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Population status, threats and conservation of the Yangtze finless porpoise

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The Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*) is currently limited to the middle and lower reaches of the Yangtze River from Yichang to Shanghai, China, and the adjoining Poyang and Dongting Lakes. Its population size has decreased remarkably during the last several decades due to the heavy impact of human activities, including overfishing of prey species, water development projects that cause attendant habitat loss and degradation, water pollution, and accidental deaths caused by harmful fishing gear and collisions with motorized vessels. It was estimated that the number of remaining individuals was down to approximately 1800 in 2006, a number that is decreasing at a rate as high as 5% per year. Three conservation measures – *in situ* and *ex situ* conservation and captive breeding have been applied to the protection of this unique porpoise since the early 1990s. Seven natural and two "semi-natural" reserves have so far been established. Since 1996, a small group of finless porpoises has been successfully reared in a facility at the Institute of Hydrobiology of the Chinese Academy of Sciences; three babies were born in captivity on July 5, 2005, June 2, 2007 and July 5, 2008. These are the first freshwater cetaceans ever born in captivity in the world. Several groups of these porpoises caught in the main stream of the Yangtze River, or rescued, have been introduced into the Tian'e-Zhou Semi-natural Reserve since 1990. These efforts have proven that, not only can these animals survive in the area, they are also to reproduce naturally and successfully. More than 30 calves had been born in the reserve since then, with one to three born each year. Taking deaths and transfers into account, there were approximately 30 individuals living in the reserve as of the end of 2007. Among eight mature females captured in April 2008, five were confirmed pregnant. This effort represents the first successful attempt at off-site protection of a cetacean species in the world, and establishes a solid base for conservation of the Yangtze finless porpoise. A lesson must be drawn from the tragedy of Chinese River Dolphin (*Lipotes vexillifer*), which has already been declared likely extinct. Strong, effective and appropriate protective measures must be carried out quickly to prevent the Yangtze finless porpoise from becoming a second Chinese River Dolphin, and save the biodiversity of the Yangtze River as a whole.

Yangtze finless porpoise, *in situ* and *ex situ* conservation, captive breeding

The finless porpoise (*Neophocaena phocaenoides*) is a small, toothed whale species living in coastal and riverine areas of Asia, with a range extending from the Persian Gulf in the west, to Pakistan, India, Indonesia, Borneo and China in the south, and up to Japan in the east[1]. The Yangtze finless porpoise (*N. p. asiaeorientalis*) is the sole freshwater subspecies of *N. phocaenoides*, and one of 6 extant species of porpoise (Phocoenidae) that survives only in the middle and lower reaches of the Yangtze River (from Yichang to Shanghai, China) and its adjoining Poyang and Dong-

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ting Lakes[2] (Figure 1). As a mammalian species at the top of the food chain, its survival depends heavily on habitat stability and food resource availability. However, the Yangtze River, as the third largest river in the world and so-called "golden channel of the country", has been heavily used and explored by all manners of human activities. The Yangtze River Dolphin, known locally as "baiji" (*Lipotes vexillifer*) is another endemic cetacean species encountered only in the Yangtze River; it has already been declared likely extinct[3]. The Yangtze finless porpoise is now listed in the Second Order of Protected Animals in China, and is also listed as an endangered population in the IUCN Red Data Book since 1996[4]. Is the Yangtze finless porpoise going the same way of the baiji? What have we done to put this lovely animal in such imminent jeopardy and what can we do to save it from extinction? This paper will summarize the population status, threats to continued survival, conservation achievements, and future prospects of the Yangtze finless porpoise.

1 Population status and main threats

Prior to late 1978, when the Baiji Research Collaboration Group was organized by the Chinese Academy of Sciences (CAS), there was no systematic research on the Yangtze finless porpoise. While this group, whose members included the Institute of Hydrobiology (CAS), Nanjing Normal College (renamed Nanjing Normal University), the Institute of Acoustics (CAS), and the Institute of Biophysics (CAS), initially focused primarily on the study of the baiji, information pertaining to the Yangtze finless porpoise was also collected. Since establishing the Baiji Research Collaboration Group, the Institute of Hydrobiology (CAS) and the Nanjing Normal College had carried out ecological surveys[5–12]. Most of these surveys were conducted by a single survey ship that was sometimes accompanied by several small fishing boats, and applied no standard survey methods. On the basis of 13 surveys conducted between 1984 and 1991 that covered the section of the river between Yichang and Shanghai and Dongting and Poyang Lakes, Zhang et al.[11] made the first range-wide estimate of finless porpoise abundance in the Yangtze River system, estimating their numbers at approximately 2700. Between 1997 and 1999, a series of designated "Synchronous Surveys" were conducted annually by the Ministry of Agriculture and the Institute of Hydrobiology (CAS). In those surveys, the historic distribution ranges of the baiji and Yangtze finless porpoise comprising the middle and lower reaches of the Yangtze River from Yichang to Shanghai, and Poyang and Dongting Lakes as well as their main tributaries, were divided into 21 sections or areas. These areas/sections, which varied in length from 50 to 200 km, were each searched by two large boats (~30 m long) over the course of a 1-week period in November of each year. Preliminary analyses of the data collected by these surveys showed that approximately 2000 animals might have been left in the river at that

