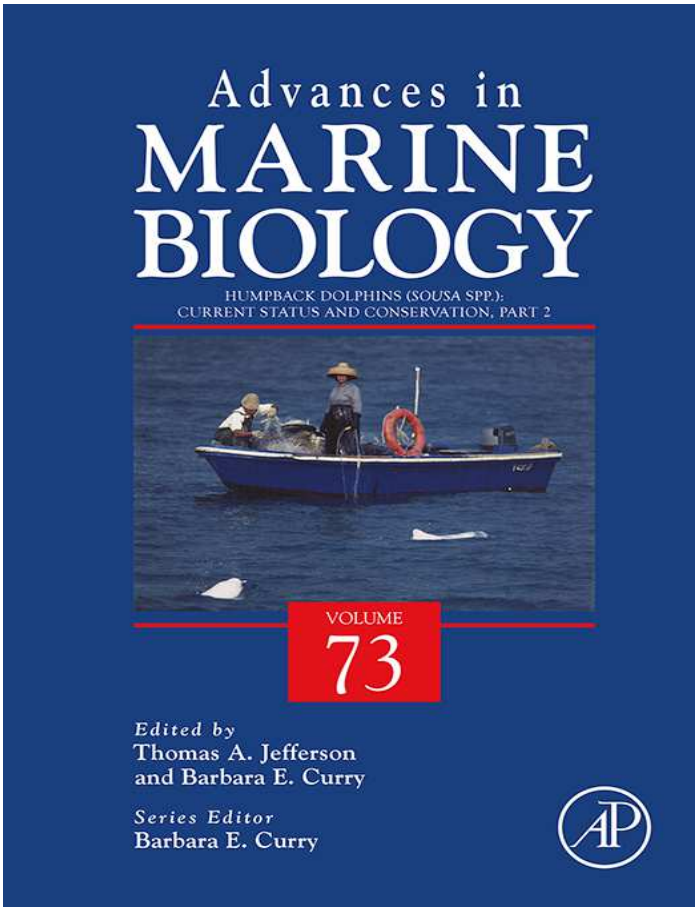

From Thomas A. Jefferson and Brian D. Smith, Re-assessment of the Conservation Status of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Using the IUCN Red List Criteria. In: Thomas A. Jefferson and Barbara E. Curry, editors, *Advances in Marine Biology, Vol. 73*, Oxford: Academic Press, 2016, pp. 1-26.
ISBN: 978-0-12-803602-0

CHAPTER ONE

Re-assessment of the Conservation Status of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Using the IUCN Red List Criteria

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Contents

Advances in Marine Biology, Volume 73
ISSN 0065-2881
http://dx.doi.org/10.1016/bs.amb.2015.04.002

Abstract

The IUCN Red List designation of the Indo-Pacific humpback dolphin (*Sousa chinensis*) is re-assessed in light of its newly recognized taxonomic status (it has recently been separated into three species) and findings that humpback dolphins along the coast of Bangladesh, and possibly eastern India, are phylogenetically distinct from other members of the *Sousa* genus. *Sousa chinensis* is found in Southeast/South Asia (in both the Indian and Pacific oceans), from at least the southeastern Bay of Bengal east to central China, and then south to the Indo-Malay Archipelago. There are no global population estimates, and the sum of available abundance estimates add up to about 5700 individuals, although only a portion of the range has been covered by surveys. This species occurs in shallow (<30 m deep), coastal waters of the tropics and subtropics, and feeds mainly on small fishes. It has a similar reproductive biology to other large dolphins, occurs mostly in small groups, and generally has individual movements of about 50–200 km^2. Major threats throughout the range include entanglement in fishing nets (primarily gillnets) and habitat destruction/degradation, although in some more industrialized areas, vessel traffic, and environmental contamination from organochlorines are also serious issues. Conservation management is largely lacking in most parts of the species' range, although there has been significant (though still inadequate) attention in some parts of China (e.g. Hong Kong and adjacent areas, and Taiwan). Much greater efforts are needed toward conservation of Indo-Pacific humpback dolphins to stop apparent declines, and to lower the species' extinction risk. *Sousa chinensis* meets the IUCN Red List requirements for Vulnerable (under criteria A4cd), with fisheries bycatch and habitat loss/degradation being the main pervasive threats.

1. INTRODUCTION

The IUCN Red List status of the Indo-Pacific humpback dolphin (*Sousa chinensis* Osbeck, 1765) was last assessed on 30 June 2008 by Reeves et al. (2008). In that document, *S. chinensis* was assessed as Near Threatened; however, it has now been separated into three species, *S. chinensis*, *S. plumbea*, and *S. sahulensis* (Jefferson and Rosenbaum, 2014; Mendez et al., 2013). Although, some parts of that previous IUCN assessment addressed *S. chinensis* and *S. plumbea* separately (since even at that time they were considered to be separate forms and possibly distinct species), and concluded that both geographic forms qualified as Vulnerable C2a(i) and possibly also A4cd, when assessed separately. However, due to taxonomic uncertainty at the time, the overall assessment was for a single species: *S. chinensis*, ranging throughout the Indian and western Pacific oceans (Reeves et al., 2008).

It has been suggested that the current IUCN status designation of Near Threatened may seriously underestimate the extinction risk for these dolphins (Huang and Karczmarski, 2014). The recent revision of the taxonomy of this genus (Jefferson and Rosenbaum, 2014; Society for Marine Mammalogy, 2014) has resulted in the need for updating the Red List assessments to reflect acceptance of *S. chinensis*, *S. plumbea*, and *S. sahulensis* as separate species, each requiring its own assessment. As such, the eastern Taiwan Strait population of *S. chinensis* (now proposed to be the subspecies, *Sousa chinensis taiwanensis*, pending confirmation by the Society for Marine Mammalogy's Ad Hoc Committee on Taxonomy) has been assessed as an intra-specific taxon (see Wang et al., 2016).

