

Behaviour and Habitat Selection of Yangtze Finless Porpoises in Dongting Lake, China, and the Adjacent Waters: Impact of Human Activity

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Abstract.- Seven ecological surveys on the Yangtze finless porpoise (*Neophocaena asiaorientalis asiaorientalis*) were carried out in Dongting Lake, China, and the adjacent waters between September 2006 and January 2010 using the line transect sampling method. The surveys covered a total of 2135.1 km, and 954 individuals were observed in 419 sightings. Among these sightings, traveling behaviour was predominant (52.5%), followed by infant care (19.3%), foraging (14.8%), socializing (1.0%) and resting (1.0%). A total of 68.0% of sightings (285 sightings) belongs to the situation that these behaviours occurred within or near the classified habitats (soil bank, river and lake confluences, riffles, islets, open water, sand bars, rock banks, water channels within the sand bar, eddies and areas with mixed currents, and river bends). Among these 285 sightings, traveling, infant care and foraging behaviours predominantly occurred near soil banks (35.1%, 12.6% and 4.9%, respectively). A total of 73.7% of sightings (309 sightings) belonged to the situation in which five behaviours were associated with at least one human activity (shipping, fishing, pollution, dredging and hydroprojects). Among these 309 sightings, traveling was predominantly associated with shipping (22.7%), followed by fishing (8.7%), pollution (6.8%) and dredging (1.6%). For infant care, it was shipping (5.5%), fishing (3.6%), pollution (1.9%) and hydroprojects (0.3%). For foraging, it was fishing (7.4%), shipping (3.2%), pollution (1.0%) and dredging (0.6%). To protect Yangtze finless porpoises in Dongting Lake and the adjacent waters, over-fishing and illegal fishing operations should be banned, and boat traffic should be urgently managed, particularly close to soil banks.

Key words: Yangtze finless porpoise, *Neophocaena asiaorientalis asiaorientalis*, soil bank, shipping, fishing, regional extinction.

INTRODUCTION

The Yangtze finless porpoise (*Neophocaena asiaorientalis asiaorientalis*) is the only identified freshwater sub-species of Phocoenidae. This subspecies is distributed in the middle and lower reaches of the Yangtze River in China and two appended lakes, Dongting Lake and Poyang Lake (Gao and Zhou, 1995). Previous studies have indicated that intensive human activities, such as the depletion of fish stocks, the use of illegal fishing methods, dam construction, dredging, boat traffic and pollution (Wang, 2009), have contributed to a decrease in population from approximately 2,700 in the early 1990s (Zhang *et al.*, 1993) to 1,800

0030-9923/2013/0003-0635 \$ 8.00/0

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in 2006, with dramatically fragmented habitats (Zhao *et al.*, 2008). Zhao (2009) recommended that the population status of this subspecies should be upgraded from "Endangered" (Baillie and Groombridge, 1996) to "Critically Endangered" by the IUCN.

In order to protect the Yangtze finless porpoise, *in-situ* conservation, *ex-situ* conservation and captive breeding programs have been undertaken since the 1980s (reviewed in Wang, 2009). To enhance the efficiency of *in-situ* and *ex-situ* conservation (*e.g.*, on the selection, design and management of reserves, and population monitoring), it is important to study the behaviour and habitat selection of the Yangtze finless porpoise and the impact of human activities on both, as these are considered to be the main threats to this subspecies (Wang, 2009). Previous studies have

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indicated that the behavioural patterns of grouping, traveling, escaping, mating, resting, playing and particularly foraging and infant care could be observed in Poyang Lake and the adjacent Yangtze River (Yu *et al.*, 2001, 2005; Xiao and Zhang, 2002; Wei *et al.*, 2002, 2003). With regards to habitat selection, this animal tends to live in environments with islets, sand bars, soil banks, rock banks, open water, river bends, eddies, mixing currents, or river and lake confluences, or a combination of any of these (Zhang *et al.*, 1993; Yu *et al.*, 2001, 2005; Xiao and Zhang, 2002; Wei *et al.*, 2002, 2003). According to the studies, these habitats are considered to be abundant in food resources and suitable for care of the porpoise infants. However, these habitats are impacted by intensive human activities, particularly fishing (mainly the setting nets).