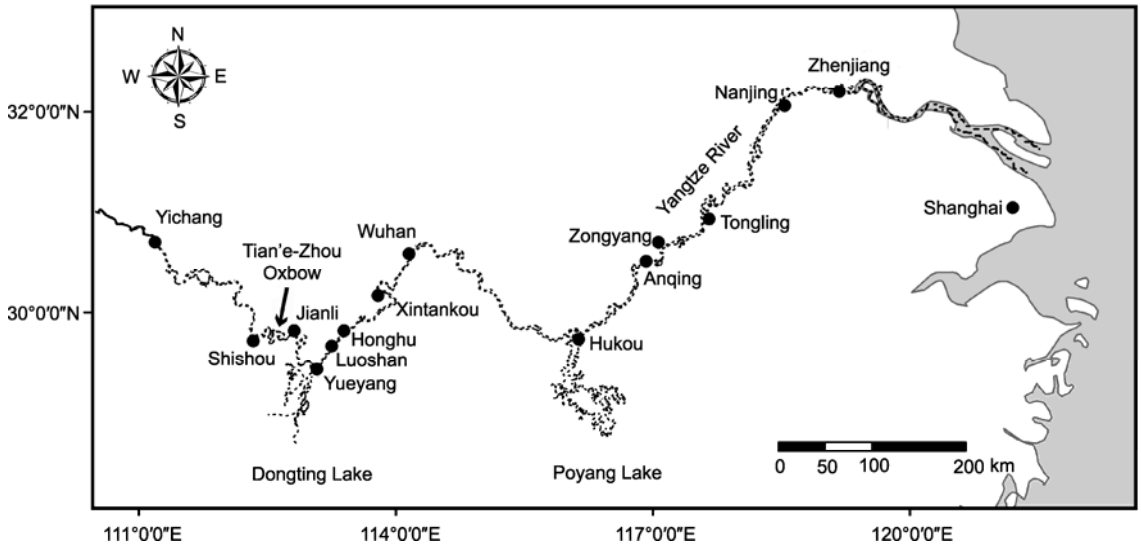

Figure 1 Distribution map of the Yangtze finless porpoise. Dashed line and area show the distribution range of the porpoise from Yichang to Shanghai and two lakes.

point (Ding Wang et al., unpublished data; for the design of the surveys, please see Zhang et al.[13]), Based on a 1989－1999 survey of a porpoise group in a ~40-km section (Balijiang, a river section near Hukou; Figure 1) that connected the mouth of Poyang Lake, Wei et al.[7] claimed that the population in this short section had declined annually by 7.3%. In November and December of 2006, a systematic survey was conducted over the entire current range of the population in the main stem of the Yangtze River (excluding the two lakes, Poyang and Dongting) using a modified standard line-transect survey method pre-designed based on the results of a pilot survey between Wuhan and Yueyang[14] (Figure 1). Experts and researchers from the USA, UK, Germany, Japan, Switzerland, Canada and China joined this international collaborative effort, which utilized both visual and acoustic methods[14,15]. The findings of this extensive survey indicated that the population of the Yangtze finless porpoise in the main stem was approximately 1000－1200; if the populations in the two lakes were included, the entire extant population was approximately 1800. These survey results indicate that the current finless porpoise population in the main stem of the river is less than half that estimated from surveys conducted between 1984 and 1991, when the total size of the population in this same section was approximately 2550[11]. It further implies an annual rate of decline of at least 5% for the entire population in the main stem of the river[14]. The results of the survey also prompted Zhao et al.[14] to warn that the distribution of the Yangtze finless is becoming more fragmented, and some gaps in the range may already exist. For example, no porpoises were found in a round trip survey of a section between Yueyang and Shishou (~150 km) (Figure 1), an section where sightings had previously been common.

