Challenges and priorities for the conservation of the Vulnerable Atlantic humpback dolphin (*Sousa teuszii*), with a case study from Namibe Province, Angola

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ABSTRACT

Atlantic humpback dolphins (Sousa teuszii) are endemic to tropical coastal waters between Western Sahara and Angola, West Africa. They are classified as Vulnerable by the IUCN due to their restricted geographic range, low abundance and declining status. Seventy-one Atlantic humpback dolphin sightings were recorded along 55km of coast in Namibe Province, Angola, during two three-week periods in the summer and winter of 2008. Photo-identification documented 10 individuals, indicating low abundance of the Angola Management Stock. Most sightings (n=46, 65%) occurred in a restricted niche within 300m of shore rendering dolphins highly susceptible to anthropogenic impacts. Nearshore (<1km from the coast) anthropogenic activity was highest (4.8 fishing boats and 2.0 gillnets per km in sector 10) in the southernmost sectors of the study area where no dolphins were sighted. In Namibe Province, as throughout their range, bycatch (incidental capture) in gillnets is the greatest likely cause of mortality, with directed capture, habitat degradation and over-fishing also potential impacts. Other threats include marine pollution, climate change and anthropogenic sound. Low abundance, fragmentation of populations and low genetic variation may increase the vulnerability of the species to stochastic processes. Conservation challenges include a paucity of biological data, absence of education programmes, and widespread poverty amongst coastal communities which rely heavily on artisanal fisheries for subsistence. Recommended priorities for Atlantic humpback dolphin conservation include: (i) distribution and abundance surveys; (ii) bycatch monitoring programmes; (iii) awareness schemes; (iv) protected areas where healthy populations remain; and (iv) reduction/elimination of nearshore gillnet use within core habitat.

KEYWORDS: ATLANTIC HUMPBACK DOLPHIN, CONSERVATION, MONITORING, INCIDENTAL CATCHES, ATLANTIC OCEAN, AFRICA

INTRODUCTION

In 2007, Turvey *et al.* reported that the baiji or Yangtze River dolphin (*Lipotes vexillifer*) was the first cetacean species likely to be extinct due to human activities, primarily through habitat loss and bycatch (incidental capture) in fishing gear. The baiji's demise was not unforeseen; scientists had reported a rapid decline in the species over several decades, producing a minimum estimate of only 13 animals by 1999 (Zhang *et al.*, 2003). Although scientific workshops, field surveys and an ambitious programme to relocate remaining baijis to a protected reserve were developed, the population had become too small to salvage (Yang *et al.*, 2006). The baiji may not represent a unique situation; Jefferson (2009) lists the vaquita (*Phocoena sinus*), North Pacific right whale (*Eubalaena japonica*), North Atlantic right whale (*Eubalaena glacialis*), South Asian river dolphin (*Platanista gangetica*) and the Atlantic humpback dolphin (*Sousa teuszii*) as the current five most endangered cetacean species worldwide, all as a consequence of anthropogenic activities.

Atlantic humpback dolphins are the least studied of these species, and a thorough review by Van Waerebeek *et al.* (2004) revealed that current knowledge is predominantly restricted to anecdotal reports and occasional stranding and capture records, few of which are recent. The species is endemic to tropical and sub-tropical waters along the west coast of Africa, and is documented from ten range states between Western Sahara and Angola (Van Waerebeek *et al.*, 2004; Tim Collins, unpublished data). Their distribution is apparently discontinuous, probably as a result of sustained bycatch and habitat degradation (Van Waerebeek and Perrin, 2007). For example, no humpback dolphins have been recorded during recent monitoring effort in Ghana (Ofori-Danson *et al.*, 2003; Van Waerebeek *et al.*, 2009) or Benin (Van Waerebeek *et al.*, 2002). It has never been considered a numerous species (Van Waerebeek and Perrin, 2007). However, there is evidence that the species has become rare in areas where apparently healthy populations previously occurred, for example off Mauritania (Van Waerebeek and Jiddou, 2006). None of the contemporary stocks appear to contain more than a few hundred animals (Van Waerebeek and Perrin, 2007), and two stocks apparently consist of less than 30 animals (Notarbartolo di Sciara *et al.*, 1998; Weir, 2009).

Several factors render this species highly vulnerable to anthropogenic impacts: (1) a restricted geographic range; (2) their exclusive occurrence within the waters of developing countries where poverty levels are high; (3) their occupancy of strictly nearshore habitat; and (4) low worldwide population size (unknown, but 'thought to amount to at most hundreds, not thousands, of animals'; Van Waerebeek and Perrin, 2007). Consequently, it is classified as 'Vulnerable' ('considered to be facing a high risk of extinction in the wild') by the IUCN (IUCN, 2009) and is included on the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) Appendix I (Threatened). Since 2007, it has been included on the Convention on Migratory Species (CMS) Appendix I (Endangered migratory species). In 2003, the IUCN Cetacean Specialist Group identified Atlantic humpback dolphins as a priority species for research in light of their restricted geographic range, narrow ecological niche and the paucity of available information (Reeves *et al.*, 2003). However, despite increasing concern over their status, few scientific studies or conservation measures have been implemented to date.

The occurrence of Atlantic humpback dolphins in Angola was first established in 2004, when an amateur naturalist provided photographs taken during a kayak trip off Namibe Province (Van Waerebeek *et al.*, 2004; Weir, 2010). In the absence of cranial or genetic data Angolan humpback dolphins are presumed to be S. teuszii rather than the closely-related Indo-Pacific humpback dolphin (*S. chinensis*)[1], based on the known distributional gap off south-western Africa in the region washed by the cold Benguela Current. An Angolan management stock was consequently proposed (Van Waerebeek *et al.*, 2004), and in 2008 a dedicated study of Atlantic humpback dolphins was carried out in Angolan waters (Weir, 2009). This paper has four main objectives:

1. To summarise the scientific results of the Namibe Province study relevant to conserving Atlantic humpback dolphins both there and throughout their range.
2. To evaluate the likely anthropogenic impacts on humpback dolphins in Namibe Province.
3. To identify further threats documented for the species elsewhere in its geographic range; and
4. To identify challenges for the conservation of the species throughout its range, establish conservation priorities and provide recommendations towards a management programme.

NAMIBE PROVINCE CASE STUDY

Study area and methods

The Namibe Province study area comprised 55km of coast centred on Flamingos (15°33'S 12°01'E), between Tombwa and Namibe (Figure 1a). The coastline is exposed and is characterised by shelving sandy beaches, with intermittent short sections of cliffs and rocky coast.

[1]The taxonomic status of the genus *Sousa* is unresolved and awaiting wide-scale genetic analysis (Frère *et al.*, 2008). Many authorities currently recognise only two species, *S. chinensis* (Indo-Pacific) and *S. teuszii* (Atlantic). However, many biologists consider the Indo-Pacific humpback dolphin to consist of at least two species: *S. plumbea* (western Indo-Pacific) and *S. chinensis* (eastern Indo-Pacific).

The data collection and analysis methods are explained fully by Weir (2009) and are summarised here. Data were collected from 11–30 January 2008 (summer) and 16 June–5 July 2008 (winter). A total of 1106.2km (1006.1 in summer and 100.1 in winter) of boat survey data were collected using a 5m rigid-hulled inflatable boat fitted with an 85hp Yamaha outboard engine to carry out return surveys of the area either 30km north or 25km south of Flamingos (Figure 1a). Only survey data collected while the boat was within 1km of the shore are included in effort-related analysis (since humpback dolphins occupied the nearshore zone). In the winter, 520.6km of data were collected using a 4x4 vehicle which was driven along the beach along 7km of coast south of Flamingos and up to 30km north of Flamingos (Figure 1a), within 100m of the water and at a survey speed of around 15km/hr. A total of 53.7hr of shore-based search data (30.9hr summer and 22.8hr winter) was conducted from Flamingos. During humpback dolphin sightings, the GPS position, group size and composition, and behaviour of the animals were recorded. Focal follow behaviour sampling and photo-identification were carried out whenever opportunity arose.

