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Endangered fishes and economics: intergenerational obligations**

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Synopsis

The diversity of fishes is declining worldwide, largely as the result of habitat alterations created by decisions that foster short-term economic gain. While the best arguments for preserving endangered fishes and ecosystems are non-economic arguments, they have been relatively ineffective. Therefore, it is necessary to provide economic arguments as well. Fish in general have high market values and are a vital source of protein for humans but these values have contributed more to their decline than to their conservation. Fish also have high value as indicators of the health of ecosystems which provide many services to humans, such as clean water. This has not prevented the degradation of aquatic ecosystems, although the value of fisheries has occasionally justified ecosystem protection. Existence values have been developed as a way of putting an economic value on some of the less tangible aspects of fish and ecosystems but they also make it possible to justify extinctions. If the continuous increase in the number of endangered fishes and aquatic ecosystems is to be halted, then the economic costs of environmental degradation to future generations must be included as part of the cost of doing business today (intergenerational value). Political action is needed to protect fishes and aquatic habitats against the day when more benign economic and philosophical systems become predominant.

Introduction

The fish faunas of the world are changing rapidly as the result of human-caused extinctions and invasions (Bruton 1995). This change reflects major alterations of marine and freshwater ecosystems and a rapid loss of aquatic organisms of all types (Moyle & Leidy 1992). The loss of aquatic biodiversity is most severe in fresh water and estuaries, although the problem is becoming increasingly obvious in marine systems as well (Norse 1993). Moyle & Leidy (1992) estimate that 20% of the world's freshwater fish fauna is extinct or in danger of extinction in the foreseeable future. In regions with Mediterranean climates, this figure is typically greater than 65%, reflecting the intense demand for water in watershort regions. In California, for example, distinct fish taxa are being lost at the rate of about one every six years (Moyle & Williams 1991) and genetically distinct populations of anadromous fishes, such as Pacific salmon (*Oncorhynchus* spp.) are being lost at even more rapid rates (Brown et al. 1993, Moyle 1994). Given that human populations are continuing to grow rapidly and that the demand for water and other resources is increasing even faster than population growth, the extinction rates seen in Mediterranean climatic regions are likely to become characteristic of other climatic regions soon.

* Invited essay

As Bruton (1995) points out, this downward spiral in biodiversity loss requires 'urgent action' in order to be halted. A major stumbling block in taking protective action is convincing people that such action is in fact desirable and beneficial. The best arguments for protection of biodiversity, from our perspective, are the ethical and moral arguments that have their roots in both Western and Eastern religious beliefs (e.g., Norton 1987, Rolston 1994). Ultimately, if these arguments do not prevail, much of the world's biodiversity is likely to be lost. In the short run, however, the most effective arguments are probably economic arguments, ranging from those that point out the limits of the Earth's ability to sustain humanity (Daily & Ehrlich 1992) to those that deal with local issues such as the value of protecting fisheries in a particular stream (Adams et al. 1993). These arguments can be particularly effective when dealing with freshwater fishes because of the high food value of such fishes and the connection between healthy water supplies for sustaining human populations and healthy fish populations. We recognize that economic arguments have largely failed to protect natural resources in the past (Ludwig et al. 1993) but recent developments in ecological economics offer some hope of changing this pattern (Constanza & Daly 1992). We also recognize that economic arguments are not independent of other cultural values, so they need to be used in a cultural context. Modern economic theory is tied to Western values and economic systems which historically have justified environmental degradation (Meffe & Carroll 1994). Although Western economic values dominate the world today, there are other ways of valuing things (e.g., Snyder 1990) which are not discussed here.

In this essay, for convenience, we consider four major categories of economic values: market values, ecosystem values, existence values, and intergenerational values. Our purpose is to summarize some of the major economic arguments that can be used to justify protection of fishes and aquatic habitats, especially endangered species. Our examples come mainly from California and the Pacific northwest, both because of our personal familiarity with the region and its problems and because the problems are similar to those found elsewhere in the world, only more extreme.