The Yangtze finless porpoise was once a common inhabitant of the Yangtze River system[16]. What has happened to so remarkably decrease its numbers over the last several decades? Historically, lake clusters have been densely distributed along the mainstream in the middle and lower Yangtze River. In the past, most of these lakes were naturally connected but have gradually lost their hydrological and biological linkages with the river. This has been caused by both natural and human factors; land reclamation projects, and dam and dike construction during the mid-20th century have had a particularly large impact. With the exception of Dongting and Poyang Lakes, which are now the only two large lakes that remain naturally connected to the Yangtze, all other lakes except a small one have become separated from the main stem of the river by dikes and sluice gates[17]. The disconnection between river and lakes within the middle and lower Yangtze River has directly resulted in the deterioration of ecosystem functions and a loss of biodiversity in the river and the disconnected lakes. The consequence has been a shortage of food fish and a loss of habitat that has taken a toll on the baiji and the Yangtze finless porpoises, and threatens their continued existence. Illegal fishing techniques, including electric shock, gill nets, and rolling hook—a long rope equipped with many large, sharp hooks that is either dangled in the middle of the water or placed on the bottom of the river to catch fish—can directly kill the baiji and the Yangtze finless porpoises[16]. The Yangtze River Basin is the largest developing economic area in China, and the river itself—the golden channel—has always provided the transportation corridor that has been a key to its development. Dynamite explosions used to dredge out navigable channels may accidentally kill the baiji and the Yangtze finless porpoise. Shipping is a direct threat, with noises generated by boat engines disturbing the animals' sonar navigation systems and resulting in sometimes-fatal collisions with ship propellers[16]. Although damaging effects of pollution on river dolphins are not well documented, the continuing degradation of water quality has raised widespread concern that such contamination poses a potential hazard to aquatic life in the Yangtze River. In 2004, a rash of sudden deaths in the central Yangtze justified this concern: six Yangtze finless porpoises died in Dongting Lake between April and June as a result of the abuse of a chemical pesticide used to control schistosome infection (Wang Ding, unpublished data). The Three Gorges Project (TGP), as one of the biggest hydropower-Complex-projects in the world, cut off the natural flow of the Yangtze River in 1997. Started in 1993 and scheduled to be completed in 2009, the TGP dam and its annual regulation is expected to moderate natural fluctuations in river flow, resulting in fewer, lower-magnitude flood events; it will also decrease fish spawning activities in the middle reaches of the Yangtze River[18]. Since starting to fill in 2004, the TGP reservoir has trapped a high proportion of the silt content carried in river water. The water discharged by the TGP reservoir will be less

silt-saturated and more transparent, but it will have a higher capacity to dissolve and scour the riverbed and channel downstream. Such downstream modifications will change the spatial distribution of the water in the complex river-lake ecosystem in the middle and lower Yangtze River. Although direct, definitive proof may not yet be in hand, the TGP will undoubtedly have some adverse impact on river dolphin habitat and food supply in the coming days[19].

Based on the data available, Wang et al.[5] summarized the anthropogenic factors that have contributed to the population decline and range contraction of the baiji and Yangtze finless porpoises as follows: (1) Food shortages caused by overfishing and a loss of fish habitat; (2) accidental deaths caused by illegal harmful fishing; (3) boat collisions and shipping development; (4) habitat loss and degradation by the construction of water projects; and (5) impacts of pollution. In one incomplete survey, for example, of 64 baiji specimens collected from the middle (Yichang to Hukou; n = 33; 1973—1983) and lower (Hukou to Shanghai; n = 31; 1978—1985) reaches of the Yangtze River between 1973 and 1985, 53 had been killed as a direct result of various human activities, such as harmful fishing gear, boat collisions, and blasting to widen/deepen the shipping channel[16]. The story is the same for the finless porpoise, which shares the same river and almost the same habitat as the baiji, and thus faces similar threats. Most of the 80 finless porpoise specimens collected by Nanjing Normal University since 1974 were reportedly killed by rolling hooks or gillnets[20]. A preliminary analysis of a fishermen survey conducted in 2008 shows that rolling hooks, nets and boat collisions are the three main causes of mortality of finless porpoises (Samuel Turvey, personal communication).

2 Development of survey methods

A precondition for effective implementation of measures to protect a threatened or endangered species is an understanding of the species distribution and an accurate estimate of its abundance. Most of the Yangtze finless porpoise surveys to date have been conducted using direct accounting methods with subjective correction factors (e.g., see ref. [11]) that might incompletely account for missed porpoises[14]. The results of these surveys are considered unreliable because the study areas were not well covered, and no standard statistical methods were applied to the analysis of the collected data[14]. In March of 2006, a group of internationally known survey and survey-design experts joined forces to conduct a pilot survey in the Yangtze River between Wuhan and Yueyang (Figure 1). A modified standard line-transect survey method was developed based on information on river conditions generated by this pilot survey, and applied to a range-wide survey from Yichang to Shanghai[14] (Figure 1). The survey design and analytical methods established by this effort were proved to be practical and effective for the particular challenges posed by the complex Yangtze River environment, especially the "high density of large cargo vessels in the Yangtze River (approximately one ship every 100 m) and the requirement to travel in the relatively narrow shipping channel"[14].

