A note on observations of cetaceans in the Indian Ocean Sanctuary, Australia to Israel, April 1995

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ABSTRACT

A forty-day voyage from Hobart (Australia) to Haifa (Israel) included a visual and acoustic census for cetaceans in the Indian Ocean Sanctuary. One hundred and sixty-three sightings were made, 156 occurring within the Sanctuary. Twelve species were identified. Sperm whales (*Physeter macrocephalus*) were encountered most frequently (51% of identified encounters), whilst spinner dolphins (*Stenella longirostris*) were numerically dominant. Other species identified included bottlenose dolphins (*Tursiops* spp.), short-beaked common dolphin (*Delphinus delphis*), pan-tropical spotted dolphin (*Stenella attenuata*), rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), Bryde's whale (*Balaenoptera edeni*) and Cuvier's beaked whale (*Ziphius cavirostris*). The most sightings occurred WNW of the Seychelles, east of Somalia, and in the Gulf of Aden and Red Sea. Half of the sperm whale sightings were to the east of Ras Hafun (Somalia), and included adults, subadults and at least one calf. Thirteen hours were spent listening for cetaceans using a towed array whilst the ship was underway. Cetaceans were detected at 78% of the listening stations, with a possible four species recorded (sperm whale, spinner dolphin, pilot whale, bottlenose dolphin). The survey shows the value of platforms of opportunity for studying the pelagic communities of cetaceans in the Indian Ocean Sanctuary. It highlights the need for further research in the northwestern sector where anthropogenic threats are varied and increasing.

KEYWORDS: INDIAN OCEAN; SPERM WHALE; SPINNER DOLPHIN; PAN-TROPICAL SPOTTED DOLPHIN; BOTTLENOSE DOLPHIN; ROUGH-TOOTHED DOLPHIN; BRYDE'S WHALE; RISSO'S DOLPHIN; COMMON DOLPHIN; PILOT WHALE; KILLER WHALE; CUVIER'S BEAKED WHALE; FALSE KILLER WHALE; SURVEY-ACOUSTIC; SURVEY-VESSEL

INTRODUCTION

Cetacean studies within the IWC's Indian Ocean Sanctuary (IOS) have largely been carried out in coastal waters (including Australia, Sri Lanka, Oman, South Africa and India). Fewer studies have been undertaken offshore, although Mörzer-Bruyns (1971), Keller *et al.,* (1982), Kasuya and Wada (1991), Eyre (1995), Ballance and Pitman (1998), de Boer (2000a) and the Ocean Alliance Odyssey voyage (Ocean Alliance, 2009; Wise *et al.*, 2009) have contributed to our current knowledge of the pelagic cetacean fauna. Acoustic studies of cetaceans to supplement visual observations have been primarily used for sperm whales (Godard *et al.*, 2003; Gordon, 1987; Khan *et al.*, 1993; Whitehead and Gordon, 1986).

The non-government environmental organisation Greenpeace International makes regular oceanic transits with its vessels. Cetacean surveys in the IOS have been undertaken using these vessels in 1993 (Eyre, 1995), 1995 (Eyre, 1997), 1998/99 (De Boer *et al.*, 1999), 1999 (De Boer, 2000a), 1999/2000 (De Boer, 2000b; De Boer *et al.*, 2003) and 2000 (Eyre, 2000).

This paper reports on results obtained during a transit of the Sanctuary during the austral autumn of 1995, originally presented as an unpublished report to the IWC (Eyre, 1997). Subsequent research conducted by other organisations in the locations covered here are briefly mentioned.

METHODS

The survey vessel was the *MV Greenpeace*, a 58m deep-sea salvage tug which averaged 9.9 knots during the transit. A *Furuno* GP-500 Navigator provided vessel position, and navigational charts were used for approximate depth in addition to the ship's depth sounder in shallow water. Water temperature was taken from the ship's engine cooling system at a depth of approximately 2.5m, and sea and wind conditions were estimated using the Beaufort scales.

The vessel left Hobart, Australia on 25 March 1995 and entered the IOS on 29 March. The course continued northwest to the northeastern waters of Africa and into the Red Sea, arriving at Haifa, Israel on 3 May 1995. Fig. 1 shows the vessel's cruise track.

Although the principle purpose of the transit was one of vessel delivery, the course or speed was altered to close in on large cetaceans for data collection or to survey areas of interest. An area WNW of the Seychelles which was covered in the 1993 survey (Eyre, 1995) was transited, and the vessel also detoured off Ras Hafun (Somalia) for a day when large numbers of sperm whales were encountered.

Visual survey

Visual observations were conducted during daylight hours and in sea conditions below Beaufort 6 (Fig. 2). Most observations were carried out from a platform 12m above sea level. Searching also occurred from the crow's nest (20m), wheel-house roof (10m) and bridge (8m) depending on environmental conditions.

Two observers were usually present, each searching 180° on each side, with most effort concentrated 90° forward. From 26 April to 3 May, only one observer was present, concentrating search effort 180° forward. The crew on watch

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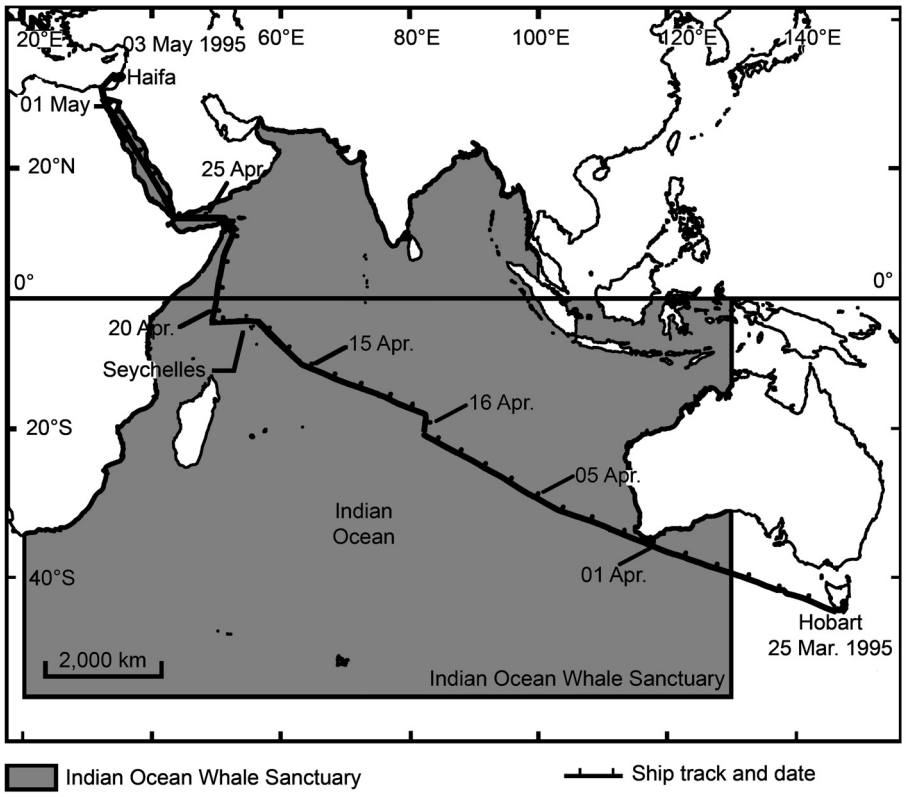