The above studies have increased our understanding of the behavioural ecology of the Yangtze finless porpoise; however, there several limitations remain. Firstly, the habitat types have often been broadly classified. Secondly, the relationships between behaviour and habitat and between behaviour and human activity have generally been qualified, although some studies have made an effort to quantify data (Wei *et al.*, 2002). Thus, it is difficult to compare results from different studies. Thirdly, no research of this kind has been performed previously in Dongting Lake or the adjacent waters, where only about 198 porpoises are left; even these are under intense pressure from human activities (Zhang, 2011). For example, six individuals died in 2004 and a further four in 2009 due to illegal fishing, pollution and boat collisions, amongst other causes (unpublished data). In the near future, this population may be the first to face complete regional extinction (Zhang, 2011). This study aims at understanding the behaviour and habitat selection of Yangtze finless porpoises in Dongting Lake and the adjacent waters to assist their conservation. In addition, this research also aims at enriching our knowledge of the behavioural ecology of this lesser known freshwater cetacean.

MATERIALS AND METHODS

Study area and time

Dongting Lake is the second largest freshwater lake in China, and the Xiangjiang, Zijiang, Yuanjiang and Lishui rivers are the main tributaries. The lake consists of eastern (between Sanjiangkou and Nianyukou), southern and western parts, which are connected by Caoweihe River (Fig. 1). Over the course of a year, the width of the lake varies from 600 m to 7 km (Dou and Jiang, 2000). During the study period (Sep. 2006 to Jan. 2010, covering the four yearly hydrological seasons; Table 1), the width was generally less than 2 km. As the water depth is less than 1.5 m in the southern and western parts of Dongting Lake, which makes navigation difficult, surveys have mainly been carried out in eastern Dongting Lake, the Xiangjiang River (from Nianyukou to Quyuan, ~30 km), and the Caoweihe River (from Nianyukou to Chapanzhou, ~25 km; Fig.1).

Habitat type classification

According to previous studies (Zhang *et al.*, 1993; Xiao and Zhang, 2002; Wei *et al.*, 2002; Yu *et al.*, 2003) and our observations in Dongting Lake and the adjacent waters, ten types of habitat were classified: 1) soil bank; 2) river and lake confluences; 3) riffles (areas with depths between 2 to 4 m); 4) islets; 5) open water; 6) sand bars; 7) rock banks; 8) water channels within the sand bar; 9) eddies and areas with mixed currents; and 10) river bends.

Behaviour definition

According to previous studies on the behaviour of Yangtze finless porpoise and other toothed whales (Hua *et al.*, 1993; Yang and Chen, 1996; Zhang, 1997; Müller *et al.*, 1998; Gubbins *et al.*, 1999; Mann and Smuts, 1999; Wei *et al.*, 2002, 2003; Xiao and Wang, 2005; Yu *et al.*, 2005; Azevedo *et al.*, 2007; Ribeiro *et al.*, 2007), and our observations in Dongting Lake and the adjacent waters, five basic behavioural patterns commonly observed in Yangtze finless porpoise have been defined: 1) traveling: the animal moves in a certain direction and maintains a relatively constant speed; 2) infant care: any behaviour that occurs between a calf and the most closely associated individual (the suspected mother), including carrying, lifting, synchronous breathing and swimming; 3) foraging:

the animal dives repeatedly in a specific area, after which fish may jump out of the water and birds may

