Proceedings of the International Symposium on Conservation and Eco-friendly Utilization of Wetland in the Three Gorges Reservoir

# Eco-Design of River Fishways for Upstream Passage: Application for Hanfeng Dam, Pengxi River, China*

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**Abstract**: This paper provides a scientific approach for the eco-design of river fishways to allow upstream movement of fish past new and existing dams in China. This eco-design approach integrates principles of fish biology and engineering, a scientific field also known as bio-engineering or eco-hydraulics. We define a fishway as a structure or mechanism for conveying fish upstream past a dam. Man-made or natural stream beds can be part of the fishway. The problem is dams block access to upstream habitat used for spawning, rearing, and refuge; i. e., dams decrease habitat connectivity. A solution to alleviate this problem is to design fishways, preferably while the dam is being designed, but if necessary, as retrofits afterward to provide a route that fish can and will use to pass safely upstream without undue delay. Our eco-design approach for fishways involves eight steps: 1) identify the primary species of importance; 2) understand the basic ecology and behavior of these fish; 3) characterize the environmental conditions where passage is or will be blocked; 4) establish eco-design criteria for the fishway, either from management agencies or, if necessary, developed specifically for the given site; 5) identify fishway alternatives and select a preferred alternative; 6) where needed, identify and perform research required to resolve critical uncertainties and finalize the eco-design criteria; 7) apply the eco-design criteria and site-specific considerations to design the fishway, involving peer-review by local stakeholders in the process; 8) build the fishway, monitor its effectiveness, and apply lessons learned. Types of fishways are described, showing a range of eco-designs depending on the dam site and fish species of concern. We use the eco-design principles as a basis to recommend an approach and next steps for a fishway to pass fish upstream at Hanfeng Dam, an existing regulating dam forming Hanfeng Lake on the Pengxi River near Kaixian, China.

**Key words**: eco-design; fishways; Hanfeng Dam; China

**Chinese Library Classification**: X171.4　　**Document Code**: A　　**Article ID**: 1672-6693(2012)03-0104-10

## Introduction

Dams alter riverine habitats and adversely affect aquatic ecosystems, in particular fish populations [1-3]. With the formation of reservoirs, dams fundamentally change habitat from riverine to lacustrine[4]. Dams can block upstream movements of fishes, thereby restricting their range and access to potential spawning, refuge, or rearing habitats[5]. Dams can injure or kill fish moving downstream through the structures[6-7]. Adverse effects during both upstream and downstream movements can reduce population size and change population structure by changing the flooding regime[8]. Realistically, the impacts on fish populations are not always a primary consideration when larger societal and economic decisions are made about dam construction. It is clear though that, even if a dam is inevitable or has already been constructed, well-functioning ecosystems in areas above and below the project can support subsistence and recreational fisheries, offer aesthetic benefits, remediate pollution impacts, and generally provide advantageous ecosystem services.

Hydropower development in China and elsewhere

* **Recieved**: 01-23-2012

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in East Asia is underway in earnest[3]. Dams are also being constructed for purposes of flood control, irrigation, river regulation, or other reasons. Regardless of purpose or functionality, dams affect fish populations[3]. For example, China's Danjiangkou Dam completed in 1973 without fish passage facilities had harmful and non-harmful effects on fish populations above and below the dam[4]. Efforts are underway to incorporate environmental considerations into new hydropower development[3,9]. It is preferable to include structures for fish passage as soon as possible during design of a dam. Where dams have already been constructed without regard to fish passage, existing projects can be retrofitted with fish passage systems[10].

A primary approach to enable fish passage at dams currently blocking upstream movements is to install a fishway of some kind[11-12]. As used here, a fishway is a structure or mechanism to convey fish upstream past a dam. The goal of a fishway is to provide a route that fish can and will use to pass safely upstream without undue delay. Although a fishway will never be as good for fish as when there is no dam, they can often minimize adverse effects of dams on fish, but success is by no means guaranteed[13-14]. An eco-design for a fishway integrates principles of fish ecology/behavior and engineering, a process also known as bio-engineering or eco-hydraulics. Fishways are often structures, but natural stream beds or "nature-like" mechanisms can also be developed to pass fish around a dam[15]. Fishway research and development, mostly focused on salmonids, has been extensive over the last 30 years in the United States[16], Canada[17], and western Europe[18]. Much important work has also been done in Latin America[13,19-20] and Australia[21]. Many reviews of fishways around the world are available[12,22]. Whatever the chosen mechanism or region of the world, an eco-design approach is required to create an effective, successful fishway.

