

# First human-caused extinction of a cetacean species?

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**The Yangtze River dolphin or baiji (*Lipotes vexillifer*), an obligate freshwater odontocete known only from the middle-lower Yangtze River system and neighbouring Qiantang River in eastern China, has long been recognized as one of the world's rarest and most threatened mammal species. The status of the baiji has not been investigated since the late 1990s, when the surviving population was estimated to be as low as 13 individuals. An intensive six-week multi-vessel visual and acoustic survey carried out in November–December 2006, covering the entire historical range of the baiji in the main Yangtze channel, failed to find any evidence that the species survives. We are forced to conclude that the baiji is now likely to be extinct, probably due to unsustainable by-catch in local fisheries. This represents the first global extinction of a large vertebrate for over 50 years, only the fourth disappearance of an entire mammal family since AD 1500, and the first cetacean species to be driven to extinction by human activity. Immediate and extreme measures may be necessary to prevent the extinction of other endangered cetaceans, including the sympatric Yangtze finless porpoise (*Neophocaena phocaenoides asiaorientalis*).**

**Keywords:** baiji; China; extinct; *Lipotes vexillifer*; river dolphin; Yangtze

## 1. INTRODUCTION

The Yangtze River dolphin or baiji (*Lipotes vexillifer*), an obligate freshwater odontocete known only from the middle-lower Yangtze River system and neighbouring Qiantang River in eastern China (figure 1), has long been recognized as one of the world's rarest and most threatened mammal species (e.g. Chen *et al.* 1980; Chen & Hua 1989; Lin *et al.* 1985; Zhou & Li 1989; Zhou *et al.* 1998; Würsig *et al.* 2000; Zhang *et al.* 2003). Baiji have not been seen in the Qiantang River since the 1950s (Smith *et al.* 2000), and Chinese scientists reported a steady rapid decline in the Yangtze through the 1980s and 1990s from an estimated 400 individuals in 1979–1981 (table 1). Surveys during 1997–1999 provided a minimum estimate of only 13 animals (Zhang *et al.* 2003). The last authenticated baiji records were of a stranded pregnant female found in 2001 and a live animal photographed in 2002, although a few more recent unverifiable sightings have been reported by fishermen to reserve managers in National and Provincial Baiji Reserves along the Yangtze (see electronic supplementary material).

A range of anthropogenic extinction drivers (e.g. boat collisions, dam construction), which also threaten freshwater cetaceans in other river systems (e.g. Smith *et al.* 2000), have been implicated in the baiji's precipitous decline. However, the primary factor was probably unsustainable by-catch in local fisheries, which use rolling hooks, nets (gillnets and fyke nets) and electro-fishing (Zhou & Wang 1994; Zhou *et al.* 1998); similar by-catch constitutes the principal cause of mortality in many populations of small cetaceans worldwide (Reeves *et al.* 2003). Although relatively few data are available on baiji mortality, at least half of all known baiji deaths in the 1970s and 1980s were caused by rolling hooks and other fishing gear, and electro-fishing accounted for 40% of baiji deaths recorded during the 1990s (Lin *et al.* 1985; Chen & Hua 1989; Zhou & Li 1989; Zhou & Wang 1994; Zhou *et al.* 1998; Zhang *et al.* 2003). Harmful fishing practices are still widespread and may be increasing in the Yangtze, despite national legislation banning the use of rolling hooks, electro-fishing and fyke nets, and repeated recommendations for more effective regional regulation (Zhou *et al.* 1998). Establishment of a closely monitored *ex situ* baiji population in a semi-natural reserve has been consistently advocated by scientists and policy makers as an essential short-term goal for continued survival of the species (Chen & Hua 1989; Zhou *et al.* 1998; Zhang *et al.* 2003).

## 2. MATERIAL AND METHODS

We made a systematic visual and acoustic survey for baiji from Yichang to Shanghai in two independently operating research vessels travelling at average speeds of 15 km/h, covering the in-channel distance of 1669 km twice between 6 November and 13 December 2006 (figure 2; see electronic supplementary material). The survey was designed both to maximize the probability of finding baiji and to estimate the abundance of the Yangtze finless porpoise (*Neophocaena phocaenoides asiaorientalis*), the other cetacean present in the river system. The line-transect sampling design was adapted from that of standard marine cetacean surveys (Wade & Gerrodette 1993; Barlow 1995). Methods used for this survey were generally consistent with previous freshwater cetacean survey recommendations (Zhou & Hua 1989; Vidal *et al.* 1997; Smith & Reeves 2000), although variations from an ideal design (e.g. zigzag transects for mid-channel coverage) were necessary owing to navigational and logistical constraints.

