Integrated Conservation Strategy for Endangered Small Cetaceans: Insights from the Case of the Yangtze Finless Porpoise

HAO Yujiang[a, b], TANG Bin[a, b], MEI Zhigang[a], ZHENG Jinsong[a, b], WANG Kexiong[a], FAN Fei[a, b], WANG Ding[a, l, *]

a.Institute of Hydrobiology, the Chinese Academy of Sciences, China
b.National Aquatic Biological Resource Center, NABRC, China

Abstract: The Yangtze finless porpoise (YFP) is an endemic freshwater cetacean species that exclusively inhabits the middle and lower reaches of the Yangtze River basin. Since the late 1970s, the YFP has experienced a drastic population decline and was classified as critically endangered by the IUCN in 2013. To save this unique species, a range of integrated conservation measures have been implemented, including strengthening natural habitat protection (*in-situ*), enhancing insurance populations (*ex-situ*), and advancing captive breeding and research initiatives. These efforts have yielded significant progress in the conservation of the YFP. The natural population has been starting to increase after a sharp decline, and the establishment of three insurance populations has provided a solid foundation for recovery. Additionally, advancement in captive breeding and research has delivered crucial technical support for population conservation. As a flagship species of Yangtze River biodiversity and an indicator of the river's ecosystem health, the YFP's integrated conservation strategy not only benefits its own population but also offers valuable insights for the protection of other endangered aquatic species in the Yangtze River and other threatened small cetaceans worldwide.

Keywords: Integrated conservation strategy, Yangtze finless porpoise, Endangered, Small cetaceans, Yangtze River biodiversity

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* To whom correspondence may be addressed. Email: wangd@ihb.ac.cn
l. Leading scientist for Yangtze cetacean conservation and research of the Institute of Hydrobiology, CAS; Member of IUCN Cetacean Specialist Group and the Honored member of the Society for Marine Mammalogy; Secretary General of the China National Committee for Man and Biosphere (MAB) Programme, UNESCO.

Introduction

The Yangtze River is the largest river in China and Asia, and it is also the longest river in the world that flows through only one country, from its source to its mouth to the sea. Known as the "Mother River of China," it plays a crucial role in the nation's culture and economy while also supporting a rich diversity of aquatic life (Zhang *et al.*, 2020). More uniquely, the river is one of the only two big rivers in the world that harbors two freshwater cetacean species, the Yangtze River dolphin or Baiji (*Lipotes vexillifer*), and the Yangtze finless porpoise (YFP) (*Neophocaena asiaorientalis*) (Wang, 2009) (Fig. 1-2). However, since the late 20th century, increasing anthropogenic activities in the Yangtze River region have significantly altered the habitats of both species. Despite numerous conservation efforts, the Baiji, the ancient freshwater cetacean species, experienced a dramatic population decline and was declared functionally extinct in 2007 (Turvey *et al.*, 2007). This serves as a stark warning of the urgent need to protect the biodiversity and environment of the Yangtze River.

With the disappearance of Baiji in the Yangtze River, YFP subsequently became the only remaining freshwater cetacean species in the Yangtze River. Moreover, despite its biological resilience to environmental changes, its population has still experienced a significant decline. The first estimated population in literature of YFP was approximately 3,600 in the early 1990s (Zhang *et al.*, 1993). However, this number fell to 1,800 by 2006 (Zhao *et al.*, 2008), and further declined to 1,045 in 2012 (Mei *et al.*, 2014) and 1,012 in 2017 (Huang *et al.*, 2020). Based on its decreas-

