Study on Determination Method of Target Fishes for Ecological Flow in the main Stream of Huaihe River

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Abstract. Reasonable ecological flow based on biological indicator is crucial for river ecosystem health and restoration. Selection of biological indicator, often being the target fishes, is of great importance. Differentiating from the traditional way of choosing the rare or economic fishes as the target fishes, a more objective approach was applied in this study. Firstly, the field investigation was conducted to determine the alternative fishes range. Then, the Analytic Hierarchy Process (AHP) was employed to construct the judgment matrixes, aiming at obtaining the order weight values of the selected fishes and screening for the target fishes. This step made sure that the target fishes were representative for habitat requirement for Huaihe River. Based on fish resources data, 20 alternative fishes were selected, including 12 Cypriniformes, 3 Siluriformes, 4 Perciformes, and 1 Clupeiformes species. The results of the order weight values of the judgmental matrix showed that *Parabramis pekinensis* might be taken as target fishes for calculating ecological flow because it could represent hydrological requirement for aquatic biology in the main stream of Huaihe River. This study provided a promising method for target species selection in the rivers where rare and endemic species are unavailable.

1. Introduction

With the increase of water resources demand, river regulation through dams and floodgates has become a global phenomenon (Nilsson, 1994; 2005). Currently, 60% of the world’s rivers are fragmented by hydrologic alteration, and this figure is projected to grow to 70% by 2025 (Revenga et al., 1998; 2000). To reduce the ecological impacts of flow alteration, flow restoration is attracting more interest (Dolédec et al., 2015). The need to sustain the ecological values of rivers is widely recognized and implement in different policies and legislations (Ahmadi-Nedushan, et al., 2006). In a recent review of the status of ecological flow methodologies, Tharme recognized the existence of 207 individual methodologies, recorded in 44 countries around the world. These methods can be categorized into four types: hydrological, hydraulic, habitat simulation and holistic methodologies (Tharme, R.E., 2003). Habitat simulation methods consider both environmental flow and biological process, and define ecological water requirement by aquatic organism reacting to water environmental factors. They are not only more meaningful in ecology than hydrology and hydraulics methods, but also easier and more objective than integrated methods, and have already achieved good results in practice (Li, et al., 2011a).

Fish are the climax community in river ecosystem. They are affected by water environment, and have influence on the structure and function of water ecosystem in return (Vehanen et al., 2005).
Therefore, fish habitat study is effectual and objective for evaluating river health (Li, et al., 2011b). However, the selection of target species for habitat simulation representing the maximum level of the habitat requirement of their community is very difficult since the fishes are very abundant (Siddig, et al., 2016). Due to the lack of justification behind the choice of any given target species, the selection of target species is often subjective. Therefore, this paper attempted to provide a promising method for target species selection in the rivers especially where rare and endemic species are unavailable.

2. Materials and Method

2.1. Study Area
The Huaihe River Basin (HRB) locates in the semi-humid monsoon climate region of eastern China, between the Yangtze River and the Yellow River (Fig1). The basin's topography is characterized by low plains with numerous lakes and depressions, except for moderately high mountains near the basin's boundaries. Rainfall mainly occurs in summer from June to September, with large annual and seasonal variability. Fishes and other aquatic economic animals and plants resources are very rich in the HRB. The main stream of the Huaihe River is about 1 000 km long, with 120 main tributaries (Hu, et al., 2008). There are four main flood control gates on the Huaihe River, about 4300 sluices, and over 5000 reservoirs, of which 16 are major reservoirs. During the 1980s and the beginning of the 1990s, with rapid economic development in the basin, water pollution became more and more serious, causing many incidents of severe contamination of the river (Jiang et al., 2009).

![Figure 1. The location of Huaihe River and the studied river reach](image_url)

2.2. Method
The selection of target species consists of two parts. Firstly, the field investigation was conducted to determine the alternative fishes range. Secondly, the Analytic Hierarchy Process (AHP) was used to further determine the target fishes.

The Analytic Hierarchy Process (AHP) is a theory of measurement for dealing with quantifiable and/or intangible criteria that has been widely used in decision theory. Application of AHP to a decision problem involves four steps (Ramanathan, R., 2001).

i. Define the problem and determine the kind of knowledge sought;
ii. Determine the criterion or property with respect to the characteristic of the elements;
iii. Make pair-wise comparisons and obtain the judgmental matrix;
iv. Test the consistency of comparison matrix.

