught along this same coast (Cockcroft *et al.*, 1989). This implies that the two species experience different predation pressures. It is reasonable to postulate that behavioural differences between the two account for this. In Natal, bottlenose dolphins avoid turbid, inshore waters (Ross, 1977) while hump-backed dolphins inhabit these areas, particularly in the vacinity of estuarine mouths (Ross, 1982) where they feed primarily on estuarine-associated fish (Cockcroft and Ross, 1983). The incidence of large sharks, particularly Zambezi and dusky sharks, is greater in these turbid, inshore waters (Bass *et al.*, 1973; VGC unpublished data); so, hump-backed dolphins are likely to encounter sharks more frequently than bottlenose dolphins. Other behavioural differences may also be important. The two species have different group sizes: bottlenose dolphins commonly occur in groups of between 20 and 50 animals (Ross, 1984) while hump-backed dolphins are more often found in groups of less than seven (Saayman and Tayler, 1979; Ross, 1984). Norris and Dohl (1980b) suggest that schooling of dolphins is a defence against predation and that group size is directly related to predation pressure. If the apparent incidence of shark bites on hump-backed and bottlenose dolphins is representative of predation pressure on these species, their respective school sizes seem incongruous with the suggestions of Norris and Dohl (1980b), this implies that the strategies used by the two species to avoid shark predation may not be comparable.

The low number of hump-backed dolphins shorter than 200cm which exhibited bite scars, may mean that either young animals are protected by their mothers from attempted attacks or attacks on young animals almost invariably prove fatal. Corkeron *et al.* (1987) found a relatively high proportion of nursing female bottlenose dolphins in Moreton Bay with fresh bites. They suggest that females and their calves may be more vulnerable to predation than are other reproductive classes and this may explain their observed avoidance of sharks. This may also be true for hump-backed dolphins in Natal, although no differences between the sexes in scar frequency was evident in the small sample.

Most bites on hump-backed dolphins were sited as bite wounds noted on seals and other porpoises, in a posteroventral position suggestive that attacks almost invariably occur from below and behind (Arnold, 1972; Tricas and McCosker, 1984; Ainley *et al.*, 1985; McCosker, 1985). Geraci *et al.* (1975) suggested that this area may be particularly desirable to sharks and may be the most vulnerable in resting dolphins because it is in an acoustically and visually 'blind' area. However, bites do occur at other localities on the body. The majority of wounds on bottlenose dolphins in Moreton Bay, Australia were situated on the flanks of animals (Corkeron *et al.*, 1987). Presumably the limitations of onboard observations prevented viewing the ventral surface of dolphins.

The present study was based on the incidence of scars on animals that were obviously survivors of shark attack. It is impossible from these data to determine the actual number of animals attacked and the mortality resulting from attacks. Similarly, it is difficult to assess the age of healed scars, and therefore the age at which the animal received the bite. Scars resulting from bites received when the animal was young and smaller would increase in size with growth. Many dolphins showed multiple scars from repeated attack or the same attack with multiple bites. Despite shortcomings, this preliminary study suggests that throughout Natal a significant number of hump-backed dolphins are attacked by sharks at some time during their lives; the level and implication of apparent shark predation on the Natal population of these animals remains unknown.

REFERENCES

Ainley, D.G., Henderson, R.P., Huber, H.R., Boekelheide, R.J., Allen, S.G. and McElroy, T.L. 1985. Dynamics of white shark/pinniped interactions in the Gulf of the Farallones. *Calif. Acad. Sci. Mem.* 9:109-22.

Alcorn, D.J. and Kam, A.K.H. 1986. Fatal shark attack on a Hawaiian monk seal (*Monachus schauinslandi*). *Mar. Mammal Sci.* 2:313–5.

Arnold, P.W. 1972. Predation on harbour porpoise, *Phocoena phocoena* by a white shark, *Carcharodon carcharius*. *J. Fish. Res. Board Can.* 29:1213–4.

Bass, A.J., D'Aubrey, D. and Kistnasamy, N. 1973. Sharks of the east coast of Southern Africa. I. The genus *Carcharhinus* (Carcharhinidae). *Investl Rep. S. Afr. Assoc. Mar. Biol. Res.* 33:1–168.