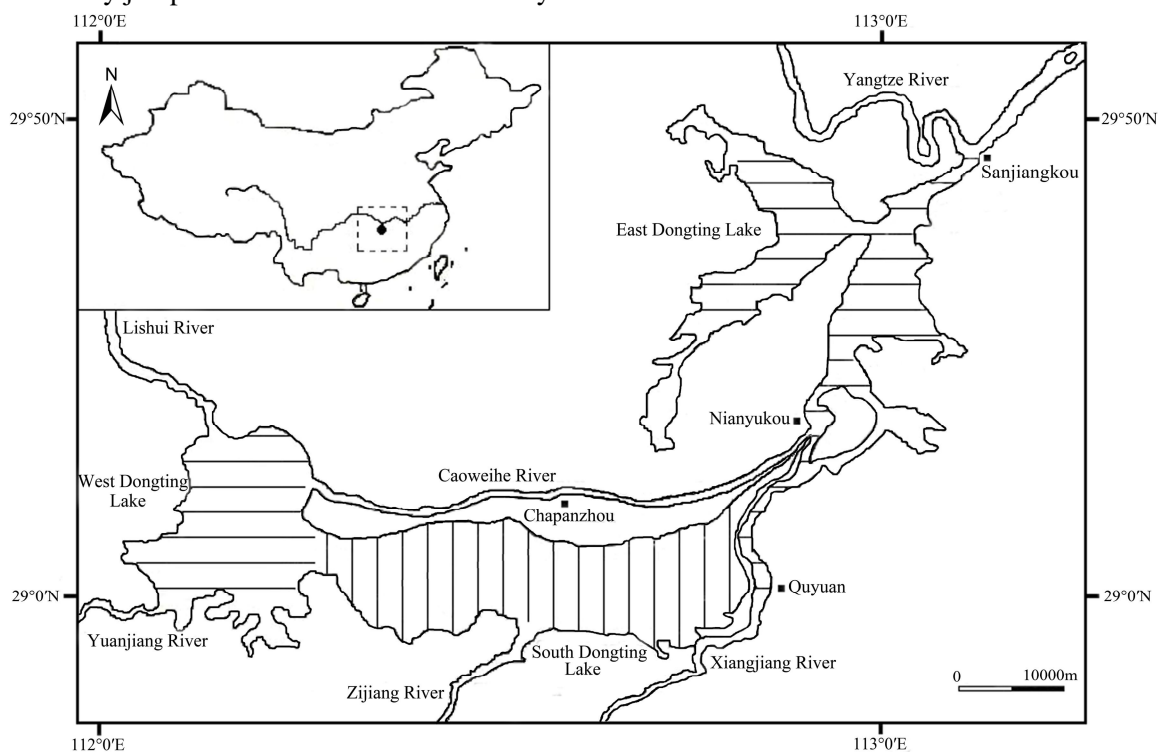


Fig. 1. Study area and the parallel systematic sampling transect lines in Dongting Lake in China and the adjacent waters.

hover overhead. Sometimes, a fish is observed in the mouth of the porpoise; 4) socializing: the animal initiates an approach, chase, follow etc., toward another individual or several other porpoises, and body contact may occur; and 5) resting: the animal moves slowly at the surface or stays afloat for at least five seconds. It should be noted that, in some sightings, two or more behaviours might occur at the same time. In this situation, behaviours were recorded and analyzed together.

Human activity classification

According to previous studies (Yang and Chen, 1996; Wang *et al.*, 1998; Dong *et al.*, 2000; Xiao and Zhang, 2002; Yu *et al.*, 2005), and our observations in Dongting Lake and the adjacent waters, human activities in this study were classified into five types: 1) shipping: areas within 500 m from the middle line of shipping; 2) fishing: areas within 500 m from sites of fishing operations; 3)

pollution: areas within 500 m from cities, towns, ports or terminals that discharge sewage into the water; 4) dredging: areas within 500 m from sand dredging sites; and 5) hydroprojects: areas within 500 m from bridges and ports.