Fig. 1. Vessel cruise track and associated dates.

also assisted during this time. On-effort watchers scanned with the naked eye and used Steiner 7 × 50 field glasses to search from the vessel out to the horizon.

Effort, ship's course and speed and environmental data were collected hourly or when a sighting was made. School sizes were estimated using low/high/best estimation of numbers of individuals. Photographs were obtained where possible using Pentax and Canon SLR cameras with 50–200mm lenses.

The term 'sighting' refers to cetaceans separated spatially or temporally. It is recognised that sperm whale sightings are likely to be sub-groups of larger aggregations. The methods do not allow abundance to be estimated.

Acoustic survey

Two hydrophone systems were used. One was a single element hydrophone with 12m of cable deployed from a

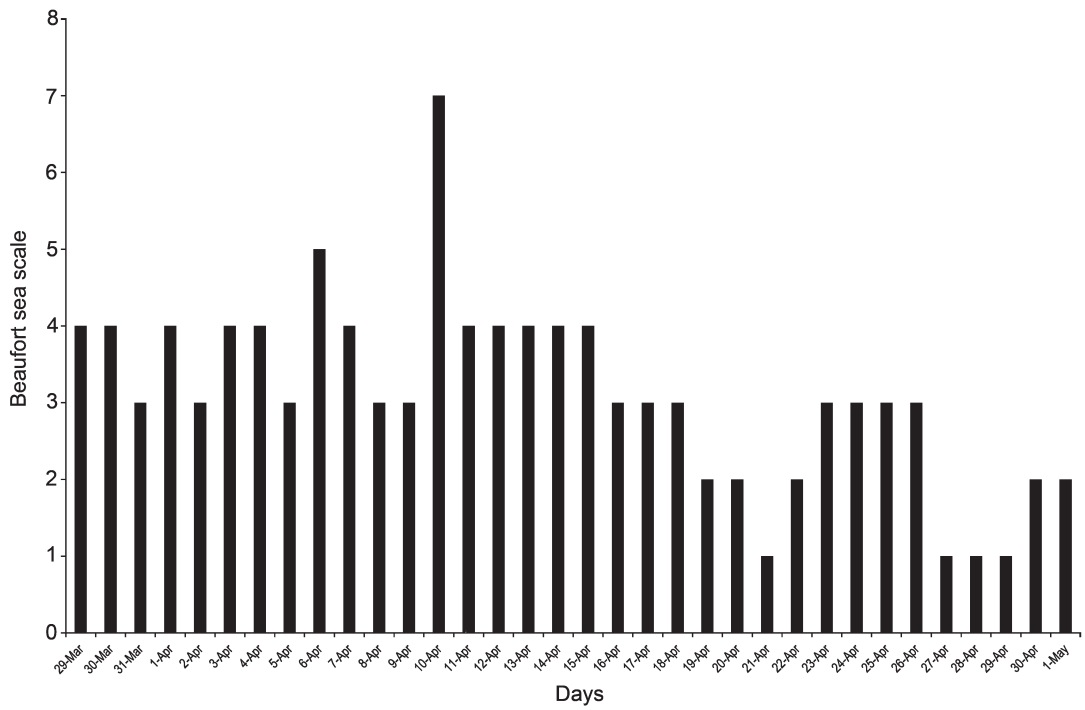

Fig. 2. Average Beaufort sea state during on-effort watching whilst in the Sanctuary (29 March–1 April 1995).

rigid-hulled inflatable. A preamplifier with a range of 20–60dB covering a bandwidth of 50Hz–20kHz was connected to a *Panasonic* SV-250 portable DAT recorder.

The second system was a two element towed array, consisting of 90m of strengthened cable towed approximately 78m behind the vessel and with a rope tail for stability. The array contained two *Benthos* AQ-4 elements with 30dB gain preamplifiers and a frequency response of 200Hz–35 kHz, mounted in a 10m long reinforced polyurethane tube filled with deodorised paraffin oil. The array was connected to a Sony Pro TCD-D10 DAT recorder. The hydrophone array was developed by the International Fund for Animal Welfare, based on equipment used by Leaper *et al*., (1992) and had been used by Pierpoint *et al.,* (1997) prior to this survey.

Routine tows were conducted from 17–26 April, between 08:30–09:30 hours. Three evening tows were also conducted during this period (Fig. 3). The ship slowed to 6.5 knots, and the visual survey was maintained during daylight tows. During one hour of listening, recording was done at alternate 10 minute intervals (total 30 minutes recorded). Non-routine tows occurred when cetaceans were in the vicinity and ship schedule allowed.

Recordings were aurally analysed for presence/absence and identification of cetacean sounds and were then sent to the Cetacean Group at the University of Oxford for sperm whale abundance analysis using the 'Cartwheels' program (Conservation Research Group, 1989) but unfortunately the quality of the recordings precluded estimates being developed.

RESULTS

Visual

A total 16,688km was covered from Hobart to Haifa, with 14,563km (87.2%) within the IOS. There were 378 hours of effort in total of which 332 hours (87.8%) were in the IOS, giving an average of 9.5hrs per day. Of the 163 sightings made (on 22 of the 40 days) 156 sightings (95.7%) were within the IOS. All but 4 sightings were on effort. On-effort encounter rate was 1.05 sightings/100km within the IOS.

An estimated 2,560 individual cetaceans were sighted, and twelve species identified. Sightings are summarised in Table 1 and locations given in Figs. 3 and 4.

The most individuals sighted were of spinner dolphins (n = 1,059) and the most sightings were of sperm whales (n = 69).

