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Short Note

External Injuries of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Xiamen, China, and Its Adjacent Waters as an Indicator of Potential Fishery Interactions

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Interactions between marine mammals and fisheries have been reported worldwide and are probably the greatest conservation concern for cetaceans (Read et al., 2003, 2006; Reeves et al., 2003). The International Whaling Commission has recognized that mortality in fisheries will likely continue to pose a threat to marine mammal populations in the future, as these interactions are increasing in frequency and intensity (DeMaster et al., 2001), especially to species living in coastal and estuarine habitats (Nery et al., 2008). Although entanglements in fishing gear often result in fatality for marine mammals, many individuals survive these interactions but are often left with non-fatal, though potentially severe, wounds or scars. Entanglement in fishing gear is one of four major sources of such scars and wounds, which include completely or partially collapsed dorsal fins, missing dorsal fins, missing flukes, various scar markings, and skin ulcerations (Norman, 2000; Flores, 2002; López et al., 2003; Read et al., 2003; Reeves et al., 2003; Kock et al., 2006). Other sources of scars include teeth marks from inter-/intraspecific interactions (Kato, 1984; Ford, 1986; Luksenburg, 2014), biting wounds from predators such as sharks and killer whales (*Orcinus orca*) (Corkeron et al., 1987a, 1987b; Heithaus, 2001; Luksenburg, 2014), and vessel collisions or propeller strikes (Bloom & Jager, 1994; Wells & Scott, 1997; Visser & Fertl, 2000; Dwyer et al., 2014).

Because wounds and scars have been widely reported among cetaceans in the wild (Bigg et al., 1987; Perrin et al., 1994; Visser, 1998; Wells et al., 1998; Robbins & Mattilla, 2001; Baird & Gorgone, 2005; Azevedo et al., 2008; Nery et al., 2008; Luksenburg, 2014), and because they can be signs of previous interactions with fishing gear, studying the occurrence of these markings may help to understand the level of fishery interactions in marine mammal populations. For this purpose, the present study examined the level of external injuries on Indo-Pacific humpback dolphins (*Sousa chinensis*) in Xiamen and its adjacent waters (including all waters around Xiamen and part of the adjacent regions of Zhangzhou and Quanzhou), China (Figure 1), and used data on these injuries to assess interactions with local fisheries.

The Indo-Pacific humpback dolphin occurs in the eastern Indian and western Pacific Oceans (Jefferson et al., 1993; Ross et al., 1994; Jefferson & Karczmarski, 2001; Jefferson & Rosenbaum, 2014). This species is typically found in estuarine and coastal waters, mainly in shallow waters less than 25 m in depth (Saayman & Tayler, 1979; Ross et al., 1994; Karczmarski et al., 2000; Jefferson & Karczmarski, 2001). Because their habitats are usually close to areas with intensive human activities, humpback dolphins face substantial anthropogenic impacts, including interactions with fisheries. The status of the Indo-Pacific humpback dolphin is currently classified as *Vulnerable* (VU) under the global/species scope, although evidence suggests that some populations should receive a higher status classification (Huang & Karczmarski, 2014) such as humpback dolphins off the western coast of Taiwan that are categorized as *Critically Endangered* (CR) on the International Union for Conservation of