Market values

There are over 24 000 species of fishes (Nelson 1994) and virtually all of them can be consumed by humans. The fact that most species are not eaten is mainly the result of difficulty of capture (e.g., deep-sea fishes) and cultural preferences. Many unlikely fishes can be eaten. For example, Salt Creek pupfish, *Cyprinodon salinus,* small fish from a saline stream in Death Valley, California, were once consumed in large numbers by Panamint Indians (Moyle 1976). Certain highly toxic puffers (Tetraodontidae) are considered to be gourmet food (fugu) in Japan. With modern technology, virtually any fish, caught in enough numbers, can be turned into anonymous patties and fish sticks or converted into protein meal for animal food. In 1988–1992, over 80 million metric tons of fish and shellfish were harvested annually, including 15 million tons from fresh water (O'Bannon 1994). Fisheries have a direct economic value of billions of dollars worldwide and are the principal source of income of many coastal communities and regions. In 'developed' countries, recreational fisheries add another layer of economic value to many species, especially of freshwater and anadromous fishes.

More important than the direct economic value of fishes is that they are the major source of animal protein for millions of the world's people (Norse 1993). In most parts of the world, the rarity of a fish makes little difference as to whether or not it is eaten. This is especially true if the rare fish is captured in fisheries for more abundant species (e.g., Roberts 1993). However, one of the important aspects of fisheries is that, in theory, they can be sustained indefinitely, climate permitting. Anadromous fishes, for example, have the potential to come back year after year, bringing the productivity of the seas to streams and to human society. Indeed, the elaborate culture of the Indians of the Northwest Coast of North America was based on the predictability of large salmon runs. Likewise, the wide variety of fishes that can be fished around the world has potential to provide new sources of food for people. For example, the influx of Asian immigrants into California has resulted in the development of fisheries and markets for native cyprinids, species which were once heavily used by the Indians but despised by the European settlers (Moyle 1976). These fishes are particularly well adapted for thriving in the natural waters of California but are in a general state of decline (Moyle & Williams 1990). At least one of the species preferred by Asian fishers, splittail, *Pogonichthys macrolepidotus,* is now threatened with extinction due to habitat loss.

Fish have economic values beyond fisheries as well. The global retail value of aquarium fishes and accessories is estimated to be in excess of seven billion dollars per year (Andrews 1990). Most freshwater fishes and many tropical marine fishes can be kept in aquaria, so the trade ultimately involves thousands of species. Potential endangered species may have especially high value in this trade because of their rarity. Public aquaria are also major tourist attractions as are accessible tropical reefs and salmon spawning streams. Such attractions can be valuable assets to local economies. Still other species, such as mosquitofish (*Gambusia* spp.) have high value for biological control of pestiferous invertebrates and plants in aquatic systems.

Despite the enormous value of fishes and their importance as both food and a source of income, they are declining in both diversity and in numbers. In recent decades there have been a series of collapses of major ocean fisheries, most recently the cod, *Gadus morhua,* and groundfish fisheries in the Atlantic and the Pacific salmon fisheries of the Pacific northwest (Egan 1994, Holmes 1994). The causes of the collapses have been overfishing, environmental degradation, and fluctuating natural conditions, all interacting in different ways in each fishery. Similar situations exist in fisheries in freshwater around the world, but they are poorly documented (e.g., Roberts 1993). In most cases, the collapse of fisheries and fish faunas can be (and has been) predicted and yet corrective measures are rarely taken in time to prevent great economic, social, and ecological losses. The principal reason for this is the focus on short-term monetary gains in our present economic system. 'Wealth or the prospect of wealth generates political and social power that is used to promote unlimited exploitation of resources' (Ludwig et al. 1993, p. 17). This clearly indicates the need to adopt alternative economic strategies that sustain both fish diversity and fisheries (Constanza et al. 1991).

