



## Short communication

# Drastic decline in spawning activity of Chinese sturgeon *Acipenser sinensis* Gray 1835 in the remaining spawning ground of the Yangtze River since the construction of hydrodams

By J. M. Wu<sup>1,2,\*</sup>, C. Y. Wang<sup>1,2,\*</sup>, H. Zhang<sup>1,2</sup>, H. Du<sup>1,2</sup>, Z. G. Liu<sup>1,2</sup>, L. Shen<sup>1,2</sup>, Q. W. Wei<sup>1,2</sup> and H. Rosenthal<sup>3</sup>

<sup>1</sup>Key Laboratory of Freshwater Biodiversity Conservation, Ministry of Agriculture of China, Yangtze River Fisheries Research Institute, Chinese Academy of Fishery Sciences, Wuhan, Hubei, China; <sup>2</sup>Freshwater Fisheries Research Center, Chinese Academy of Fishery Science, Wuxi, Jiangsu, China; <sup>3</sup>World Sturgeon Conservation Society, Home Office, Neu Wulmstorf, Germany

### Introduction

As a typically anadromous fish, the Chinese sturgeon *Acipenser sinensis* Gray 1835 grows in waters off the continental shelf of East Asia and spawns in upper river reaches (Yangtze Aquatic Resources Survey Group, 1988; Wei, 2003). At present, all sturgeon populations around the world are at risk of extinction. The need for urgent countermeasures has been expressly pronounced in the 'Ramsar Declaration on Global Sturgeon Conservation', formulated during the 5th International Symposium on Sturgeons (ISS5) held in Ramsar, Iran (Rosenthal et al., 2006), and during subsequent global conferences such as the ISS6 in Wuhan, China (2009), and ISS7 (Nanaimo, Canada) in 2013 (Rosenthal et al., 2011, 2014) and on many other occasions. Principal reasons for these dramatic declines have been clearly identified: (a) construction of hydroelectric dams, (b) overfishing, (c) navigation, and (d) pollution. The Yangtze River population is at present the last remaining population of *Acipenser sinensis* (Wei et al., 1997). Scientists have identified and tested strategies and tools for effective conservation, including extensive monitoring efforts to observe the spawning intensity and success, with the additional initiation of extensive programmes for release (Wei, 2003). *A. sinensis* was classified as Critically Endangered (CR) in the 2010 IUCN Red List.

A brief account of the observations readily explains the reproductive strategy of the species: Adults in stage III of gonadal development enter the Yangtze River every year between June and October, then migrate upstream for more than 2 600 km to the upper reaches of the river to overwinter. They thereafter reach full gonadal maturity and spawn during the autumn of the subsequent year (Wei et al., 1997; Wang et al., 2012), thus spending about 12–15 months on

the spawning grounds to complete their gonad development while preparing for reproduction. However, construction of the Gezhouba Dam (rkm 1678) has blocked the spawning migration of the species since 1981. As a result, all upstream spawning grounds covering an 800 km river stretch with at least 16 known spawning locations were no longer accessible, as no fish passage was available to overcome the dam during spawning migration. Fortunately, the fish formed almost a type of emergency measure by creating a new – but lone – Gezhouba spawning ground (GSG) in 1982, within 3.85 km below the dam (Zhang et al., 2009; Wang et al., 2013, 2014; Fig. 1). Spawning events were observed every year from 1982 through 2012, showing that although small, this spawning ground was successful for over 31 years for this remaining population. However, no *A. sinensis* was observed to spawn in the GSG in the past 2 years (2013 and 2014), although spawners were documented by echosounder surveys and in by-catches of each year.

The objective of this brief summary on long-term observations describes the trend (over the past 33 years) in the numbers of *A. sinensis* spawners as well as the timing of spawning activity and location of spawning on the only known spawning reach below the Gezhouba Dam since its construction.

### Materials and methods

To acquire basic information on the size of the spawning population, scientific studies were obtained regularly via capture data (1983–2008), accompanied by hydroacoustic surveys from 2006 to 2014. Four approaches were applied to identify the *A. sinensis* spawning time and locations: (i) From 1996 to 2014, D-drift nets were placed near the spawning ground river bottom to sample eggs and larvae. Typical results were provided by Wei et al., 2009; (ii) Egg-predatory fishes were collected in the spawning reach, then dissected to determine the predation rate of *A. sinensis* eggs in their

