Pakistan J. Zool., vol. 49(6), pp 2263-2269, 2017. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2017.49.6.2263.2269

Spatial and Temporal Distribution Dynamics of the Yangtze Finless Porpoise at the Confluence of the Yangtze and Wanhe Rivers: Implications for Conservation

Minmin Chen[1], Xiaoke Zhang[1], Kexiong Wang[2], Zhigang Liu[1], An Wan[3], Daoping Yu[1,*], Hong Ji[3] and Fangzhen Peng[1]

[1]*Research center of Aquatic Organism Conservation and Water Ecosystem Restoration in Anhui Province, College of Life Science, Anqing Normal University, Anqing 246133, China*

[2]*The Key Laboratory of Aquatic Biodiversity and Conservation of Chinese Academy of Sciences, Institute of Hydrobiology of Chinese Academy of Sciences, Wuhan 430072, China*

[3]*College of Resources and Environment, Anqing Normal University, Anqing 246133, China*

Article Information
Received 12 December 2016
Revised 17 April 2017
Accepted 24 May 2017
Available online 06 December 2017

Authors' Contribution
MC analyzed the data and wrote the manuscript. XZ, ZL and AW helped to observe the occurrence of the porpoise. HJ recorded observations. FP helped to improve the manuscript. DY and KW designed the study.

Key words
Yangtze finless porpoise, Neophocaena asiaeorientalis asiaeorientalis, Distribution patterns, Habitat selection, Confluence.

ABSTRACT

The Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) is a critically endangered species, as the whole population in the wild suffered sharp decline and fragmentation. Observations of the local spatial and temporal distribution dynamics can help establish better conservation strategies. In order to understand the characteristics of habitat chosen, a continuous 15 months observation on the distribution patterns of the Yangtze finless porpoise at the confluence of Yangtze and Wanhe rivers was conducted. The results showed that the distribution of the porpoise changed seasonally. From October 2013 to March 2014 and from December 2014 to January 2015, the observation rate ranged from 12.5% to 100% of each observation day, with the average being 60%. The average maximum number of individuals observed per day was 4 (range, 1–8). Porpoises was not observed in September 2013 and from April 2014 to September 2014. Spatial distribution dynamics analyses showed that from the six different hydrological zones of the confluence, the porpoise was more likely to prefer the flow deflection and flow stagnation zones of the confluence. The average occurrence rate in the flow deflection and flow stagnation zones was 32% and 44%, respectively. Based on these observations, we concluded that the confluence of the Yangtze and Wanhe rivers is a popular habitat of the Yangtze finless porpoise in autumn and winter. Conservation measures should be taken to conserve this kind of habitat.

INTRODUCTION

The Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) is a critically endangered sub-species of the narrow-ridged finless porpoise (*Neophocaena asiaeorientalis*) that exclusively occurs at Yangtze River and adjacent Poyang Lake and Dongting Lake (Gao and Zhou, 1995; Jefferson and Wang, 2008). This sub-species of porpoise was previous occurred throughout the 1700 km Yangtze River mainstream from Yichang to Shanghai (Gao and Zhou, 1995), but its distribution is now primarily confined to about 1000 km of the Yangtze River mainstream, from Ezhou to Shanghai (Mei *et al*., 2012). The latest Yangtze Freshwater Dolphin Expedition (YFDE2012) revealed that at the end of 2012, there were only approximately 1,040 individuals remaining (Mei *et al*., 2012). This sub-species has been affected by a sharp decline in the population and population fragmentation (Mei *et al*., 2012). The heavy impact of human activities in the Yangtze River, including overfishing of prey species, water development projects, water pollution and accidental deaths was considered as the primary threaten to this sub-species (Wang, 2009).

