West Africa's Atlantic humpback dolphin (*Sousa teuszii*): endemic, enigmatic and soon Endangered?

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Atlantic humpback dolphins (*Sousa teuszii*) are endemic to nearshore West African waters between Western Sahara and Angola. They are considered Vulnerable by the International Union for Conservation of Nature based on restricted geographic range, low abundance and apparent decline in recent decades. We review the human activities most likely to affect the species and consider appropriate conservation actions. Bycatch (incidental capture) in gillnets is the greatest immediate threat. Deaths from entanglement have been documented in Mauritania, Senegal, Guinea-Bissau, Guinea and the Republic of the Congo. In Namibe Province, Angola, 4.8 artisanal fishing boats and two gillnets per km were observed in some areas within 1 km of the coast and gillnets are deployed regularly inside bays used by dolphins. Other concerns include the 'marine bushmeat' trade, habitat loss/degradation, overfishing, marine pollution, anthropogenic sound and climate change. Conservation challenges include a paucity of scientific data on the species, and widespread human poverty within most range states, resulting in high dependence on artisanal fisheries. Recommended conservation and research priorities include: (1) distribution and abundance surveys in known and potential range states, (2) bycatch monitoring programmes, (3) education/awareness schemes, and (4) protection of core areas via reduction/elimination of nearshore gillnetting.

Key words: Atlantic humpback dolphin, bycatch, conservation, monitoring, research priorities.

INTRODUCTION

The African continent supports a diverse and well-studied mammal fauna, particularly the many species of large herbivores and carnivore predators that roam the plains and the primate communities inhabiting tropical forests and savannas. In Central and West Africa many populations are undergoing marked declines in abundance (Walsh *et al.* 2003; Craigie *et al.* 2010) and several endemic flagship species are currently listed as 'Endangered' or 'Critically Endangered' by the International Union for Conservation of Nature (IUCN 2010), for example the black rhinoceros (*Diceros bicornis*), African wild dog (*Lycaon pictus*) and the Western gorilla (*Gorilla gorilla*). Although the local circumstances surrounding their declining status varies, common to all are over-hunting and habitat loss driven by human population growth and increased resource consumption (Walsh *et al.* 2003; Laurance *et al.* 2006; Craigie *et al.* 2010).

Although Africa's marine mammals are similarly vulnerable to human activities, particularly those species inhabiting coastal waters, they attract considerably less public attention. The species include the 'Critically Endangered' Mediterranean monk seal (*Monachus monachus*) and three species currently classified as 'Vulnerable'[1] by the IUCN (2010): the West African manatee (*Trichechus senegalensis*), dugong (*Dugong dugon*) and Atlantic humpback dolphin (*Sousa teuszii*). The latter species

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[1] Endangered migratory species to be given full protection.

