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# Seasonal changes in the local distribution of Yangtze finless porpoises related to fish presence

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## ABSTRACT

The Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) is an endangered freshwater porpoise subspecies unique to the Yangtze River basin. Seasonal variations in local distribution of the animal, as well as fish presence, sand dredging, ship navigation, and bridges were examined as potential factors affecting the occurrence of the animals. Passive acoustic surveys were performed regularly from

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May 2007 to August 2010, near the conjunction of the Yangtze River and Poyang Lake. The distribution of the porpoises was seasonally site-specific. In May and August, the animals were detected more often at river junctions than in the lake, but *vice versa* from November to February. The rate of the porpoise detection was significantly higher in areas of fish presence than in areas of absence. The number of porpoises detected did not differ significantly between the sand dredging operation and the prohibition period (in 2008), although the number of vessels obviously declined in 2008. Ship traffic and bridges also did not appear to affect the presence of porpoises. These results showed the relative importance of the various environmental factors, which is important for conservation of not only Yangtze finless porpoise but also endangered isolated cetaceans.

Key words: bioacoustics, cetacean, odontocete, dolphin, echolocation, prey availability, anthropogenic impact, towed passive acoustic monitoring.

The narrow-ridged finless porpoise (*Neophocaena asiaeorientalis*) is distributed throughout East Asian coastal waters from the South China Sea to Sendai Bay, northern Japan (Wang *et al*. 2008). This porpoise is considered to have a unique subspecies native to the Yangtze River basin, China, Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*), which comprises the only freshwater population of porpoises in the world. In the early 1990s, the population size was estimated at approximately 2,700 individuals (Zhang *et al*. 1993). By 2006, the estimates had decreased to as low as 1,800 over the porpoise's entire distribution range (Zhao *et al*. 2008). Without conservation measures, the animal could soon become extinct, just as the Yangtze River dolphin (baiji, *Lipotes vexillifer*) likely has been driven to extinction directly by human activity (Turvey *et al*. 2007). Immediate and extreme conservation measures are necessary (Wang *et al*. 2006, Turvey *et al*. 2007, Wang 2009).

This subspecies is distributed throughout about 1,700 km of the middle and lower reaches of the Yangtze River, from Yichang to Shanghai, and two connecting lakes, Dongting and Poyang (Zhao *et al*. 2008). Zhao *et al*. (2008) showed that the detection of the porpoise was highest in the middle of the habitat area, which is important for conservation of the species. Different patterns of mtDNA haplotypes among populations in the Yangtze freshwater system suggest that they may have been genetically isolated into two subpopulations (above and below Wuhan, 274 km west of Poyang Lake) subpopulations (Zheng *et al*. 2005). Yang *et al*. (2008) found that the genetic structure of the porpoise populations in the middle and lower reaches of the Yangtze differed significantly when porpoises above and below Poyang Lake were putatively grouped into middle and lower Yangtze populations, respectively. These findings indicate that Yangtze finless porpoises have long been isolated in different river sections, leading to some genetic differentiation among certain local populations and suggesting that local populations in the different river sections should be managed and conserved as separate units.

Accurately describing and understanding the processes that determine the distribution of aquatic species is a fundamental problem in ecology, with important conservation and management implications (Redfern *et al*. 2006). Yangtze finless porpoises can move into some side streams and appended lakes of the Yangtze River system. However, changes in local population densities and seasonal distribution patterns in the main river, tributaries, and appended lakes have not been studied. Molecular biology is not suitable to observe such short-term change in the population. The factors affecting distributional changes also have not yet been elucidated. Anthropogenic effects on this animal, such as heavy ship traffic, bridges, and sand dredging, are also of concern (Wang *et al.* 2006, Wang 2009, Li *et al.* 2010).

Recently, passive acoustic monitoring (PAM) of aquatic mammals has been widely used to observe the presence, movement, and behavior of the target species (reviewed by Mellinger *et al.* 2007). In the wild, PAM can be divided roughly into stationary and towed methods of detection (Mellinger *et al.* 2007). Towed passive acoustic platforms have been developed as simultaneous or alternative methods to visual transects during vessel-based surveys (*e.g.*, Thomas *et al.* 1986, Miller and Tyack 1998, Barlow and Taylor 2005). Acoustic systems often consist of cabled hydrophones, which are towed behind a ship or affixed to a mobile platform to detect echolocating dolphins and porpoises in a large area (*e.g.*, Jefferson *et al.* 2002, Oswald *et al.* 2003, Thode 2004, Barlow and Taylor 2005, Rankin *et al.* 2007). Some studies reported that a combined approach of visual and acoustic observation is the best option (*e.g.*, Jefferson *et al.* 2002) to remove biases of each method. In joint visual-acoustic surveys for Yangtze finless porpoise, the probability of detection of porpoises by acoustic systems was about twice that of visual surveys, possibly due to less aerial activities of this species (Akamatsu *et al.* 2008), which was because of frequent sonar emission of the target animals, 5 s on average (Akamatsu *et al.* 2005*a*). Due to the low visibility of the water (<1 m), it is assumed that the porpoises produce the echolocation signals not only when they are foraging but also navigating. They rarely travel more than 20 m without vocalizing (Akamatsu *et al.* 2005*a*), suggesting that the porpoises do not usually travel far without producing detectable sounds.