Four sightings were of mixed species associations. These included pilot whales and bottlenose dolphins (two occasions), Risso's and rough-toothed dolphins, and spinner and pan-tropical spotted dolphins. Oceanographic conditions within the IOS predictably shifted from cool to warm as the vessel headed northwest (Table 1), with calmer conditions within the Red Sea. Fig. 2 shows the average daily Beaufort sea state whilst on-effort within the IOS. On April 10 the weather intensified and watching conditions deteriorated due to the proximity of Cyclone '*Marlene*'.

Acoustic

A total of 14h 14min were spent listening at nineteen stations (Fig. 3), with 8h 47s recorded. Almost 11 hours were scheduled tows, which covered 134.3km. Non-routine tows occurred on five occasions after cetaceans had been sighted, totalling 2h 3min of listening. On two occasions the single-element hydrophone was used from an inflatable. This included 23 minutes recorded on 23 April in the company of a widely dispersed sperm whale group. No cetacean sounds were heard on the other occasion.

Cetaceans were heard at 78% of the stations. These sounds included sperm whale clicks, as well as odontocete whistles. Whistles could be detected on 50% of recordings, and whilst it was not possible to positively assign whistle series to a species, spinner dolphins were in the vicinity on at least three occasions and a mixed aggregation of pilot whales and bottlenose dolphins were in the area on one occasion. Sperm whales were heard but not seen on two occasions.

SPECIES ACCOUNTS

Short-beaked common dolphin (*Delphinus delphis*)

Two confirmed sightings of this species were made (Table 1, Fig. 2) The first sighting was of a large, widely dispersed group accompanied by seabirds (Australasian gannets, *Morus serrator*), assumed to be engaged in feeding. The animals were in shallow coastal water off Tasmania. The second sighting occurred 4 days later when several large animals bowrode for approximately 11min. No calves were observed.

Spinner dolphin (*Stenella longirostris*)

Spinner dolphins were encountered in several locations and conditions (Figs 3 and 4) and in small and large aggregations (Table 1). In mid-ocean, the species was often observed travelling slowly or milling amongst sea birds, presumably feeding. Aerial activity was always seen. Sightings occurred during all daylight hours, with a slight peak near midday. A mother and calf was seen on 28 April in the Red Sea and smaller individuals within pods were seen northwest of the Seychelles and in the northern Red Sea.

Bowriding was only observed in the Red Sea, including a mixed pod with pan-tropical spotted dolphins (Fig. 3).

There was some variation in size and colour pattern amongst the Red Sea animals. A tripartite pattern was common in all animals, but many were dark grey dorsally and on the pectoral fins with a band of the same colour separating the lateral and ventral fields, originating from and enclosing the eye and terminating parallel to the genitals. This band varied in width and shade for individuals (possibly an indication of age) and on larger animals was a very pronounced stripe. Other groups of animals were uniformly smaller and lighter in colour; the flippers were similar in shade to the lateral field; the rostrum was shorter and the dark lateral band was absent.

Pan-tropical spotted dolphin (*Stenella attenuatta*)

Spotted dolphins were positively identified in the Red Sea (Fig. 3), but were likely to account for some of the 'unidentified delphinids' encountered throughout the survey. Most (70%) of the sightings involved bowriding, including the mixed group with spinner dolphins. Group sizes ranged from 9–70 individuals. Calves were seen in the southern Red Sea.

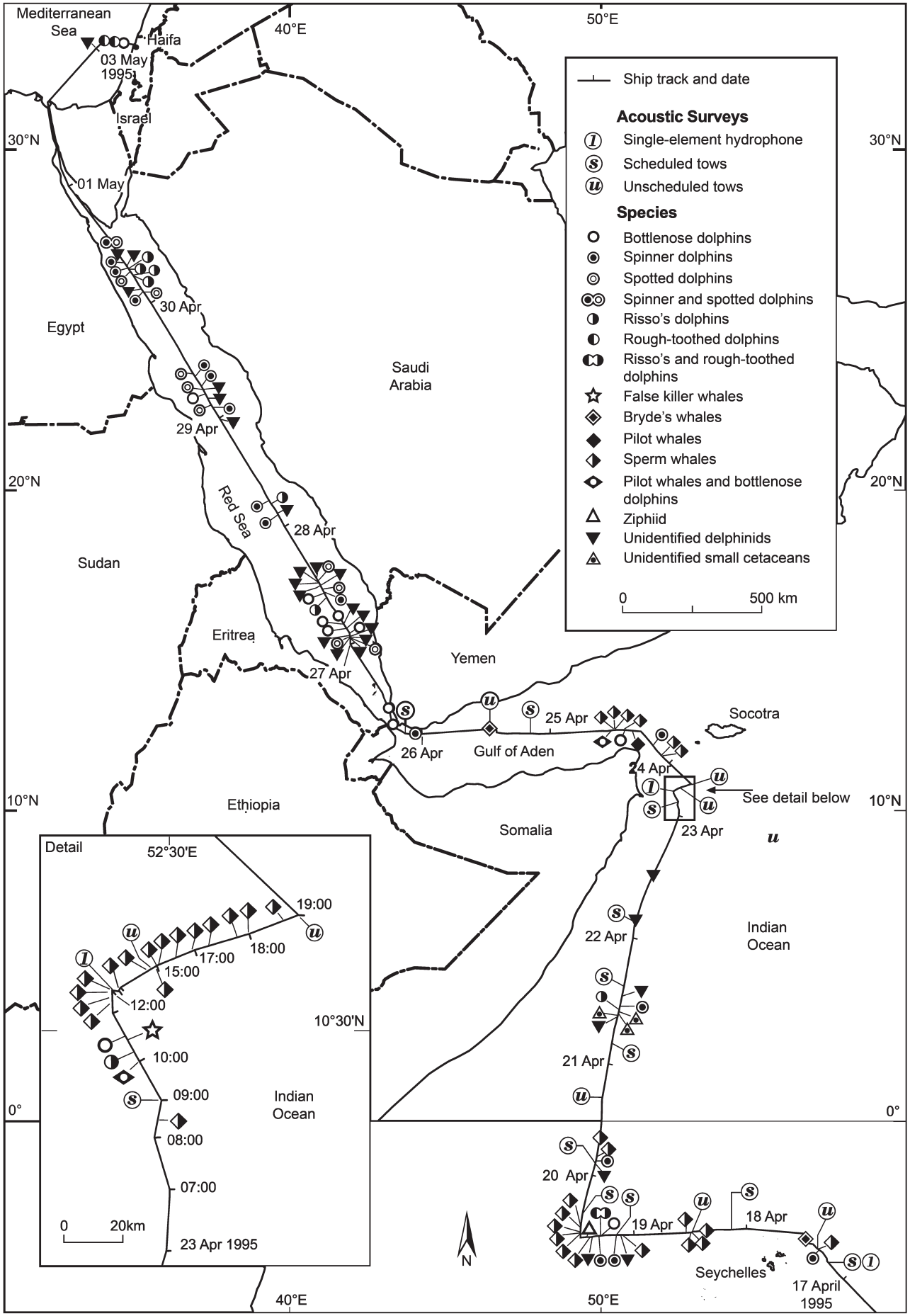

Fig. 3. Vessel cruise track, sightings positions and listening stations throughout the western sector of the Indian Ocean Sanctuary and Mediterranean. Some symbols are for multiple sightings of the same species.

