Pakistan J. Zool., vol. 44 (5), pp. 1209-1214, 2012.

The Northernmost Distribution of Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in the World: Evidence From Preliminary Survey in Ningde, China

Bing Yao Chen,[1] Dong Mei Zheng,[2] Lian Wang,[1] Xin Rong Xu[1] and Guang Yang[1]*
[1]*Jiangsu Key Laboratory for Biodiversity and Biotechnology, College of Life Sciences, Nanjing Normal University, Wenyuan Road 1, Qixia District, Nanjing City, Nanjing 210046, China*
[2]*College of Oceanography and Environmental Science, Xiamen University, Xiamen 361005, China*
Bing Yao Chen and Dong-Mei Zheng equally contributed in this work

Abstract.- Northernmost distribution area of Indo-Pacific humpback dolphin or Chinese white dolphin *Sousa chinensis* in China and world is not certain. From October 2009 to June 2010, we conducted 42 boat surveys and filled in 112 questionnaires. The surveys covered 1756.4km distance in Southeastern China, *i.e.*, Yueqing, Fuzhou and Ningde waters. We sighted the dolphin six times in Ningde that represents the current northernmost distribution area of this species in China and the world. One to two dolphins were recorded in each sighting; four individuals were identified using photographic technology. The encounter rate was 0.47 sightings/100km survey route and 0.79 dolphins/100km survey route. Dolphins' 95% Kernel range and MCP range were 68.1 km^2 and 14.39 km^2 respectively. These results implied that dolphins inhabiting Ningde waters represented a small community. Considering current various serious threats, it would be difficult for this community to survive for long. Future research prospects have also been put forward.

Key words: Ningde, Encounter rate, Indo-Pacific humpback dolphin

INTRODUCTION

The genus *Sousa* includes three species: *S. teuszii* in Atlantic Ocean/West Africa, *S. plumbea* in the western Indian Ocean, from South Africa to at least the east coast of India, and *S. chinensis* from the east coast of India to China and Australia (Jefferson and Karczmarski, 2001; Jefferson and van Waerebeek, 2004). *S. chinensis*, the Indo-Pacific humpback dolphin, is categorized as "Near Threatened" by the International Union for the Conservation of Nature (IUCN, 2011), and is included in the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2011). The species is also listed in Appendix II of the Convention on Migratory Species (CMS) (Heidrun, 2010). In China, this species has been categorized as a Grade I National Key Protected Animal since 1988.

* Corresponding author: gyang@njnu.edu.cn
0030-9923/2012/0005-1209 $ 8.00/0

Indo-Pacific humpback dolphin is the only *Sousa* species that is distributed in coastal waters of China. Jefferson (2000) suggested eight *Sousa* populations around the mouths of large rivers in mainland China, however only five populations have been confirmed with systematic field surveys so far. These populations were respectively found in i) Xiamen/Jiulongjiang River Estuary (Huang and Liu, 2000; Liu and Huang, 2000; Chen *et al*., 2008, 2011), ii) Pearl River Estuary (Jefferson, 2000; Hung and Jefferson, 2004; Jefferson and Hung, 2004), iii) Leizhou Bay (Zhou *et al*., 2007; Xu *et al*., 2011), iv) Beibuwan Gulf (Chen *et al*., 2009), and v) western Taiwan (Wang *et al*., 2004, 2007).

Of the five confirmed populations, Xiamen is the northernmost distribution area. However, there were also some incidental deaths and/or sighting records in the north of Xiamen, *i.e.*, Fuzhou, Ningde, Yueqing, Rugao, Hengsha and Dalian (Zhou *et al*., 1995, 1997; Han *et al*., 2003; Wang and Han, 2007; Zhang and Tang, 2008; see Figure 1 in Chen *et al*., 2009). Most researchers are of the view that the dead individuals in Dalian, Hengsha, and Rugao were stragglers, and nowadays dolphins no longer occur there (personal communication). Wang and Han (2007) reported that there might be a few individuals dispersed in Yueqing and a small

population may also exist in the Fuzhou waters. The fragmental data collected through the first stranding and incidental catch network for cetaceans in China established in 2002-2004 also suggested that there might be some Indo-Pacific humpback dolphins in Ningde and Fuzhou. For example, local fishermen and fisheries officials told us of year-round sightings of Indo-Pacific humpback dolphin in Luoyuanwan Bay (Fuzhou) and SanduaoBay (Ningde). However, to date, no special survey on this species had been conducted. Consequently, no direct evidence such as photos or video of living dolphins in Yueqing, Ningde and Fuzhou are available.