The spatial and temporal distribution of animals is a complex and dynamic function of the species requirements for food, mates, avoidance of predators and competition, and the ability to move between habitat patches (Davis *et al*., 2002; Schofield, 2003). The distribution of freshwater dolphins is also impacted by the hydrological and geomorphological features and flow patterns of their

* Corresponding author: ahyudp@163.com
0030-9923/2017/0006-2263 $ 9.00/0

habitat (Braulik *et al*., 2012; Kreb and Budiono, 2005). Yu *et al*. (2005) revealed that the Yangtze finless porpoise prefers slow water and shallow water areas around sand benches because of the low current and rich food resources. Xiao and Zhang (2002) reported that the Yangtze finless porpoise also preferred water areas around fishing nets and deep water areas near shipping channels.

Confluences, because of their deep water, abundance of fish, countercurrents that cause fish to be momentarily trapped and special topography that allow for easy foraging, are a favorite habitat of river dolphins (Hastie *et al*., 2004; Kreb and Budiono, 2005). The Yangtze finless porpoise also prefer confluences. For example, Kimura *et al*. (2012) revealed seasonal changed distribution patterns of the Yangtze finless porpoise near the conjunction of the Yangtze River and Poyang Lake. Wei *et al*. (2002) and Zhang *et al*. (1993) reported the conjunction of the Yangtze River and Poyang Lake, and the confluence of the Yangtze and Wanhe Rivers were Yangtze finless porpoise's favorite habitat, respectively. However, confluences have complex hydrological characteristics. For example, a typical asymmetrical confluence, the most common style of confluence found in the Yangtze River, can be divided into six different hydrological zones based on flow dynamics: flow deflection, flow stagnation, flow separation, maximum velocity, shear layer, and the mainstream (Best, 1987; Wang, 2007). Each zone has very different flow patterns. It would be interesting to study the hydrological zone/zones preferred by the porpoise.

Wanhe River is the largest tributary of the Yangtze River in Anhui Section. Anhui Section has the highest porpoise density according to YFDE2012 (Fig. 1). At the confluence of the Yangtze and Wanhe rivers, Zhang *et al*. (1993) once observed large-scale porpoise distribution in 1991. Zhang *et al*. (2015) also reported seasonal changes in the distribution pattern of the Yangtze finless porpoise at this confluence, as these porpoises were found only in autumn and winter. However, Zhang *et al*. (2015) did not study the distribution patterns on the occurrence days and the distribution differences between the hydrological zones. In this study, we want to explore the spatial and temporal distribution dynamics of the Yangtze finless porpoise at the confluence of the Yangtze and Wanhe Rivers on the occurrence days in order to understand the habitat chosen by this sub-species. The observations may be useful for establishing effective conservation strategies for this porpoise.

MATERIALS AND METHODS

Study area

The Wanhe River, which originates from the Dabie Mountain, is the largest tributary in the north bank of the Yangtze River in Anhui Section (Fig. 1A). The estuary of the Wanhe River is located in the West of Anqing City, and it has a width of 140 m (Fig. 1). Due to huge water level fluctuations in the Yangtze River mainstream, there were large variations in the water level in the estuary during the field investigation. The maximum, minimum, and average water depth in the estuary was 14.4, 4.6 and 8.5 m, respectively.

