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Notes on the Economics of Fish Biodiversity: Linkages between Aquaculture and Fisheries

by

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Clem Tisdell*

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Abstract

While genetic selection and cultivation of organisms have helped to support a larger human population at a higher standard of living, than otherwise, these developments have also led to a loss of biodiversity, particularly in the wild. The more recent development of aquaculture continues this development process. In this note, aquaculture practices that are likely to lead to biodiversity loss are listed and their consequences are specified. Trends in fish supplies from aquaculture compared to supplies from the wild are outlined. These indicate increasing replacement of supplies form the wild by aquaculture. A similar pattern seems to be emerging as has emerged in agriculture and in silvaculture. This is likely to accelerate biodiversity loss in wild fish stocks, but it is not the only factor bringing this about. While the development of aquaculture and of genetic selection has its economic advantages, considerable uncertainty exists about how much genetic alteration is desirable from an economic point of view. More research is needed to reduce this uncertainty. Although it may be impossible to eliminate such uncertainty completely, there is scope for reducing it and improving on the rationality of our decision making

Notes on the Economics of Fish Biodiversity: Linkages between Aquaculture and Fisheries

1. Introduction

To date, the development of aquaculture, and the husbandry of terrestrial organisms generally, has helped to support a larger human population at a higher standard of living than would have been possible by depending solely on the gathering and capture of wild terrestrial organisms.

The relative economic advantage of supplies from cultured organisms has meant that human dependence on economic supplies from wild stocks has largely been replaced by supplies from agriculture, animal husbandry and silviculture. As a result, there has been a loss of biodiversity in the wild and a change in the composition of the genetic stock of domesticated organisms for reasons that are well documented. These are summarised in relation to aquaculture in Table 1. Concerns have been raised that losses in the wild genetic stock and changes in the gene pool of domesticated species could result in lack of sustainable economic production from biological resources.

Table 1: Aquaculture Practices and their Consequences for Biodiversity Loss

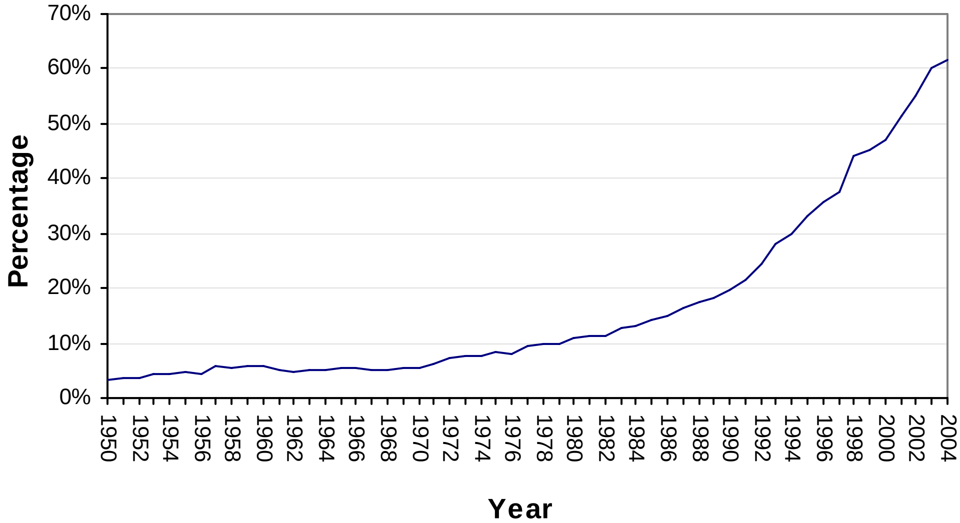
PRACTICE	CONSEQUENCES
Translocation of fish species or varieties of fish with their accidental or deliberate release to the wild	Loss of indigenous fish species and other wild species due to competition, habitat disturbance and so on. Examples include translocation of European carp, tilapia and trout.
Release (accidental or deliberate) of improved varieties of fish or transgenic varieties to the wild (Myhr and Dalmo, 2005)	May alter the genetic composition of the wild stock if they are sufficiently fit for survival in the wild and the releases are sufficient in number (cf. Muir, 2005).
Narrowing of the diversity of the genetic stock in aquaculture due to human selection of species and their varieties (Hulata, 2001).	The genetic diversity of farmed fish stock is often much less than the wild stock for which it is a substitute or replacement. Consider the example given by Stotz (2000) of scallops. Market extension and globalisation are strong forces working in favour of reduced biodiversity of farmed organisms. The economic mechanisms resulting in this are varied but the operation of the economics of comparative advantage plays an important role. See Tisdell (2003a).
Appropriation of habitat and space of areas used by wild species for aquaculture and destruction or significant alteration of habitat	Wild species excluded or partly excluded from aquaculture areas. Lose food sources, shelter and breeding areas.
Exploitation of wild aquatic fish and materials to provide food for aquaculture organisms	Because of the loss of food sources of wild fish and over harvesting of targeted species, loss of biodiversity in the wild may occur.
Use of chemicals and antibiotics in aquaculture may adversely affect local aquatic microfauna and macrofauna (Beardmore et al., 1997).	Possible loss of some such fauna with negative impacts on the food chain and potentially therefore, on higher order species.
Intensive collection of seed for aquaculture ranching	May threaten wild stocks or alter the genetic composition of these.
Movement of objects (biological and non-biological) over considerable distances for use in aquaculture.	Accidental or incidental introduction of new pathogens, parasites or pests generally to new areas with biodiversity loss possible.

