A preliminary assessment of the frequency, distribution and causes of mortality of beach cast cetaceans in the Sultanate of Oman, January 1999 to February 2002

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Abstract
Data are presented on beach cast cetaceans recorded in central and southern Oman between January 1999 and February 2000 during systematic beach surveys. Crude encounter rates of cetacean specimens are comparable with previous published data and indicate relatively high levels of mortality of *Tursiops sp*. and *Sousa plumbea.* Over two-thirds of specimens are recorded as stranding state V with cause of mortality unknown. Of the remaining specimens, empirical and circumstantial evidence for cause of death is suggestive of interactions with fisheries activities in the majority of cases. Direct evidence of interactions between cetaceans and fisheries, including information on incidental catch, is also presented. Other possible causes of mortality are hypothesised. Two mass strandings of small cetaceans are also discussed. Given the high numbers (725 records) and diversity (18 spp.) of beach cast cetaceans recorded in Oman, and the value of specimens to scientific study and conservation and fisheries management, recommendations are made to expand the scope of research and application of data.

Introduction

The value of beach cast cetacean remains for studies of systematics, distribution, fisheries interactions, ecology and other factors has been previously acknowledged (Geraci and Lounsbury, 1993; Salm, 1991; Kuiken 1994, Van Waerebeek *et al*., 2000 Van Waerebeek and Reyes, 1994) Several authors have recorded beach cast cetacean remains from beaches within the Sultanate of Oman and the Arabian Region. Gallagher (1991) documented collections of specimens from Bahrain, United Arab Emirates (UAE) and Oman that date back to 1969. Leatherwood (1986) refers to early collections of skeletal material from the region in general. Papastavrou and Salm (1991) provide an assessment of the distribution, frequency and underlying causes of mortality of cetaceans encountered on beaches in Oman as well as an assessment of direct impacts to cetaceans (and other taxa) in fisheries. Baldwin *et al.* (1998) review available information on small cetaceans within the Arabian region including data on stranded and beach cast specimens.

Detailed analyses of specimens recovered from beaches within Oman have yielded valuable information on the distribution, systematics and genetics of humpback dolphins (SC/54/SM6,SC/54/SM34), humpback whales (SC/50/CAWS21, SC/54/H4) spinner dolphins (Van Waerebeek *et al*. 1999) sperm and dwarf sperm whales (Gallagher 1991a and 1991b) as well as other species (unpublished data held by the authors), and have contributed to the elucidation of the taxonomic status of *Delphinus tropicalis* (Jefferson and Van Waerebeek, in press). The presence of previously unrecorded species within Omani waters has also been confirmed (Van Waerebeek *et al*. 1999).

Salm (1992) and Alling (1983) report interactions between cetaceans and fisheries in Oman including direct observations of net entangled whales and dolphins and accounts of dolphin fisheries, including those targeting animals for human consumption as well as for bait. Observations of impacts to cetaceans from gill nets in Oman (Salm, 1991) and elsewhere in the Arabian region have also indicated that annual mortality for many species is probably high (Northridge 1984, Northridge 1991a and 1991b). Other published accounts provide information on directed takes in the Indian Ocean region (Leatherwood 1986, Alling 1983, Anderson 1999, Northridge 1991b, Peddemors 2001).

In this document we present preliminary analyses of data collected during dedicated beach surveys for dead and stranded cetaceans along the coast of Oman between January 1999 and March 2002, as well as data collected by the authors during other studies. The work followed recommendations made by researchers previously active in the region (Salm, 1991, Gallagher 1991), and the recommendations of the small cetacean sub-committee of the 50th International Whaling Commission Scientific Committee meeting held in Muscat, Oman, in April-May 1998. The principal objectives of the surveys were:

- To enhance knowledge of cetacean population biology (stock identification), natural history and local distribution within Omani [EEZ] waters;
- To collect voucher specimens and sample tissue from stranded cetaceans for subsequent DNA analysis, leading to investigations of the phylogenetic origin of populations within Oman;
- To examine the underlying causes of cetacean mortality within Oman, including investigations of bycatch and other forms of fisheries interactions;
- To provide an indication of stranding rates in the regions surveyed.