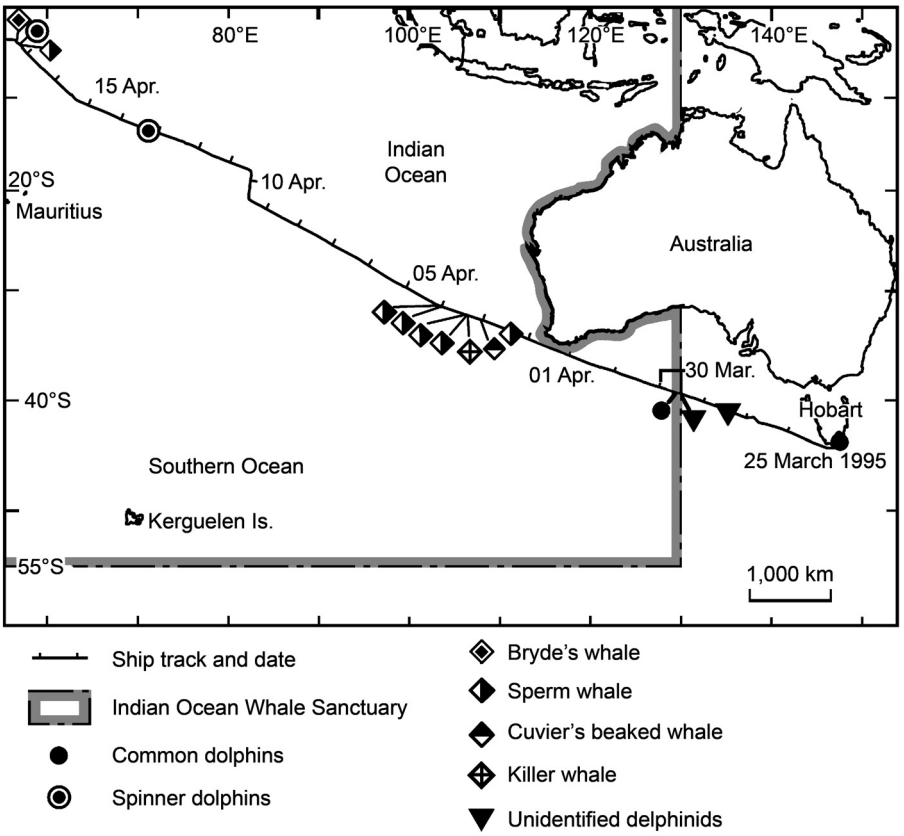

Fig. 4. Vessel cruise track and sightings positions for the eastern sector of the Indian Ocean Sanctuary. Some symbols are for multiple sightings of the same species.

The white rostral tip and dark cape was common to all groups observed, with some groups having distinctive white lips. Larger animals had dark flecks below the cape. Three groups contained a large number of individuals with a dark band extending from the gape, continuing beyond eye patch and ending above the trailing edge of the pectoral fin. Their size was comparable to other individuals without a band.

Bottlenose dolphin (*Tursiops* spp.)

Bottlenose dolphins were seen in different environmental conditions, including clear, deep oceanic waters and shallow, murky coastal waters on the approach to Haifa port (Table 1). The genus was only positively identified in the western part of the Sanctuary, including the Gulf of Aden and Red Sea (Figs 3 and 4).

The largest groups of animals (n = 60 and 40) were seen in the company of pilot whales. Most (79%) of sightings involved bowriding, including those associated with pilot whales.

Most of the animals encountered were quite large, robust and with short, blunt rostrums. Colour varied from dark grey (except for the ventral surface), to grey gradation along the flanks. Only three sightings were of lighter and smaller animals identified as Indo-Pacific bottlenose dolphins, *Tursiops aduncus*. One was mid-Red Sea (29 April, Fig. 3) and the other two were off the Horn of Africa (24 April, separate and with pilot whales, Fig. 3).

A mother and calf bowrode on two separate occasions in the Red Sea and the multi-species group in the Gulf of Aden had smaller animals present.

Rough-toothed dolphin (*Steno bredanensis*)

This species was seen on three occasions: once mid-ocean in deep, warm water and twice in the Mediterranean in deep, relatively cool water of 18°C (Table 1, Fig. 3). In the IOS the species was associated with Risso's dolphins and were broken up into units containing 1–4 animals which appeared boat-shy. All animals in the Mediterranean bowrode for an average of four minutes, including one juvenile.

The animals surfaced in synchrony when closely grouped and had a peculiar 'space shuttle' appearance when bowriding by holding their large pectoral fins at right angles to their body.

Risso's dolphin (*Grampus griseus*)

Risso's dolphins were encountered mid-ocean and in the Red Sea (Fig. 3). The largest group (n = 25) was associated with rough-toothed dolphins and consisted of young and old animals dispersed throughout the Steno groups. This was the only time the species approached to within 10m of the vessel. Group sizes varied from 1–5 animals for other encounters. Smaller animals were seen on three occasions in the Red Sea.

They were often (78%) seen 'sailing', with their flukes held vertically above the water or resting motionless at the surface on days of warm sea and air temperatures (≥24°C and ≥25°C respectively).

Killer whale (*Orcinus orca*)

One group (about 10 animals of mixed age and sex) was encountered in cool, deep water in the eastern sector of the

Table 1
Group sizes of identified species, including water depth and temperature.