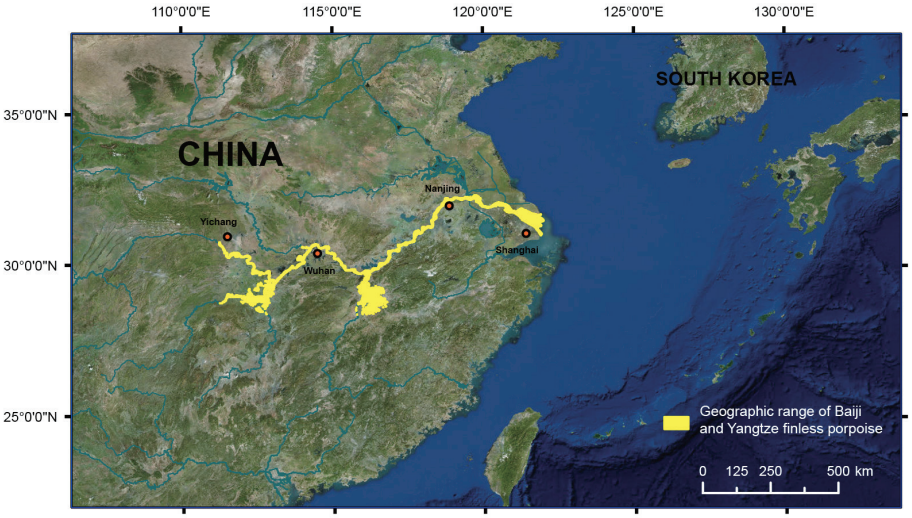

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Fig. 1. The geographic range of Baiji and Yangtze finless porpoise.

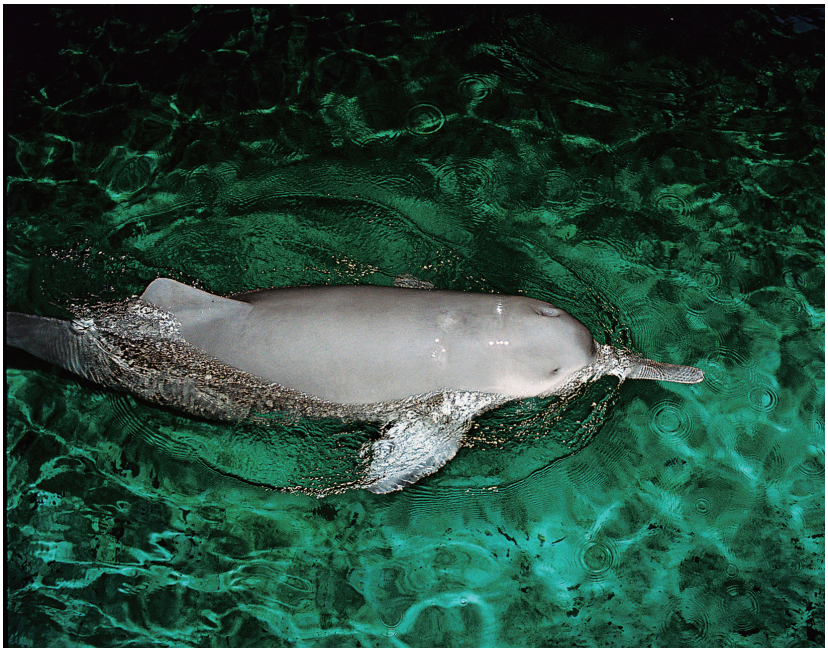

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Fig. 2. The baiji (Yangtze River dolphin) *Qiqi* housed in the Baiji Dolphinarium in Wuhan.

ing population size and rapid decline trend, the species was classified as critically endangered by the IUCN Red List in 2013 (Wang *et al.*, 2013), and it has even been estimated that YFP could vanish from the main stem of the Yangtze River within the next ten years if no drastic conservation measures were implemented (Mei *et al.*, 2012; Mei *et al.*, 2014). Then it has become an urgent and imperative task for China to save YFP from facing a fate similar to that of the Baiji.

The loss of the Baiji serves as a significant lesson for the conservation of biodiversity in the Yangtze River, offering invaluable insights and experiences for the protection of YFP. Despite the long-standing proposals and implementation of various conservation measures, including *in-situ* and *ex-situ* strategies as well as captive breeding for the Baiji, these efforts failed to be fully realized due to multiple challenges (Hao *et al.*, 2023; Hao *et al.*, 2024). To protect YFP, a comprehensive strategy that combines these efforts is essential to reversing the decline of its population and ultimately promoting its recovery.