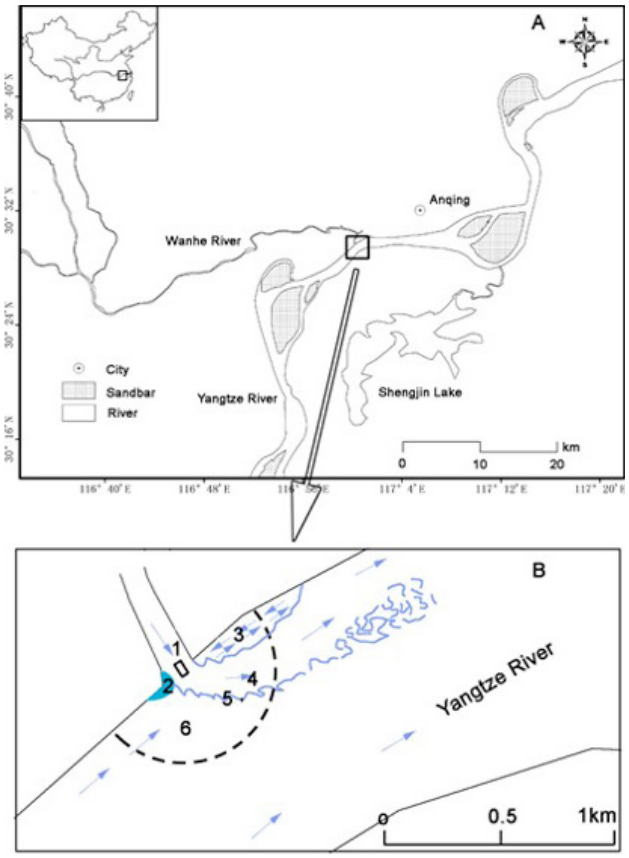

Fig. 1. The location of the estuary of Wanhe River (A) and the divided six different zones (B): 1 flow deflection; 2 flow stagnation; 3 flow separation; 4 maximum velocity; 5 shear layer; 6 mainstream. Black rectangle represents the observation boat and the dotted curve represents the observation area.

The confluence of the Yangtze and Wanhe rivers is divided into the following six zones: flow deflection, flow stagnation, flow separation, maximum velocity, shear layer, and the mainstream (Best, 1987). The flow deflection zone, which is located on the tributary side of the confluence, is the zone where the tributary modifies its flow to conform to the downstream mainstream. The flow stagnation zone is located in the upstream intersection

angle of the tributary and the mainstream. In this zone, the flow velocity is small or even non-existent because of the block from the side wall (Wang, 2007). The flow separation zone is located downstream of the confluence. The mainstream flow is separated because of the injection of the tributary flow. The flow separation zone is usually characterized by backflow or a vortex. Further, the flow is disordered, and the flow velocity is low (Wu *et al*., 2007). In the maximum velocity zone, the flow velocity is rapid because of the change in the discharge area and the block of the flow separation zone. The shear layer is the zone where the flow from the tributary and the mainstream mixes. This layer is characterized by Kelvin Helmholtz instability (Best and Roy, 1991; De-Serres *et al*., 1999), and it is inundated with vortex and turbulence flow because of the large current gradient (Fig. 1B). The water from the Wanhe River is clear while the water of the Yangtze mainstream is muddy. On windless days, different zones can be easily judged according to the different color and the ripple. Therefore, different zones can be identified based on both theoretical knowledge and visual observation.

Data collection and analysis

During the period September 2013 to January 2015, the occurrence of porpoise were monitored at the confluence of the Yangtze and Wanhe Rivers. Observations were conducted on one to four randomly chosen windless days each month. Stationary observation with the naked eye was the method used in this study. A boat (length 15m; width 3m) was anchored at the center of the estuary. Three trained personnel (including two observers and one recorder) stood on the platform of the boat to to look for any porpoises within a radius of 300 m. One observer focused on the left (0°~90°), while the other one focused on the right (0°~90°). The recorder was used to record all the data.

Table I.- Occurrences of the Yangtze finless porpoise at the confluence of the Yangtze and Wanhe Rivers in different hydrological zones.