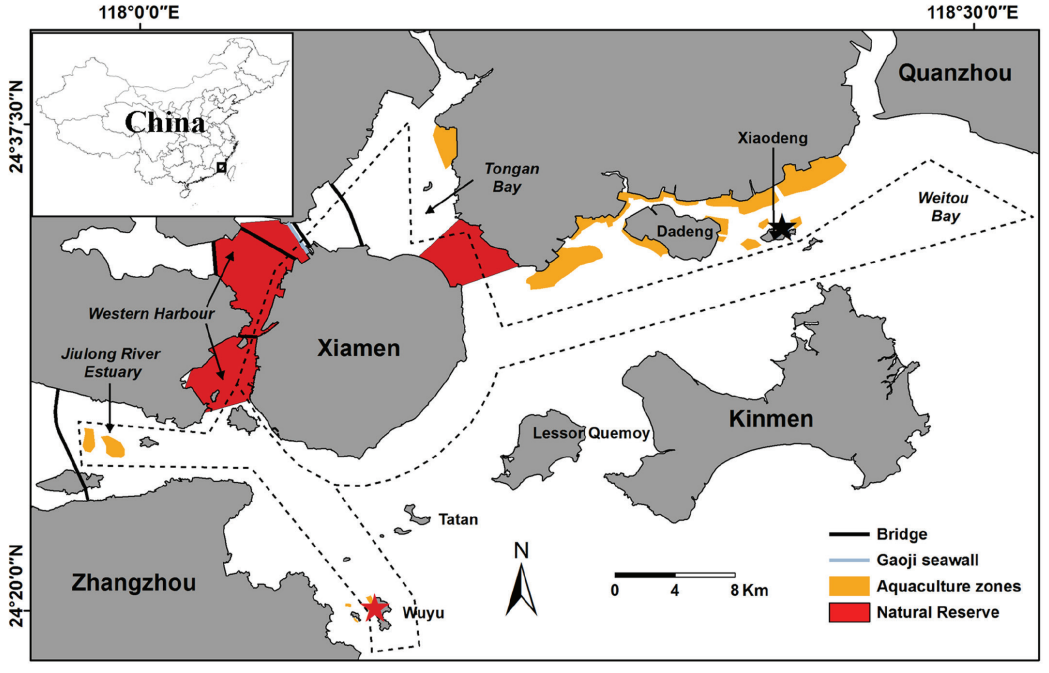

Figure 1. Map of Xiamen, China, and its adjacent waters, showing the study area and survey route (dash line), the Humpback Dolphin National Nature Reserve (red area), the aquaculture zones (orange area), and the stranding locations of Individual XM61 (black star) and an unknown individual (red star)

Nature's *Red List of Threatened Species* (Reeves et al., 2008).

Humpback dolphins are known to occur in Xiamen and its adjacent waters (Huang & Liu, 2000; Chen et al., 2008), located at the estuary of the Jiulong River in southeastern China (Figure 1). Field surveys conducted in the mid-1990s and in 2008 estimated the abundance to be 60 to 76 individuals (Huang & Liu, 2000; Chen et al., 2009). Humpback dolphins in this area are highly threatened, not only because its small size is intrinsically vulnerable to extinction (Huang & Liu, 2000; Chen et al., 2008), but also due to intense anthropogenic threats, including busy vessel traffic, coastal construction, contaminants, shipping lane dredging, and underwater noise, which also represent substantial extrinsic pressures on these dolphins (Huang & Liu, 2000; Wang et al., 2003; Chen et al., 2011; Guo et al., 2011; Xiao et al., 2014). Due to intensive anthropogenic disturbance, mortality of humpback dolphins in Xiamen and its adjacent waters is high. At least 37 dead humpback dolphins were found between 1997 and 2011 (Xiao et al., 2014), representing an average of two to three individuals each year. As a consequence, conservation management measures for the population have been mainly focused on reducing known anthropogenic threats—for example, by prohibiting fishing activity and limiting vessel speed in some areas with the highest density of dolphins (Huang & Liu, 2000). However, during our field surveys in Xiamen and its adjacent waters, a substantial percentage of humpback dolphins were found to have noticeable external injuries that appear to have been caused by fishing gear. So far, no information about the relationship between humpback dolphins in Xiamen waters and local fisheries is available. Humpback dolphins in Hong Kong waters (Jefferson, 2000), along the western coast of Taiwan (Slooten et al., 2013; Wang et al., 2017) and the coast of Donsak of Thailand (Jutapruet et al., 2015) were found to bear human-induced injuries, and fishing gear were identified as the main cause. Information on fishery interactions based on external scars and injuries could therefore provide valuable information on the significance of this threat to humpback dolphins in Xiamen and its adjacent waters that would strengthen the scientific evidence base to inform effective conservation management.