Bass, A.J., D'Aubrey, D. and Kistnasamy, N. 1975a. Sharks of the east coast of southern Africa. III. The families Carcharhinidae (excluding *Mustelus* and *Carcharhinus*) and Sphyrnidae. *Investl Rep. S. Afr. Assoc. Mar. Biol. Res.* 38:1–100.

Bass, A.J., D'Aubrey, D. and Kistnasamy, N. 1975b. Sharks of the east coast of southern Africa. IV. The families Odontaspididae, Scapanorhynchidae, Isuridae, Cetorhinidae, Alopiidae, Orectolobidae and Rhiniodontidae. *Investl Rep. S. Afr. Assoc. Mar. Biol. Res.* 39:1–88.

Brodie, P. and Beck, B. 1983. Predation by sharks on the grey seal (*Halichoerus grypus*) in eastern Canada. *Can. J. Fish. Aquat. Sci.* 40:267–71.

Cockcroft, V.G. 1990. Catches of dolphins in the Natal shark nets, 1980 to 1988. *S. Afr. J. Wildl. Res.* 20:44-51.

Cockcroft, V.G. and Ross, G.J.B. 1983. Feeding of three inshore delphinid species in Natal waters. Presented to the 5th Oceanographic Symposium, Grahamstown, South Africa, January 1983 (unpublished).

Cockcroft, V.G., Cliff, G. and Ross, G.J.B. 1989. Shark predation on Indian Ocean bottlenose dolphins (*Tursiops truncatus*) off Natal, South Africa. *S. Afr. J. Zool.* 24(4):305–10.

Compagno, L.J.V. 1984. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. *FAO Fish. Synop.* 4:251–655.

Corkeron, P.J., Morris, R.J. and Bryden, M.M. 1987. Interactions between bottlenose dolphins and sharks in Moreton Bay, Queensland. *Aquat. Mamm.* 13:109–13.

Geraci, J.R., Testaverde, S.A., St. Aubin, D.J. and Loop, T.H. 1975. A mass stranding of Atlantic white-sided dolphin, *Lagenorhynchus acutus*: A study into pathobiology and life history. Contract MMC-47 presented to the US Marine Mammal Commission (unpublished).

Kenyon, W.K. 1981. Monk seals. pp. 195–220. *In:* S.H. Ridgeway and R.J. Harrison (eds.) *Handbook of Marine Mammals*. Vol. 2. *Seals*. Academic Press, New York.

Leatherwood, J.S., Perrin, W., Garvie, R. and LaGrange, J. 1972. Observations of sharks attacking porpoises (*Stenella* spp. and *Delphinus* of *D. Delphis*). Report TN908 of the Naval Undersea Center, San Diego, California (unpublished). 7pp.

McCosker, J.E. 1985. White shark attack behavior: Observations of and speculations about predator and prey strategies. *Calif. Acad. Sci. Mem.* 9:123–35.

Norris, K.S. and Dohl, T.P. 1980a. Behavior of the Hawaiian spinner dolphin, *Stenella longirostris*. *Fish. Bull., US* 77:821–49.

Norris, K.S. and Dohl, T.P. 1980b. The structure and function of cetacean schools. pp. 211–61. *In:* L.M. Herman (ed.) *Cetacean Behaviour: Mechanisms and Functions*. John Wiley and Sons, New York. xiii+463pp.

Patterson, R. 1986. Shark prevention measures working well in Queensland. *Aus. Fish.* 45:12–8.

Ross, G.J.B. 1977. The taxonomy of bottlenosed dolphins *Tursiops* species in South African waters, with notes on their biology. *Ann. Cape Prov. Mus. (nat. Hist.)* 11:135–94.

Ross, G.J.B. 1982. A preliminary survey of bottlenosed dolphin *Tursiops aduncus* and humpback dolphin *Sousa plumbea* populations on the south-east coast of southern Africa. Internal report to South African Nature Foundation, 25pp.

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. *Ann. Cape Prov. Mus. (nat. Hist.)* 15:173–410.

Ross, G.J.B. and Bass, A.J. 1971. Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen). *S. Afr. J. Sci.* 67:413–4.

Saayman, G.S. and Tayler, C.K. 1979. The socioecology of humpback dolphins (*Sousa* sp.). pp. 165–226. *In:* H.E. Winn and B.L. Olla (eds.) *Behavior of Marine Animals*. Vol. 3. *Cetaceans*. Plenum Press, New York and London. xix+438pp.