During boat surveys, the location of fishing vessels, beach seines and gillnets (indicated by pairs of marker buoys) were recorded during the outward leg (total of 554.4km of fishing monitoring effort) of each survey. The low eye height of the survey boat meant that reliable detection of gillnet buoys was restricted to within 2km of the trackline. Since semi-industrial and industrial fishing vessels (usually operating trawls, purse seines or long-lines in Angolan waters) are legally obliged to fish at least 4nm (7.4km) from shore (Du Preez, 2009), most of the fishing activity recorded during coastal boat surveys was assumed to belong to subsistence (fishing carried out for non-commercial purposes) or artisanal (fishing for commercial purposes where boats are ≤14m long; Du Preez, 2009) sectors (analysed together in the remainder of this paper as 'artisanal'). Artisanal fishing vessels mostly comprised wooden boats or simple canoes made of wood or fibre and powered by paddles, or, less commonly, modern fibreglass boats powered by outboard engine. Hand lines and gillnets were the primary fishing methods. Occasionally, larger motorised vessels from Namibe were observed in coastal waters, usually operated by multiple crew fishing with hand-lines. As an indication of fishing activity further offshore, the minimum number and closest distance to shore of fishing vessels were recorded during shore-based watches at Flamingos during the summer months. Vessels were often too distant to assess their size and fishing method, and therefore artisanal and industrial fishing boats were not distinguished between.

To examine whether certain locations within the study area were of particular importance for dolphins, the survey area coastline was divided into ten sectors of 5km latitude (Figure 1). To determine whether dolphins used particular fine-scale locations within the study area for specific activities, the coast was divided into sections of 0.1km latitude and the relative proportions of forage/feed and travel behaviour per section were examined using shore-based focal follow data (since boat-based focal follows may have affected behaviour).

The Angola management stock: Summary of results

The study yielded the following key results (Weir, 2009) relevant to the conservation of Atlantic humpback dolphins. A total of 71 Atlantic humpback dolphin sightings was recorded (32 during boat surveys, 20 during vehicle surveys, six during timed watches at Flamingos and 13 opportunistically), with sightings distributed throughout sectors 1 to 8 of the study area and at similar relative abundance. No dolphins were sighted in southernmost sectors 9 and 10. Combined boat- and shore-based photo-identification during 49 sightings documented a total of 10 dolphins using the study area, comprising seven adults, one juvenile and two calves. High re-sighting rates and an absence of unmarked animals suggested that all animals in the area at the time of the study were identified. Only one new individual was identified between the two seasons; a calf born probably during late April or May.

All sightings occurred within 800m of the coast (except for one individual associated with bottlenose dolphins (*Tursiops truncatus*) at 1.4km offshore). During most sightings (n=46, 65%) humpback dolphins occurred exclusively within 300m of the shore, and often (n=31, 44%) approached to distances of ≤20m (Figure 2). Travel and foraging comprised the majority of daylight behaviour, and humpback dolphins exhibited more forage/feed behaviour than expected in sectors 3 and 6 and more travel behaviour than expected in sectors 4, 5, 7 and 8. Fine-scale analysis revealed that forage/feed behaviour occurred in particular locations, primarily around rocky reefs within Blue water and Skull Bays in the north of the study area, the area around High Rocks and north of Flamingos at the (dry) mouth of the Flamingo River.

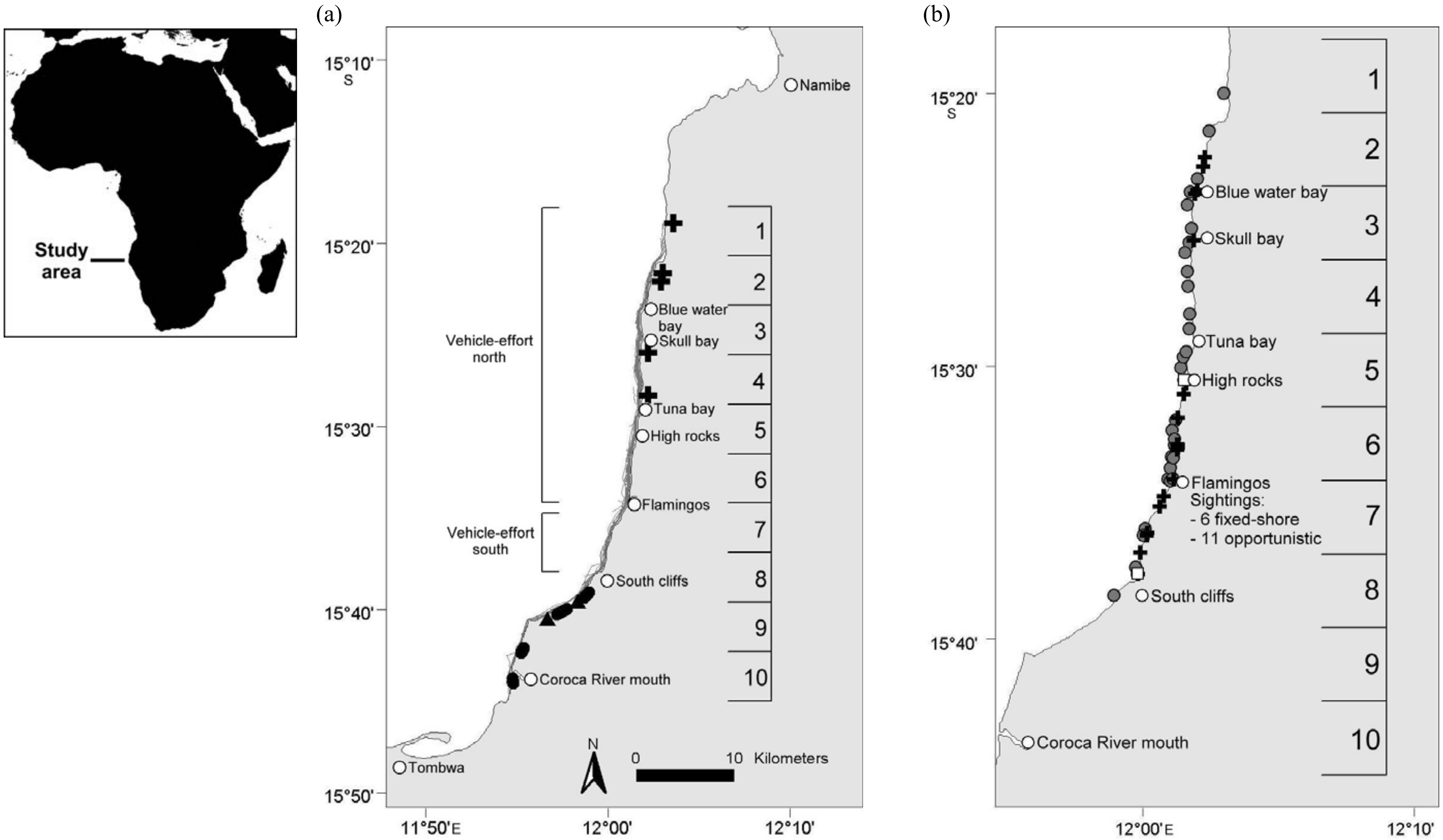


Figure 1. The Flamingos study area showing: (a) place names, the 10 area sectors, boat effort (grey), the extent of vehicle effort (all vehicle effort was along immediate coast) and location of coastal communities (black lines), other buildings (triangles) and fisherman huts (crosses); and (b) location of boat (circles), vehicle (crosses) and opportunistic (square) Atlantic humpback dolphins sightings (position of initial sighting).

Figure 2. Atlantic humpback dolphins foraging close to shore in Namibe Province

Anthropogenic activity

Within the study area human habitation was mostly limited to sectors 9 and 10 in the south of the study area, where four large fishing communities and a salt mine were located (Figure 1b). In addition, five huts used occasionally by local hand-line fishermen were located in sectors 1 to 4, and a tourist ecolodge for shore-anglers was located at Flamingos (Figure 1b).