Surveys were conducted under a number of logistical and financial constraints and accordingly their scale and frequency varied considerably.

Methods

Dedicated beach surveys

Survey locations.

Survey locations were selected using a number of criteria and included sites identified from previous surveys to have high yields of cetacean remains (Salm 1991, Gallagher 1991), observations made by the authors prior to 1999 and a preference for beaches easily accessible by four-wheel-drive vehicle (4WD). Beaches surveyed for this study are depicted in Figure 1. Wherever possible beaches were also surveyed opportunistically during the course of other marine and coastal fieldwork, including small-boat surveys for cetaceans.

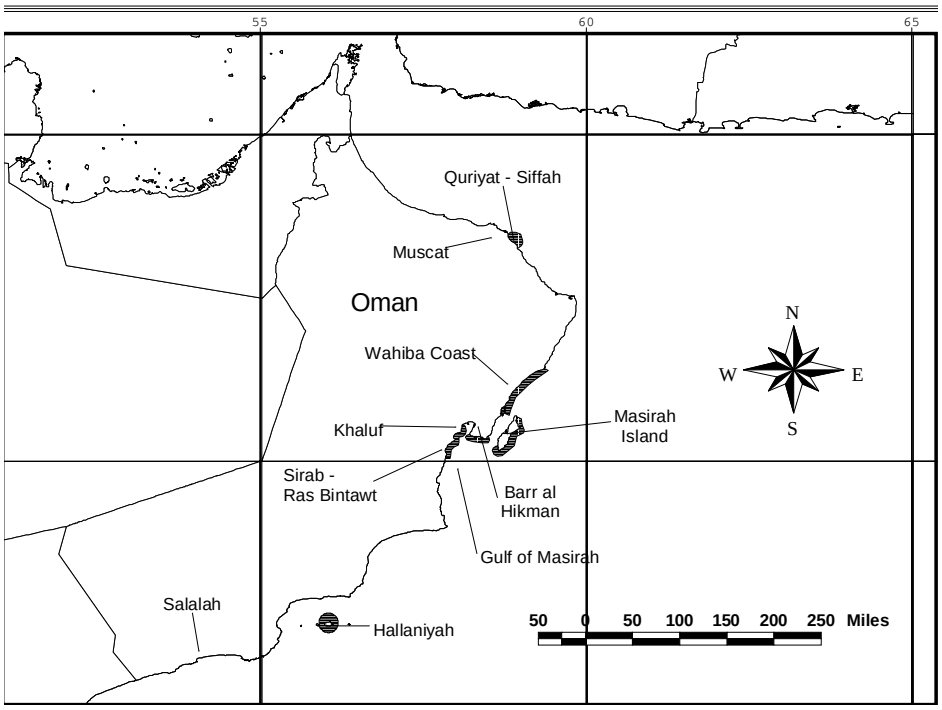

Figure 1. Beaches surveyed for cetacean remains.

Survey Methods
Surveys were conducted with a 4WD moving at less than 15kph with two observers searching from a rooftop platform. On beaches where poor access or substrate prevented 4WD use, searches were conducted by at least two observers walking parallel to the shoreline; one at or above the high tide line and another below. This latter method is probably the most effective for detecting all signs of cetacean remains (Van Waerebeek *et al* 2000), but is also slow (thereby limiting the distance covered). No direct comparisons of the comparative yield (as a measure of effectiveness) of each method are made here

All observations were recorded on standard datasheets and accompanying data included search effort, GPS derived positions and standard descriptions of beach morphology, vegetation, litter and substrate types. The presence/absence of other specimens (and taxa) nearby and proximity to fisheries landing sites was also recorded.