In the present study, we used a stereo acoustic event recorder to count the number of animals. The independent sound source direction provides the number of animals present, not just the number of sounds (Kimura *et al.* 2009*a*). Besides the frequent sound production, there is a risk of missing animals even using acoustic detection. The independent monitoring using visual or acoustic methods has already provided the probabilities of detecting or failing to detect animals for both methods for Yangtze finless porpoises (Kimura *et al.* 2009*b*).

Here, we report site preference and seasonal distributions of a local population of Yangtze finless porpoises living in the conjunction area of the middle reaches of the Yangtze River, side streams, and appended Poyang Lake, as monitored by a moving acoustic platform. We also examine factors that may affect the presence of porpoises.

## Materials and Methods

### *Study Area*

We investigated about 36 km of the main stem of the Yangtze River, 22 km of side streams, and 19 km of appended Poyang Lake (Fig. 1). The survey courses were performed in three different directions from the port: downstream on the main river (parts of J2 and J3, and M3–4; 42 km round trip), inside the lake (part of J2 and B, J4, and D; 38 km round trip), and around an island, including upstream on the main river and side streams (parts of J2 and J3, S1–3, J1, and M1–2; 41 km). During round trips on the river and lake, the boat cruised one bank on the outward journey and the other on the return. These data were recorded as two independent data sets, as the detection radius of the recording system was about 300 m (see below), and the river was more than 1 km wide. We examined the number of porpoises detected

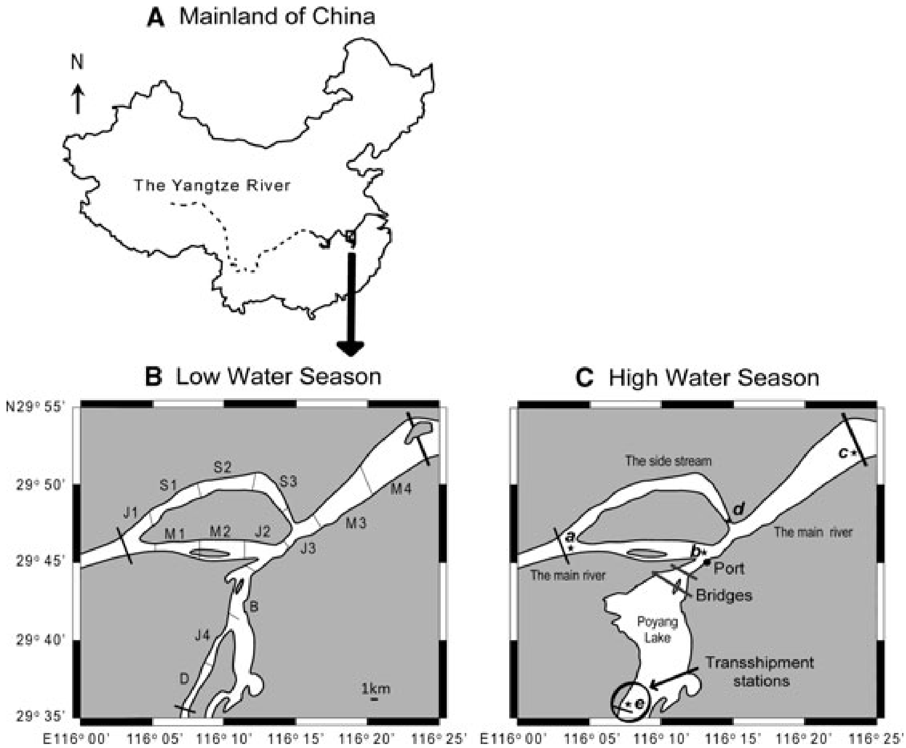


*Figure 1.* Map of the study area. The solid line of the Yangtze River in (A) indicates the historical habitat of Yangtze finless porpoises. Sections comprising 5–7 km were classified into five types, depending on environmental characteristics: J1–4 (junctions), M1–4 (main river), S1–3 (side streams), B (bridges), and D (dredged sand transshipping area) as shown in (B). a–b–c, a–d, b–e in (C) are the middle reaches of the Yangtze River, side stream, and part of appended Poyang Lake, respectively. Lowercase letters, a–e correspond to section numbers in Figure 3. The water level was lowest in February (B), highest in August (C), and at mid-level in May and November. Thick lines at the ends of the J1, M4, and D sections indicate the ends of the survey area.

every 1 km. Sections comprising 5–7 km were classified into five types, depending on environmental characteristics: J1–4 (junctions), M1–4 (main river), S1–3 (side streams), B (bridges), and D (dredged sand transshipping area) as shown in Figure 1B.

In the survey area, the water level was highest in August (summer), lowest in February (winter), and at mid-level in May (spring) and November (autumn). Because of shoals, the water area inside the lake changes greatly. During the low-water season from November to May, the lake is bottlenecked into two narrow channels (Fig. 1B).

### *Possible Factors Affecting Porpoise Presence*

A fish echo sounder was used simultaneously with PAM in four surveys to investigate fish presence as an indicator of porpoise prey. The sand dredging, ship navigation, and bridge were considered anthropogenic factors that might affect the presence of porpoises in the focal area.

