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A review on conservation issues in the upper Yangtze River – a last chance for a big challenge: Can Chinese paddlefish (*Psephurus gladius*), Dabry´s sturgeon, (*Acipenser dabryanus*) and other fish species still be saved?

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Summary

Considerations on conserving biodiversity are presently of central concern to ecologists and are also frequently debated among aquatic biologists and resource use scientists. In this paper we provide an overview of the state of knowledge on the biodiversity, mainly of fish species in the upper Yangtze River system and their level of endangered status as well as some overall data on other taxa (primarily of the benthos). Habitat issues are briefly addressed while also options for biodiversity management are discussed. Of specific concern is the Chinese paddlefish. Also, new hydro dams are being constructed, requiring further mitigation measures. An expanded concept of creating a new much more comprehensive reserve complex within which and the existing natural reserve is included, maintained and adjusted for a better and additional protection of the upper Yangtze River fish bioresources is introduced in this paper. It is clear that no reserve installation can fully compensate the loss of habitat and ecosystem structures caused by damming, however, it is hoped that the mitigation effect is substantial.

Introduction

Biodiversity considerations are mainly viewed from various science aspects and can be categorized at genetic, species and ecosystem level where habitat and biological diversity are highly important for human development (CAO et. al., 2001). Considering these levels, species diversity is presently the level mostly paid attention to. Before the emergence of man, the formation and extinction (he "coming and going") of species were balanced by evolutionary processes. However, after man appeared on this planet, and especially during the last few hundred years, technological and management interventions have set a new pace in species diversity changes, characterized by high speed of species loss, as well as species community change (through the introduction of exotic species). The rate of change is faster than ever due to the many interferences of modern human globalizing activities. However, it is worth noting that more and more people recognize the consequences of these changes and become concerned about the problems that threaten the sustainable use of natural resources. Therefore, conservation biologists consider biodiversity conservation within a given geographic area as critically important. The installation of ature reserves plays also a critical role in maintaining biodiversity. By 2000, there were globally about 30,000 protected areas assigned, encompassing over 13,250,000 km^2 of the land surface and representing about 8% of land area of the planet. A much smaller proportion of the world's water resource areas (0.25%) are protected (Green and Paine, 1997; Orians and Soulé, 2001). In China, nature reserves are now classified into forests and others vegetation reserves, natural and historic reliques reserve and wild animals reserves. In 1956 the first nature reserve of the P. R. China, i. e. Ding Hushan Nature Reserve, was created in and around Zhaoqing City, Guangdong Province. At present there are 2194 nature reserves of different size and level of protection in China, covering a total area of 14,822 km^2, and a land area of about 14222 km^2 while including a water body area of about 600 km^2. Certainly, it is in the interest of aquatic biologists to enforce the conservation measures for water reserves which are often neglected compared to land reserves.

The upper Yangtze River is very rich in species and is considered to have highest biodiversity in the Palearctic region (Nelson, 1994; Matthews, 1998), however, because of human activities causing environment fragmentation, water pollution, and over-fishing, many of the fish populations had declined rapidly and some species are considered as highly endangered. There is an urgent need to set aside certain areas to protect the aquatic wildlife (Xie and Chen, 1999) and in particular fish species such as *Psephurus gladius* and *Acipenser dabryanus,* both of which are listed in China as in need of the highest protection level. The significance for the need and challenges associated with the creation of reserves is reviewed in this contribution.

The upper Yangtze River: a region of high biodiversity in fish

Description of the upper Yangtze River system

The Yangtze River is the longest river in China and the third longest in the world with a length of about 6,300 km. For many years the documented average water flow volume of the Yangtze River is around 9.6×10^{11} m^3, and the theoretical hydropower capacity is estimated with 2.68×10^8 kW, accounting for more than 40% of the total capacity in China. The river stretch between the headstream and Yichang comprise the upper reaches of Yangtze River with a total length of 2,300 km, and the stretch between Yushu, Qinghai