The aim of this study was to initially determine whether there were living Indo-Pacific humpback dolphins in the Southeast China including Ningde, Fuzhou and / or Yuqing, and furthermore to collect some basic information such as individual identification, distribution, movement pattern etc. Once some living Indo-Pacific humpback dolphins were sighted, it would represent a finding and confirmation of the northern most distribution of this species in the world.

MATERIALS AND METHODS

Study area

Ningde, Fuzhou and Yueqing are potential distribution areas of the Indo-Pacific humpback dolphin. Some local fishermen and officials in the three areas were interviewed through questionnaires. Based on the information obtained from questionnaire surveys, we further conducted boat surveys in Mingjiang River Estuary (Fuzhou), Luoyuanwan Bay (Fuzhou), and Sanduao Bay (Ningde) (see study area in Fig. 1). The effective survey areas in Sanduao Bay and Luoyuanwan Bay were 554.49 km^2 and 241.95 km^2, respectively. Due to bad sea conditions, only one boat survey (30.1-km) could be conducted in Mingjiang River Estuary, where the survey area was less than 50 km^2.

Questionnaire surveys

We interviewed local officials and fishermen to gather preliminary data. Collected the relevant information, such as time and position of dolphins sighted, group size, morphologic and behavioral traits, boat and fishing information (boat type, boat power, fishing net type, fishing years engaged, fishing area etc.), fishery resources, carcass information etc.

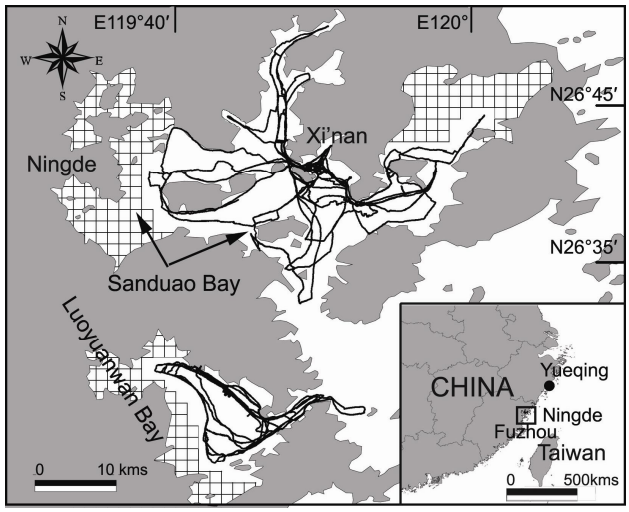

Fig. 1 The study area and tracks for boat surveys in the Sanduao Bay and Luoyuanwan Bay. Grid parts represent 1-2 m shallow waters, mud bank or reclamation land where survey boat could not enter.

Day time boat surveys

Because marine culture occupied at least 50% and 60% area of Sanduao Bay and Luoyuanwan Bay respectively, the survey route was determined according to local situation (see tracks in Fig.1). The boat surveys were conducted using a fishing boat powered with a 36 HP engine. In the field survey, the boat mainly traveled at a speed of 6-11 km/h. Once dolphins were sighted, the boat slowly approached the individual dolphins. The maximum possible time was dedicated to follow dolphins. The dolphins were photographed using a Canon EOS-1Ds Mark autofocus Digital camera, equipped with a 100-400 zoom lens. Sighting time, radial distance, group size, age class, various behaviors, and human activities such as fishing, were recorded. Besides, latitude and longitude of all sightings, boat speed and tracks were also recorded using a global positioning system (GPS). Some environmental conditions, such as visibility, wind power and direction, ebb and flow, sea water depth, salinity, and Beaufort sea state were also gathered.

