Aquatic Mammals 2004, *30*(1), 111-124, DOI 10.1578/AM.30.1.2004.111

The Indo-Pacific Humpback Dolphin of the Arabian Region: A Status Review

Robert M. Baldwin,[1] Moth Collins,[1] Koen Van Waerebeek,[2] and Gianna Minton[1]

[1]*Oman Whale and Dolphin Research Group, P.O. Box 2531, CPO 111, Sultanate of Oman*
[2]*Peruvian Centre for Cetacean Research (CEPEC), Museo de los Delfines, Pucusana, Peru*

Abstract

Records of Indo-Pacific humpback dolphin sightings, strandings, and museum specimens in the Arabian region were compiled and used to review the distribution and status of this species. Nominal usage of *Sousa chinensis* (Osbeck, 1765) has been retained as a pragmatic measure, although the species present in the region resembles *Sousa plumbea* (Cuvier, 1828). Little is known about the ecology of this species in the region. Most available information on *S. chinensis* in the region originates from the Sultanate of Oman, where this species is among the most commonly recorded cetaceans; however, there is no absolute measure of abundance for anywhere in the region and the status of the species is unknown. Distribution is described for the region to include much of the Arabian (Persian) Gulf, Arabian Sea, Gulf of Aden, and Red Sea, but notably excludes the Gulf of Oman. This discontinuous distribution suggests the possible presence of discrete populations within the region. Beach-cast/dead individuals represent nearly two-thirds of all records (n=303) of this species in Oman. Live sightings indicate unusually large group sizes (up to 100 individuals) in the Arabian Sea and Arabian Gulf. Occasional associations with *Tursiops* sp. and *Delphinus capensis tropicalis* were documented. Mating behavior and the presence of calves were recorded in the months of April and May, and calves were also reported in June, October, November, and December. Threats to humpback dolphins in the Arabian region include incidental capture in fishing nets, coastal and offshore development (e.g., land reclamation, dredging, port and harbor construction), pollution, boat traffic, oil and gas exploration (including seismic surveying), military exercises, and biotoxins associated with red tide events. Evidence for historic and current directed catches of *S. chinensis* is limited, but opportunistic hunting may occur. Intraspecific variation in cranial measurements of individuals from the Arabian Sea coast of Oman fall within relative values found in individuals from the Saudi Arabian Gulf coast. Cranial abnormalities were few. Recommendations are made for conservation management-oriented research focusing on stock identity and status assessments, as well as for monitoring of fisheries by-catch, clearer definition of other threats, continued specimen and sample collection, and training of local scientists.

Key Words: Humpback dolphin, *Sousa*, Arabia, Persian Gulf, Middle East, Oman, distribution, abundancy conservation

Introduction

Available information on general and specific aspects of small cetaceans of the Arabian region, including *S. chinensis*, can be found in reviews by Leatherwood (1986), de Silva (1987), and Baldwin et al. (1999) and in results of surveys (Baldwin, 1995; Beadon, 1991; Frazier et al., 1987; Gallagher, 1991; Papastavrou & Salm, 1991; Preen, 1987; Small & Small, 1991). Research and observations of cetaceans in the region have focused on defined areas, with most available information on humpback dolphins coming from waters off the Sultanate of Oman and the southern shores of the Arabian Gulf, particularly the United Arab Emirates (UAE) and Saudi Arabia. In the Arabian region, *S. chinensis* was first identified from a skull collected in March 1948 from Karaman Island, Red Sea, by D. Thompson. The specimen is curated at the Natural History Museum in London (BM 1948.3.13.1) (Leatherwood, 1986). Subsequent records came from both the western (Al Robbae, 1970, 1974) and the eastern (Pilleri & Gihr, 1974) Arabian Gulf. Evidence that additional early work was in progress in the region is provided by Gallagher (1991), who documented collections of humpback dolphins from Bahrain, United Arab Emirates (UAE), and Oman that date back to the 1970s.

Surveys conducted specifically to observe and record cetaceans in the region began in 1973

(Pilleri, 1973). Several surveys were conducted in the region during the early 1980s (Alling et al., 1982; Harwood, 1981; Keller et al., 1982; Robineau & Rose, 1984). These included a survey of humpback dolphins in the UAE in 1984 (UAECD) and surveys conducted for dugongs (*Dugong dugon*) in the Arabian Gulf (1986 and 1999) and Red Sea (1986), which included documentation of sightings of humpback dolphins (Preen, 1989, in press a). Results of the latter survey prompted an investigation of extensive marine mammal mortality in the Arabian Gulf (Preen, in press b; ROPME, 1986). Other survey work in the Arabian Gulf focused specifically on small cetaceans, including *S. chinensis* (Baldwin, 1995, 1996; Robineau & Fiquet, 1994, 1996).

Recent data on humpback dolphins of the region come from incidental observations recorded during more general surveys of marine and coastal habitats, particularly along the coast of Oman (Papastavrou & Salm, 1991; Salm, Jensen, & Papastavrou, 1993; Weidleplan, 1992), as well as in Somalia (e.g., Schleyer & Baldwin, 1999; Small & Small, 1991). Cetacean research in Oman undertaken by the authors included systematic small boat surveys in nearshore and offshore waters, as well as surveys for beach-cast cetaceans.

The taxonomy of the genus *Sousa* remains unresolved. A wide variety of species' definitions have been suggested in the past few decades, from a single highly variable species, *S. chinensis,* to recognition of all five nominal species (see discussion by Rice, 1998). As a pragmatic measure, and until morphological and molecular genetic studies more firmly establish taxonomic relationships and nomenclature, we temporarily retain nominal usage of *S. chinensis* (Osbeck, 1765). Populations in the Arabian region show morphological affiliation to *S. plumbea* (Cuvier, 1829), however—a species recognized by Hershkovitz (1966) and followed by Rice (1998) for animals that inhabit waters from the western Bay of Bengal, the Arabian Sea, and south to South Africa. Fairly translated in English as "plumbeous dolphin," *S. plumbea* aptly describes the widely recognized colouration distinction from the lightly coloured Pacific humpback dolphin or Chinese white dolphin *S. chinensis*. The plumbeous dolphin also exhibits a highly conspicuous dorsal hump that is absent in *S. chinensis* (see Jefferson & Karczmarski, 2001), while its cranial characteristics indicate taxonomic differentiation at least at the subspecific level (Jefferson & Van Waerebeek, 2004).

Materials and Methods

Review of Available Literature and Databases

Data reviewed here come from published literature, and from databases of cetacean records for both the United Arab Emirates (UAE) and Oman, held by the Emirates Natural History Group, Abu Dhabi, and the Oman Natural History Museum (ONHM), respectively. These are referred to in this paper as the UAE Cetacean Database (UAECD) and the Oman Cetacean Database (OMCD). The latter is current and comprehensive, whereas the former was discontinued in 1995. These databases were established and maintained by one or more of the authors and incorporate records from a variety of sources, including published literature, data collected by the authors during systematic surveys at sea and along shorelines, data collected during other dedicated cetacean surveys, data from additional specimens curated at the ONHM and in private collections in the UAE, and some incidental data submitted by other recorders. All unpublished records referred to in the present account were either made by the authors or verified to have sufficient and reliable supporting data to enable discussion. Unconfirmed records or those lacking supporting information have been discounted and are not included. Because records from published sources also are stored in the databases, analysis of information included the sorting of data to ensure that no duplication of records occurred.