	Total sightings	Total individuals ('best')	Mean group size (SD; range)	Approx depth, m (SD; range)	SST,°C (SD; range)
Pan-tropical spotted dolphin	10	361	36 (24; 9–70)	657 (378; 178–1,302)	27 (3; 24–30)
Bottlenose dolphin spp.	14	151	11 (17; 1–60)	912 (1,396; 14–5,000)	29 (3; 19–32)
Risso's dolphin	9	53	6 (7; 1–25)	1,744 (1,605; 509–5,000)	28 (4; 24–32)
Sperm whale	69	100	1 (1; 1–4)	2,461 (1,624; 1,000–5,000)	30 (3; 20–32)
Spinner dolphin	19	1,059	56 (54; 4–250)	2,016 (1,929; 64–5,000)	28 (3; 24–32)
False killer whale	1	2	2 (0; 2–2)	1,251 (0; 1,251–1,251)	30 (0; 30–30)
Short-beaked common dolphin	2	310	155 (205; 10–300)	2,684 (3,768; 20–5,349)	15 (0; 15–15)
Bryde's whale	2	2	1 (0; 1–1)	2,250 (1,768; 1,000–3,500)	30 (1; 30–31)
Killer whale	1	10	10 (0; 10–10)	3,934 (0; 3,934–3,934)	20 (0; 20–20)
Pilot whale	3	66	22 (14; 6–30)	1,938 (597; 1,251–2,328)	30 (0.3; 30–30)
Rough-toothed dolphin	3	31	10 (13; 2–25)	2,708 (1,990; 1,425–5,000)	23 (8; 18–32)
Ziphiids	2	3	2 (1; 1–2)	4,950 (71; 4,900–5,000)	26 (8; 21–32)

IOS (Table 1, Fig. 4). The animals were travelling fast, and blows were clearly visible 1km away in Beaufort sea state 4. They had a brown rather than black appearance and the saddle patch was faint.

Pilot whale (*Globicephala* spp.)
Pilot whales were encountered in the Somali Basin and the Gulf of Aden (Fig. 3). They were probably short-finned pilot whales (*G. macrorhynchus*) given their position (Leatherwood *et al.*, 1991). Pilot whales were associated with bottlenose dolphins on two occasions, and were noticeable even at a distance by their blows. Large animals appeared in all groups and no calves were seen. Six animals were observed surfing in sea state 4 with a 1.5m swell.

False killer whale (*Pseudorca crassidens*)
One sighting of two animals occurred in an area east of Somalia where a high number of other species were encountered, notably sperm whales (Fig. 3). They appeared disturbed by the vessel's presence, altering course away from the ship and spending little time at the surface,

Ziphiids
Two Cuvier's beaked whales (*Ziphius cavirostris*) were seen in the east of the IOS. Both were brownish grey dorsally, however one was cream-coloured anterior to the dorsal fin in a well-defined demarcation. The skin around the eye was dark and noticeable against the light background, and scarring was not evident on either animal. The whales had sloping melons with short rostrums and the dorsals were large and falcate, positioned well back. The trailing edge of the dorsals were grey. The animals had been slowly milling at the surface and sounded as the vessel approached.

An unidentified single whale (Fig. 4) was seen in deep water (SST 32°C). It was medium-sized and resting motionless at the surface. A small triangular dorsal fin was positioned over half way along the body. The animal submerged as the vessel approached.

Bryde's whale (*Balaenoptera edeni*)
Two sightings of single animals were made in warm deep water (Table 1, Fig. 3). A large individual was sighted near Mahé (Seychelles). It had a variable swim pattern and submergence times from 1–9 minutes. The ship's course was slowed and altered without causing obvious disturbance to the whale.

The second sighting was in the Gulf of Aden. The whale was only seen briefly and no sounds were detected.

Sperm whale (*Physeter macrocephalus*)
This was the most frequently encountered cetacean species (Table 1). Sightings occurred throughout the IOS (Figs 3 and 4) with the exception of the Red Sea. Concentrations of animals occurred WNW of the Seychelles Group, south east of the Horn of Africa and in the Gulf of Aden.

Group numbers and estimated size of individuals showed a latitudinal pattern, with large, lone individuals (presumably adult males) seen in the south east IOS, in temperate (20–22°C), deep (3,934–5000m) water. Small groups, primarily thought to be subadults, were seen WNW of the Seychelles and south of the Equator, in warm (32°C), deep (2,000–5000m) water. Large, dispersed groups of adults, subadults and at least one occurrence of a calf were observed 10° north

of the Equator, west of Ras Hafun (SST 30.5–31°C, depth 1,200–2,000m). In the Gulf of Aden most animals were adults, either alone or in pairs (SST 30°C, depth 1,000–1,500m).

The highest number of sightings and individuals occurred on 23 April, when the vessel deviated 69km off course, 98km from Ras Hafun (Fig. 3). Sightings were divided roughly into four groups as the track progressed east throughout the day. The first group was of three sightings, totalling five adults encountered early in the morning. The second group consisted of adults, subadults and at least one calf (estimated 5m long) dispersed in subgroups of 1–3 animals, either resting at the surface or diving. Photographs were taken, and 23 minutes of recordings were made using the single element hydrophone deployed from an inflatable boat. Despite considerable surface noise, multiple clicks could be heard. Fifteen minutes prior to joining this group, two noticeably large, lone animals were seen. The group was observed from late morning to early afternoon.

An hour after leaving these whales and continuing east, the next group was encountered. This consisted of mostly large animals, either singly or in pairs. Whilst some rested at the surface, others were active. One pair was observed to roll together whilst swimming underwater, and a single animal with a dorsal fin callus was also seen swimming upside down just below the surface. Another pair of large whales was engaged in lob tailing. The array was towed whilst the vessel slowly circled in the area. At one stage all animals had sounded, but many animals could be clearly heard. One and a half hours were spent with this group mid-afternoon before course and speed were resumed. In the late afternoon, the final group was observed, with whales alone and at the surface.

Of a total 19 listening stations, sperm whales could be heard on five occasions, including three when animals were in view. Sperm whales are most often silent when at the surface (Whitehead and Gordon, 1986), making it probable that more animals were in the area than were seen.

Dorsal fin calluses were seen on 70% of individuals photographed. Dorsal fin calluses are associated with female sperm whales (Arnbom and Whitehead, 1989; Kasuya and Ohsumi, 1966).

Unidentified delphinids and small cetaceans

Some 17% of sightings were animals of dolphin-like appearance for which no species could be assigned. Lack of closure on sightings other than large whales made identification difficult unless animals approached or showed distinctive features or behaviour. Reduced visibility due to sea conditions contributed to unconfirmed identification, as did elusive behaviour. Some sightings made by the crew could not be positively identified.