Encounter rate and abundance

The dolphins were found only in the Sanduao Bay. The encounter rate was calculated using the following formula:

$$E_n = N/L$$

$$E_s = \sum_{i=1}^{6} (S_i)/L$$

Where, E_n, sighting encounter rate (sightings/100 km survey route); E_s, individual encounter rate (individuals/100 km survey route) ; N, number of sightings; S_i, group size in i-th sightings, i=1, 2, 3, 4, 5, 6 and L, total length of survey route (kilometers).

Range

Following Hung and Jefferson (2004), Parra (2006) and Chen *et al*. (2011) we used the 95% Fixed Kernel method and Minimum Convex Polygon (MCP) method to estimate the range size of dolphins. All the estimates were made using GIS, ArcView 3.3, with the Animal Movement extension. Kernel ranges were estimated using smoothing parameters; calculated using a cross-validation procedure for the least squares (Seaman *et al*., 1999; Parra 2006). Any land mass in MCP or Kernel range was subtracted.

RESULTS

From October, 2009 to June, 2010, we completed 112 questionnaires, including 26, 33 and 53, respectively in Yueqing, Fuzhou and Ningde (Table I). 75.7% interviewees had been engaged in fishing or culturing for over 20 years.

In Yueqing, all the interviewees had not seen the Indo-Pacific humpback dolphins for at least 15 years, in confirmation of the result of our 2002-2004 interview surveys. Therefore, we did not conduct boat survey in these waters.

In Minjiang Estuary, Fuzhou, the exploratory surveys were conducted as two interviewees (16.7%) had seen dolphins five years ago. However, only one boat survey covering 30.1-km survey route was conducted, even that was terminated due to bad sea conditions; no dolphin was sighted. In Luoyuanwan Bay, Fuzhou, five interviewees (23.8%) had seen dolphins in the past five years, two interviewees (9.5%) had seen dolphins in 2009. In addition, one dead dolphin was found in 2007, which was disposed of by local fisheries bureau. We conducted 12 boat surveys (457.2-km) in Luoyuanwan Bay where no dolphins were sighted.

In Sanduao Bay, Ningde, 29 interviewees (54.7%) had sighted the dolphins during the past five years. Twelve interviewees (22.6%) had seen dolphins between 2009 and 2010; and they informed us that the Indo-Pacific humpback dolphins were distributed in Sanduao Bay all the year round. The most dolphin groups (82.8%) sighted by interviewees consisted of less than 5 animals; only three groups (10.3%) consisted of more than 10 dolphins. In 2005, one dead dolphin was found in Xi'nan, a small town in Sanduao Bay. In total, 29 boat surveys were conducted in Sanduao Bay, which covered 1269.4-km survey route.

We sighted the Indo-Pacific humpback dolphin six times in Sanduao Bay (Fig. 2), which represented the current northernmost distribution in China and the world for this species.

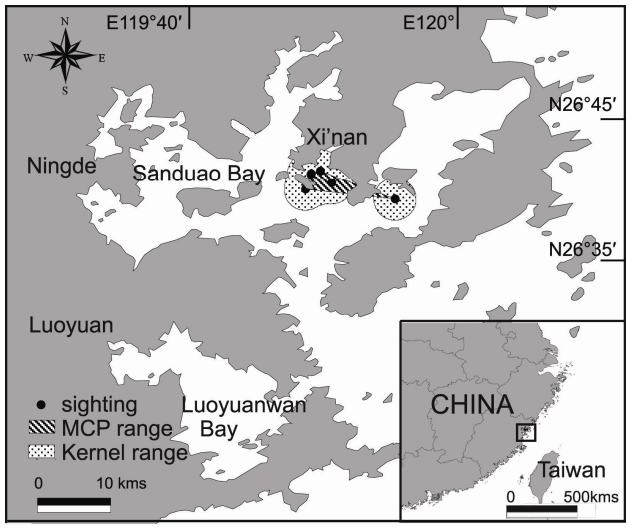

Fig. 2. The sightings and range of dolphins in Sanduao Bay.