Integrated Conservation Strategy

Learning lessons from the loss of the Baiji, it is essential to develop and implement a comprehensive conservation strategy. For larger aquatic species, such as the Baiji and the YFP, safeguarding their natural habitats is paramount. The establishment of protected areas or nature reserves within their critical habitats is a direct and effective approach to preserve these endangered species. However, it is important to recognize that simply having several disconnected protected areas or nature reserves within the banded river ecosystem does not guarantee effective protection for the large free-ranging aquatic animals. Since the late 1980s, numerous hotspots of the Baiji have been designated as nature reserves; however, the function of these reserves has been significantly limited by intense human economic activities throughout the Yangtze region. As the overall Yangtze ecosystem continues to deteriorate, the Baiji population has declined at an alarming rate. In light of this situation, alternative approaches, such as *ex-situ* conservation measures, should be considered and integrated into our toolbox of conservation.

The use of *ex-situ* conservation for large aquatic animals has long been a topic of controversy. Despite vigorous debate among international cetacean specialists regarding the *ex-situ* protection of the Baiji, Chinese researchers have remained resolute in their commitment to implementing *ex-situ* practices for the species. The first *ex-situ* reserve for the Baiji was established in the Swan Oxbow in Hubei Province in 1992, and a female Baiji was relocated to this river-shaped lake in 1995. Unfortunately, she passed away in less than a year, primarily due to the inadequate infrastructure in the oxbow. Due to the escalating difficulties in capturing Baiji amid the rapid decline of their natural population and the unsatisfactory results of the initial attempt, no additional Baiji have been introduced into this oxbow since that time. However, this failure does not imply that *ex-situ* conservation is not worth pursuing. On the contrary, it underscores the need to initiate *ex-situ* practices earlier and allocate more resources to enhance the infrastructure and capacity of the *ex-situ* reserve. Imagine if a small *ex-situ* population of Baiji had been successfully established in early 1990s, the fate of the Baiji could have been totally different. Therefore, it is crucial to carefully choose the right timing and invest sufficient effort into establishing *ex-situ* populations of endangered large aquatic animals.

Captive breeding of endangered cetacean species also remains a contentious issue globally due to numerous concerns, including animal welfare, inbreeding, health risks, and emotional well-being (Nelms *et al.*, 2021). Despite these challenges, it can serve as a viable strategy for maintaining a small insurance population of endangered species. Additionally, captive breeding programs can provide valuable insights, such as effective handling techniques for rescue operations, an understanding of reproductive behaviors, knowledge of health and disease management, and insights into animal behavior, etc. These contributions can play a critical role in the conservation of endangered cetaceans. A renowned Baiji named "*Qiqi*" lived in captivity for nearly 23 years, offering a unique opportunity to study this rare cetacean species. Unfortunately, efforts to establish a captive breeding population of Baiji ultimately failed when "*Zhenzhen*," the only female Baiji captured for reproduction with *Qiqi*, died in an accident attributed to inadequate infrastructure and limited understanding of the species' medical care. Despite this setback, the potential for captive breeding to preserve a genetic pool for endangered cetaceans should not be overlooked. If a captive breeding population of Baiji were maintained today, we could explore various strategies to recover their natural population. Instead, we are now left with a deep sense of regret for what could have been.

Drawing lessons from Baiji conservation, it is crucial to integrate *in-situ* and *ex-situ* measures into a comprehensive "One Plan" toolbox for the conservation of YFP (Fig. 3). Key elements of this integrated approach include:

1. *Natural Habitat Protection* (*In-Situ*): Protecting natural habitats is the most fundamental and effective measure for conserving endangered small cetaceans. It is essential to identify the major threats to the target species and work by all means to eliminate or mitigate these threats within designated protected areas.

2. *Ex-Situ Options*: Establishing *ex-situ* insurance populations in protected natural sanctuaries and/or maintaining small captive populations under human care can serve as valuable tools for supporting the survival and recovery of small cetacean populations.