Ecosystem values

There is a growing realization that natural ecosystems with high integrity (Regier 1993) provide many goods and services to human society. For example, they can process and detoxify pollutants. Healthy watersheds in particular can provide various services, including profitable fisheries and clean water for human use. When watersheds are degraded they provide fewer 'free' services and the costs of degraded water quality increase in terms of treatment costs and human health problems. Because fishes and other aquatic organisms are sensitive to a wide variety of ecological changes, they are excellent indicators of aquatic ecosystem health (Karr 1993). An endangered species is often part of an endangered ecosystem that has reduced capacity to provide services to humans. For example, recovery of the endangered delta smelt, *Hypomesus transpacificus,* and other threatened species in the Sacramento-San Joaquin estuary, California, will entail allowing increased flows of fresh water, with major benefits to fisheries for non-endangered species and to water quality in diversions from the upper estuary (Moyle et al. 1992).

Fishes can also have considerable value for monitoring of aquatic systems given their sensitivity to change and their relative ease of sampling. Changes in fish communities (including species diversity) can give early warnings of ecosystem degradation (Karr 1993). Endangered species are likely to be the most sensitive components of these communities and their recovery can indicate ecosystem recovery. For example, most of the endangered fishes of Sri Lanka are rain forest endemics and protection of these fishes will ultimately require protection of the watersheds in which they occur (Pathiyagoda 1991), with many benefits (better water quality, reduced flooding, etc.) to downstream users of the water. In these cases, the fish themselves may have little direct economic value, but they can serve as indicators of processes that do have high economic value.

On the other hand, the economic value of many fishes can often contribute to justifications for the protection and enhancement of ecosystems that might otherwise be degraded. Adams et al. (1993), for example, present a bioeconomic model showing that the costs of restoring a watershed in Oregon, U.S.A., could be justified on the basis of economic benefits from enhanced salmon and trout populations. This enhancement would also benefit non-salmonid fishes in the stream as well as other aquatic and riparian organisms. Likewise, protection of coho salmon and other valuable fishes is being used as a justification to protect old growth forest ecosystems along the Pacific coast of the United States, forests upon which the health of the fisheries depend (Wilderness Society 1993).

Existence values

In recent years, economists have been looking for ways to attach monetary value to endangered species and ecosystems even when they are not yielding direct income to humans. The most promising approach is through the development of the concept of existence value. According to Portney (1994), existence value is 'the value that individuals may attach to the mere knowledge that rare and diverse species, unique natural environments, or other "goods" exist, even if these individuals do not contemplate ever making active use of or benefitting in a more direct way from them (p. 4).' Existence values are calculated mainly by the contingent valuation method (Castle & Berrens 1993). This method involves the use of public-opinion surveys to measure respondents' willingness to pay, or willingness to accept compensation for, some hypothetical change in an environmental commodity (Castle & Berrens 1993). Using this approach, it is possible to put a dollar value on otherwise intangible benefits such as the preservation of an endangered species or the continued presence of an undammed river system that the respondent might never see. Contingent valuation attempts to define and quantify the value that society as a whole places upon aspects of the environment. It essentially places a market value on species and ecosystems, allowing the net economic benefits of preservation to be calculated (Castle & Berrens 1993). This allows existence values to be compared with the value of conventional commodities and hence be represented in decision making and policy analysis where economic factors play a key role.

Although contingent valuation is one of the most controversial areas in resource economics, it will almost certainly play a role in future public policy decisions (Portney 1994). Contingent valuation is presently the economist's only means of measuring existence values (Castle & Berrens 1993). It potentially offers a reliable way of assessing damage done to the environment and of calculating the costs of further degradation. However, the measurement techniques and experimental design of the approach are subject to the criticism that they result in too high a value being placed on the environment, resulting in a hindrance to economic development (Diamond & Hausman 1994). Because existence values can be identified for virtually every citizen who may benefit from or be injured by an action, it is difficult to limit the scope of contingent valuation surveys. Critics also cite the lack of precision and the presence of bias in responses to contingent valuation surveys as methodological weaknesses which inhibit reliability (Diamond & Hausman 1994). In addition, respondents' willingness to pay is determined by the capacity of a resource to support life or generate wealth over the long run, a concept that is often difficult for individuals to quantify in their own minds. For many people it is easier to pay money to repair damage that has already occurred rather than to invest in long-term conservation practices whose benefits are unknowable. Nevertheless, improvements in the methodology are being made and contingent valuation remains one of the most widely used means of estimating the indirect costs and benefits of environmental regulation (Loomis 1993).