The Yangtze finless porpoise is one of the smallest cetacean species in the world without a dorsal fin. They are relatively difficult to sight as they stay under water most of the time, and only appear at the water surface briefly when they breathe. Their maximal swim speed may be nearly 4 m/s, and their maximal dive duration could be as long as 3 min. This means that they are capable of traveling underwater several hundred meters without breaking the water surface[21,22]. Even when they breathe, only a small part of their tiny body is exposed above the water surface; and because of their dark body color, it is difficult to make them out against the backdrop of the dark water. This makes visual detection quite difficult, and results in a substantial portion of the animals being missed by observers. However, cetaceans make frequent sounds, such as communication signals and echolocation clicks, which can be effectively detected using an acoustical survey (e.g., ref. [23]). Based on our own findings, the sounds of the baiji are quite different from those of the Yangtze finless porpoise. The baiji communicates by making whistling sounds, whereas the Yangtze finless porpoise does not. Echolocation signals generated by the two species are also very different in terms of time and frequency characteristics[22,24–37]. These unique acoustical properties make it possible to identify which species is vocalizing by recording them in the wild. As early as in 1998, we developed the first acoustical survey system using two hydrophones positioned 6.3 m apart from each other and deployed at a depth of 0.8 m on both sides of the survey vessel[21]. We subsequently developed three different towed systems equipped with hydrophones, or so-called

data loggers (i.e., A-tags; ML200-AS2, Marine Micro Technology, Saitama, Japan, see ref. [15]), to record whistles from the baiji and echolocation clicks from both the baiji and Yangtze finless porpoise[15]. With an effective detection range of approximately 300 m, this acoustic method was calculated to have a detection probability approximately twice that of visual detection methods[15]. In addition to these towed systems, stationary passive acoustical observation systems have also been developed to monitor local migration of the Yangtze finless porpoise in some hot spots within its distribution range[38,39]. Wang et al.[38] used several data loggers (W20-AS, Little Leonardo, Japan) arranged across the river channel to created an "acoustic gate" capable of detecting passing porpoises. This system can be used to detect the presence of porpoises and can even be used to estimate the size of passing animal groups. Kimura et al.[39] stationed three acoustic data loggers (W20-ASII, Little Leonardo, Japan) at three different locations in the confluence of Poyang Lake and the Yangtze River, and confirmed that this passive acoustical method was an effective, long-term way to monitor the presence of the Yangtze finless porpoise in the area.

In summary, modified line-transect survey and acoustical survey methods developed by us can be used to estimate abundance and track the trends of population dynamics of the Yangtze finless porpoise. The stationary passive acoustical monitoring system can be used to monitor local presence and movement of the Yangtze finless porpoise in specific locations or sections of interest.

3 Progress of conservation efforts

At the First Workshop on Biology and Conservation of the Platanistoid Dolphins held at the Institute of Hydrobiology (CAS) in Wuhan in October 1986, Chen and Hua[40] proposed the following three measures for protecting the baiji: (i) *in situ* conservation using natural refuges established in the river; (ii) *ex situ* conservation using semi-natural reserves established in oxbows or other similarly suitable sites; and (iii) intensifying captive breeding studies and establishing captive colonies. At the same meeting, Zhou and Li[41] also suggested that one urgently needed protective measure was the establishment of a number of semi-natural reserves to develop protected breeding colonies. Since the Yangtze finless porpoise has been facing the same kind of threats as those that have apparently driven the baiji to likely extinction, the applicability of these three measures to the conservation of the porpoises was a natural topic of discussion at the Workshop to Develop a Conservation Action Plan for the Yangtze River Finless Porpoise, held in Hong Kong in 1997[42]. At the Second Meeting of the Asian River Dolphin Committee, held in Bangladesh in February 1997, Wang et al.[6] made three further recommendations for the conservation of the Yangtze finless porpoise: (i) establish a breeding population of Yangtze finless porpoises in the Shishou Baiji Semi-natural Reserve; (ii) establish more natural reserves, such as the mouth area of Poyang and Dongting Lakes and adjacent waters in the Yangtze River; and (iii) initiate captive breeding programs. Subsequently, a Conservation Action Plan for Cetaceans in the Yangtze River was developed by scientists of the Institute of Hydrobiology (CAS) and approved by the Chinese government[43]. This plan emphasized the importance of protecting the Yangtze finless porpoise, and proposed that the three measures identified at the 1986 baiji workshop also be implemented to help conserve the Yangtze finless porpoise population. The Chinese government and scientists have been pushing this plan forward ever since, applying the three agreed-upon measures. The following is a summary of the work that has been done, the difficulties that have been encountered, and the progress that has been achieved.