Common names include Indo-Pacific Humpback Dolphin, Indo-Pacific Hump-backed Dolphin, Chinese White Dolphin (English), *Dauphin À Bosse de l'Indo-Pacifique* (French), *Bufeo Asiático*, *Delfín Jorobado del Indo-Pacifico* (Spanish), *Jung wat bat hoi tun* (Cantonese), *Zhonghua bai haitun* (Mandarin), *Lumba lumba putih Cina* (Indonesian), *Golapi* (Bengali), and *Parampaun laut* (Malay).

2. TAXONOMY

Until recently, all Indian and Pacific Ocean humpback dolphins were considered to be part of a single widespread and highly variable species, *S. chinensis*, whose range extended throughout the coastal rim of the Indian Ocean to the western Pacific, from South Africa in the west to northern Australia and central China in the east (see for example Jefferson and Karczmarski, 2001). However, there has long been a suspicion that the form with a distinctive dorsal hump and a distribution restricted to the western Indian Ocean may be a distinct species—*S. plumbea* (see Jefferson and Van Waerebeek, 2004). In the last few years, mitochondrial (mt) DNA analyses also suggested that humpback dolphins from Australia (previously also included in the *S. chinensis* species) were highly distinct from other Indo-Pacific populations, possibly at the species level (Frére et al., 2008, 2011).

A global study of variation in the genus *Sousa*, combining data on skull morphology with both mtDNA and nuclear DNA data obtained throughout its range, confirmed that both *S. plumbea* and the Australian form were in fact distinct species (Mendez et al., 2013). A follow-up paper by Jefferson and Rosenbaum (2014) reviewed all the available taxonomic evidence and nomenclature and proposed a formal revision of the genus' taxonomy. In this scheme, humpback dolphins found in the Indian and Pacific oceans

are split into three species: *S. plumbea* (Indian Ocean humpback dolphin), found only in the western Indian Ocean; *S. chinensis* (Indo-Pacific humpback dolphin), found in the eastern Indian Ocean and throughout Southeast Asia; and *S. sahulensis* (Australian humpback dolphin), found off the coasts of northern Australia and southern New Guinea. The Atlantic humpback dolphin, *S. teuszii*, is the fourth species in the genus, found only off West Africa. This view has been accepted by the Society for Marine Mammalogy's Ad Hoc Committee on Taxonomy (Society for Marine Mammalogy, 2014).

There are still several unresolved issues in humpback dolphin taxonomy. Humpback dolphins off the coast of Bangladesh have been assumed to correspond to *S. chinensis*, based on external appearance (primarily the shape of the dorsal fin, absence of a dorsal hump, and similar spotting patterns; see Smith et al., 2008), but recent mtDNA genetic evidence suggests that they do not group with either *S. chinensis* or *S. plumbea* and may in fact be more closely related phylogenetically to *S. sahulensis* (Amaral et al., 2015). Further work is needed to clarify their taxonomic status, but in this assessment they are provisionally included, with the caveat that future work may very well show them to be of a species separate from *S. chinensis*. In fact, the taxonomic affinities of humpback dolphins in the entire Bay of Bengal (i.e. eastern India, Sri Lanka, Bangladesh, and Myanmar) urgently need to be re-examined.

There is extensive geographic variation below the species level in *S. chinensis*, most of it not yet properly documented, and the validity/limits of most proposed subspecies or geographic forms are not yet well known (Figure 1). The taxonomic status of animals in Borneo is still unclear (Minton et al., 2016). However, the taxonomic status of the Eastern Taiwan Strait population has recently been evaluated, and it has been proposed to be a subspecies, *S. c. taiwanensis* (Wang et al., 2015). The nominotypological subspecies, *Sousa chinensis chinensis*, would then apply to all other animals in the species (Wang et al., 2015).

3. GEOGRAPHIC RANGE

3.1 Range Description

Indo-Pacific humpback dolphins have been considered to occur in shallow, coastal waters from central China (the northernmost records are from near the mouth of the Yangtze River) in the east, southward throughout Southeast Asia, and westward around the coastal rim of the Bay of Bengal to at least the Orissa coast of eastern India (Jefferson and Rosenbaum, 2014; Figure 2). However, humpback dolphins along the coast of

Figure 1 External appearance of *Sousa chinensis* from various parts of the species's range: Hong Kong (top), Taiwan (upper middle), Bangladesh (lower middle), and Borneo (bottom). Photographs by T.A. Jefferson (top), J.Y. Wang (upper middle), R. Mansur, WIldlife Conservation Society (lower middle), and J. Ngeian, Sarawak Dolphin Project (bottom). Note that recent evidence suggests that the Bangladesh dolphins may belong to a different species of *Sousa*.