Province, and the estuary of Min River, Yinbin City, Sichuan Province, is usually called the Jinsha River with a length of about 2300 km (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). The upper Yangtze River is located in the transitional region from the south Sichuan Basin and the Yun?Gui Plateau adjacent to the Sichuan Basin. Some mountains with low or middle heights are located around these areas, and medium-high mountains become abruptly to low-heighted ones. The changeable topography results in the complex flow state of river with narrow and wide reaches arrayed, and zigzag shape. The upper Yangtze River contains the majority of waterpower recourses of the entire river, while the Jinsha River stretch receiving also the most potential waterpower from the upper reach. Because of a rather large change in altitude of about 3280 m, the potential water power is estimated with 1.124×10^8 kW which is about 42.3% of that the energy source calculated for the whole Yangtze River basin (Peng, 2004). Chishui River is one of the tributaries of the southern bank in upper Yangtze River. Its basin area is 21,010.5 km^2 with a total river length of 436.5 km, an altitude 200-1,890m, and a total fall 1690 km. At present this is the only river that has not yet been exploited for hydroelectric power constructions. Because of the economic condition, the region is relatively undeveloped, and the Chishui River is less influenced by human activities. It seems attractive to consider the Chishui River and its tributary as a potentially suitable habitat for protecting endemic fishes and among other considerations the feasibility for protecting fish species has been estimated by using the SOM Algotithm as analytical tool (Park et al., 2003).

Aquatic Biodiversity of the Upper Yangtze River

Fishes

Because of the remarkable differences of topography and altitude, the upper Yangtze River has diversified micro-environment and exhibits highly diverse habitats, leading to a rich biodiversity in terms of both fish species richness and benthic fauna composition. There is a present listing of 261 species of fish in the upper Yangtze River (Chang, 2001), representing the highest diversity in the Palearctic region (Nelson, 1994; Matthews, 1998), and 112 of these species are exclusively distributed in this reach of the river and its tributaries, accounting for 42.9% of the total species number (Liu et al., 2004). In this river section, 162 species inhabit the main channel, including 44 endemic species (Park et. al., 2003).

The proposed large-scale reserve system would support 189 species of fishes (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Species of Fishes, 2004) including 66 fishes endemic to the upper Yangtze River, belonging to 8 orders, 20 families and genera. An overview of these taxa is given in Table 1. Among the 189 fish species, many are listed in the protected directory, including *Psephurus gladius* Martens and *Acipenser dabryanus* Dumeril, which listed as the first order category of the protected animals in China. *Myxocyprinus asiaticus* Bleeker is at the second order for nationally protected animals (Table 2). These highly endangered species are followed by numerous species of Cypriniformes (with 76 genera, 141 species or subspecies), and Siluriformes (with 9 genera, 27 species). Most of these species appear in the first and second largest orders of freshwater fish, respectively. The distributions of fishes in the new reserves are shown in Table 2. *Psephurus gladius* Martens is an endemic species to China. It has ever lived in the mainstreams and tributaries of the Yangtze River as well as lakes connecting the rivers and estuary of the Yangtze River. It occurs in the East China Sea, and even the upper Yellow River. Historically the spawning grounds of *Psephurus gladius* Martens were in the upper Yangtze River as well as upstream of the Chongqing city. But after large hydroelectric projects which cut the river flow through large dams, the spawning grounds were restricted in the reach between Hejiang and Pingshan which resulted in the sharp decline of the *Psephurus gladius* Martens resources. The species was then listed as Category I under the national key protection list in China. The year of 2003 is the last time that *Psephurus gladius* Martens was captured.

The fauna composition of the reserve has the character of the upper Yangtze River fauna, including fish community components of the early tertiary period (14.9%), covers a large proportion of the river and plains of China (55.7%), the southern plains (14.7%), the plateau and mountainous areas of middle Asia as well as of China-India (7.0%) (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). It can be concluded that the fauna composition within these reserves has the transitional traits of fishes of the east, west, south and northern patterns that ever co-existed here, reflecting the complexity and richness of the fish fauna. According to life history strategies, the reproductive guilds of the endemic fishes are categorized into the following 4 modes: (1) pelagic spawning with drifting eggs in the flow of the mainstream or upper large tributaries; (2) spawning of demersal sticky eggs on the riverbeds of the upper mainstream; (3) spawning of adhesive eggs in the upper reaches of river branches, tricked by the sudden water level rise due to heavy rainfall, and (4) spawning species in suitable micro-environments along the river banks.