Study Area

We define the Arabian region as coastal and offshore waters of the Arabian Peninsula, including waters of the Arabian Gulf, Gulf of Oman, western Arabian Sea, Gulf of Aden, and Red Sea. Data from elsewhere, such as along the African coast of the Red Sea, are included in cases where these are considered relevant or appropriate.

Museum Specimens

To describe intraspecific cranial variation, 38 cranial measurements and tooth counts (Table 1), slightly modified from Perrin (1975), were taken for 28 skulls collected from the coasts of Oman (Table 2). The sample was not gender-stratified, as skulls were derived exclusively from beach-cast specimens, many of which were too decomposed to allow for sex determination. Cranial maturity was determined from the degree of fusion in seven indicative cranial suture lines (Van Waerebeek, 1993), while taking into account possible secondary suture de-fusing in highly weathered specimens.

Table 1. Cranial measurements and tooth counts used for descriptive craniometrics of *Sousa* from Oman; slightly modified from Perrin (1975).

1. Condylobasal length (cbl)
2. Rostrum length (rl)
3. Rostrum width at base (rwb)
4. Rostrum width at 60mm (rw60)
5. Rostrum width at ¼ length (rw14l)
6. Rostrum width at ½ length (rw12l)
7. Rostrum width at ¾ length (rw34l)
8. Premaxillary width at ½ length (prmx12l)
9. Tip of rostrum to right external nare (trextn)
10. Tip of rostrum to internal nares (trintns)
11. Preorbital width (prorbwi)
12. Postorbital width (postorw)
13. Zygomatic width (zygw)
14. Parietal width (parwi)
15. Greatest width of premaxillaries (gwprmx)
16. External nares width (extnsw)
17. Internal nares width (intnsw)
18. Temporal fossa length (temfosl)
19. Temporal fossa width (temfow)
20. Orbital length (orl)
21. Antorbital length (antprl)
22. Length upper tooth row (lutr)
23. Length lower tooth row (lltr)
24. Ramus length (ral)
25. Ramus height (rah)
26. Number alveoli upper left (ul)
27. Number alveoli upper right (ur)
28. Number alveoli lower left (ll)
29. Number alveoli lower right (lr)
30. Tooth width transverse (tw)
31. Bulla length (bul)
32. Bulla width (buw)
33. Periotic length (perl)
34. Height braincase (hbr)
35. Length braincase (lbr)
36. Maximum width palatine (mxwpal)
37. Maximum span occipital condyles (mxsocc)
38. Maximum width nasals (maxwnas)

Results and Discussion

Distribution

The range of *S. chinensis* in the Arabian region includes much of the Arabian Gulf, Arabian Sea, Gulf of Aden, and Red Sea (Figure 1). In the Arabian Gulf, records confirm its presence in Iraqi waters (Al Robbae, 1970, 1974), coastal and offshore waters of Bahrain (e.g., Gallagher, 1991), Saudi Arabia (e.g., Robineau & Fiquet, 1996), Kuwait (de Silva, 1987), Qatar (Leatherwood, 1986), UAE (e.g., Baldwin, 1995; Preen, 1989), in the Musandam region of Oman (Baldwin & Salm, 1994; Pilleri & Gihr, 1974), and off Iran (Pilleri & Gihr, 1974).

This species' distribution (Figures 2 & 3) extends into the coastal waters of the northern extreme of the Gulf of Oman as far south as 26°07'N, 56°23'E in Musandam. No sightings or strandings of *S. chinensis* have been reported between Musandam and Ra's Al Hadd (22°30'N, 59°49'E), which marks the boundary between the Gulf of Oman and the Arabian Sea (Baldwin & Salm, 1994; Salm et al., 1993). The range of *S. chinensis* appears to be continuous along the Arabian Sea coast of Oman (Baldwin & Salm, 1994), including some offshore islands such as Masirah. In some areas, the distribution of humpback dolphins in Oman spans coastal and island continental shelves that are separated by deep water, such as in the Musandam region, and, based on a single record only, at the island of Al Hallaniyah, Dhofar.

Evidence that the distribution of humpback dolphins extends south into Yemen is provided by records from Gulf of Aden shores (e.g., Leatherwood, 1986). *S. chinensis* also occurs along the African coast of the Gulf of Aden near Djibouti (Alling et al., 1982; Mörzer-Bruyns, 1960; Robineau & Rose, 1984; Small & Small, 1991) and along the coast of Somalia (Schleyer & Baldwin, 1999; Small & Small, 1991). In the Red Sea, the humpback dolphin has been documented along the Arabian coast by de Silva (1987) and Leatherwood (1986), and other evidence indicates its occurrence in the Gulf of Suez (Beadon, 1991; Smeenk et al., 2002).

Stock Identity

It is unclear if the apparent discontinuous distribution of *S. chinensis* between the population(s) in the Arabian Gulf and extreme north of the Gulf of Oman and populations in the Arabian Sea results from the influence of recent human population expansion and associated development or has an ecological basis. The possibility remains that humpback dolphins in different areas, for example in the Arabian Gulf, Gulf of Oman, Arabian Sea, and Red Sea, represent discrete populations (see also Jefferson & Van Waerebeek, 2004). Salm et al. (1993) suggested two discrete populations in Arabian waters: one in the Arabian Gulf and extreme north of the Gulf of Oman and one in the western Arabian Sea. Samples from humpback dolphins in Oman collected for genetic analyses currently all originate from beach-cast specimens collected along the Arabian Sea coast. Rosenbaum et al. (2002) provided some preliminary estimates of mtDNA diversity and population structure based on a 500 bp region