3.1 Progress and difficulty of *in situ* protection

In 1992, the first two national baiji reserves were established. One, the Honghu Xin-Luo Baiji National Natural Reserve, is a 135-km section of the Yangtze River between Xintankou and Luoshan located in Honghu City of Hubei Province (Figure 1). The other, Shishou Tian'e-Zhou Baiji Natural Reserve, includes an 89-km section of the Yangtze River in Shishou and a 21-km long Tian'e-Zhou Oxbow connected to this section (Figure 1). The baiji and the Yangtze finless porpoise are the two main protected target animal species for these two reserves. In 1996, the Ministry of Agriculture of China organized the Workshop on Conservation Measures of Baiji and Yangtze Finless Porpoise, after which, an additional 5 protection stations were established in Jianli, Chenglingji (a small town near Yueyang), Hukou, Anqing and Zhenjiang (Figure 1). Yueyang City set up a local reserve in east Dongting Lake in 1996 that covers a 66700-ha area of the lake (Figure 1). A provincial Yang-

tze Freshwater Cetacean Natural Reserve Located in Tongling of Anhui Province covering a 110-km section of the river was established in 2000, and this reserve was upgraded to national reserve status in 2006 but only covering a 58-km section of the original provincial reserve between Laozhou (Zongyang County) and Jinniudu (Tongling County) (Figure 1). The Zhenjiang Protection Station, which covers approximately a 15-km section of the river located in a side channel at Zhenjiang, was upgraded to a provincial reserve in 2003 (Figure 1). A provincial Poyang Lake Yangtze Finless Porpoise Reserve, which covers an 8600-ha area of the lake, was established in 2004 (Figure 1). The Anqing Protection Station, which covers a 243-km section of the river at Anqing, was upgraded to a local (city) reserve in 2007.

Most areas of the Yangtze River and two lakes that contain relatively high densities of the Yangtze finless porpoise are now covered by these reserves. But the Yangtze River basin also has the highest-density human population in all of China; approximately 40% of people in China—approximately 10% of the world's human population—live in the basin. Its legacy as the "golden channel" conveys the important role that the Yangtze River has played in the development of the country. Against this ingrained historical backdrop, reserve management staff strives to lessen the harmful effects of human activities on the baiji and the Yangtze finless porpoise. But, many of these activities are ongoing, and even expanding in scale. For example, the number of boats in the river has increased approximately five-fold since the late 1980s[44], and total transportation through the TGD has tripled in just three years from 47500000 t in 2003 to 439300000 t in 2005[45]. A survey of the region between Yichang and Shanghai in 2006 counted a minimum of 19830 large shipping vessels—or more than one ship every one hundred meters[3]. Fishery harvests in the Yangtze River have been decreasing remarkably due to overfishing and habitat loss. Fish yields reached a peak of 427000 t in 1954 and have declined to approximately 100000 t in recent years despite much more intensive fishing efforts[18]. Sewage runoff into the Yangtze River has shown the opposite trend, increasing from 9500000000 t/a at the end of the 1970s, to 15000000000 t/a by the end of the 1980s and 29640000000 t/a in 2005[46]. Although rules to protect baiji and Yangzte finless porpoise habitats are in place, effective enforcement remains an immense problem given the huge size of the river and the dense population of this developing area. For example, despite the fact that some fishing gear (described above) that are harmful to cetacean and fish resources are now illegal, they quite often continue to be used, even in reserve areas[3]. Thus, while these reserves may help slow the slide toward extinction for both the baiji and Yangtze finless porpoise, they are ultimately unable to keep the harmful human activities that hasten this process from occurring. As a result, *in situ* conservation can be considered, at best, a limited success[3,44].

3.2 Establishment of semi-natural protected populations

Because the baiji and finless porpoises can hardly be said to be thriving now in the Yangtze River, the fact that conditions in the river are not expected to improve any time soon make their future prospects here particularly bleak. This dynamic makes it imperative that other ways be found to help the porpoise before their options run out. As early as the mid-1980s, our research group started to search for a suitable site for a "semi-natural" reserve where we could establish an *ex situ*, protected population of the porpoise. Tian'e-Zhou Oxbow (112°31′—112°37′N, 29°46′—29°51′E), an old course of the Yangtze River, lies at the north bank of the river in Shishou County in Hubei Province, China (Figure 2). This oxbow, approximately 21 km long and 1—2 km wide, was once a section of the Yangtze River before