Other aquatic organisms

There are also numerous other aquatic organisms that certainly cannot be dealt with in detail here. These include species of phytoplankton, zooplankton, benthic fauna, aquatic vascular plants and water birds, all of which are thriving in the existing and proposed reserve (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). The moderate

Table 1
The number of fish species in each of the recorded upper Yangtze River reach reserves as identified by order, family, genus and species level with special emphasis on endemic species

River reach	Order	Family	Genus	Species (Subspecies)	Endemic fish species to upper Yangtze River
Lower Jinsha River	7	18	81	136	49
Mainstream of the upper Yangtze River	8	20	94	160	43
Lower Min River	6	7	83	134	44
Chishui River	6	16	73	111	28
Total of reserve	8	20	100	189	66

Table 2.
Fish species listed at different protection levels by the different directories: I = IUCN (International Union for the Conservation of Nature and Natural Resources, 1996), C = CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1997); R = RDB (China Red Data Book of Endangered Animals, 1998); N = Directory of key wild animals protected in China; P = Wild aquatic animals locally protected; In RDB, En is listed as extinct in China, CR is listed as critically at risk, E as endangered in China, V as vulnerable, and NE as no estimation presently available. Under IUCN: En means listed as endangered, V as Vulnerable, cd as lowly critical or needing protection, nt as nearly threatened, lc as lowly critical or needing attention

Order	Family	Fish name	Protected directory				
			R	I	C	N	P
Acipenseriformes	Acipenseridae	*Acipenser dabryanus* Dumeril	V	CR	?	?	
	Polyodontidae	*Psephurus gladius* Martens	E	CR	?	?	
Cypriniformes	Catostomidae	*Myxocyprinus asiaticus* Bleeker	V			?	
	Cobitidae	*Leptobotia elongate* Bleeker	V				Y
		Leptobotia *rubrilabrs* Dabry					Y
		Leptobotia microphthalrna Fu et Ye					Y
	Cyprinidae	*Leuciobrama macrocephalus* Lacep.	V				Y
		Xenocypr yunnanensis Nichols	E				
		Procypris rabaudi Tchang	V				Y
		Procypris pingi pingi Tchang					Y
		Anabarilius liui Chang					Y
		Schizothorax chongi Fang					Y
		Megalobrama elongate Huang *at* Zhang					Y
		Ochetobius elongatus Kner					Y
	Homalopteridae	Hemimyzon yaotanensis					Y
		Jinshaia sinensis Sauvage *et* Dabry					Y
		Sinogastromyzon szechuanensis					Y
		Metahomaloptera omeiensis Chang					Y
Siluriformes	Bagridae	*Pseudobagrus medianalis* Regan	E	En			
	Amblycipitidae	*Liobagrus kingi* Tchang	E				
Perciformes	Gobiidae	C. szechuanensis liu					Y

climate and extended forests spreading widely supply not only suitable habitats for birds, but also stabilize water run-off to sustain numerous aquatic species. According to primary surveys, over 100 species of birds live in the reserve water area. Additionally, there are amphibians, reptiles, and mammals which include also nationally protected animals of the second order such as *Megalobatrachus japonica* Dauidianus, *Lutra lutra* Linnaeus, and locally protected animals including *Chinemys reevesi* Gray, and *Pelodiscus sinensis* Wiegman.

Fish habitats

The proposed "adjusted" reserve distributes over a wide area in the Sichuan Province, the Guizhou Province, the Yuanna Province and the Chongqing City. This area mainly lies in the southern mountainous region of the Sichuan Basin, with parts of the zones bordering to northern Guizhou Province mountainous region of the Yun Gui Plateau, and including the lower Jinsha River, parts of river reaches of the upper Yangtze River and some of its tributaries (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). The upper Yangtze River flows from west to east and takes up water from relatively large tributaries. It therefore forms rather dense network of river systems and represents rich water resources. The altitudes and topographies of different river reaches in the proposed reserve change significantly within the reserve as it is the transitional zone between plateaus and basins. With the various topographies, the currents also vary drastically, including large water falls, alternating with wide and narrow sections of the river bed and flood land. The reserve lies in the zone of subtropical wet climate, and is affected by the southeast monsoon, the southwest monsoon and also influenced by the position of the Qinghai-Tibet Plateau, which is the cause for wet and hot climate situations. The average annual temperature is usually in the range of 16~20 ? which is suitable for many aquatic organisms. Because of the special topography, the specific climate and the highly diverse natural habitats, the river ecosystem within