Cetacean remains were treated in a standard manner using detailed specimen data sheets adapted from a variety of sources (refs). *In situ* examinations included a detailed assessment of the external condition of the specimen, including a determination of 'stranding state' ranging from I-V and examination for possible causes of mortality (Geraci and Lounsbury 1993, Kuiken e*t al.* 1994, Tregenza 1994, Van Waerebeek *et al.* 2000). The ability to assess each of these varied widely dependent on the condition of the specimen and the available expertise.

External features considered diagnostic of fisheries interactions included gear still entangled on the specimen lesions caused by contact with gear and severed (absent) fins and flukes. Diagnostic internal evidence included the presence of undigested or partially digested food remains in the stomach and food trapped in the oesophagus (Cockcroft and Ross 1991, Hartmann *et al.* 1994, Kuiken *et al.* 1994, Tregenza and Collett 1998). The conspicuous absence of other evidence for mortality was also considered (Hartmann *et al* 1994, Tregenza and Collett 1998).

Tissue samples were taken for DNA analysis. Wet tissues (typically muscle or skin) were stored in 20% DMSO saturated salt solution (Amos and Hoelzel 1991). Dry tissues (including bone fragments) were stored in Ziploc plastic bags or sterilised plastic containers. Skulls and mandibles were collected whenever available, and postcranial skeletal material was collected from complete specimens whenever feasible. All skeletal remains are curated at the Oman Natural History Museum (Ministry of National Heritage and Culture, Oman).

Stomach contents were sieved with a set of sieves (the smallest with a mesh size of 5 mm) and typically reduced to otoliths, beaks (squid, cuttlefish and octopus) and any other important items. These were temporarily stored in 50% ethanol solution. Organ and blubber samples were recovered from specimens of stranding state II and III and frozen or stored in 10% formalin solution according to protocols provided by the Texas Marine Mammal Stranding Network (Galveston, USA). Detailed information on available specimens is provided in Appendix II.

Where complete specimens were not collected remains left *in situ* were marked to avoid re-sampling on subsequent surveys. This included removal to a recorded site well above the high tide line, and/or directly marking them with paint or some other identifier.

Opportunistic/incidental observations
These include observations and collections made opportunistically by the authors. No search effort is associated with these data and therefore they are not included in assessments of crude encounter rates. However, remains were processed in the manner described above, and the data provide a valuable addition to systematic investigations of the distribution and causes of mortality. These observations extend beyond the range of beaches searched during surveys and include specimens recovered in response to reports from third parties.

Results
Survey encounter rates
A total of 338 observations of beached cetacean remains involving at least 317 individuals (identifiable from cranial material only) were recorded between January 1999 and February 2002. Of these approximately 65% (n=248) were encountered during beach surveys. The crude beach encounter rate for individual specimens (those remains with cranial evidence only) for all dedicated beach surveys (all stranding states) was approximately 0.34 specimens per kilometre. Data for specific survey areas and

periods are presented in Table 1. Encounter rates are determined as the number of individual specimens (confirmed with cranial material) per linear kilometre searched and no other factors are considered. The distances searched varied between surveys. However, minimally surveyed sections of beach were always re-surveyed in instances where a greater distance is indicated.