Line transect sampling

Line transect sampling method (Buckland *et al.*, 2001) was used and the systematic transect lines were parallel to each other; the width between the transect lines was 4 km (Dawson *et al.*, 2008) (Fig.1). In each survey (round trip), four trained observers stood on the deck of a fishing boat (Zhao *et al.*, 2008). When the porpoises were found, navigation was suspended for two minutes to record the GPS location, habitat pattern, animal behaviour and any type of human activity in the vicinity. Details of the sampling and recording methods can be found elsewhere (Zhang, 2011). Data analysis was performed using Microsoft® Excel.

RESULTS

2,135.1 km in total, from which 954 individuals

Seven surveys were conducted, covering

Table I.- Summary of the ecological surveys on the Yangtze finless porpoise in Dongting Lake and the adjacent waters in China from 2006 to 2010.

Time	Survey days	Hydrologic season	Surveyed area and Length of survey line (km)					Number of individuals sighted
			East Dongting Lake (km)	South Dongting Lake (km)	West Dongting Lake (km)	Xiangjiang River (km)	Caoweihe River (km)	
Sep. 2006	7	Falling water	127.6	-	60	64.4	150	137
Dec. 2006	5	Low water	98.8	-	-	58.3	47.6	264
Mar. 2007	6	Rising water	104.3	-	-	64.8	46.1	181
Jun. 2007	9	High water	132.5	94	60	63.8	90	73
Jan. 2009	12	Low water	98.2	-	-	62.6	48	107
Jun. 2009	15	High water	133.4	97.4	60	67.6	90	65
Jan. 2010	5	Low water	107.7	-	-	58.1	49.9	127
Total	59	-			2135.1			954

-, not surveyed.

were observed in 419 sightings (Table I). Among these sightings, the following observations were made:

1. Traveling behaviour was predominant (52.5%), followed by infant care (19.3%), foraging (14.8%), socializing (1.0%) and resting (1.0%). The infant care behaviour sometimes occurred at the same time as foraging behaviour (10.0%).

2. A total of 68.0% of sightings (285 sightings) belonged to the situation that the five behaviours occurred within or near the classified habitats. Among these 285 sightings, traveling, infant care and foraging behaviours predominantly occurred near soil banks (35.1%, 12.6% and 4.9%, respectively). When traveling and resting behaviours occurred at the same time, the animals were more frequently near soil banks than any of the other classified habitats (4.9%; Table II). Among the classified habitats, nearly all of the setting nets were deployed near soil banks.

3. A total of 73.7% of sightings (309 sightings) belonged to the situation that the five behaviours were associated with at least one human activity (shipping, fishing, pollution, dredging and hydroprojects). Among the 309 sightings, traveling was predominantly associated with shipping (22.7%), followed by fishing (8.7%), pollution (6.8%) and dredging (1.6%). For infant care, it was

shipping (5.5%), fishing (3.6%), pollution (1.9%) and hydroprojects (0.3%). For foraging, it was fishing (7.4%), shipping (3.2%), pollution (1.0%) and dredging (0.6%). It should be noted that infant care and foraging behaviours occasionally occurred together near sites of fishing (4.5%). The defined behaviours sometimes occurred alongside at least two types of human activity, particularly shipping and fishing (26.9%, Table III).

DISCUSSION

Behaviours

Animal behaviour is triggered by their needs in specific situations (Barnard, 2004). Our study found that travelling, infant care and foraging were the most frequently observed behaviours for Yangtze finless porpoises in Dongting Lake and the adjacent waters. These results are similar to those of previous studies conducted in Poyang Lake and the adjacent Yangtze River (Wei *et al.*, 2002, 2003; Xiao and Zhang, 2002). The prevalence of travelling behaviours in our study may indicate that by moving among patchy habitats (as implied by the heterogeneity of habitats and clustered distribution of fishing boats) with relatively low cost of energy (Schmidt-Nielsen, 1972), the animals might increase their chances of finding prey or mate. In addition,

our study found that infant care behaviour occurred together with foraging, which might be helpful for the calf and adult. The calf could learn foraging skills from the adults, while the adults could fulfill

their nutritional requirements while staying tightly bonded to the calf (Gubbins *et al.*, 1999; Weihs,

Table II.- The relationship between behavioural patterns and habitat types in Dongting Lake and the adjacent waters.

