LETTERS

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Three-Gorges Dam: Risk to Ancient Fish

THE HUGE THREE-GORGES DAM (TGD) OF THE Yangtze River is going to demonstrate the mighty power of humanity to change and fragment an area of about 58,000 km^2 with the formation of a huge reservoir of 1080 km^2. It is expected to exert disastrous influences on many terrestrial plants and animals, as discussed by J. Wu *et al.* in their Policy Forum "Three-Gorges Dam—experiment in habitat fragmentation?" (23 May, p. 1239). However, loss of biodiversity will take place not only terrestrially but also aquatically. More attention should be given to ancient endemic fish species that are extremely vulnerable.

The Yangtze River basin is one of the richest areas in freshwater fish species diversity, with 361 fish species belonging to 29 families and 131 genera, accounting for 36% of all freshwater fish species in China (*1*). There are as many as 177 endemic fish species in this area, of which 25 already have endangered status, accounting for 27% of all endangered freshwater fish species in China (*2*).

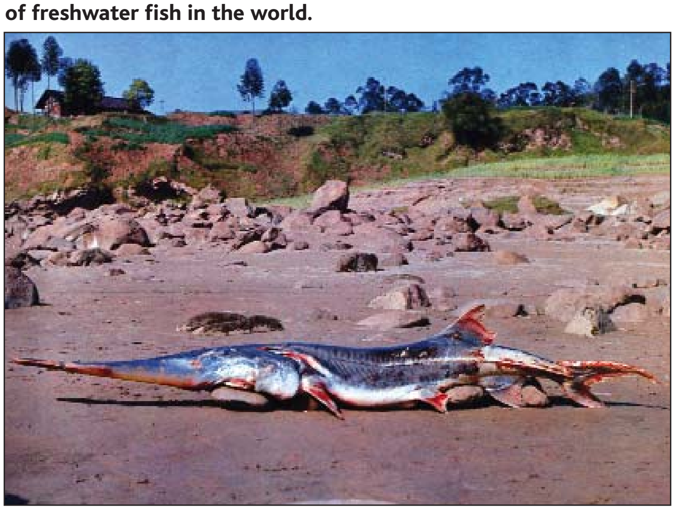
The construction of the Gezhou Dam (38 km downstream from the TGD) in 1981 led to sharp declines in the populations of three endemic ancient fish species, Chinese sturgeon (*Acipenser sinensis*), River sturgeon (*A. dabryanus*), and Chinese paddlefish (*Psephurus gladius*) (*3*). These three species are listed as Grade I endangered species in *China Red Data Book of Endangered Animals* (*2*).

The Chinese sturgeon originally migrated from brackish water or the sea into their breeding ground in Jinsha River, the upper branch of the Yangtze River, swimming over 3000 km. However, the construction of the Gezhou Dam has completely prevented their upstream spawning migration, and although a new spawning site formed below the dam, their breeding ground shrank from 600 km to only 7 km. The TGD will reduce 41% of the water flow below the dam, which will most likely destroy the only breeding ground.

The spawning of Chinese paddlefish was also severely impaired by the completion of the Gezhou Dam, and since 1988, only 3 to 10 adults have been found below the dam annually. Some spawning takes place above the dam, but TGD will further damage the paddlefish population when it is completed.

The middle and lower basins of the Yangtze River are the most densely populated part of China. This region was originally a huge flood plain characteristic of a network of water systems, including the river and its tributaries, and many interconnected shallow lakes (*4*). Mainly to increase farmland, the Chinese have constructed numerous flood-control projects along the river and separated thousands (almost all) of the lakes from the river, which caused serious fragmentation of the water system and lamentably promoted, in turn, the construction of the world's largest dam, which has decreasing flooding as one of its major roles (*5*). Many ancient fish coevolved with the flood plain, and the local monsoon climate has been threatened by these environmental modifications to such a rate and extent that the TGD will deepen fragmentation of the river and will undoubtedly bring more problems to migratory fish such as Chinese sturgeon. Additionally, consequential salinization of the estuary might potentially contribute to the extinction of related fish species.

A Chinese paddlefish from the Yangtze River. A huge individual over 7 m long was captured in Nanjing, which is still the longest record of freshwater fish in the world.



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Although the dam will start storing water and generating electric power in late 2003, these concerns could possibly change the way the dam is operated in the future, increasing public awareness and promoting urgent adoption of a conservation agenda and substantial international collaborations in research and protection activities for endangered fish in the Yangtze River, where the Chinese government is still planning to construct more than 10 dams in the future.

