

## Impact of Hardened Riverbanks on Habitat Use by the Yangtze Finless Porpoise (Post-Print)

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### Abstract

The Yangtze finless porpoise primarily inhabits nearshore shallow waters and prefers sandy-mud riverbanks. However, in the main stream of the Yangtze River, many natural riverbanks have been hardened, and the impact of riverbank hardening on the distribution and habitat use of the Yangtze finless porpoise remains poorly understood. From March 2016 to January 2017, 12 surveys were conducted on the population and distribution of finless porpoises in two natural river sections of the Yangtze River main stream, and relevant data on the bank types of these two sections were collected to analyze the impact of hardened riverbanks on porpoise habitat use. A total of 215 porpoise sightings were recorded across the 12 surveys, with an average of  $(17.92 \pm 7.09)$  sightings per survey. Hardened riverbanks accounted for approximately 59% of the total shoreline length in the study area. Analysis revealed that only about 13.9% of porpoises were distributed in waters adjacent to hardened riverbanks, while 86.1% were found in waters adjacent to natural riverbanks. The number of porpoises per unit riverbank length was significantly negatively correlated with the proportion of hardened riverbank length in that section ( $r = -0.639$ ,  $P < 0.01$ ). In natural riverbank areas, 31.8% of porpoises were distributed within 50 m of the shore, whereas in hardened riverbank areas, only 2 individuals were observed within the 50 m nearshore zone. This indicates that hardened riverbanks have a significant impact on the nearshore distribution of finless porpoises. The surveys also found that no porpoises were detected in the approximately 10 km river section through the urban construction belt of Anqing City across all 12 surveys, suggesting that urban construction belts may have severely impacted porpoise habitat. The proportion of hardened riverbanks in the Yangtze River main stream is very high. The study results suggest this may lead to accelerated habitat loss and fragmentation for Yangtze finless porpoises. This factor must be carefully considered when developing conservation measures for the species, and corresponding habitat protection and restoration plans should be proposed

accordingly.

## Full Text

# Effects of Artificial Riverbanks on Distribution of the Yangtze Finless Porpoise in the Anqing Section of the Yangtze River Main Stem

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## Abstract

The critically endangered Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) inhabits near-shore shallow waters and particularly prefers areas with natural muddy or sandy riverbanks. However, a considerable stretch of the natural riverbank along the Yangtze main stem has been replaced by artificial riverbanks since the 1990s, such as rocky embankments and dock structures. While artificial riverbanks appear to cause destructive effects on the ecological environment of the Yangtze River, their impacts on the Yangtze finless porpoise remain largely unknown. This study conducted twelve consecutive surveys in two natural reaches of the Yangtze River (~57 km) from March 2016 to January 2017, recording abundance and distribution patterns of the Yangtze finless porpoise and documenting riverbank characteristics. A total of 215 porpoises were sighted during the twelve surveys, with 9–32 individuals observed per survey. The average number of porpoises was  $17.92 \pm 7.09$  individuals per survey. No significant difference was found in porpoise numbers across different seasons ( $P > 0.05$ ). Artificial riverbanks accounted for approximately 13.9% of the total shoreline length in the study area. Only 13.9% of observed porpoises were distributed in waters adjacent to artificial riverbanks, while 86.1% were found in natural riverbank waters. The number of porpoises per unit riverbank length showed a significant negative correlation with the proportion of artificial riverbank length in that segment ( $r = -0.639$ ,  $P < 0.01$ ). In natural riverbank areas, 31.8% of porpoises were sighted within 50 m of the shore, whereas in artificial riverbank areas, only two porpoises were sighted within 50 m of the shore. These findings suggest that artificial riverbanks have caused habitat loss and fragmentation for the Yangtze finless porpoise. The study also found that during multiple surveys, no porpoises were observed in the approximately 10 km urban construction belt of Anqing City. This factor should be carefully

considered when developing conservation measures for the Yangtze finless porpoise, and corresponding habitat protection and restoration strategies should be proposed accordingly.

**Keywords:** *Neophocaena asiaeorientalis asiaeorientalis*; habitat selection; artificial riverbank; natural riverbank

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## Introduction

Species occupying the top of ecosystem food chains and requiring large habitats are particularly sensitive to habitat destruction, which can directly alter food web structure and lead to extinction. Freshwater cetaceans, as apex predators in river ecosystems, are among the first species to disappear during habitat fragmentation. The functional extinction of the Yangtze River dolphin (*Lipotes vexillifer*), the dramatic decline of the Indus River dolphin (*Platanista gangetica minor*), and the population collapse of the Irrawaddy dolphin (*Orcaella brevirostris*) all represent consequences of direct habitat destruction by human economic activities.

The Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) is endemic to the middle and lower reaches of the Yangtze River main stem and the connected Poyang and Dongting lakes. The 2012 survey estimated that only about 500 individuals remained in the Yangtze main stem, with the population declining at an annual rate of 13.7%. As the population continues to decline, its distribution in the Yangtze main stem has become increasingly fragmented, with patchy, discontinuous distribution from Yichang to Shanghai. The porpoise exhibits strong habitat selectivity, preferring near-shore waters within 300 m of natural muddy or sandy banks, particularly in areas with abundant aquatic resources, gentle riverbed slopes, silty substrates, and minimal human disturbance, such as river confluences and sandbank vicinities.

Since the 1990s, extensive natural riverbanks in the Yangtze main stem have been hardened with riprap or concrete for navigation channel regulation, port construction, and flood control. The impacts of this riverbank hardening on porpoise distribution and habitat use remain unclear. The Anqing Yangtze Finless Porpoise Nature Reserve, extending from Hukou to Lanjiangji in Zongyang County (approximately 150 km), represents one of the most densely populated porpoise habitats in the Yangtze main stem, featuring diverse natural habitats including tributary mouths and lake connections. However, natural riverbanks are disappearing annually within the reserve. This study selected the Guanzhou and Anqing river reaches within the reserve to investigate porpoise abundance and distribution across different water levels, combined with data on artificial riverbanks, to examine the relationship between riverbank type and porpoise distribution patterns and assess the impacts of riverbank hardening on porpoise habitat use.

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## 1. Study Area and Time

This study was conducted in two natural reaches within the Anqing Yangtze Finless Porpoise Nature Reserve: the Guanzhou reach and the Anqing reach, covering a total length of 57 km that includes both buffer and experimental zones. Twelve visual surveys were conducted across different months in 2016. Due to hydrological variations affecting porpoise distribution, surveys were categorized into three water level periods: low water level (March, September), medium water level (June, July), and high water level (November, December, January), based on seasonal water level fluctuations in the Yangtze River.

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## 2. Methods

**2.1 Survey Platform and Observation Protocol** Previous studies have shown that approximately 80% of Yangtze finless porpoises inhabit near-shore waters within 300 m of the bank. This study employed small fishing boats as visual observation platforms to survey porpoise distribution along both riverbanks and sandbank shores within the 300 m near-shore zone, a method proven effective for characterizing porpoise distribution patterns and widely used in previous research.

For each survey, two small fishing boats were chartered to simultaneously navigate along the north and south banks or sandbank shores. Researchers conducted observations primarily with naked eyes, supplemented by binoculars (Fujinon 7×50), to monitor porpoises within 300 m of the shore. Given the porpoise's average swimming speed of 4.5 km/h, boat speed was controlled at 10 km/h to avoid duplicate records. Each boat carried a survey team of four members: two primary observers (PO), one recorder, and one resting observer. The primary observers monitored 150 m on either side of the boat's axis, with observation angles of  $-10^{\circ}$  to  $10^{\circ}$ , while the recorder documented sightings. Observers rotated positions every 1.5 hours, with 0.5-hour rest periods to maintain alertness. Surveys were conducted in windless or light-wind conditions during sunny, cloudy, or light rain days to ensure optimal observation distance and efficiency. To minimize inter-survey variability, the same vessels and observers were used across all surveys, with a one-day training session conducted before each survey to standardize observation and data recording protocols.

**2.2 Data Recording and Analysis** A handheld GPS was used to record survey tracks and porpoise sighting coordinates. Following methods employed in the 2006 Yangtze cetacean survey, detailed information was recorded for each sighting, including group size and habitat characteristics. Mother-calf pairs were identified based on behavioral cues: calves are smaller, positioned above the

mother's flank, and exhibit brief, nearly vertical surfacing behavior compared to adults' more leisurely breathing.

Artificial riverbank types and their start/end points were recorded during surveys. The lengths of artificial and natural riverbanks along survey tracks were measured using ArcGIS 10.0 distance tools. The relationship between riverbank type proportions and porpoise distribution patterns was analyzed using SPSS 19.0 (SPSS Inc., Chicago, IL, USA).

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### 3. Results

**3.1 Porpoise Abundance** A total of 215 porpoises were observed across all surveys, with 9-32 individuals per survey (Table 1). The average number per survey was  $17.92 \pm 7.09$  individuals. No significant difference was found in porpoise numbers across water level periods (One-Way ANOVA,  $F = 0.314$ ,  $P > 0.05$ ). Low water level surveys recorded 62 porpoises ( $15.5 \pm 3.87$  per survey), medium water level recorded 94 porpoises ( $18.7 \pm 11.24$  per survey), and high water level recorded 59 porpoises ( $19.4 \pm 7.40$  per survey).

**3.2 Group Size** The cumulative observed group sizes ranged from solitary individuals to large aggregations. Groups of 1-2 individuals accounted for 59.1% of sightings, while groups of 5 or more accounted for 6.9%. During high and low water periods, groups of 1-2 individuals comprised 78.6% and 78.8% of sightings respectively, while groups of 3-4 individuals accounted for 18.6% and 5-7 individual groups represented 7.4%. The proportion of large groups (5 individuals) was significantly lower during medium water level compared to high and low water periods. The maximum group size observed in artificial riverbank areas was 3 individuals, while natural riverbank areas supported larger aggregations.