Habitat type	Behavioural pattern										Total
	Traveling	Infant care	Foraging	Socializing	Resting	Traveling and resting	Socializing and resting	Traveling, socializing and resting			
Soil banks	100	36	14	0	2	14	2	0			168
River and lake confluences	11	7	7	0	0	6	0	0			32
Riffles	22	3	3	0	0	2	0	0			30
Islets	15	2	4	1	0	7	0	0			29
Open water	12	2	2	1	0	0	0	0			17
Sand bars	4	1	1	0	0	0	0	0			6
Rock banks	0	0	1	0	0	0	0	0			1
Water channels within the sand bar	0	0	0	0	0	1	0	0			1
Eddies and areas with mixed currents	0	0	1	0	0	0	0	0			1
River bends	0	0	0	0	0	0	0	0			0
Total	164	51	33	2	2	30	2	1	1	1	285

Table III.- The relationship between behavioural patterns and types of human activities in Dongting Lake and the adjacent waters.

Behaviour pattern	Type of human activities*																Total
	S	F	P	D	H	SF	SP	SD	FP	FD	FH	PD	FPD	SFD	SFP	SFPH	
Traveling	70	27	21	5	0	11	7	4	5	2	2	0	1	2	0	0	157
Infant care	17	11	6	0	1	6	5	1	6	0	2	0	0	0	1	1	57
Foraging	10	23	3	2	0	4	1	2	4	0	0	1	0	0	0	0	50
Socializing	0	1	1	0	0	0	0	0	4	0	0	0	0	0	1	0	3
Resting	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Infant care and foraging	5	14	2	1	2	3	1	0	3	0	1	0	0	0	3	0	35
Infant care and socializing	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Infant care and resting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Infant care, foraging and socializing	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Total	105	77	33	8	3	25	14	7	19	2	5	1	1	2	6	1	309

*D, Dredging; F, Fishing; H, Hydroprojects; P, Pollution; S, Shipping

2004; Noren *et al.*, 2006, 2008; Noren and Edwards, 2007, 2011).

With regard to the least prevalent behaviours of socializing and resting, we attributed this to the constraints of environment (Barnard, 2004). In the *ex-situ* reserves, socializing and resting behaviours were frequently observed as well as the other three defined behaviours (Jiang, 2000; Xian, 2010; personal observation). Compared with the natural habitats, these *ex-situ* areas are less affected by human activities and are much richer in food resources. In such environments, socializing and resting behaviours are predicted to be triggered more easily; however, due to intensive human activities and the depletion of fish stocks in our study area, the animals might have to spend more time finding food (Barnard, 2004).

Habitat selection

Our study found that the Yangtze finless porpoise selected a variety of habitats, which is similar to the results of previous studies (Zhang *et al.*, 1993; Xiao and Zhang, 2002; Wei *et al.*, 2002; Yu *et al.*, 2003). Further analysis indicated that the animals selected soil banks predominantly for traveling, infant care and foraging. Compared with other classified habitats, soil banks are characterized by richer sediments, slighter slopes and less variable topography, where small-sized fishes are predicted to be more abundant (Huntingford and Torricelli, 1993). These fishes are the predominant part of the diet of Yangtze finless porpoises (Zhang, 1997). However, local fishermen often choose soil banks to deploy setting nets. The Yangtze finless porpoises are likely to be entangled when they venture to find food in this habitat (Jefferson and Curry, 1994), and instances of this occur every year (unpublished data).