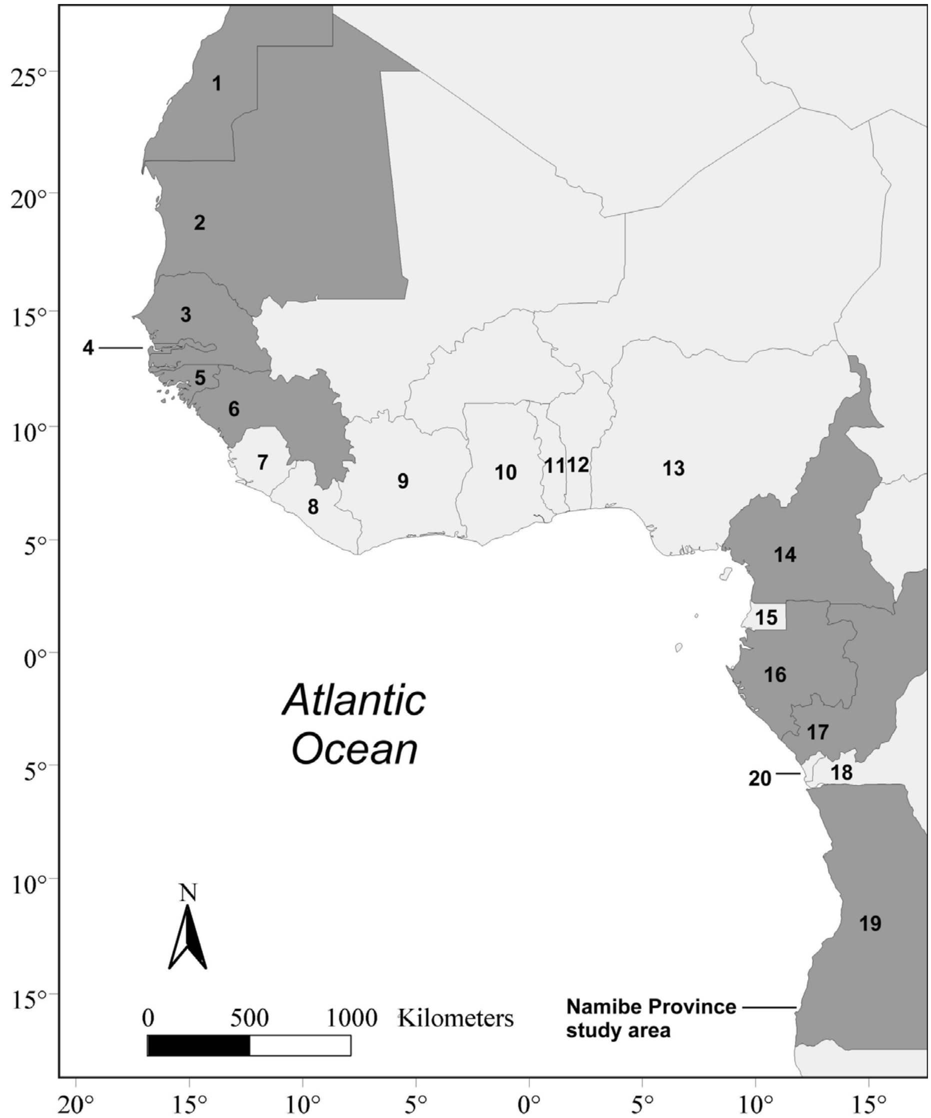

Fig. 1. Study area, with confirmed range states of the Atlantic humpback dolphin shown in dark grey: 1, Western Sahara; 2, Mauritania; 3, Senegal; 4, The Gambia; 5, Guinea Bissau; 6, Guinea; 7, Sierra Leone; 8, Liberia; 9, Côte d'Ivoire; 10, Ghana; 11, Togo; 12, Benin; 13, Nigeria; 14, Cameroon; 15, Equatorial Guinea; 16, Gabon; 17, Republic of the Congo; 18, Democratic Republic of Congo; 19, Angola; 20, Cabinda (Angola).

is endemic to tropical and subtropical waters along the west coast of Africa and is documented from ten range states between Western Sahara and Angola (Van Waerebeek *et al.* 2004; Collins *et al.* 2010; Weir 2010; Fig. 1). Its distribution is apparently discontinuous, probably as a result of decades of bycatch, directed takes and habitat degradation. A review by Van Waerebeek *et al.* (2004) revealed that much of the knowledge at that time consisted of anecdotal reports and occasional stranding and capture records, few of which were recent.

The conservation status of the Atlantic humpback dolphin has much in common with that of several other small and endangered cetacean species worldwide, for example the vaquita (*Phocoena sinus*) and the South Asian river dolphin (*Platanista gangetica*), which are declining predominantly as a result of bycatch (incidental capture) in fishing gear and habitat loss (Reeves *et al.* 2003).

Fig. 2. Part of a group of seven Atlantic humpback dolphins foraging close to shore in Namibe Province, Angola (15°27.89′S, 12°01.81′E) on 20 January 2008.

Several factors render the Atlantic humpback dolphin highly vulnerable to human activities: (1) a restricted geographic range; (2) exclusive occurrence within the waters of developing countries; (3) occupancy of strictly nearshore habitat (Fig. 2); and (4) low total population size (unknown, but 'thought to amount to at most hundreds, not thousands, of animals'; Van Waerebeek & Perrin 2007). It is included on the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) Appendix I (Threatened), and since 2007 it has been included on the Convention on Migratory Species (CMS) Appendix I[2]. In 2003, the IUCN Cetacean Specialist Group identified the Atlantic humpback dolphin as a priority species for research in light of its restricted geographic range and narrow ecological niche and the paucity of available information (Reeves *et al.* 2003). Recently, the Scientific Committee of the International Whaling Commission (IWC) noted serious concern about its conservation status and recommended that the IUCN reassess the Atlantic humpback dolphin, as it may qualify for a more threatened category than 'Vulnerable' (IWC 2010). Despite all of those expressions of concern, few scientific studies have been undertaken or conservation measures implemented to date.

[2]Endangered migratory species to be given full protection.

This paper has three main objectives: (1) to assess the key human activities that are likely harmful to the Atlantic humpback dolphin; (2) to evaluate the main social, economic, political and biological challenges to its conservation; and (3) to assist intergovernmental organizations, range state governments and other stakeholders to identify conservation priorities and help formulate potential recommendations towards establishing a practical management programme.

THREATS AND ANTHROPOGENIC IMPACTS

The narrow ecological niche occupied by the Atlantic humpback dolphin means that the potential for, and its vulnerability to, interactions with humans are unusually high among marine cetaceans. This species occupies strictly nearshore habitat within several hundred metres of the coast (Fig. 2), in both estuarine areas and along exposed coastlines (Van Waerebeek *et al.* 2004; Weir 2009; Collins *et al.* 2010).

Four key processes are likely to affect Atlantic humpback dolphins throughout their range (Van Waerebeek *et al.* 2004): (1) bycatch; (2) directed capture; (3) habitat degradation; and (4) reduction of prey through over-fishing. Additional human activities that have been documented to affect

Indo-Pacific humpback dolphins (*S. chinensis*)[3] and other small, coastal cetacean species may also apply to Atlantic humpback dolphins. Many of the threats described in the following sections may act cumulatively, increasing their overall impact. For example, Bearzi *et al.* (2004) noted that the combined impact of deliberate culls and habitat degradation caused the disappearance of short-beaked common dolphins (*Delphinus delphis*) from the Adriatic Sea.

It should be emphasized that Atlantic humpback dolphin mortality is poorly documented, as would be expected given the paucity of research attention and reporting schemes to date, the fact that local people may distribute bycaught animals for meat before they can be recorded (Van Waerebeek *et al.* 2004), and the reluctance to openly bring cetaceans ashore illegally in several countries due to the risk of prosecution, e.g. in Togo (Segniagbeto & Van Waerebeek 2010).

Bycatch

Incidental capture in fishing gear is the main source of anthropogenic mortality for small cetaceans worldwide (Reeves *et al.* 2003), involving a range of fishing gear such as gillnets, trawls and long-lines. Bycatch is the primary cause of mortality identified to date for humpback dolphins in West Africa (Van Waerebeek *et al.* 2004; Van Waerebeek & Perrin, 2007; Bamy *et al.* 2010; Collins *et al.* 2010), 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 vaquita (Vidal 1993; Rojas-Bracho *et al.* 2006), Maui's dolphin (*Cephalorhynchus hectori maui*) (Baker *et al.* 2002; Slooten *et al.* 2006) and Irrawaddy dolphin (*Orcaella brevirostris*) (Baird & Beasley 2005; Kreb & Budiono 2005), as well as the baiji (*Lipotes vexillifer*), which was recently declared functionally extinct (Zhou & Wang 1994; Turvey *et al.* 2007). Shark set nets to protect beaches off Kwazulu-Natal, South Africa (Cockcroft 1990) and regular gillnets in the eastern Taiwan Strait (Wang *et al.* 2007) and around the Indian Ocean (Ross *et al.* 1994) are also frequent causes of mortality for Indo-Pacific humpback dolphins.