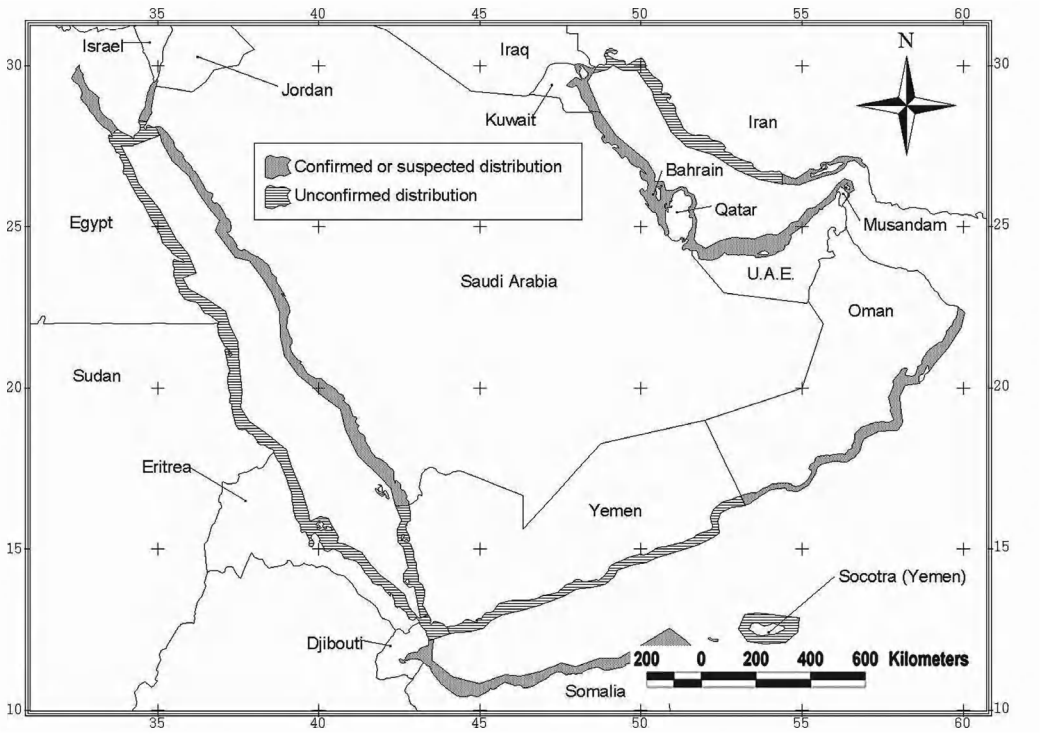

Figure 1. Distribution of humpback dolphins in Arabia

Table 2. Humpback dolphin skulls from Oman used for descriptive craniometrics

Adults	Subadults
Khaluf (ONHM 2864, 2865, 2866, 2889, 2958, 2975, 2983, 2959, 2986, 2987, 2988, 2990, 3040, 3041)	Khaluf (ONHM 2867, 2868, 2869, 2985, 2989, 2980)
Ra's Ru'ways (ONHM 2631, 2633)	Ra's Ru'ways (ONHM 2632, 3051)
An Nuqdah (ONHM 2635)	Dhofar, W. of Mughsayl (ONHM 3054, 3058)
Hallaniyah Islands (ONHM 2916)	

OMCD	Oman Cetacean Database (administrated by the Oman Whale and Dolphin Research Group)
UAECD	United Arab Emirates Cetacean Database (administrated by the Emirates Natural History Group)
UAE	United Arab Emirates
ONHM	Oman Natural History Museum, Muscat
BM	British Museum (Natural History), now known as the Natural History Museum, London
ZMA	Zoological Museum Amsterdam

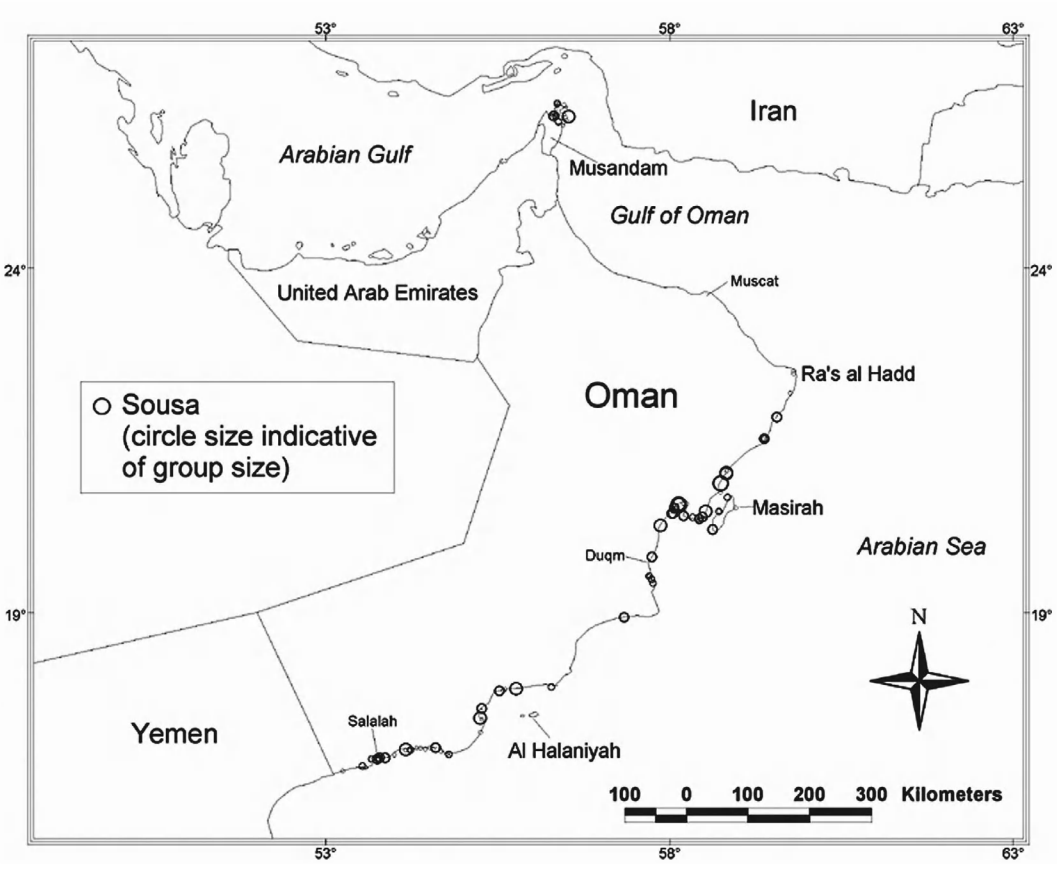

Figure 2. Records of live sightings of humpback dolphins in Oman

of the mtDNA control region. The relationships of humpback dolphins from southern Oman with those from northeast Oman are being examined with additional samples. Their relationship to other populations in the Arabian Sea and those distributed throughout the Indian Ocean is also being examined (Rosenbaum et al., in prep.).

Morphology and Cranial Morphometrics

In the Arabian region, and the northern Indian Ocean generally, humpback dolphins are typically uniformly plumbeous or brownish-grey and most closely resemble *S. plumbea* (Cuvier, 1829). Some individuals from the Musandam region of Oman present dark bluish-black longitudinal flecks on the body and may be associated with the *lentiginosa* (Gray, 1866) form, the holotype of which is from Vishakhapatam, India. This form is most probably synonymous with *S. plumbea* (Pilleri & Gihr, 1974; Ross, 1981; Ross et al., 1994). Osteologically, the *lentiginosa* form does not differ from the *plumbea* form (Pilleri & Gihr, 1972, 1974). Robineau and Fiquet (1996) described humpback dolphins from the Arabian Gulf coast of Saudi Arabia, and descriptions and photographs of humpback dolphins from the Musandam region and the Arabian Gulf appear in Baldwin and Salm (1994) and Baldwin (1995), respectively.

There is some published information on external morphometrics (n=4), craniometrics (n=3) and colouration for *S. chinensis* from the eastern Arabian Sea and the Gulf of Aden (Robineau & Rose, 1984) and limited study on the genus in Oman (Baldwin & Salm, 1994; OMCD). As in populations described from South Africa (Ross et al., 1994), the dorsal fin in northern Indian Ocean animals is elongated and thickened basally (the "hump") at all ages, becoming shorter and thinner mid-dorsally, thus forming a small finlike falcate structure. This feature is evident in all recent sightings and in photographic documentation of animals in the Arabian Gulf and Arabian Sea off Oman.