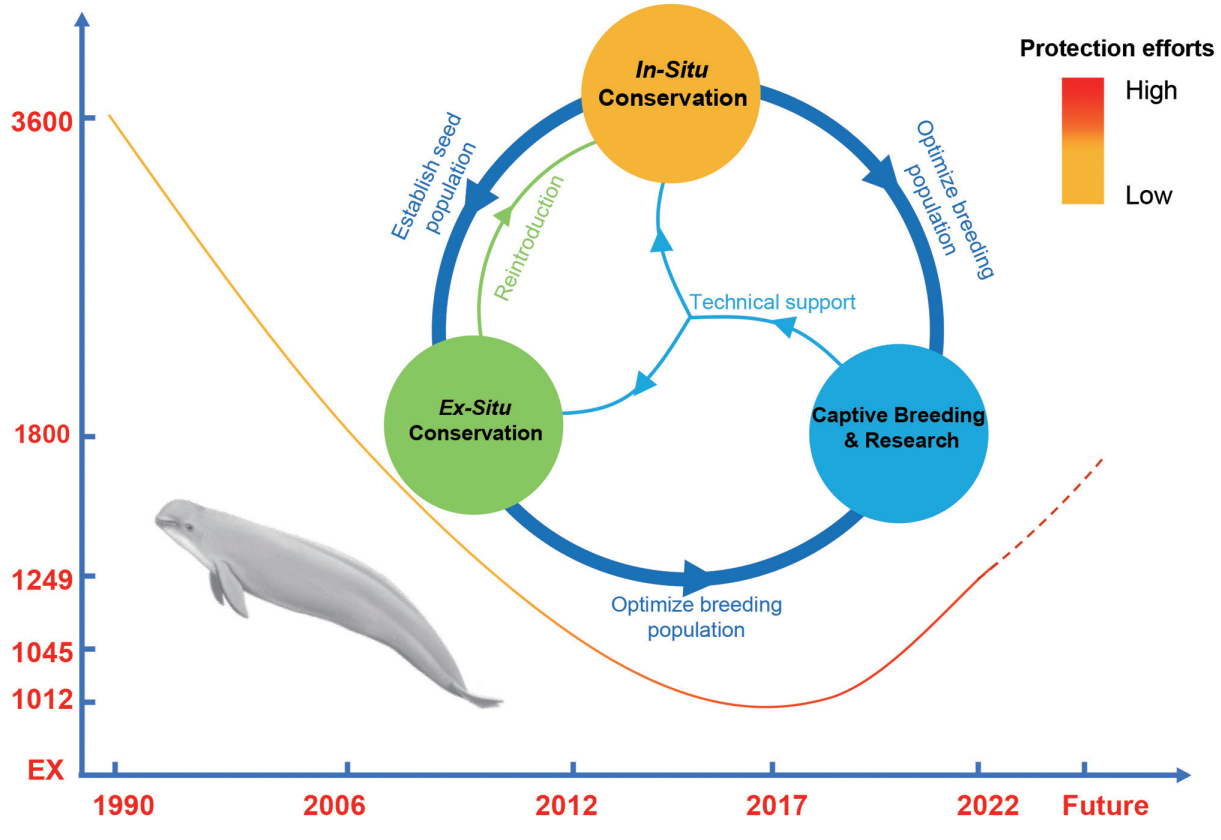
3. *Timing of Ex-Situ Interventions*: The timing of introducing *ex-situ* options is critical, as implementing these measures requires significant time and resources. It is important to proceed cautiously; hasty or forced implementation of *ex-situ* actions may lead to unforeseen losses, especially if these measures are introduced before the necessary infrastructure and tools are in place, particularly for critically endangered populations.

By thoughtfully incorporating these elements, the effectiveness of conservation efforts for YFP has been significantly improved, establishing a model for the conservation of endangered small cetaceans worldwide.

Progress in the Conservation of YFP

Ex-situ practices for the conservation of YFP were initially introduced in 1990 as a pretest to exploring the potential for establishing an *ex-situ* Baiji population in Swan Oxbow, Hubei Province, despite the fact that the natural population of YFP was not a major concern at that time. Coincidentally, the first *ex-situ* population of YFP was established and gradually expanded through

Fig. 3. Schematic overview of the integrated conservation strategy for endangered small cetaceans: a case study of Yangtze finless porpoise conservation practices (the colored line indicates the population trajectory of the Yangtze finless porpoise).