Fish presence confirmed by an echo sounder was used as the index of abundance of fish in each section of the focal area. Fish presence was monitored using an echo sounder (Hondex HE-6100; Honda Electronics Co., Ltd., Tokyo, Japan), which recorded echograms of fish, in November 2009 and February, May, and August 2010. The transducer was fixed 50 cm underwater from the middle of the survey ship, which was approximately 50 m ahead of an acoustic device. The echo sounder sensitivity was calibrated using an acoustical measurement tank (10 m wide, 15 m long, 10 m deep) at the National Research Institute of Fisheries Engineering, Fisheries Research Agency, Ibaraki, Japan. A tungsten carbide sphere (9.525 mm diameter) was used for calibration. At a sensitivity setting of 2 on the echo sounder, the detection threshold of the target strength of the echo sounder registered −46.8 dB or more, which corresponds to a 10.8 cm fish, according to the formula of the target strength by Foote (1987). Using a simple echo sounder system, target species and precise body size estimation was not possible. The presence of fish in each section was used as the presence of possible prey resources for the porpoises. The echo sounder had a time variable gain function, so the detected target strength was independent of depth. The frequency of the transmitted pulses from this echo sounder is 200 kHz, which was considered out of audible range of the target porpoise (Popov *et al*. 2005, 2006). It has a very narrow beam width at 7° perpendicular to the bottom of the boat. It was unlikely that the echo sounder beam hit porpoises except when they swam just beneath the boat. In addition, the acoustic device was towed 50 m behind of the echo sounder so there was no contamination of echo sounder signals.

A camera photographed the echogram every 30 s. Echograms were randomly chosen every 10–20 min to categorize fish presence or absence. Because of the distance between echo sounder and acoustic device, fish and porpoise detection could be matched within 1 min, and the porpoise could be expected to be present in the area the echogram examined. Ratios of porpoise detection in areas where fish were present and absent were compared.

Wu *et al*. (2007) reported heavy ship traffic and high turbidity inside the lake due to sand dredging that was conducted at the upper stream of the lake. There are some stations to change ships for dredged sand in the survey area (D area in Fig. 1C), which causes high density of the sand carrying vessels in D, J4, and B area. During 2008, dredging was prohibited in the lake; hence, the number of ships in the lake was also reduced. To examine the effect of prohibition of dredging on the distribution pattern of the animals, we compared the number of the porpoises detected inside Poyang Lake (B, J4, and D areas; Fig. 1B) between 2008 and other years.

Large-ship traffic was the heaviest in the river and lake (M1–4, J1–4, B, and D). No big-ship traffic occurred in the side streams (S1–3). Two bridges, a highway and railway, were located in section B. The bridges were constructed in 2000 and 2007, respectively, and were approximately 3 km from each other. We also examined the possible effects of the ship traffic and bridges on the presence of porpoises.

### *Acoustic Device*

We used an acoustic data logger, A-tag (Marine Micro Technology, Saitama, Japan), for all experiments and monitoring (Akamatsu *et al*. 2005*b*). It consisted of two ultrasonic hydrophones approximately 170 mm apart, with a passive band-pass filter circuit (−3 dB, with a range of 55–235 kHz), a high-gain amplifier (+60 dB), a CPU (PIC18F6620; Microchip, Detroit, MI), flash memory (128 MB), and lithium battery (CR2) housed in a waterproof aluminum case. This system is a pulse event recorder, recording the sound pressure level (SPL) and the time difference in sound arrival between the two hydrophones. As a pulse event recorder, it does not record the waveform of the received sound. The band-pass filter of 55–235 kHz was used to eliminate background noise. This filter received the frequency band of Yangtze finless porpoise sonar signals, which are in the 87–145 kHz range and average $125 \pm 6.92$ kHz (Li *et al*. 2005). Detailed specification of the A-tag is available at http://cse.fra.affrc.go.jp/akamatsu/A-tag/index.html.

### *Acoustic Observation*

The survey boat, with the A-tag trailing 44 m behind, navigated approximately 300 m from the bank, with some course changes due to ship traffic or shoaling banks. To prevent double-counting of animals, the boat speed was kept faster than the swimming speed of finless porpoises, which is about 4.5 km/h with no current (Akamatsu *et al*. 2002). The relative speed of the boat to the ground, as measured by GPS, was 4.5–6 km/h upstream and 10–15 km/h downstream. Although boat speeds relative to the ground differed upstream and downstream, the speed relative to the water was fairly constant and had little effect on the detection of the porpoises, which were counted mainly by tracing click trains (see below).

The survey boat was 12 m long and had a 12 horse power diesel engine at the top deck of the stern and directly rotated the shaft of the screw. Thus, the engine was relatively isolated from the hull and did not directly transmit noise in the water. The 6-mm diameter floating rope used for towing the A-tag rode at a depth of $<1$ m given the speed of the boat. To prevent the A-tag from jumping out of the water, a small weight was added in front of the data logger. A 5 m tail was added to stabilize the position to prevent swaying.

