



MARINE MAMMAL SCIENCE, \*\*(\*) : \*\*\*\_\*\*\* (\*\*\*) 2010)

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DOI: 10.1111/j.1748-7692.2010.00422.x

## Evidence for year-round occurrence of the eastern Taiwan Strait Indo-Pacific humpback dolphins (*Sousa chinensis*) in the waters of western Taiwan

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The eastern Taiwan Strait (ETS) population of Indo-Pacific humpback dolphins (*Sousa chinensis*) is distinct morphologically and isolated geographically from provisional populations of mainland China (Wang *et al.* 2008), numbers fewer than 100 individuals, and inhabits a small stretch of shallow (<25 m deep) coastal waters along central-western Taiwan (Wang *et al.* 2007*a, b*). Its continued existence is being jeopardized by many anthropogenic threats that are found either directly in the coastal waters of western Taiwan or originate in adjacent coastal lands and associated watersheds. The five most serious threats include: habitat degradation and loss due to industrial development involving massive land reclamation (*e.g.*, Formosa Plastics Group's Mailiao Industrial Area and the proposed 4,000 ha Kuokuang Petrochemical complex over the wetlands and coastal waters of Dacheng); entanglement in fishing gear; air and water pollution from industrial, agriculture, and municipal sources; reduction of river flow to estuaries that appear to be important to the dolphins; and noise from coastal construction, shipping, and military activities (see Wang *et al.* 2007*b*). In August 2008, the ETS Indo-Pacific humpback dolphins were listed in the International Union for Conservation of Nature's Red List of Threatened Species as "Critically Endangered" (Reeves *et al.* 2008).

Since the discovery of the ETS population of Indo-Pacific humpback dolphins in 2002 (Wang *et al.* 2004*a*), dedicated surveys for these dolphins have only been conducted from April to September (inclusive) when marine conditions are calmest. Even though the importance of understanding the seasonal distribution and movements of this population was specifically identified (Wang *et al.* 2004*b*), the strong and persistent northeast monsoon winds have been an effective deterrent for researchers

wanting to conduct boat-based surveys during winter (*i.e.*, December–March). Anecdotal reports and opportunistic sightings support the winter presence of humpback dolphins in the waters of western Taiwan but their affinity to the ETS population has not been confirmed. On the basis of the best available information about humpback dolphins and that typical humpback dolphin habitat along western Taiwan is limited and separated from other known areas, along mainland China, by the Taiwan Strait, where deep water appears to be a barrier to movement for this species (see Jefferson and Karczamariski 2001), year-round residency of the ETS population in the waters of western Taiwan is a logical assumption. However, without direct evidence, winter residency of the ETS Indo-Pacific humpback dolphins in the waters of western Taiwan remains an important question to be resolved (Wang *et al.* 2007b).

The aim of this project was to survey the coastal waters of western Taiwan for dolphins during each month of the winter season (from the winter solstice, roughly 21 December, to the vernal equinox, roughly 21 March). This study tested the null hypothesis that the ETS Indo-Pacific humpback dolphins migrated out of the shallow coastal waters of western Taiwan (*i.e.*, they do not inhabit, or are absent from, these waters) during the winter. By surveying these waters during winter months and comparing photographs of any dolphins observed to an existing catalogue of individuals from the ETS population, the presence of dolphins from this population can be determined. Positive matches of known individuals would provide direct evidence for rejecting the null hypothesis.

Attempts were made to conduct boat-based surveys in each of the winter months of 2008–2009 (*i.e.*, December–March), but trips were only conducted successfully on 19 January, 27 February (with only marginal success), and 16 March. The waters surveyed extended from the northern end of Taichung Harbor and industrial area to almost the Luen Wei Channel (Fig. 1), which is an area where dolphins are often observed during nonwinter months (see Wang *et al.* 2004a, 2007a, b). Surveys followed more or less parallel tracks varying between about 0.5 and 2.5 km from the shoreline, but to increase the chance of sighting dolphins, most of the search effort was in waters within about 1 km from shore. The surveys were conducted using a 19-m-long fishing boat, traveling at 10–16 km/h. A minimum of two observers searched the waters using binoculars (8× and 10× magnification) and unaided eyes from a sighting platform that was about 3.5 m above sea level (observers' eyes were roughly about 5.2 m above sea level). Observers searched a quadrant covering 90° of arc from the center line to the sides of the boat, but most of the search effort was focused on the waters from the center line to approximately 30° on each side of the boat.