Season	Date	Weather	Six different hydraulic zones						$Max_{individual}$/ day	$Cum_{frequency}$/ day
			Flow deflection	Flow stagnation	Flow separation	Maximum velocity	Shear layer	Main-stream		
Autumn	2013/9/15	Cloudy	0	0	0	0	0	0	0	0
	2013/9/28	Cloudy	0	0	0	0	0	0	0	0
	2013/10/13	Sunny	-	-	-	-	-	-	5	129
	2013/10/20	Sunny	-	-	-	-	-	-	3	104
	2013/10/27	Sunny	-	-	-	-	-	-	3	180
	2013/11/2	Cloudy	16	28	0	3	0	8	1	55
	2013/11/16	Sunny	94	98	19	9	0	9	7	229
Winter	2013/12/15	Sunny	132	155	54	0	15	0	7	356
	2013/12/23	Sunny	49	26	7	0	0	0	5	82
	2013/12/30	Sunny	67	128	10	0	0	0	5	203
	2014/1/5	Sunny	71	92	22	47	12	6	6	250
	2014/1/16	Sunny	61	39	26	0	0	0	4	126
	2014/2/22	Cloudy	98	106	31	3	0	0	5	238
Spring	2014/3/10	Cloudy	239	358	0	22	36	148	8	803
	2014/3/23	Cloudy	1	42	0	26	0	18	3	87
	2014/3/31	Cloudy	0	0	0	0	0	0	0	0
	2014/4/9	Sunny	0	0	0	0	0	0	0	0
	2014/4/28	Sunny	0	0	0	0	0	0	0	0
	2014/5/15	Sunny	0	0	0	0	0	0	0	0
	2014/5/31	Cloudy	0	0	0	0	0	0	0	0
Summer	2014/6/22	Sunny	0	0	0	0	0	0	0	0
	2014/7/7	Sunny	0	0	0	0	0	0	0	0
	2014/7/27	Cloudy	0	0	0	0	0	0	0	0
	2014/8/6	Sunny	0	0	0	0	0	0	0	0
Autumn	2014/9/27	Cloudy	0	0	0	0	0	0	0	0
Winter	2014/12/1	Sunny	283	39	81	28	0	0	3	431
	2014/12/21	Sunny	0	35	0	0	0	0	3	35
	2015/1/18	Sunny	4	8	8	0	0	2	2	22
	2015/1/19	Sunny	-	-	-	-	-	-	2	65

From 08:00 am to 16:00 pm, monitoring was carried out for 10 min every hour. Thus, a total of 80 min were spent on an observation day. If the porpoise was detected in anyone of the six different zones, the corresponding time and site were recorded. The total frequency of detection above the water surface and individual number of observations were recorded every 10 min. Subsequently, the cumulative frequency ($Cum_{frequency}$) and cumulative individual number ($Cum_{individual}$) per day were calculated. The observation rate per day (number of time periods in which the YFP occurred/8 time periods) and the occurrence percentage per day ($Cum_{frequency}$ at a certain hydrological zone/the total $Cum_{frequency}$) were also calculated.

Statistical analysis

All data were analyzed using the SPSS 19.0 (SPSS, Inc., Chicago, IL, USA). Differences in the $Cum_{frequency}$ of the six different hydrological zones and of observation times were assessed using the Kruskal-Wallis H test.

RESULTS

During the 15-month observation period, from September 2013 to January 2015, a total of 29 surveys were conducted at the confluence of the Wanhe River. On 17 of the 29 observation days, porpoises were observed: the $Cum_{frequency}$ per day ranged from 22 to 803 (with an average of 199), and the $Max_{individual}$ per day ranged from 1 to 8 (with an average of 4, Table I). The distribution of porpoises at the confluence demonstrated seasonal variations (Fig. 2). From October 2013 to March 2014 and from December 2014 to Journal 2015, or in autumn and winter, the observation rate ranged from 12.5% to 100% for each observation day (with an average of 60%) (Table II, Fig. 2). No significant differences in distribution were found among the different observation times in a day (Table II, $P > 0.05$). In September 2013 and from April 2014 to September 2014, or in spring and summer, no porpoise was spotted.

Table II.- Occurrences of the Yangtze finless porpoise at the confluence of the Yangtze and Wanhe Rivers at different times.