Table 1. Crude encounter rate per survey January 1999 – February 2002

Survey Area	Survey period	Distance surveyed (km)	Total # of specimens stranding state I-IV	Total # of specimens all stranding states	Crude encounter rate for I-IV	Crude encounter rate for 1-V
Quriyat – Siffah	November 2000	15.87	19	23	1.20/km	1.45/km
Wahiba Coast	March 2001	67.50	5	10	0.07/km	0.149/km
	November 2001	48.00	0	4	0.00/km	0.08/km
Masirah	October 2001	75.47	11	26	0.15/km	0.34/km
Barr al Hikman	October 2000	16.00	1	3	0.06/km	0.18/km
	May 2001	15.06	2	5	0.13/km	0.33/km
	September 2001	16.14	4	12	0.25/km	0.74/km
	November 2001	41.00	1	10	0.02/km	0.24/km
Khaluf	October 2000	12.14	1	20	0.08/km	0.61/km
	September 2001	22.00	0	4	0.00/km	0.18/km
	November 2001	20.05	0	1	0.00/km	0.05/km
	December 2001	24.08	8	5	0.33/km	0.21/km
Sirab – Ras Bintawt	May 2001	15.07	1	8	0.07/km	0.53/km
	September 2001	33.66	0	7	0.00/km	0.21/km
	November 2001	31.80	0	1	0.00/km	0.03/km
Hallaniyah	February 2000	18.27	2	24	0.11/km	1.31/km
	April 2000	4.12	0	6	0.00/km	1.46/km
	February 2001	3.39	0	1	0.00/km	0.29/km
	February 2001	3.39	0	0	0.00/km	0.00/km

Distribution of remains

The distribution and incidence of species varies between locations. Table 2 presents data for the four most frequently recorded species, as well as a single category for baleen whales (including Bryde's and humpback whales). The two species most commonly encountered by a considerable margin were Tursiops (n=112) and Sousa (n=76). The distribution of these specimens is depicted in Figure 2 (Appendix I)

Table 2. Distribution of species between survey areas

Survey Area	*Tursiops. sp*	*Sousa plumbea*	*D. capensis tropicalis*	*S. longirostris*	Baleen whales
Quriyat	4	0	6	19	7
Wahiba Coast	1	17	4	0	2
Masirah	23	1	4	0	4
Barr al Hikman	28	9	1	0	7
Khaluf	11	37	2	0	2
Sirab – Ras Bintawt	5	7	0	0	0
Hallaniyah	12	1	5	0	0
Other areas	28*	4	16	2	5

**this includes 11 animals that live stranded at Ra's al Hadd*

Evidence for cause of death

The condition of specimens was a significant factor in the assessment of mortality (Table 3). Factors identified as evidence for the cause of death were determined in 28.4% (n=90) of all specimens (Table 4). However, approximately 74% (n=235) of all specimens were of stranding state V, and in many instances these were represented by cranial material only. If specimens of stranding state I-IV (n=95) are considered independently of these then evidence for the cause of death was ascertained for 78% (n=82) of specimens. Flensed animals are not considered in these calculations.

Table 3

Stranding State	% of specimens showing evidence for the cause of death
I	100%
II	90.5%
III	80.5%
IV	56.3%
V	8.6%

Table 4. Evidence for causes of death in all recovered specimens January 1999 – February 2002

		Evidence for cause of death								
Stranding State	Number of specimens	net/rope lesion	Net/rope on animal	severed fins or flukes	Bites	distinct cuts or lacerations	food in stomach	haemorrhage	anecdotal evidence	no evidence
I	1	1	0	0	0	0	0	0	0	0
II	21	2	0	0	0	0	4	13	0	2
III	41	8	3	5	2	2	13	0	0	8
IV	32	1	1	1	3	0	11	0	1	15
V	243	1	6	2	0	0	6	0	1	227
Total	338	13	10	8	5	2	34	13	2	0

** n.b. Some specimens showed more than one factor*

Evidence for death associated with fisheries interactions

Evidence for interactions with fisheries was inferred in 78% (n=71) of cases where evidence for a cause of death could be identified (n=90). This included lesions inflicted by nets and ropes, nets and ropes entangled around carcasses and remains and severed fins and flukes. Fisheries interactions were also inferred in instances where stomachs were exceedingly full. Internal examinations of 33 carcasses suggested that animals had been feeding just prior to death. In three of these food was also found in the oesophagus. This included data recorded during a single survey on Barr al Hikman in September 2001 when 5 bottlenose dolphins (stranding state III) with exceedingly full stomachs were recovered within a 5 km stretch of beach. A survey of beaches on the south-western tip of Masirah Island that followed immediately afterwards recovered an additional 5 bottlenose dolphins and two common dolphins of stranding states III-IV. The stomach contents of a total of 34 individuals were collected and await further analysis.