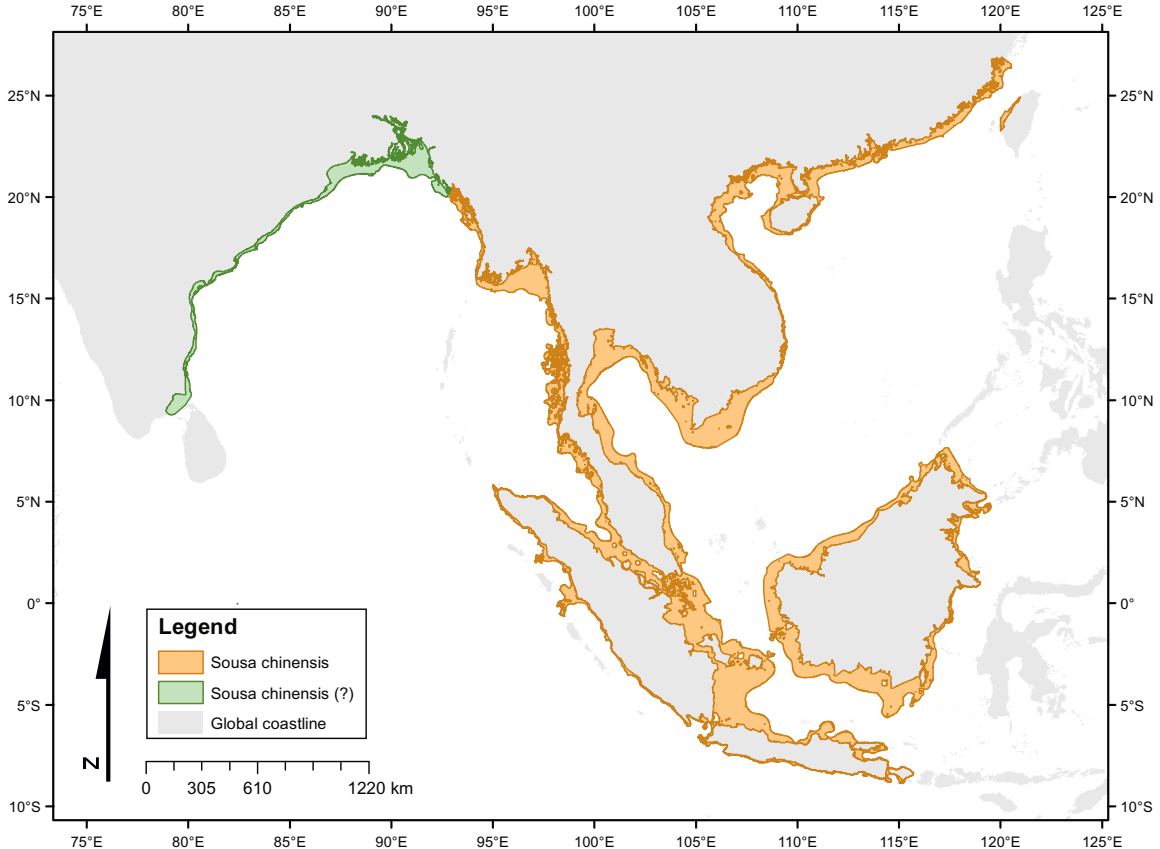

Figure 2 Suggested range of *Sousa chinensis* (yellow (dark gray in the print version) shading) in Southeast Asia. Note that the overall range is not well known, and that in many areas, there are likely gaps in the distribution that are not shown here (as for instance, in Chinese waters). The Bangladesh/eastern India area is included here among the suggested range of the species as it is currently recognized (green (light gray in the print version) shading). There are, however, indications that humpback dolphins in this area are likely of a different species.

Bangladesh (and possibly along the coast of eastern India) were recently found to be phylogenetically distinct (see Section 2). The species regularly occurs in enclosed seas, such as the Gulf of Thailand, and they appear to have their highest densities in and around estuaries (see Jefferson and Karczmarski, 2001; Parra and Ross, 2009). Their distribution is apparently fragmented, with relatively long stretches of coastline between river mouths often having very low or zero densities. It appears the only places where these dolphins range reasonably far offshore are limited to waters of the continental shelf <30 m deep. Due to the uncertain taxonomic status of humpback dolphins from Bangladesh, eastern India, and Sri Lanka, at this time the confirmed range of *S. chinensis* should only be considered to extend west to the Bangladesh/Myanmar border (Figure 2).

There is evidence from several sources suggesting that a range contraction has occurred, as least in southern and central China, where fishermen reported seeing humpback dolphins nearly continuously along the mainland coast several decades ago, but where today only about six to eight areas of regular occurrence are thought to occur (Wang et al., 2012a,b; Wu et al., 2014). Some range contraction has undoubtedly occurred in Hong Kong, as documented by long-term line-transect survey monitoring (Jefferson, 2000, 2007; Karczmarski et al., 2016). This means that in some areas, fragmented populations may now occur in what was once occupied by one or more larger, continuous population units.

3.2 Range Countries

Native: Brunei Darussalam; Cambodia; Indonesia; Malaysia; People's Republic of China (including Hong Kong SAR and Macau SAR); Singapore; Taiwan (Province of China); Thailand; Vietnam. Unconfirmed: Bangladesh; India; Myanmar. Extralimital: Philippines—there is a single confirmed stranding from the Turtle Islands, southern Philippines, but that specimen may have been carried by currents to the Philippines from a population in nearby Malaysian Borneo (L. Dolar, National Oceanic and Atmospheric Administration, pers. comm., 22 September 2014).

4. POPULATION

4.1 Population Parameters

Assessment of population structure has not been well studied in this species, with many different stocks or 'population units' having been hypothesized

to occur, but most of these have not been confirmed. In particular, along the Chinese coastline, *Sousa* is known to occur in about six to eight areas of the coast, and there is some evidence suggesting distinct units. However, for the most part, survey effort in intervening sections of the coast is sparse, and empirical studies to examine stock structure using morphological and/or molecular methods have been limited and sometimes of poor quality. Up-to-date comparisons of photo-identification catalogues from different studies are generally lacking. The exception is for the west coast of Taiwan, which is known to have a distinct population (now considered to be a subspecies) of *S. chinensis*, from both lack of photo-ID matches and distinct colour pattern differences in relation to mainland study sites (Wang et al., 2008, 2015, 2016).