During summer shore-based watches at Flamingos, between 1 and 20 (mean=6.6; SD=5.1; n=18) fishing vessels were visible at all times, operating at closest distances of 1 to 6 km (mean=3.5; SD=1.3; n=16) from the coast (during two watches vessels were on the horizon and distance could not be estimated). During dolphin boat surveys, fishing vessel activity was relatively low (especially within 1km of the coast) in sectors 1 to 8, but increased markedly in sector 9 and reached over 4.8 boats per km in sector 10 (Figure 3a). Almost all fishing boats in sectors 9 and 10 were artisanal, comprising small canoes or wooden boats operated with paddles or motors. Since humpback dolphins were recorded only in sectors 1–8 and most fishing vessel activity occurred in sectors 9 and 10, it was not often possible to observe interactions between vessels and dolphins. However, on the single occasion that Atlantic humpback dolphins were observed travelling towards two small artisanal fishing canoes (drifting and using hand-lines) a marked avoidance response was observed at 100m distance where the dolphins turned 180° to travel away and then moved 200m offshore to deviate widely around the canoes.

Gillnets were recorded only in sectors 4 to 10, and density peaked markedly in sector 10 when 2 nets per km were recorded within 1km of the shore (Figure 3b). Gillnets were also recorded <1km from shore in sectors 5 and 7 (Figure 3b), where single gillnets were repeatedly deployed in the same location. For example, at Tuna Bay (Sector 5) a gillnet was observed at distances of 30 to 500m from the shore throughout the summer and winter surveys. Beach seining was observed at coastal fishing villages in sectors 9 and 10.

CONSERVATION ASSESSMENT

Potential impacts at Namibe Province

The apparent high site fidelity, narrow ecological niche and use of specific foraging areas by Atlantic humpback dolphins at Namibe Province mean that their potential for, and vulnerability to, anthropogenic interactions is unusually high among marine cetaceans. The lack of observed mortality in Namibe Province should not be interpreted as zero mortality, since the dolphin population was very small and the chances of observing a mortality event during a 6 week period were consequently slim. Furthermore, local people may potentially use bycaught animals for meat rather than discarding them (there was evidence of use of other marine fauna such as marine turtles). Van Waerebeek *et al.* (2004) reported that dolphin remains are often hidden in some areas of West Africa. The evaluation of anthropogenic activity in the region revealed four potential impacts: (1) bycatch; (2) directed capture; (3) habitat degradation; and (4) over-fishing.

Bycatch

Incidental capture in fishing gear is the main source of anthropogenic mortality for small cetaceans worldwide (Reeves *et al.*, 2003), including humpback dolphins in West Africa (Van Waerebeek *et al.*, 2004; Tim Collins, unpublished data). Given that industrial fishing vessels are prohibited from coastal waters in Angola (Du Preez, 2009), any bycatch of coastal cetaceans is likely to occur in the artisanal fishery. The persistent deployment of gillnets close to shore in areas used by dolphins (e.g. Tuna Bay) in Namibe Province probably comprises the single most important immediate threat to humpback dolphins in the region. Furthermore, very high gillnet densities occur along the coast of central Angola between Luanda and the Cuanza River mouth (Iain Nicolson, pers. comm.) and there is potential for bycatch to impact coastal dolphins throughout Angola. One Atlantic humpback dolphin was taken alive in a beach seine in Senegal (Van Waerebeek *et al.*, 2004), and it is therefore possible that beach seining activities in Angolan waters also occasionally impact humpback dolphins.

Deliberate takes

Directed captures of dolphins for human consumption ('marine bushmeat') or fishing bait occurred in all five of the West African countries examined by Alfaro-Shigueto and Van Waerebeek (2001), and Ofori-Danson *et al.* (2003) highlighted increasing targeted captures of dolphins in Ghana due to growing coastal human populations and declining commercial fish stocks. Specific accounts of directed takes of Atlantic humpback dolphins are scarce, but they are believed to occur with some regularity (Van Waerebeek and Perrin, 2007). Consumption of dolphin meat has not been documented in Namibe Province to date, although it has not been investigated.

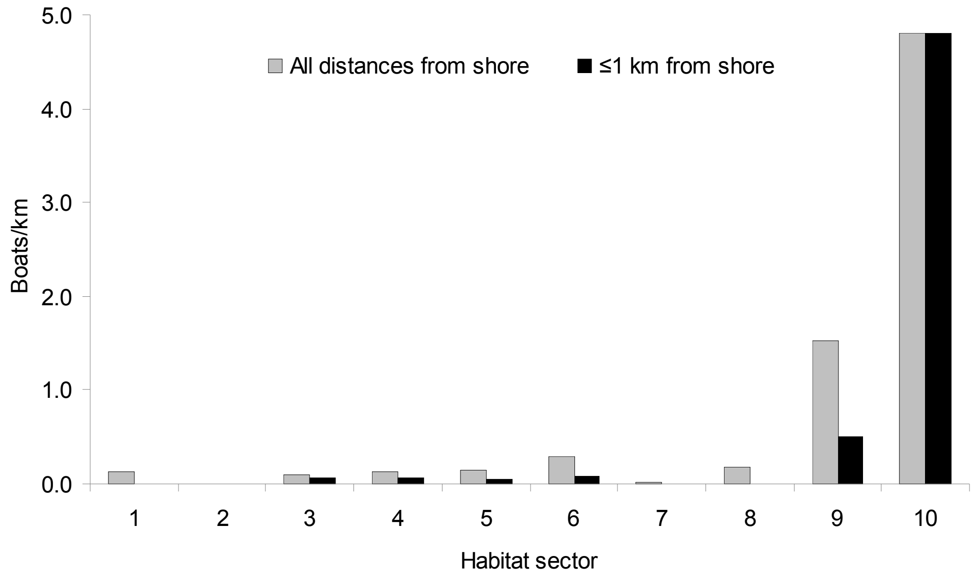
Habitat degradation

The loss and fragmentation of habitat due to expanding coastal communities, coastal development, dredging, trawling, deforestation, mangrove destruction, pollution, aquaculture, eutrophication and oil spills represent a worldwide threat to many marine species. The reliance of humpback dolphins on restricted nearshore waters in Namibe Province renders them especially vulnerable to habitat degradation, a threat that has also been identified for Atlantic humpback dolphins in Senegal (Van Waerebeek *et al.*, 2004) and for Indo-Pacific humpback dolphins in several parts of their range (e.g. Jefferson and Karczmarski, 2001; Jefferson *et al.*, 2009; Karczmarski, 2000; Wang *et al.*, 2007). In Angola, habitat degradation may result particularly from expanding coastal fishing communities, trawling, harbour construction and expansion (the Namibe Province study area is located between two major Angolan fishing ports and shipyards; Tombwa, located 5km to the south and Namibe, located 13km to the north), and offshore industry (e.g. construction of LNG plants, pipe-lines and coastal terminals).

Over-fishing

Prey depletion, resulting from intensive exploitation of local fish stocks, can cause marked declines in cetacean species (e.g. Bearzi *et al.*, 2006). Van Waerebeek *et al.* (2004) considered reduced foraging success from over-fishing to be a potentially restricting factor for the recovery of depleted Atlantic humpback dolphin populations. Limited data indicate prey species including grunt (*Pristipoma juvelini*), bongo (*Ethmalosa fimbriata*) and mullet (*Mugil* spp.) (Cadenat, 1959; Van Waerebeek *et al.*, 2003, 2004; Weir, 2009), and, similar to the Indo-Pacific humpback dolphin (Barros and Cockcroft, 1991), they probably also prey upon reef-dwelling species. Fish are a crucial source of protein and income in Angola; 95% of the country's fish catch is consumed domestically and up to half of the Angolan population depends on fisheries for a significant part of their livelihood (Du Preez, 2009). Declines in the estimated biomass of most fish groups between 1996 and 2003 suggest that catches may have been unsustainable (Du Preez, 2009). Localised, nearshore over-fishing by artisanal fishers may potentially impact humpback dolphins; national artisanal catches increased from 31,131 tonnes to 50,420 tonnes between 1998 and 2001 (FAO, 2004) and the government is prioritising further investment in artisanal fisheries as a means of reducing poverty (Du Preez, 2009).