Note: Anderson (1985) argues that aquaculture adds to the supply of fish, reduces fish prices, and therefore, may have positive consequences for the conservation of wild stocks. While this is theoretically possible, it does not appear to have been so in practice. This can be attributed, in part to the processes outlined above. (See Tisdell, 2003b, Ch.28).

2. Trends in Fish Supplies from Aquaculture versus Supplies from Wild Catch

Terrestrial patterns now appear to be repeating themselves in aquatic areas as aquaculture develops rapidly. In 1950, supplies of fish from aquaculture were negligible relative to the wild catch but in proportion to the wild catch they increased exponentially. By 2004, they amounted to more than 60 per cent of the wild catch. (See Figure 1.)

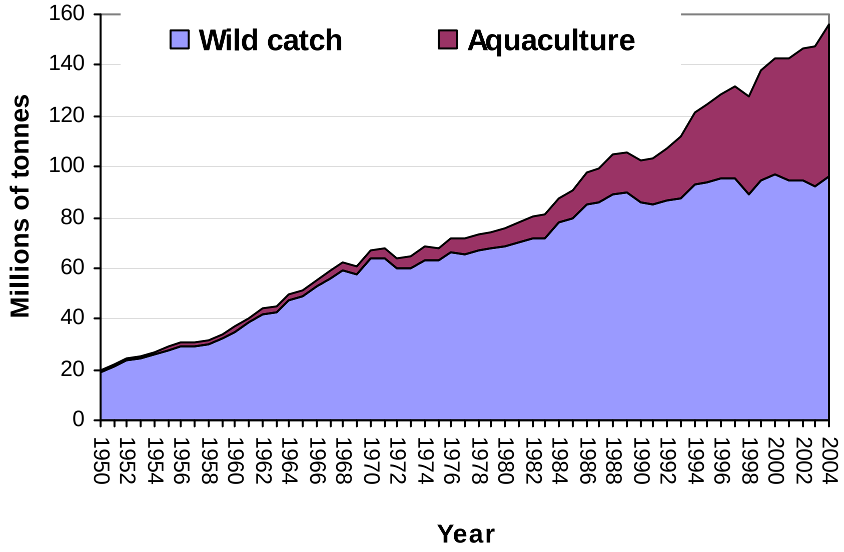
Figure 1: Global aquaculture production as a percentage of global wild catch, 1950-2004
(Source: based on FAO statistics -- FishStat)



Indeed, since the late 1980s aquaculture has been the sole source of the increase in global supplies of fish; production from the wild catch has been virtually stagnant since then (Figure 2). If the same pattern is followed as on land, one might expect supplies from the wild catch to fall eventually due to such factors as habitat loss as a result of the expansion of aquaculture. However, this displacement effect will probably be less strong than it has been on land. This is because a larger expanse of the aquatic space could be more difficult (costly) for humans to transform or convert to farming than the terrestrial area.

Figure 2: Global fish production, 1950-2004

(Source: based on FAO statistics -- FishStat)



China is by far the largest producer of aquacultured fish in the world and aquaculture in China has developed earlier and on a greater scale than elsewhere in the world. Therefore, its experiences may provide a pointer to future global patterns as far as the development of aquaculture relative to the captive fisheries is concerned. By 1983, China's production of fish from aquaculture had overtaken its wild catch. By 2004, China's supply of aquacultured fish was nearly two and a half times its wild catch (see Figure 3).