Field surveys were conducted in Xiamen, China, and its adjacent waters from August 2010 to March 2016. The survey route is shown in Figure 1. All dolphins were individually identified using photo-identification techniques by documenting the natural spotting patterns or non-natural marks on/around their dorsal fins. Every sighting record of each identified dolphin included

information on identification (ID) number, date and time, geographical location, specific observed behaviors, and associated environmental information. Survey and photo-identification methods are described in Wang et al. (2015, 2016).

During the study period, a total of 60 humpback dolphins were photographically identified, representing 78.9 to 100% of the dolphin abundance estimated by Huang & Liu (2000) and Chen et al. (2009) in the study area. In this sample, seven (11.7%) individuals displayed significant external injuries, including missing the anterior part of the lower or upper rostrum, missing the upper part of the dorsal fin, or exhibiting various scars on their bodies. These injuries are summarized in Table 1 and shown in Figures 2 and 3. The wounds observed on these individuals all appear to have healed, and there were no observable behavioral differences between injured and uninjured dolphins in the field. At the time of the preparation of this note, all of the injured individuals continued to inhabit the study area.

In addition to these seven injured individuals, on 25 May 2013, a humpback dolphin (designated as Individual XM61) was found live-stranded on the beach of northern Xiaodeng Island (Figure 1), entangled with gillnet from its mouth to its flukes. This individual died 10 d later, and subsequent anatomical examination revealed that it exhibited serious intestinal and lung disease. On 20 April 2017, another individual was found dead and entangled with gillnet on the beach of Wuyu Island (Figure 1). This dolphin was seriously decayed as some epidermis had already been removed, and it was impossible to compare with identified individuals. A third bycatch event not directly observed by the survey team was also known to have occurred in the Kinmen region (Taiwan) on 4 May 2010, shortly before the start of the survey period, where a dead adult male humpback dolphin was found entangled by a crab trap (Prof. Chou Lien-siang, pers. comm., 26 October 2010).

Wounds from propeller strikes often exhibit a series of parallel curved slash marks (Bloom & Jager, 1994), and injuries from inter-/intraspecific or predator interactions are characterized by rake marks made by teeth (Ford & Ford, 1986; Heithaus, 2001; Luksenburg, 2014). Some injuries observed on humpback dolphins in Xiamen and its adjacent waters and reported in the present study, such as having the upper part of the dorsal fin missing (Individual XM30), body scars (Individuals XM12, XM21, and XM48), and scars around the mouth (Individuals XM27 and XM61), are similar to injuries characteristic of entanglement in fishing nets that have previously been observed in bottlenose dolphins (*Tursiops truncatus*) (Wells et al., 1998; Friedlaender et al., 2001; Luksenburg, 2014), Guiana dolphins (*Sotalia guianensis*) (Nery et al., 2008), false killer whales (*Pseudorca crassidens*) (Nitta & Henderson, 1993; Carretta et al., 2003; Baird & Gorgone, 2005; Luksenburg, 2014), and humpback whales (*Megaptera novaeangliae*) (Robbins & Mattila, 2001), as well as humpback dolphins in Hong Kong waters (Jefferson, 2000), along the western coast of Taiwan (Slooten et al., 2013; Wang et al., 2017) and the coast of Donsak of Thailand (Jutapruet et al., 2015). It is also possible that Individuals XM11 and XM39, which are both missing parts of their rostra, sustained these injuries either through

Table 1. Information on eight Indo-Pacific humpback dolphins (*Sousa chinensis*) with external injuries observed in Xiamen, China, and its adjacent waters between August 2010 and April 2016