Stevens, J.D. 1984. Biological observations of sharks caught by sportfishermen off New South Wales. *Aus. J. Mar. Freshw. Res.* 35:573–90.

Stewart, B.S. and Yochem, P.K. 1985. Radio-tagged harbor seal, *Phoca vitulina richardsi*, eaten by white shark, *Carcharodon carcharius*, in the southern California bight. *Calif. Fish Game* 71:113–5.

Tricas, T.C. and McCosker, J.E. 1984. Predatory behaviour of the white shark, (*Carcharodon carcharius*), with notes on its biology. *Proc. Calif. Acad. Sci.* 43:221–38.

Wood, F.G., Caldwell, D.K. and Caldwell, M.C. 1970. Behavioral interactions between porpoises and sharks. *Invest. Cetacea* 2:264–77.

Factors in Evaluating the Indian Ocean Sanctuary

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ABSTRACT

A framework for the evaluation of the Indian Ocean Sanctuary is outlined. The role of sanctuaries in the broad field of marine ecological research is discussed, and it is suggested that sanctuaries have an essential role to play in providing the opportunity to study ecosystems under conditions in which some components are unexploited. Of potential importance is the use of sanctuaries in providing some level of experimental control in experiments concerning ecological perturbation. The role of sanctuaries is also examined from the narrower perspective of the management of exploited whale populations. It is argued that sanctuaries have a role to play in refining the predictions of the range in which the yields from exploited whale stocks might lie, particularly by permitting monitoring of the recovery of previously depleted stocks. It is further suggested that sanctuaries have a role in the development, calibration and refinement of methodology for whale assessments.

Keywords: sanctuary; Indian Ocean; ecosystem; management; large whales-general.

INTRODUCTION

In 1979, the International Whaling Commission (IWC) established a sanctuary in the Indian Ocean north of latitude 55°S in which the commercial exploitation of whales is prohibited. The sanctuary provision was to last for 10 years, with the provision for a review after five years (International Whaling Commission, 1980). The Commission decided to review the sanctuary in 1987. This paper outlines some of the aspects of the review that the author proposed be considered at the Scientific Committee meeting held in the Seychelles in February 1987.

FUNCTION OF A MARINE SANCTUARY

To review the success of the Indian Ocean Sanctuary and to consider its future requires some set of objectives against which its performance can be assessed. The broad functions of a marine sanctuary are succinctly stated by IUCN (International Union of Conservation and Nature and Natural Resources, 1976) as:

(a) to preserve and manage representative samples of marine habitats and ecosystems;
(b) to protect endangered species and habitats;
(c) to preserve and manage important breeding areas for commercially important species;
(d) to preserve aesthetic values for present and future generations;
(e) to protect valuable archaeological, historical and cultural sites;
(f) to establish sites for the interpretation of marine areas for the purposes of tourism, recreation and education of the public;
(g) to establish sites for the education and training of marine reserve managers;
(h) to encourage research and establish sites for the installation of research stations in which to study marine ecosystem processes;
(i) to establish sites for monitoring the environmental effects of human development and its various perturbations; and
(j) to provide a broad spectrum of recreational opportunities within an aquatic setting.

Although these may be broader than functions envisaged by the IWC in setting up the Indian Ocean Sanctuary, they form a useful point of departure for the review to be

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conducted by the Commission. The Scientific Committee of the IWC could not be expected to examine the Sanctuary against all of these functions, but items a, b, c, g, h and i would seem to fall within its purview. The scientific aspects of the sanctuary review should include consideration of the use and usefulness of a sanctuary: (1) in the broad sense of its value for scientific research on Cetacea and marine ecosystems, and (2) within the narrow sense of its role in managing exploited whale populations.

SOME POSSIBLE FUTURE ROLES OF THE SANCTUARY FOR SCIENTIFIC PURPOSES

The maintenance of marine sanctuaries may be justified for a whole range of scientific pursuits, but the emphasis in this paper is on marine ecology. Marine ecosystems are complex, involving interactions among the environment, primary production and a host of species, which are in turn predators and prey. Some of these species are of importance to humans as the bases of fisheries.