### *Signal Processing*

Before counting the number of animals, we eliminated contamination from background noise using a custom-made program developed by IGOR PRO 6.03 (Wave Metrics, Lake Oswego, OR). The detection threshold level of the data logger was set to 132.5 dB re 1 μPa (peak to peak). Because A-tags differ slightly in sensitivity, we confirmed sensitivity levels *via* a calibration experiment. In off-line analysis the highest threshold level was used to standardize the data set for comparison. Pulses within 1 ms after the direct path pulse were considered possible noise and eliminated (Kimura *et al*. 2010).

### *Separation of Individuals*

Processed data shown in Figure 2 illustrate the SPL, the bearing angle calculated by the time of arrival difference between the two hydrophones, and interclick interval (ICI) of porpoise clicks. As shown in Figure 2, ICIs and SPLs changed smoothly, whereas background or boat noise caused randomly changing patterns in the ICI and sound pressure.

The bearing angle to vocalizing porpoise always changed from positive to negative (see middle of Fig. 2), as the porpoises always passed the vessel from bow to stern because the survey boat was moving faster than the porpoises (see above).

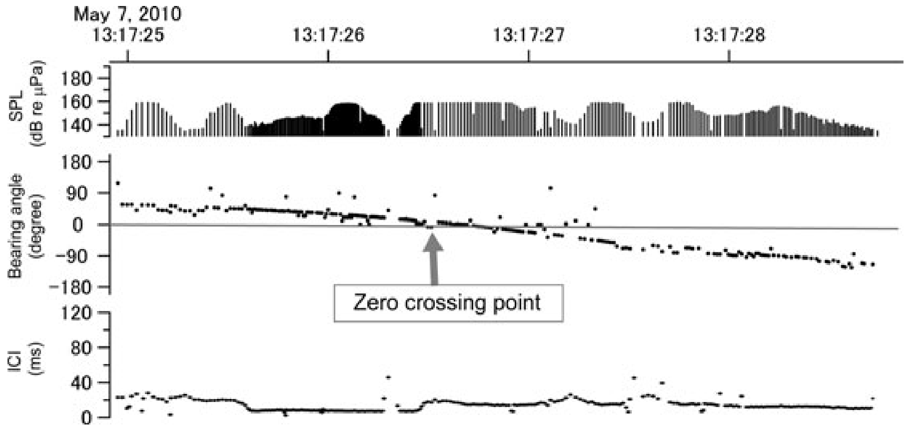


*Figure 2.* An example of echolocation signals from a single porpoise passing the data logger. Vertical axes show the received SPL (dB re 1 μPa), bearing angle (degree), and interclick intervals (ICI; ms). The bearing angle tracks from positive to negative, indicating that an echolocating porpoise passed from bow to stern of the towed A-tag.

### *Assignment of Detection Time of the Porpoise*

The number of animals was counted based on the method of Akamatsu *et al.* (2008). The time of porpoise detection was defined as the zero crossing point of the bearing angle corresponding to the perpendicular line of the survey course, *i.e.*, the closest time of zero crossing point of the independent traces of the sound source (Fig. 2). At this moment, the animal was adjacent to the data logger on a line perpendicular to the cruise line. If sound was detected away from the zero crossing point and the animal was not vocalizing near the zero crossing point, the detection time was defined as when the bearing angle of sonar signal was closest to the zero crossing point. When more than two animals were swimming in synchrony, the sound source directions were similar and could be identified through the double different cyclic changing pattern of the sound pressure and/or ICIs within a single trace. The number of porpoises detected was accrued per kilometer in each section along the survey line using GPS (GPSmap 76S; Garmin, Olathe, KS).

## RESULTS

### *Detection of Finless Porpoise in the Focal Area*

The survey was conducted 12 times from May 2007 to August 2010. The survey effort was not uniform in each area (Fig. 3) because some of the sections were duplicated in two predetermined courses. In addition, weather condition sometimes did not allow completion of the entire section of a course. The average number of the porpoises detected per kilometer varied from 0.53 to 1.26 individuals (Fig. 4). No significant trend showing decreasing porpoise numbers was detected (one-way ANOVA, $P > 0.05$), although the standard deviation was large.

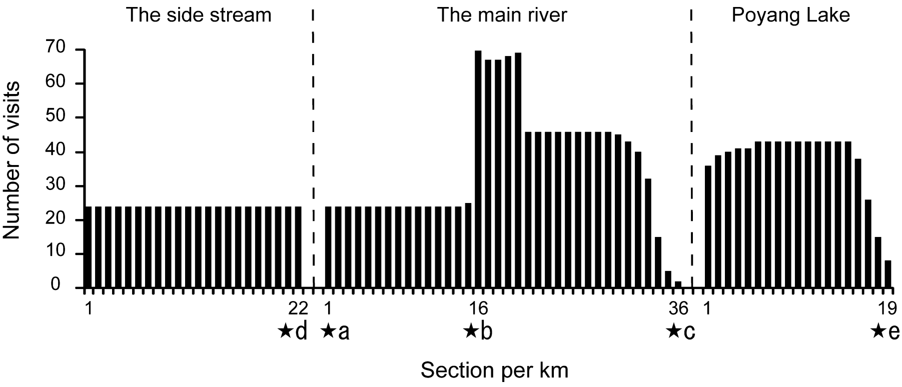


*Figure 3.* Survey effort per kilometer. Starred letters a–e correspond to those in Figure 1(C).