Standard survey information was recorded when the survey vessel made a major course change, dolphins were observed, marine or weather conditions changed noticeably, or at approximately 20 min intervals if no events had been recorded. The information collected included: date, time, geographic positions (determined using handheld global positioning systems, Garmin GPS MAP76), species observed, and number of individuals. Attempts were made to obtain high-quality photographs of the dorsal fins (both sides) of as many individuals as possible before returning back to the track line to search for other dolphins. Photographs were taken with

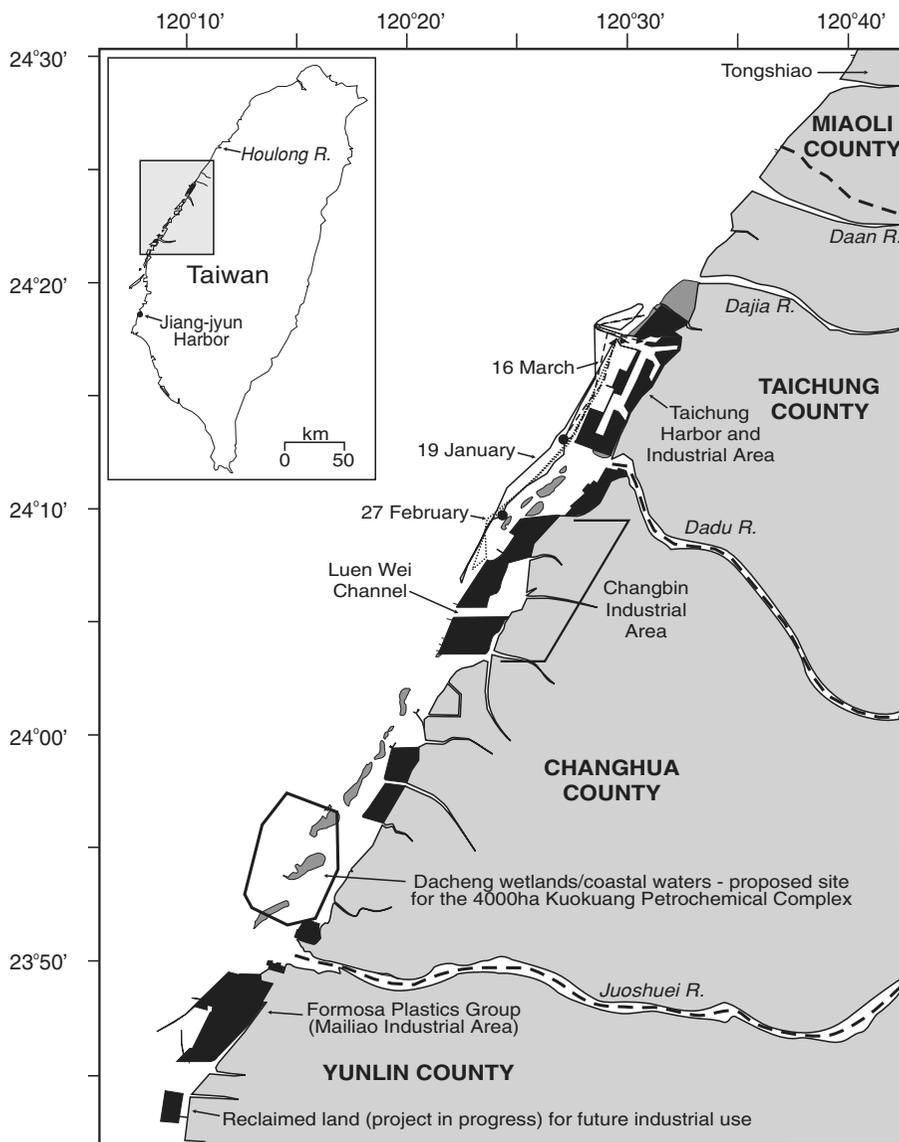


Figure 1. Map of the main known distribution of the ETS population of *Sousa chinensis*. Survey track lines for the three boat-based survey trips are shown by different lines and dolphin sightings are indicated by the solid circles. Large black polygons along the shoreline represent areas of considerable land reclamation and the open polygon represents the proposed site of the Kuokuang Petrochemical complex. Sizeable sandbars are indicated by gray irregular shapes and thick broken lines designate county lines.

digital single lens reflex cameras with 80–200 mm and 300 mm lenses. Individuals in photographs were compared independently by both authors to the photographic reference catalog of ETS humpback dolphins that was established and maintained by *FormosaCetus* Research and Conservation Group since 2002. This catalog contains

76 individuals, but 12 are either known to have died or likely deceased because they have not been seen for at least 5 yr. Of the remaining 64 individuals that have been seen within the last 5 yr, 61 (about 95.3%) have photographs of both sides. Dolphins of this population are identified mainly by their unique spotting patterns on the dorsal fin and adjacent region on the back that change little over several years (JYW, unpublished data) and offer easy photo-identification of individual dolphins. Major scars on the body, and nicks and notches on the dorsal fin also provide additional features to help in identifying individuals.