Population assessments have been carried out in only a few parts of the species' range and most have only begun in the last 10–15 years. There is no overall estimate of total population size for *S. chinensis*. By far, the largest known (putative) population is in the Hong Kong/Pearl River Estuary (hereafter called HK/PRE), which based on line-transect estimates was estimated to contain 2555 animals in the late 2000s (CVs range from 19% to 89%) in mainland Chinese waters and about additional 82 animals in Hong Kong in 2013 (Chen et al., 2010; Hung, 2014; T. A. Jefferson, unpublished; Table 1). The HK/PRE population is the only one with long-term, quantitative data on trends, and the portion of the population in Hong Kong waters has declined by about 50% in the last 10 years, although this is at least partially due to range shifts (Hung, 2014; Jefferson, 2007). Modelling of demographic parameters from stranding data predicts that the HK/PRE population may be declining at about 2.46% annually, resulting in potential times to local extinction of as short as around 80 years (Huang et al., 2012). There is also some evidence of a possible decline in line-transect survey sighting rates of dolphins in the western PRE, from 2007/08 to 2010/11 (South China Sea Fisheries Research Institute, 2011); however, a robust analysis of abundance trends for the entire population from empirical survey data is currently unavailable.

Abundance has been estimated for several other locations in Chinese waters, mostly using photo-identification and mark/recapture methods. Abundance for all of the Chinese sites adds up to 4730 animals (Table 1). Estimates of abundance do not exist for suspected small populations in the Dongshan/Shantou, Quanzhou Bay, Ningde, and southern Hainan Island areas (Wang et al., 2012a,b; Wu et al., 2014). There are only a handful of abundance estimates available for areas outside of China, including three sites in Malaysia and Thailand (Table 1). Most of these estimates are several years old, and so current numbers may be reduced.

Table 1 Best Available Estimates for Areas in Which *S. chinensis* Abundance/Population Size Has Been Assessed

Area	Years Assessed	Abundance Estimate	CV	95% CI	Method	Trend	Reference(s)
Bay of Bengal, Bangladesh[a]	2005–2009	636	–	531–761	Mark/recap	Unknown	Smith et al. (2015)
Kuching, Malaysia	2010–2011	84	16%	61–116	Mark/recap	Unknown	Minton et al. (2016)
Donsak, Thailand	2011–2013	193	–	167–249	Mark/recap	Unknown	Jutapruet et al. (2015)
Khanom, Thailand	2008–2009	49	–	–	Mark/recap	Unknown	Jaroensutasinee et al. (2010)
Belbu Gulf–Dafenjiang/ Nanliujiang (Sanniang Bay), PRC	2011–2014	316	–	264–368	Mark/recap	Unknown	Chen et al. (2015)
Belbu Gulf–Shatian/Caotan, PRC	2011–2014	152	–	123–217	Mark/recap	Unknown	Chen et al. (2015)
Leizhou (Zhanjiang), PRC	2005–2012	1485	[b]	1371–1629	Mark/recap	Unknown	Xu et al. (2012, 2015)
Hong Kong/Pearl River Estuary (Xujiang), PRC	2005–2008	2637[b]	19–89%	–	Line transect	Decreasing	Chen et al. (2010) and T. A. Jefferson (unpublished)
Xiamen/Kinmen (Jiulongjiang), PRC	2004–2008	76	–	43–109	Mark/recap	Decreasing	Chen et al. (2009) and Chou et al. (2013)
Eastern Taiwan Strait, Taiwan	2007–2010	64	4–13%	–	Mark/recap	Decreasing	Wang et al. (2012a)

[a]Recent genetic analyses (Amaral et al., 2015) suggest that these animals may be taxonomically distinct from *S. chinensis*.
[b]This includes 2555 estimated in the PRC (Chen et al., 2010) plus an additional 82 animals in Hong Kong waters (T. A. Jefferson, unpublished data).
It should be noted that although each of these is assumed to be a separate subpopulation for this assessment, in most cases, this has not been confirmed through empirical studies.

From photo-identifications of 468 individuals in Bangladesh during 88 sightings, abundance estimates were generated of 132 (95% CI 115–153), 131 (95% CI 124–137), and 635 (95% CI 531–761) for three winter seasons, respectively (Smith et al., 2015). The considerable increase in the third season estimate can be explained by the large number of new dolphins identified for the first time during the third year despite the similar intensity and spatial coverage of effort. A robust mark-resight analysis indicates that these abundance estimates are for only a portion of a larger 'superpopulation' of unknown size that occupies a more extensive area in both Bangladesh and India (Smith et al, 2015). However, as discussed above, these animals may be a species other than *S. chinensis*. Finally, although not a population estimate *per se*, the sighting of a group of dolphins estimated at over 100 individuals off Langkawi, Malaysia, suggests that abundance is at least 100 animals in that region (Kimura et al., 2013).

Although the information available is quite sparse, population parameters relevant to the IUCN assessment process have recently been re-examined for *S. chinensis*, and new estimates have been calculated based on the best available information (Moore, in press), updating the earlier estimates provided by Taylor et al. (2007). A generation time (T_0) of 25 years was estimated, and it was determined that human-caused mortality rates of only 3.7% and 4.1% would be needed to lead to 30% (corresponding to Vulnerable) and 50% (corresponding to Endangered) declines in abundance within three generations (Moore, in press).

The available abundance estimates for *S. chinensis* (reviewed above; see Table 1) range from a few dozen individuals to over 2500 for the few areas of the species' range that have been studied so far (less than one-third of the total range). The sum of the abundance estimates currently available is 5056 individuals (5692 if one includes estimates from Bangladesh). There is reason to believe that the relatively large population in the Pearl River Estuary, estimated at about 2600 individuals in 2007, may be exceptional in terms of its size. That population is the best studied of the species, and it likely includes about 60–75% or 1560–1950 mature individuals (see Jefferson, 2000; Jefferson et al., 2012). This means that the total species population would have to number from 13,333 to 16,666 for it to include 10,000 mature individuals. This total appears unlikely, due to the fragmented range, with this species generally occurring only in association with freshwater inputs, the much-lower population estimates in other areas where the species has been studied, and the probable exclusion of humpback dolphins from Bangladesh and eastern India from the total species estimate.

