



# Spatiotemporal response of pelagic fish aggregations in their spawning grounds of middle Yangtze to the flood process optimized by the Three Gorges Reservoir operation



Jiangping Tao<sup>a,b</sup>, Zhi Yang<sup>a,b</sup>, Yupeng Cai<sup>a</sup>, Xiang Wang<sup>a</sup>, Jianbo Chang<sup>a,b,\*</sup>

<sup>a</sup> Key Laboratory of Ministry of Water Resources for Ecological Impacts of Hydraulic-projects and Restoration of Aquatic Ecosystem, Institute of Hydroecology, Ministry of Water Resources & Chinese Academy of Sciences, Wuhan, 430079, China

<sup>b</sup> Hubei Provincial Collaborative Innovation Center for Water Resources Security, Wuhan 430072, China

## ARTICLE INFO

### Article history:

Received 27 October 2016

Accepted 4 March 2017

Available online 31 March 2017

### Keywords:

Fish aggregations

Dam operation

Spatiotemporal distribution of fish

Three Gorges Reservoir

Yangtze River

Hydroacoustic surveys

## ABSTRACT

Flood patterns altered by regulation and operation of the Three Gorges Reservoir (TGR) on the Yangtze has negatively affected fish spawning downstream, particularly results in the decline of spawning sizes. The TGR release was optimized by reoperation for enhancing fish reproduction downstream since 2011. Response of spawning sizes to the flood alteration was documented, yet little is known concerning the adult fish. Accurate estimate of spatiotemporal changes and abundance of adults in the spawning grounds is critical for quantifying the contribution of flood changes to the spawning. This study used hydroacoustic surveys to document the response of fish aggregations to the changes of flood process (i.e., deployed before-, during- and after flood) on the Jingjiang- and Yichang spawning ground. Acoustic signals from fish tracking were allocated into two groups according to frequency distributions of Target strength (TS), defined as small fish ( $-60 \text{ dB} < \text{TS} < -35 \text{ dB}$ ) and large fish ( $\text{TS} > -35 \text{ dB}$ ). Sizes of small fish acquired before- and during flood were significant larger than those acquired after flood whereas no significant different observed for large fish. Both small and large fish aggregated in both spawning grounds during flood and disappeared after flood. Besides, fish numbers presence in both spawning grounds during flood was greater than those before and after flood. This study suggested spatial distributions of fish aggregations with different sizes in both spawning grounds shifted with the flood changes. Fish aggregated into the spawning grounds for spawning during the flood and departed after the flood, resulting in large fish numbers presence during the flood period. Further research is required to reveal relationships between the hydrological and hydraulic changes results from flow alteration and fish responses to realize their precise requirements and behaviors for spawning.

© 2017 Published by Elsevier B.V.

## 1. Introduction

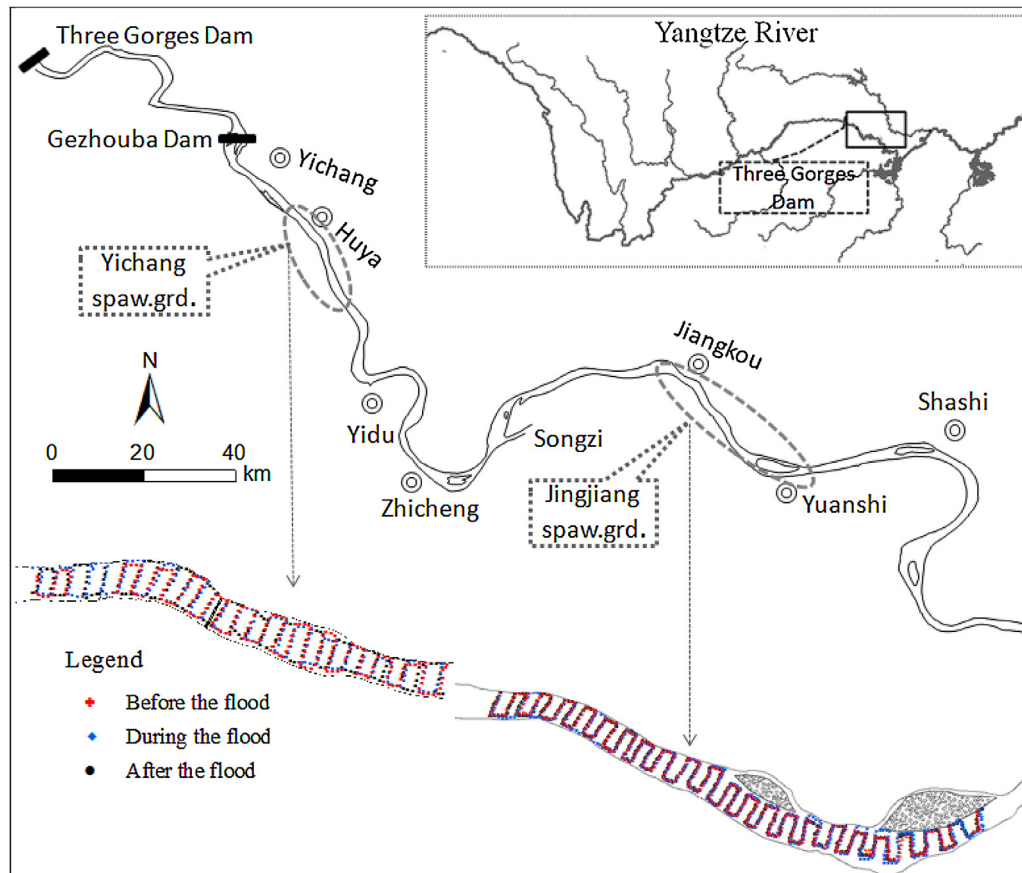
The construction and operation of dams is a major global threat to river, floodplain and estuary ecosystems (Nilsson et al., 2005; Górski et al., 2012). Of all the environmental variables, the alteration of flow patterns and water thermal regimes affects aquatic biotic integrity and perhaps is the greatest anthropogenic impact on the functioning of large river ecosystems (Richter and Thomas, 2007; Bailly et al., 2008). The flow patterns and water thermal regimes altered by regulation and operation of dam have negatively affected life history of fish species (Baumgartner et al., 2014) since