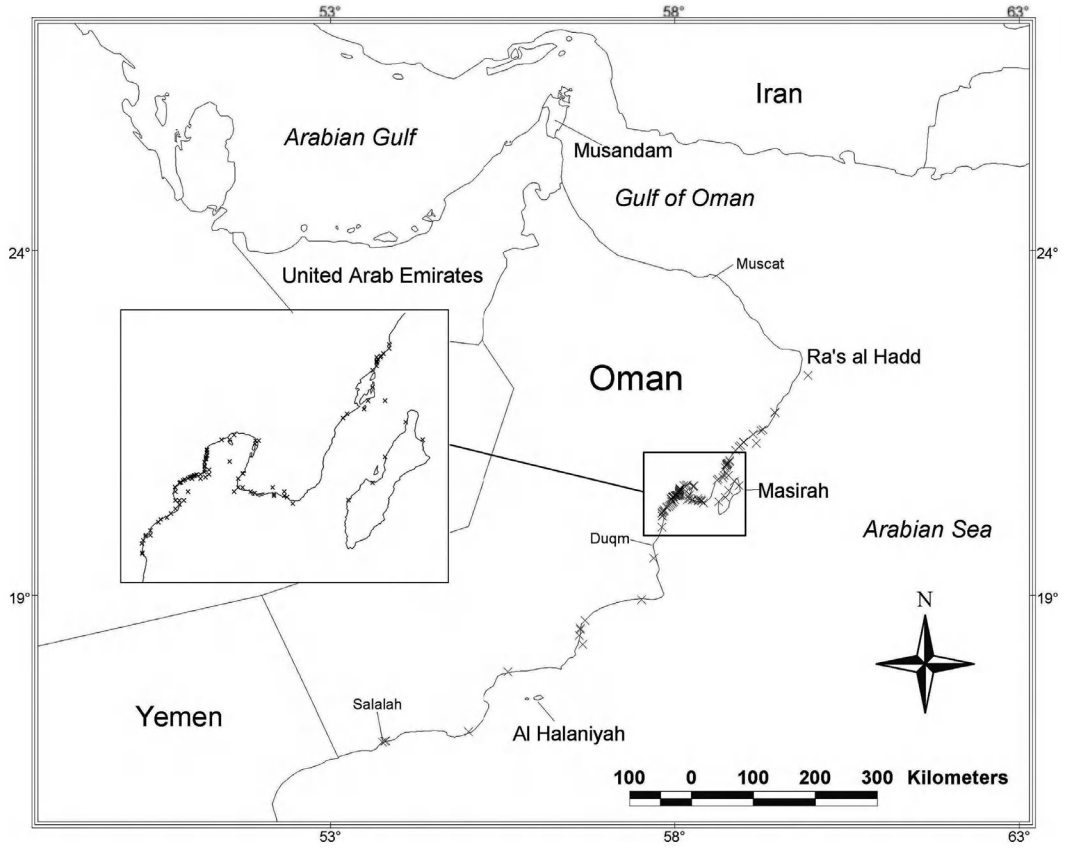

Figure 3. Records of dead humpback dolphins in Oman

Pilleri and Gihr (1972) provided photographic information for cranial and postcranial material of *S. chinensis* from Rehri Creek, Pakistan. They claimed the main difference between the vertebral formula of the nominal species *S. chinensis* and that of *S. plumbea* to be the number and relative length of the thoracic (Th) vertebrae (12 Th, 26% of the vertebral length in *S. chinensis*; 11 Th, 22-24% of the vertebral length in *S. plumbea*) (Pilleri & Gihr, 1974); however, the sample size (Pilleri & Gihr, 1972) was very small (n=3 and n=1 for *S. plumbea* and *S. chinensis* forms, respectively). Therefore, the thoracic region may be relatively longer in *S. chinensis* than in *S. plumbea*. There may also be some differences in configuration of the scapula; however, material to support these claims is very limited, and efforts should be directed to acquire adequate sample sizes of osteological specimens from different regions to allow for appropriate statistical analysis. The few organ and soft-tissue descriptions available for *Sousa* spp. are from specimens collected outside the Arabian Peninsula region (see Jefferson & Karzmarski, 2001).

Intraspecific variation in cranial measurements, both in absolute measurement (mm) and as a percentage of condylobasal length, are presented for cranially adult (n=18) and subadult (n=10) humpback dolphin skulls originating from the Arabian Sea coast of Oman between Ra's Al Hadd and Dhofar (Tables 4 and 5). The five cranial measurements for 13 specimens of humpback dolphins from the Arabian Gulf given by Robineau and Fiquet (1996) fall within the relative values (% CBL) found in our Arabian Sea specimens. Minimum absolute measurements were lower for the Arabian Gulf, but 9 of the 13 specimens in the Robineau and Fiquet sample "had not reached physical maturity," and, therefore, the samples are not directly comparable. Mean tooth counts in lower left (34.4) and upper left (35.8) tooth rows in the Arabian Gulf specimens seemed slightly higher than those from the Omani coasts (32.7 and 34.7, respectively; see Table 3); however, no statistical analysis has been applied to the raw data.

Table 3. Curated specimens (skulls, partial and complete skeletons) from the Arabian Region

Museum	Accession number	Country of origin
BM	1970.1505, 1970.1506, 1970.1507, 1970.1508, 1970.1509, 1970.1510, 1973.1748, 1984.1758, 1984.1759, 1984.1761, 1984.1762, 1984.1763, 1984.1768	Bahrain
BM	1955.2.23.1	Gulf of Aden
BM	1924.9.11.1	Suez Canal
BM	1948.3.13.1, 1948.3.13.2, 1954.9.9.5, 1962.2.19.1, 1962.7.19.1	Red Sea
MC	47000	Qatar
ONHM	439, 523, 524, 525, 526, 683, 684, 1015, 1016, 1017, 1020, 1022, 1045, 1047, 1049, 1050, 1222, 1483, 1516, 1557, 1558, 1559, 1560, 1564, 1571, 1572, 1662, 1679, 1911, 1918, 1972, 1973, 2482, 2631, 2632, 2633, 2635, 2677, 2864, 2866, 2867, 2868, 2869, 2889, 2958, 2959, 2975, 2980, 2983, 2985, 2986, 2987, 2988, 2989, 2990, 2916, 3040, 3041, 3051, 3054, 3058, 3062, 3064, 3077, 3080, 3083, 3099, 3100, 3101 Oman	
ZMA	19.781, 19.782	Red Sea
ZMA	20.721, 20.725, 20.726, 20.727, 20.728, 20.736, 20.737, 20.738, 20.899, 21.431, 21.437, 21.450, 21.451, 25.221	Oman
CEPEC	KVW3035	Oman
MNHN	1993-88	Saudi Arabia

BM British Museum (Natural History), now known as the Natural History Museum, London
MC Museum of Comparative Zoology, Cambridge, Massachusetts USA
ONHM Oman Natural History Museum, Muscat
CEPEC Museo de los Delfines, CEPEC, Pucusana, Peru
ZMA Zoological Museum Amsterdam
MNHN Musée National d'Histoire Naturelle, Paris

Cranial Abnormalities

None of the 28 skulls from Oman that were examined showed characteristic (basket-like) bone lesions of the ventral cranium commonly associated with *Crassicauda* spp. nematode infestations (e.g., Raga et al., 1982), and in general, cranial aberrations were few. The proximal ends of both upper tooth rows of adult skull ONHM 2864 exhibited, symmetrically, an unusual vacuolar-like depression with smooth contours from unknown origin. The right exoccipitale of ONHM 2631 showed evidence of a healing fracture, and significant exostosis was present on the right condylus occipitalis of adult ONHM 2987.

Group Size and Status

The status of humpback dolphins in the Arabian region is unknown, and there have been no absolute measures of abundance of *S. chinensis* or any other species to our knowledge. Humpback dolphins are one of the most commonly observed cetaceans in Oman. A high percentage of records of live sightings are incidental observations made from shore, while boat-based surveys, which have not focused on nearshore areas, have produced relatively low encounter rates. Of all confirmed records of *S. chinensis* in Oman, 63% are of dead individuals (mostly as beach-cast specimens), a higher percentage than that recorded for any other species in the OMCD. This may be partially attributed to the relative lack of nearshore boat survey effort. In the UAE, records of *S. chinensis* also are relatively high, but include only a small percentage (5%) of dead individuals (UAECD). Although this difference in the relative proportion of dead and live individuals in Oman and the UAE requires further investigation, it may reflect the higher coastal fisheries pressures in Oman (see below).