(a)



(b)

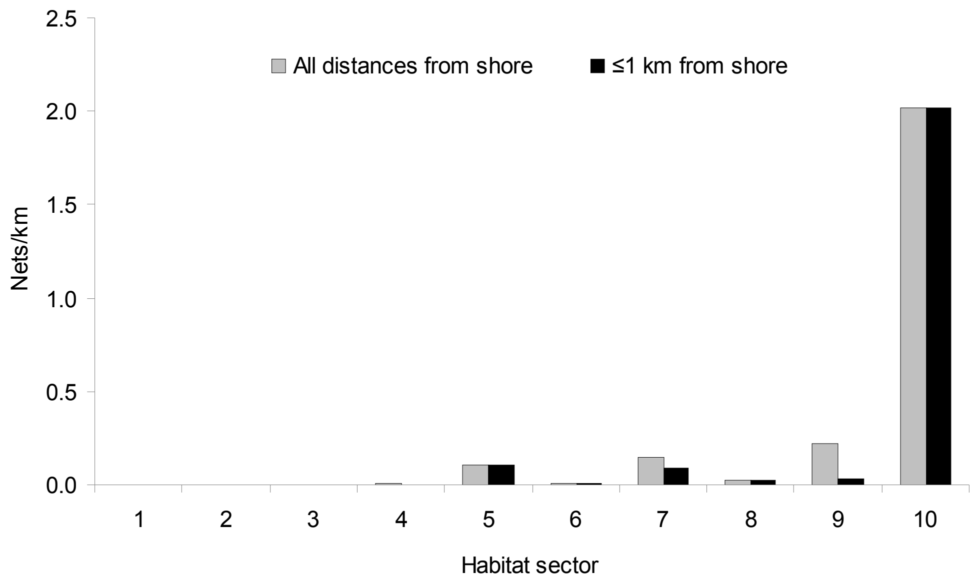


Figure 3. Anthropogenic activities recorded during boat surveys in ten 5km latitude study area sectors in Namibe Province: (a) relative abundance of fishing boats; and (b) relative abundance of gillnets.

Other potential impacts

While vessel strikes and live captures for aquaria are documented threats for Indo-Pacific humpback dolphins (Jefferson *et al.*, 2006, 2009; Parsons and Jefferson, 2000; Reeves *et al.*, 2003; Ross *et al.*, 1994; Van Waerebeek *et al.*, 2007), these are unlikely to significantly affect Atlantic humpback dolphins at present. However, several other anthropogenic impacts might be relevant.

Marine pollution

Marine pollution originates from terrestrial, atmospheric and ship sources including sewage, industrial waste discharges and emissions, run-off from urban and agricultural areas, vehicle and vessel exhausts, garbage and oil spills. To date most studies of cetaceans have focussed on organochlorines such as polychlorinated biphenyls (PCBs) and the pesticide dichlorodiphenyltrichlorothane (DDT) which can cause disruption of the immune system (increasing susceptibility to disease), reproductive failure, physical deformities and direct mortality via the nervous system (Parsons, 2004). Parsons (2004) and Jefferson *et al.* (2006) found that Indo-Pacific humpback dolphins in Hong Kong contained sufficiently elevated concentrations of organochlorines (predominantly DDT) and trace elements (particularly mercury) to cause serious health problems. Hong Kong is a large industrial city, and pollution levels in the region may be far higher than those encountered in most of West Africa. Nevertheless, PCB and DDT levels in humpback dolphins from less industrialised regions may also be high (e.g. De Kock *et al.*, 1994). Several large port cities exist within the geographic range of Atlantic humpback dolphins, and the prevalence of the oil and gas industry in the region may also generate pollution. Coastal cetaceans are also vulnerable to sewage-borne bacteria originating from untreated sewage entering the environment and being transferred via prey or wounds (Parsons and Jefferson, 2000). Bacterial infections may directly cause mortality, or may debilitate animals and increase their vulnerability to disease. The tendency for Atlantic humpback dolphins to inhabit coastal bays and estuarine systems increases their susceptibility to pollution, particularly when these areas are located downstream of significant human habitation.

Climate change

Water temperature influences the geographic range of cetacean species, and climate change is likely to impact their occurrence both directly and indirectly (via prey) (Macleod, 2009). Atlantic humpback dolphins are a subtropical/tropical species, and increases in water temperature predicted during climate change are generally expected to be favourable, potentially resulting in range expansion. However, one future impact suggested by MacLeod (2009) is mixing of Atlantic humpback dolphins and Indo-Pacific humpback dolphins off south-west Africa should the cold-water Benguela Current system weaken and the ranges of both species increase sufficiently to overlap. It is unclear whether the two species would maintain their genetic distinctiveness in such an eventuality (MacLeod, 2009), but if they are indeed two separate species as most current data seem to indicate (Jefferson and Van Waerebeek, 2004), then this would be expected.

Anthropogenic sound

The potential impacts of anthropogenic sound on cetaceans may include hearing loss or tissue damage, behavioural disturbance, masking of communication sounds and indirect impacts via prey species (Gordon *et al.*, 2004). Underwater sound from shipping and industrial activities has been highlighted as a major threat to Indo-Pacific humpback dolphins in the eastern Taiwan Strait (Wang *et al.*, 2007) and off Hong Kong (Jefferson *et al.*, 2009). Coastal cetaceans may be impacted by both water-borne and terrestrial sound sources; for example, South Asian river dolphins avoided areas of noisy shoreline activity during the grass-cutting season (Smith, 1993). Atlantic humpback dolphins may be subject to increasing anthropogenic sound associated with coastal activities, development and shipping. Certain areas of West Africa (especially Nigeria, Ghana, Equatorial Guinea, Gabon, Congo and northern Angola) are the focus of growing hydrocarbon exploration, with high-amplitude impulsive sound produced during geophysical seismic surveys and additional sound (e.g. drilling, pile-driving, explosions and dredging) produced during platform installations. In continental shelf waters, particularly in nearshore areas, these activities have the potential to disturb and displace humpback dolphins.

Consequences of anthropogenic impacts

Direct mortality or displacement of dolphins may result in: (1) reduced abundance; (2) habitat fragmentation; and (3) genetic factors.

Low abundance

Atlantic humpback dolphins may never have been especially numerous. Most of the management stocks identified to date appeared to contain fewer than 100 animals (Van Waerebeek and Perrin, 2007; Van Waerebeek *et al.* 2004), and there is evidence for recent declines of stocks in some areas, for example the Banc d'Arguin stock in Mauritania (Van Waerebeek and Jiddou, 2006). To date, the only verified sightings off Angola are from Namibe Province where 10 individuals were identified (Weir, 2009), and it is probable that the Angola Management Stock proposed by Van Waerebeek *et al.* (2004) is therefore of extremely low abundance. The northernmost stock in Dahkla Bay, Western Sahara, also appears to consist of fewer than 30 animals (Notarbartolo di Sciara *et al.*, 1998). However, the latter two stocks are at the edges of the species' current geographic range, and may be naturally low as a consequence of occupying marginal niche habitat. The low abundance of some existing stocks greatly increases their susceptibility to stochastic perturbations.

Habitat fragmentation

There is evidence for current distribution gaps in the range of Atlantic humpback dolphins (Van Waerebeek *et al.*, 2004). While some of these gaps may result from poor survey coverage, others appear to be genuine, for example the lack of Atlantic humpback dolphins in long-term Ghanaian bycatch monitoring programmes (Ofori-Danson *et al.*, 2003; Van Waerebeek *et al.*, 2009), and are probably a result of prolonged anthropogenic mortality and habitat loss (Van Waerebeek and Perrin, 2007). Given that Atlantic humpback dolphins occupy a very narrow, specialised ecological niche, the loss of coastal habitat is likely to directly fragment and isolate existing populations. The biological population status of Atlantic humpback dolphins is currently unclear due to lack of genetic data and poor knowledge of current distribution. However, Van Waerebeek *et al.* (2004) consider it likely that some stocks will obtain biological population status in the future, following genetic drift through geographic isolation.