On-effort search in decent survey conditions (*i.e.*, in Beaufort Sea State < 4, in little-to-no rain, and during daylight hours), covered 95.5 km of water in 7.8 h. Sightings were made on-effort during the 19 January and 16 March survey trips. The first encounter was of a pair of dolphins in the shallow (about 4.5 m deep) waters at the southern edge of the Dadu-River estuary (the most northern part of the Changbin Industrial Park). These dolphins were confirmed from photographs as TW-50 and TW-51. The second sighting was made at the northern edge of the Dadu River estuary. The group size estimated in the field was 16 dolphins while photographs revealed a minimum of 16 individuals, of which 13 were known individuals, one dolphin's identity was uncertain due to inadequate photograph quality, and two others were young calves, including a neonate (likely born earlier in the year) (see Fig. 2 for examples of a matched individual). Combined, at least 18 different dolphins were observed in only two encounters and 15 individuals were positively identified as members of the ETS population. Inadequate photographs (one individual) or the absence of long-lasting marks (*i.e.*, two young calves) precluded three individuals from being identified individually. Of the dolphins possessing identifiable marks, none were "new" to the photographic catalog. The individuals of these two sightings represented 33% and 35% of the total number of different individuals that were photographed during our more extensive summer surveys in 2008 and 2009, respectively (JYW, unpublished data).

By examining anecdotal and opportunistic records of humpback dolphins from the waters of western Taiwan for winter records, we were able to confirm humpback-dolphin sightings in December ( $n = 3$ ), January ( $n = 3$ ), and March ( $n = 1$ ) (Table 1). Records were confirmed only if photographs were adequate for positive species identification and accompanied by a date and location, or the information was obtained from trained observers or the captain of the survey vessel used in the present and past surveys of ETS humpback dolphins. These records were from as far north as the mouth of the Houlong River (Miaoli County) to the Luen Wei Channel. The quality of only one photograph from a sighting in January was adequate to allow positive identification of an individual, TW-50, which was also photographed during the first winter boat-based survey (see above).

Even though the marine conditions along western Taiwan during the winter months were not conducive to cetacean surveys, this study succeeded in providing unequivocal, direct evidence to reject the null hypothesis of the seasonal migration of all ETS humpback dolphins from the coastal waters of western Taiwan. The best available information about humpback-dolphin biology also supports year-round residency of the ETS humpback dolphins in the coastal waters of western Taiwan. The

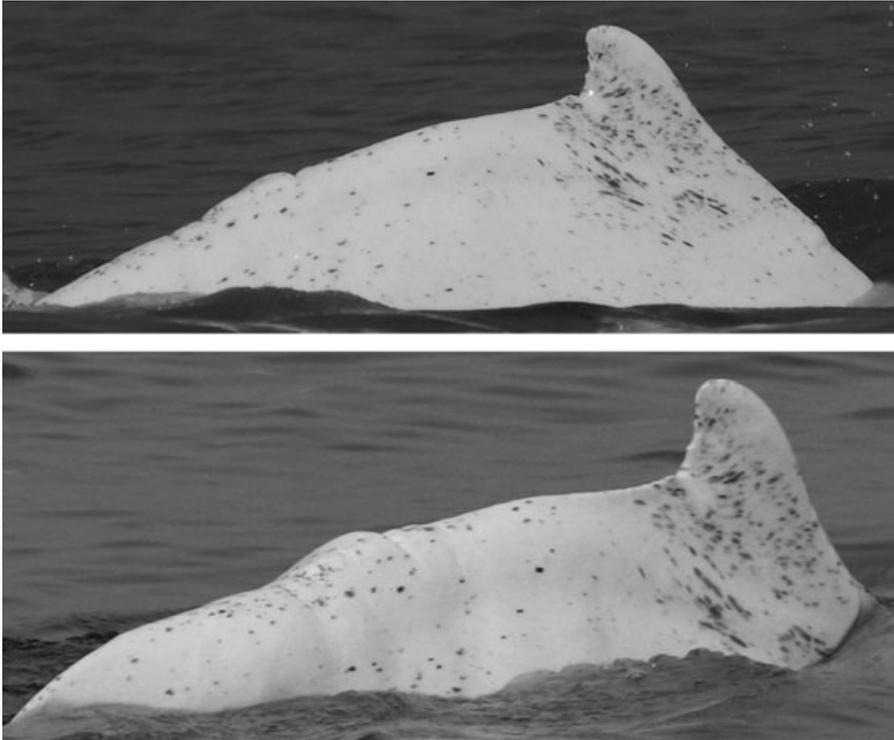


Figure 2. Images of an individual (TW-22 “Pele”) that had been cataloged (top photograph) and was also photographed again during the winter of 2009 (bottom photograph). Photographs by J. Y. Wang (top) and S. C. Yang (bottom).