\*Equal contributors

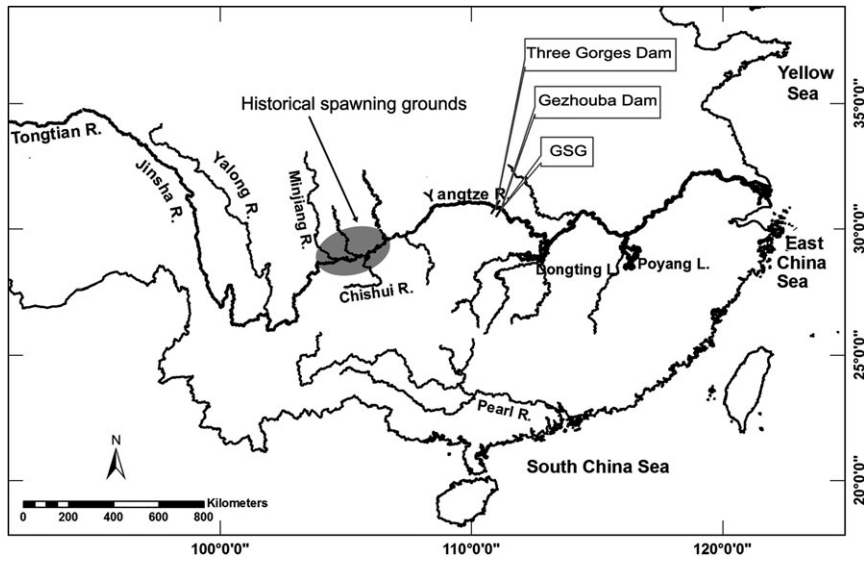


Fig. 1. Historical (grey shaded area) and current (arrow-marked) spawning grounds, *Acipenser sinensis*, Yangtze River. GSG = Gezhouba spawning grounds (only known remaining spawning grounds since 1984)

stomachs, thereby providing an approximate estimate of the spawning intensity; (iii) Acoustic telemetry of tagged spawners was additionally employed to confirm the position of selected spawning sites, and (iv) The occurrence of the developmental stage of larvae was followed in order to back-calculate the spawning time and identify the possible spawning location.

In order to determine whether or not potential spawning events took place not only on the Gezhouba spawning ground, but also in the other parts of the Yangtze River downstream of the Gezhouba Dam during the autumn-winter period of 2013, juvenile-surveys were additionally performed beginning at the Gezhouba Dam downstream to the Yangtze estuary in April–September of 2014 and April–July of 2015.

**Results**

**Observations and estimates on spawner population numbers**

From the time the Gezhouba dam became operational in January 1981, the number of adult sturgeons arriving at the GSG accounted for a total of 2176 individuals over the next 2 years (Fig. 2). All subsequent observations since that time

have indicated that the spawner population gradually declined further: Between 1996 and 2001, the breeding population arriving at the GSG varied from 292 to 473 individuals, with an average just above 360 fish per spawning season. In 2002, an estimate of only 222 breeders remained at the spawning ground; the numbers fluctuated each year thereafter (Qiao et al., 2006; Zhang et al., 2014). Between 2006 and 2014, the spawner population was significantly smaller and varied from 57 to 188 individuals (Fig. 2).

**Spawning time and frequency of active spawner cohorts 1984 – 2012**

From the time of the alternative spawning site below the Gezhouba Dam, two typical trends related to the main spawning dates of *A. sinensis* in the Yangtze River: (i) prior to the impoundment of the Three Gorges Dam (TGD, 1984–2002); and (ii) thereafter, between 2003 and 2014. During the first period, all spawning occurred reliably in October. In these 19 years of observations, active spawning periods occurred ten times in mid-October and nine times in late October. However, the spawning dates were delayed to November after completion of the TGD impoundment in

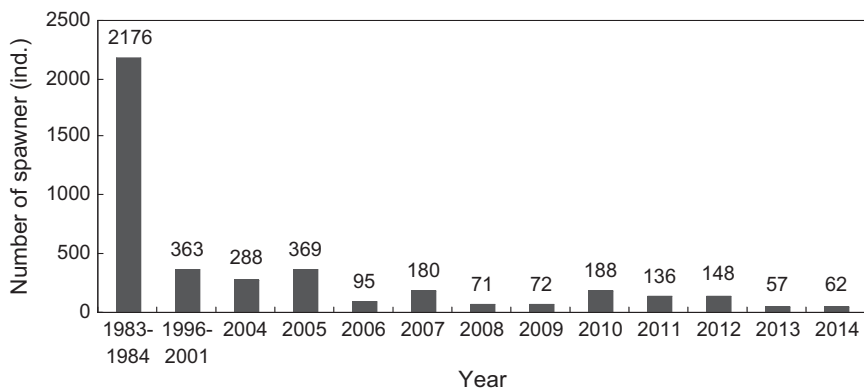


Fig. 2. Total annual observed number of *A. sinensis* spawners in GSG (Gezhouba Spawning Grounds) since monitoring began in 1983

2003. During the subsequent years of observation, spawning took place in November, five times even in late November (Fig. 3). In addition, the average subsequent frequency of occurrence of active breeding cohorts during one season dropped from 1.8 during 1984–2003, to 1.1 cohorts per period during the years 2004–2012 (Fig. 4). Noteworthy is that there were no conditional or operational changes made in the spawning ground during the entire observation period, which was restricted to a stretch of reach 3.85 km in length just below the GZD between 1984 and 2012.