Installing satisfactory mechanisms for upstream movements will not in itself prevent adverse impacts or population declines if downstream fish passage is not also a primary consideration[5,13]. The problems caused by dams for fish passing downstream are well-documented[23], as are many potential solutions to these problems[24]. This paper does not cover downstream passage except to note that the eco-design process for fishways to pass fish upstream should also consider provisions for assessment of downstream issues and solutions as necessary.

The objectives of this paper are to describe a process for eco-design of fishways, provide examples of different types of fishways, and apply eco-design principles to recommend an approach and next steps for designing a fishway to facilitate fish passage upstream at the existing Hanfeng Dam on the Pengxi River near Kaixian, China.

## 1 Eco-Design Approach

The "eco-design" approach is the most common method used worldwide to design fishways. As used here, eco-design means using knowledge of species-specific fish biology to drive engineering design of a fishway. The eco-design approach described here is based on experience from the U. S. Pacific Northwest, and works such as Clay[11], Larinier and Travade[25], and Parasiewicz et al[26]. Our approach for upstream moving fish, which is similar to many others, has eight successive steps (Fig. 1).

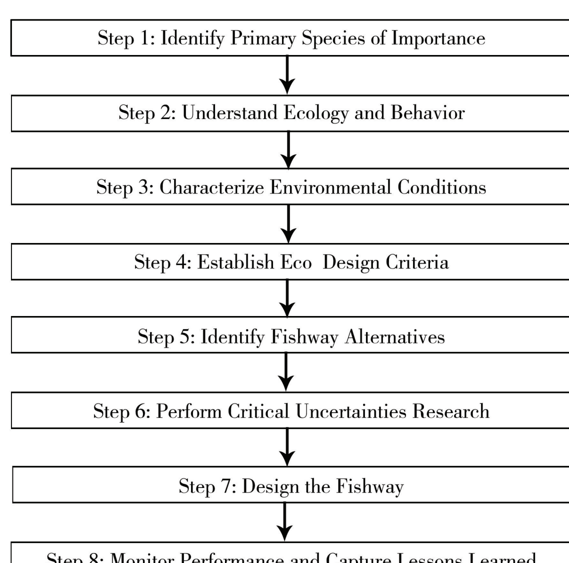


Fig. 1 Eight-Step Approach for Eco-Design of a Fishway

First, identify the ***primary species*** of importance. Importance could be determined based on cultural significance, commercial fishery, recreational fishery, environmental regulations, and/or local concerns. A single or multiple species could be identified. Multiple species situations are more complex and often require more thought than single species situations. Different species likely have different life-history patterns, swimming capabilities, and other ecological and behavioral characteristics. Since fishways are designed to provide hydraulic conditions to optimize passage, compromises may be required to pass both strong and weak swimming species; one size does not fit all. Separate fishways may in fact be required if weak- and strong-swimming species are of equal importance and need to be passed. The selection of the primary species of importance drives the entire eco-design process.

Second, understand the basic ***ecology and behavior*** of the primary species of importance. An in-depth literature review is necessary at this point in the eco-design process. Ecological factors to be considered include population size and geographic distribution, reproduction and life-history patterns (stages, sizes, preferred habitats, spatial and temporal distributions), feeding, and competitors and predators. For fish moving upstream, behavioral considerations include motivation for upstream movement, movement patterns (seasonal, diel), swimming capabilities, sensory cues, physiological state, and others. These factors determine responses to hydraulic and other conditions at the new fishway, such as flows that serve to attract fish or flows that form a velocity barrier. The relative timing of water flows and fish movement patterns is also important. For example, upstream movement primarily during high flow periods leads to a different fishway design than one needing to accommodate movements under low flows. The ecology and behavior of the primary species provides the focal point for the engineering design.