The majority of live sightings of humpback dolphins in Oman (96 of 110) are of groups ranging in size from 1 to 20 individuals, although some large groups of up to 100 individuals have been documented (see below). Average group size is 11.7 (SD=14.6, n=110). Similar average group sizes are revealed for the much smaller datasets available for the UAE (UAECD) and Somalia (Schleyer & Baldwin, 1999).

Records of humpback dolphins in the western Arabian Gulf include 12 skulls collected from Bahrain between February 1969 and April 1974 by Gallagher (1991) and 50 sightings of groups of

Table 4. Cranial morphometrics (in mm) and tooth counts of cranially adult Indian Ocean humpback dolphins (n=18) from Oman

Cranial measurements	n	Minimum	Maximum	Mean	Standard deviation
CBL	13	502.0	562.0	521.615	16.546
RL	14	301.0	347.0	317.821	13.129
RWB	16	107.00	121.00	113.3437	3.7493
RW60	15	72.00	83.00	78.1333	3.0965
RW14L	14	66.50	76.50	72.2857	2.5997
RW12L	14	41.50	49.00	45.9643	2.0982
RW34L	13	29.00	34.50	31.5769	1.8467
PRMX12L	14	24.50	34.00	28.3929	2.3220
TREXTNS	13	337.00	384.00	357.7692	13.4855
TRINTNS	11	351.50	392.00	363.6818	13.1154
PRORBWI	15	175.00	201.00	182.3667	7.1651
POSTORW	16	202.00	229.00	208.9375	7.1621
ZYGW	16	198.00	226.00	206.5625	7.8270
PARW1	16	150.50	170.00	159.2813	5.1768
GWPRMX	16	79.50	87.50	82.9688	2.3977
EXTNSW	17	52.50	62.00	56.2059	2.6871
INTNSW	14	58.00	64.00	61.1786	1.7498
TEMFOSL	16	100.00	122.00	107.0625	5.7500
TEMFOW	16	78.50	93.00	84.8750	3.8622
ORL	16	53.5	60.5	57.313	1.905
ANTPRL	15	37.5	47.5	43.733	2.871
LUTR	14	263.0	310.0	279.500	12.468
LLTR	5	235.0	272.0	260.800	15.023
RAL	5	436.0	446.0	440.200	4.494
RAH	5	81.5	88.0	85.200	2.660
UL	10	33.0	37.0	34.700	1.418
UR	11	33.0	36.0	34.182	1.168
LL	3	31.0	34.0	32.667	1.528
LR	5	31.0	34.0	32.800	1.095
TW	6	5.6	6.1	5.800	.210
BUL	1	36.0	36.0	36.000	.
BUW	1	19.9	19.9	19.900	.
PERL	1	32.5	32.5	32.500	.
HBR	16	129.0	148.0	133.500	4.861
LBR	16	140.5	167.0	150.938	5.651
MXWPAL	16	44.5	52.5	48.219	2.316
MXSOCC	16	91.0	115.0	103.781	6.565
MAXWNAS	14	48.5	58.0	52.964	2.735

1-15 individuals near Jubail between December 1991 and April 1993 (Robineau & Fiquet, 1996). Preen (1989) reported 25 positive sightings of humpback dolphins in groups of 1-17 individuals during aerial surveys for dugongs in the Arabian Gulf in 1986. The majority of these sightings were in nearshore waters of Saudi Arabia, Bahrain, and Qatar, despite the surveys also covering most of the coast of the UAE. In 1999, a repeat aerial survey was conducted in UAE waters only (Preen, in press a). Although the nature of these surveys prevented estimation of population size, an index of abundance was obtained, and the results provide the only trend data for the region. The data indicate a statistically significant decline in abundance of 70% of all cetaceans observed, which included the humpback dolphin, bottlenose dolphin, and finless porpoise (*Neophocaena phocaenoides*). This long-term decline is partly attributed to three die-offs of marine mammals and other wildlife coincident with the Norwuz oil

Table 5. Cranial morphometrics expressed as percentage of condylobasal length for Indian Ocean humpback dolphins from Oman; sample includes cranially adult and subadult specimens.

Cranial measurements	n	Minimum	Maximum	Mean		Standard deviation
	Statistic	Statistic	Statistic	Statistic	Std error	Statistic
RL%	20	59.4	62.2	60.872	.203	.907
RWB%	20	20.70	22.82	21.8903	.1327	.5935
RW60%	19	14.37	15.98	15.1841	.1033	.4502
RW14L%	19	13.23	15.14	14.0967	.1294	.5641
RW12L%	19	8.27	9.70	9.0494	.1082	.4717
RW34L%	16	5.48	6.89	6.1393	9.697E-02	.3879
PRMX12L%	19	4.63	6.31	5.5419	9.051E-02	.3945
TREXTNS%	20	66.47	69.43	68.3093	.2045	.9144
TRINTNS%	16	67.42	70.75	69.3226	.2690	1.0760
PRORBWI%	19	34.06	36.55	35.2663	.1698	.7402
POSTORW%	19	39.32	42.12	40.4749	.1753	.7641
ZYGW%	20	38.77	41.65	40.0384	.1957	.8754
PARWI%	20	28.40	34.59	31.2207	.3347	1.4967
GWPRMX	19	15.19	17.01	16.0333	.1052	.4586
EXTNSW%	19	10.00	11.83	10.9427	.1040	.4535
INTNSW%	18	11.01	13.01	11.8150	.1142	.4846
TEMFOSL%	20	19.15	21.71	20.5142	.1715	.7671
TEMFOW%	20	15.57	17.62	16.3964	.1387	.6205
ORL%	20	10.1	12.1	11.085	.106	.475
ANTPRL%	20	7.4	9.1	8.423	.100	.448
LUTR%	18	50.6	55.2	53.274	.282	1.197
LLTR%	5	44.3	53.3	50.688	1.622	3.626
RAL%	4	85.5	86.4	85.821	.192	.384
RAH%	4	16.0	17.4	16.578	.284	.569
HBR%	20	24.4	28.0	25.992	.221	.987
LBR%	20	27.7	31.1	29.260	.199	.889
MXWPAL%	19	8.4	10.2	9.346	.119	.518
MXSOCC%	20	17.5	23.0	20.010	.317	1.416
MAXWNAS%	14	8.9	11.4	10.207	.173	.646

spill, the Iran-Iraq War, and the Gulf War Oil Spill (Preen, in press b).

Additional records of this species in the region are documented by Pilleri and Gihr (1974) who recorded 18 animals, mostly singly or in pairs, off the southern Iranian coast in the Gulf of Oman. There appear to be no published data on the abundance of the humpback dolphin in the Red Sea, although Frazier et al. (1987) suggested that it is "present in small numbers throughout the Red Sea and Gulf of Suez" (p. 306); however, Smeenk et al. (2002) reported only one record from the Red Sea (Suez Canal).