Discussion

The data presented here were collected as opportunity allowed and although a specific protocol was adhered to throughout surveys, there are significant limitations to the assessment of various factors determining (observed) stranding rates, including many that are difficult to assess in the span of a fieldtrip. These include coastal currents, variations in coastal morphology and differing propensities of beaches to sequester remains. Other factors include the removal of beach cast animals to municipal landfills from public beaches and where decaying remains pose a health hazard. Weather patterns are also strongly seasonal and alternate between strong southwest and northeast winds. Salm (1991) hypothesises that many beaches are swept clean during the annual monsoon and that peak abundances for dead dolphins (and other taxa) on the Arabian Sea coast are reached at the end of May, just prior to the onset of the monsoon. Fisheries activity also decreases in many coastal areas during the monsoon.

Encounter rates

Available data on background encounter rates for beach cast cetaceans are rare and assessing the significance of calculated rates is difficult. Previous publications provide encounter rates for beach cast

cetaceans in Oman. Salm (1991) recorded 8 fresh specimens 'intact and relatively fresh' over 25 kilometres of surveyed beach on the southern shore of Barr al Hikman (0.32/km). He also noted an abundance of older 'dolphin material' as well as the remains of at least five whales. Gallagher (1991a) reports finding more than 30 dolphins of predominantly 2 species (*Delphinus capensis tropicalis* and *Sousa plumbea*) along 60km of coast (0.50/km) examined for cetacean remains during April 1990 (Sirab - Ras Bintawt).

There is some evidence to suggest that the frequency of encountered remains increases with proximity to fisheries landing sites (Salm 1991, Gallagher 1991, Alling 1982). Recent observations suggest that the incidence of remains over wider areas increased as the incidence of fisheries landing sites increased (See figs I and II). Gallagher (1991) notes that 'it is not uncommon to find whole dolphins or parts of dolphins in the vicinity of fishermen or their boats,' and suggests that they may drown in fishermen's nets. This pattern was observed at both Khaluf and a popular landing site in central Barr al Hikman (Khor Milh). However, also noted was an increased incidence of remains on beaches that were less exposed to wave action and beaches near to headlands.

The distribution of remains

Species were distributed unevenly between areas. Some of this apparent variation may be due to uneven survey effort. However, the two species most commonly encountered (53% of all records) were bottlenose dolphins (*Tursiops* sp.) and humpback dolphins (*Sousa plumbea)* and the majority of these were recovered from beaches peripheral to the Gulf of Masirah and from the southern Wahiba coast; figures I and II show high densities in the Khaluf region (particularly *Sousa*) and on the southern shore of Barr al Hikman (particularly *Tursiops*). Limited observations during small boat surveys have indicated that the two species are unevenly distributed throughout the Gulf of Masirah and that their respective ranges may reflect habitat preferences (data held by authors). These observations concur with the apparent distribution of beached remains for each of these species.

Remains of baleen whales are recorded at most survey areas although there is an increased abundance on beaches bordering the Gulf of Masirah and on beaches close to Muscat. Observations by the authors and others (Salm 1991, Gallagher 1991a) suggest that baleen whales in the Gulf of Masirah may be especially vulnerable to entanglement in gill nets. Three humpback whales (*Megaptera novaeangliae*) have been released from nets by the authors in this region and fishermen have provided accounts of other incidents. A dead juvenile baleen whale (*Balaenoptera sp.*) completely shrouded in gill net was observed floating at sea during a small boat survey in October 2001. There is also an increased incidence of baleen whales on beaches close to Muscat although factors indicating a possible cause of mortality were not identified in any of these cases.