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Table 1. Baiji population counts and estimates based on surveys carried out from 1979 to 1999 (after Zhang *et al.* 2003). (S, single vessel survey; M, multi-vessel survey; B, observation from riverbank; P, opportunistic photo-identification of individual animals was possible.)

year	survey area	survey method	no. of boats	no. of km surveyed	no. of surveys	no. of baiji sighted	estimated baiji population	reference
1979	Wuhan–Chenglingji	S	1	230	1	19	—	Chen <i>et al.</i> (1980)
1979	Nanjing–Taiyangzhou	S	1	170	2	10	—	Zhou <i>et al.</i> (1980)
1979–1981	Nanjing–Guichi	S	1	250	6	3–6 groups	400	Zhou <i>et al.</i> (1982)
1978–1985	Yichang–Nantong	S	1	1600	9	> 20 groups	156	Lin <i>et al.</i> (1985)
1985–1986	Yichang–Jiangyin	M	1 + 4–6 <sup>a</sup>	1510	2	42 groups	300	Chen & Hua (1989)
1979–1986	Fujiangsha–Hukou	S	1	630	18	78–79	100 <sup>b</sup>	Zhou & Li (1989)
1987–1990	Yichang–Shanghai	M + B	1 + 4–6 <sup>a</sup>	1669	12	108	200	Chen <i>et al.</i> (1993)
1989–1991	Hukou–Zhenjiang	P	8	500	5	29	120	Zhou <i>et al.</i> (1998)
1991–1996	Xinchang–Wuhan	M	1 + 4–6 <sup>a</sup>	413	10	42	< 100	Wang <i>et al.</i> (1998)
1997–1999	Yichang–Shanghai	M	34, 14, 16	1687	3	21–23	13+	Zhang <i>et al.</i> (2003)

<sup>a</sup> one large vessel plus four to six small boats.

<sup>b</sup> lower reaches only.

We did not survey Dongting and Poyang Lakes, two large water bodies appended to the main Yangtze channel which were also part of the baiji's historical range, because they are surveyed by Institute of Hydrobiology staff every three months, and baiji have not been seen in either lake since the 1970s (Chen *et al.* 1997).

### 3. RESULTS

The lack of any baiji sightings or acoustic recordings in the Yangtze during this survey forces us to conclude that the species is now likely to be extinct. While it is conceivable that a couple of surviving individuals were missed by the survey teams, our inability to detect any baiji in the main channel of the river despite this intensive search effort indicates that the prospect of finding and translocating them to an *ex situ* reserve has all but vanished. The continued deterioration of the Yangtze ecosystem means that the species has no hope of even short-term survival as a viable population in the river, if it has not already disappeared.

### 4. DISCUSSION

The baiji is the only recent representative of the Lipotidae, a clade that diverged from other cetacean lineages more than 20 Myr ago (Nikaido *et al.* 2001). Its extinction represents the loss of a disproportionately large amount of mammalian evolutionary history (Isaac *et al.* 2007), and only the fourth disappearance of an entire mammal family since AD 1500 (MacPhee & Flemming 1999). It also represents the first documented global extinction of a 'mega-faunal' (greater than 100 kg) vertebrate for over 50 years, since the disappearance of the Caribbean monk seal (*Monachus tropicalis*) in the 1950s (MacPhee & Flemming 1999), and the first such species extinction since the emergence of an international network of



Figure 1. Yangtze River dolphin or baiji (*Lipotes vexillifer*). Male individual ('Qi Qi'), held at the Wuhan dolphinarium from 1980 to 2002.

conservation organisations that have tended to prioritise conservation efforts on charismatic vertebrates. Indeed, despite intensive historical persecution of marine mammals, very few cetacean populations have been extirpated (e.g. Atlantic population of gray whale *Eschrichtius robustus*), and the baiji is the first cetacean species known to have been driven to extinction by human activity. The vaquita or Gulf of California porpoise (*Phocoena sinus*) is now the world's most Critically Endangered cetacean species; incidental mortality in fishing gear is again the major threat, and the future of this species is uncertain (Rojas-Bracho *et al.* 2006).