The relevant information on sightings is shown in Table II. We observed the dolphins for 190 minutes in total, and took 582 pictures. One or two individuals in each sighting were recorded, with an average of 1.67 dolphins per sighting. Using

Table I.- The questionnaire and boat survey efforts and relevant information.

Study area		Date	Number of questionnaires	Survey effort (days)	Length of survey lines (km)
Yueqing		11-15 Oct. 2009	26	0	
Fuzhou	Minjiang Estuary	5 May 2010	12	1	30.1
	Luoyuanwan Bay	21-26 Oct. 2009	12		
		27 Nov.-10 Dec.2009		10	365.2
		29-30 April 2010	9	2	92
Ningde	Sanduao Bay	29 Oct.- 5 Nov. 2009	31		
		13 Nov.-14 Dec.2009		9	345.6
		25-26 April 2010	5	2	96
		25 May-13 June 2010	17	18	827.8
Total			112	42	1756.7

Table II.- The relative information on sightings of Indo-Pacific humpback dolphins in Sanduao Bay, Ningde, China.

Date	Water depth (m)	Salinity (‰)	Group size	Age class	Behavior	Observation time (min) /pictures	Individual identification
Nov.14, 2009	20.1	-	1	A	moving	9 /36	ND1
Nov. 22, 2009	14.5	30.2	1	A	moving	15 /39	ND1
Dec. 11, 2009	12.9	30.1	2	A, A	preying, moving	50 /247	ND1,ND2
May 30, 2010	4.9	30.1	2	A, J	moving	2/83	ND3
9:23 June 7, 2010	2	26.5	2	A, A	preying	96 /88	ND2,ND4
14:01 June 7, 2010	18.8	26.2	2	A, A	Preying, moving	18/89	ND2,ND4

Abbreviations used: A, Adult; J, Juvenile

photographic technology, four individuals (three adults and one juvenile) were identified. Preying and continuous movements were the predominant behaviors. The 95% Kernel range and MCP range of dolphins were 68.1 km^2 and 14.39 km^2, respectively. The mean 12.2m sea water depth and 28.6‰ salinity were recorded in the waters where dolphins were sighted .

The encounter rate in Sanduao Bay was 0.47 sightings/100km and 0.79 dolphins/100km. In 2009 winter, the encounter rate was 0.87 sightings/100km and 1.16 dolphins/100km, whereas in summer of 2010, both values were lower; 0.32 sightings/100km and 0.65 dolphins/100km, respectively.

DISCUSSION

Yueqing and Fuzhou

The present study and the questionnaire survey in 2002-2004 both indicated that no dolphin existed in Yueqing Bay.

Probably due to little survey effort in the Minjiang Estuary, Fuzhou, we did not encounter any dolphins in the area. Therefore, more boat surveys should be conducted in future to confirm their presence or otherwise. In Luoyuanwan Bay, Fuzhou, the interviewees were of the opinion that the dolphins often occurred there about ten years ago but seldom in recent years. We did not observe any dolphin during 12 boat surveys, which suggested that the encounter rate of dolphin in Luoyuanwan Bay had declined to a very low level. In the past decade, extensive marine culture (> 60% area of Luoyuanwan Bay) has been developed. A fuel-burning power plant has been constructed and two ports developed in this bay; a bridge is also under construction. In addition, fishing still continues, that is known to have killed a dolphin in 2007. The anthropogenic activities might have driven this species away from Luoyuanwan Bay.

Ningde

We sighted Indo-Pacific humpback dolphins in Sanduao Bay, Ningde. However, only one or two dolphins per sighting were recorded, and it was also supported by the questionnaire survey. This indicates that even though a *Sousa* population exists in this bay, the number of individuals must be very small.

We did not estimate the abundance of this population; however we compared the encounter rate in Sanduao Bay with that in Xiamen. The encounter rate in Sanduao Bay was 0.47 sightings/100km and 0.79 dolphins/100km, which is significantly lower than that in Xiamen (1.66 sightings/100km and 7.68 dolphins/100km, 86 individuals in Xiamen (Chen *et al*., 2008).

Historically, the dolphins were distributed along the coast of China. Since the late twentieth century, the abundance of dolphins has however reduced sharply, and the distribution of this species has shrunk southwards and apparently fragmented.