Spinner dolphins (*S. longirostris*) and common dolphins (*D. capensis tropicalis*) are more evenly distributed between survey areas, although an increased incidence is noted on coasts bordered by a narrow coastal shelf. Surveys also yielded complete specimens of pygmy killer whale *Feresa attenuata* and rough-toothed dolphin, *Steno bredanensis*, two latter species previously identified during offshore surveys (Ballance *et al.* 1996) or from very limited remains (Van Waerebeek *et al*., 1999).

Possible causes of cetacean mortality in Oman

Evidence for fisheries interactions and bycatch

There are few published accounts of the background rate of stranding, i.e. low levels of strandings due to natural mortality alone, because fishing effort has been virtually ubiquitous in coastal areas for some time**.** As in many other coastal nations, direct evidence for cetacean mortality associated with fisheries is limited. Fishermen world-wide are aware that public knowledge of marine mammal deaths related to their fisheries may have a legislative impact on the fishery.

Nonetheless the available empirical and circumstantial evidence suggests that at least in some areas of Oman many deaths are related to fisheries interactions. Gillnetting has been documented to cause high levels of small cetacean mortality from entanglement in numerous fishing nations on all continents (Perrin, 1990, Tregenza *et al.* 1997). It is unlikely that Oman is an exception, particularly in areas such as the Gulf of Masirah, where use of drift and gill nets is prevalent. Rates of recruitment for fresh specimens encountered are high in repeatedly surveyed areas (Khaluf, Barr al Hikman) which are in close proximity to high-density fishing grounds.

In some instances evidence for mortality associated with fisheries was compelling. Thirty-one dolphins showed direct evidence of entanglement in nets and ropes (Table 4). These included specimens that were either still entangled in gear when encountered or bore lesions consistent with entanglement. In eight specimens flukes and fins were clearly severed (a clean separation), which is the universal method to facilitate the separation of entangled cetacean carcasses from fishing gear. It is also routinely done before butchering a carcass. The removal of the dorsal muscle mass in eight specimens indicates that fishers utilized these casualties for some purpose, most probably either for food or as bait. Observations made by the authors and discussions with fishers have determined that dolphin flesh is popular bait for shark fishing and there is some evidence to indicate that dolphins are actively targeted to fuel this demand (Alling *et al.* 1982, Alling 1983, Gallagher 1991a, Papastavrou and Salm 1993 and photographs held by authors).

Mass Strandings

At least two mass strandings of dolphins were recorded. One event involved at least 16 spinner dolphins (*Stenella longirostris*) and two common dolphins (*Delphinus capensis*) that were found on 2km section of beach during a dedicated beach survey in November 2000. All remains were found on the same strand line, and were in a similar state of decomposition. 17 of 18 animals were determined to be cranially adult or sub-adult animals (KVW pers. comm) although the stranding state (IV) precluded determination of a possible cause of mortality.

Most recently (January 2002) a mixed group of bottlenose dolphins and at least 3 rough toothed dolphins stranded at the coastal village of Al Ayjah, near to Ras al Hadd. Eyewitnesses reported that a minimum of 30 animals stranded alive, and that local fishermen and rangers towed approximately 20 back to sea. At least 13 animals subsequently died and the authors and local veterinary surgeons examined these on 11th January 2002. The majority were female (n=11), including one pregnant with a near-full term foetus, and all had empty stomachs. Local fishermen attributed the event to panic induced by a large pod of orca (*Orcinus orca)*, a species rarely encountered in Oman and typically only seen in groups of two to three. Interactions of this kind are rare and the authors were able to identify only one other published account of an orca induced stranding of bottlenose dolphins (Van Bressem *et.al.* 2001). Internal and external examinations revealed extensive bruising and haemorrhaging consistent with the injuries sustained by animals in the surf on a rocky shoreline. Attendant veterinary surgeons deemed these injuries to be extensive enough to be the ultimate cause of mortality. However, alternate hypotheses for the cause of this event remain under investigation and include possible interactions with increased naval vessel activity and HAB related illnesses. Blood and organ samples from these animals remain frozen and await further analyses.