Photo-ID	Number of sightings	First sighting date	Last sighting date	Description of injuries
XM11	19	19 Dec 2010	9 June 2015	Upper rostrum missing
XM12	37	23 Dec 2010	12 April 2016	Traverse scar on back
XM21	41	30 Oct 2010	25 March 2016	Deep traverse scar on right side of back
XM27	8	30 June 2013	23 Aug 2015	Narrow scar at right corner of mouth and two small scars at left corner of mouth
XM30	31	4 Aug 2010	15 Jan 2016	Upper part of dorsal fin cut off
XM39	43	23 Nov 2010	25 March 2016	Anterior part of lower rostrum missing
XM48	13	23 May 2013	18 Feb 2016	Deep circular scar around body behind blowhole
XM61	Live-stranded at Xiaodeng Island on 25 May 2013; it was entangled with gillnet from mouth to tail flukes.			

fishing gear entanglement or through entrapment in heavy underwater foreign objects such as pipelines, resulting in parts of their rostra being damaged to the point of breaking off.

The level of probable fishery-related injuries recorded in Xiamen and its adjacent waters (11.7% or seven out of 60 observed individuals) is higher than that documented in Hong Kong waters (2.3%; Jefferson, 2000) but lower than that recorded along the western Taiwan coast (> 30%; Slooten et al., 2013; Wang et al., 2017). This comparatively high level of observed injuries suggests that fishing activities likely pose a previously underappreciated threat to humpback