Third, characterize the ***environmental conditions*** at the site, landscape, and drainage basin where upstream passage is or will be blocked. The site is the location of a proposed dam or the dam itself for an existing structure. The landscape is the region a few kilometers above and below the dam site. Landscape features and drainage basin characteristics often determine site characteristics. For example, drainage basin hydrology is a determining factor for seasonal river discharge conditions at the site. It is also important to define localized hydraulic conditions for different project flows. Fish are responding to the hydraulic environment, so it is important to highlight localized hydraulic conditions when selecting the optimum fishway location. Sometimes a physical or hydraulic model is needed to aid in fishway site selection for the range of conditions the fishway is to be designed for because fish will not enter a fishway at a poor location. Generally, environmental conditions entail geographic and physical features, topography/bathymetry (elevation gain, wetted area), river discharge hydrograph, water quality (temperature, turbidity, pH, etc.), the vegetation community, and the fish community.

Fourth, establish ***eco-design criteria*** for the fishway. These criteria may come from management agencies or, if necessary, be developed specifically for the given site. In the latter case, the National Marine Fisheries Service[10] criteria parameters can serve as a template for adaptation to the target species (Tab. 1). Establishing eco-design criteria involves identifying the suite of applicable design parameters and setting the appropriate criteria values. This is typically an iterative process among the stakeholders and the bioengineers (see the multidisciplinary technical design group described in the seventh step). Hydraulic modeling, either physical scale or computational fluid dynamics may be necessary to help refine eco-design criteria. The eco-design parameters can overlap, such as where different locations for a fishway entrance may require different attraction flows. A relatively small flow at the optimum location could pass fish more successfully than high flows at a poor location. The process of applying existing or developing new eco-design criteria often illuminates critical uncertainties in the knowledge base.

Fifth, identify ***fishway alternatives*** and select a preferred alternative. Based on the primary species, its ecology and behavior, and the environmental conditions, alternative approaches for the fishway should be identified. Each alternative will have advantages and disadvantages that are weighed and evaluated to select a preferred alternative. This process should involve the multidisciplinary technical design group described in the seventh step.

Tab. 1 Selected Fishway Design Parameters from *Anadromous Salmonid*

| Parameter | Passage Facility Design by NMFS (2011) | |
|---|---|---|
| | Definition | Comment |
| Location | "Fishway entrances must be located at points where fish can easily locate the attraction flow and enter the fishway." | In retrofits at existing dams, it may be possible to find where fish hold and at what range of flows, then design the fishway entrances to discharge into this zone. If the dam has not been constructed, only physical hydraulic modeling will ensure that tailrace hydraulics are compatible with fish holding habitats near their upstream terminus. |
| Attraction Flow | "Attraction flow from the fishway entrance should be between 5% and 10% of fish passage design high flow … the higher percentages of total river flow used for attraction into the fishway, the more effective the facility will be in providing upstream passage." | This is often a large amount of flow, and can result in a large fishway footprint and high costs. This criterion often inspires fish tracking studies to aid in selecting the optimum fishway entrance site(s). NMFS[10] allows lower fishway attraction flows, if documented fish behavior at the site suggests fish will approach and/or congregate at the proposed fishway entrance location. |
| Hydraulic Drop | "The fishway entrance hydraulic drop (also called entrance head) must be maintained between 1 and 1.5 feet, depending on the species present at the site …" | This presumes strong swimming species. This an important issue to reconcile for the target species. Weaker swimming species require reduced hydraulic drop from the fishway entrance, and at weirs between each fishway pool. More pools are required and the fishway footprint is larger for weaker swimming species. |
| Dimensions | "The minimum fishway entrance width should be 4 feet, and the entrance depth should be at least 6 feet …" | Dimensions are totally dependent on scale issues, size of fish runs, and total biomass entering (and/or residing in) the fishway. |
| Flow Conditions | "The desired flow condition for …. discharge jet hydraulics is streaming flow …" | There are three primary type entrance configurations: submerged weir, slot, or orifice. At mid-sized and smaller fishways, orifice entrances are often best, as they entail more passive operation. |

Sixth, where needed, identify and perform research required to resolve critical uncertainties and finalize the eco-design criteria. Some species are known to use fishways to pass upstream, so their behavior may be better understood than that of other species whose passage behavior and success are not certain. In the latter case, a much more research-oriented approach is required, and designs should include flexibility for modification; e. g., the design should include the ability to add more attraction flow later, as needed. Topics that could be uncertain and require further research include fish swimming capabilities, fish responses to attraction flows, fish jumping abilities, fish preference for passage through weirs versus submerged orifices, and the effects of light, sound, etc. Tu et al.[27] provide a good example of a critical uncertainties study. After critical uncertainties have been resolved, the project's bioengineers and stakeholders review and finalize the eco-design criteria, thereby leading to the next step of designing the fishway.