4.2 Population Trend

Several populations have been suggested to be depleted and facing unsustainable anthropogenic threats, e.g. Eastern Taiwan Strait (Araujo et al., 2014; Wang et al., 2007), HK/PRE (Jefferson et al., 2009; Huang et al., 2012; Hung, 2014), and Xiamen (Jefferson and Hung, 2004; Chen et al., 2008). However, declines in abundance have not been confirmed through consistent, long-term monitoring, except in Hong Kong (see Hung, 2014). Unfortunately, detecting significant declining trends in many humpback dolphin populations may be unlikely before they reach a critical stage, due to their small population sizes and lack of high-precision survey data (see Taylor et al., 2007).

In Hong Kong, an area where humpback dolphins have been intensively studied for over 20 years and management efforts have been more attentive than in most areas (Jefferson et al., 2009), numbers have declined by about 50% in the last decade. Although much of this decline is evidently due to distribution shifts, based on evidence from documented mortalities and the abandonment of areas previously occupied by humpback dolphins coincident with coastal development, some portion of this decline may also be explained by an actual reduction in total abundance (Huang et al., 2012 modelled a 2.46% annual decline in size of the putative HK/PRE population). This in turn supports the inference that declines of at least this magnitude are probably occurring in other parts of their range over three generations (about 75 years), especially where populations face similar or greater threats. Although many areas of the range of *S. chinensis* are not subject to the same levels of habitat degradation from coastal development as humpback dolphins in HK/PRE, rates of fatal entanglements in gillnets are likely to be especially high in other countries of their range where coastal waters are subject to particularly high levels of small-scale fisheries to support growing human populations.

Thus, although no overall population trend for the species can be determined, a declining population can be inferred throughout their range, due to intensive threats, especially entanglement in fishing gears, known to kill humpback dolphins, and degradation and loss of critical habitat.

5. HABITAT AND ECOLOGY

5.1 Habitat

Indo-Pacific humpback dolphins occur in tropical to warm-temperate coastal waters, including open coasts and bays, coastal lagoons, over rocky

reefs, mangrove swamps, estuarine areas, and areas with sandbanks and mudbanks (Jefferson and Karczmarski, 2001; Parra and Ross, 2009; Ross et al., 1994). They are rarely encountered in waters more than about 20–30 m deep, or more than a few kilometres from shore (see Chen et al., 2007; Jefferson and Karczmarski, 2001; Parra and Ross, 2009). Maximum water depths reported for areas where extensive studies have occurred are: 22–23 m (Bangladesh; Smith et al., 2008, 2015), 25 m (Taiwan; Wang et al., 2007), and 37.2 m (HK/PRE; Hung, 2014). Indo-Pacific humpback dolphins sometimes enter rivers and inland waterways of mangrove forests, but they do not appear to move more than a few kilometres upstream and usually remain within the range of tidal influence. In at least China and southern Asia, they are rarely found far from estuaries or mangrove habitats (Jefferson and Karczmarski, 2001; Wang et al., 2007). In Hong Kong and the PRE, where they have been most-intensively studied, their entire habitat is influenced by freshwater flow from the Pearl River (China's second largest) (Jefferson, 2000). Within Hong Kong, they prefer somewhat deeper-water channels for feeding and occur in higher densities along island shores and natural rocky coastlines (Hung, 2008).

5.2 Feeding Ecology

Indo-Pacific humpback dolphins appear to be opportunistic feeders, consuming a wide variety of nearshore, estuarine, and reef fishes. They also eat cephalopods in some areas, but crustaceans are rare in their diet (Jefferson and Karczmarski, 2001; Parra and Ross, 2009). In Hong Kong waters, they are known to feed on at least 24 species of fishes and one cephalopod. The most common prey species in Hong Kong are the croaker *Johnius* sp., the lionhead, *Collichthys lucida*, and anchovies, *Thryssa* spp. (Barros et al., 2004). Dolphins often follow trawlers in the Pearl River Estuary and appear to feed on species that evade or are stirred up by these nets (Hung, 2008; Jefferson, 2000). In the Bay of Bengal, Bangladesh, they are frequently observed preying on fish that fall out of set-bag nets and gillnets when they are being pulled to the surface (Smith et al., 2015). Predation on Indo-Pacific humpback dolphins is almost unknown, and the estuarine waters where the species most often occurs generally have lower densities of potential predators (e.g. large sharks and killer whales, *Orcinus orca*).

5.3 Reproductive Biology

Reproductive biology has only been studied in detail in HK/PRE (Jefferson et al., 2012), and to a lesser extent in Xiamen (Wang, 1965, 1995). Typically,

a single calf is born after a gestation period of slightly less than a year (Parra and Ross, 2009). In Hong Kong, calving occurs throughout the year, but there is a significant peak in births from March to June, near the start of the wet season (Jefferson et al., 2012). The average apparent calving interval among a sample of 60 females studied through long-term photo-identification was 5 years, which is quite long for dolphins (Jefferson et al., 2012). Newborns calves are on average 101 cm in length, and sexual maturity occurs at ages of about 9–10 years for females, and a few years later for males (Jefferson et al., 2012). Physical maturity is reached at ages of about 14–17 years, and the oldest known individual was 38 years of age, although it is suspected that some dolphins may live into their 40s (Jefferson et al., 2012). Apparent survival for adults and juveniles was estimated to be 0.85 (95% CI 0.725–0.919) in coastal waters of Bangladesh (Smith et al., 2015). Age-specific mortality rates have been estimated for the HK/PRE population and for adults from 10 to 25 years of age ranges from about 0.03 to 0.15 (Huang et al., 2012).