On 21 April off the east coast of Somalia, five of the seven sightings were of small animals which could not be assigned to species (Fig. 3). This was on a warm, still day. Despite these good sighting conditions where animals could be detected resting at the surface from considerable distance, on approach they would sink below the surface until the vessel passed. It is possible that at least two of these sightings were of *Kogia* sp.

In the Red Sea, 37% of sightings were of indeterminate species. Many of these sightings were at distances greater than 800m and the behaviour exhibited was either slowly travelling or resting at the surface. Vessel speed had increased and there was only one dedicated watcher present.

DISCUSSION

The Indian Ocean is characterised by monsoon-driven upwelling north of the Equator. The southwest monsoon current flows from late April to October, producing upwelling and nutrient-rich waters off the Somali east coast (Small and Small, 1991; Wyrtki, 1973). As a result of this upwelling, influx of nutrients and increased phytoplankton biomass during the southwest monsoon, the NW Indian Ocean is considered a significantly productive ocean basin (Veldhuis *et al.*, 1997). Ballance and Pitman (1998) reported that the southwest monsoon began in late May in 1995, and April is often referred to as an inter-monsoon period. The northward flowing Somali Current commences near 10°S, where a large number of sightings were recorded and many species seen (Fig. 3). Upwelling is significant between 5°and 11°N (Small and Small, 1991), where the highest number of sightings were recorded. The mouth of the Gulf of Aden, where the Somali Current converges with the waters of the Gulf was also associated with a high number of sightings (Fig. 3); Small and Small (1991) present similar data on species, area and time of year for offshore sightings.

Our results confirm the conclusions of previous cruises, Balance and Pitman (1998) and Eyre (1995), that spinner dolphins and sperm whales are probably the most abundant cetacean species in the IOS.

As noted, it is likely that some of the unidentified sightings were spotted dolphins. This species appears to be an important part of the deep water fauna of the Red Sea. Beadon (1991) found that spotted dolphins were the most frequently encountered cetacean species off the southern tip of the Sinai Peninsula, but did not record spinner dolphins in the area. Gilpatrick *et al.,* (1987) and Eyre (1995) note a similar distribution for spinner and spotted dolphins in the Red Sea.

Risso's dolphins and bottlenose dolphins occurred throughout the Red Sea and western portion of the Indian Ocean. Kruse *et al.* (1991) refers to the frequency and distribution of Risso's dolphin sightings in the IOS from a review of available information and Beadon (1991) noted that they were the second most commonly encountered species in the Gulfs of Aquaba and Suez. The tail-up behaviour of Risso's dolphins observed on many of the encounters may be related to thermoregulation and has been observed in the Maldives (Anderson, 2005), Oman (Baldwin, 2003), Indonesia (B. Kahn, pers. comm.) and Papua New Guinea (Mörzer-Bruyns, 1971).

The two reported types of bottlenose dolphin would appear to be consistent with other reports (e.g. Beadon, 1991; Leatherwood, 1986; Mörzer-Bruyns, 1971). The association between *Tursiops* sp. and short-finned pilot whales is not uncommon (e.g. Anderson, 2005; Ballance and Pitman, 1998; Small and Small, 1991).

Pilot whales may have a seasonal distribution in the Gulf of Aden and east of Somalia. Small and Small (1991) recorded sightings from February–May and November and Ballance *et al.,* (1996) recorded them in May. Leatherwood

(1986) and Leatherwood *et al.* (1991) reported sightings in similar months in this area. Eyre (1995) transited this in June/July 1993 and reported no sightings of pilot whales. The lack of reported sightings from May–October may be related to the monsoon periods and associated weather patterns.

The single sighting of killer whales in the southeastern portion of the IOS may have been of Antarctic migrants; the brownish colouration may be attributed to diatoms (R. Pitman, pers. comm.). Unfortunately no photographs were obtained.

Although rough-toothed dolphins have been observed with other cetaceans (Perrin and Walker, 1975), this appears to be the first record of the species associating with Risso's dolphins. The two sightings of *Steno* in the eastern Mediterranean were not aberrant. A specimen was previously collected from Haifa (Watkins *et al.*, 1987) and the species is now considered to be a permanent part of the Mediterranean fauna (Miyazaki and Perrin, 1994). Sightings and strandings have been recorded off Israel and Palestine in March and April 1997, 1998 and 2005 (Goffman *et al.*, 2009; Khalaf, 2008).

The Seychelles is an important cetacean area (e.g. Ballance *et al.*, 1996; Claro and Hergueta, 2002; Eyre, 1995; Hermans and Pistorius, 2008; Kasuya and Wada, 1991; Keller *et al.*, 1982). Survey and whaling records suggest that the Seychelles area is an important region for sperm whales in all seasons (e.g. Wray and Martin, 1983). Townsend's (1935) charts show the Mahé Banks were an important whaling ground. Robineau (1991) notes that sperm whales were the most frequently encountered species around the Seychelles, but does not elaborate on whether the seasonal decline for balaenopterid sightings during April extends to sperm whales.

The only one other reference to large concentrations of sperm whales near the area off Ras Hafun is that of Ballance *et al.* (1996), who recorded over 20 sightings of sperm whales from 7–10 May 1995, in an area slightly east of the present study. No mention was made of group composition. Leatherwood (1986) reported two records of single animals from this region on 24 April 1977. Townsend (1935) and Kasuya and Wada (1991) show concentrations of animals SE of this area during April. The presence of sperm whales in this area is probably seasonal (Berzin, 1971) and related to a breeding and calving season that includes March and April (Klinowska, 1991). The presence of a calf amongst an assumed nursery group and the presence of adult animals engaged in close contact suggests that east of Ras Hafun may be a breeding and nursery site. The Gulf of Aden supports large numbers of sperm whales and 'young' sperm whales were recorded from the area in March and May (Small and Small, 1991). Yukhov (1969) noted females and 'small' whales in the later months of the year.

While there has been increased research effort in some parts of the IOS in recent years (e.g. Feingold and Kerem, 2008; Marsden *et al.*, 2004; Notabartolo di Sciara *et al.*, 2007; Notabartolo di Sciara *et al.*, 2009; Reijnders, 2001; 2002; Wise *et al.*, 2009) it is clear that long-term, year-round dedicated studies are required to obtain necessary information on abundance, distribution, seasonal patterns and behaviour of cetaceans within the IOS to address potential anthropogenic threats. However, this study has shown that increased use of platforms of opportunity could provide valuable information for relatively little cost.