[Figure 1: see original paper]

**3.3 Distribution Patterns** A total of 34 mother-calf pairs were observed across all surveys, with a maximum of 6 pairs in a single survey (average  $2.86 \pm 1.069$ ). Mother-calf pair sightings were significantly higher in spring-summer than in autumn-winter (One-Way ANOVA,  $F = 12.78$ ,  $P < 0.01$ ), with  $2.3 \pm 1.26$  pairs recorded in spring-summer versus  $0.8 \pm 0.837$  pairs in autumn-winter.

The cumulative distribution of porpoise sightings revealed that waters near the E' mao Sandbank head and the southern bank were high-density areas. The 10 km urban construction belt of Anqing City showed no porpoise sightings across all surveys. Porpoises exhibited near-shore distribution patterns in both natural and artificial riverbank areas, with 84.9% of all sightings occurring within 300 m of the bank. Specifically, 31.8% of porpoises in natural riverbank areas were

sighted within 50 m of shore, compared to only two individuals (representing 13.4% of artificial bank sightings) within 50 m of artificial banks.

[Figure 2: see original paper] [Figure 3: see original paper]

**3.4 Relationship Between Artificial Riverbanks and Porpoise Distribution** Artificial riverbanks in the Guanzhou and Anqing reaches totaled 71.3 km, accounting for 13.9% of the total shoreline length. These included riprap embankments, mortared precast blocks, urban floodwalls, and dense dock areas. Porpoises observed in artificial riverbank waters represented 13.9% of total sightings (9.6% during medium water, 19.6% during low water), while 86.1% of porpoises were found in natural riverbank waters (91.4% during medium water, 80.4% during low water). Correlation analysis revealed a significant negative relationship between the number of porpoises per unit riverbank length (3 km segments) and the proportion of artificial riverbank ( $r = -0.639$ ,  $P < 0.01$ ).

[Figure 4: see original paper]

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#### 4. Discussion

The Anqing Yangtze Finless Porpoise Nature Reserve hosts the highest porpoise density in the Yangtze main stem. This study found no significant seasonal variation in porpoise numbers across different water level periods in the Guanzhou and Anqing reaches, suggesting a relatively stable resident population. However, mother-calf pairs showed clear seasonal variation, with more pairs observed in spring-summer, consistent with the peak calving season reported in previous reproductive biology studies.

Group size patterns differed from earlier research: while 1990s studies reported 1–4 individual groups as most common, this study found 1–2 individual groups dominated (59.1%), with groups of 5 individuals comprising only 6.9%. The proportion of large groups (5 individuals) was significantly lower during medium water level periods. Notably, groups in natural riverbank areas were larger than those in artificial riverbank areas, where the maximum group size was only 3 individuals.

Freshwater cetaceans exhibit strong habitat selectivity and sensitivity to environmental changes. Human economic activities, including water conservancy projects, represent major factors driving population declines through direct habitat destruction. This study demonstrates that artificial riverbanks, particularly urban construction belts and dense dock areas, severely impact porpoise distribution. While natural sandbank and main channel waters consistently supported porpoise presence, artificial structures such as the northern Guanzhou embankment, Anqing urban floodwall, and Dukou riprap zone showed minimal porpoise activity.

Statistical analysis confirmed a significant negative correlation between porpoise abundance and artificial riverbank proportion. Yangtze finless porpoises prefer near-shore shallow waters with gentle slopes and silty substrates—conditions destroyed by artificial bank hardening that replaces gentle gradients with riprap footings, altering hydrological and ecological conditions essential for porpoises and their prey. One exception was the dock area west of Anqing City near the Wan River estuary, where frequent porpoise activity was detected, likely due to concentrated fishing vessel anchoring and abundant fishery discards attracting fish and porpoises.

Artificial riverbanks not only cause direct habitat loss but also degrade habitat quality and reduce connectivity between habitat patches. The 10 km stretch between Anqing's urban floodwall and the opposite Dukou riprap zone showed no porpoise sightings, indicating severe habitat degradation and minimal probability of porpoise occurrence. If these areas are not effectively restored or continue to deteriorate, porpoise populations at E' mao and Guanzhou sandbanks may become isolated, exacerbating habitat fragmentation. Research on other riverine cetaceans demonstrates that smaller, fragmented habitats increase extinction risk.

In the Yangtze main stem, artificial riverbanks already constitute a high proportion of shoreline and may increase further. This study's findings suggest that continued riverbank hardening will intensify habitat loss and fragmentation for Yangtze finless porpoises. Conservation measures must carefully consider this factor and propose corresponding habitat protection and restoration strategies, including managing migration corridors such as the central channel of E' mao Sandbank, which appears critical for maintaining connectivity between habitat patches.

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