From a species conservation perspective, contingent valuation surveys can be criticized for implying that *present* existence values are equivalent to market values so in theory a fish species could be driven to extinction if the market value of altering its environment exceeded the existence value of the species. One way around this is to assume that species and ecosystems belong to the people as a whole (i.e., have an uncalculated existence value) and that economic beneficiaries of degradation should pay for the right to alter a river and endanger a species (Shogren et al. 1994). Presumably the latter costs, which can be determined through a combination of direct cost estimates and contingent value surveys, would often be so high that severely damaging projects would be modified or abandoned. This method of valuing species and ecosystems is a way to avoid externalizing the real costs of environmental damage. For example, the bays, estuaries, and inland seas around the world are suffering enormous ecological and economic damage because of massive introductions of non-native organisms, including fishes, through the discharge of ship ballast water (Carlton & Geller 1993). In the Laurentian Great Lakes alone, the direct cost of dealing with these introductions has already run to billions of dollars. Shipowners are currently not required to include the price of environmental damage in their overhead cost calculations, in part because environmental damage is traditionally not included in cost-benefit analyses and in part because such costs are difficult to assess. In this case, contingent valuation surveys would help identify the value to society of preventing further invasions of these aquatic ecosystems. These values could then be presented as costs to the shipping industry that must be paid if ship operations are not changed to prevent further introductions. The added cost of changing ship operations (presumably a cheap alternative to paying some pro-rated portion of the damage caused by invasions) would be absorbed into higher prices for consumers and/or lower profits for shipowners, changes that would more accurately reflect the true cost of shipping operations.

Intergenerational values

While the development of existence values is a major step towards developing an economic rationale for the protection of endangered species and ecosystems, at least in western countries, existence values are still short-term values that fit into standard economic practices. As Norgaard & Howarth (1991) point out 'All decisions over time have been simply treated by economists as investment questions, as if all resources were this generation's resources' (p. 88). There is clearly a need to consider the economic costs to future generations of activities taking place now, especially since we can no longer assume that modern technological advances will continue to mitigate the stress placed upon the environment by a burgeoning human population (Norgaard & Howarth 1991). If the human population continues to grow at the present rate (doubling once every 30 to 40 years) and efficient intergenerational allocation mechanisms are not adopted, many of the earth's natural resources will approach a dangerous level of scarcity (Daily & Ehrlich 1992). Substitutes for depletable and non-renewable natural resources are limited, as is the capacity of the earth to process the excesses of economic activity.

A result of this realization is growing support for the principle of sustainability, which, simply stated, promotes an equitable distribution of resources between generations. In other words, decisions should be made now to ensure that future generations are no worse off than current generations (Daily & Ehrlich 1992). The quest for sustainability is reflected in the moral conviction that the current generation should 'pass on its inheritance of natural wealth, not unchanged, but undiminished in potential to support future generations' (Daily & Ehrlich 1992, p. 764). The economic basis for the sustainability principle is still in its formative stages because there is much disagreement about how to define its parameters (Toman 1994). It is extremely difficult to determine how to distribute resources equitably across generations, for many reasons. Perhaps the most prominent reason is that the preferences of future generations are unknowable and therefore difficult to factor into present-day decision making analyses. In addition, the economic benefits of conservation efforts can take decades or centuries to accrue, while environmentally detrimental development projects may quickly yield profits and generate politically-desired attention (Soule 1991). For example, introduction of Nile perch (*Lates* sp.) into Lake Victoria, Africa, has resulted in profitable fisheries for the perch, with much of the fish exported from the basin (Riedmiller 1994). However, the predatory perch has apparently eliminated about 200 endemic species of small cichlids from the lake (Goldschmidt et al. 1993), which were the mainstays of subsistence fisheries. In addition, local deforestation has occurred in order to provide wood for kiln drying of the large perch (Riedmiller 1994). These effects of the introduction clearly have negative consequences for the well-being of future generations of the local people.