The identification of areas with high abundance and species diversity supports the implementation of more intense efforts in these areas, ideally combining visual and acoustic techniques. Unfortunately the northwestern sector of the IOS has in recent years become affected by war and piracy, making it difficult to conduct vessel-based research. The apparent dependence of some cetacean populations on areas of high primary productivity within the IOS implies that future management of these regions should be considered with respect to fisheries, pollution and climate change.

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REFERENCES

Anderson, R.C. 2005. Observations of cetaceans in the Maldives, 1990–2002. *J. Cetacean Res. Manage.* 7(2): 119–36.

Arnbom, T. and Whitehead, H. 1989. Observations on the composition and behaviour of groups of female sperm whales near the Galapagos Islands. *Can. J. Zool.* 67(1): 1–7.

Baldwin, R. 2003. *Whales and Dolphins of Arabia*. Mazoon Printing Press, Muscat. 111pp.

Ballance, L.T. and Pitman, R.L. 1998. Cetaceans of the western tropical Indian Ocean: Distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. *Mar. Mammal Sci.* 14(3): 429–59.

Ballance, L.T., Pitman, R.L., Reilly, S.B. and Force, M.P. 1996. Report of a cetacean, seabird, marine turtle and flying fish survey of the western tropical Indian Ocean aboard the research vessel *Malcolm Baldrige*, March 21–July 26, 1995. *NOAA Technical Memorandum NMFS* NOAA-TM-NMFS-SWFSC-224: 132pp.

Beadon, J.J. 1991. 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. pp.111–14. *In*: Leatherwood, S. and Donovan, G.P. (eds). *Cetaceans and cetacean research in the Indian Ocean Sanctuary*. United Nations Environment Programme Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.

Berzin, A.A. 1971. *Kashalot*. Izdatel'stvo `Pishchevaya Promyshlennost', Moscow. (+ Aendices and Indices). 324pp. [Translated in 1972 as *The Sperm Whale* by the Israel Program for Scientific Translations, Jerusalem. i–v + 394pp.].

Claro, F. and Hergueta, S. 2002. Mise en place d'un reseau d'observateurs des cetaces aux Seychelles. Mission report for the Museum national d'Histoire Naturelle and Societe Zoologique de Paris. 14pp.

Conservation Research Group. 1989. Acoustic survey techniques for sperm whales. Paper SC/41/Sp3 presented to the IWC Scientific Committee, May 1989 (unpublished). 60pp. [Paper available from the Office of this Journal].

De Boer, M.N. 2000a. A note on cetacean observations in the Indian Ocean Sanctuary and the South China Sea, Mauritius to the Philippines, April 1999. *J. Cetacean Res. Manage.* 2(3): 197–200.

De Boer, M.N. 2000b. Observations on occurence and distribution of cetaceans in the Southern Ocean Sanctuary and southern part of the Indian Ocean Sanctuary. Paper SC/52/O9 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). 10pp. [Paper available from the Office of this Journal].

De Boer, M.N., Baldwin, R., Burton, C.L.K., Eyre, L., Jenner, K.C.S., Jenner, M.N.M., Keith, S.G., McCabe, K.A., Parsons, E.C.M., Peddemors, V.M., Rosenbaum, H.C., Rudolph, P., Thiele, D. and Simmonds, M. 2003. *Cetaceans in the Indian Ocean Sanctuary: a review*. Whale and Dolphin Conservation Society, UK. 52pp.

De Boer, M.N., Frizell, J. and Sonntag, R.P. 1999. Cetacean observations in the Southern Ocean and Indian Ocean sanctuaries. Paper SC/51/O12 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 14pp. [Paper available from the Office of this Journal].

Eyre, E.J. 1995. Observations of cetaceans in the Indian Ocean Whale Sanctuary, May–July 1993. *Rep. int. Whal. Commn* 45: 419–26.

Eyre, E.J. 1997. Preliminary composite cetacean survey in the Indian Ocean Sanctuary, April 1995. Paper SC/49/O33 presented to the IWC Scientific Committee, September 1997 Bournemouth (unpublished). 24pp. [Paper available from the Office of this Journal].

Eyre, E.J. 2000. Observations of cetaceans in the Indian Ocean Sanctuary, Mauritius to Singapore, April 2000. Paper SC/52/O16 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia. [Paper available from the Office of this Journal].

Feingold, D. and Kerem, D. 2008. Cetacean conservation as part of an eco-tourism project in the northern Red Sea. 22nd Annual Conference of the European Cetacean Society, Egmond aan Zee, The Netherlands, 10–12 March 2008.

Gilpatrick, J.W., Perrin, W.F., Leatherwood, S. and Shiroma, L. 1987. Summary of distribution records of the spinner dolphin, *Stenella longirostris*, and the pantropical spotted dolphin, *S. attenuata*, from the western Pacific Ocean, Indian Ocean and Red Sea. *NOAA Technical Memorandum NMFS* NOAA-TM-NMFS-SWFC-89: 42pp.

Godard, C., Clark, R., Kerr, I., Telberg Madsen, P. and Payne, R. 2003. Preliminary report on the sperm whale data collected during the *Voyage of the Odyssey*. Paper SC/55/O17 presented to the IWC Scientific Committee, May 2003, Berlin. 8pp. [Paper available from the Office of this Journal].

Goffman, O., Granit, S.-L., Roditi-Elasar, M., Scheinin, A., Hadar, N. and Kerem, D. 2009. Rough-toothed dolphins (*Steno bredarensis*, G.Cuvier in Lesson, 1828) in Israeli Mediterranean waters: 1993–2008. 23rd Annual Conference of the European Cetacean Society, Istanbul, Turkey, 2–4 March 2009.

Gordon, J.C.D. 1987. The behaviour and ecology of sperm whales off Sri Lanka. PhD dissertation, Darwin College, University of Cambridge. 347pp.

Hermans, A. and Pistorius, P.A. 2008. Marine mammal diversity in the remote waters of Aldabra Atoll, southern Seychelles. *Atoll Res. Bull.* 564: 700. National Museum of Natural History.

Kasuya, T. and Ohsumi, S. 1966. A secondary sexual character of the sperm whale. *Sci. Rep. Whales Res. Inst., Tokyo* 20: 89–94.

Kasuya, T. and Wada, S. 1991. Distribution of large cetaceans in the Indian Ocean: data from Japanese sightings records, November–March. pp.139–70. *In*: Leatherwood, S. and Donovan, G.P. (eds). *Cetaceans and cetacean research in the Indian Ocean Sanctuary*. United Nations Environment Programme Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.