5.4 Social Organization

Indo-Pacific humpback dolphins throughout most of their range occur most commonly in groups of two to six individuals (Parra and Ross, 2009). However, aggregations of several dozen have been observed, especially when they are following fishing vessels, in Hong Kong (Hung and Jefferson, 2004). Group sizes in the Bay of Bengal, Bangladesh, are considerably larger than those recorded elsewhere, with a median estimated size of 19 individuals ($n = 55$) and groups of at least 81 and 205 documented through photo-identified individuals (Smith et al., 2015). Social organization, in the few places where humpback dolphins have been studied, is largely characterized by a fission/fusion society of mostly short-term associations; e.g. Hong Kong/PRE (Chen et al., 2011b; Dungan et al., 2012; Jefferson, 2000), Zhanjiang/Leizhou area (Xu et al., 2012), and the Beibu Gulf area (Chen, 2013). However, humpback dolphins in Taiwanese waters have stronger social bonds and more stable association patterns (Dungan et al., 2012, 2015). There is also some of evidence of communal calf rearing in Taiwan. The unusual social structure in Taiwan may be related to the very small population size and restricted habitat there (Dungan et al., 2015).

5.5 Movement Patterns

Indo-Pacific humpback dolphins are not known to undergo large-scale migrations, although seasonal shifts in abundance have been identified in

the HK/PRE area (Hung, 2008; Jefferson, 2000). Ranging patterns of individuals have been studied in only a few locations, using photo-identification data. In Hong Kong, individual movements tend to occur over relatively small areas of from 39 to 339 km^2, with an average of about 135 km^2, much smaller than the population's overall range of several thousand km^2 (Hung and Jefferson, 2004; Hung, 2008). Similar patterns were found for Xiamen, with an average range of 84 km^2 (Chen et al., 2011a), and the Zhanjiang/Leizhou area, with an average estimated range size of 169 km^2 (Xu et al., 2015).

6. USE AND TRADE

There are few records of direct exploitation or trade in products of this species. In the 1960s, there was short-term interest in commercial hunting for humpback dolphins in mainland China to use their skin in making leather (Jefferson and Hung, 2004; Wang, 1965). One Indo-Pacific humpback dolphin carcass was recorded during a visit to a fish market in Maungmagan, southern Myanmar, along with 13 Indo-Pacific bottlenose, *Tursiops aduncus*, and three spinner dolphins, *Stenella longirostris*. These dolphins were believed to have been caught in a directed harpoon fishery (Tun, 2006). Significant numbers of Indo-Pacific humpback dolphins have been captured for the aquarium industry, mostly from the Gulf of Thailand, and the impacts of these captures remain unknown (see Smith, 1991). Similar live captures could be a future threat to humpback dolphin populations in Chinese waters.

7. THREATS

7.1 Major Threats

Most Indo-Pacific humpback dolphins inhabit coastal or estuarine waters of countries with scarce resources and competing economic and food security priorities. Range-wide, incidental mortality in fishing gear (especially in gillnets and trawls) is probably the greatest threat to this species, followed by habitat loss and degradation (Jaaman et al., 2009; Jefferson and Karczmarski, 2001; Parra and Ross, 2009; Ross et al., 1994). Primary threats for the Eastern Taiwan Strait subspecies (currently assessed as Critically Endangered) have been determined to be habitat loss from marine development, noise and behavioural disturbance, fisheries interactions (especially

bycatch), chemical pollution, and reduction of freshwater flow to estuaries (Dungan et al., 2011).

7.1.1 Fishing Gear Entanglement

We know of no onboard fisheries observer programmes that have been able to document accurate bycatch rates of Indo-Pacific humpback dolphins in fisheries, so most information comes from opportunistic observations or inference from stranded specimens. Specific threats and their impacts have been studied most extensively in Hong Kong. Based on data from strandings, the greatest direct sources of human-caused mortality in Hong Kong appear to be incidental catches in fishing gear (most commonly pair trawls, but also occasionally gillnets), followed by vessel collisions (Jefferson, 2000; Jefferson et al., 2006; Parsons and Jefferson, 2000). Of 10 stranded humpback dolphins in Hong Kong documented between 1995 and 2004, where the cause of death could be identified, net entanglement was determined to be responsible for three and vessel collision for four (the other three had other diagnosed causes; Jefferson et al., 2006). A trawling ban went into effect in Hong Kong in 2013, but illegal trawling still occurs and gillnetting is still permitted.

Of 407 humpback dolphin individuals in a photo-identification catalogue compiled from photographs taken during 2010–2013 in Bangladesh, 15.0% of the individuals exhibited scars, wounds, or mutilations that were almost certainly associated with entanglements in fishing gears, while 8.6% exhibited marks that were possibly caused by entanglements in fishing gear. This information combined with the extensive spatial overlap between fishing gears indicates that the population is probably threatened with increases in the intensity of fisheries (Smith et al., 2015).

Based on a photo-identification catalogue, >30% of the Eastern Taiwan Strait subspecies exhibited injuries caused by fishing gear, with three individuals photographed with fishing gear attached to their bodies, and one dolphin found dead with fresh injuries caused by fishing gear (Slooten et al., 2013). This is from a Critically Endangered population where human-caused mortality needs to be reduced to <1 individual every 7 years to ensure long-term survival (Slooten et al., 2013).

Although in most other areas, there has been little or no research directed at documenting *Sousa* bycatch, captures in gillnets and other types of fishing gear are known or suspected in most parts of the range; e.g. the Yellow Sea (Han et al., 2003), Vietnam (Smith et al., 1997), Borneo (Jaaman et al., 2009; Minton et al., 2016), and India (Krishna Pillai, 2002).

7.1.2 Habitat Loss/Degradation and Disturbance from Marine Development

Rapid and accelerating development in many urban areas of the range of *S. chinensis* results in destruction and/or degradation of their habitat. Reclamation, port development, dredging of shipping channels, and building of bridges and other structures all can destroy or damage habitats for these dolphins to the point of reducing the carrying capacity of the environment. Reclamation and other types of land-formation can result in the permanent loss of habitat. This is a major issue for the conservation of these dolphins in areas such as Hong Kong, Taiwan, Xiamen, and many other areas in China (Jefferson et al., 2009). Although much less studied in other portions of the species' range outside of China, most of the same types of impacts are occurring to varying degrees.