Seventh, apply the eco-design criteria and site-specific considerations to ***design the fishway***. For best results, this step should involve a small multidisciplinary technical design group (approximately eight for best efficiency) composed of design engineers, bioengineers, biologists, and a manager with budget oversight. The purpose of this group would be to integrate biological, structural, and operational (hydraulic) variables in a manner that optimizes the potential for successful fish passage at the completed project. Steps of design typically include fishway site selection (based on integration of known hydraulic conditions and fish behavior at the site), reconciling fishway functional needs, and preparation of the preliminary design drawings and report (sometimes called the basis of design report). This juncture represents the approximately 25% completion of the entire design. By this point, most fishway features are sized, located, and depicted in drawings. The design report typically includes background information about the dam and fisheries resources, design criteria, functional requirements, fish passage performance goals, and site information collected from investigations needed for design. These include identification of target fish species, hydrology, tailwater hydraulics, bathymetry, topography, descriptions of fishway features, rough cost estimates, and other pertinent information. Stakeholders and managers can then review the report and provide comments and managers can assure the scope of work is within budget constraints. Completion of the preliminary design process is a springboard for proceeding into the detailed design phase. Structural, mechanical, electrical, and other engineers can then proceed toward completion of the fishway design. However, design reviews are often requested at 50%, 75%, and 90% design junctures. Detailed engineering drawings (Fig. 2) and specifications are a primary outcome of the fishway design step as these drawings form the basis for solicitations to construction companies to build the fishway.

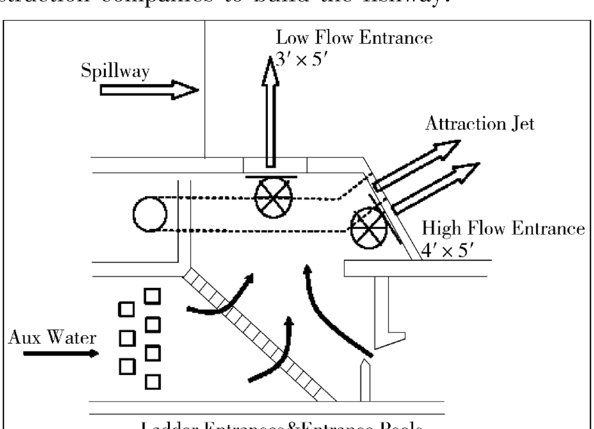


Fig. 2 Example of an Engineering Schematic Showing Fishway (Ladder) Entrances, Pools, and Location of Attraction Flows. (Drawing obtained from US Fish and Wildlife Service, Fisheries Academy, Leetown, West Virginia.)

Lastly, the eighth step is to construct the fishway, ***monitor its performance***, and ***capture lessons learned***. Having the technical design group select performance standard(s) at the beginning is important so that post-construction performance monitoring focuses on the right metric and provides an established standard to which the results can be compared to measure success. Using adaptive management, this process can potentially lead to some predetermined modifications that can be implemented readily if performance is not up to the desired standards. In situations where the fishway and eco-design criteria have no or few precedents, the effectiveness monitoring step is the primary method for determining whether the targeted migrating fish will respond as desired to the new fishway. For species for which previous knowledge of fishway use is not available, risks related to whether fish will enter and pass upstream successfully can only be addressed during post-construction effectiveness monitoring. Monitoring parameters will depend on the site and primary species, but could include fish approach and entry efficiencies at the fishway entrance(s), ladder passage rates, extent of passage below and in the ladder, travel times, survival rates, effects of dam operations, and effects of environmental conditions. The philosophy is to use the fish to indicate the level of success, and apply the lessons learned from observing their behavior to improve the current and future fishways through adaptive management (e.g., Oldani and Baigun[28]).