Figure 3: China's aquaculture production as a percentage of its wild catch, 1950-2004
(Source: based on FAO statistics -- FishStat)

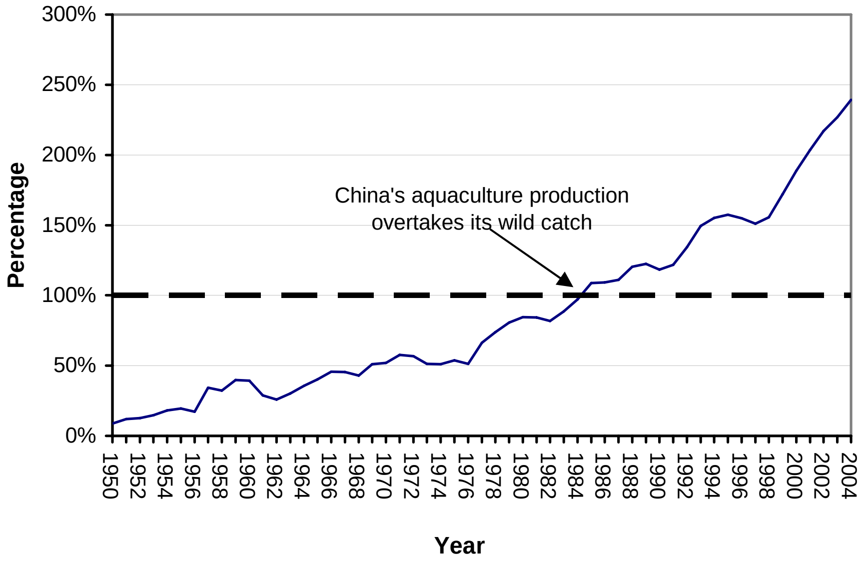
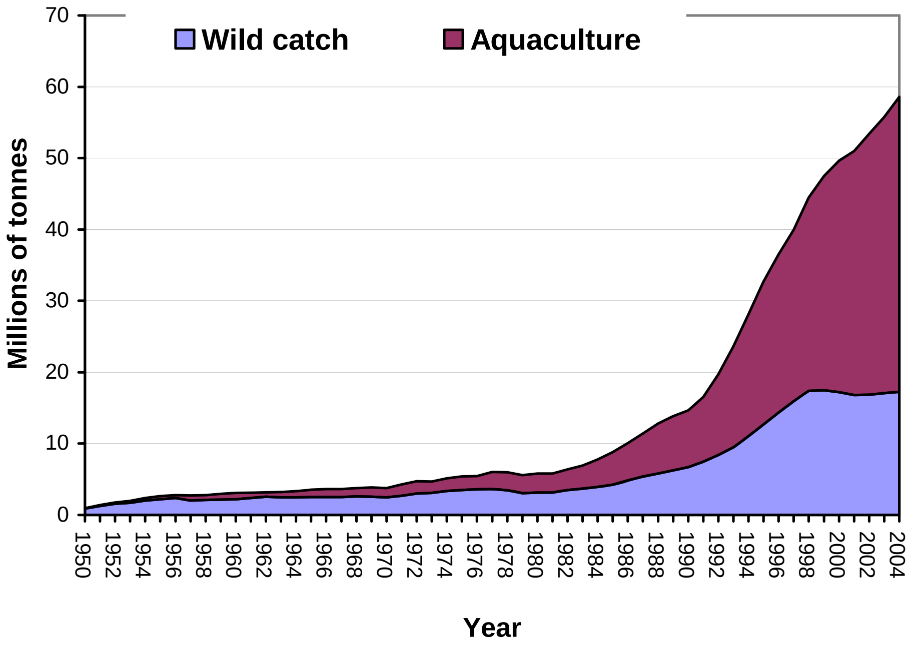


Figure 4 reveals that the volume of China's wild catch has been constant since about 1998 and that growth in fish supplies in China has come from aquaculture. However, because an increasing share of China's fish catch has been obtained from distant water fishing, it can be inferred that China's domestic wild catch has been falling in recent years. However, I do not have the figures for China's domestic catch.

Figure 4: China's fish production, 1950-2004

(Source: based on FAO statistics -- FishStat)



The most common explanation given for falling wild catches is usually that increasing catch effort pushes yield beyond its maximum sustainable level and consequently, yields begin to decline. However, this is only part of the explanation. Environmental changes which alter available habitat for wild fish stocks also play a role. Such adverse environmental impacts arise generally from the expansion of economic activity. They are not exclusively due to the development of aquaculture but as aquaculture expands, it can add significantly to these adverse environmental spillovers, (see Table 1).