3. Result and Discussion

3.1. Field Investigation
Fish resources data was collected from four field sampling during 2011-2015. The sampling data in 2011 March and September were provided by the Huaihe River Water Resources Protection Bureau, and the investigation in 2015 May and August was conducted by this study. Based on the fishes resources data in the main stream of Huaihe River, the species that appeared more than two times in the captured fish were chosen as alternative species. Finally, 20 alternative fishes were selected, including 12 Cypriniformes, 3 Siluriformes, 4 Perciformes, and 1 Clupeiformes species (Table 1). The spawning grounds and predatory feeding habit characteristic of alternative fishes were summarized to further determine the target fishes by the HAP.

3.2. Comparable Criterion
For further determining the target fishes, the comparable criterion with respect to biological characters of alternative fishes were developed (Table 2). Given the species vulnerable to environmental disturbance, fishes with velocity requirement of spawning ground and sexual maturity age more than 2 years were preferred. Since benthic fishes have better adaptability for the influence of gate and dam construction, fishes living in the middle and upper layer of water were consider with priority. Herbivorous and carnivorous medium-sized fishes were given priority to select with respect to the structure and function of river ecosystem. Wide distribution of fishes and native fishes and economic fishes was also has its advantage to choose, due to their contribution of fishery resources.

Table 1. Species composition of the captured fishes in the main stream of Huaihe River

| Species                      | 2011.3 | 2011.9 | 2015.5 | 2015.8 |
|------------------------------|--------|--------|--------|--------|
| **Cypriniformes**            |        |        |        |        |
| Hemiculter leucisculus       | √      |        | √      |        |
| Parabramis pekinensis        |        |        | √      |        |
| Abbottina rivularis          |        | √      |        | √      |
| Saurogobio dabyri            |        |        | √      |        |
| Pseudorasbora parva          | √      |        |        | √      |
| Hopophthalmichthys moliarix  |        |        | √      |        |
| Cyprinus carpio              | √      |        |        | √      |
| Carassius auratus            |        |        | √      |        |
| Opsariichtys uncirostrisbiden| √      |        |        |        |
| Erythroculter ilishaeformis   |        | √      |        |        |
| Rhodeus sinensis             | √      |        |        |        |
| Misgurnus anguillicaudatus    |        |        | √      |        |
| **Siluriformes**             |        |        |        |        |
| Pelteobagrus fulvidraco      | √      | √      |        |        |
| Leiocassis longirostris      |        | √      |        |        |
| Silurus meridionalis         |        | √      |        |        |
| **Perciformes**              |        |        |        |        |
| Siniperca chuatsi            |        |        | √      |        |
| Ophicephalus argus           | √      |        |        |        |
| Mastacembelus aculeatus      |        |        | √      |        |
| Ctenogobius giurinus         | √      |        |        |        |
| **Clupeiformes**             |        |        |        |        |
| Cpilia ectenes               | √      |        |        |        |

Note: √ means species was identified.
3.3. Target Species

Based on the habitat requirement of potential target species in the main stream of Huaihe River and the selected principle of target fishes, the judgment matrix was constructed. The maximum eigenvalue of the judgment matrix was 22.33, with the consistency ratio (CR) of 0.075. The CR was less than 0.1, which exhibited the judgmental matrix has good consistency. The result of the order weight values show that *Parabramis pekinensis* might be used as the target fishes for calculating ecological flow because it could represent hydrological requirement for aquatic biology in the main stream of Huaihe River (Table 3).

| Selection principles | Instruction |
|----------------------|-------------|
| Reproductive age     | Prefer fishes after sexual maturity age of 2 years old |
| Spawning environmental requirements | Prefer fishes with velocity requirement of spawning ground |
| Migratory habits     | Prefer the settling fishes |
| Feeding habits       | Prefer herbivorous and carnivorous fishes |
| Environmental requirements of life | Prefer fishes living in the middle and upper layer of water |
| The size of the adult fish | Prefer Large and medium- and large sized fishes |
| Distribution range   | Prefer widespread distribution fishes |
| Economic value       | Prefer native fish and economic fishes |

| Table 2. The selection principle of target fishes |

| Table 3. The order weight values of potential target species in the main stream of Huaihe River |
|---|---|---|---|---|---|
| species                      | Parabramis pekinensis | Erythroculter ilishaeformis | Siniperca chuatsi | Silurus meridionalis | Ophicephelus argus |
| Order weight values          | 4.09                | 3.06                | 2.96                | 2.59                | 2.06                |

4. Conclusions

With the HAP which combined the field sampling data and biological habits of alternative fishes with selected principle, *Parabramis pekinensis* might be taken as an target fish for calculating ecological flow because it could represent hydrological requirement for aquatic biology in the main stream of Huaihe River.

The selection of target fishes was the prerequisite and foundation for ecological flow calculation by Habitat simulation methods. This study provided a promising method for target species selection in the rivers where rare and endemic species are unavailable.

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