## 2 Types of Fishways

Various types of fishways have been designed to pass fish upstream at river obstructions such as dams. Fishway design is dependent on the primary species of importance, environmental, and other site-specific considerations, as explained in the eco-design approach presented above. Some of the more common types of fishways are listed below (See plate 3, color page Ⅵ):

· ***Pool*** - The pool includes the weir-orifice fishway, which is the classic "Ice Harbor" fishway (See plate 3a, color page Ⅵ), and the vertical slot fishway (See plate 3b, color page Ⅵ). In weir-orifice fishways, fish typically move upstream through the orifice at the floor of the fishway, not over the weir. The pool-type fishway was first developed in the 1930s for Bonneville Dam on the Columbia River. A defining characteristic is that energy is dissipated in each pool.

· ***Baffled Chute*** - Baffled chutes include the Denil fishway (See plate 3c, color page Ⅵ) and the Alaska Steeppass fishway (See plate 3d, color page Ⅵ). These types of fishways are useful where the elevation gradient is a constraint.

· ***Hybrid Pool and Chute*** - An example of a hybrid pool and chute is the full width sill (See plate 3e, color page Ⅵ). This fishway acts as a pool fishway during low discharges and a baffled chute fishway during high discharges. This is a relatively new concept that is still evolving.

· ***Nature-like*** - Nature-like fishways attempt to provide a "natural" route with as few man-made structures as possible (See plate 3f, color page Ⅵ). This method has been attempted in many locations, including the U.S. Midwest, Canada, South America, Europe, and elsewhere, and typically applies to weaker-swimming fish.

· ***Rock Ramps*** -Rock ramps are intended to facilitate upstream passage by installing river gravel and boulders to create a 5% ~10% slope gradient within the fishway structure. Pools form around large boulders providing a place for fish to stage. Rock ramps are applicable for low-head situations. Rock ramps are similar to nature-like fishways (See plate 3f, color page Ⅵ).

· ***Elevators***—Fish "elevators", which lift fish in a large hopper for release upstream of the dam, have also been used, e.g., shad on the Susquehanna River in Pennsylvania.

· ***Trap and Haul*** - In this approach, fish are collected in a trap structure downstream of the dam, loaded onto a tank truck, then hauled to upstream release sites. This method is typically used for upstream passage at high-head dams (>50 m) where other types of fishways are impractical because of the dam's height.

## 3 A Potential Fishway at Hanfeng Dam

Hanfeng Dam (See plate 4 and 5, color page Ⅴ) is located near the city of Kaixian in Kaixian County, Chongqing Municipality, China. The dam is on the Pengxi River, a tributary of the Yangtze River. The Three Gorges Reservoir (TGR) inundates the entire portion of the Pengxi River downstream of Hanfeng Dam during TGR's full pool (Fig. 6). The water level fluctuation for TGR is 145 ~ 175 m above mean sea level, whereas the fluctuation range behind Hanfeng Dam is 172 ~ 175 m. Flooding from TGR occurs during November—December. During this period, there is opportunity for fish to move upstream past the dam, but not during the other 7 ~ 8 months of the year when the TGR elevation is lower than 172 m. For the purposes of this paper, we chose Hanfeng Dam as an example site of a potential fishway because of concerns about fish passage there (personal communication, October 2011, Professor YUAN Xing-zhong).

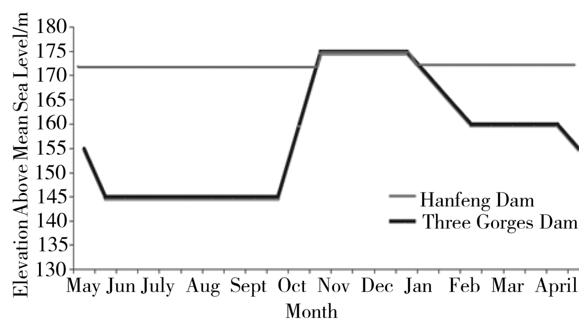


Fig. 6 Seasonal Elevations for the Three Gorges Dam Reservoir and the Hanfeng Dam Reservoir (figure provided by Dr. Wang Qiang)

Constructed in 2007—2010, the purpose of Hanfeng Dam is to eliminate the TGR water level fluctuation zone in the area upstream of the dam, the urban area of Kaixian. Hanfeng Dam, therefore, serves to regulate the water surface elevation for Hanfeng Lake, the impoundment behind the dam, and shield this area from the effects of TGR fluctuations. Hanfeng Lake is a key public attraction in Kaixian. The lake provides aesthetic views, recreation, fishing, and wetland ecosystem services. Hanfeng Lake has a perimeter of 36.4 km, a surface area of 14.8 $km^2$, and a volume of $5.6 \times 10^7$ $m^3$.