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several introductions in the following years. As management capacity for the *ex-situ* population grew, the number of YFP in the oxbow began to increase rapidly after 2010. By 2015, this population had grown to more than 60 individuals from an initial 25 in 2010, representing a net increase of 108% in five years (Wang, 2015). This number continued to rise, surpassing 100 individuals by 2021 (Hao *et al.*, 2023). However, during the same period, the natural population of YFP experienced a drastic decline due to the ongoing degradation of its habitat in the Yangtze River (Mei *et al.*, 2014; Huang *et al.*, 2020). In response, researchers from the Institute of Hydrobiology (IHB), CAS and other research institutions advised the Ministry of Agriculture and Rural Affairs of China to efficiently mobilize the necessary resources, successfully establishing two additional *ex-situ* populations in Hewangmiao Oxbow in Hubei Province (named as Jicheng in Hunan Province) and Xijiang Oxbow in Anhui Province in 2015 and 2016, respectively (Hao *et al.*, 2023). Drawing on the lessons learned from the experiences in Swan Oxbow, these new *ex-situ* populations have shown steady growth, with current populations exceeding 40 and 20 individuals, respectively. Collectively, the three *ex-situ* populations now comprise over 150 animals, providing a solid foundation for the conservation of this species. In 2023, four animals from the Swan Oxbow were systematically acclimated to the wild and successfully released into the Yangtze River. This marks the first instance of releasing *ex-situ* protected YFP, demonstrating the completion of a comprehensive technological framework of *ex-situ* conservation for this species. This achievement serves as a significant encouragement for *ex-situ* conservation practices aimed at other endangered small cetaceans.

Establishing a captive breeding population of YFP was also a long and challenging journey for Chinese researchers. In the mid-1990s, scientists from IHB, Nanjing Normal University, and other institutions began their efforts to raise finless porpoises in captivity. Unfortunately, most of these initial attempts ended in failure due to inadequate infrastructure and a lack of technical expertise. However, thanks to the tireless dedication of IHB researchers, the first successful captive population was established at the Baiji Dolphinarium of IHB, also known as the Yangtze Cetacean Breeding and Research Center, in 1996. This initial population consisted of two young females and one male. Through ongoing research into husbandry and reproduction, the first baby porpoise was successfully born in captivity in 2005 (Wang *et al.*, 2005). As knowledge of reproductive practices continued to grow, the survival rate of newborn porpoises improved steadily. Currently, there are five porpoises that have been successfully born and are alive in captivity, including

Fig. 4. The Yangtze finless porpoise housed in the Baiji Dolphinarium in Wuhan.

Graphic: IHB

three second-generation individuals (Fig.4). This captive breeding initiative has not only generated a wealth of knowledge and experience in the care and management of these animals but has also created unique opportunities for the public to learn about the YFP. This increased awareness has significantly inspired public concern, compassion, and commitment to the conservation of these unique small cetaceans and their ecosystem, effectively fostering widespread involvement in the conservation of YFP and the Yangtze River ecosystem overall.

As mentioned earlier, *in-situ* efforts to protect key habitats are essential for the conservation of endangered species. However, implementing these measures is particularly challenging due to the significant conflict between development and protection. This is especially true for the Baiji and YFP, which inhabit the Yangtze River—a region affected by intensive human activities such as fishing, shipping, industrial and agricultural pollution, sand dredging, and hydro-project construction, etc. Initial nature reserves were established from the late 1980s to the early 1990s; however, the ongoing decline of the natural Baiji and YFP populations indicates that these disconnected reserves have been ineffective in the bustling economic belt of the Yangtze River. The disappearance of the Baiji and the dramatic decline of YFP have heightened awareness of the need to protect the Yangtze River in China, leading to a significant shift in the country's approach to development and conservation. In response to appeals from scientists and conservationists, the central government of China launched the Yangtze River Great Protection Program in 2016, which has been effectively implemented across various initiatives. These include a comprehensive 10-year fishing ban in the Yangtze basin, restrictions and regulations on sand dredging, cleaning and restoration of waterfront zones, and the relocation or renovation of chemical enterprises, etc. Thanks to the strong determination of the central government and effective actions of respective departments, the environment of the Yangtze River has shown rapid improvement over the past few years. Reports indicate that approximately 158 kilometers of the Yangtze River coastline has been restored, and 121,300 m^2 of beaches and banks have been rehabilitated. As a result, the water quality in 96.4% area of the Yangtze River basin was classified as good in 2020, and for the first time, the water quality of the entire mainstream reached Grade II of China (*News China*, 2022).