Season	Date	Weather	Observation time/day								$Cum_{frequency}$/ day
			08:00-09:00	09:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	
Autumn	2013/9/15	Cloudy	0	0	0	0	0	0	0	0	0
	2013/9/28	Cloudy	0	0	0	0	0	0	0	0	0
	2013/10/13	Sunny	-	-	-	-	-	-	-	-	129
	2013/10/20	Sunny	-	-	-	-	-	-	-	-	104
	2013/10/27	Sunny	-	-	-	-	-	-	-	-	180
	2013/11/2	Cloudy	0	55	0	0	0	0	0	0	55
	2013/11/16	Sunny	0	45	26	11	35	28	47	37	229
Winter	2013/12/15	Sunny	31	74	84	45	53	73	9	0	356
	2013/12/23	Sunny	40	0	7	4	21	10	0	0	82
	2013/12/30	Sunny	67	17	0	62	35	0	24	0	203
	2014/1/5	Sunny	31	0	47	41	92	2	0	37	250
	2014/1/16	Sunny	23	0	0	48	0	51	0	4	126
	2014/2/22	Cloudy	12	0	0	73	42	0	40	71	238
Spring	2014/3/10	Cloudy	127	37	141	119	71	167	97	44	803
	2014/3/23	Cloudy	0	26	42	19	0	0	0	0	87
	2014/3/31	Cloudy	0	0	0	0	0	0	0	0	0
	2014/4/9	Sunny	0	0	0	0	0	0	0	0	0
	2014/4/28	Sunny	0	0	0	0	0	0	0	0	0
	2014/5/15	Sunny	0	0	0	0	0	0	0	0	0
	2014/5/31	Cloudy	0	0	0	0	0	0	0	0	0
Summer	2014/6/22	Sunny	0	0	0	0	0	0	0	0	0
	2014/7/7	Sunny	0	0	0	0	0	0	0	0	0
	2014/7/27	Cloudy	0	0	0	0	0	0	0	0	0
	2014/8/6	Sunny	0	0	0	0	0	0	0	0	0
Autumn	2014/9/27	Cloudy	0	0	0	0	0	0	0	0	0
Winter	2014/12/1	Sunny	37	0	2	137	57	36	79	83	431
	2014/12/21	Sunny	0	35	0	0	0	0	0	0	35
	2015/1/18	Sunny	0	9	5	8	0	0	0	0	22
	2015/1/19	Sunny	0	12	23	0	6	11	8	5	65

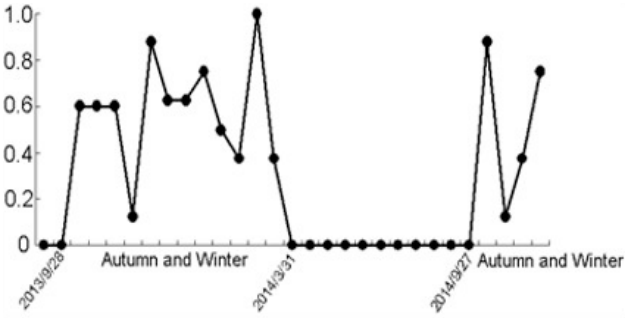

Fig. 2. Observation rate of the Yangtze finless porpoise at the confluence of Yangtze and Wanhe Rivers in different seasons.

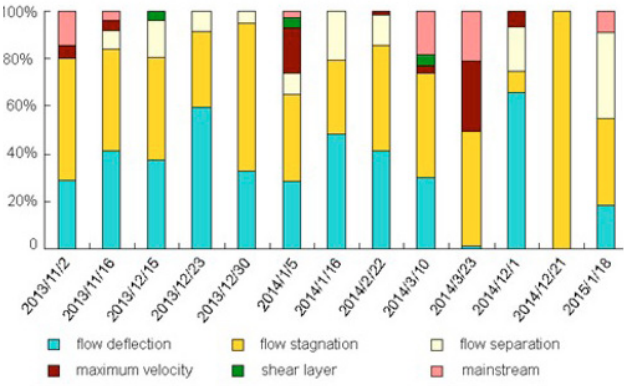

Fig. 3. Occurrence percentage of the Yangtze finless porpoise in the six different hydrological zones.