Hanfeng Dam was constructed without fish passage facilities. Recently, authorities, having realized the value of successful passage of fish upstream through the dam, requested that a process be initiated to develop a fishway at Hanfeng Dam. Therefore, the first five steps of the eco-design approach (Fig. 1) outlined previously are recommended for implementation as a systematic approach to developing a fishway at Hanfeng Dam:

1) Identify the primary species of importance. (A list of fish resources in Hanfeng Lake and Pengxi River is provided in the appendix. Designations are made for "protected fish of Chongqing" and "national wildlife under second class protection.")

2) Understand the basic ecology and behavior of these fish.

3) Characterize the environmental conditions at the Hanfeng Dam site, its landscape, and river hydrology, bathymetry, topography, and dam operations, including tailwater hydraulics.

4) Establish eco-design criteria for the preferred alternative fishway.

5) Select one (or two) optimum fishway locations, based on fish migration behavior and hydraulics downstream of the dam (and secondarily on constructability and costs)

6) Identify alternative fishway types, list positive and negative aspects of each, and select the preferred fishway alternative.

Toward this end, some initial observations based on plate 4 and 5 are appropriate. There appears to be an apron extending downstream from the dam, and that flow off the apron creates a standing wave/jump that is manifested in a reverse 'C' in tailrace hydraulic conditions (See plate 4, color page Ⅴ). While this is only one discharge, and it would be important to observe a range of discharges and associated tailwater hydraulic conditions, it appears lower velocity approaches to the upstream terminus of the dam's abutment in the tailwater may be workable for a fishway entrance on one or both sides of the river. Much more study and information are obviously needed.

An important caveat is that a fishway will not necessarily pass all fish when there are weaker swimming fish than the primary species for the eco-design. However, if weak swimming fishes are the primary species, then use of eco-design principles should enable their successful passage. Integrating sound fishway design principles with the primary fish species, their ecology and behavior, and environmental conditions at the site (dam configuration, hydrology, and localized hydraulics) embodies an eco-design of an upstream passage fishway that should result in successful upstream fish passage.

**Acknowledgments**: The authors appreciate the assistance provided by Dr. Wang Qiang, Professor Yuan Xingzhong (Chongqing University), Professor Li Ruoxi (Chongqing Normal University) and Dr. Meng Haixing (East China Normal University). It was Professor Yuan who suggested investigating development of an eco-design for a possible fishway at Hanfeng Dam. We also thank Professor Yuan and Professor Lu Jianjian (East China Normal University) for the opportunity and support for Johnson to attend the International Symposium on Conservation and Eco-Friendly Utilization of Wetland in the Three Gorges Reservoir during October 2011 in Chongqing Province, China.

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## APPENDIX: Fish Resources in Hanfeng Lake and Pengxi River

The following table of potential fish resources in Hanfeng Lake and the Pengxi River was provided by Dr. Wang Qiang. The triangle, ▲, signifies fish endemic to the upper reaches of the Yangtze River. The single asterisk, *, signifies protected fish of Chongqing. The double asterisk, **, signifies national wildlife under second class protection.