Genetic factors

Virtually nothing is known about the genetics of the Atlantic humpback dolphin, due to a lack of samples. High mortality and habitat fragmentation can reduce populations to levels at which stochastic variation in demography and in the environment significantly affect their viability (Shaffer, 1981). Small populations tend to contain lower genetic variation (Frankham, 1996), increasing their vulnerability to stochastic processes. The Atlantic humpback dolphin management stocks identified by Van Waerebeek *et al.* (2004) number from tens to (at best) a few hundred animals each, and several of these, particularly the Dahkla Bay and Banc d'Arguin stocks (Van Waerebeek *et al.*, 2004) and the Angola stock (known only from Namibe Province; Weir, 2009) currently appear to be isolated. Franklin (1980) calculated that short-term erosion of genetic variability would be expected when the effective population size (i.e. the number of animals contributing to the genetic diversity of the next generation) was less than 50 individuals. Therefore, genetic variation in Atlantic humpback dolphins needs to be maintained by both conserving adequately large population sizes and maintaining connectivity between populations.

CHALLENGES AND PRIORITIES FOR CONSERVATION

Key challenges for Atlantic humpback dolphin conservation

The long-term conservation of Atlantic humpback dolphins throughout their range involves multiple biological, economic, sociological and political factors. The paucity of accurate baseline data on Atlantic humpback dolphins, their habitat and threats is an immediate hindrance to the development of an effective conservation and management strategy. Their contemporary occurrence in several historic and potential range states has not been ascertained (Van Waerebeek *et al.*, 2004) and the species was only shown to occur as far south as southern Angola as 2004 (Weir, 2010) and confirmed in the Congo

Republic as recently as 2008 (Tim Collins, unpublished data). Information on abundance is anecdotal and often dated (Van Waerebeek *et al.*, 2003, 2004), and only currently available for the Namibe Province study area (Weir, 2009). Genetic, morphological, life-history and fine-scale distributional data are required to assess population structure over its range. The impacts of bycatch and other threats on the species cannot be evaluated without life history data on fecundity, calving interval and longevity to enable rates of population growth and sustainable take to be calculated.

Perhaps the greatest challenge for conserving Atlantic humpback dolphins is the widespread human poverty that occurs throughout its range states. The Human Development Index (HDI) is a composite statistic used to broadly rank countries according to standard of living (gross domestic product per capita), life expectancy at birth and education (adult literacy rate) (UNDP, 2009). Of the 10 confirmed and nine potential Atlantic humpback dolphin range states, all (except Western Sahara for which data are lacking) are classified either low or medium in the HDI world classifications (Table 1); 14 of these countries are in the lowest 20% of the 182 ranked countries. Any conservation measures implemented for Atlantic humpback dolphins must therefore bear in mind the significant contribution that artisanal fishing activities make to the livelihoods of coastal communities throughout West Africa. The low HDI of range states is also reflected in a paucity of local scientists carrying out cetacean research, and a lack of awareness of conservation and ecological sustainability amongst fishing communities who currently have little incentive to conserve the Atlantic humpback dolphin.

Table 1. The Human Development Index (HDI) classification (UNDP, 2009) of the 10 confirmed and nine potential range states where Atlantic humpback dolphins occur

Country	HDI world rank (out of 182 countries)	HDI human development classification
Confirmed range states		
Western Sahara	N/A	N/A
Mauritania	154	Medium
Senegal	166	Low
The Gambia	168	Low
Guinea-Bissau	173	Low
Guinea	170	Low
Cameroon	153	Medium
Gabon	103	Medium
Congo Republic	136	Medium
Angola	143	Medium
Other potential range states		
Sierra Leone	180	Low
Liberia	169	Low
Cote d'Ivoire	163	Low
Ghana	152	Medium
Togo	159	Low
Benin	161	Low
Nigeria	158	Medium
Equatorial Guinea	118	Medium
Democratic Republic of Congo	176	Low

Significant challenges also originate from the fact that, unlike the baiji and the vaquita, the geographic range of the Atlantic humpback dolphin extends across at least 10 range states (Van Waerebeek *et al.*, 2003, 2004) and multiple countries must coordinate conservation plans. In some countries, particularly Western Sahara, Mauritania and Angola, the number of dolphins remaining is apparently low, while others such as Guinea-Bissau may have larger populations (Van Waerebeek *et al.*, 2003, 2004). Yang *et al.* (2006) highlighted the predicament of whether to invest limited resources in attempting to conserve all species/populations or whether to direct funding towards those populations with the highest likelihood of persistence and accept the extinction risk to others. In the long-term, protection of Atlantic humpback dolphins might be most cost-effective if focussed in core areas where healthy dolphin populations still exist, particularly when conservation measures (such as gillnet restrictions) may have significant repercussions on human welfare through diversion of funding or impacts on artisanal fisheries.

Priorities for instigating conservation measures

Scientific assessment

A thorough scientific evaluation of the species throughout its known and potential range states (see Table 1) is required. It is possible to effectively study Atlantic humpback dolphins from shore (Weir, 2009), and given the difficulties with surveying nearshore areas by boat (e.g. shallow water, surf breaks, reef, sand banks) then shore-based surveys may be both logistically and economically the most viable starting point for assessing the species. While ultimately a robust scientific assessment of the core areas inhabited by dolphins is required to evaluate abundance, seasonal distribution and population structure, a network of trained local shore-based observers along the coast might be sufficient to provide initial baseline information on the distribution and approximate number of dolphins using each range state. Given adequate training and survey design, monitoring of wildlife by local communities can produce cost-effective and accurate results (e.g. Gaidet *et al.*, 2003), and simultaneously generate awareness.

Range states should also establish cetacean stranding and bycatch monitoring programmes (possibly with reward incentives to encourage local people to report animals), and train local biologists in conducting post-mortems to establish cause of death and collect material to examine life-history, diet and contaminant loads. One such monitoring scheme of small cetacean landings has been periodically implemented in Ghana since 1998, and although no takes of Atlantic humpback dolphins were recorded (Ofori-Danson *et al.*, 2003; Van Waerebeek *et al.*, 2009) (potentially signifying an absence of humpback dolphins in that state or a drastic reduction in numbers due to bycatch and hunting: Van Waerebeek *et al.*, 2004, 2009), the programme provides valuable information on cetacean occurrence.

Bycatch mitigation

Although quantitative data are lacking, bycatch in gillnets is the most common cause of mortality recorded in Atlantic humpback dolphins (Van Waerebeek *et al.*, 2004; Tim Collins, unpublished data), and is likely to represent the most important threat to the species throughout its range, as is the case for other small endangered cetaceans such as the baiji (Turvey *et al.*, 2007), vaquita (Rojas-Bracho *et al.*, 2006; Vidal, 1993), Maui's dolphin (*Cephalorhynchus hectori maui*) (Baker *et al.*, 2002; Slooten *et al.*, 2006) and Irrawaddy dolphin (*Orcaella brevirostris*) (Baird and Beasley, 2005; Kreb and Budiono, 2005). Gillnets and shark nets are also a frequent cause of mortality for Indo-Pacific humpback dolphins in the eastern Taiwan Strait (Wang *et al.*, 2007), off Kwazulu-Natal, South Africa (Cockcroft, 1990) and around the Indian Ocean (Ross *et al.* 1994). As noted by Choudhary *et al.* (2006) and Van Waerebeek and Perrin (2007), bycatch may be very difficult to address in impoverished fishing communities, given their high reliance on the marine ecosystem for food and income.

Data from Namibe Province indicate that restricting gillnet use to areas beyond 1km from the shore would reduce most potential interactions with humpback dolphins. A similar measure was introduced in a protected area for Hector's dolphin in New Zealand, where gillnet use was prohibited within 7.4km of the coast (Slooten *et al.*, 2006). However, the complete removal of gillnets was recommended by Wang *et al.* (2007) for Indo-Pacific humpback dolphin habitats in the eastern Taiwan Strait, by Baird and Beasley (2005) for the Irrawaddy dolphin in key parts of the Mekong River, and by Rojas-Bracho *et al.* (2006) for the entire region inhabited by the vaquita in the northern Gulf of California. Site-specific studies are needed to ascertain whether gillnet restrictions (e.g. on size, number and deployment) only in nearshore waters would suffice or whether total exclusion is required. Such restrictions would likely require subsidisation of local fishers and other stakeholders to compensate for loss of income, or the development of other incentive schemes (e.g. alternative employment) to encourage communities to participate. Provision of alternate sustainable fishing gear might also be effective, as recommended for conserving the vaquita (Rojas-Bracho *et al.*, 2006). For example, fishing with lines could be carried out in coastal areas without causing humpback dolphin mortality.