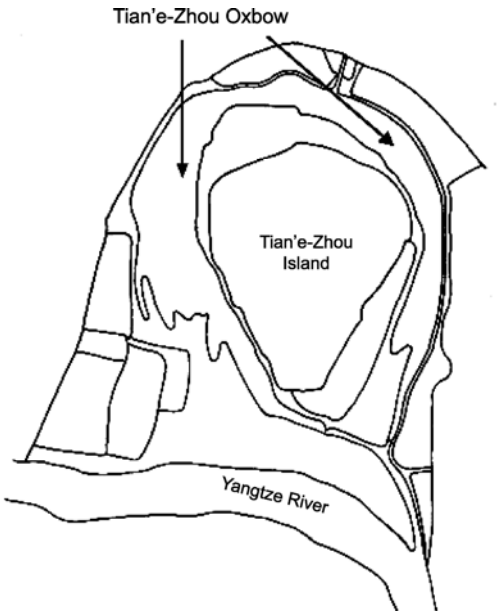

Figure 2 Sketch map of the Tian'e-Zhou Oxbow.

becoming isolated from the mainstream of the river by natural forces of the water channel in 1972. After making a systematic investigation of a number of relevant parameters, including water quality, biological productivity and fish production, Zhang et al.[47] concluded that the oxbow represented an ideal semi-natural habitat for the finless porpoise. The first group of 5 finless porpoises, three females and two males, were captured in the Yangtze River and transferred to the oxbow in 1990. Since then, several groups of Yangtze finless porpoises, captured or rescued from the river, have been introduced. The animals have been left to live freely in the oxbow; their survival there has not been facilitated by outside intervention (e.g. feeding). The results confirm that these animals are not only able to survive, but can also reproduce naturally and successfully in this reserve. Approximately two calves are born each year; all told, at least 31 babies have been born in the reserve to date (Table 1). Taking into account that some animals released or escaped into the river and moved into captivity for captive breeding, and the natural or accidental death of others, there were approximately 30 individuals living

Table 1 Establishment of the Yangtze finless porpoise breeding colony in the Tian'e-Zhou National Natural Reserve[a)]

Dates	Locations where porpoises were captured	Number of porpoises translocated into the reserve		Number of porpoises born in the reserve	Out/Loss	Remained
		Female	Male			
March 2—April 25, 1990	Chenglingji	3	2	2^{+}	2 deaths/one infant was killed accidentally by rolling hooks, one male died on April 25, 1990 from injuries during capture.	5
May 28, 1992					1 death/one male was killed accidentally by rolling hooks.	4
Spring 1992				1^{++}		5
April 1993	Chenglingji	3	2	3^{+}	1 death/one infant was found dead on April 26, 1993, born prematurely due to capture.	12
Oct 18,1993					7 deaths/seven killed accidentally.	5
May, 1995	Chenglingji	1	2	1^{+}		9
Dec 6, 1995	Chenglingji	2	2			13
Apr 20, 1996	Jianli	3	2	2^{+}		20
June-August 1996					14 escaped into the river	6
Dec 1996	Chenglingji & Shishou	5	9			20
Spring 1997					15 released into the river	5
Autumn 1997				2^{++}		7
Spring 1998				1^{++}		8
Dec 1998	Shishou	2	1			11
April 1999				1^{++}		12
Dec 1999	Shishou & Jiayu	2	4		1 translocated to Wuhan	17
Spring 2000				2^{++}		19
Spring 2001				1^{++}		20
Jun 2002				2^{++}	5 death/ one found died naturally and four killed accidentally by capture operation	17
Spring 2003				1^{++}		18
Nov 2003	Shishou	3				21
Jan 2004	Honghu	1				22
Spring 2004				$1^{+}2^{++}$		25
Oct 2004					1 translocated to Wuhan	24
Spring 2005				2^{++}		26
Oct 2005					2 deaths/two killed accidentally by capture operation	24
Spring 2006				2^{++}		26
Spring 2007				3^{++}		29
April 2008					6 deaths/five killed by ice, and one died naturally	>22*
Total		25	24	31	57	>22*

a) "+", pregnant in the Yangtze River; "++", pregnant in the Reserve; "*", confirmed minimum size of the current colony (nine females and 13 males). Of 8 mature females, 5 were confirmed pregnant in April 2008.

in the reserve at the end of 2007 (Table 1). In early spring of 2008, an immense, long-lasting snowstorm ravaged south China, almost completely covering Tian'-Zhou Oxbow with a layer of ice. This ice cover, which had never occurred since the oxbow had formed, was confirmed to have caused the death of five porpoises, who died as the result of wounds caused during their attempts to break through the ice to breathe. There were more than 22 individuals living in the area in April of 2008 (Table 1). An examination made in April 2008 confirmed that five of eight captured, mature females were pregnant. "Thus, a viable population capable of breeding and expanding has been established. This effort represents the world's first attempt and a successful example of *ex situ* preservation of a cetacean species"[48]. As Braulik et al.[49] noted "China's successful program of capture, translocation and maintenance of finless porpoise in the Shishou oxbow has demonstrated its adequacy as an *ex situ* environment for cetaceans". The Shishou Tian'e-Zhou Reserve success story serves as a guide for future efforts to protect the Yangtze finless porpoise.