Although the above data indicate that humpback dolphins generally occur in small groups, much larger groups also occur in the Arabian region (see Figures 2 & 3). Along the Arabian Sea coast of Oman, humpback dolphins have been recorded in groups of 30 individuals or more on ten occasions, including records of three groups of over 50 individuals, one of which was a group of approximately 100 individuals. The latter may have been an aggregation of several groups, possibly involved in breeding (R. Salm, *in litt.* to R. Baldwin, 19 March 1998). A large group (35 individuals) also is documented for the Musandam region of northern Oman. Relatively large groups of humpback dolphins, comprising 30 or more individuals, have also been encountered in offshore waters of Abu Dhabi, UAE (Baldwin, 1995). Such large groups are atypical of *Sousa* spp., which generally occur in small groups of up to 25 individuals (Ross et al., 1994).

Incidental Takes
Gallagher (1991) suggested that humpback dolphins and other cetacean species suffer incidental capture and drowning in fishing nets in Oman. Five butchered individuals discovered on beaches in Oman (Papastavrou & Salm, 1991; OMCD) may have been incidentally captured in fishing nets or may have been intentionally caught. In addition, five dead individuals have been found entangled in fishing nets or ropes, and a further eight individuals with typical scarring/rostrum damage from net entanglement (Read & Murray, 2000) are listed in the OMCD. There are several other records of dead animals on beaches in the vicinity of fishing boat landing sites and/or villages. Given the abundance of set and lost or discarded fishing nets in the shallow coastal waters of Oman (Salm, 1992) and the coastal distribution of *S. chinensis*, drowning in inshore gill nets represents a major potential threat to this species in the region.

Directed Catches
Humpback dolphins reportedly were hunted in former years in the Arabian Gulf and Red Sea (Ross et al., 1994). Leatherwood and Reeves (1983) suggested that hunting also took place in the Arabian Sea; however, neither publication pointed to evidence upon which these statements are based. Alling (1983) mentioned a limited dolphin fishery off Masirah Island in the Arabian Sea, without mentioning species. Gallagher (1991), Papastavrou and Salm (1991), and Baldwin and Salm (1994) all suggested a limited directed catch of cetaceans in Oman, based on observations of butchered animals, including humpback dolphins, and interviews with fishers from the islands of Masirah and al Halaaniyat. There is some anecdotal as well as photographic evidence viewed by the authors for the continued hunting of dolphins in Oman using small, motorised boats and handheld harpoons. The effect of such practices on this species' status is unknown. Evidence for the deliberate capture of humpback dolphins is scant, however, and we believe that this practice is probably restricted in the region to occasional opportunistic hunting.

A single humpback dolphin was intentionally caught in a purse seine net in the Gulf of Suez, Red Sea, in January 1981 as part of a programme to supply animals to a dolphinarium/aquarium in the region. The individual was not retained, however, and was released immediately after capture (Beadon, 1991). A humpback dolphin caught by fishers in Kuwait was reported by de Silva (1987). Whether this animal was deliberately or incidentally caught is not stated.

Other Threats
Coastal and offshore development in the Arabian region leads to loss and degradation of *S. chinensis* habitat. This may be particularly severe in the Arabian Gulf, but also threatens parts of the Arabian Sea coast of Oman, where there are several new port and harbor developments. Pollution and boat traffic, particularly in the Arabian Gulf (Baldwin, 1995), also threaten this species. Disturbance to small cetaceans from offshore oil and gas exploration—for example, seismic surveys—also is documented (Baldwin, 1997). War and military exercises are another source of disturbance (OWDRG, 2002a) and habitat degradation (Preen, in press b).

Gallagher (1991) suggested that poisoning caused by toxins originating from phytoplankton associated with "red tides" may have caused the death of eight humpback dolphins found near Duqm (approximately 19°40'N, 57°42'E) on the Arabian Sea coast of Oman in April 1990. Toxic phytoplankton associated with seasonal deep-water upwellings may have been a causal factor of mass mortality of sea turtles, fishes, and other taxa along the coast of southern Oman during 2001 and 2002 (OWDRG, 2002b). At least 13 humpback dolphins, among other cetaceans, were recorded as having died during this period (OMCD).

Habitat and Ecology
In the Arabian region, *S. chinensis* can mainly be found in coastal waters with soft sediments and a low-energy sandy shoreline; however, in the Dhofar and Musandam regions of Oman, parts of its range include rocky substrate with a higher-energy, rocky shoreline. In some of these areas, there are several sightings of humpback dolphins over coastal waters exceeding 40 m in depth. There are only two permanent rivers in the region (the Tigris and the Euphrates) and, thus, little available estuarine habitat with which this species is commonly associated elsewhere in the world (Ross et al., 1994).

Humpback dolphins have been observed feeding in shallow waters in the Arabian Gulf, with individuals herding fishes of unknown identity onto exposed sand banks and apparently deliberately beaching to seize their prey (Baldwin, 1995). The only other reference to such behavior by this genus is reported from Bazaruto, Mozambique (Peddemors & Thompson, 1994). Fish otiliths collected from the stomach of an adult individual found on Merawah Island (24°28'N, 53°23'E), Abu Dhabi, and now at the Centre for Dolphin Studies, Port Elizabeth, South Africa, have yet to be identified (Baldwin & Cockcroft, unpublished information). Salm (pers. comm., 1991) suggested that humpback dolphins in Oman may feed on

sciaenid fishes. Stomach samples collected from eight dead individuals in southern Oman indicate a high incidence of cephalopods and crustaceans in the diet, although detailed analysis has yet to be undertaken (OMCD).

Association with Other Species

Humpback dolphins have been observed in association with both *Tursiops* sp. and *D. capensis tropicalis* in Arabia, but only very rarely. The latter involved a single individual swimming with a group of common dolphins close to shore in Musandam, Oman. Interaction with bottlenose dolphins includes a record of aggressive behavior shown by a group of 15 individuals towards a lone humpback dolphin (OMCD), as well as two non-aggressive associations. Schleyer and Baldwin (1999) observed humpback dolphins off the Gulf of Aden shoreline of northern Somaliland on three occasions, two of which were in mixed schools with bottlenose dolphins. On one occasion, a single humpback dolphin among a group of bottlenose dolphins exhibited surfacing behavior more closely resembling that of the latter species than its own (Baldwin, pers. obs.). Karczmarski (1999) recorded groups of humpback dolphins mixed with bottlenose dolphins infrequently in Algoa Bay, South Africa, whereas Stensland et al. (2001) reported such mixed groups as common in the Menai Straits, Zanzibar, citing predator protection or resource/habitat competition as a possible explanation.

Life History

Observations of socialising and adults with small calves in the months of April and May are listed in the UAECD. The OMCD lists infrequent sightings of calves during the same two months, as well as in June, October, November, and December, and a single sighting of up to ten calves in a group of over 50 individuals in October. Robineau and Rose (1984) recorded a newborn calf in Djibouti, Gulf of Aden in the same month. There are also two reports of dead calves found in Oman: one was found on 25 March 1991 at 20°44'N, 58°47'E, measuring 1.1 m in length, while the second was found on 16 December 2001 at 20°30'N, 58°01'E, measuring just under 1 m in length. The teeth had not yet erupted on either specimen (OMCD). Perrin and Reilly (1984), who reviewed reproductive parameters in delphinids, cited 97 cm (n=9) as the smallest known individual of *Sousa chinensis* (all regions), lacking an estimate for neonate length. These data largely correlate with the observations of Karczmarski (1996) for South African populations in which 70% of births occur between October and May. The largest specimen on record in Oman was a beach-cast adult male, which measured 3.14 m in length (OMCD reference number 18-12-01-02). This is considerably larger than the maximum of 2.8 m recorded elsewhere in the world (Jefferson & Karczmarski, 2001; Ross et al., 1994).