*Site Fidelity and Seasonal Distribution Changes*

Figure 5 shows the detailed sites and numbers of porpoises detected per kilometer in each survey. The largest number of animals, 19 and 18 individuals per kilometer, were detected in area J4 in November 2007 and J2 in August 2008, respectively. Densities in some areas were relatively stable and independent of the season: high in J2 and J3, low in S1 and S2, and mid-level in M1 and M2 (Fig. 6).

The general distribution pattern of this species changed seasonally (Fig. 6). In May, the porpoises were detected in all sections, but tended to aggregate at the junctions of the river (J1–J3 and S3), and few were detected in the lake (B, J4, and D). In August, the distribution tended to be similar to that of May, but the detection of the porpoise in area J1, S1–2, and D was much lower than May. However, in November/December, the porpoises gathered in area M3 and the lake (B, J4, and D), especially in area J4, and showed a very low animal detection in side streams. In February, the animals were relatively dispersed, but still showed high detection of the porpoise in the lake (B, J4, and D). The numbers of the porpoises detected at J1 and S3 were high only in May and at M3, only in November/December.

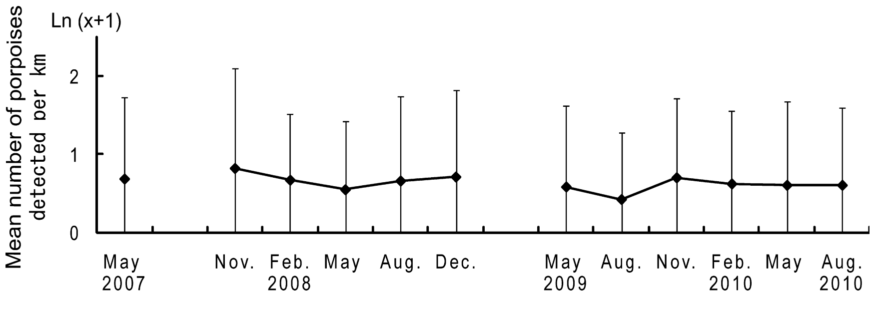


*Figure 4.* Mean number (± SD) of porpoises detected per 1 km of survey line.

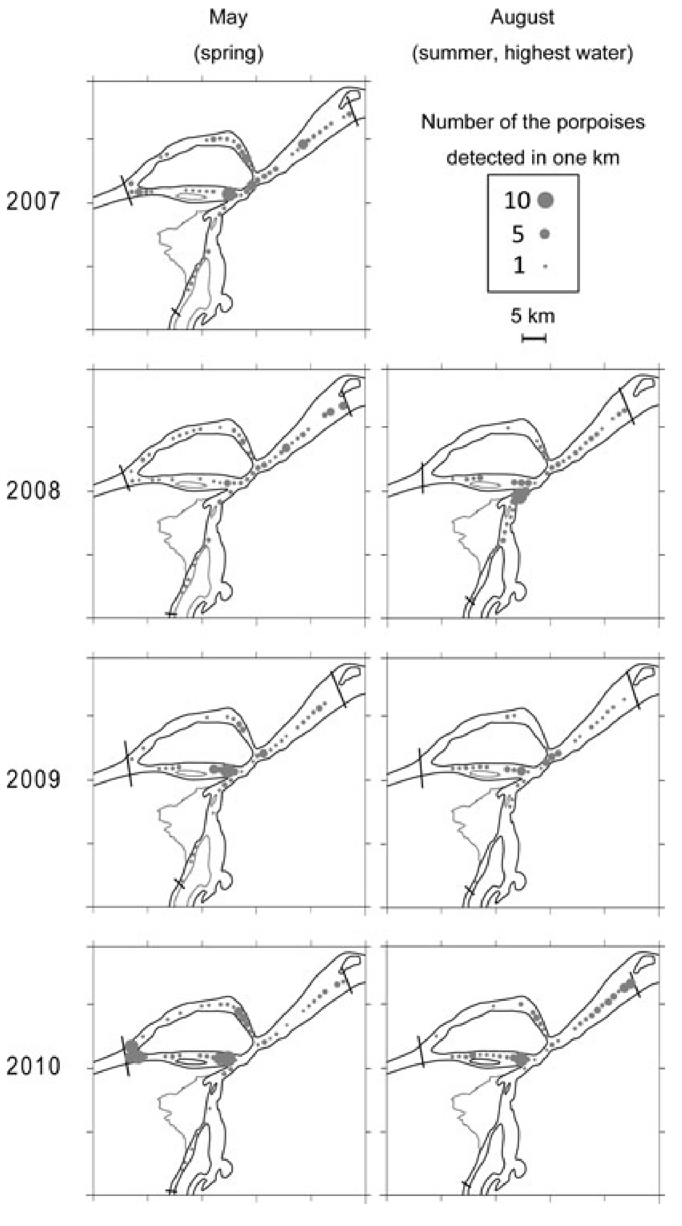


*Figure 5.* Distribution of the porpoises per 1 km of survey line.

*Effect of Fish Presence*

The percentage of the porpoises detected was compared between the area of fish presence and absence (Fig. 7). It was significantly higher in areas where fish were detected in November 2009 and February, May, and August 2010 (chi-squared test, $P < 0.01$).