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

Khalaf, N.A. 2008. Cetacea Palaestina: the whales and dolphins in Palestinian waters. Cetacea species guide for Palestine. *Gazelle: the Palestinian Biological Bulletin* 83: 1–14.

Khan, B., Whitehead, H. and Dillon, M. 1993. Indicators of density-dependent effects from comparisons of sperm whale populations. *Mar. Ecol. Prog. Ser.* 93: 1–7.

Klinowska, M. 1991. *Dolphins, Porpoises and Whales of the World. The IUCN Red Data Book*. IUCN, Gland, Switzerland and Cambridge, UK. viii + 429pp.

Kruse, S.L., Leatherwood, S., Prematunga, W.P., Mendes, C. and Gamage, A. 1991. Records of Risso's dolphins, *Grampus griseus* in the Indian Ocean, 1891–1986. pp.67–77. *In*: Leatherwood, S. and Donovan, G.P. (eds). *Cetaceans and cetacean research in the Indian Ocean Sanctuary*. United Nations Environment Programme Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.

Leaper, R., Chappell, O. and Gordon, J. 1992. The development of practical techniques for surveying sperm whale populations acoustically. *Rep. int. Whal. Commn* 42: 549–60.

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., McDonald, D., Prematunga, W.P., Girton, P., Ilangakoon, A. and McBrearty, D. 1991. Records of the 'Blackfish' (killer, false killer, pilot, pygmy killer and melon-headed whales) in the Indian Ocean, 1772–1986. pp.33–65. *In*: Leatherwood, S. and Donovan, G.P. (eds). *Cetaceans and cetacean research in the Indian Ocean Sanctuary*. UNEP Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.

Marsden, P.T., Kerr, I. and Payne, R. 2004. Echolocation clicks of two free-ranging, oceanic delphinids with different food preferences: false killer whales *Psuedorca crassidens* and Risso's dolphin *Grampus griseus*. *J. Exp. Biol.* 207: 1811–23.

Miyazaki, N. and Perrin, W.F. 1994. Rough-toothed dolphin – *Steno bredanensis* (Lesson, 1828). pp.1–21. *In*: Ridgway, S.H. and Harrison, R. (eds). *The First Book of Dolphins*. Academic Press, London and San Diego. 416pp.

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

Notabartolo di Sciara, G., Addink, M., Baldwin, R.M., Rudolph, P. and Smeenk, C. 2007. A review of cetaceans from the Red Sea. 21st Annual Conference of the European Cetacean Society, San Sebastian, Spain, 23–25 April 2007.

Notabartolo di Sciara, G., Hanafy, M.H., Fouda, M.M., Afifi, A. and Costa, M. 2009. Spinner dolphin (*Stenella longirostris*) resting habitata in Sanadai Reef (Egypt, Red Sea) protected through tourism management. *Journal of the Marine Biological Association of the UK* 89(1): 211–16.

Ocean Alliance. 2009. *The voyage of the Odyssey Executive Summary, circumnavigating the globe: March 2000–August 2005*. Ocean Alliance, Lincoln, Massachusetts. 33pp. [Available at *http://www.oceanalliance.org*, accessed 1 October 2011].

Perrin, W.F. and Walker, W.A. 1975. The rough toothed porpoise *Steno bredanensis*, in the Eastern tropical pacific. *J. Mammal.* 56(4): 905–07.

Pierpoint, C., Gordon, J., Mathews, J., Sargent, T. and Frizell, J. 1997. Acoustic detections and incidental sightings of cetaceans in the Southern Ocean Sanctuary. *Rep. int. Whal. Commn* 47: 955–62.

Reijnders, P.J.H. 2001. Netherlands. Progress report on cetacean research, May 2000 to May 2001, with statistical data for the calendar year 2000. Paper SC/53/ProgRep Netherlands presented to the IWC Scientific Committee, July 2001, London. [Paper available from the Office of this Journal].

Reijnders, P.J.H. 2002. Netherlands Progress report on cetacean research, May 2001 to May 2002, with statistical data for the calendar year 2001. Paper SC/54/ProgRep Netherlands presented to the IWC Scientific Committee, April 2002, Shimonoseki, Japan. [Paper available from the Office of this Journal].

Robineau, D. 1991. Balaenopterid sightings in the western tropical Indian Ocean (Seychelles area), 1982–1986. *UNEP Mar. Mamm. Tech. Rep. 3*: 171–78.

Small, J.A. and Small, G.J. 1991. Cetacean observations from the Somali Democratic Republic, September 1985 through May 1987. pp.179–210. *In*: Leatherwood, S. and Donovan, G.P. (eds). *Cetaceans and Cetacean Research in the Indian Ocean Sanctuary*. United Nations Environment Programme Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica (NY)* 19(1–2): 1–50+6 maps.

Veldhuis, M.J.W., Kraay, G.W., van Bleijswijk, J.D.L. and Baars, M.A. 1997. Seasonal and spatial variability in phytoplankton biomass, productivity and growth in the northwestern Indian Ocean: the southwest and northeast monsoon, 1992–1993. *Deep-Sea Res. I* 44(3): 425–99.

Watkins, W.A., Tyack, P., Moore, K.E. and Notabartolo di Sciara, G. 1987. *Steno bredanensis* in the Mediterranean Sea. *Mar. Mammal Sci.* 3(1): 78–82.

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.

Wise, J.P., Payne, R., Wise, S.S., Lacerte, C., Wise, J., Gianios, C., Thompson, W.D., Perkins, C., Zheng, T., Zhu, C., Benedict, L. and Kerr, I. 2009. A global assessment of chromium pollution using sperm whales (*Physeter macrocephalus*) as an indicator species. *Chemosphere* 75(11): 1461–67.

Wray, P. and Martin, K.R. 1983. Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Commn (special issue)* 5: 213–41.

Wyrtki, K. 1973. Physical oceanography of the Indian Ocean. pp.18–36. *In*: Zeitschel, B. and Gerlach, A. (eds). *The Biology of the Indian Ocean*. Springer-Verlag, Berlin. 549pp.

Yukhov, V.L. 1969. Observations of cetaceans in the Gulf of Aden and the northwestern part of the Arabian Sea. pp.327–28. *In*: Arsenev, V.A., Zenkovich, B.A. and Chapskii, K.K. (eds). *Marine Mammals*. Akad. Nauk., Moscow. [Original in Russian, this article translated by S. Pearson, National Marine Mammal Lab., Seattle, USA].