Recommendations for Conservation Management and Future Research

Development of appropriate conservation management of humpback dolphins in the Arabian region is urgently required. Such management should be based upon results of scientific research. Priority should be given to studies of stock identity and status assessments as well as systematic monitoring of by-catch in fisheries. Research into other threats is also required, which would be aided by the establishment of networks to detect, record, examine, and collect biological samples from stranded cetaceans on a systematic basis. Continued collection and curation of specimens is encouraged and should include biopsies and other tissue samples for genetic analyses of population structure and for pollutant assays. Continuation and expansion of studies of the systematics of humpback dolphins is also required. For these and other studies, there is an urgent need for training and increased involvement of local scientists.

Acknowledgments

The authors thank the Governments of Oman and the United Arab Emirates (UAE) for permission to collect information, specimens, and samples, particularly the Ministry of Regional Municipalities, Environment and Water Resources in Oman, and the Environmental Research and Wildlife Development Agency, UAE. The assistance and cooperation of the Oman Natural History Museum and the Emirates Natural History Group is also gratefully acknowledged. Vic Cockcroft, Anna Hywel-Davies, Fergus Kennedy, and Andy Willson all provided valuable contributions during field surveys for which thanks are extended. Koen Van Waerebeek was supported by CMS, CSI, GSM, IFAW, IWC, and MER. We also thank the reviewers and editors for their valuable comments on the draft manuscripts.

Literature Cited

Al Robbae, K. (1970). First record of the speckled dolphin, *Sotalia lentiginosa* Gray, 1866, in the Arabian Gulf. *Säugetierk Mitt*, *28*, 227-228.

Al Robbae, K. (1974). *Tursiops aduncus*, bottlenose dolphin: A new record for the Arab Gulf, with notes on cetacea of the region. *Bulletin of the Basrah Natural History Museum*, pp. 7-16.

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

Alling, A. (1986). Records of odontocetes in the northern Indian Ocean (1981-1982) and off the coast of Sri Lanka (1982-1984). *Journal of the Bombay Natural History Society*, *83*, 376-394.

Alling, A., Gordon, J., Rotten, N., & Whitehead, H. (1982). *WWF-Netherlands Indian Ocean sperm whale study: 1981-1982 interim report* (SC/34/Sp9). Paper presented to the IWC Scientific Committee, June 1982. (Unpublished). 46 pp. (Available from the IWC, The Red House, 135 Station Road, Impington, Cambridge, UK.)

Baldwin, R. M. (1995). *Whales and dolphins of the United Arab Emirates*. Dubai, UAE: Emirates Printing Press. [Also in Arabic]. 111 pp.

Baldwin, R. M. (1996). Marine mammals of the United Arab Emirates. In *Natural Emirates* (pp. 199-212). London: Trident Press.

Baldwin, R. M. (1997). *Records of wildlife and observed operational impacts on wildlife. Seismic Survey, Block 22, Oman* (pp. 1-76). (Environmental Observation Report 1). Unpublished report for Triton Oman Inc., Oman.

Baldwin, R. M., Gallagher, M. D., & Van Waerebeek, K. (1999). A review of cetaceans from waters off the Arabian Peninsula. In M. Fisher, A. Spalton, & S. Gazanfar (Eds.), *Oman's natural history* (pp. 161-189). Leiden: Backhuys Publishers.

Baldwin, R. M., & Salm, R. V. (1994). *Whales and dolphins along the coast of Oman*. Muscat, Sultanate of Oman: Muscat Printing Press. 65 pp.

Basson, P. W., Burchard, J. E., Hardy, J. T., &. Price, A. R. G. (1977). *Biotopes of the Western Arabian Gulf*. Dhahran: Aramco. 284 pp.

Beadon, J. J. (1991). A note on cetaceans seen and live-captured in the Gulf of Aqaba and the Gulf of Suez, 15 September 1980 through 1 September 1981. *UNEP, Marine Mammal Technical Report*, *3*, 111-114.

Cuvier, G. (1829). *Le regne animal distribue d'apres son organization, pour servir de base a l'histoire naturelle des animaux et d'introduction a l'anatomie comparee.* Chez Deterville, Libraire.

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 the Red Sea. *Journal of the Bombay Natural History Society*, *84*, 505-525.

Frazier, J. G., Bertram, G. C., & Evans, P. G. H. (1987). Turtles and marine mammals. In A. J. Edwards & S.M. Head (Eds.), *Red Sea* (pp. 288-314). Oxford: Pergammon Press.

Gallagher, M. D. (1991). Collections of skulls of cetacea: Odontoceti from Bahrain, United Arab Emirates and Oman, 1969-1990. *UNEP, Marine Mammal Technical Report*, *3*, 89-97.

Gray, J. E. (1866). *A catalogue of seals and whales in the British Museum* (2nd ed.). London: British Museum. 402 pp.

Harwood, J. (1981). *Observation of cetaceans in the Arabian Sea, November-December 1980* (Document 7). Presented to the Workshop to Plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary, Zeist, Netherlands. (Unpublished). 7 pp.

Hershkovitz, P. (1966). *Catalog of living whales.* Washington, DC: Smithsonian Institution. 259 pp.

Jefferson, T. A., & Karczmarski, L. (2001). *Sousa chinensis. Mammalian Species*, *655*, 1-9.

Jefferson, T. A., & Van Waerebeek, K. (2004). Geographic variation in skull morphology of humpback dolphins (*Sousa* spp.). *Aquatic Mammals*, *30*(1), 3-17.

Karczmarski, L. (1996). *Ecological studies of humpback dolphins* Sousa chinensis *in the Algoa Bay region, Eastern Cape, South Africa*. Ph.D. thesis, University of Port Elizabeth, Port Elizabeth, South Africa.

Karczmarski, L. (1999). Group dynamics of humpback dolphins *Sousa chinensis* in the Algoa Bay region, South Africa. *Journal of Zoology, London*, *249*, 283-293.

Keller, R. W., Leatherwood, S., & Holt, S. J. (1982). Indian Ocean cetacean survey, Seychelles Islands, April through June 1980. *Reports of the International Whaling Commission*, *32*, 503-513.

Leatherwood, S. (1986). Whales, dolphins and porpoises of the Indian Ocean Sanctuary: A catalogue of available information. *Hubbs Marine Research Centre Technical Report*, 87-197.

Leatherwood, S., & Reeves, R. R. (1983). *The Sierra Club handbook of whales and dolphins*. San Francisco: Sierra Club Books. 302 pp.

Mörzer-Bruyns, W. F. J. (1960). The ridgebacked dolphin of the Indian Ocean. *Malayan Nature Journal*, *14*, 159-165.

Oman Whale and Dolphin Research Group (OWDRG). (2002a). *Saif Saree'a II joint forces military operations Sultanate of Oman marine life surveys and environmental monitoring.* (Unpublished report). 41 pp.

OWDRG. (2002b). *A rapid assessment of the causes and extent of a mass stranding of green turtles in the Sultanate of Oman.* Final report prepared for MCS. (Unpublished report).

Osbeck, P. (1765). *Reise nach Ostindien und China.* Rostock, Germany: Koppe.

Papastavrou, V., & Salm, R. V. (1991). A note on the recent sightings of cetaceans in Oman: Ra's Suwadi to Rakhyut. *UNEP, Marine Mammals Technical Report*, *3*, 211-218.