The average occurrence rate of porpoises in the flow deflection, flow stagnation, flow separation, maximum velocity, shear layer, and mainstream was 32.5%, 44.0%, 10.2%, 5.2%, 1.0% and 5.2%, respectively (Fig. 3). No significant difference in the occurrence rate was found between the flow deflection and flow stagnation zones. However, significantly more porpoises were observed in these two zones than in the other four zones. No significantly difference in distribution was observed between the flow separation, maximum velocity, shear layer and mainstream, with the exception of the difference between the flow separation zone and shear layer, which was significant (Table III).

DISCUSSION

Zhang *et al*. (2015) reported that the Yangtze finless porpoise appeared at the confluence of the Yangtze and Wanhe rivers only in autumn and winter in studies on the effect of the fish community on the occurrence of the Yangtze finless porpoise. In this study, detailed analyses were conducted on the spatial and temporal distribution dynamics of the Yangtze finless porpoise in autumn and winter. We found that in this season, porpoises appeared quiet often at this confluence. In the eight recording time periods per observation day, porpoises were spotted 60% of the time (on an average), and porpoise could be observed nearly in each observation day with an average size of four. Moreover, on 4 of 14 observation days with detailed records, porpoises was spotted in seven observation-time periods. That means, on 29% of the observation days, the porpoise was observed at this confluence nearly entire day.

Table III.- Significant differences between six different hydrological zones.

	1	2	3	4	5
2	-				
3	*	**			
4	**	***	-		
5	***	***	*	-	
6	**	***	-	-	-

1, flow deflection; 2, flow stagnation; 3, flow separation; 4, maximum velocity; 5, shear layer; 6, mainstream; *, P<0.05; **, P< 0.01; ***, P< 0.001.

The distribution of aquatic animals is considerately impacted by the hydrological characteristics of a habitat. Researches have shown that cetaceans in running-water environments prefer countercurrent pools, where they find refuge from downstream currents and where much of the biological productivity is concentrated (Smith and Reeves, 2012). In the present study, statistical analyses of the distribution pattern of *N. a. asiaeorientalis* in the six different hydrological zones of the confluence showed that the porpoise spent significantly more time in the flow deflection and flow stagnation zones than in the other four zones. This is probably related to the hydrodynamics of these zones, as the current in the flow separation, maximum velocity and shear layer zones is highly disordered and turbulent (Wang, 2007). From the findings, it seems that the flow stagnation zone may be the porpoises' favorite zone. The flow stagnation region is where the flow velocity is small or non-existent (Wang, 2007). Porpoises probably prefer this zone both because of the high concentration of the prey species and the more stable water environment. These findings are similar to those of Yu *et al*. (2005), who argued that the Yangtze finless porpoise preferred slow current areas. The flow deflection zone is also the porpoises' favorite habitat. Information from fishermen shows that before the year 2001, the porpoise seasonally inhabited the Wanhe River several kilometers from the estuary. However, in recent years, the porpoises have

hardly been observed in the Wanhe River. In the present study, we found that the porpoises were distributed in the Wanhe River no more than several hundred meters from the estuary. The disappearance of the porpoise from the Wanhe River may be caused by lots of reasons, including increasing negative impacts from human activities.

At the confluence of the Yangtloö-p99ze and Wanhe Rivers, according to our observations, porpoises usually hovered and showed behaviors of prey. Zhang *et al*. (2015) found that at this confluence, fish resource were significant higher in autumn and winter than in spring and summer. Therefore, we inferred that this confluence is porpoise's feeding habitat. Unfortunately, fishing and shipping were also dense here. Once on an observation day, nearly forty illegal fishing nets (trap net) were counted by us around the estuary and the flow deflection area near the estuary. The estuary was also dredged regularly, and 500-tonne ships can pass through the estuaru at all seasons. Habitat loss and fragmentation causing by human activities is one of the main factors that lead to sharp decline of the Yangtze finless porpoise population (Wang, 2009). Therefore, reducing the intensity of fishing and shipping around this confluence is probably the most effective measure to conserve porpoises and their feeding habitat. In the end, this study only explored the spatial and temporal distribution dynamics of the Yangtze finless porpoise at the confluence of the Yangtze and Wanhe Rivers. This kind of distribution dynamics may be regional specificity. More studies should be conducted to get understanding how porpoises use confluences commonly.