At present, our knowledge of ecological processes is limited. We may have detailed information about specific components of marine food webs, but to date this information falls short of that required to characterise the nature of ecosystems in the form of models which generate reliable predictions about future states of ecosystems in response to perturbation. Ecological literature is replete with hypothetical models of ecosystems or subsystems thereof, usually derived on intuitive or weak empirical bases. Such models often make sweeping simplifying assumptions which ignore the inherent complexity of ecosystems (Pielou, 1981).

Yet it would be impossible to understand the dynamics of an ecosystem from the study of the minutiae of all its components with static data collection (Schaffer, 1981; Bender *et al.*, 1984). Learning about the dynamics of a system requires observation of the response of that system to a perturbation. It is now recognised that in complex systems there are fundamental difficulties in interpreting the results of 'natural experiments' which arise from naturally occurring perturbations (Bender *et al.*, 1984). The bridge between abstract modelling of ecosystems and intense observation of their components is the experimental manipulation of some of the variables.

Unfortunately, experiments conducted outside laboratories rarely give results which can be interpreted unambiguously. There are many variables outside the control of the experimenter(s) which could explain the observations. Conversely, the limitations of laboratory experiments arise from their reduction of complex systems to simple ones, such that important processes of real systems are excluded. Thus, perforce, ecology is a branch of science which must include studies of the behaviour of ecosystems as they occur in nature.

Interpretation of an experimental perturbation of a system is stronger if some form of experimental control is applied. In an ecological 'field' experiment, the experimental design would involve observing the state of the system prior to the perturbation, then applying the perturbation and observing the response of the system. The perturbation in such an experiment is usually the alteration of the abundance of one or more of the species in the ecosystem. This 'longitudinal' design leads to confounding between time (and therefore variables not constant with time) and the application of the experimental 'treatment' (perturbation). The existence of a sanctuary can provide the opportunity for some level of experimental control over extraneous factors if the same programme of observation being conducted elsewhere is conducted in the sanctuary over the duration of the experiment, but without the application of the perturbation.

Inevitably, if an experimental perturbation is carried out, it will not be possible to observe all the species in a food web. Some species will be ignored, others may be grouped. System models built from such experimental manipulations do not necessarily represent the true nature of interactions between species (Schaffer, 1981). For this reason, Bender *et al.* (1984) suggest that no single approach is complete for gaining ecological knowledge and that ecological experiments need to be accompanied by the fullest amount of natural history, combined with ecological 'common sense'. This observation indicates that the second important role for a sanctuary in the conduct of ecological investigations is the opportunity to study various species under circumstances where they have not been subject to alterations in their natural history arising from the effects of exploitation.

ASPECTS OF THE ROLE OF SANCTUARIES IN THE MANAGEMENT OF EXPLOITED WHALE POPULATIONS

Given that the management of exploited whale populations will be reviewed extensively as part of the IWC's Comprehensive Assessment of the status of whale stocks (International Whaling Commission, 1988), in this paper it is perhaps more appropriate to merely sketch out possible contributions of sanctuaries to the management of whaling.

The management of whale stocks by the IWC has certain objectives which include the conservation of the stocks of whales. Since 1975, under the New Management Procedure (NMP), conservation of the stocks has been defined in terms of maintaining them at levels above those giving maximum sustainable yields. Leaving aside the difficulties in determining MSY and MSY level, experience with the NMP has shown that it is extremely difficult to decide whether a given rate of exploitation will achieve conservation.

There are two fundamental questions in managing whale stocks: (1) stock identity and (2) estimating sustainable rates of exploitation. Estimates of the sustainable rates of exploitation are derived from estimates of exploitable stock size and per capita yield.

There is no obvious unique role for whale sanctuaries in addressing questions of stock identity, except in the negative sense that declines in a stock within a sanctuary may indicate that the sanctuary does not cover the entire range of that stock. Clearly, from the point of view of defining sanctuaries, solving the stock identification problem is important; many of the scientific benefits of a sanctuary will be lost if it fails to offer a sufficient level of protection to unit stocks of a range of species (a unit stock is defined by Holden and Raitt (1974) as '... a group of individuals of the same species whose gain by immigration and whose losses by emigration if any, are negligible in relation to the rates of growth and mortality.').

It is not possible to do any better than predict the range in which the yield of a whale stock might lie from conventional demographic analysis of catches (de la Mare, 1987). In principle, it is possible to determine the yield of a stock by empirical examination of the response of the stock to exploitation. The empirical approach has close parallels with the conduct of an ecological field experiment; therefore, one potential role of a sanctuary in understanding whale movement is similar to that in the general case of ecological investigations.