mobility of the species is limited (from a few tens to few hundred kilometers in linear distance; see Durham 1994, Karczmarski 1996, Hung 2000, Hung and Jefferson 2004) and although slight seasonal shifts in distribution have been reported, large-scale seasonal migrations are not known from anywhere in its range (see Jefferson and Karczamarski 2001). Moreover, the limited humpback dolphin habitat along western Taiwan is disconnected from other known suitable waters (*i.e.*, along mainland China) by a considerable expanse of deep water in the Taiwan Strait and movements of this species appear to be restricted to water depths of about 25 m or less (Jefferson and Karczamarski 2001). Confirmed opportunistic observations (supported by photographic and video images) of humpback dolphins in the waters of the Changbin Industrial Park on 18 October 2006 by researchers conducting seabird studies (JYW, unpublished data) and of Jiang-jyun Harbor (Tainan County) by coast guard officers on 25 October 2005 (see Wang *et al.* 2007a) mean that only the months of February and November remain without confirmed records, probably not because the dolphins are absent but because of the lack of research effort during these poor-weather months. Although the present study provided direct evidence that at least a considerable proportion of the ETS dolphins is found in the waters of western Taiwan

*Table 1.* Anecdotal and opportunistic winter sightings of Indo-Pacific humpback dolphins in the coastal waters of western Taiwan.

Date	Sighting location	Reported group size	Source
22 January 1995	Taichung Harbor	7 in 3 small groups	Y.-B. Chen (reported in Chou <i>et al.</i> 1996) <sup>a</sup>
6 March 2001	Tongshiao Beach	3	United Daily News (9 March 2001)
2 December 2007	Site M; northern end of the Dadu River estuary	5–7	B.-H. Chen, Matsu Fish Conservation Union <sup>b</sup>
12 December 2007	Site S; Songbuo Fishing Harbor	>2	B.-H. Chen, Matsu Fish Conservation Union <sup>b</sup>
3 January 2008	Site F; south shore of the mouth of Luen Wei Channel	1	B.-H. Chen, Matsu Fish Conservation Union <sup>b</sup>
7 January 2008	Taichung Harbor	6–8	United Daily News (12 January 2008); TW-50 identified in photograph
30–31 December 2008	Houlong River estuary	2	K.-C. Hong (captain of survey vessel)

<sup>a</sup>Chou, L.-S., S. C. Yang and W.-L. Tsai. 1996. Rescuing the Indo-Pacific humpback dolphins in Taiwanese Waters. Final report to Memotime Watch Company. National Taiwan University, Taipei, Taiwan. 22 pp. [In Chinese].

<sup>b</sup>Observer trained by the authors.

during the winter, to better understand how individual dolphins use these waters seasonally, more survey effort in the winter is needed.

Year-round residency of the ETS population in the coastal waters of western Taiwan confirms concerns about its extinction risk because of increasing habitat degradation in these waters. With fewer than 100 individuals, the loss of even a single ETS humpback dolphin per year due to human activities may be unsustainable.

#### ACKNOWLEDGMENTS

We would like to thank the members of the Matsu Fish Conservation Union who assisted during different parts of this project (B.-H. Chen, C.-Y. Gan, C. MacFarquhar, and M. Wilkie). We also appreciate the help from the captain of our survey vessel, Mr. K.-C. Hong. Primary funding for this work was granted to SCY. by Ocean Park Conservation Foundation, Hong Kong. S. K. Hung, K. N. Riehl, and three anonymous reviewers provided helpful comments to improve this paper. Additional support was provided by *FormosaCetus* Research and Conservation Group and the Hong Kong Cetacean Research Project. JYW is also supported by and affiliated with the National Museum of Marine Biology and Aquarium (Checheng, Pingtung County, Taiwan) and the Department of Environmental Science and Policy, George Mason University (Fairfax, VA).

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Received: 30 January 2010

Accepted: 1 June 2010