One other smaller-scale semi-natural reserve was set up in Tongling in Anhui Province in 1994. This reserve is located in a small channel (1.6 km long, 80—220 m wide) between two sandbars of the Yangtze River. A small group of five porpoises were introduced into the channel in 2001; one calf was born there each year in 2003, 2005, 2006, 2007 and 2008 (Wenhua Jiang, personal communication).

3.3 Progress of captive breeding program

As one available protection measure, captive breeding efforts provide important insights that help with conservation work in the wild, particularly with regard to their breeding biology. The first attempts to rear Yangtze finless porpoises in captivity in China began in the mid-1960s; but most of these animals survived only a very short time in pools, usually less than one year[50]. The Baiji Dolphinarium, a new facility for rearing the baiji and finless porpoise, was established in 1992 at the Institute of Hydrobiology (CAS) in Wuhan. The first two Yangtze finless porpoises, a 1.5-year-old male and a 1.5-year-old female, were captured from the Yangtze River and introduced into the Dolphinarium's in-door pools at the end of 1996. A second 1.5-year-old female and one other adult male from the Tian'e-Zhou Oxbow were subsequently introduced into the same pool in 1999 and 2004, respectively. Since establishing the program, the Dolphinarium has enabled extensive research on the rearing, behavior, acoustics, physiology and breeding biology of these endangered animals (e.g., refs. [28, 34, 36, 51—55]). With the exception of one female introduced in 1999, who died accidentally in 2007, all animals in the facility are in good health. Both individuals introduced in 1996 have survived in captivity for almost 12 years. This success marks a significant milestone in efforts to rear the Yangtze finless porpoise in captivity, representing the first achievement of its kind[50].

For porpoises to successfully breed in captivity, their physiological status, including serum reproductive hormones cycles, must be fully understood. Initially, we took monthly blood samples to evaluate the physical status of the animals, but have since found that this sampling interval is too long to allow hormonal changes to be effectively monitored. Therefore, after receiving additional medical training on the animals, we began collecting the samples we needed, such as feces, mouth saliva and blowhole secretion, on a daily basis or even at every feeding. We also established a laboratory protocol to use feces to evaluate the cycles of the animal's serum reproductive hormones. Growth continued to be monitored monthly and behavior was observed daily. Collectively, the results obtained indicate that the two animals that arrived in 1996 reached sexual maturity in 1999, and the animal that arrived in 1999 reached sexual maturity in 2002. They clearly began mating at a very early stage even before their maturity, although no confirmed copulations were recorded[55]. Beginning in 2004, we physically separated the females and the male for a short period, placing them in different two pools that were connected by a channel that allowed them to communicate with each other prior to ovulation. We also cancelled routine physical examinations during ovulation to avoid disturbing the animals during this sensitive period. In addition, we stroked the female's genital regions to stimulate sexual behavior, making them more receptive to the males during the breeding season[48]. Shortly after reintroducing males and females into the same pool, the younger female introduced into captivity in 1999 was found to be pregnant. This female successfully gave birth on July 5, 2005 to a male (Figure 3)—the first freshwater cetacean ever born in captivity in the world[48]. This baby porpoise remains in good health in captivity. On June 2, 2007, the same female gave birth to another

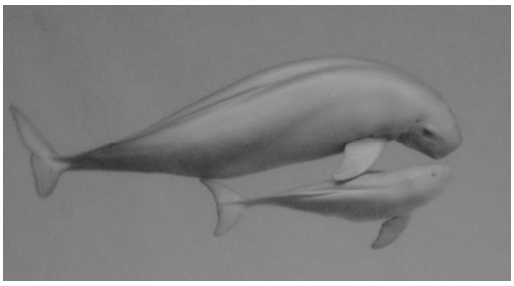

Figure 3 Picture showing the first born Yangtze finless porpoise in captivity in July 5, 2005, and his mother.

male. Unfortunately, this female ate some cast from the pool wall and ultimately died 39 days later. Eleven days after the death of the mother, the second baby also died, despite efforts to feed him with a milk mixture. On July 5, 2008, the elder female who was introduced in our pools in 1996, gave birth to another male baby. For unknown reasons, she failed to excrete milk; unable to nurse, the baby died 5 days later.

4 Future conservation prospects

Because China can be expected to continue its course of fast-paced economic development, we cannot expect the quality of Yangtze River environment to improve in the near future; if anything, it will likely continue to worsen. The severe impacts of human activities in the Yangtze River have probably already driven the baiji to extinction[3]. Is there any way for us to prevent the baiji tragedy from befalling the Yangtze finless porpoise, or is its continued decline and eventual extinction already a foregone conclusion?