Impact of human activities

In our study area, the Yangtze finless porpoises were subject to intensive human activities. Sometimes, the animals were affected by more than one type of human activities, particularly shipping and fishing. Traveling, infant care and foraging predominantly occurred along with shipping. Previous studies indicated that, like other toothed

whales, Yangtze finless porpoises use acoustic signals to navigate, find food, avoid predators and communicate with intraspecifics (Akamatsu *et al.*, 2005; Li *et al.*, 2005). Shipping can not only produce noises to interfere with their acoustic systems, but also result in injury, death and mother-calf separation after collisions (Noren and Edwards, 2007; Jefferson *et al.*, 2009). Our fixed-site observations indicated that, during the study period, more than 200 boats navigated in the estuary of Dongting Lake every daytime, and this number has increased over the years (Zhang, 2011). Besides shipping, fishing is another important factor that affected the survival of the Yangtze finless porpoise. As with the main stream of the Yangtze River and Poyang Lake, overfishing and the use of illegal fishing methods are common in Dongting Lake and the adjacent waters, including the use of electricity, hooks, poison, explosives and setting nets (Zhang, 2011). The harm caused by these techniques might be intensified when they occur near soil banks.

CONCLUSIONS

The predominant behaviours, variety of habitat selection and the impact of human activities of the Yangtze finless porpoise in Dongting Lake and the adjacent waters resemble those found previously in Poyang Lake and the adjacent Yangtze River. Specifically, we found that porpoises predominantly selected soil banks for their predominant behaviours. In addition, these behaviours predominantly occurred in shipping and fishing areas. The banning of over-fishing and illegal fishing operations, particularly those near soil banks, is required to protect the Yangtze finless porpoises in this area, in addition to enhancing the management of boat traffic.

ACKNOWLEDGMENTS

We thank the researchers of Huazhong Agricultural University, Central China Normal University, Institute of Hydrobiology of Chinese Academy of Sciences, and the staff of Xintankou-Luoshan Beijing National Natural

Reserve for their help in the data collection. We thank Jianfeng Leng of Yueyang Fishery Administration for his logistic assistance. This work was supported by grants from Special Fund for Agro-scientific Research in the Public Interest of the Ministry of Agriculture of China (201203086), Chinese Academy of Sciences (KSCX2-EW-Z-4), WWF Wuhan Program Office (CN0088.04-HS04) and WWF Changsha Program Office (N2505).

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(Received 28 November 2012, revised 18 April 2013)

Table II.- The relationship between behavioural patterns and habitat types in Dongting Lake and the adjacent waters.

Habitat type	Behavioural pattern								Total
	Traveling	Infant care	Foraging	Socializing	Resting	Traveling and resting	Socializing and resting	Traveling, socializing and resting	
Soil banks	100	36	14	0	2	14	2	0	168
River and lake confluences	11	7	7	0	0	6	0	1	32
Riffles	22	3	3	0	0	2	0	0	30
Islets	15	2	4	1	0	7	0	0	29
Open water	12	2	2	1	0	0	0	0	17
Sand bars	4	1	1	0	0	0	0	0	6
Rock banks	0	0	1	0	0	0	0	0	1
Water channels within the sand bar	0	0	0	0	0	1	0	0	1
Eddies and areas with mixed currents	0	0	1	0	0	0	0	0	1
River bends	0	0	0	0	0	0	0	0	0
Total	164	51	33	2	2	30	2	1	285

Table III.- The relationship between behavioural patterns and types of human activities in Dongting Lake and the adjacent waters.

Behaviour pattern	Type of human activities*																Total
	S	F	P	D	H	SF	SP	SD	FP	FD	FH	PD	FPD	SFD	SFP	SFPH	
Traveling	70	27	21	5	0	11	7	4	5	2	2	0	1	2	0	0	157
Infant care	17	11	6	0	1	6	5	1	6	0	2	0	0	0	1	1	57
Foraging	10	23	3	2	0	4	1	2	4	0	0	1	0	0	0	0	50
Socializing	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3
Resting	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Infant care and foraging	5	14	2	1	2	3	1	0	3	0	1	0	0	0	3	0	35
Infant care and socializing	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Infant care and resting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Infant care, foraging and socializing	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Total	105	77	33	8	3	25	14	7	19	2	5	1	1	2	6	1	309

*D, Dredging; F, Fishing; H, Hydroprojects; P, Pollution; S, Shipping