During the present study, dolphins were found to occur in winter of 2009 and summer of 2010, with one dolphin ID2 recorded in both seasons. This suggested that the dolphins might reside in Sanduao Bay throughout the year. However, in Sanduao Bay, some negative effects might have adversely impacted this small community of dolphins such as:

i. The existence of extensive marine culture of fish, kelp and abalone in the shallow waters (<20m), occuping >50% area of Sanduao Bay, greatly reducing the habitat of dolphin.
ii. Some direct or indirect pollution discharged from coastal fire power plant, drainage and marine culture declining the water quality and further exacerbating because of the relatively slow exchange of water due to the narrow entrance of Sanduao Bay (3.02 km).
iii. Fishery resources in the bay having been diminished, very few fish of small body size could be found during the surveys.
iv. Deliberate kills is a potentially serious threat to the dolphins. The dolphins chewed up the cultured nets, and preyed upon the young fish such as large yellow drum (*Nibea albiflora*) and red drum (*Sciaenops ocellatus*). The fishermen suffered the heavy losses, and claimed to catch and kill the dolphins. These factors will continue to threaten this small dolphin community. It seemed to be difficult for the dolphins to have a long term survival in these waters.

In view of this situation, currently, we recommend to conduct the following scientific researches: (a) expand the scope of investigation, such as Minjiang River Estuary, offshore waters around the mouths of Sanduao Bay and Luoyuanwan Bay, to determine if there are some dolphins there, and if yes to further detect whether there is some exchange of population with dolphins in Sanduao Bay; (b) increase survey efforts on Sanduao Bay and Luoyuanwan Bay, especially in spring and autumn; (c) conduct fixed-site observations in Sanduao reclamation area, and assess the adaptability of the dolphins to the reclamation for dock construction; (d) suggest local fishery bureau to release large yellow drum and red drum for improving prey resources; (e) reduce marine culture in the preferred area of humpback dolphins and (f) educate the fishermen on the law of the People's Republic of China on the protection of wildlife, e.g. fishermen who kill grade I national key protected animal (Indo-Pacific humpback dolphin) would be fined and sentenced.

ACKNOWLEDGEMENTS

This study was supported by the Ocean Park Conservation Foundation, Hong Kong (OPCFHK), and the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD) to G. Yang. We are thankful to Mr. Lin Jinquan for the help in field boat surveys.

REFERENCES

CHEN, B.Y., ZHENG, D.M., JU, J.F., XU, X.R., ZHOU, K.Y. AND YANG, G., 2011. Ranging patterns of resident Indo-Pacific humpback dolphins (*Sousa chinensis*, Osbeck 1765) in Xiamen, China: implications for conservation and management. *Zool. Stud.*, **50**: 751-762.

CHEN, B.Y., ZHENG, D.M., YANG, G., XU, X.R. AND ZHOU, K.Y., 2009. Distribution and conservation of the Indo-Pacific humpback dolphin in China. *Integr. Zool*,.**4**: 239-246.

CHEN, B.Y., ZHENG, D.M., ZHAI, F.F., SUN, P., WANG, Q., XU, X.R. AND YANG, G., 2008. Abundance, distribution and conservation of Chinese white dolphin (*Sousa chinensis*) in Xiamen, China. *Mammal. Biol.*,**73**: 156-164.

CITES, 2011. 2011 *CITES appendices*. Available from http://www. cites.org/eng/app/appendices.shtml, 18 July 2011.

HAN, J.B., MA, Z.Q., WANG, P.L. AND DONG, Y., 2003. The by-catching Chinese White Dolphins in North of Yellow Sea □. Measurement of morphology and organs. *Fisher. Sci*., **22**: 18-20 (in Chinese).

HEIDRUN, F., 2010. *Cetacean conservation under the convention on migratory species*. UNEP/CMS Secretariat, Bonn, Germany.

HUANG, Z.G. AND LIU, W.H., 2000. Dead and freed dolphins in Xiamen waters between 1994 and 1999. *J.Oceanogra.Taiwan Strait*, **19**: 42-47 (in Chinese).