CONCLUSION

Confluence is a favorite habitat of river dolphins (Hastie *et al*., 2004; Kreb and Budiono, 2005). Our study found that confluences, as well as slow current water areas are all important habitat patches of the Yangtze finless porpise. Habitat loss and fragmentation is one main factor for the Yangtze finless porpoise population decline (Wang, 2009). This study proposes that measures should be required to conserve important habitats such as the confluence area, the slow current and shallow water areas. In addition, travelling among habitat patches is a common behaviour of the Yangtze finless porpoise as revealed by Zhang *et al*. (2013), which may increase their chance of finding prey or mate. Therefore, measures should also be required to conserve the connection of different habitats.

ACKNOWLEDGEMENTS

We are grateful to undergraduates Feng Tao and Jialei Li for their helps in field work. We also thank our colleague Zhigang Mei for his help in analyzing the data. This work was supported by the Ocean Park Conservation Foundation of Hong Kong (AW05_134, AW05_1617) and the Doctoral Research Foundation of Anqing Normal University, China (150002010).

Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Best, J.L., 1987. Flow dynamics at river channel confluences: implications for sediment transport and bed morphology. *Recent Develop. Fluvial Sedimentol.,* **39**: 27-35. https://doi.org/10.2110/pec.87.39.0027

Best, J.L. and Roy, A.G., 1991. Mixing-layer distortion at the confluence of channels of different depth. *Nature,* **350**: 411-413. https://doi.org/10.1038/350411a0

Braulik, G.T., Arshad, M., Noureen, U. and Northridge, S.P., 2014. Habitat Fragmentation and Species Extirpation in Freshwater Ecosystems; Causes of Range Decline of the Indus River Dolphin (*Platanista gangetica minor*). *PLoS One,* **9**: e101657. https://doi.org/10.1371/journal.pone.0101657

Braulik, G.T., Reichert, A.P., Ehsan, T., Khan, S., Northridge, S.P., Alexander, J.S. and Garstang, R., 2012. Habitat use by a freshwater dolphin in the low-water season. *Aquat. Conserv.,* **22**: 533-546. https://doi.org/10.1002/aqc.2246

Davis, R.W., Ortega-Ortiz, J.G., Ribic, C.A., Evans, W.E., Biggs, D.C., Ressler, P.H., Cady, R.B., Leben, R.R., Mullin, K.D. and Würsig, B., 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. *Deep Sea Res. Pt. I,* **49**: 121-142. https://doi.org/10.1016/S0967-0637(01)00035-8

De Serres, B., Roy, A.G., Biron, P.M. and Best, J.L., 1999. Three-dimensional structure of flow at a confluence of river channels with discordant beds. *Geomorphology,* **26**: 313-335. https://doi.org/10.1016/S0169-555X(98)00064-6

Dong, S.Y., 2009. *Studies on distribution and movement pattern of Yangtze finless porpoise in Hukou area by acoustic data loggers*. Master Dissertation, University of Chinese Academy of Sciences, China.

Gao, A. and Zhou, K., 1995. Geographical variation of external measurements and three subspecies of *Neophocaena phocaenoides* in Chinese waters. *Acta Theriol. Sin.,* **15**: 81-92.

Hastie, G.D., Wilson, B., Wilson, L., Parsons, K. and

Thompson, P., 2004. Functional mechanisms underlying cetacean distribution patterns: Hotspots for bottlenose dolphins are linked to foraging. *Mar. Biol.,* **144**: 397-403. https://doi.org/10.1007/s00227-003-1195-4

Jefferson, T.A. and Wang, J.Y., 2011. Revision of the taxonomy of finless porpoises (genus *Neophocaena*): The existence of two species. *J. Mar. Anim. Ecol.,* **4**: 3-16.