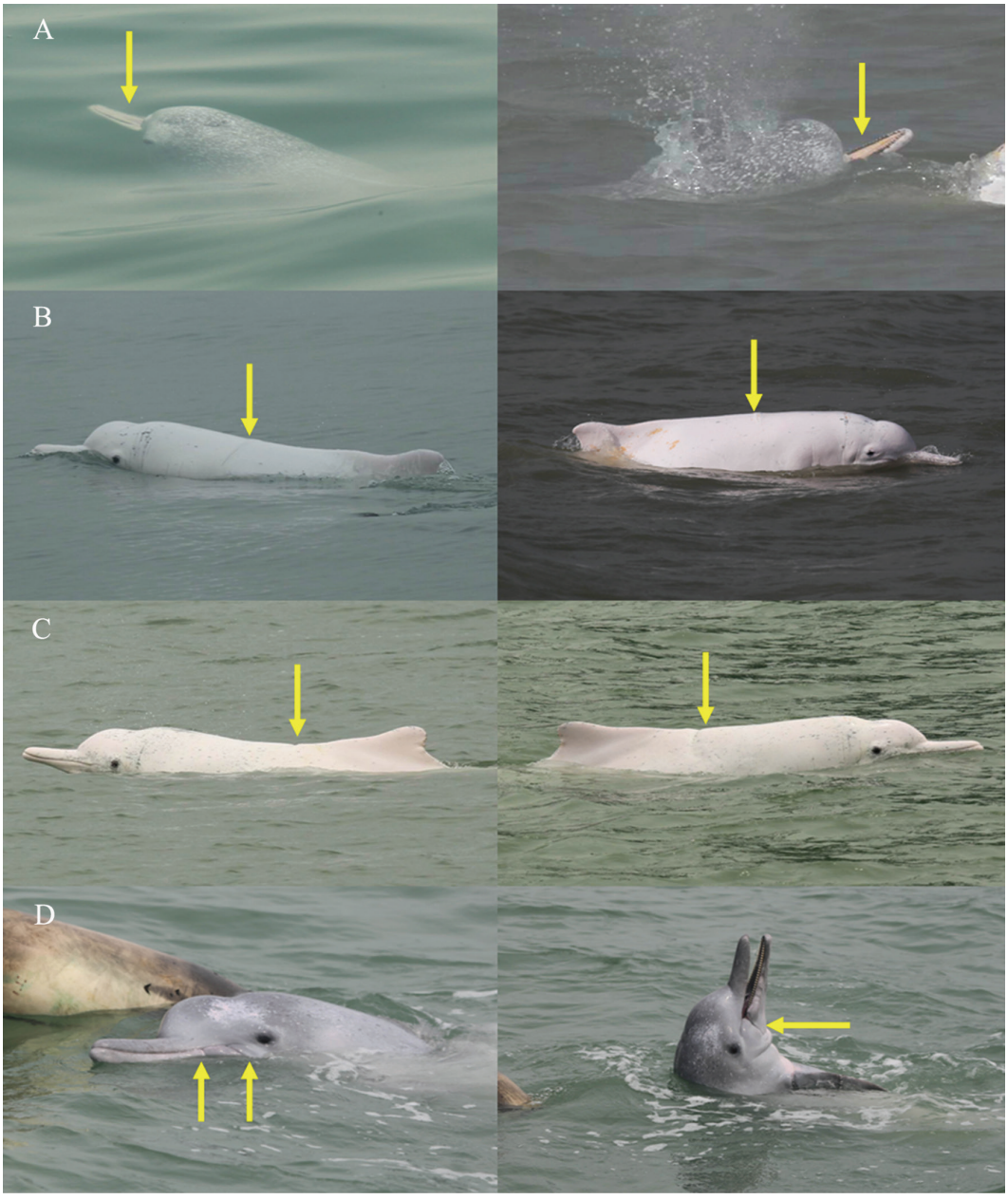

Figure 2. Injuries on Indo-Pacific humpback dolphins (*Sousa chinensis*) in Xiamen and its adjacent waters: (A) XM11, (B) XM12, (C) XM21, and (D) XM27 (*Photo credit:* Dr. Wang Xianyan)

dolphins in Xiamen and its adjacent waters. The three stranded individuals that were found entangled by gillnets or crab traps provide further direct evidence that humpback dolphins are accidentally caught by fishing gear in the study area.

The present study was only able to investigate humpback dolphins that had been photo-identified and had survived fishery interactions, together with data on three directly observed bycatch events. Studies on humpback dolphins along the western Taiwan coast show that external injuries may be an underestimation of fisheries impact (Wang et al., 2017). It is therefore likely that further humpback dolphin individuals have also been killed or injured