some key stages of several species are essentially connect to the these regimes (Bailly et al., 2008). Correlations between flow patterns and water thermal regimes to the key stage of fish spawning have been documented in a number of river systems (King et al., 1998; Robinson et al., 2004).

The middle Yangtze River (from Yichang to Hukou, ~898 km in terms of length) has 107 fish species on record, including ~40 of which are endemic and commercially important to the river (Yi et al., 1988; Duan et al., 2009). The reach from Yichang to Chengjingji, ~380 km in terms of length, is one of the most important habitats for the endemic and commercially important species. In this river reach there were eleven spawning grounds recorded for the commercially important species such as four Chinese carps, i.e., black carp (*Mylopharyngodon piceus*), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) (Yi et al., 1988), as well as for other pelagic species (Qiu

\* Corresponding author at: 578#, Xiongchu Avenue, Wuhan, Hubei Province 430079, China.

E-mail address: [jbchang@mail.ihe.ac.cn](mailto:jbchang@mail.ihe.ac.cn) (J. Chang).



**Fig. 1.** Acoustic surveys in the spawning grounds of fish that spawn pelagic eggs in the middle Yangtze River during the different periods of the Three Gorges Reservoir reoperations.

et al., 2002; Duan et al., 2008). These spawning grounds together shared 42.7% of fish larvae production of the total Yangtze River in 1960s (Yih and Liang, 1964; Yi et al., 1988). Since the construction of the Gezhouba dam in 1981 and the phased impoundments of the Three Gorges Reservoir (TGR) from 2003 plus other anthropogenic effects, annual fish larvae abundance declined by more than 80% (Duan et al., 2008, 2009), with a gradual delay of their spawning time (Xu et al., 2014; Wang et al., 2014a).

The decline of larvae abundance and the delay of spawning time are significantly attributed to the changes in flow patterns and water thermal regimes that altered by the dam operations (Wang et al., 2014b). Previous studies suggest three hydrological and environmental variables are the synchronizing trigger for spawning events: a suitable water temperature between 18 °C and 28 °C with an optimum one between 21 °C and 24 °C (Yih and Liang, 1964; Yi et al., 1988), simultaneously occurrence of daily flow increase and suitable flood peaking (Zhang et al., 2000; Yi et al., 2010). Moreover, the flow increase, such as duration, daily increasing rate and timing directly results in the spawning events (Zhang et al., 2000; Wang et al., 2014b). The regulation and operation of the TGR have altered the discharge by a range of 21–100% since the first impoundment in 2003 (Cai et al., 2013), particularly resulted in the alterations of daily increasing rate, lowering flow pulses and hydrological reversals (Wang et al., 2014b, 2016). Due to the impoundments and regulations of TGR, the water temperature of discharge lowers by 2–5 °C during the flood seasons from April to June compared to the corresponding period of pre-impounding (Yu et al., 2007; Wang et al., 2014a). This type of change in water temperature indicated a delay of the temperature-rising process (Yu et al., 2007), resulting

in the delay of spawning activities (Zhang et al., 2012; Wang et al., 2014a).

To reduce the adversely effects of dam operations on the fish spawning, one way to this end is to simulate a nature flow and thermal regime by dam reoperation (Baumgartner et al., 2014). With purpose of enhancing the natural reproduction of fish downstream, the TGR conducted the experimental reoperation to release suitable flow process since 2011 (Xu et al., 2014). During which periods the optimized flood process was adopted to satisfying the fish spawning. Xu et al. (2014, 2015) documented the relationship between spawning sizes and flood process optimized by the TGR. Moreover, the existing studies focused on the response of production of eggs and larval fish to the flood changes. Yet litter is known concerning the response of the spatiotemporal patterns and abundance of adult fish. It is of importance to estimate the potential abundance of adults present in the spawning grounds so as to eliminate the effect of adults' abundance on the spawning sizes to quantify the efficiency of flood changes on fish spawning.

Additionally, adult fish are frequently highly selective in their use of habitat (Tao et al., 2012; Li et al., 2015), especially in their use of spawning grounds (Winfield et al., 2015). Spatial heterogeneity of fish abundance is correlated to certain hydrological and environmental variables (Horne et al., 1999; Li et al., 2015). Luo (2013) studied the migration pattern of adult four Chinese carps in the middle Yangtze using the ultrasonic telemetry. Yet litter is known about the temporal and spatial response of adult species to the changes of flood process because it is difficult to deploy by traditional techniques (DeMérone and Albert, 1999; Wang et al., 2014b). The development and improvement of scientific acoustic

Download English Version:

<https://daneshyari.com/en/article/5743566>

Download Persian Version:

<https://daneshyari.com/article/5743566>

[Daneshyari.com](https://daneshyari.com)