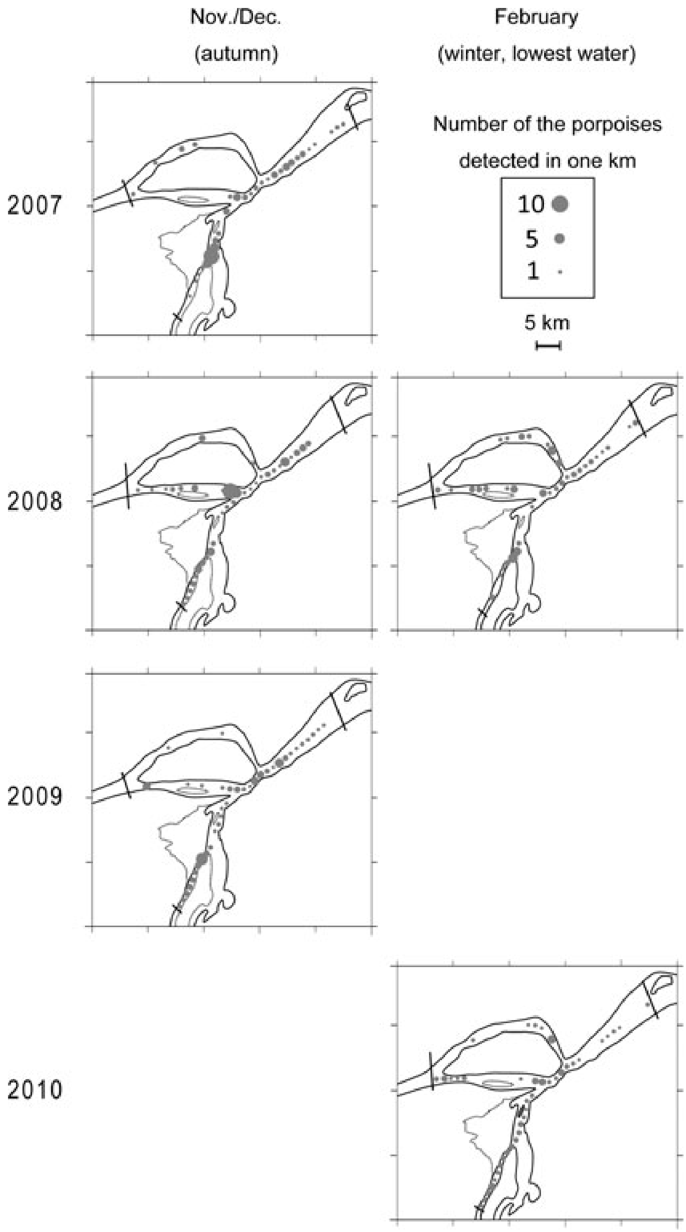


*Figure 5. (Continued)*

*Effect of Ship Traffic and Bridges*

The average number of porpoises detected per kilometer during prohibition (2008) and operation periods (2007, 2009, and 2010) of sand dredging inside the lake (Fig. 8) did not differ significantly at B, J4, or D (three-way ANOVA, $P = 0.875$),