To date, bycatch of Atlantic humpback dolphins has been documented in Mauritania, Senegal, Guinea-Bissau, Guinea and the Republic of the Congo, and it has been highly suspected or inferred to occur in (at least) Western Sahara and The Gambia (Van Waerebeek *et al.* 2004; Van Waerebeek & Perrin 2007; Bamy *et al.* 2010; Collins *et al.* 2010). Entanglement in gillnets is the most frequently reported form of humpback dolphin bycatch in West Africa. However, these dolphins have also been taken on octopus lines and in beach seines and fish traps (Van Waerebeek *et al.* 2004; Van Waerebeek & Perrin 2007).

Estimates of small cetacean mortality in gillnets are difficult to obtain, especially for artisanal fisheries (Reeves *et al.* 2003). However, the known instances of humpback dolphin bycatch and the prevalence of nearshore gillnetting in many areas (see Namibe Province case study below) are suggestive of a widespread impact. The lack of systematic monitoring effort at fish landing sites and markets, e.g. in Guinea (Bamy *et al.* 2010) and Nigeria (Uwagbae & Van Waerebeek 2010), prevents an assessment of the scale of dolphin bycatch in most West African states. Ghana is an exception because cetacean landings have been monitored there since 1995, yet no Atlantic humpback dolphins have been recorded (Van Waerebeek *et al.* 2009; Debrah *et al.* 2010). This suggests that the species is now either absent or extremely rare due to high fisheries mortality in the past (Van Waerebeek & Perrin 2007; Van Waerebeek *et al.* 2009). Alternatively a natural distribution gap may exist off Ghana/Togo related to periodic cool upwelling (Debrah *et al.* 2010).

A case study: Nearshore fishing activity in Namibe Province, Angola

Data on the location of fishing nets, boats and coastal villages were collected as part of a wider study of the ecology of the humpback dolphins in Namibe Province, Angola (Fig. 1), during the summer and winter of 2008 (Weir 2009).

Methods. The locations of fishing vessels, beach seines and gillnets (indicated by pairs of marker buoys) were recorded during the outward legs of boat surveys along 55 km of coast centred on Flamingos (Fig. 3). A 5 m rigid-hulled inflatable boat fitted with an 85-hp outboard engine was used. Low eye height of the observers meant that recording of gillnet buoys was mostly restricted to 1 km on either side 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 4 nm (7.4 km) from shore (du Preez 2009), most of the fishing activity recorded during coastal boat

[3]The taxonomic status of the genus *Sousa* is unresolved and awaiting wide-scale genetic analysis (Frère *et al.* 2008; H. Rosenbaum, pers. comm.). Many authorities currently recognize only two species, *S. chinensis* (Indo-Pacific) and *S. teuszii* (Atlantic).

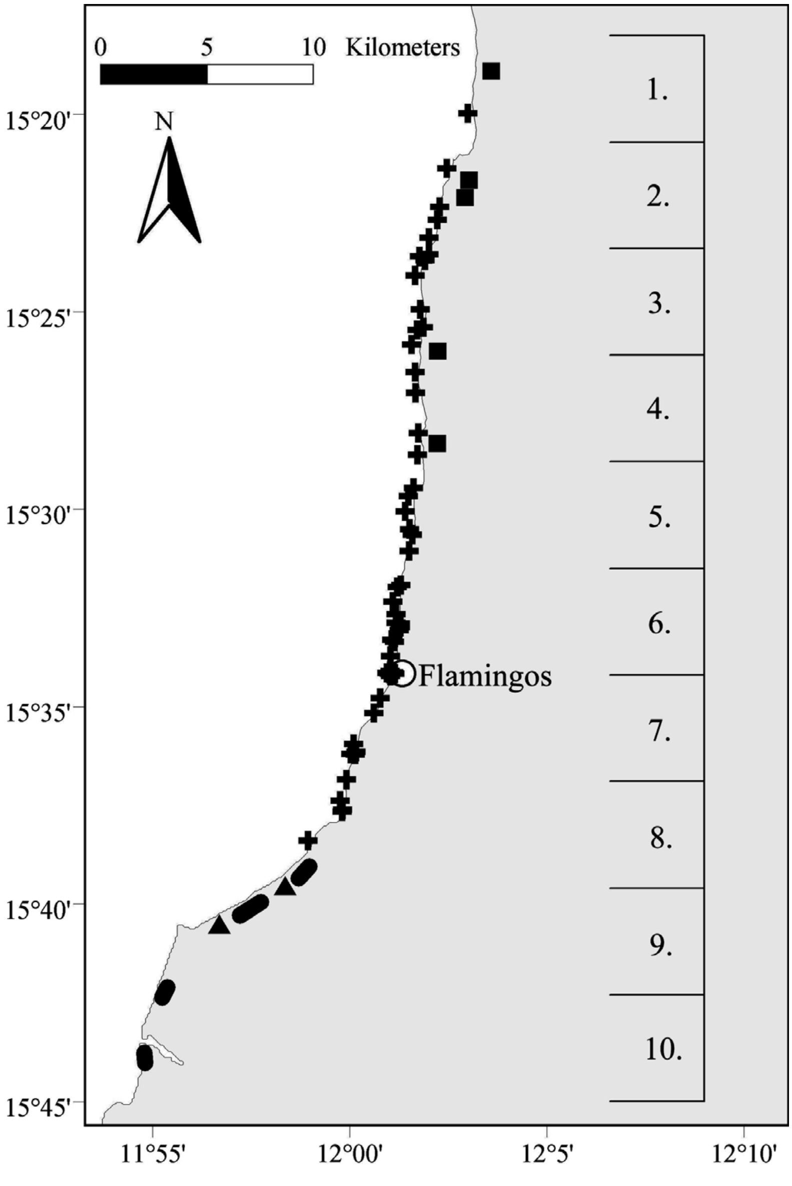

Fig. 3. Namibe Province study area showing Flamingos, the ten 5-km area sectors, location of fishing villages (⬮), other buildings (▲) and fisherman huts (■) and Atlantic humpback dolphins sightings (✚).