3. Consequences of the Development of Aquaculture for Fish Biodiversity

Expansion in aquaculture has come about both as a result of its extension and intensification and this expansion is continuing. Genetic 'improvements' in cultured fish and greater attention to human selection of species and strains of fish have contributed to the economics of expanding aquaculture. However, economic gains from genetic selection usually depend on the use of a narrow package of supporting inputs in the farming of selected organisms. For example, environmental conditions, nutrition, and so on, of improved varieties of fish may need to be carefully controlled to achieve high yields and satisfactory economic returns, as in the case, for example, of high yielding rice varieties. Consequently, issues involving economic sustainability, variability of high yields, and income distribution arise (Conway, 1987; Tisdell, 1999, Ch.4).

To an ever increasing extent, human selection of genetic material is and has been replacing its natural selection. In addition, environmental changes brought about by humans are altering the global genetic stock by accelerating the extinction of some species, favouring others, and creating a new array of environments capable of affecting the natural selection of organisms. It is difficult to know how these changes can be confidently assessed from an economic point of view.

Because human selection of genetic material has become so important, institutional arrangements for this selection have also become of increasing significance. Different types of institutional arrangements are likely to result in different types of selection and development of the domesticated genetic stock of fish and other species. For example, if private companies are able to have property rights in fish varieties, they are likely to want to conserve and develop genetic material from which they can appropriate the greatest economic benefit. Their selfish choices may displace other existing genetic assets and alter development paths in socially inferior ways. Consequently, the social benefits from human-controlled genetic change may be socially unsatisfactory. To what extent should genetic selection and development be the province of public bodies or international public organizations, such as WorldFish? What criteria should be applied to the human selection and development of genetic material?

4. Uncertainty about the Economic Benefits of Alterations in Fish Biodiversity

Because the selection of genetic material involves decision-making under uncertainty and because the economic costs of loss of biodiversity (or of genetic material) are uncertain and reduce future economic options, the question arises of how much and what types of biodiversity should be conserved in cultured stocks of species, such as fish species, and in wild stocks. Economists have no ready answer to this question.

We do know, however, that the development of aquaculture has already started to reduce genetic diversity in wild fish stocks. On the basis of experience with land-based farming, it is reasonable to predict that this process will continue with the further development of aquaculture. Furthermore, the genetic diversity of farmed fish may also eventually decline as has happened to crops and livestock. While economists are aware that a sustainability problem may emerge as a result of the genetic changes arising from farming, they are not able yet to provide a definitive economic valuation of the processes involved. They cannot confidently determine the very long-term economic consequences of genetic manipulation and change for farmed and wild fish. They cannot say whether present economic benefits from genetic change are sufficient to outweigh possible future costs of it, and whether future generations will be richer or poorer as a result human impacts on our genetic stock. We don't know. We may never know until the future becomes the present, and then the situation will be irreversible. Should we take the risk? The answer does not depend solely on economics but is a major challenge for economists.

Some social scientists, including economists, favour the adoption of the precautionary principle. However, this leaves open the question of how much caution really should be shown in decision making. Also we should bear in mind that the presence of uncertainty does not rule out completely the possibility of rational decision. Even if uncertainty exists, some types of choices can be irrational in all the possible circumstances, and should not be made. Consequently, in making a rational decision, we should confine our choices to the non-inferior subset of possible choices. Loss of genetic material which is certain to make us worse off should naturally be avoided.

5. Concluding Comments

It also seems probable that supplies of fish from aquaculture will continue to increase and supplies from the wild will probably fall. Marine areas are most likely going to be the main sources from which increased cultured supplies of fish will be obtained, given that freshwater is an increasingly scarce commodity.

To conclude: This note has listed several mechanisms by which the development of aquaculture can reduce biodiversity of wild fish stocks, although as pointed out, it is not the only factor leading to reduced genetic diversity of wild fish stocks. Furthermore, if the same pattern is followed as in the development of agriculture, the genetic diversity of stocks husbanded in aquaculture is likely to decline eventually. Nevertheless, because of the late development of aquaculture compared to agriculture, biodiversity of stocks used in aquaculture may still rise, before declining. Many scientists are of the view that such loss of biodiversity is likely to make it difficult to sustain the economic production of fish or cultivated organisms generally. While there is a real possibility, uncertainty makes it difficult to predict accurately the likely economic consequences of declining biodiversity.

6. Acknowledgements

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