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Response

IN OUR POLICY FORUM, WE DISCUSSED THE possible effects of the Three-Gorges Dam (TGD) on, primarily, the terrestrial biodiversity in the Three Gorges Reservoir Region, an area of 58,000 km^2 that includes 19 counties and cities where 1.13 million people will eventually be resettled. Our main focus was that the construction of TGD might provide a unique opportunity for conducting a grand-scale experiment to study the effects of habitat fragmentation on the biodiversity of the landbridge islands created by inundation. However, habitat fragmentation caused by damming affects not only terrestrial biodiversity but also aquatic fauna because dams can disrupt the natural seasonal flow patterns to which aquatic animals are adapted, block and destroy spawning grounds and migratory paths, and fragment populations (*1*–*3*). Distinct regional trends of biodiversity loss resulting from the construction of large dams have recently been documented (*2*).

As Xie argues, the aquatic habitat fragmentation caused by Gezhou Dam (Gezhouba) and TGD on the Yangtze River is particularly inimical to ancient endemic fish species. Many other migratory species may also be affected. Chinese scientists have warned of the threats of TGD to native fish biodiversity over the past two decades, but, except for a few flagship species, detailed studies are still lacking. Nevertheless, in a recent survey and synthesis, Fu *et al.* (*4*) estimated that Gezhouba, TGD, and about 10 more dams that are expected to be built on the Yangtze will adversely affect more than 40 fish species, including 19 endemic to the river. Riverine mammals (e.g., manatees, dugong, and Chinese river dolphin) are even more vulnerable to damming effects than fish and freshwater invertebrates (*4*, *5*). Sedimentation, altered food web and species interactions, and physical injuries and noise disturbance from increased navigation are also likely to negatively impact the riverine biodiversity. To alleviate these problems and conserve biodiversity, establishing nature reserves in biodiversity hotspots and reconnecting the river with its disconnected lakes are critically important (*4*).

Nothing alters a river and impairs its associated aquatic and riparian biodiversity like a dam (*5*). Globally, numerous studies have shown that dams reduce fishery productivity, release toxic substance into water, cause eutrophication and the depletion of dissolved oxygen, build up sediment, and result in a series of downstream habitat changes (*3*, *6–8*). Riparian ecosystems are particularly sensitive to hydrological changes caused by dam operations and may serve as ecological indicators for environmental monitoring (*9*). The total surface area of reservoirs in the world is estimated to be as large as 1,500,000 km^2 (*3*, *10*), an area more than six times the size of the United Kingdom. Recent studies also suggest that these reservoirs, inundating vast areas of terrestrial biotic communities, may reduce the regional carbon sink and increase the emission of greenhouse gases (CO_2 and CH_4) because of the accelerated decomposition by bacteria of the organic matter stored in plants and soil (*10*, *11*). These emissions are estimated to be 7% of the global warming potential of other documented anthropogenic sources, thus challenging the common view of hydroelectric generation as a carbon-free source of energy (*10*).

The construction of dams is increasingly regarded as the biggest conservation threat to aquatic and riparian biodiversity in many river basins throughout the world. To fully understand the ecological consequences of a single dam may prove extraordinarily complex because of the multiplicity of its effects. Much remains to be learned about the real impact of TGD on the aquatic biodiversity. One thing is for sure, though: The rising water brings a tremendous amount of energy, but what it buries beneath are thousands of years of cultural heritage and millions of years of biological evolution.

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Have Clouds Darkened Since 1995?

IN MODELING CLIMATE, CLOUDS HAVE BEEN A cause of great uncertainty. In his article "Making clouds darker sharpens cloudy climate models" (News of the Week, 20 June, p. 1859), Richard A. Kerr reports on some recent findings concerning the cloud absorption anomaly (CAA) debate. The essential message of his article is that radiative transfer models (RTM) underestimated the amount of solar radiation absorbed by clouds 40% in 1995 and that this underestimate has been fixed as a result of the debate, leading to much greater absorption in Global Climate Models (GCMs). This is incorrect—our perception of cloud reflection remains as bright as in 1995, although the atmosphere as a whole may have darkened in some GCMs due chiefly to enhanced absorption by aerosols and gases, but not clouds. We do agree that the debate has played certain positive roles in improving GCMs.

Although the CAA has been discussed for over 50 years (*1*), it did not become a big issue until 1995, when three studies claimed that clouds absorbed about 25 to 30 W m^{-2} (annual and global mean) more solar radiation than models had previously predicted (*2–4*). This claim has been debated from the very beginning (*5*). Because nearly all recent studies show good agreement between observations and models, the dust of the CAA debate appears to be settling down. Unfortunately, the interpretation of the