the reserve can be considered as special. Gravel beds in the river reserve are major spawning grounds for most of the endemic fishes, releasing adhesive or non-adhesive demersal eggs which either attach to the substrate or sink into the interstital spaces of gravel and bolder. Appropriate water temperatures and sufficient dissolved oxygen is available to support effective spawning and normal embryonic development.

Strategy for the biodiversity conservation of the Upper Yangtze River

The previous nature reserve

Because of environmental pollution, construction of hydraulic dams, navigation, river dredging and over-fishing, most fish populations drastically declined since the 1970s, and some species, especially migratory fishes became highly endangered (Zhang, 2002). With the Three Gorges Project, it is anticipated that at least 162 fish species will lose their natural habitats (Zhong & Power, 1996; Chang, 2001). Consequently, some endemic fishes may disappear, contributing to the loss of biodiversity.

To offset the detrimental effects of the continued damming, the State Department of the P. R. China authorized in 2000 the foundation of a National Reserve of Hejiang-Leibo Reaches of Yangtze River for Rare and Endangered Fishes. This initial reserve included the mainstream of the upper Yangtze River from Leibo county to Hejiang county in the Sichuan Province, and Leibo, Pingshan, Cuiping, covering 11 cities or counties, with a river length of about 420 km and area 18052 ha (Table 3). The reserve mainly protected 3 endangered fishes, e. g. *Psephurus gladius* Martens, *Acipenser dabryanus* Dumeril, *Myxocyprinus asiaticus* Bleeker, 37 endemic fish and their habitats (Survey Report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004).

The adjusted (enlarged) nature reserve

At first the reserve played an important part in protecting wildlife. However, Jinsha River is one of the famous rivers with rich waterpower recourses in China, counting for 42.26% of the total exploitable water resources for power generation within the whole Yangtze River watershed. The exploitation of Jinsha River for hydropower is of high economic and strategic importance for the West-East Power Transmission because energy sources are very short in China (Peng, 2004). The Chinese Government, therefore, had already planned to build over 10 hydroelectric dams on the Jinsha River (Park, 2004), and this will inevitably have serious effects on the ecology and environment of the upper Yangtze River system because it converts the core zone into a reservoir. The 400 km long reach from the end of the Three Gorges reservoir to the Xiangjiaba Hydroelectric Dam converts the habitats into fragmented sections with consequences to the endangered and additional 66 endemic fish species. In order to mitigate the conflict between hydroelectric projects and the maintenance of the functionality of the reserve, the Ministry of Agriculture of PRC organized surveys by environment related departments and specialist groups in the upper Yangtze River and negotiated with local departments, provinces and cities, and they found that the original reserve was impossible to be replaced without losing environmental compatibility. Eventually a proposal was put forward to adjust the range and extension of the original reserve. In 2005, the Chinese Government authorized the creation of a "new" reserve. The area of the new reserve will become now the largest aquatic reserves in China. The total river length of the proposed reserve will increase to 1162.6 km in which the length of the main stream will be 436.5 km, and the total area to 331.7 km^2 (Table 3), including (a) the mainstream of the Xiang Jiaba Dam, Sichuan Province, up to Ma Sangxi, Chong Qing City, (b) the mainstream of the Chishui River and some of its tributaries, (c) the lower Min River and its tributaries Yuexi River, and (d) the estuaries of the Nanguang River, Changning River, Tuo River and the Yongning River (Figure 1). Totally 67 endangered or endemic fish species thriving in these areas were clearly listed as protected objects. Accordingly, the name of the original reserve was changed to the "National Reserve of the Upper Yangtze for Endangered and Endemic Fishes".