| Taxon | Chinese Name | Scientific Name | Symbol |
|---|---|---|---|
| 鲤形目 | | CYPRINIFORMES | |
| 鲤科 | | Cyprinidae | |
| 鱲属 *Zacco* | 宽鳍鱲 | *Zacco platypus* | |
| 马口鱼属 *Opsariichthys* | 马口鱼 | *Opsariichthys bidens* | |
| 青鱼属 *Mylopharyngodon* | 青鱼 | *Mylopharyngodon piceus* | |
| 草鱼属 *Ctenopharyngodon* | 草鱼 | *Ctenopharyngodon idellus* | |
| 鲹鰵属 *Hemiculter* | 鲹 | *Hemiculter leucisulus* | |
| | 油鲹 | *H. bleekeri bleekeri* | |
| 鳑鲏属 *Rhodeus* | 彩石鳑鲏 | *Rhodeus lighti* (Wu) | |
| | 高体鳑鲏 | *R. ocellatus* | |
| | 中华鳑鲏 | *R. sinensis* | |
| 彩石鲋属 *Pseudoperilampus* | 彩石鲋 | *Pseudoperilampus light* | |
| 倒刺鲃属 *Spinibarbus* | 中华倒刺鲃 | *Spinibarbus sinensis* | |
| 结鱼属 *Tor* | 瓣结鱼 | *Tor brevifilis brevifilis* | |
| 光唇鱼属 *Acrossocheilus* | 宽口光唇鱼 | *Acrossocheilus* (*Acros.*) *monticola* | ▲ |
| 泉水属 *Semilabeo* | 泉水鱼 | *Semilabeo prochilus* | |
| 突吻鱼属 *Varicorhinus* | 粗须铲颌鱼 | *Varicorhinus.* (*Scap.*) *barbatus* | |
| | 多鳞铲颌鱼 | *V.* (*Scap.*) *macrolepis* | |
| 白甲鱼属 *Onychostoma* | 白甲鱼 | *Onychostoma sima* (Sauvage et Dabry) | |
| | 小口白甲鱼 | *O. lini* (Wu) | |
| 䱻属 *Hemibarbus* | 唇䱻 | *Hemibarbus labeo* | |
| | 花鱼骨 | *H. maculatus* | |
| 麦穗鱼属 *Pseudorasbora* | 麦穗鱼 | *Pseudorasbora parva* | |
| 银鮈属 *Squalidus* | 银鮈 | *Squalidus argentatus* | |
| 蛇鮈属 *Saurogobio* | 蛇鮈 | *Saurogobio dabryi* | |
| | 光唇蛇鮈 | *S. gymnocheilus* Lo, Yao, et Chen | |
| 裂腹鱼属 *Schizothorax* | 齐口裂腹鱼 | *Schizothorax* (*Schizoth.*) *prenanti* | ▲ |
| | 四川裂腹鱼 | *S.* (*Schizop.*) *kozlovi* | |
| 鲤属 *Cyprinus* | 鲤 | *Cyprinus carpio* | |
| 原鲤属 *Prcxypris* | 岩原鲤 | *Prcxypris rabaudi* | * ▲ |

| Taxon | Chinese Name | Scientific Name | Symbol |
|---|---|---|---|
| 鲫属 *Carassius* | 鲫 | *Carassius auratus auratus* | |
| 鳙属 *Aristichthys* | 鳙 | *Aristichthys nobilis* | |
| 鲢属 *Hypophthalmichthy* | 鲢 | *Hypophthalmichthy molitrix* | |
| 吻鮈属 *Rhinogobio* | 圆筒吻鮈 | *Rhinogobio cylindricus* | ▲ |
| | 吻鮈 | *R. typus Bleeker* | |
| | 长鳍吻鮈 | *R. ventralis* Sauvage et Dabry | ▲ |
| 棒花鱼属 Abbottina | 棒花鱼 | Abbottina rivularis (*Basilewsky*) | |
| 近红鲌属 Ancherythroculter | 汪氏近红鲌 | Ancherythroculter wangi (*Kimura*) | |
| 圆吻鲴属 Distoechodon | 圆吻鲴 | *Distoechodon tumirostris* Peters | |
| 平鳍鳅科 | | Homalopteridae | |
| 间吸鳅属 *Hemimyzon* | 中华间吸鳅 | *Hemimyzon sinensis* | * |
| 华吸鳅属 *Sinogastuomyzon* | 四川华吸鳅 | *Sinogastuomyzon szechuanensis szechuanensis* | * ▲ |
| 鳅科 | | Cobitidae | |
| 条鳅属 *Nemacheilus* | 短体条鳅 | *Nemacheilus potanini* | |
| | 红尾条鳅 | *N. berezowski* | |
| 副鳅属 *Paracobitis* | 红尾副鳅 | *Paracobitis variegatus* | ▲ |
| | 短体副鳅 | *Paracobitis potanini* (Günther) | ▲ |
| 沙鳅属 *Botia* | 花斑沙鳅 | Botia fasciata | |
| | 宽体沙鳅 | *B. reevesae* Chang | ▲ |
| | 中华沙鳅 | *B. superciliaris Günther* | |
| 泥鳅属 Misgurnus | 泥鳅 | *Misgurnus anguillicaudatus* | |
| 山鳅属 *Oreias* | 山鳅 | *Oreias dabryi Sauvage* | ▲ |
| 高原鳅属 *Triphophysa* | 贝氏高原鳅 | *Triphophysa bleekeri* (Sauvage et Dabry) | |
| 副沙鳅属 *arabotia* | 花斑副沙鳅 | *Parabotia fasciata* Dabry et Thiersant | |
| 薄鳅属 *Leptobotia* | 红唇薄鳅 | *Leptobotia rubrilabris* (Dabry et Thiersant | * ▲ |
| | 长薄鳅 | *L. elongata* (Bleeker) | * ▲ |
| 胭脂鱼科 | | Catostomidae | |
| 胭脂鱼属 *Myxocyprinus* | 胭脂鱼 | *Myxocyprinus asiaticus* | * * |