More encouragingly, a survey conducted in 2021 revealed improvements in the fish community structure in the Yangtze River, with fish resources showing signs of replenishment (Yang *et al.*, 2023a; Yang *et al.*, 2023b). Additionally, some rare or endangered fish species have begun to reemerge (Yang *et al.*, 2023a). Due to habitat improvements, the population of YFP has reversed its declining trend, reaching 1,249 individuals, according to a survey conducted in 2022. This marks the first increase in the natural population of YFP since systematic assessments began in the early 1990s.

The success of conservation efforts for the YFP serves as a valuable model for endangered cetacean conservation through the implementation of an integrated conservation strategy. Proactive measures, including the establishment of natural *ex-situ* insurance populations and the initiation of captive breeding programs, were implemented before the decline of the wild population became apparent. Furthermore, despite significant progress in maintaining insurance populations within *ex-situ* reserves and captive facilities, Chinese authorities have continued to pursue strategies for conserving the wild population, even amidst the intense pressures of economic development. These outcomes demonstrate that, under appropriate circumstances, an integrated strategy can yield successful results. This provides critical insights for the conservation of other endangered small cetaceans worldwide.

Insights for Protection of Other Endangered Small Cetaceans

Like the Baiji and YFP, numerous small cetaceans around the world are grappling with various threats stemming from human activities. The IUCN Cetacean Specialist Group has evaluated and identified several small cetacean species that are currently in a precarious status (Taylor *et al.*, 2020). These species inhabit areas that are adjacent to expanding human populations, making them highly vulnerable to human impacts.

In this discussion, we will adopt the integrated approach to analyze case studies on three selected species that represent different levels on the endangerment spectrum. We will examine their threats, biological characteristics, knowledge gaps, and other influencing factors to highlight insights that can inform conservation strategies for these species.

1. Vaquita:

The vaquita (*Phocoena sinus*) is a critically endangered small por-

poise native to the Upper Gulf of California, Mexico. Its habitat lies entirely within the narrow waters heavily exploited for fishing, primarily through the use of trawls and gillnets (Jefferson *et al.*, 2011). As a result, bycatch poses a significant threat to the survival of this species. Although a protected area was designated in 2005, efforts to enforce a ban on gillnets within its range have proven ineffective. Acoustic monitoring has indicated a dramatic population decline, estimated at over 40% per year since approximately 2011 (Jaramillo-Legorreta *et al.*, 2019; Cisneros-Mata *et al.*, 2021). Currently, the vaquita population is believed to consist of fewer than 20 individuals, raising concerns that it may become the next extinct species after the Baiji.

Attempts at *ex-situ* conservation yielded tragic outcomes in 2017, when two vaquitas were captured. One old female died due to confinement stress, while the other juvenile female was promptly released after exhibiting severe stress responses. Following this failure, these efforts were halted, underscoring the necessity for a comprehensive evaluation of an integrated conservation strategy.

The case of the vaquita demonstrates that establishing an *ex-situ* population for a cetacean species that has not been extensively studied is a formidable challenge. Different species can exhibit varied behavioral and physiological responses to interventions, making the learning curve steep. A critical insight gained from the vaquita situation is that *ex-situ* options should be pursued well before a population reaches critically low numbers. In the current dire circumstances, the loss of even a single individual during capture operations is untenable. The most viable strategy now for ensuring the survival of this species is to implement robust law enforcement within its core habitat, similar to the comprehensive fishing ban enforced in the Yangtze River in China. Given the complexity of the political, social, and economic issues involved, implementing a widespread fishing ban in this region is exceedingly challenging. However, without such extreme measures, we have to risk witnessing the extinction of yet another small cetacean species in the near future.

2. Irrawaddy dolphin

The Irrawaddy dolphin (*Orcaella brevirostris*) is widely distributed in coastal and freshwater habitats throughout Southeast Asia (Jefferson *et al.*, 2011). The freshwater subpopulations are primarily small and fragmented, with five of these populations classified as Critically Endangered (located in Cambodia/Laos, Indonesia, Myanmar, the Philippines, and Thailand) (Beasley *et al.*, 2013; Jackson-Ricketts *et al.*, 2020; Kreb *et al.*, 2020). Current estimates suggest that all these populations number fewer than 100 individuals. The primary threat to this species across its range is bycatch in gillnets (Smith & Tun, 2007).