surveys was assumed to belong to the subsistence sector (fishing carried out for non-commercial purposes) or artisanal sector (fishing for commercial purposes where boats are ≤14 m long; du Preez 2009), which were analysed together in the remainder of this paper as 'artisanal'. The artisanal fishing vessels were mostly wooden boats or simple canoes made of wood or fibre and powered by paddles or, less commonly, modern fibreglass skiffs powered by outboard engines. Hand lines and gillnets were the primary fishing methods. Occasionally, larger motorized vessels from Namibe were observed in coastal waters, usually operated by multiple crewmen fishing with hand lines.

For analysis, the survey area coastline was divided into ten sectors of 5 km latitude (Fig. 3), and the relative abundance of fishing nets and vessels was calculated in each sector.

Results. Fishing activities and coastal develop-

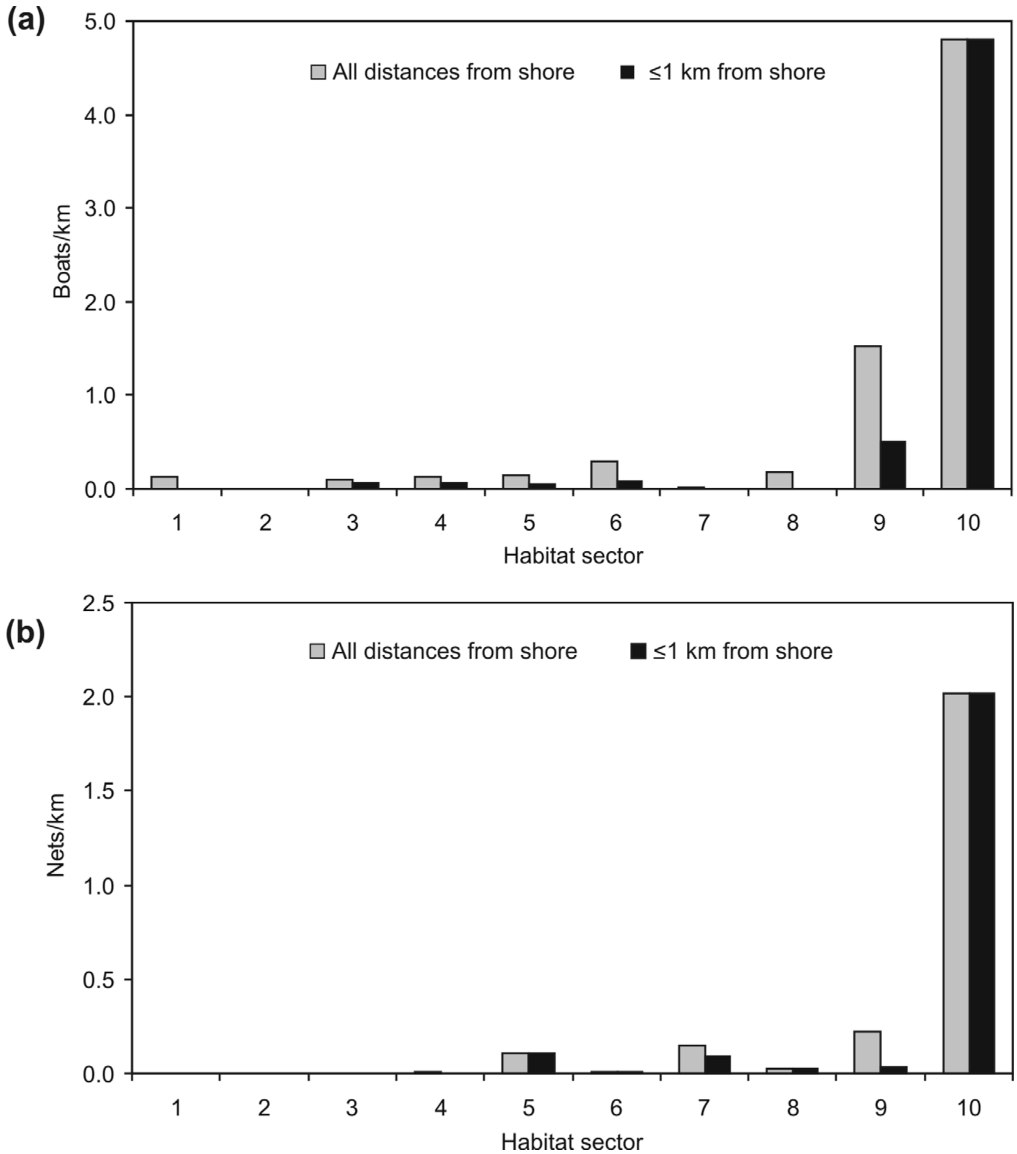

Fig. 4. Anthropogenic activities recorded during boat surveys in ten 5-km latitude study area sectors in Namibe Province: **a**, relative abundance of fishing boats; **b**, relative abundance of gillnets.

ment were monitored for a total of 554.4 km of boat travel. Human habitation was mostly limited to sectors 9 and 10 in the south of the study area, where four large coastal fishing communities and a salt mine are located (Fig. 3). Habitation in sectors 1 to 8 was low, comprising only five small huts in occasional use by fishermen and a tourist lodge for shore anglers at Flamingos (Fig. 3).