Unlike most historical-era extinctions of large-bodied animals, the baiji was the victim not of active persecution but of incidental mortality resulting from massive-scale human environmental impacts,

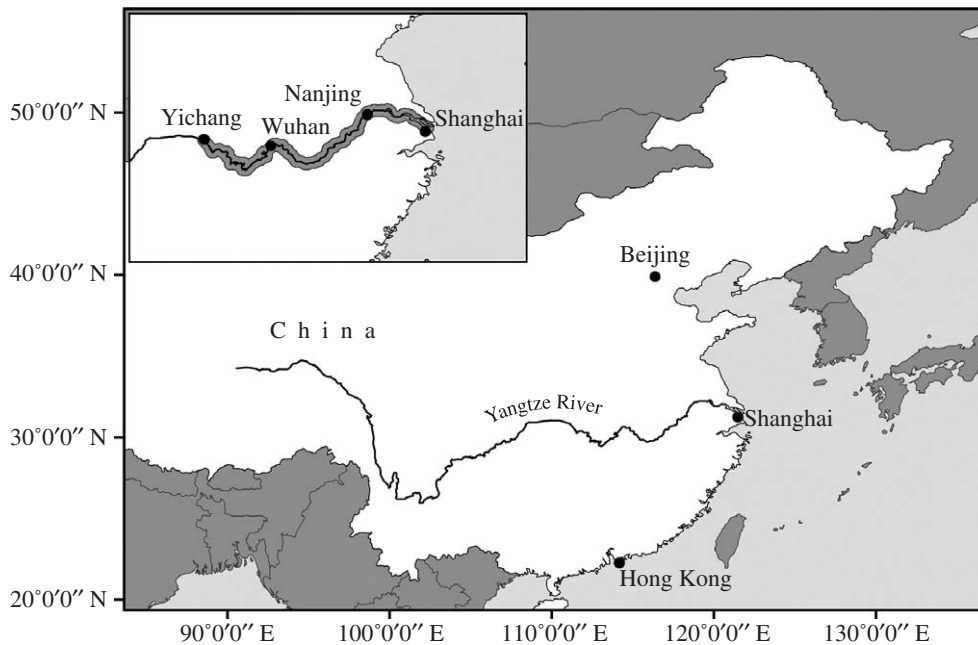


Figure 2. November–December 2006 survey route, covering entire historical distribution of baiji in the main Yangtze channel.

primarily uncontrolled and unselective fishing. Its extinction merely reflects the latest stage in the progressive ecological deterioration of the Yangtze region, home to approximately 10% of the world's human population (Zhou *et al.* 1998). During the survey, we counted a minimum of 19 830 large shipping vessels (more than 1 vessel per 100 m of river surveyed) and 1175 fishing vessels as minimum estimates of boat traffic between Yichang and Shanghai, and also observed illegal fishing activities daily along the river. Many other endemic species (e.g. the 7 m Chinese paddlefish *Psephurus gladius*, not reported since 2003) are similarly on the verge of extinction or may be extinct, and the sympatric Yangtze finless porpoise is also experiencing a rapid decline (Zhang *et al.* 2003); this subspecies has been classified as Endangered by IUCN (The World Conservation Union) since 1996, and its isolation from contiguous marine populations has been confirmed by recent genetic studies (Zheng *et al.* 2005). Furthermore, despite extensive debate and a series of international workshops over more than two decades, little effort was ever made to implement the *ex situ* baiji recovery programme. The baiji's probable extinction serves as a potent reminder to conservationists that even large charismatic and nominally protected animals are still in grave danger of being lost; species cannot be expected to save themselves, and intervention may need to be swift and decisive.

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- Barlow, J. 1995 The abundance of cetaceans in California waters. Part I. ship surveys in summer and fall of 1991. *Fish. Bull.* **93**, 1–14.
- Chen, P. & Hua, Y. 1989 Distribution, population size and protection of *Lipotes vexillifer*. *Occ. Papers IUCN SSC* **3**, 78–81.
- Chen, P., Liu, P., Liu, R., Lin, K. & Pilleri, G. 1980 Distribution, ecology, behaviour and protection of the dolphins in the middle reaches of the Changjiang River (Wuhan-Yueyang). *Oceanol. Limnol. Sin.* **11**, 73–84.
- Chen, P., Zhang, X., Wei, Z., Zhao, Q., Wang, X., Zhang, G. & Yang, J. 1993 Appraisal of the influence upon baiji *Lipotes vexillifer* by the Three-gorge Project and conservation strategy. *Acta Hydrobiol. Sin.* **17**, 101–111.
- Chen, P., Liu, R., Wang, D. & Zhang, X. 1997 *Biology of baiji, and its rearing and conservation*. Beijing, China: Science Press.
- Isaac, N. J. B., Turvey, S. T., Collen, B., Waterman, C. & Baillie, J. E. M. 2007 Mammals on the EDGE: conservation priorities based on threat and phylogeny. *PLoS One* **2**, e296. (doi:10.1371/journal.pone.0000296)
- Lin, K., Chen, P. & Hua, Y. 1985 Population size and conservation of *Lipotes vexillifer*. *Acta Zool. Sin.* **5**, 77–85.
- MacPhee, R. D. E. & Flemming, C. 1999 Requiem æternam: the last five hundred years of mammalian species extinctions. In *Extinctions in near time: causes, contexts, and consequences* (ed. R. D. E. MacPhee), pp. 333–371. New York, NY: Kluwer Academic/Plenum.
- Nikaido, M. *et al.* 2001 Retroposon analysis of major cetacean lineages: the monophyly of toothed whales and the paraphyly of river dolphins. *Proc. Natl Acad. Sci. USA* **98**, 7384–7389. (doi:10.1073/pnas.121139198)
- Reeves, R. R., Smith, B. D., Crespo, E. A. & Notarbartolo di Sciara, G. (eds) 2003 *Dolphins, whales and porpoises: 2002–2010 conservation action plan for the world's cetaceans*. Gland, Switzerland; Cambridge, UK: IUCN/SSC Cetacean Specialist Group.
- Rojas-Bracho, L., Reeves, R. R. & Jaramillo-Legorreta, A. 2006 Conservation of the vaquita *Phocoena sinus*. *Mammal Rev.* **36**, 179–216. (doi:10.1111/j.1365-2907.2006.00088.x)