Marine construction can also cause behavioural disturbance (e.g. construction of the Hong Kong/Zhuhai/Macau Bridge, and Hong Kong's Chek Lap Kok International Airport, including planned third runway expansion, as well as the associated infrastructure for both projects; see Hung, 2014; Jefferson et al., 2009; Würsig et al., 2016). While disturbance effects can be temporary, the most serious concerns are related to activities that may cause injury or mortality, such as percussive pile-driving during pier and bridge construction, and the use of underwater explosives used for channel modification.

7.1.3 Vessel Traffic

Vessel collisions are a significant threat for *S. chinensis* in some industrialized areas, especially in Chinese waters (see Araujo et al., 2014; Parsons and Jefferson, 2000). The most commonly determined cause of death for stranded dolphins within Hong Kong is vessel collision, and many dolphins in the photo-ID catalogue show clear evidence of having been hit by the hulls or propellers of vessels (Parsons and Jefferson, 2000). Excessive vessel traffic, including high-speed ferries, has changed humpback dolphin distribution and behaviour in Hong Kong and may potentially interfere with their acoustic communication (Hung, 2014; Piwetz et al., 2012; Sims et al., 2012; Würsig et al., 2016). Within the Pearl River Estuary, high-speed ferries that travel among major cities reach speeds of 30–40 knots, and there is growing evidence that this threat is a major reason for the declining numbers of dolphins in this area (Hung, 2008; Marcotte et al., 2015; Sims et al., 2012).

7.1.4 Organochlorine Contamination

Environmental contamination is also a threat, at least for populations in highly industrialized areas like China. However, it is more difficult to assess the relative impacts of this threat compared to others such as bycatch, because pollutants generally do not kill dolphins outright. Concentrations of organochlorines (mainly DDTs, PCBs, and HCHs) in cetaceans from Hong Kong coastal waters are significantly higher than those found in cetaceans in many other parts of the world (Gui et al., 2014a; Minh et al., 1999; Parsons and Chan, 1998), and it has been suggested that the reproductive success of Hong Kong's humpback dolphins (including neonatal survival) is being adversely affected (Jefferson et al., 2006; Parsons, 2004). In HK/PRE, the organochlorines consistently found in the highest concentrations have been DDTs, and these occur at levels known to cause health effects in other species. Despite being illegal in Hong Kong and China, these chemicals are still being introduced into coastal ecosystems (Gui et al., 2014a; Jefferson et al., 2006; Parsons, 2004; Ramu et al., 2005; Wu et al., 2013). A number of other environmental contaminants (e.g. flame retardants, HBCDs, PBDEs, perfluorinated compounds) have also been identified in Hong Kong humpback dolphins, with unknown long-term effects (Lam et al., 2009; Yeung et al., 2009).

7.2 Minor Threats or Those Affecting Only Parts of the Range

7.2.1 Direct Capture

In 1960–1962, 36 humpback dolphins were killed in Xiamen waters to evaluate the potential for developing a commercial fishery to provide skin for making leather; however, this fishery was not developed (Jefferson and Hung, 2004; Wang, 1965, 1995). Currently, *S. chinensis* is not known to be hunted directly in significant numbers, although directed catches and the sale of humpback dolphin meat have been documented in southern Myanmar (B. D. Smith, unpublished). The large number of oceanaria recently proliferating in Asia suggests that live captures may potentially be a significant threat to this species in the future.

7.2.2 Metals and Other Environmental Contaminants

In Hong Kong, large volumes of sewage discharge and the close proximity of contaminated mud pits mean that there is considerable potential for trace metal contamination of local dolphins (Parsons, 1997). Mercury is highly toxic and these dolphins show strong sensitivity to it, although they may possess physiological mechanisms to detoxify this metal (Gui et al., 2014b).

Indeed, mercury levels were high enough (max: 906 μg kg^{-1} dry weight) to be considered potentially health threatening (Jefferson et al., 2006; Parsons, 2004). The disposal of contaminated mud from Hong Kong's dredging and reclamation projects poses an indirect risk to humpback dolphins via their consumption of contaminated prey (Clarke et al., 2000). Humpback dolphins inhabit the waters of several coastal ports in Asia that host large volumes of ship traffic, such as Shanghai, Singapore, and Hong Kong. Therefore, they may be highly contaminated with butyltins (BTs) (see Parsons, 2004; Tanabe, 1999; Tanabe et al., 1998). Such port cities also often have shipyards, where BT from wet paint or paint flecks enters the environment.

7.2.3 Other Threats

Other threats mentioned for *S. chinensis* populations in Chinese waters, but that are currently thought to be less problematic than the ones described above, or to only affect specific portions of the range, include mariculture/aquaculture activities, restriction of freshwater flow to estuaries, dynamite fishing, and harassment by dolphin-watching ecotourism operations (Chen et al., 2009).

8. CONSERVATION ACTIONS

Sousa chinensis is listed in Appendix I of CITES. Throughout most parts of its range in Southeast/South Asia, conservation actions have been either extremely limited or non-existent. There is active management in Hong Kong (by the Agriculture, Fisheries and Conservation Department, AFCD, and other government entities), where since about 1993, the species has been protected by the Wild Animals Protection Ordinance, Marine Park Ordinance, and the Environmental Impact Assessment Ordinance. Therefore, Indo-Pacific humpback dolphins have been the subject of long-term monitoring and extensive environmental impact assessment for over 20 years (Hung, 2014; Jefferson et al., 2009). Long-term monitoring in Hong Kong has shown that mitigation measures, such as bubble curtains, monitored dolphin exclusion zones, acoustic decoupling of noisy equipment, vessel speed limits, no-dumping policies, and silt curtains, can reduce impacts, when guided by good science and applied wisely (Jefferson et al., 2009). The establishment of several marine parks form an integral part of the management strategy in Hong Kong, although the most critical habitats are still unprotected, and it is also recognized that other measures are needed for

the long-term conservation of the overall population (Jefferson et al., 2009; Karczmarski et al., 2016). A major focus in Hong Kong is now one of examining and mitigating the cumulative impacts of multiple development projects, although methods for doing so effectively are still in their infancy (Marcotte et al., 2015).