There is an additional important consideration in managing whale stocks; the conservation objectives for the perturbed (exploited) stocks have to be met in the period before the results of the 'experiment' give reliable estimates of the yield. Because the time scale required to estimate the yield is long (de la Mare, 1987), it is important that initial estimates of the yield are close to sustainable levels. There are two lines of enquiry which may help to refine estimates of the range in which the yield from a whale stock may lie. The first of these is the study of the recovery of depleted stocks, and the second is the study of the natural history of the animals at various levels of exploitation. Both these approaches have been prominent in attempts to manage whaling to date.

The existence of a Sanctuary can assist in both types of study. For the case of monitoring the recovery of depleted whale stocks, gaining information on yield over a large range of stock abundance requires the monitoring to continue until the stock has recovered to a point where further population growth is negligible. Sanctuaries would allow this monitoring process to continue through that part of the range in stock abundance where the stock would normally be exploited (under the NMP, exploitation could resume on a protected stock when it has recovered to a level somewhat above 50% of its estimated pristine abundance). Continual monitoring by 'benign' research methods of the natural history of a recovering stock would lead to a much greater understanding of the nature of density dependence.

For studying life history, sanctuaries are important beyond their roles as a complement to the study of recovering populations. Natural history observations from stocks which have not been exploited will give some information of use in refining estimates of the range of likely yield within a much shorter time scale than that involved in monitoring the recovery of depleted stocks.

In general, sanctuaries can provide the opportunity to undertake various kinds of calibration work and develop new or revised methods for use in whale stock assessment. Comparative studies between exploited and unexploited stocks may be of considerable use in interpreting data collected from exploited whale stocks. For example, if whale management were to be based on continual application of shipborne sighting surveys, the question may arise whether the behaviour of whales towards ships has changed as a result of whaling. A 'control group' of unexploited whale stocks in a sanctuary could allow direct experimental testing of such a hypothesis.

Another area where sanctuaries may have a role is in the study of the effects of pollutants, marine debris and other anthropogenic activities on the health of whale stocks. Studies of the interaction between marine mammals and fisheries could also benefit from the existence of marine mammal sanctuaries.

CONCLUSION

If the management of whale stocks is to have a sound scientific foundation, more research into whales and whaling has to be carried out than has been accomplished to date. Whale sanctuaries have the potential to play an important role in such research. This role is likely to become even more important as human impact on marine ecosystems intensifies.

An example of key importance of the Indian Ocean Sanctuary to the IWC is the prospect of intensified exploitation of krill in the Antarctic. There would seem to be a great deal of scientific and management utility in cooperation between the IWC and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in setting up some sanctuary areas in the Antarctic to provide scientific reference areas for the study of interactions among krill, whales and fisheries.

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REFERENCES

Bender, E.A., Case, T.J. and Gilpin, M.E. 1984. Perturbation experiments in community ecology: theory and practice. *Ecology* 65:1-13.

de la Mare, W.K. 1987. An overview of some recent work on the management of exploited whale populations. Paper SC/M87/M2 presented to the Comprehensive Assessment Workshop on Management, Reykjavík, March 1987 (unpublished).

Holden, M.J. and Raitt, D.F.S. 1974. Manual of fisheries science. Part 2. Methods of resource investigation and their application. *FAO Fish. Tech. Pap.* 115:214pp.

International Union of Conservation and Nature and Natural Resources. 1976. An international conference on marine parks and reserves: papers and proceedings. *IUCN Publ. (New Ser.)* 37:132pp.

International Whaling Commission. 1980. *International Convention for the Regulation of Whaling, 1946. Schedule (As Amended By the Commission At the 31st Annual Meeting, London, July 1979 and Replacing That Dated April 1979).* International Whaling Commission, Cambridge. 19pp.

International Whaling Commission. 1988. Report of the Scientific Committee. *Rep. int. Whal. Commn* 38:32–155.

Pielou, E.C. 1981. The usefulness of ecological models: a stocktaking. *Quart. Rev. Biol.* 56:17–31.

Schaffer, W.M. 1981. Ecological abstraction: the consequences of reduced dimensionality in ecological models. *Ecol. Monogr.* 51:383–401.