Generally speaking, *in situ* protection should always be considered the first choice among available conservation measures. Every effort should be made to protect the Yangtze finless porpoise in its natural habitat, notwithstanding the fact that the habitat of the Yangtze River has been, and continues to be, remarkably degraded. Fortunately, there are still relatively enough animals in the wild to provide what should be a base sufficient to support protective measures.

Overfishing and illegal fishing activities that deplete the fish resources that sustain the baiji and Yangtze finless porpoise have been blamed as one of main reasons for the decline of both species (e.g., refs. [5, 44, 48, 56]). As fishing efforts in the Yangtze River become much more intensive, fish production continues to decrease, from its peak of 427000000 kg in 1954 to approximately 100000000 kg in recent years[18]. This development should be taken as a warning that fish populations in the river are nearing collapse. Because of the growth of freshwater aquaculture, which has been estimated to account for the production of as much as 21000000000 kg/year nationwide in recent years[18], fish production in the Yangtze River is a small player in fishery economic development plans. However, the roe from fish of the Yangtze River is among the best in the country[18]. To protect the remaining fish resources, the Chinese government has prohibited fishing activity in the middle and lower reaches of the Yangtze River for three months from April 1 to the end of June each year since 2003. This measure may have improved the status of the fish populations in the river[18], but it falls short of solving the problem because fisherman can simply spend more time and effort fishing during the legal period. To truly protect the river fish resources to benefit aquiculture development and Yangtze cetacean protection, we suggest that fishing should be forbidden year-round in the entire river; as a minimal initial first step, fishing should be forbidden in all reserves. Furthermore, re-establishing linkage between the Yangtze River and its appended lake clusters could greatly improve the habitat status of fish resources of the river.

We have already established some natural reserves in the river and lakes that encompass almost every hot spot of the animal's distribution (Figure 1). However, most of these reserves are in a very difficult position because the river is being used to support so many different human activities, most of which are beyond the influence of reserve management. For example, we cannot expect to stop the transportation in the river that is blamed for harming the baiji and the porpoise[5,6,16]. In a case like this, additional navigational rules need to be developed and implemented. We suggest that the speed of all ship passing through the reserve should be limited, possibly to below 10 km/h. In addition, it is important to eliminate the use of blasting to deepen and widen shipping channels in the reserve.

Ex-situ conservation measures have already proved their worth as a means to establish a sustainable population of the Yangtze finless porpoise, as demonstrated by our experience with the Tian'e-Zhou Reserve. There are other similar oxbows or old courses in this section of the Yangtze River that could be used to establish additional off-site protected populations of the porpoise, and help assure their long-term survival in a near-natural habitat. Conducting a systematic survey to investigate such sites

and establishing additional semi-natural reserves for the porpoise in sites deemed suitable should be a high priority. Since completion of the TGD, the water current above the dam is much slower than before, eliminating what had been the main factor impeding the movement of the baiji and the porpoise into the upper reaches of the Yangtze River. We suggest that the possibility of establishing a population of Yangtze finless porpoises in the huge reservoir above the dam be explored; if successful, this strategy could provide another reliable option for saving the Yangtze finless porpoise.

Some progress has been made in captive breeding and could ultimately prove to be a great benefit to porpoise conservation efforts[48]. We should consider expanding the captive colony to establish a group with the potential to sustain itself. In addition to increasing porpoise numbers, this effort would create an invaluable research opportunity, allowing us to study rearing biology, breeding biology, physiology, behavior and acoustics in captive animals and ultimately help conservation efforts in the wild.

A network composed of governmental agencies, reserves, and research institutions has recently been organized to effectively protect the baiji and the finless porpoise. The hope is that this network will serve as a platform to help exchange information, train staff, organize surveys, and educate the public on the importance of baiji and porpoise conservation efforts.

We should note that most of the measures proposed above have been suggested in countless workshops, published papers and reports to the government. Despite these repeated urgings, little attention has been paid to the suggested remedies and even less progress has been made in carrying out them. Most of the well-characterized threats posed by human activities are still present, and at least some of them have continued to grow. In an environment dominated by the pressure for rapid economic development, the best that might be hoped for from the government is a balance between development and conservation. But in a developing country like China, when these goals are at odds, development almost always prevails. In a situation such as this, suggestions based on conservation-oriented research—regardless of what they might be—often amount to nothing more than "conservation on paper" (for example, please see ref. [57]). The will of government agencies and the care and support of the public are the two keys to the possible success of any conservation program. Eventually, we must face a question that is simple to ask but difficult to answer: are we prepared to lose one more mammal species—the Yangtze finless porpoise—after having already likely lost the baiji? Can we really afford the cost, not just of one or two species of animals, but the eventual loss of the biodiversity of the river as a whole? We hope that we can all learn a lesson from the tragedy of the baiji and react immediately to help keep the finless porpoise from becoming a second baiji. Ultimately, the life of the entire river is at stake.

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