Challenge to the management of the reserve

Major users of the upper Yangtze reaches

As mentioned above, the reserve extents over several provinces. The statistic data in 2002 show that the total human population in the area of the reserve is about 14.6 millions. Only a smaller fraction of this population agglomerates in the cities while most are living in the countryside. Therefore, the conflicts between the protected land area and the relatively high human population who wishes to use it are rather drastic. There are more than 40 minorities, except the Han Nationality, including the Miao Nationality, the Hui Nationality, the Tujia Nationality and others, with their own demands and views on protection and use (Program report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). Those people living in the range of the reserve utilize the water and land resources with different methods for their own interests, which increases the difficulty to manage the reserve using common criteria.

Major threats and constraints to effective reserve operation

Power dams

River damming is the most dramatic anthropogenic factor affecting freshwater environments. The continuously increasing construction activities for power dams will inevitably result in a series of ecological problems, cascading downstream, such as loss of river banks and beach habitat, increasing water pollution, drastic changes in river bed erosion and sedimentation, and substantial changes in hydrology along the lower reaches below each of the dams (Jia, 2005). Many scientific studies showed that the construction of power dams was the main factor causing 1/5 of the 9000 species of freshwater fishes all over the world to either become extinct or to become highly endangered. Almost 3/4 of freshwater fishes in German and 2/5 of those in North America were influenced by this type of human intervention (Jia, 2005). Although the most dramatic ecological impacts of dams are identified downstream as a result of water flow regulation and river fragmentation (Baxter, 1977; Dynesius and Nilsson, 1994; Dudgeon, 2000), the extensive ecological impacts on upstream fish populations have

Table 3
Comparison of reserve areas (in ha) involved in the upper Yangtze River reserve before and after the adjustments for enlarged area protection have become effective

Area of different zones (ha)	The original reserve	The new extended reserve
The total	18,052	33,174
Core zone	3,448	10,803
Buffer zone	7,290	15,804
Experiment zone	7,315	6,566
Total	36,105	66,347

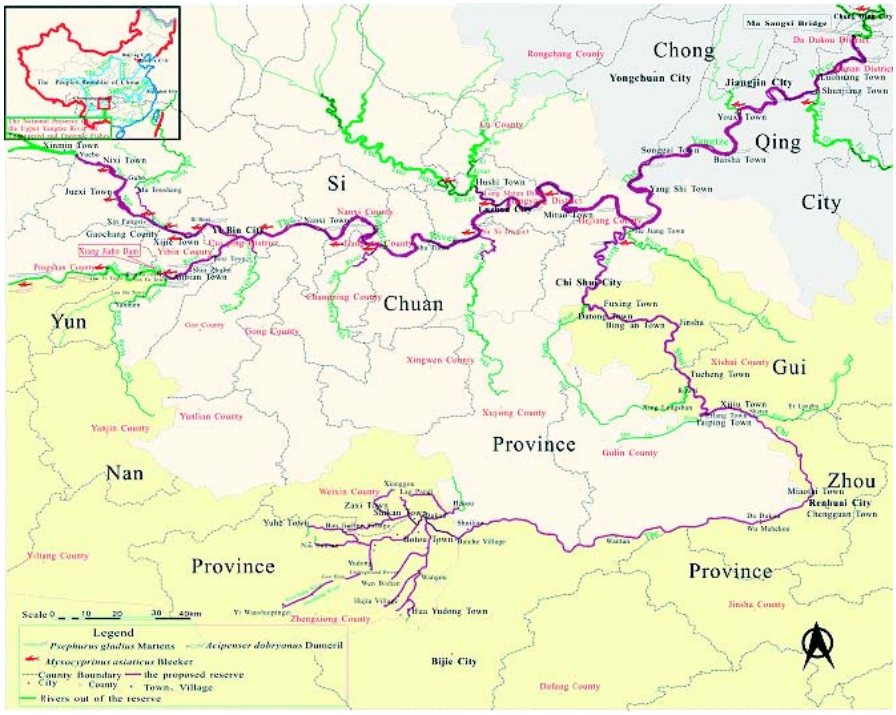

Fig. 1. The map showing the distribution of nationally protected fishes in the National Preserve of Upper Yangtze for Endangered and Endemic Fishes. The red pane in the top left corner shows the location of the reserve in the People's Republic of China

rarely been investigated except for some highly valuable migratory fishes (Allan, 1996; Helfman et. al., 1997).