Gillnet restrictions are ineffective unless they are properly enforced. National legislation banning harmful fishing practices was implemented in the Yangtze River yet these practices increased during the period of the baiji's demise (Zhou *et al.*, 1998). Illegal gillnetting also continues in protected areas for Hector's dolphins in New Zealand (Slooten *et al.*, 2006) and vaquitas in the northern Gulf of California (Rojas-Bracho *et al.*, 2006). The 2004 Law on Biological Aquatic Resources in Angola makes provision for community observers to work as monitors in the areas reserved for subsistence and artisanal fisheries (Du Preez, 2009), and such people would be ideally placed to monitor compliance with regulations and to report dolphin bycatch events.

While there has been success at reducing bycatch in some small cetacean species using acoustic deterrent devices ('pingers') (e.g. for harbour porpoise *Phocoena phocoena*; Kraus *et al.*, 1997), this is not considered a reasonable long-term option for mitigating Atlantic humpback dolphin bycatch. Pingers were considered as a means of reducing vaquita bycatch (Rojas-Bracho *et al.*, 2006), and were rejected on the basis that they have not been field-tested with vaquita (and could not be without incurring additional mortality), bycatch would not be completely eliminated, there is a risk of displacing animals from favoured habitat and there are considerable logistical problems with implementation of pingers in artisanal fisheries. These issues apply equally to the Atlantic humpback dolphin in West Africa, where the logistics and expense of issuing pingers to all artisanal fishing communities, fitting them to every net and maintaining them over the long-term are prohibitive. Furthermore, even small-scale displacement of Atlantic humpback dolphins from an already restricted nearshore habitat may be detrimental.

Marine protected areas

Karczmarski (2000) suggested that the designation of protected areas might be the most effective measure to protect Indo-Pacific humpback dolphins in Algoa Bay. There is evidence that Atlantic humpback dolphins exhibit site fidelity in at least some areas, for example in Namibe Province (Weir, 2009) and in the Saloum Delta, Senegal (Van Waerebeek *et al.*, 2003, 2004). Year-round use of such areas indicates the presence of sufficient breeding and feeding habitat to support the species, potentially making them appropriate Marine Protected Areas (MPAs). Given the reliance of local communities on coastal waters and the apparently patchy distribution of the species, an MPA system covering the entire range of the Atlantic humpback dolphins is not feasible. However, core areas where the largest concentrations of Atlantic humpback dolphins are currently located should be considered for nomination as internationally-supported MPAs, with associated restrictions on coastal development and gillnet use.

Four MPAs used by Atlantic humpback dolphins already exist in the West Africa region: the Banc d'Arguin National Park and Biosphere Reserve in Mauritania, the Saloum Delta National Park and Biosphere Reserve in Senegal, Mayumba National Park in Gabon and Conkouati-Douli National Park in the Congo Republic (Hoyt, 2005; Tim Collins, unpublished data). There are smaller marine reserves at Niumi National Park and the Tanji Bird Reserve in The Gambia, and at the Konkoure Estuary in Guinea, which are also used by Atlantic humpback dolphins (Van Waerebeek *et al.*, 2003, 2004). However, the status of the dolphin populations inhabiting those reserves is unclear. For example at the Banc d'Arguin National Park and Biosphere Reserve the population was thought to be 'not more than 100 animals' in 1980 (Maigret, 1980) but a three day survey of the region in 2006 did not locate any (Van Waerebeek and Jiddou, 2006). Furthermore, artisanal fishing occurs in all of those protected areas and dolphin bycatch is a known problem (Hoyt, 2005). As aptly illustrated by continued takes of vaquitas in the Biosphere Reserve of the Upper Gulf of California and Colorado River Delta (Rojas-Bracho *et al.*, 2006), MPAs are unlikely to be effective for conserving Atlantic humpback dolphins unless gillnet restrictions are fully enforced.

Awareness and training schemes
The most successful conservation ventures are often those implemented in conjunction with local communities (Beasley 2007; Danielsen *et al.*, 2007; Sheil and Lawrence, 2004). Regional conservation plans should therefore aim to raise awareness of Atlantic humpback dolphins in coastal communities. For example, efforts to publicise the plight of the baiji in China resulted in their adoption as a symbol by a beer company, a hotel and a fertiliser manufacturer (Carwardine, 2007), while a critically endangered population of Irrawaddy dolphins are the adopted symbol of East Kalimantan Province in Indonesia (Kreb and Budiono, 2005). The Indo-Pacific humpback dolphin was selected as the mascot for the handover ceremony of Hong Kong from the United Kingdom to China in 1997 (Jefferson *et al.*, 2009). Awareness campaigns should also seek to educate local communities on the concept of ecological sustainability. Baird and Beasley (2005) found that villagers in Cambodia were generally supportive of the development of 'Fish Conservation Zones' where gillnet use was stopped or restricted, since subsequent increases in fish stocks were beneficial to all. Such incentives might be the most effective method of implementing gillnet bans in the areas inhabited by Atlantic humpback dolphins.

One method by which awareness of cetaceans, and economic incentives for their protection, can be raised within local communities is via the introduction of community-based ecotourism projects. Whale and dolphin-watching is growing in Africa, and small-scale community-involved cetacean ecotourism projects exist in Gabon (Rosenbaum and Collins, 2006) and The Gambia (Van Waerebeek *et al.*, 2000), and have been trialled in Benin (Van Waerebeek *et al.*, 2002). At present, most of the range of the Atlantic humpback dolphin comprises countries where tourism is underdeveloped and where appropriate infrastructure is lacking. However, properly-regulated ecotourism could provide future opportunities to ensure local community involvement in conserving dolphins.

In addition to providing scientific expertise and logistical support in establishing training programmes for local scientists, the international community should also provide long-term financial support to guarantee trained people employment in marine mammalogy in their respective countries. This might be carried out through development of an international working group to address Atlantic humpback dolphin conservation, including stakeholders, scientists and governmental representation from known and potential range states.

CONCLUSIONS: THE OUTLOOK FOR THE ATLANTIC HUMPBACK DOLPHIN

The Atlantic humpback dolphin currently faces many of the same threats and conservation issues as other endangered small cetaceans including the functionally-extinct baiji and the critically endangered vaquita. All three species occupy restricted geographical ranges and habitats, have low worldwide abundance and face heavy anthropogenic pressures particularly from fisheries bycatch. In 2003, the IUCN Cetacean Specialist Group identified the Atlantic humpback dolphin as a high priority for research and conservation (Reeves *et al.*, 2003). However, in contrast to the baiji and the vaquita whose demises have been the focus of extensive international scientific survey work, conservation plans and public awareness campaigns (Rojas-Bracho *et al.* 2006; Turvey *et al.*, 2007; Vidal, 1993; Zhou *et al.*, 1998), the decline of the Atlantic humpback dolphin has been documented only anecdotally and has prompted little response.

Van Waerebeek and Perrin (2007) reported that the Atlantic humpback dolphin requires 'the maximum possible legal and other protection, considering its low abundance, threatened habitat, suspected fragmentation of distribution range, unknown natural history and low prospects for efficient monitoring of stock status'. This paper has made some suggestions towards how this might be achieved in Namibe Province and throughout the species' range. Recommended priorities for all known and potential range states of the Atlantic humpback dolphin include: (i) surveys of current distribution and abundance; (ii) bycatch monitoring programmes to obtain an estimate of annual mortality and to conduct post-mortems for life-history data; (iii) local awareness and training schemes; (iv) protection of core areas; and (iv) reduction/elimination of nearshore (at least ≤1km from shore) gillnet use in core areas.