Fishing vessel activity was relatively low (especially within 1 km of the coast) in sectors 1 to 8, but increased markedly in sector 9 and reached over 4.8 boats per km of coast in sector 10 (Fig. 4a). Almost all fishing boats in sectors 9 and 10 were artisanal.

Gillnets were recorded only in sectors 4 to 10. Net density peaked markedly in sector 10, where 2 nets per km were recorded within 1 km of the shore (Fig. 4b). Gillnets were also recorded <1 km from shore in sectors 5 and 7 (Fig. 4b), 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 500 m from the shore every day. Beach seining was observed at coastal fishing villages in sectors 9 and 10.

Conclusions. High densities of human habitation, gillnets and fishing boats were recorded in the two southernmost sectors of the study area, which were the only areas where no humpback dolphins were observed during the study (Weir 2009). The persistent deployment of gillnets close to shore in some local areas used regularly by dolphins (e.g. Tuna Bay; Weir 2009) probably comprises the single most important threat to humpback dolphins in the region. Furthermore, very high gillnet densities also occur along the coast of central Angola between Luanda and the Cuanza River mouth (I. Nicolson, pers. comm.), and therefore coastal dolphins are probably at risk of being bycaught throughout Angola.

Deliberate takes

Directed exploitation is usually driven by the demand for products (Reeves *et al.* 2003). Dolphins taken in fisheries are used for human consumption ('marine bushmeat' *sensu* Clapham & Van Waerebeek 2007) or fishing bait to varying degrees in several West African countries (Van Waerebeek *et al.* 2000; Alfaro-Shigueto & Van Waerebeek 2001; Van Waerebeek *et al.* 2003), including Senegal, The Gambia and Mauritania, three confirmed humpback dolphin range states.

On four occasions between 2007 and 2009 'dolphin bushmeat' *en route* to Pointe Noire was confiscated by officials at Conkouati-Douli National Park in the Republic of the Congo (Collins *et al.* 2010). In Nigeria common bottlenose dolphins (*Tursiops truncatus*) and probably other, undetermined species are deliberately captured with gillnets and then sold for human consumption (Uwagbae & Van Waerebeek 2010), and small cetaceans were known to be taken with some regularity in Senegal until at least 2001 (Van Waerebeek *et al.* 2000, 2003).

Hunting for terrestrial bushmeat in Ghana is linked directly to the availability of fish, with poor fishing years reflected by increased bushmeat trade (Brashares *et al.* 2004). There is evidence that dolphin takes in West African countries are also linked to socioeconomic factors. For example, a growing commercialization of small cetacean products in 1995–2009 has occurred in Ghana following a gradual decline of the per capita fish supply since 1975 and concurrent with a decline in total catches of 'aquatic organisms' (from shellfish to sharks) since 1999 (Debrah *et al.*, 2010).

Segniagbeto & Van Waerebeek (2010) reported that catches of small cetaceans increased in response to declining fish stocks in Togo, and Uwagbae & Van Waerebeek (2010) noted that dolphin captures in Nigeria had increased following the recent economic downturn and a decrease in fish sales.

Specific accounts of directed takes of Atlantic humpback dolphins are scarce, but they are believed to occur with some regularity (Van Waerebeek & Perrin 2007). Most reported instances of consumption of humpback dolphin meat have been the result of bycatch, e.g. a bycaught animal in Conkouati-Douli National Park in Congo was butchered and distributed amongst fishermen (Collins *et al.* 2010), and one was found for sale at the fish landing site of Dixinn in Guinea (Bamy *et al.* 2010). However, there is concern that consumption of bycaught dolphin meat will lead to deliberate capture via 'directed entanglement' (Clapham & Van Waerebeek 2007). This has happened in other less-developed countries with coastal fisheries, for example in Peru (Van Waerebeek & Reyes 1994), the Philippines (Dolar 1994) and Tanzania (Amir *et al.* 2002).

Habitat loss and degradation

The loss and fragmentation of habitat due to expanding coastal communities, coastal development, dredging, trawling, deforestation, mangrove destruction, pollution, mining, mariculture, eutrophication and oil spills represents a worldwide threat to many marine species. The reliance of Atlantic humpback dolphins on restricted nearshore waters and their particular sensitivity to disturbance from boat traffic[4] renders them especially vulnerable to habitat degradation, a threat that has been specifically identified for Atlantic humpback dolphins in Senegal (Van Waerebeek *et al.* 2004) and Angola (Weir 2009), and has been suggested as one potential cause (besides bycatch) for the species' apparent absence in Ghana (Van Waerebeek *et al.* 2009; Debrah *et al.* 2010). Habitat degradation is also reported as a threat for Indo-Pacific humpback dolphins in several parts of their range (e.g. Karczmarski 2000; Jefferson & Karczmarski 2001; Wang *et al.* 2007; Jefferson *et al.* 2009).

In West Africa, the destruction and degradation of coastal habitat used by humpback dolphins may result particularly from expanding coastal fishing communities and cities, industrial development (e.g. construction of liquefied natural gas

[4]The Atlantic humpback dolphin is a shy species; when approached by boat it will often flee (Van Waerebeek & Perrin 2007).

(LNG) plants, pipelines and coastal terminals) and harbour construction and expansion. Some specific examples include: (1) the coastal waters off Lagos, Nigeria, where over 68% of trawl catches consist of solid waste and debris and there is pollution from oil discharges (Solarin 2010); (2) the discarding of phosphorite tailings from a mining site directly into the sea off Togo causing pollution with toxic trace elements (Segniagbeto & Van Waerebeek 2010); and (3) prevalent and increasing illegal fishing activity in nearshore waters, including protected areas such as Mayumba National Park in Gabon (Witt *et al.* 2008) and Conkouati-Douli National Park in Congo (Collins *et al.* 2010).