Because of the immense water resources of the Yangtze River, this river has attracted massive interest to serve as the main hydroelectric power base. The Gezhouba Dam, the first power dam on the Yangtze River, was built in 1981. The serious effects of this dam are directly visible in the drastic decline of the Chinese Sturgeon population while cutting its spawning migration route (Xiao et. al., 1999). By 1986, a total of 25 dams with the generation power of 330×10^4 kW have been constructed or are presently under construction. In 2003, the Three Gorges Project began generating power. In 2005, the first part of hydroelectric projects on the Jinsha River was constructed and it will start to generate power in 2012. According to statistics, 48,000 power dams accounting for 50% of the total dams in China have been constructed in the tributaries and main streams of the Yangtze River system, including 157 dams of large size and 1025 dams of moderate size (Jia, 2005).

In 2003, the largest hydroelectric dam in the world, the Three Gorges Dam in the lower section of the upper Yangtze River was sluiced for the first time, resulting in a reservoir water level of 135 m above the base outflow (Chen, 2003). The reservoir will flood a river stretch of over 600 km of the main channel, with a catchment area of 1.9 million km2 (Park, 2005). After closing of the Three Gorges, the seasonal fluctuation of water flows will be largely levelled resulting in all-time overall slow flows. Many fish species adapted to the spring water rapid flows will lack the trigger for initiation of spawning migration or spawning activity (Jia, 2005). About 24 endemic fish species will be able to complete their life histories in these tributaries while the fate of 14 species is hard to forecast, and 6 species will most likely become extinct (Park, 2003). The Three Gorges Reservoir will disrupt spawning migration leading inevitably to population decline while also changing the hydrological regime. Sedimentation will increase, water temperature decrease, gas supersaturation occur, and daily variations in water temperatures downstream of the dams will be remarkably reduced due to the drainage of floodgates. All of these will disturb the reproductive cycles in many fish species.

For *Psephurus gladius* Martens, *Acipenser dabryanus* Dumeril, and *Myxocyprinus asiaticus* Bleeker, the effects of the hydroelectric projects were different (Survey report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). The spawning grounds of *Psephurus gladius* Martens are mainly located in the upstream reaches of the Xiangjia Dam where the Jinsha River hydroelectric stations are located in. The spawning grounds upstream of the Xiangjia Dam could be inundated and disappear. Furthermore, the Xiangjia Dam Reservoir and Xiluodu Dam with deep water will lead to lower water temperatures in the deepeer water masses, resulting in spawning failures of *Psephurus gladius*. Even though *Psephurus gladius* may succeed to spawn in certain years, long-term low temperatures will affect the growth of juveniles thereby seriously influencing the population structure and size. However, *Acipenser dabryanus* Dumeril and *Myxocyprinus asiaticus* Bleeker are able spawn in more diverse locations than *Psephurus gladius* , so the population effects may be less pronounced (Zhang and Zhao, 2001).

Water pollution

With the rapid of the industrial and agricultural development, pollution will increase, including heavy metals such as copper, oil, hydrocarbons and nutrients such as ammonia and phosphorus. These will directly enter the rivers in the reserve and affect the entire ecosystem in which fish thrive with all globally known consequences (i.e. eutrophication, accumulation of toxicants, disruptive effects on physiology and reproduction). There is an urgent need that the expansion of the reserve being accompanied by adequate measures to prevent pollution by appropriate construction of wastewater collection and treatment facilities. Otherwise the reserve environment will become contaminated and will lose the compensatory effect the reserve is supposed to achieve.

Navigation

Shipping is one of the important transportation methods in the region. Mainstream and branches of the Yangtze River are critical navigation routes. It is considered necessary to alter and improve navigation in the upper Yangtze River system because of many dangerous hydro-dynamic situations (i.e. rapids and whirlpools with rather high velocity). By the end of 2005, there were 669 passenger or cargo ships with a total capacity of 93,149 tonnes in the reaches belongs to the domination range of Yibin City from Pinshan County to Jiang'an County. However, the reaches from Luzhou to Chongqing are also habitats, which include reproductive grounds of many fishes while also presenting migratory passages for long-distance migrants. Reconstructing navigation routes will directly or indirectly affect these fishes. Explosions (rock blasting) under water during the construction phase will also at large scale kill or injure fish physically or physiologically. The construction phase is long (over years) and will definitely disturb physiological and lifecycle functions for many species, for example, reproduction, feeding and growth as well as behavior. The changes within the river bed will irreversibly and rapidly alter the particular topography, geography, hydrography and habitat structures which were formed over long historical times when these natural habitats evolved. With the increase of shipping, ship size and larger engine horsepowers, operating ship propellers will also hurt a substantial biomass of aquatic animals than ever before (a factor that is often simply overlooked).