HUNG, S.K. AND JEFFERSON, T.A., 2004. Ranging patterns of Indo-Pacific humpback dolphins (*Sousa chinensis*) in the Pearl River Estuary, People's Republic of China. *Aquat. Mammals*, **30**: 159-174.

IUCN 2011. *IUCN red list of threatened species*. Version 2011.1. <www.iucnredlist.org>. Downloaded on 18 July 2011.

JEFFERSON, T.A., 2000. Population biology of the Indo-pacific humpback dolphin in Hong Kong waters. *Wildl. Monogr.*, **144**: 1-65.

JEFFERSON, T.A. AND HUNG, S.K., 2004. A review of the status of the Indo-Pacific humpback dolphin (*Sousa chinensis*) in Chinese waters. *Aquat. Mammals*, **30**: 149-158.

JEFFERSON, T. A. AND KARCZMARSKI, L., 2001. *Sousa chinensis*. *Mammal. Sp.*, **655**: 1-9.

JEFFERSON, T.A. AND VAN WAEREBEEK, K., 2004. Geographic variation in skull morphology of humpback dolphin (*Sousa* spp.). *Aquat. Mammals*, **30**: 3-17.

LIU, W.H. AND HUANG, Z.G., 2000. Distribution and abundance of Chinese white dolphins (*Sousa chinensis*) in Xiamen. *Acta Oceanol. Sin.*, **22**: 95-101 (in Chinese).

PARRA, G.J., 2006. Resource partitioning in sympatric delphinids: space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins. *J. anim. Ecol.*, **75**: 862-874.

IUCN, 2011. *IUCN red list of threatened species*. Version 2011.1. Available from http://www.iucnredlist.org, 21 July 2011.

SEAMAN, D. E., MILLSPAUGH, J. J., KERNOHAN, B. J., BRUNDIGE, G. C., RAEDEKE, K. J. AND GITZEN, R. A., 1999. Effects of sample size on kernel home range estimates. *J. Wildl. Manage.*, **63**: 739-747.

WANG, P.L. AND HAN, J.B., 2007. Present status of distribution and protection of Chinese white dolphin (*Sousa chinensis*) population in Chinese waters. *Mar. Environ. Sci.*, **26**: 484-487 (in Chinese).

WANG, J.Y., HUNG, S.K. AND YANG, S.C., 2004. Records of Indo-Pacific humpback dolphins, *Sousa chinensis* (Osbeck, 1765) from the waters of Western Taiwan. *Aquat. Mammals*, **30**: 189-196.

WANG, J.Y., YANG, S.C., HUNG, S.K. AND JEFFERSON, T.A., 2007. Distribution, abundance and conservation status of the eastern Taiwan Strait population of Indo-Pacific humpback dolphins, *Sousa chinensis*. *Mammalia*, **32**: 157-165.

XU, X., ZHANG, Z., MA, L., YANG, G. AND ZHOU, K.Y., 2011. Site fidelity and association patterns of Indo-Pacific humpback dolphins off the east coast of Zhanjiang , China. *Acta Theriol.* DOI: 10.1007/s13364-011-0058-5.

ZHANG, L.F. AND TANG, S.M., 2008. Distribution of Chinese white dolphin in the coast waters of China. *J. Oceanogr. Taiwan Strait*, **27**: 79-86 (in Chinese).

ZHOU, K., XU, X. AND TIAN, C., 2007. Distribution and abundance of Indo-Pacific humpback dolphins in Leizhou Bay, China. *N.Z. J. Zool.*, **34**: 35-42.

ZHOU, K.Y., GAO, A.L. AND XU, X.R., 1997. Stranding of an Indo-Pacific hump-backed dolphin on a sandbank in the Yangtze River. *Acta Theriol. Sin.*, **17**: 73-74 (in Chinese).

ZHOU, K.Y., LEATHERWOOD, S. AND JEFFERSON, T.A., 1995. Records of small cetaceans in Chinese waters: a review. *Asian Mar. Biol.*, **12**: 119-139.

(Received 19 October 2011, revised 14 April 2012)