Prey depletion from overfishing

Prey depletion, resulting from intensive and unsustainable 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 overfishing to be a potentially restricting factor for the recovery of depleted Atlantic humpback dolphin populations. Limited data indicate that prey species include 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 & Cockcroft 1991), Atlantic humpback dolphins probably also prey on reef-dwelling species.

Fish are a crucial source of protein and income in all West African coastal countries. For example, 95% of Angola's fish catch is consumed domestically and up to half of the Angolan population depends on marine fisheries for a significant part of their livelihood (du Preez 2009). Although reported Angolan artisanal catches increased from 31 131 tonnes to 50 420 tonnes between 1998 and 2001 (FAO 2004), declines in the estimated biomass of most fish groups between 1996 and 2003 indicate that the catches may have been unsustainable (du Preez 2009). Similarly, trawl surveys in the Gulf of Guinea since 1977 indicate that fish biomass in nearshore and offshore waters has declined by at least 50% (Brashares *et al.* 2004).

Although overfishing of nearshore fish stocks may directly reduce prey availability for both dolphins and humans, overfishing of offshore fish stocks by foreign and domestic commercial fleets also potentially impacts humpback dolphins by reducing fish availability to local fishers and communities resulting in: (1) intensified fishing effort in nearshore waters, which further depletes available prey and increases the risk for dolphin entanglement in nets; and (2) greater use of bushmeat. Fishery cooperation agreements between the European Union (EU) and West African coastal states to supply European markets place growing pressure on marine resources (Kaczynski & Fluharty 2002), and fish harvests by EU vessels in West African waters increased by a factor of 20 between 1950 and 2001 (Brashares *et al.* 2004). Fleets from the People's Republic of China, Korea and Japan also have extensive agreements to use West Africa's coastal resources to supply their own domestic markets (Kaczynski & Fluharty 2002), and illegal pirate fishing is widespread (Brashares *et al.* 2004). Commercial export of fish by both foreign and domestic fleets causes further reductions in the supply of fish to local people. In protein-deficient countries any declines in fish availability will result in enhanced reliance on bushmeat (Brashares *et al.* 2004), including marine bushmeat.

Other potential threats

Marine pollution. Pollution of the marine environment may originate from terrestrial, atmospheric and shipping 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 focused on organochlorines such as polychlorinated biphenyls (PCBs) and the pesticide dichlorodiphenyltrichlorothane (DDT), which can cause immunosuppression leading to increased susceptibility to infectious diseases, reproductive failure, physical deformities and direct mortality from neuropathology (Ross *et al.* 2000; Parsons 2004; Van Bressem *et al.* 2009). 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 industrialized regions may also be high (e.g. De Kock *et al.* 1994), and several large port cities (e.g. Nouadhibou, Dakar, Conakry, Lagos, Douala, Luanda) exist within the geographic range of Atlantic humpback dolphins.

Coastal cetaceans are vulnerable to a variety of bacterial, fungal and viral pathogens originating from untreated sewage and ballast water discharged from ships entering the aquatic environment and being transferred via prey or wounds, leading to debilitating morbidity or mortality (Parsons & Jefferson 2000; Van Bressem *et al.* 2009). The tendency for Atlantic humpback dolphins to inhabit bays and estuarine systems increases their susceptibility to pollution, particularly when these areas are located downstream of significant human habitation.

The oil and gas industry in the region also generates pollution. Oil spills can have toxic effects if cetaceans breathe contaminated air in the vicinity of a spill; this may result in lung congestion, pneumonia and neurological damage and liver disorders (Reeves *et al.* 2003; Matkin *et al.* 2008). Additionally, the ingestion of contaminated prey may have chronic impacts. Two populations of killer whales (*Orcinus orca*) in Prince William Sound declined by 33% and 41% respectively in the year following the 1989 *Exxon Valdez* oil spill (Matkin *et al.* 2008), emphasizing the potential vulnerability of coastal cetacean populations to localized oil spills.

Climate change. The potential consequences of climate change are poorly understood but in the long term such a change will likely affect many cetacean species, since water temperature appears to be one of the main factors influencing their geographic range and may also impact them indirectly via their prey distribution (MacLeod 2009). The Atlantic humpback dolphin is a subtropical/tropical species, and increases in water temperature predicted during climate change are expected to be favourable, theoretically with the potential to result in range expansion (MacLeod 2009). However, it has been suggested that greater frequency and severity of storms, flooding, and drought predicted for climate change in tropical areas may intensify resource-use conflicts between people and dolphins (Reeves *et al.* 2003).

Anthropogenic sound. The impacts of anthropogenic sound on cetaceans may include hearing loss, tissue damage, behavioural disturbance, masking of communication sounds and displacement of prey species (Gordon *et al.* 2004). Underwater sound from shipping and industrial activities has been highlighted as a potentially 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 respond to both water-borne and terrestrial sound sources; e.g. 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 exposure to anthropogenic sound associated with coastal development and shipping. Certain areas of West Africa (especially Nigeria, Ghana, Equatorial Guinea, Gabon, Congo and 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) associated with the construction and operation of platforms, underwater pipelines, ship-mooring structures and LNG terminals. All of these activities have the potential to disturb and displace humpback dolphins.