Peddemors, V. M., & Thompson, G. (1994). Beaching behaviour during shallow water feeding by humpback dolphins *Sousa plumbea*. *Aquatic Mammals*, *20*(1), 65-67.

Perrin, W. F. (1975). Variation of spotted and spinner porpoise (genus *Stenella*) in the eastern tropical Pacific and Hawaii. *Bulletin of the Scrips Institution of Oceanography*, *21*, Berkeley: University of California Press. 206 pp

Perrin, W. F., & Reilly, S. B. (1984). Reproductive parameters of dolphins and small whales of the family Delphinidae. *Reports of the International Whaling Commission*, *6* (Special Issue), 97-133.

Pilleri, G. 1973. *Cetologische expedition Zum Indus Perzischen Golf und Forschungsreise Nach Goa und Thailand im Jahre 1973*. Waldau-Bern: Verlag Hirnanatomisches Institut. [In German].

Pilleri, G., & Gihr, M. (1972). Contribution to the knowledge of the cetaceans of Pakistan with particular reference to the genera *Neomeris*, *Sousa*, *Delphinus* and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaeorientalis*). In *Investigations on Cetacea*, *4*, 107-162.

Pilleri, G., & Gihr, M. (1974). Contribution to the knowledge of the cetaceans of Southwest and Monsoon Asia (Persian Gulf, Indus Delta, Malabar, Andaman Sea, and Gulf of Siam). In G. Pilleri (Ed.), *Investigations on cetacea, Volume 5* (pp. 95-150). Berne, Switzerland: Institute of Brain Anatomy, University of Berne.

Preen, A. (1987). Dugongs, dolphins and porpoises. In C. Cross (Ed.), *Mammals of the southern gulf* (pp. 74-77). Dubai: Motivate Publishing.

Preen, A. (1989). Dugongs. Vol. 1: The status and conservation of dugongs in the Arabian Region. *MEPA Coastal and Marine Management Series* (Report No. 10). Jeddah: MEPA. 200 pp.

Preen, A. (In press a). Distribution, abundance and conservation status of dugongs and dolphins in the southern and western Arabian Gulf. *Biological Conservation*.

Preen, A. (In press b). Die-offs of marine mammals and other wildlife in the Arabian Gulf coincident with the Norwuz oil spill, the Iran-Iraq war and the Gulf War oil spill. *Biological Conservation*.

Raga, J. A., Casinos, A., Filella, S., & Raduan, A. (1982). Notes on cetaceans of the Iberian coasts. V. *Crassicauda grampicola* Johnston & Mawson, 1941 (*Nematoda*) cause of injuries in the pterygoids of some specimens of *Grampus griseus*. *Säugetierk Mitt*, *30*(4), 315-318.

Read, A. J., & Murray, K. T. (2000). Gross evidence of human-induced mortality in small cetaceans. *NOAA Technical Memorandum* (NMFS-OPR-15).

Rice, D. W. (1998). *Marine mammals of the world: Systematics and distribution* (Special Publication 4). San Francisco: Society for Marine Mammalogy. 231 pp.

Robineau, D., & Fiquet, P. (1994). Cetaceans of the Gulf Sanctuary and adjacent waters. In *Establishment of a marine habitat and wildlife sanctuary for the Gulf region. Final report for Phase II* (pp. 501-513). Jubail and Frankfurt: CEC/NCWCD.

Robineau, D., & Fiquet, P. (1996). The cetacea of the Jubail Marine Wildlife Sanctuary, Saudi Arabia. In *A marine wildlife sanctuary for the Arabian Gulf: Environmental research and conservation following the 1991 Gulf War oil spill* (pp. 438-458). Frankfurt: NCWCD, Riyadh and Senckenberg Institute.

Robineau, D., & Rose, J. M. (1984). Les cétacés de Djibouti. Bilan des connaissances actuelles sur la fauna cétologique de la mer Rouge at du golfe d'Aden. *Bulletin of the Museum of Natural History, Paris*, (4)*6*(1), 219-249.

ROPME. (1986). *Report of the first meeting of experts on mortality of marine mammals* (November 22-23, 1980). Kuwait: ROPME.

Rosenbaum, H. C., Glaberman, S., Jefferson, T., Collins, T., Minton, G., Peddemors, V., & Baldwin, R. (2002). *Phylogenetic relationships and population structure among humpback dolphins based on mtDNA variation* (Document SC/54/SM34). Presented to the 54th meeting of the International Whaling Commission.

Ross, J. P. (1981). *Recent marine mammal sightings in the Sultanate of Oman (1980/1981)* (Document 23). Presented at the Workshop to Plan a Programme of Scientific Research on Cetaceans in the Indian Ocean Sanctuary, September 28-October 1, Zeist, Netherlands. (Unpublished).

Ross, G. J. B., Heinsohn, G. E., & Cockcroft, V. G. (1994). Humpback dolphins *Sousa chinensis* (Osbeck, 1765), *Sousa plumbea* (G. Cuvier, 1829) and *Sousa teuszii* (Kükenthal, 1892). In S. H. Ridgway & R. Harrison (Eds.), *Handbook of marine mammals. Volume 5: The first book of dolphins* (pp. 23-42). New York: Academic Press.

Salm, R. V. (1991). *Live and beached cetacean observations, Sultanate of Oman: Scientific Results of the IUCN Coastal Zone Management Project* (CZMP4:F14). Report prepared for the Ministry of Commerce and Industry, Sultanate of Oman. (Unpublished). 26 pp.

Salm, R. V. (1992). *Impact of fisheries on environment and wildlife, Sultanate of Oman: Scientific results of the IUCN Coastal Zone Management Project* (CZMP4: F17). Report prepared for the Ministry of Commerce and Industry, Sultanate of Oman. (Unpublished). 19 pp.

Salm, R. V., Jensen, R. A. C., & Papastavrou, V. A. (1993). *Marine fauna of Oman: Cetaceans, turtles, seabirds and shallow water corals*. Gland, Switzerland: IUCN. 66 pp.

Schleyer, M. H., & Baldwin, R. M. (1999). *Biodiversity assessment of the Northern Somali Coast east of Berbera*. Gland, Switzerland: IUCN East Africa Programme, Somali Natural Resources Management Programme, IUCN. 42 pp.

Small, J. A., & Small, G. (1991). Cetacean observations from the Somali Democratic Republic, September 1985 through May 1987. *UNEP, Marine Mammal Technical Report*, *3*,179-210.

Smeenk, C, M., Addink, J., & Cadee, G. C. (2002). *Dolphins in the Red Sea and adjacent waters*. 16th Annual Conference of the European Cetacean Society, April 7-11, Liège, Belgium (poster).

Stensland, E., Berggren, P., & Kohler, F. (2001). Function of mixed species groups of humpback and bottlenose dolphins in Menai Bay, Zanzibar. In *Abstracts*, 14th Biennial Conference on the Biology of Marine Mammals, November 28-December 3, Vancouver, BC, Canada. 204 pp.

Van Waerebeek, K. (1993). Geographic variation and sexual dimorphism in the skull of the dusky dolphin, *Lagenorhynchus obscurus* (Gray, 1828). *Fishery Bulletin*, *91*, 754-774.

Weidleplan. (1992). *Study for wildlife and conservation areas: Master plan for the coastal areas of the Barr al Hikman and Masirah Island*. Muscat, Sultanate of Oman: Weidleplan. (Unpublished report for the Government of Oman).