Current generations tend to view decisions that provide for the welfare of future generations as sacrifices. There is no guarantee that investing money in a particular project instead of saving it will transfer endowments to future generations (Toman 1994). The continued existence of endangered fish species, from the smallest goby to the largest salmon, may be valued by future generations, but it is impossible to tell to what extent. The value to the current generation of constructing a dam is easily calculated in terms of the aggregate direct and indirect economic benefits of the construction process and of projected benefits of flood control and power production. If the same dam is an insurmountable obstacle to anadromous fishes, forcing them towards extinction and irrevocably damaging upstream ecosystems, future generations are denied the benefit of the fishes' existence, including the economic gains from harvesting them. However, if a region is suffering from economic hardship, the construction option is an attractive one. The cost of dealing with the resulting environmental degradation can be deferred to future generations while the short-run benefits stimulate the region's economy. Examples of the problems created by deferring the payment of environmental costs are found on all major rivers of the United States that have been modified by dams. On the Colorado River, large costs are being incurred through the changing of dam operations and other actions in order to protect endemic cyprinid and catostomid fishes. The people of the United States, through the Endangered Species Act of 1973, essentially decided that the species were worth preserving for future generations, even though they currently have little economic value. Likewise, the costs are extremely high to protect the various endangered salmon populations that must pass the multiple dams of the Columbia River on their upstream and downstream migrations. The protective measures are based on the assumption that extinction is an unacceptable alternative.

A seemingly simple solution to such dilemmas in relation to future projects is the implementation of conservation tactics that are acceptable to current generations because of their low cost but whose effects over time will encourage sustainability (Page 1991). These policies must be guided by decisions that are based on careful and thoughtful research, taking into consideration that damage to the environment and to native species is often irreversible. Norgaard (1994) mentions three principles that should guide policymakers: the humility principle, the precautionary principle, and the reversibility principle.

According to **the humility principle,** humans must accept that technological advances will not compensate for poor intergenerational management of the earth's resources. Black (1994), for example, recounts the various technological fixes that have been employed to solve the problem of declining chinook salmon, *Oncorhynchus tshawytscha,* runs in the Sacramento River, since the 1870s. When one such fix fails, a new one, usually bigger and more costly, has been tried. The result of successive failed fixes has been the listing of the winter run chinook salmon as an endangered species and the severe declines of the other three runs. **The precautionary principle** advocates strict adherence to caution when dealing with issues whose complexities are not clear or adequately researched. In the Sacramento-San Joaquin estuary, for example, there is considerable debate over the status of various native fishes and the effects of increased water diversions on the fishes (Moyle et al. 1994). Under the precautionary principle, increased diversions should not be permitted until the biological consequences of such actions are understood. **The reversibility principle** states simply that irreversible changes to the environment should not be made. Clearly, the introduction of Nile perch into Lake

Victoria was a major mistake because it resulted in so many extinctions.

The irreversibility of decisions that harm the environment is often overlooked by policy makers who are confronted daily with the pressing demands of individual citizens and organized interest groups (Norgaard 1994). These groups often have the power to influence decisions in their self-interest and usually exclude all consideration of the environment in favor of short-term economic gains. The major fault with this approach to policy decisions is that the environment is undervalued and the true costs of natural resource exploitation are not included in traditional cost-benefit analyses. In addition, the long-term costs of environmental degradation are difficult to quantify and involve many uncertainties. As a result, some conservation-minded economists now advocate the **safe minimum standard** approach as a means of ameliorating this dilemma. Proponents of the safe minimum standard argue that when information is limited and there is high potential for loss, it is better to assume that the species has a high economic value and is worth preserving rather than to risk its extinction (Toman 1994). Setting a safe minimum standard ensures the survival of the species and preserves its potential economic worth.