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

IMPLICATIONS OF HUMAN ACTIVITIES FOR DOLPHIN CONSERVATION

Reduced abundance

The eight Atlantic humpback dolphin management stocks identified by Van Waerebeek *et al.* (2004) were thought to number from tens to a few hundred animals each. Only one area, Namibe Province in Angola, has a recent abundance estimate and only 10 individuals were repeatedly photo-identified (Weir 2009). Given the small number of animals recorded and their high site fidelity off Namibe Province (Weir, 2009), and the lack of verified sightings from anywhere else in Angola (Van Waerebeek *et al.* 2004; Weir, 2009), the Angola Management Stock proposed by Van Waerebeek *et al.* (2004) is probably very small. The northernmost stock in Dakhla Bay, Western Sahara, also appeared to consist of very few animals in the late 1990s (Notarbartolo di Sciara *et al.* 1998). However, these two stocks are at the edges of the species' current geographic range and may be naturally small as a consequence of occupying marginal habitat. The low abundance of some stocks greatly increases their susceptibility to stochastic perturbations.

Habitat fragmentation

There is evidence of gaps in the current range of Atlantic humpback dolphins (Van Waerebeek *et al.* 2004). While some of these gaps are likely due to poor survey coverage (e.g. off Sierra Leone, Liberia, Cameroon, Equatorial Guinea and the Democratic Republic of Congo, where almost no cetacean research has been carried out), others appear to be genuine, e.g. the lack of Atlantic humpback dolphin records in the long-term Ghanaian bycatch monitoring programmes (Ofori-Danson *et al.* 2003; Van Waerebeek *et al.* 2009; Debrah *et al.* 2010), and are probably a result of fisheries-related mortality and habitat loss (Van Waerebeek & Perrin 2007) or may be natural (Debrah *et al.* 2010). Given that Atlantic humpback dolphins occupy a very narrow, specialized ecological niche, loss of coastal habitat is likely to further fragment the species' range and create isolated groups. The population status of Atlantic humpback dolphin stocks is currently unclear, due to paucity of genetic and morphologic data and poor knowledge of current distribution. However, Van Waerebeek *et al.* (2004) considered it likely that some of the eight management stocks that they defined on geographic grounds alone will need to be recognized also as separate biological populations, following genetic drift through geographic isolation (Futuyma 1998).

Genetic factors

Virtually nothing is known about the population 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 genetic variation and viability (Shaffer 1981; Frankham 1996). Soulé (1976) and Frankham (1996) reported positive relationships between genetic variability and population size in a number of taxonomic groups, including mammals. Therefore, genetic variation in Atlantic humpback dolphins needs to be maintained both by conserving adequately large population sizes and maintaining connectivity between populations.

CHALLENGES FOR CONSERVING ATLANTIC HUMPBACK DOLPHINS

The conservation of Atlantic humpback dolphins involves multiple biological, economic, sociological and political factors. The paucity of recent or detailed baseline data on life history, habitat and threats is an immediate hindrance to the development of an effective conservation and management strategy. Their contemporary occurrence in several historical and potential range states has not been ascertained, and the species was only shown to occur as far south as southern Angola in 2004 (Van Waerebeek *et al.* 2004; Weir 2010) and was confirmed in the Republic of the Congo as recently as October 2008 (Collins *et al.* 2010). Data on abundance are anecdotal and often outdated (Van Waerebeek *et al.* 2003, 2004), and recent information is available only for Namibe Province in Angola (Weir 2009), and for Ghana (Debrah *et al.* 2010), where none have been recorded in a decade of monitoring. Genetic, morphological, life history and fine-scale distributional data are required to assess population structure throughout their range. The impacts of bycatch and other threats on the species cannot be quantified without life history data, including age at sexual maturity, 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 by the United Nations Development Programme (UNDP 2009) to broadly rank countries according to standard of living (gross domestic product per capita), life expectancy at birth and education (adult literacy rate). 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. It should be borne in mind when establishing conservation measures that artisanal fishing activities significantly contribute to the protein intake and livelihoods of impoverished coastal communities, and that the potential exists for increased reliance on dolphins as bushmeat should the local fisheries be reduced (Alfaro-Shigueto & Van Waerebeek 2001; Clapham & Van Waerebeek 2007). The low HDI of range states is also reflected in a paucity of local scientists carrying out cetacean research, and it may contribute to a lack of awareness of conservation and sustainable exploitation amongst fishing communities that currently have little incentive to conserve dolphins.

Significant challenges also originate from the

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

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
Republic of the Congo	136	Medium
Angola	143	Medium
Other potential range states		
Sierra Leone	180	Low
Liberia	169	Low
Côte 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

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). To ensure the most effective species management, these range states will need to coordinate their conservation plans at least to some extent. Regional collaboration within an Intergovernmental Organization framework, such as the Convention on Migratory Species (CMS), may help in promoting transboundary conservation policies.

CONSERVATION AND RESEARCH PRIORITIES

Scientific assessment

A thorough scientific evaluation of the species throughout its known and potential range states (see Table 1) is required. Atlantic humpback dolphins can be effectively studied from shore at least in some areas (Weir 2009), and given the difficulties with surveying nearshore areas by boat (e.g. shallow water, surf breaks, reef, sand banks), then the potential for shore-based surveys as a logistically and economically viable method should be evaluated. 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 in each range state. The recent use of local observers to record dolphins along the coasts of Gabon and the Republic of the Congo is one such example (Collins *et al.* 2010). Surveys should encompass open coasts where Atlantic humpback dolphins are regularly seen in Angola, Congo and Gabon (Weir 2009; Collins *et al.* 2010), in addition to documented estuarine habitats. Status assessments would be greatly facilitated by standardizing and coordinating survey activities across the range states, as far as possible.

It is recommended that range states establish cetacean stranding and bycatch monitoring programmes and encourage training of local biologists in survey methodology and post-mortem protocols that include life-history and contaminant load sampling. One scheme of monitoring small cetacean landings has been periodically implemented in Ghana since 1998 (Ofori- Danson *et al.* 2003; Van Waerebeek *et al.* 2009; Debrah *et al.* 2010), and has provided valuable information on cetacean occurrence and trends in exploitation.