River dredging

River dredging is one of the factors greatly influencing fish and their essential environments. By 2005, there are 10, 6, 3 river dredge ships in the Yangtze River, the Jinsha River, and the Min Jiang, respectively. The aim is to prevent sedimentation along shipping routes and maintain navigation. The tonnage of these ships ranges from 80 to 100 tonnes, and the power of their engines is over 100 horsepower. The monthly mean dredged volume is between 3,000 and 4,000 tonnes per ship. River dredging does alter the bottom topography of the riverbeds, resulting in loss of intact benthic habitat in general and specifically in loss of spawning grounds for many fish species. Furthermore, the noise resulting from river dredging does interfere with fish behaviors and habitat use not only for adults but also during development of juveniles. New regulatory measures are urgently needed to restrict dredging to the absolute essential and also to provide strict guidelines how to handle and deposit dredge spoils so that the benthic river habitat in the reserve is not exceedingly affected.

Fishing

It has to be recognized that many fish species within the reserve have high economic values, for example, *Acipenser dabryanus* Dumeril*Myxocyprinus asiaticus* Bleeker and some endemic fish species have ever provided important economic products in the upper Yangtze River (Survey report on the National Reserve of the Upper Yangtze for Endangered and Endemic Fishes, 2004). On the one hand, with the development of the economy, market needs for valuable fish will further increase. On the other hand, the increasing capture efficiency of new fishing gear greatly enhanced the fish exploitation rate. As a consequence fish populations in the reserve area were over-fished. Particularly driven by economic benefits, local people are willing to employ any new and more effective methods to exploit the fish stocks more radically, also with the illegal use of explosives and electricity. All of these increasing exploitation methods are counter-productive to the objectives of the reserve and will endanger the fish resources unless strict regulatory measures are taken to limit over-exploitation. Establishment of fishing regulations appropriate for the reserve and adequate enforcement of these regulations will be the two key factors to effectively support the objectives of the reserve. In 1958 the capture of *Myxocyprinus asiaticus* Bleeker is above 13% of the total in Min River, and it is 13% of the total in Pian Chuangzi reservoir, Yibin city. But since the 1970s, *Myxocyprinus asiaticus* Bleeker resources notably declined, and between 1973 and 1974, it reduced to 2% of the total (Zhang and Zhao, 2001). Today we will certainly need a total ban on fishing this species (and perhaps others as well) within the new reserve or part of the reserve for a long time. The level of fishing needs to be re-investigated with time and therefore adequate accompanying fish stock research programs must be installed to provide the sound data base for the management and for the wise and sustainable use of the fishery resources in and around the new reserve area.

Conclusions

With the expansion of human activities, large-scale natural habitats will be critically affected if not destroyed, eventually leading to extinction or threatening of many species. It is necessary to protect wildlife and their habitats also for sustained use of natural resources and the well-being of humans. There are mainly two potential strategies for conservation of highly endangered species. *Ex situ* conservation and *in situ* conservation.

Ex situ conservation means to maintain a reasonable number of specimens in captivity that do reflect the genetic integrity of the species and allow continued controlled reproduction in cases where even parts of the natural habitats of this species needed to complete the life cycle have already been permanently destroyed or has been so reduced in size and so fragmented that the species can no longer maintain its minimum population size and is at imminent risk of extinction (Li et al., 2002).

In-situ conservation means that essential measures are undertaken to remove or overcome serious environmental distress for species survival within the natural range and habitats of a species to permit survival and guarantee continued reproduction to maintain self-sustaining populations.