Harmful Algal Blooms

Harmful algal blooms (HABs) are known in the Arabian region. A number of HAB-related fish kills have been documented in the Arabian Gulf, including one resulting in wide spread fish mortality in 2001 (J. Landsberg, pers comm.). Additional survey work conducted by the authors includes an extensive assessment of a mass mortality of green turtles (and other taxa) along the central Arabian Sea Coast between May and December 2001. Preliminary results of tests run on water samples collected from the Gulf of Masirah during this period revealed extremely high levels of several HAB species, predominant among them being the highly toxic *Karenia selliformis* (approximately 2.5 million cells/litre) and *Prorocentrum spp*., known producers of gymnodimine and brevetoxin-like compounds (K Steidinger, pers comm.). Both of these species have been implicated in marine mammal deaths elsewhere. Some of the dolphin deaths coincident with the recent mass mortality of turtles along the Arabian Sea coast of Oman during 2001 (OWDRG 2002) may be HAB related and tissues collected from dolphins that died during this time period will be analysed for HAB-related toxins.

Other factors

Although no direct evidence was found of other causes of mortality, there are some possible factors that should be considered and require further investigation. These include military activity, pollution, acoustic impacts, pathogens and epizootics.

Conclusions

Data collected by the authors (Appendix II) demonstrates that a relatively large number of valuable samples can be relatively easily and inexpensively obtained in a short period of time. Other information valuable to science and on-going marine and coastal conservation efforts, particularly related to fisheries

management in the country can also be obtained in the process. It is therefore recommended that such surveys are conducted, preferably by locally-resident trained scientists on a regular basis. Surveys could be further expanded to include:

- Systematic monitoring of bycatch and harvest of marine mammals and turtles
- Establishment of networks for the effective reporting of mortality events and collection of specimens for investigation of mortality causes
- Sampling for pollutant assays and DNA analysis
- Investigation and comparison of the stock identity of marine mammals throughout the Arabian region
- Focused studies on the conservation status and needs of species considered to be under particular threat, such as humpback dolphins and baleen whales

In addition, Oman's marine mammals, and marine environment in general, would greatly benefit from the establishment of identified marine and coastal conservation areas and enforcement of existing legislation for protection of threatened species. The area of Barr al Hikman and the Gulf of Masirah are recommended for immediate consideration as a Protected Area. Implementation of awareness and education campaigns focusing on marine mammals and turtles would complement such actions and may be a requirement for their success. Finally, the involvement and training of regional scientists in all of the above is important for the long-term sustainability and success of the recommendations.