**Observations on the spawning status of *A. sinensis* during 2013 and 2014**

During the entire known spawning season, *A. sinensis* neither spawned in the last freshwater habitat (GSG) in 2013, nor were juveniles found in the following year along the river from the GZD to the Yangtze estuary. However, despite the fact that spawning was not documented in the GSG during the 2014 spawning period, a 10-cm long juvenile was caught in the Yangtze estuary on 21 April 2015. Subsequently, a peak of captured juveniles appeared in May and June 2015, and by early August more than 3 000 individuals were caught at the mouth of the Yangtze River. The sizes of the fish were smaller than those individuals captured in previous years, and the timing was also earlier than in previous years. Therefore, we conclude that an unknown – or even new (alternative) – spawning ground that is closer to the estuary

than to the GSG may have been formed by the remaining spawner cohort.

**Discussion and Conclusions**

The observation of an apparently complete spawning failure in the Yangtze River in 2013 must be taken as a danger signal in that our conservation measures must be greatly enhanced and expanded with additional strategic approaches if we are to save this species. Otherwise it must be realized that this remaining, but very small, natural population of China First-Class Protected Animals is at high risk of extinction.

There is an urgent need to expand the current downstream research for potential additional or alternative spawning sites, to further improve the culture methodologies, to provide juveniles with a high fitness for survival at release, and to initiate pilot trials to establish artificial spawning habitats at suitable sites. Such studies in relation to the changing annual temperature profiles since the impoundment of the TGD may also serve as model cases to study the effects of climate change on reproductive success of migratory and highly endangered fish species such as the Chinese sturgeon.

Positive news in this context is that the Central Government of China has developed an integrated rescue plan, which includes in-situ and ex-situ conservation, conservation of genetic resources, and measures for public support. It is hoped that this plan will be issued in the very near future,

Fig. 3. Timing of beginning spawning activity of *Acipenser sinensis* as identified by annual spawning dates for first spawner cohort in the GSG, 1984–2012. No spawning *A. sinensis* cohorts were observed at this site in 2013 or 2014

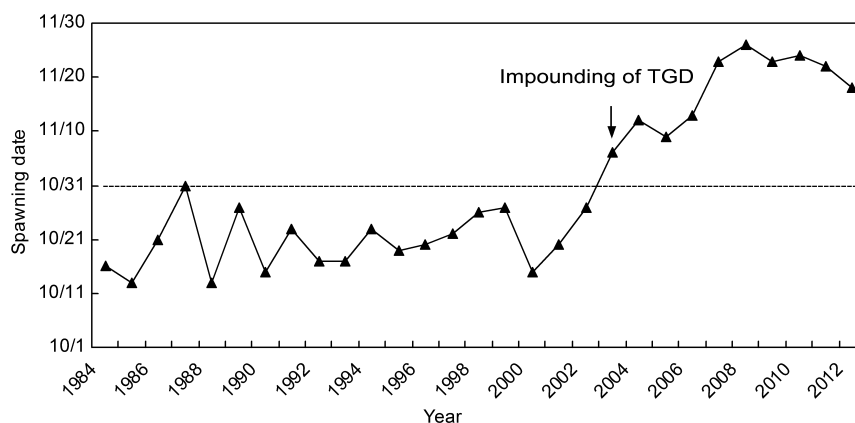
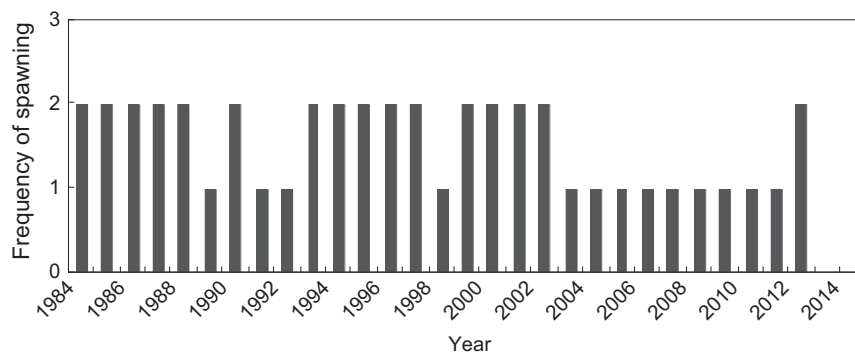


Fig. 4. Frequency of occurrence of *A. sinensis* spawner cohorts on known alternative spawning grounds below Gezhouba Dam (GSG) since its construction (observation period, 1984–2014). Note: No spawning observed in 2013 or 2014



providing the unique opportunity to bundle the available scientific expertise with the societal abilities to implement a fully integrated rehabilitation programme for *A. sinensis*. This appears to be the final opportunity to reach a future and effective recovery for this ancient bio-indicator fish in order to thrive in our waters.

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**Author's address:** Qiwei Wei, Yangtze River Fisheries Research Institute, Chinese Academy of Fisheries Science, No.8, 1st Wudayuan Road, Donghu Hi-tech Development Zone, Wuhan 430223, China.  
E-mail: weiqw@yfi.ac.cn