The best remedy to prevent species extinction is the preservation of essential habitats (*in situ* conservation), which can be achieved through site specific measures (i.e. to overcome migration barriers), or conserve critical habitats through the foundation of natural reserves of sufficient size. When creating nature reserves, however, some questions need to be resolved to determine the appropriate criteria that need to be employed to achieve the functional objectives, such as (a) selecting the proper sites, (b) selecting the proper size, (c) linking several habitats that are essential for the life cycle completion of the species, (d) confirming the areas selected with prohibitive or restrictive measures for other stakeholders operating in the selected reserve, and (e) managing the nature reserve with adequate enforcement regulation and implementation., All of these steps and measures must be done under with the guidance from sound conservation biological theory, such as the theory of island biogeography, the theory of minimum viable population size, the theory on buffer zones and linking corridors as well as others, mainly concerned with pollution abatement within the reserve and adjacent areas that affect the reserve. However, when applying ecological and sound principles to "real-world problems", there are will be disputes and conflicts with other arguments. Among these debates the most commonly discussed one is the issue of SLOSS (single large or several small) controversy. Diamond (1975) firstly proposed that single large preserves would be better at preserving species than a set of smaller, separate reserves of the same total area. In 1980, the World Conservation Strategy (1980) reproduced Diamond's suggested principles for

nature reserve design, with the general recommendation that a large reserve was better than a small one. However, other researchers believe that several small reserves are of specific advantages over a single large one. The differences in opinions originated from the facts that scientists focused on different species with different lifestyles and tried to generalize from limited studies in order to derive at a short formula (Kingsland, 2002). The protection of pristine ecosystems, rare and endangered wildlife, prominent landscapes, or unique biological phenomena face complex ecological requirements which will have to be met with diverse political, economic, social, and cultural challenges. Initially, biological conservation measures through reserves has become a land-use category in its own right that competes for available land with other land uses, such as forestry, agriculture, recreation, and urban and infrastructure development (Margules and Usher, 1981). Another problem in the design of nature reserves with inclusion of the inherent "complexity of entire ecological systems" that are not necessarily based on fixed areas but on inter-changing functions with adjacent or distant areas where water as a "non-fixed" but "moving" essential element is part of the complex ecosystem function. To consider the reserve requirements for such cross-border issues limited data are available, and a lack of theory for both determining the relevant biodiversity elements to protect the integrity of the ecosystem and setting of sufficiently appropriate conservation priorities is apparent (Bojórquez-Tapiaa, 2004).

The key issues to protect an endangered species can not be met by only creating a natural reserve, but must include appropriate management using related ecological theories and continuously adjust to required inputs to meet effective protection functions. The present case in time is a good example. At first the original reserve in the upper Yangtze River played a valid key role in species conservation but only to some extent when conditions on environmental pressures changed. With the construction of the Three Gorges project, conditions did change dramatically and disabled its originally intended conservation functions. Therefore, species conservation measures should must be continuously adjusted and harmonized with changes and growth in environmental pressures caused by human interventions such as industrial constructions and social/urban developments. Meanwhile, the National Reserve of the Upper Yangtze for Endangered and Endemic Species of Fishes is distributed over several provinces, and there is a definite need for its management through intensified cross-sectorial and cross-authority cooperation with growing and continued supports from local governments. Furthermore, different from the management of land-based nature reserves, it is impossible to prohibit human movements inside the core zone of the National Reserve of the Upper Yangtze for Endangered and Endemic Species of Fishes because transportation by passenger and/or cargo ships represents also an essential life-line connecting human settlements. However, navigation can be restricted and controlled to the extent that impacts are minimized. Therefore it is necessary to modify the actual laws and/or regulations or establish new ones if needed in order to minimize or mitigate negative effects. For example, restricting the velocity or the number of ships, setting aside specific river way routing for navigation, enforcing certain operational safety standards for shipping that minimize the risk of accidents and prohibit the release of pollutants from normal ship operations (i.e. wastes and waste oils) or restricting fishery in scale and time and prohibit fishing in sensitive areas (i.e. spawning grounds and during spawning seasons). All such measures must be accompanied by appropriate enforcement actions to become truly functional. It is hoped that with time a step by step improvement in operating and managing of the new and enlarged reserve can be achieved so that the intended objectives will be fulfilled in the near future.

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