There is understandable reluctance to implement conservation measures without strong scientific data to base them on. However, given the numerous challenges to establishing monitoring programmes in all range states, it is highly unlikely that scientific data unequivocally supporting a decline of Atlantic humpback dolphins will become available in the near future. In the case of the vaquita, it has been estimated that detecting a 10%/year decline (α=0.05) would require annual surveys over a period of 20 years at a cost of approximately US$13 million (Jaramillo-Legorreta *et al.*, 2007). Such lengthy delays while collecting adequate data may be crucial. Ample warning was provided of the high probability of extinction of the baiji (Zhang *et al.* 2003; Zhou *et al.*, 1998), yet ultimately their decline from around 400 animals in 1979–1981 to only 13 animals by 1997–1999 was too rapid and the response too slow and inefficient, for conservation measures to be implemented (Turvey *et al.*, 2007). Scientists are currently warning of a similar scenario for the long-term viability of the Atlantic humpback dolphin unless conservation measures are taken (Jefferson, 2009; Reeves *et al.*, 2003; Van Waerebeek, 2003; Van Waerebeek and Jefferson, 2004; Van Waerebeek and Perrin, 2007; Van Waerebeek *et al.*, 2003, 2004; Weir, 2009).

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REFERENCES

Alfaro-Shigueto, J. and Van Waerebeek, K. 2001. Drowning in the sea of silence: the bushmeat concept applied for marine fauna. Paper presented at the Fourth Biennial Zoos and Aquariums: Committing to Conservation Conference, Cocoa Beach, Florida, 28 November – 2 December 2001 (unpublished).

Baird, I.G. and Beasley, I.L. 2005. Irrawaddy dolphin *Orcaella brevirostris* in the Cambodian Mekong River: an initial survey. *Oryx* 39:301-310.

Baker, A.N., Smith, A.N.H. and Pichler, F.B. 2002. Geographical variation in Hector's dolphin: recognition of new subspecies of *Cephalorhynchus hectori*. *J. Roy. Soc. New Zealand* 32:713-727.

Barros, N.B. and Cockcroft, V.G. 1991. Prey of humpback dolphins (*Sousa plumbea*) stranded in eastern Cape Province, South Africa. *Aquat. Mamm.* 17:134-136.

Bearzi, G., Politi, E., Agazzi, S. and Azzellino, A. 2006. Prey depletion caused by overfishing and the decline of marine megafauna in eastern Ionian Sea coastal waters (central Mediterranean). *Biol. Conserv.* 127: 373-382.

Beasley, I.L. 2007. Conservation of the Irrawaddy dolphin, *Orcaella brevirostris* (Owen in Gray, 1866) in the Mekong River: Biological and social considerations influencing management. PhD Thesis, James Cook University, 428pp.

Cadenat, J. 1959. Rapport sur les petits Cétaces ouest-africains. *Bull. Inst. Fr. Afr. Noire* 21:1367-1409.

Carwardine, M. 2007. The baiji: so long and thanks for all the fish. *New Sci.* 195:50-53.

Choudhary, S.K., Smith, B.D., Dey, S., Dey, S. and Prakash, S. 2006. Conservation and biomonitoring in the Vikramshila Gengetic Dolphin Sanctuary, Bihar, India. *Oryx* 40:189-197.

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

Danielsen, F., Mendoza, M.M., Tagtag, A., Alviola, P.A., Balete, D.S., Jensen, A.E., Enghoff, M. and Poulsen, M.K. 2007. Increasing conservation management action by involving local people in natural resource monitoring. *Ambio* 36:566-570.

De Kock, A.C., Best, P.B., Cockcroft, V.G. and Bosma, C. 1994. Persistent organochlorine residues in small cetaceans from the east and west coasts of southern Africa. *Sci. Total Environ.* 154:153-162.

Du Preez, M. 2009. Fishing for sustainable livelihoods in Angola: the cooperative approach. SAIIA Occasional Paper, No. 45. South African Institute of International Affairs, Johannesburg, South Africa. 27pp. [Available from the author].

FAO. 2004. Information on fisheries management in the Republic of Angola. December 2004. <http://www.fao.org/fi/oldsite/FCP/en/AGO/body.htm>. Downloaded on 22 February 2010.

Frankham, R. 1996. Relationship of genetic variation to population size in wildlife. *Conserv. Biol.* 10:1500-1508.

Franklin, I.A. 1980. Evolutionary change in small populations. Pp. 135-149. In: M.E. Soulé and B.A. Wilcox (eds.) *Conservation Biology: An Evolutionary-Ecological Perspective*. Sinauer Associates, Sunderland, Massachusetts. 395pp.

Frère, C.H., Hale, P.T., Porter, L., Cockcroft, V.G. and Dalebout, M.L. 2008. Phylogenetic analysis of mtDNA sequences suggests revision of humpback dolphin (*Sousa* spp.) taxonomy is needed. *Mar. Freshwater Res.* 59:259-269.

Gaidet, N., Fritz, H. and Nyahuma, C. 2003. A participatory counting method to monitor populations of large mammals in non-protected areas: A case study of bicycle counts in the Zambezi Valley, Zimbabwe. *Biodivers. Conserv.* 12:1571-1585.

Gordon, J.C.D., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M., Swift, R. and Thompson, D. 2004. A review of the effects of seismic surveys on marine mammals. *Mar. Technol. Soc. J.* 37:16-34.

Hoyt, E. 2005. *Marine Protected Areas for whales, dolphins and porpoises: A world handbook for cetacean habitat conservation*. Earthscan, London, UK. 492pp.

IUCN. 2009. IUCN Red List of Threatened Species. Version 2009.2. <www.iucnredlist.org>. Downloaded on 14 February 2010.