| Taxon | Chinese Name | Scientific Name | Symbol |
|---|---|---|---|
| 鲇形目 | | SILURIFORMES | |
| 鲶科 | | Siluridae | |
| 鲶属 *Silurus* | 鲶 | *Silurus asotus* | |
| | 南方大口鲶 | *S. saldatovi meridionalis* | |
| | 大口鲇 | *S. meridionalis* Chen | |
| 胡鲶科 | | *Clariidae* | |
| 胡鲶属 *Clrias* | 胡子鲶 | *Clrias fascus* | |
| 鲿科 | | *Bagridae* | |
| 黄颡鱼属 *Pelteobagrus* | 黄颡鱼 | *Pelteobagrus fulvidraco* | |
| | 瓦氏黄颡鱼 | *P. vachelli* (Richard-son) | |
| | 光泽黄颡鱼 | *P. nitilus* (Sauvage et Dabry) | |
| 鳠属 *Mystus* | 大鳍鳠 | *Mystus macropterus* | |
| 拟鲿属 *Pseudobagrus* | 切尾拟鲿 | *Pseudobagrus truncatus* (Regan) | |
| | 凹尾拟鲿 | *P. emarginatus* (Regan) | |
| | 乌苏拟鲿 | *P. ussuriensis* (Dybowski) | |
| 鮡科 | | *Sisoridae* | |
| 纹胸鮡属 *Glyptothorax* | 中华纹胸鮡 | *Glyptothorax sinensis* | |
| 钝头鮠科 | | Amblycipitidae | |
| 鱼央属 *Liobagrus* | 白缘鱼央 | *Liobagrus mar-ginatus* (Günther) | |
| 鳉形目 | | CYPRINODON-TIFORMES | |
| 青鳉科 | | Oryziatidae | |
| 青鳉属 *Oryzias* | 青鳉 | *O. latipes* | |
| 胎鳉科 | | Poeciliidae | |

| Taxon | Chinese Name | Scientific Name | Symbol |
|---|---|---|---|
| 食蚊鱼属 *Gambusia* | 食蚊鱼 | *Gambusia affinis* | |
| 合鳃鱼目 | | SYMBRANCHI-FORMES | |
| 合鳃鱼科 | | Symbranchidae | |
| 黄鳝属 *Monopterus* | 黄鳝 | *Monopterus albus* | |
| 鲈形目 | | PERCIFORMES | |
| 鮨科 | | Serranidae | |
| 鳜鱼属 *Siniperca* | 鳜 | *Siniperca chuatsi* | |
| | 斑鳜 | *S. scherzeri* | |
| | 大眼鳜 | *Siniperca kneri* Gar-man | |
| 鰕虎鱼科 | | Gobiidae | |
| 栉鰕虎鱼属 *Ctenogobius* | 栉鰕虎鱼 | *Ctenogobius giurinus* | |
| 鳢科 | | *Ophiocephalidae* | |
| 鳢属 *Ophiocephalus* | 乌鳢 | *Ophiocephalus argus* | |
| 颌针鱼目 | | BELONIFORMES | |
| 鱵科 | | Hemiramphidae | |
| 鱵属 *Hemiramphus* | 鱵 | *Hemiramphus kurumeus* | |
| 鲑形目 | | SALMONIFORMES | |
| 银鱼科 | | Salangidae | |
| 间银鱼属 *Hemisalanx* | 前颌间银鱼 | *Hemisalanx prognathus* | |

(Editors: Martin WILLISON, HUANG Ying)