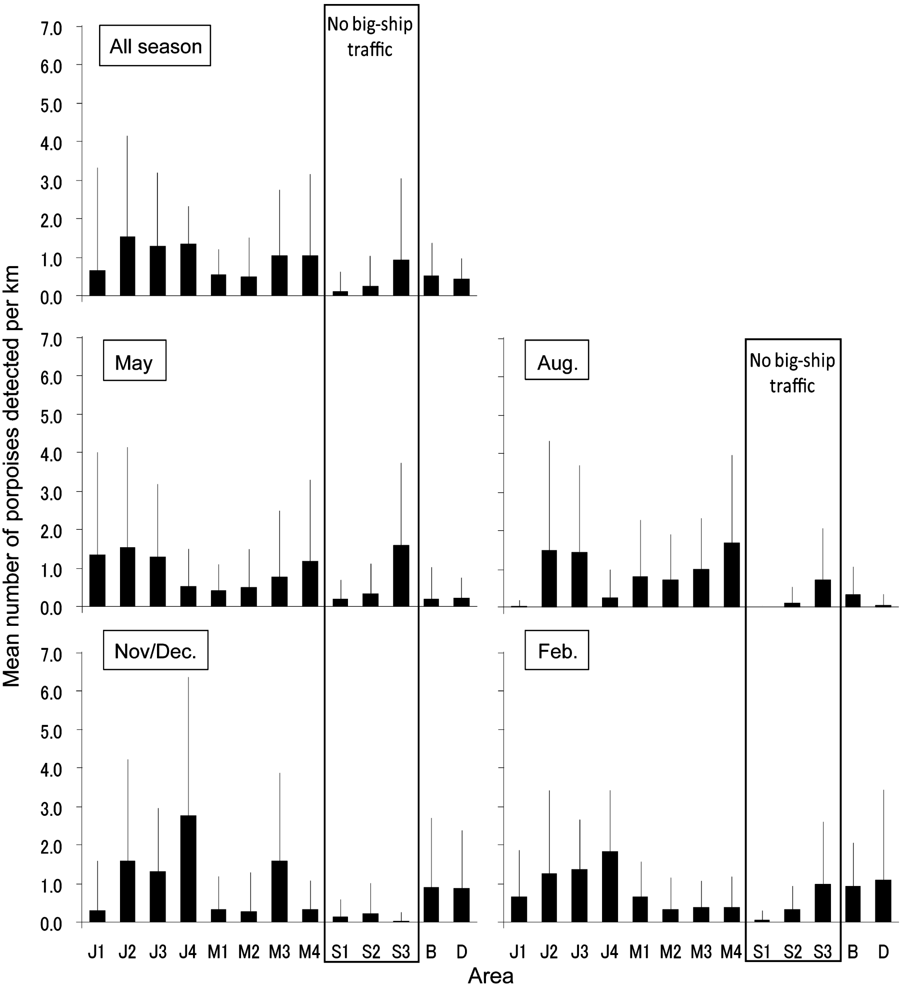


*Figure 6.* Mean number (±SD) of porpoises detected in all areas each seasons. Each area is as assigned in Figure 1(B). Side streams (S1–3) had no big-ship traffic.

although it differed between areas and seasons (three-way ANOVA, $P < 0.05$ and 0.01, respectively). The seasonal pattern corresponded as described above, higher in November and February than in May and August.

Ship traffic was high, especially in area J2, as was the detection of porpoises in these areas. Ship traffic was low in side streams (S1–3), where fewer porpoises were detected than in other areas, as shown in Figure 6 (Mann-Whitney $U$ test, $P < 0.01$). Fewer porpoises were also detected near bridges (B) than in areas J2–4 (Scheffe's test, $P < 0.05$) but showed no difference compared to other areas.

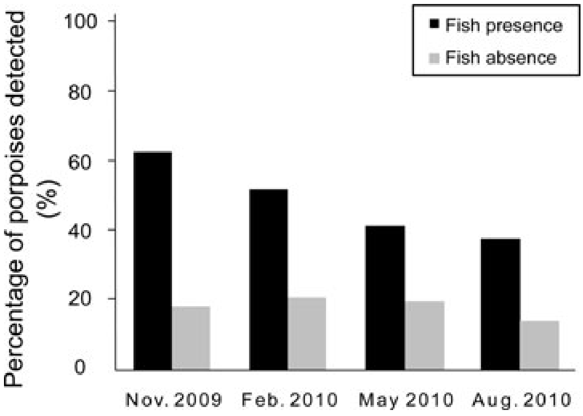


*Figure 7.* Comparison of the percentage of porpoises detected between areas of fish presence and absence ($n = 95, 94, 94$, and 74 in November 2009 and February, May, and August 2010, respectively).

## Discussion

### *Detection of Finless Porpoise in the Focal Area*

No reduction in the average number of porpoises detected per kilometer of survey was observed over the survey period (Fig. 4), although Zhao *et al*. (2008) reported that the size of the entire population of Yangtze finless porpoises declined 5% annually from the 1990s to 2006. A 3 yr period may not be sufficient to detect a population size trend. The detection rates per kilometer were high as shown in Figure 4. This corresponded to a previous study that indicated a high density of the porpoises in the investigated area (Wei *et al*. 2003), suggesting that this area continues to contain the highest density of this subspecies.

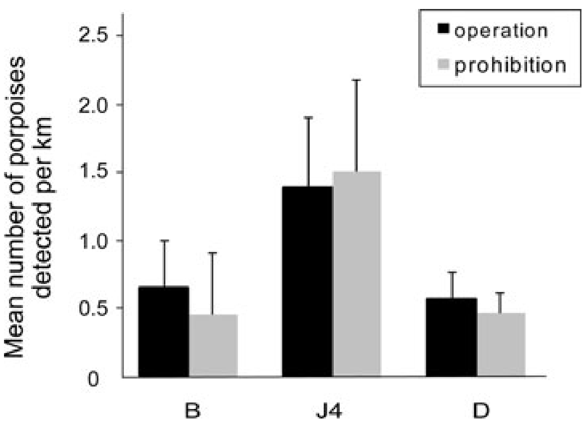


*Figure 8.* Comparison of the mean number of the porpoises detected per kilometer in three sections between sand dredging operation (2007, 2009, and 2010) and prohibition (2008) periods in Poyang Lake. The number of porpoises detected did not have significant differences at three areas.

The porpoises can exit or enter this area from three directions (upstream or downstream on the Yangtze River, and Poyang Lake), although a mtDNA genetic study has been interpreted to suggest that Yangtze finless porpoises do not move far (Zheng *et al*. 2005). If the whole population is undergoing the reduction suggested by Zhao *et al*. (2008), the porpoises might flow into a focal area. Marubini *et al*. (2009) observed large interannual fluctuations of harbor porpoises off northwest Scotland that reflected movements in and out of the region, as the study area represented only a small part of the effective range of the observed porpoises. We should continue to monitor density changes of this local population. Despite these limitations, our data enabled us to assess the effect of factors related to the local distribution of the porpoises.

### *Site Fidelity and Seasonal Distribution Changes*

Poyang Lake is much wider in summer (July–September) than in other seasons, although the size of the river, including side streams, changes little. The low density of animals in the lake in August could have been caused by the increased water volume and area. However, the average density of the porpoises within the entire surveyed area showed little difference between high- and low-water seasons (Fig. 4).