Another approach to providing an economic basis for intergenerational values is to consider the costs of *not* protecting species or ecosystems. Under this approach, features of the environment such as fossil fuels, forests, streams, and fish populations are regarded as **natural capital** and the loss of their presence or services should be included in analyses as part of the cost of production. 'Capital' in the traditional sense refers to the productive resources used by individuals and companies in the development process. Natural capital includes not only the earth's stock of natural resources but the sustainable flow of services that natural ecosystems provide (Constanza & Daly 1992). The preservation of the integrity of ecosystems, including their constituent species, is often a requirement for this sustainability. If a high economic value is not placed on preventing the further depletion of natural capital, future generations may face overwhelming and irreversible scarcity. For example, a stock of fish can provide an annual surplus which with proper care can provide a sustainable flow of an economically valuable resource.

Akire (1993) calculated the total value of salmon in the Pacific Northwest when the natural capital value was also included. She concluded: '. . . market prices drastically underestimate the value of wild salmon as a capital asset, confirming that overharvest of wild salmon is economically irrational in the long run. Furthermore, preserving wild salmon by harvesting at a sustainable rate over time will yield substantially more economic and other benefits for the future than would harvesting the entire population today' (p. vii). Akire (1993) also notes that additional costs not usually included in standard analyses of fisheries economics include the costs of mitigation for lost habitat and the costs of recovery of endangered populations, such as many salmon runs in the Columbia River drainage. Endangered species should be regarded as severely depleted natural capital and their restoration to sustainable levels should be regarded as an investment that will eventually yield long term gains, from direct harvest, from ecosystem services, or from yet unknown values.

The loss of natural capital is particularly a problem during the initial stages of a region's economic development (Tisdell 1994). It is during this period that the natural environment is extremely vulnerable to exploitation, because resources may be sacrificed to prevent a sudden rise in unemployment or a decline in per-capita income. Natural resources provide capital stock that has no agreed-upon value and is therefore often used to finance development at the expense of biodiversity. In fact, depreciation of natural resources has erroneously been calculated in development strategies as income, and not as a decline in the endowment of natural capital (Tietenberg 1992). If pollution costs, income distribution effects, and depletion of natural capital are included in economic analyses, it becomes clear that most reports of developing and healthy economies have been greatly overestimated (Constanza & Daly 1992). During the development years of the American West, countless dams and hydroelectric projects were constructed without including environmental degradation or the loss of natural industries (such as fisheries) in their calculations of construction and operation costs (Reisner 1986). Today, billions of dollars are poured into ameliorating the damage done by such projects and into restoring some of the lost natural capital, ranging from runs of salmon to populations of obscure cyprinids.

In short, adding intergenerational values to economic analyses is a way to help assure that economic development does not oppose the conservation of the world's natural resources, including fishes. It is possible for conservation and development to coexist, as long as energy and time is devoted to developing strategies that will ensure the sustainability of the natural resource base (Constanza 1991).

Conclusions

The world contains many endangered fishes and failed fisheries because economic systems fail to take into account the true value of aquatic systems and biodiversity. Fishes and their ecosystems are increasingly threatened by the negative effects of human population growth and economic development. Even species with high market values, such as Pacific salmon, can be driven to local extinction by market forces that fail to include the loss of natural capital in their estimates of production costs. Recognition of the immense value of the services that intact aquatic ecosystems provide to humanity has only recently begun to alleviate some of the stress placed upon the environment by traditional economic practices. The rise of ecologically-based economics, which takes into account existence values and intergenerational equity, provides hope for the future, but it is hard to be optimistic given the overwhelming dominance of market-driven economic activity in the world. Nevertheless, environmental decisions can be influenced by people who are well-informed about environmental issues and who are willing to transform their views into tangible protection measures. At the same time, there is a need to educate society as a whole as to the high value of conservation practices and to recognize the true costs of economic development. Although societal views toward environmental protection seem to be gradually changing, at least in some areas, the process is a slow one. In the meantime, constant political action is needed to protect species and habitats against the day when more benign economic and philosophical systems become predominant.

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