- Smith, B. D. & Reeves, R. R. 2000 Survey methods for population assessment of Asian river dolphins. *Occ. Papers IUCN SSC* **23**, 97–115.
- Smith, B. D. *et al.* 2000 Register of water development projects affecting river cetaceans in Asia. *Occ. Papers IUCN SSC* **23**, 22–39.
- Vidal, O., Barlow, J., Hurtado, L. A., Torre, J., Cendón, P. & Ojeda, Z. 1997 Distribution and abundance of the Amazon river dolphin (*Inia geoffrensis*) and the tucuxi (*Sotalia fluviatilis*) in the upper Amazon River. *Mar. Mamm. Sci.* **13**, 427–445. (doi:10.1111/j.1748-7692.1997.tb00650.x)
- Wade, P. R. & Gerrodette, T. 1993 Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Rep. Int. Whal. Commn* **43**, 477–493.
- Wang, D., Zhang, X. & Liu, R. 1998 Conservation status and the future of baiji and finless porpoise in the Yangtze River of China. In *Ecology and environment protection in the large water conservancy projects of the Yangtze River* (eds Z. Huang, B. Fu & Z. Yang), pp. 218–226. Beijing, China: Environmental Science Press.
- Würsig, B. *et al.* 2000 Baiji (*Lipotes vexillifer*): travel and respiration behavior in the Yangtze River. *Occ. Papers IUCN SSC* **23**, 49–53.
- Zhang, X., Wang, D., Liu, R., Wei, Z., Hua, Y., Wang, Y., Chen, Z. & Wang, L. 2003 The Yangtze River dolphin or baiji (*Lipotes vexillifer*): population status and conservation issues in the Yangtze River, China. *Aquat. Conserv. Mar. Freshw. Ecosyst.* **13**, 51–64. (doi:10.1002/aqc.547)
- Zheng, J., Xia, J., He, S. & Wang, D. 2005 Population genetic structure of the Yangtze finless porpoise (*Neophocaena phocaenoides asiaorientalis*): implications for management and conservation. *Biochem. Genet.* **43**, 307–320. (doi:10.1007/s10528-005-5222-7)
- Zhou, K. & Hua, Y. 1989 *Lipotes vexillifer* in China. *Occ. Papers IUCN SSC* **3**, 18–19.
- Zhou, K. & Li, Y. 1989 Status and aspects of the ecology and behavior of the baiji, *Lipotes vexillifer*, in the lower Yangtze River. *Occ. Papers IUCN SSC* **3**, 86–91.
- Zhou, K., Li, Y., Nishiwaki, M. & Kataoka, T. 1982 A brief report on observations of the baiji (*Lipotes vexillifer*) in the lower reaches of the Yangtze River between Nanjing and Guichi. *Acta Theriol. Sin.* **2**, 253–254.
- Zhou, K., Pilleri, G. & Li, Y. 1980 Observations on baiji (*Lipotes vexillifer*) and finless porpoise (*Neophocaena asiaorientalis*) in the lower reaches of the Chang Jiang. *Sci. Sin.* **23**, 785–795.
- Zhou, K., Sun, J., Gao, A. & Würsig, B. 1998 Baiji (*Lipotes vexillifer*) in the lower Yangtze River: movements, numbers threats and conservation needs. *Aquat. Mamm.* **24.2**, 123–132.
- Zhou, K. & Wang, X. 1994 Brief review of passive fishing gear and incidental catches of small cetaceans in Chinese waters. *Rep. Int. Whal. Commn Special Issue* **15**, 347–354.