Our study showed that Yangtze finless porpoises are distributed throughout the survey area but have site preferences and seasonal distribution patterns (Fig. 5, 6), which can be divided roughly into two periods: May–August (spring/summer; high-water season) and November–February (autumn/winter; low-water season). This pattern does not correspond to the winter/spring, summer/autumn distribution pattern of the coastal finless porpoise in Hong Kong (Jefferson *et al*. 2002). During May–August, fewer porpoises were detected in the lake, in contrast to the larger number in November–February (Fig. 5, 6). Instead, in May–August, the porpoises aggregated at the junctions of the main river (Fig. 5, 6).

### *Effect of Fish Presence*

Although the distribution pattern of the porpoises changed seasonally, the percentage of porpoises present was significantly higher in areas where fish were present in all seasons (Fig. 7). Spatial distribution of prey is considered to be important for conservation of porpoises. Because of its small size, this porpoise cannot carry large energy stores (Koopman 1998). Lockyer (2007) suggested that fasting periods exceeding as short as 3 d could affect the body condition of harbor porpoises. The distribution of this species is strongly tied to variation in the primary and secondary productivity that provides the basis for apex consumers (Lockyer 2007).

Akamatsu *et al*. (2010) reported that the porpoises produce sonar sound more frequently during possible foraging dives. The number of clicks per second observed by biologging methods were 2.7 and 6.6 for upright (nonforaging) and rolling (foraging) dives, respectively. This means the several acoustic signals would be available during short time even during nonforaging dives. Duration of acoustic encounters in the present study was a couple of minutes depending on the source level, ship speed, and detection range of A-tag, which seems enough to detect one of the signals of the porpoises even though the interval of sound production doubled.

Three major limitations of the echo sounder data should be addressed. First, we could not identify fish species, which is a limitation of conventional echo sounders.

Second, fish smaller than 10.8 cm and shrimp were undetectable, although target strength depends considerably on fish shape, orientation, and even more on the presence of a swim bladder. The finless porpoise is an opportunistic eater, and feeds on various fish species and crustaceans (Barros *et al*. 2002, Park *et al*. 2005, Shirakihara *et al*. 2008). Nonetheless, the data set can be treated as an index of prey availability for the porpoise. Differences in the availability and selectivity of prey likely resulted in geographical variations in diet (Shirakihara *et al*. 2008). Third, we did not examine fish swimming on the surface or shallower than 50 cm. However, Yangtze finless porpoises do catch prey near the maximum depth of each dive in the middle or lower level of the water column (Akamatsu *et al*. 2002).

### *Effects of Ship Traffic and Bridges*

Many porpoises were observed within the ship channel (Fig. 5, 6; sections M1–4, J1–4, B, and D), but few were detected in the side stream, especially S1 and S2, where less ship navigation occurred. Turvey *et al*. (2007) counted at least one large shipping vessel per 100 m section of river, and fishing boats were found every 1–2 km in the main stem of the Yangtze River (Yichang to Shanghai, the main historical river habitat of this species). Wu *et al*. (2007) also reported heavy ship traffic in the lake. During the low-water season, ship density increases in the lake. The porpoise density was also high in the lake in November and February (Fig. 5, 6). In addition, the porpoise detection did not differ significantly between sand dredging and nonsand dredging periods (Fig. 8). We thus cannot conclude that the presence of ships affects the presence of the porpoises, although the lack of a significant difference does not necessarily mean that there is no effect. A similar conclusion holds for bridges, which appeared to have no effect on the presence of this species, as the number of detections did not differ between bridges and other areas, except J1–3.

Shirakihara *et al*. (2007) suggested that bridge construction, sand dredging, and heavy vessel traffic could have resulted in the low density of finless porpoises east of the Inland Sea of Japan. Habitat deterioration may cause the porpoises to move to poor habitat areas (Shirakihara *et al*. 2007). The recovery of species composition after dredging requires more than a few years (Byrnes *et al*. 2004). Although we found a significant correlation between porpoises and fish presence and a minor effect of bridges and sand dredging, the significance of theses anthropogenic impacts should be monitored long term (Nairn *et al*. 2004). Fish presence could be affected indirectly by the construction and ship traffic. The long-term indirect factors were not considered in this paper. Moreover, the river system is more nearly one- or two-dimensional than the ocean. The porpoises are not able to travel transversely for a long distance in the river (Zheng *et al*. 2005). This means that the animals do not have sufficient space to avoid disturbances unlike in the three-dimensional open ocean.

### *Conclusion*

Acoustic towing surveys were applied to the local population of Yangtze finless porpoise and showed seasonal change of distribution. Frequent sonar signal emission of the target porpoise (Akamatsu *et al*. 2005*a*) and the detection performance of the acoustic system (Akamatsu *et al*. 2008, Kimura *et al*. 2009*b*) should be confirmed before application of the acoustic system. Possible factors that may affect their distribution were examined. The finless porpoises detected are related to fish abundance, but not to the bridge and ship traffic. Our findings have an important conservation implication not only for Yangtze finless porpoise but also endangered isolated cetaceans.

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