Some progress has been made to mitigate these threats—such as establishing protected areas, enhancing the enforcement of fishing regulations, and engaging local communities in conservation efforts, particularly with the population in the Mekong River (Thomas & Gulland, 2017). However, there is no credible evidence showing these initiatives have led to an increase in population abundance. Additionally, some *Orcaella* dolphins are held in aquariums, including a freshwater population in Indonesia and two coastal populations in Thailand and Vietnam, respectively. These existing facilities may offer valuable insights and experience that could inform the development of an *ex-situ* conservation program as part of an integrated strategy.

The threats faced by the small, discrete populations of *Orcaella* are well-defined, with overfishing through gillnets identified as the primary cause of mortality for this species. Despite considerable efforts by authorities in these countries, effective law enforcement remains a significant challenge. Local authorities could benefit from learning from China's experience by transitioning fishing communities to alternative livelihoods through training programs and social insurance arrangements. Ultimately, this is primarily an economic issue. If negotiations are prolonged, the chances of saving the freshwater subpopulations of Irrawaddy dolphins will diminish. Moreover, we must recognize that we are on the brink of a critical moment to consider *ex-situ* options. While establishing natural *ex-situ* populations, like the Oxbow model for YFP, may present challenges in Southeast Asian countries, it remains a worthwhile endeavor.

3. Indus River dolphin

The Indus River dolphin (*Platanista gangetica minor*) is endemic to the Indus River system, primarily located in Pakistan. This species has experienced an 80% reduction in its range and is estimated to number around 2,000 individuals, fragmented into five distinct sections of the river system (Jefferson *et al.*, 2011; Braulik *et al.*, 2024). Since the hunting ban was implemented in the 1970s, the dolphin population is believed to have been steadily increasing. Unlike other small cetaceans mentioned previously, bycatch is not the primary threat to this subspecies. Instead, the most significant threat comes from

ongoing habitat loss due to the diversion of river water for irrigation in arid lands, which are increasingly occupied by a growing human population. Additionally, most individuals are confined to a single section of the river, making them particularly vulnerable to catastrophic events (Nabi *et al.*, 2021).

Currently, there are no Indus River dolphins held in captivity. However, rescues of dolphins that become trapped in irrigation canals present valuable opportunities to handle these animals. Such interactions could provide crucial data to address knowledge gaps related to handling, health assessments, and husbandry practices.

Given the current population size, the effectiveness of existing *in-situ* conservation measures, and the success of recent rescues of dolphins isolated in canals, there is no immediate urgency to pursue *ex-situ* options for this species. However, it is essential to gather data to address knowledge gaps related to handling, health assessments, and husbandry practices as part of an integrated conservation strategy.

For other species within the spectrum of endangered small cetaceans listed by the IUCN specialist group, the relatively large size of their populations means that there is currently no urgent need to consider *ex-situ* options. *In-situ* conservation measures should remain the top priority within the integrated conservation toolbox. However, it is highly recommended to address existing information gaps regarding population status, threats, veterinary care, and animal husbandry. This proactive approach will ensure that we are prepared to implement *ex-situ* actions if the need arises in the future.

Conclusions

The achievements in YFP conservation exemplify a successful model for utilizing an integrated conservation strategy to protect an endangered small cetacean species and offer valuable insights for the conservation of other endangered small cetaceans worldwide. Although species-specific measures must be developed for each target species due to differences in population status, threats, and social challenges, there are several key principles that can serve as guidelines:

1. Prioritize *In-situ* Measures: *In-situ* conservation efforts should always be the top priority in any conservation strategy.

2.Proactive *Ex-situ* Preparations: *Ex-situ* measures must be prepared proactively before populations decline to critical levels.

3. Address Knowledge Gaps: Different species may respond differently to conservation interventions, so it is crucial to gradually fill knowledge gaps, such as veterinary care and animal husbandry, before they become urgent needs.

4. Avoid Last-Minute *Ex-situ* Measures: Avoid hastily resorting to *ex-situ* options at the last moment, as this leaves you with limited strategies and reduces the chances of success, as demonstrated by the case of the vaquita and Baiji.

5.Implement Extreme Measures When Necessary: In dire situations, such as the need for a comprehensive fishing ban in the Yangtze, strong will and determination from local authorities are essential for effective action.

These principles can guide broader conservation efforts for small cetaceans facing similar threats.

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