Jaramillo-Legorreta, A., Rojas-Bracho, L., Brownell, R.L., Read, A.J., Reeves, R.R., Ralls, K. and Taylor, B.L. 2007. Saving the vaquita: Immediate action, not more data. *Conserv. Biol.* 21:1653-1655.
Jefferson, T.A. 2009. The most endangered cetacean species. Pp. 5-7. In: M. Sidenstecker (ed.), *Save the Whales Newsletter*. Seaside, CA. [Available from the author].
Jefferson, T.A. and Karczmarski, L. 2001. *Sousa chinensis*. *Mamm. Species* 655:1-9.
Jefferson, T.A., Hung, S.K. and Lam, P.K.S. 2006. Strandings, mortality and morbidity of Indo-Pacific humpback dolphins in Hong Kong, with emphasis on the role of environmental contaminants. *J. Cetacean Res. Manage.* 8:181-193.
Jefferson, T.A. and Van Waerebeek, K. 2004. Geographic variation in skull morphology of humpback dolphins (*Sousa* spp.). *Aquat. Mamm.* 30:3-17.
Jefferson, T.A., Hung, S.K. and Würsig, B. 2009. Protecting small cetaceans from coastal development: Impact assessment and mitigation experience in Hong Kong. *Mar. Policy* 33:305-311.
Karczmarski, L. 2000. Conservation and management of humpback dolphins: the South African perspective. *Oryx* 34:207-216.
Kraus, S.D., Read, A.J., Solow, A., Baldwin, K., Spradlin, T., Anderson, E. and Williamson, J. 1997. Acoustic alarms reduce porpoise mortality. *Nature* 388:525.
Kreb, D. and Budiono. 2005. Conservation management of small core areas: key to survival of a Critically Endangered population of Irrawaddy river dolphins *Orcaella brevirostris* in Indonesia. *Oryx* 2:178-188.
MacLeod, C.D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. *Endang. Species Res.* 7:125-136.
Maigret, J. 1980. Données nouvelles sur l'écologie du *Sousa teuszii* (Cetacea, Delphinidae) de la côte Ouest Africaine. *Bull. Inst. Fr. Afr. Noire* 42A:619-633.
Notarbartolo di Sciara, G., Politi, E., Bayed, A., Beaubrun, P-Ch. and Knowlton, A. 1998. A winter cetacean survey off southern Morocco, with a special emphasis on right whales. *Rep. Int. Whal. Commn.* 48:547-550.
Ofori-Danson, P.K., Van Waerebeek, K. and Debrah, S. 2003. A survey for the conservation of dolphins in Ghanaian coastal waters. *J. Ghana Sci. Assoc.* 5:45-54.
Parsons, E.C.M. 2004. The potential impacts of pollution on humpback dolphins, with a case study on the Hong Kong population. *Aquat. Mamm.* 30:18-37.
Parsons, E.C.M. and Jefferson, T.A. 2000. Post-mortem investigations on stranded dolphins and porpoises from Hong Kong waters. *J. Wildlife Dis.* 36:342-356.
Reeves, R.R., Smith, B.D., Crespo, E.A. and Notarbartolo di Sciara, G. 2003. Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. IUCN, Gland, Switzerland; Cambridge, UK. 139pp.
Rojas-Bracho, L., Reeves, R.R. and Jaramillo-Legorreta, A. 2006. Conservation of the vaquita *Phocoena sinus*. *Mammal Rev.* 36:179-216.
Rosel, P.E. and Reeves, R.R. 2000.Genetic and demographic considerations for the conservation of Asian river cetaceans. Pp. 144-152. In: R.R. Reeves, B.D. Smith and T. Kasuya (eds.) *Biology and Conservation of Freshwater Cetaceans in Asia*. IUCN, Gland, Switzerland and Cambridge, UK. viii+152pp.
Rosenbaum, H.C. and Collins, T. 2006. The ecology, population characteristics and conservation efforts for humpback whales (*Megaptera novaeangliae*) on their wintering grounds in the coastal waters of Gabon. *Bull. Biol. Soc. Washington* 12:425-433.
Ross, G.J.B., Heinsohn, G.E. and Cockcroft, V.G. 1994. Humpback dolphins *Sousa chinensis* (Osbeck, 1765), *Sousa plumbea* (G. Cuvier, 1829) and *Sousa teuszii* (Kukenthal, 1892). Pp.23-42. In: S.H. Ridgway and R. Harrison (eds.) *Handbook of Marine Mammals. Vol. 5. The First Book of Dolphins*. Academic Press, London. I-xvii+416pp.
Shaffer, M.L. 1981. Minimum population sizes for species conservation. *BioScience* 31:131-134.
Sheil, D. and Lawrence, A. 2004. Tropical biologists, local people and conservation: new opportunities for collaboration. *Trends Ecol. Evol.* 19:634-638.
Slooten, E., Dawson, S., Rayment, W. and Childerhouse, S. 2006. A new abundance estimate for Maui's dolphin: What does it mean for managing this critically endangered species? *Biol. Conserv.* 128:576-581.
Smith, B.D. 1993. 1990 status and conservation of the Ganges river dolphin *Platanista gangetica* in the Karnali River, Nepal. *Biol. Conserv.* 66:159-169.
Taylor, B.L. and Rojas-Bracho, L. 1999. Examining the risk of inbreeding depression in a naturally rare cetaceans, the vaquita (*Phocoena sinus*). *Mar. Mammal Sci.* 15:1004-1028.
Turvey, S.T., Pitman, R.L., Taylor, B.L., Barlow, J., Akamatsu, T., Barrett, L.A., Zhao, X., Reeves, R.R., Stewart, B.S., Wang, K., Wei, Z., Zhang, X., Pusser, L.T., Richlen, M., Brandon, J.R. and Wang, D. 2007. First human-caused extinction of a cetacean species? *Biology Lett.* 3:537-540.
UNDP. 2009. Human Development Report 2009. Overcoming barriers: Human mobility and development. United Nations Development Programme, New York, USA. 229pp.
Van Waerebeek, K. 2003. The Atlantic humpback dolphin: In retreat? *CMS Bulletin* 17:10-11.
Van Waerebeek, K. and Jefferson, T.A. 2004. Dolphins under threat: Conservation of humpback dolphins. Newsletter of the Species Survival Commission: *Species* 41:6. [Available from the author].
Van Waerebeek, K. and Jiddou, A. 2006. Deuxième formation sur l'identification des mammifères aquatiques de l'Afrique de l'Ouest et campagne de prospection des Cétacés dans les eaux du Cap Blanc et du PNBA. Rapport à la Fondation Internationale du Banc d'Arguin. 13pp. (unpublished). [in French].
Van Waerebeek, K. and Perrin, W.F. 2007. Conservation status of the Atlantic humpback dolphin, a compromised future? Paper CMS/ScC14/Doc.6, 14th Meeting of the CMS Scientific Council, March 2007, Bonn, Germany. 10pp. (unpublished). [Available from the Convention on Migratory Species].
Van Waerebeek, K., Ndiaye, E., Djiba, A., Diallo, M. Murphy, P., Jallow, A., Camara, A., Ndiaye, P. and Tous, P. 2000. A survey of the conservation status of cetaceans in Senegal, The Gambia and Guinea-Bissau. WAFCET - I Report. UNEP/CMS Secretariat, Bonn, Germany. 80pp.
Van Waerebeek, K., Nobimé, G., Sohou, Z., Tchibozo, S., Dossou-Bodrènou, J.S., Dossou, C. and Dossou-Hountoudou, A. 2002. Introducing whale and dolphin watching to Benin, 2002 exploratory survey. Report to the Netherlands Committee for IUCN, Amsterdam, the Netherlands. 9pp.
Van Waerebeek, K., Barnett, L., Camara, A., Cham, A., Diallo, M., Djiba, A., Jallow, A.O., Ndiaye, E., Samba Ould Bilal, A.O. and Bamy, I.L. 2003. Conservation of Cetaceans in The Gambia and Senegal 1999-2001, and Status of the Atlantic humpback dolphin. WAFCET-2 Report, UNEP/CMS, Bonn, Germany. 55pp.
Van Waerebeek, K., Barnett, L., Camara, A., Cham, A., Diallo, M., Djiba, A., Jallow, A.O., Ndiaye, E., Samba Ould Bilal, A.O. and Bamy, I.L. 2004. Distribution, status, and biology of the Atlantic humpback dolphin, *Sousa teuszii* (Kükenthal, 1892). *Aquat. Mamm.* 30:56-83.
Van Waerebeek, K., Baker, A.N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A. and Wang, Y. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. *Latin Amer. J. Aquat. Mamm.* 6:43-69.

Van Waerebeek, K., Ofori-Danson, P.K. and Debrah, J. 2009. The cetaceans of Ghana: a validated faunal checklist. *West African J. Appl. Ecol.* 15:61-90.

Vidal, O. 1993. Aquatic Mammal Conservation in Latin America: Problems and Perspectives. *Conserv. Biol.* 7:788-795.

Wang, J.Y., Yang, S.C. and Reeves, R.R. (eds.). 2007. Conservation action plan for the Eastern Taiwan Strait population of Indo-Pacific humpback dolphins. National Museum of Marine Biology and Aquarium, Checheng, Pingtung County, Taiwan. 4pp. (English) + 4 pp. (Chinese).

Weir, C.R. 2009. Distribution, behaviour and photo-identification of Atlantic humpback dolphins (*Sousa teuszii*) off Flamingos, Angola. *Afr. J. Mar. Sci.* 31:319-331.

Weir, C.R. 2010. A review of cetacean occurrence in West African waters from the Gulf of Guinea to Angola. *Mammal Rev.* 40:2-39.

Yang, G., Bruford, M.W., Wei, F. and Zhou, K. 2006. Conservation options for the baiji: time for realism? *Conserv. Biol.* 20:620-622.

Zhang, X., Wang, D., Liu, R., Wei, Z., Hua, Y., Wang, Y., Chen, Z. and Wang, L. 2003. The Yangtze River dolphin or baiji (*Lipotes vexillifer*): population status and conservation issues in the Yangtze River, China. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 13:51-64.

Zhou, K.Y., Sun, J., Gao, A.L. and Würsig, B. 1998. Baiji (*Lipotes vexillifer*) in the lower Yangtze River: movements, numbers, threats and conservation needs. *Aquat. Mamm.* 24:123-132.