Bycatch mitigation

Bycatch is very difficult to address in impoverished fishing communities, given their high reliance on the marine ecosystem for food and income (Van Waerebeek & Perrin 2007). The use by humpback dolphins of waters almost entirely within 800 m of the coast in Namibe Province (Weir 2009) indicates that, at least in this area, restricting gillnet use to areas beyond 1 km from the shore would greatly reduce the likelihood of bycatch. Although in a very different socioeconomic context, such a measure was introduced in a protected area for Maui's dolphin in New Zealand, where gillnet use was prohibited within 7.4 km 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 & 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 be sufficient to protect Atlantic humpback dolphins in their core areas or whether total exclusion is required. However, to render fishing restrictions socially acceptable and enforceable at the local level in a West African context would be a formidable task. At the very least, such restrictions would likely require subsidizing local fishers and other stakeholders to compensate for loss of income, the development of other incentive schemes (e.g. alternative employment) to encourage communities to participate, or the provision of alternative less-harmful fishing gear, also recommended for conserving the vaquita (Rojas-Bracho *et al.* 2006). For example, fishing with lines could probably be carried out in coastal areas without causing humpback dolphin mortality. Considerable international aid might be a requisite for implementing subsidy schemes.

Gillnet restrictions are ineffective unless they are properly enforced. Existing national laws in some states that limit fishing in nearshore and estuarine areas are poorly enforced. National legislation banning harmful fishing practices in the Yangtze River existed in China, yet these practices continued and even increased during the last decades of the baiji's decline towards extinction (Zhou *et al.* 1998). Illegal gillnetting also continues in protected areas for Maui'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). If implemented, and with sufficient training, such people would be well-placed to monitor compliance with regulations and to report dolphin bycatch events.

While there has been success at reducing bycatch of 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 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 vaquitas (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 and financial 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 and monitoring them over the long-term would be 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 in South Africa. There is evidence that Atlantic humpback dolphins exhibit site fidelity in at least some areas, e.g. 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, criteria required for designation as 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 its entire range is not feasible. However, core areas where the largest concentrations are currently located should be considered for nomination as internationally-supported MPAs, with associated restrictions on coastal development and gillnet use.

At least seven range states have protected areas either exclusively marine or incorporating marine habitat that are either proven or likely to be used by Atlantic humpback dolphins: Dakhla National Park in Western Sahara, Banc d'Arguin National Park and Biosphere Reserve in Mauritania, Saloum Delta National Park in Senegal, Niumi National Park and Tanji Bird Reserve in The Gambia, Konkouré Estuary in Guinea, Akanda, Loango, Mayumba and Pongara National Parks in Gabon, and Conkouati-Douli National Park in the Republic of the Congo (Hoyt 2005; Collins *et al.* 2010). The Conkouati-Douli and Mayumba National Parks have a common boundary at the international border and recently signed a transboundary management agreement that created the 'Park Transfrontalier de Mayumba-Conkouati' with the protection of Atlantic humpback dolphins as one of the stated aims (Collins *et al.* 2010). However, it is unclear how many, or how often, dolphins use these reserves, or how effective the parks are in providing protection. Artisanal fishing occurs in most of the protected areas (Hoyt 2005; Collins *et al.* 2010), and the single most serious documented bycatch incident where three Atlantic humpback dolphins were killed occurred in the Saloum Delta National Park (Van Waerebeek *et al.* 2003). 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 fishing restrictions and especially a ban on gillnet use are fully enforced.

Awareness and training schemes

The most successful conservation ventures are often those implemented in conjunction with local communities (Sheil & Lawrence 2004; Lundquist & Granek 2005). Regional conservation plans that aim to raise awareness of Atlantic humpback dolphins in coastal communities are greatly encouraged. For example, efforts to publicize the plight of the baiji in China resulted in their adoption as a symbol by a beer company, a hotel and a fertilizer manufacturer (Carwardine 2007), while a 'Critically Endangered' population of Irrawaddy dolphins is the adopted symbol of East Kalimantan Province in Indonesia (Kreb & 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 & 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 schemes might be effective methods of implementing gillnet restrictions 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 nature-orientated tourism projects. Whale and dolphin-watching is growing in Africa, and small-scale community-involved cetacean-focused tourism projects exist in Gabon (Rosenbaum & Collins 2006), The Gambia (Van Waerebeek *et al.* 2000) and 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 tourism could provide future opportunities to ensure local community involvement in conserving dolphins.

CONCLUSIONS

The Atlantic humpback dolphin faces many of the same threats and conservation issues as other endangered small cetaceans including the functionally-extinct baiji and the 'Critically Endangered' vaquita. These species occupy restricted geographic ranges and habitats, have low total 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 plights have been the focus of extensive international scientific survey work, conservation plans and public awareness campaigns (Vidal 1993; Zhou *et al.* 1998; Rojas-Bracho *et al.* 2006; Turvey *et al.* 2007), the decline of the Atlantic humpback dolphin has been documented only anecdotally and has prompted little response.

Van Waerebeek & 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 review has made some suggestions towards how this might be achieved. Recommended priorities for all known and potential range states of the Atlantic humpback dolphin include: (1) surveys of current distribution and abundance; (2) bycatch monitoring programmes to obtain an estimate of annual mortality and to conduct post-mortem examinations for life-history data; (3) local awareness and training schemes; and (4) protection of core areas by the reduction/elimination of nearshore (at least ≤1 km from shore) gillnet use.

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 was estimated that detecting an annual decline of 10% (at a statistical significance probability level of 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 highly detrimental. Ample warning was provided of the high probability of extinction of the baiji (Zhou *et al.* 1998; Zhang *et al.* 2003), yet ultimately its decline 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 and soon (Reeves *et al.* 2003; Van Waerebeek *et al.* 2003, 2004; Van Waerebeek & Jefferson 2004; Van Waerebeek & Perrin 2007; Weir 2009).

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