Kimura, S., Akamatsu, T., Li, S., Dong, L., Wang, K., Wang, D. and Arai, N., 2012. Seasonal changes in the local distribution of Yangtze finless porpoises related to fish presence. *Mar. Mammal. Sci.,* **28**: 308-324. https://doi.org/10.1111/j.1748-7692.2011.00490.x

Kreb, D. and Budiono, 2005. Conservation management of small core areas: Key to survival of a critically Endangered population of Irrawaddy river dolphins *Orcaella brevirostris* in Indonesia. *Oryx,* **39**: 178-188. https://doi.org/10.1017/S0030605305000426

Mei, Z., Huang, S.L., Hao, Y., Turvey, S.T., Gong, W. and Wang, D., 2012. Accelerating population decline of Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*). *Biol. Conserv.,* **153**: 192-200. https://doi.org/10.1016/j.biocon.2012.04.029

Schofield, P.J., 2003. Habitat selection of two gobies (*Microgobius gulosus, Gobiosoma robustum*): influence of structural complexity, competitive interactions, and presence of a predator. *J. exp. Mar. Biol. Ecol.,* **288**: 125-137. https://doi.org/10.1016/S0022-0981(03)00004-2

Smith, B.D. and Reeves, R.R., 2012. River cetaceans and habitat change: Generalist resilience or specialist vulnerability? *J. Mar. Biol.,* **2012**: 1-11. https://doi.org/10.1016/j.jembe.2011.11.027

Wang, D., 2009. Population status, threats and conservation of the Yangtze finless porpoise. *Chinese Sci. Bull.,* **54**: 3473-3484. https://doi.org/10.1007/s11434-009-0522-7

Wang, X.G., 2007. Summary of study on Hydraulic characteristics of channel confluences. *China Rural Water Conserv. Hydrop.,* **10**: 82-86.

Wei, Z., Wang, D., Zhang, X., Zhao, Q., Wang, K. and Kuang, X.A., 2002. Population size, behavior, movement pattern and protection of Yangtze finless porpoise at Balijiang section of the Yangtze River. *Resour. Environ. Yangtze Basin,* **11**: 427-432.

Wu, D., Guo, W. and Liu, Z., 2007. Hydraulic characteristics of water flow at "Y"-shaped junction of river channel with compound cross-section. *Adv. Sci. Technol. Water Resour.,* **27**: 21-23.

Xiao, W. and Zhang, X., 2002. Distribution and population size of Yangtze finless porpoise in Poyang Lake and its branches. *Acta Theriol. Sin.,* **22**: 7-14.

Yu, D., Dong, M., Wang, J. and Zhang, X., 2001. Population status of Yangtze finless porpoise in the Yangtze River section from Hukou to Nanjing. *Acta Theriol. Sin.,* **32**: 330-334.

Yu, D., Wang, J., Yang, G. and Zhang, X., 2005. Primary analysis on habitat selection of Yangtze finless porpoise in Spring in the section between Hukou and Digang. *Acta Theirol. Sin.,* **25**: 302-306.

Zhang, X., Liu, R., Zhao, Q., Zhang, G., Wei, Z., Wang, X. and Yang, J., 1993. The population of finless porpoise in the middle and lower reaches of Yangtze River. *Acta Theriol. Sin.,* **13**: 260-270.

Zhang, X., Xian, Y., Wang, L. and Wang, D., 2013. Behavior and habitat selection of the Yangtze finless porpoise in Dongting Lake, China, and the adjacent waters: Impact of human activity. *Pakistan J. Zool.,* **45**:635-642.

Zhang, X., Yu, D., Wang, H., Wan, A., Chen, M., Tao, F. and Song, Z., 2015. Effects of fish community on occurrences of Yangtze finless porpoise in confluence of the Yangtze and Wanhe Rivers. *Environ. Sci. Pollut. Res.,* **22**: 9524-9533. https://doi.org/10.1007/s11356-015-4102-x