There is less management in Taiwan. While there has been some recent progress in monitoring and environmental impact assessment, this has not kept pace with the escalating severity of the local threats (Ross et al., 2010; Wang et al., 2016). In mainland Chinese waters, the species is a Protected Species of the First Order, though in most areas, there is little actual management of threats, beyond the establishment of marine protected areas (MPAs) (see Chen et al., 2009), which generally appear to be inadequately managed and are apparently little more than 'paper parks'. Therefore, recommendations for the establishment of national nature reserves as the main conservation measures for these dolphins in China, without details on how the borders are to be established and the protective measures provided and their effectiveness, must be viewed with some degree of scepticism.

In 2014, the Government of Bangladesh signed into law the country's first MPA spanning about 1700 km^2 and encompassing more than 50% of the total number of humpback dolphin sightings made in waters offshore of the Sundarbans mangrove forest between 2004 and 2012. Efforts are currently underway to establish conservation management in this new MPA through fishing closures for entangling gears and modifying fishing practices. Efforts are also being made to generate interest in expanding it into a larger bi-national MPA that includes adjacent coastal habitat in India supporting a portion of the 'superpopulation' in Bangladesh (see Section 4; Smith et al., 2015). One promising approach for reducing humpback dolphin bycatch in these waters is an initiative that requires gillnet fishermen to attend their nets, release entangled dolphins, and collect data and biological samples from mortalities in exchange for measures taken to improve fisherman safety at sea.

In the rest of the range, we know of virtually no measures to protect Indo-Pacific humpback dolphin populations (see for example, Minton et al., 2016). Clearly, more conservation-oriented research is needed throughout the range of Indo-Pacific humpback dolphins to design effective management programmes, especially in countries outside of China. There is a vital need to identify the main threats facing demographically isolated populations and to reduce the impacts of these threats to sustainable levels.

Particular attention should be given to addressing bycatch and protecting critical habitat in areas where there are strong competing interests for human development (Parra and Ross, 2009; Ross et al., 2011). Where MPAs are established for humpback dolphin conservation, it is essential that they be managed using the best available scientific information and that the major threats to animals in those area be eliminated or at least effectively reduced to sustainable levels.

Taken as a whole, the current situation does not bode well for the future of this species. Even in the areas of its range, where it has been best studied, and where significant efforts at impact assessment and mitigation have been put forth, populations appear to be declining and threats remain inadequately addressed. However, Indo-Pacific humpback dolphins occur over a large enough area, and the species contains enough total individuals and populations that the situation could improve. It is clear that this will require dramatic improvements in monitoring and management efforts by the governments of range countries.

A key outstanding question is the taxonomic identity of humpback dolphins in Bangladesh, eastern India, and Sri Lanka. Further investigation is needed on the genetic identity of these animals, with comparisons made among samples obtained from previously unsampled areas and the analysis of additional genetic markers. Due to their apparent phylogenetic distinctiveness, once the taxonomic identity of this form has been confirmed, it should be assessed separately.

9. IUCN RED LIST STATUS JUSTIFICATION

The only available population trend estimate for *S. chinensis* is an estimated 2.46% annual decline in the size of the population in HK/PRE (Huang et al., 2012), where there are a number of marine parks that have been established or proposed for dolphin protection, and where the Hong Kong authorities have put more effort into impact assessment and management than in any other part of the species' range (Jefferson et al., 2009). The situation elsewhere appears to be more dire, with fisheries bycatch being a nearly universal threat and much less attention being paid to establishing conservation measures for the species. It is therefore not unreasonable to assume a population reduction of at least 3.7% per annum, which as detailed above would lead to a 30% decline in abundance over three generations over most of the species' range, due to known incidental mortality from intensive fishing effort using entangling gears, and ongoing habitat loss

and degradation due to coastal development. Vessel collisions and environmental contamination appear to be factors as well, in at least some parts of the range. The above inference is supported in several areas by direct and/or indirect evidence, including documentation of bycatch, the intensive use of gillnets and other fishing gears known to entangle small cetaceans, interviews with fishermen who use entangling gears, and the abandonment of areas of previous occupancy (Xu et al., 2015).

The Indo-Pacific humpback dolphin therefore qualifies for Vulnerable A4cd, based on an inferred population size reduction, where subcriterion c is interpreted as quality of habitat, and subcriterion d (actual or potential levels of exploitation) includes fisheries bycatch. We can infer a population reduction of greater than or equal to 30% over three generations (75 years), from approximately 1960 in the past to 2035 in the future. This takes into account that the main causes of the suspected/inferred decline in population size, bycatch, and habitat destruction/degradation, have not ceased and are not well understood throughout most of the species' range. Other than in Hong Kong (and to a lesser extent Taiwan), there have been virtually no real conservation actions taken to address these threats, and available evidence suggests that they will continue and may even escalate in the future. The assessment of *S. chinensis* as Vulnerable based on criterion A4cd applies, regardless of whether or not the Bangladesh/eastern India animals are included, because it is based on population trends, rather than absolute numbers or a declining range.

ACKNOWLEDGEMENTS

We would like to thank all those who participated in the May 20–21, 2015 IUCN Red List Workshop in San Diego, California, USA, for useful discussions and helpful comments on the draft IUCN assessment. In particular, we would like to express our sincere appreciation to Charlotte Boyd, Robert L. Brownell Jr., Randall R. Reeves, and Barbara L. Taylor for their monumental efforts in helping to get us to this stage in the process. Trevor Joyce made the map. We also thank an anonymous reviewer for helpful comments on an earlier draft.

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