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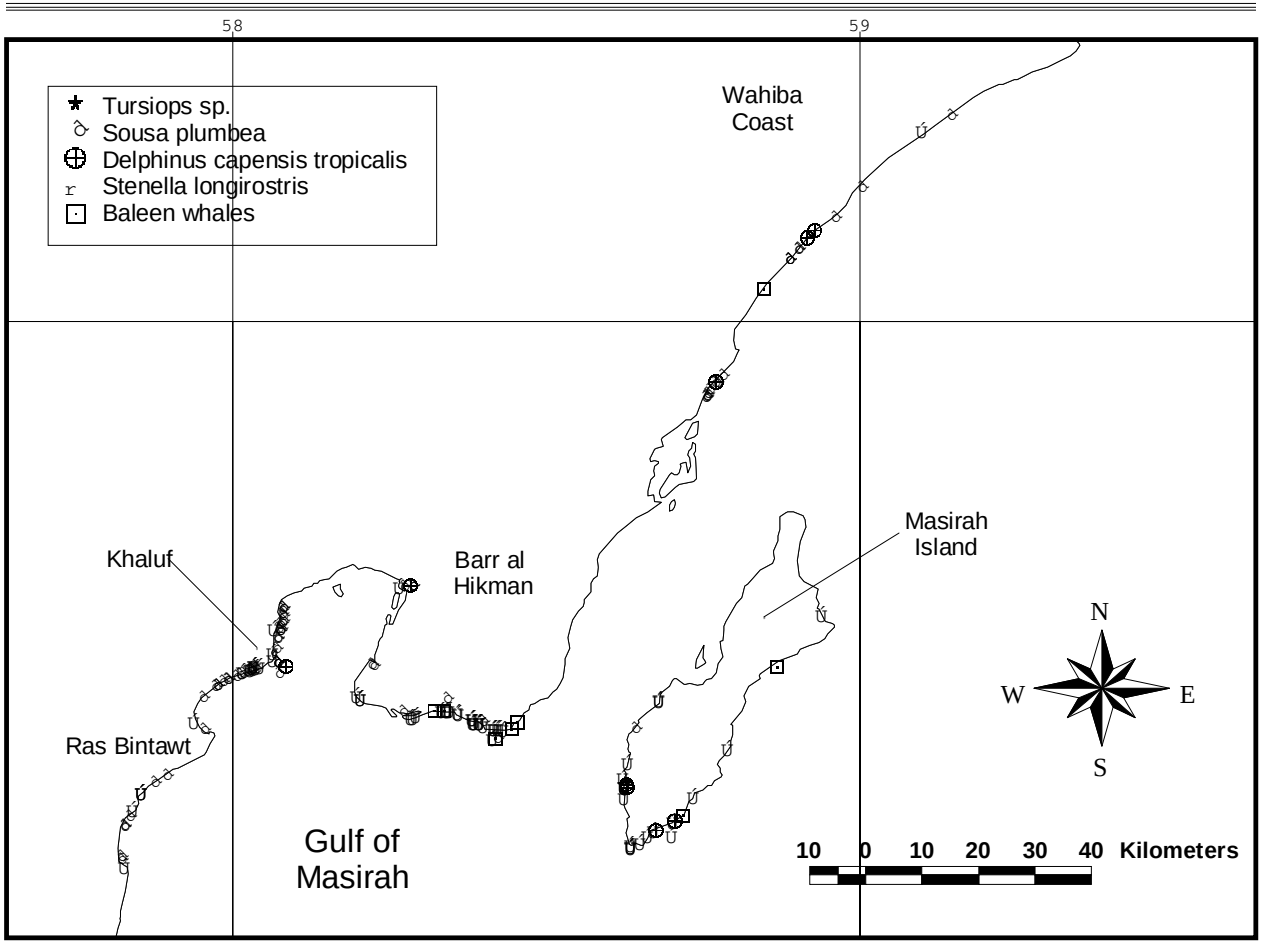
Appendix I. Distribution of specimens.



Appendix II. Specimens collected since January 1999

Species	Skull at ONHM, British Museum or Amsterdam Museum (prior to 1999)	Skulls Jan 1999-Feb 2002	Post cranial skeletal material	Skin/muscle sample for DNA	Dried tissue	Stomach contents	Blood	Liver	Kidney	Gonads	Blubber	Bullae	Bone Fragment for DNA
Balaenoptera sp.	2			6		1		1				2	
Megaptera novaeangliae				3								1	
Physeter macrocephalus	2			1		1							
Kogia simus	4	2	1		1								
Pseudorca crassidens	17	4		3		1							
Feresa attenuata	0	1	1	1									
Sousa plumbea	36	45	3	42	2	8							
Steno bredanensis	1	3		3		2	1						
Grampus griseus	8	4	1	7									
Tursiops sp.	25	76	8	59	2	15	10	2	2	1			
Stenella longirostris	15	21	6	20		2							
Delphinus sp.	35	30	8	21	1	4							
Unid dolphin				15	2								
Unid. Baleen whale	1			3								2	4
Unid. 'whale'	0			3	6								4
Total	146	185	28	184	14	34	11	3	2	1	0	5	