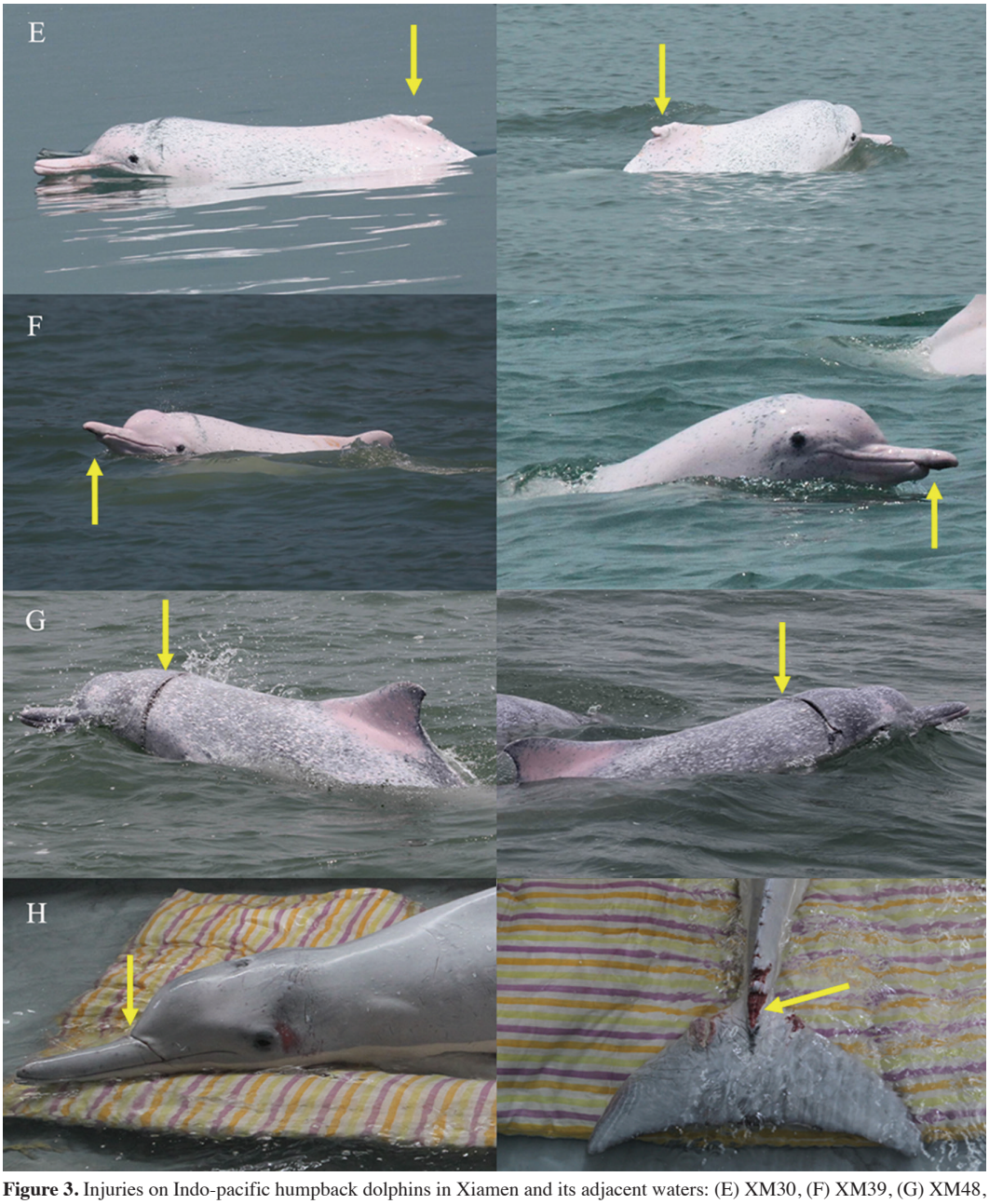

Figure 3. Injuries on Indo-pacific humpback dolphins in Xiamen and its adjacent waters: (E) XM30, (F) XM39, (G) XM48, and (H) XM61 (*Photo credit:* Dr. Wang Xianyan)

as a result of bycatch or entanglement with fishing gear in Xiamen and its adjacent waters. Interactions with local fisheries may be able to explain at least some of the currently unidentified recent mortalities of humpback dolphins recorded from the study region (Xiao et al., 2014). Further investigations, including field surveys and interviews with fishers and other marine resource users, are needed to better understand interactions between humpback dolphins and local fisheries in Xiamen and its adjacent waters.

To protect humpback dolphins and their habitat in Xiamen waters, a provincial nature reserve was established in 1997, which was upgraded to the status of national nature reserve in 2004 (Huang & Liu, 2000) (Figure 1), and a "Humpback Dolphin Conservation Regulation" prohibiting fishing activities inside the reserve was put into effect by the Xiamen Municipal Government. However, some areas inside the reserve still contain considerable amounts of set nets, and small fishing boats continue to use gillnets; trawls and hand-lines were also observed frequently during our field surveys. Humpback dolphins are known to occur outside the boundaries of the reserve (Wang et al., 2015), but a large part of the unprotected area is used as a marine aquaculture zone, and fishing activities outside the reserve are also intensive, especially in the Dadeng-Xiaodeng region, the mouth of Tongan Bay, and the Jiulong River Estuary. The findings of the present study suggest that local enforcement agencies should pay greater attention to humpback dolphin interactions with fishing gear as well as the potential threats posed by vessel traffic, coastal construction, shipping lane dredging, and underwater noise. Management of fishing activities that are harmful to humpback dolphins should be strengthened, and fisheries restrictions should be expanded to cover the entire Xiamen area and its adjacent waters.

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