Engineering the Blue Revolution

It is doubtful whether intensive aquaculture or genetic engineering is the answer to the crisis in the world's fisheries

The 1990s may well be remembered as the decade when crisis first hit global fisheries. For the 200 million people, mainly from developing countries, who depend on diverse thriving aquatic ecosystems for their livelihoods, the consequences have been most severe. Since the 1950s, the world's fishing fleet has been growing, reaching a peak between 1970 and 1989, when fleets grew at twice the rate of fish landings.

Corporate-ridden and stimulated by international development agencies and banks, the industrialization of fisheries and the race for the last fish, have led to global problems of overcapacity and over investment. Each year, the governments of the world subsidize the global fleet by US$ 54 billion to obtain catches to the value of US$ 79 billion. Ever more sophisticated technology is carried by larger vessels and bigger fleets producing more waste. The Food and Agriculture Organization (FAO) of the United Nations has calculated that close to one-fifth of the world's marine fish catches are discarded back into the sea.

As fish become scarcer, prices increase and the international fish market expands to new grounds. Fish production in the Southern countries has skyrocketed with foreign exchange earnings from their fish increasing from US$ 9 billion in 1983 to US$ 17 billion in 1993. While both states and small-scale fishermen in the South may temporarily benefit from higher prices, the poor and the not-so-poor consumers in the South gradually lose their access to a traditionally cheap protein, as fish literally travels North, either by boat or plane. Exports increase more than production and internal fish consumption decreases. In the period 1978-1988, African per capita supply decreased by 2.9 per cent and, in South America, by 7.9 per cent, while fish has become expensive even for the middle classes in India.

The average fish consumption in the North is triple that of the South, even though fish constitutes a more important part of the diet in many areas in the South, particularly Asia. For example, in Bangladesh, where fish accounts for more than half of the animal protein intake, the average annual per capita intake is 7.2 kg, in contrast to the United Kingdom and United States, where fish accounts, respectively, for around 10 per cent and six per cent of the animal protein intake, annual per capita consumption is close to 20 kg. In the long term, both in the North and South, the intensification of fishing activities results in small-scale, inshore fishermen being pushed aside.

Although global fish catches have steadily increased since the 1950s, to 116 million tonnes in 1996, there are numerous signs that this trend is unsustainable. According to the FAO, in 1994, 35 per cent of fishing grounds were overexploited or depleted, while 25 per cent were fully exploited and only 40 per cent allowed for an increase in capture under current exploitation patterns. As the FAO itself puts it, "The ever-growing total tonnage of world fishery production gives a misleading vision of the state of world fishery resources and a false sense of security."

Something fishy

There is no shortage of indications that something fishy is indeed happening to our oceans. Just a couple of examples may help to give an idea of the depth of the problem. Worldwide, only the Western Pacific still keeps healthy tuna resources, while Greenpeace reports that "scientists estimate that overfishing has reduced Southern bluefin to only 2-5 per cent of its original population levels." Almost all groundfish stocks seem to be heavily fished or overfished-in just 10 years, the world catch of groundfish species has been halved.

It had traditionally been considered that the likelihood of fishing any species to extinction was remote. Nevertheless, in 1996, the IUCN included about 100 species of marine fish in its Red List of endangered species. Besides several species of tuna, this includes sharks and more than 30 species of sea horse.

The evidence is so large, and the implications so deep (not only for the world's peoples, but also for the fish processing industry) that the problem has now been widely acknowledged. However, more than stressing the need to change fishing strategy, those who created the problem in the first place, such as the World Bank, the FAO and the agri-food industry, are keen to promote aquaculture as a new industrial sector. In the words of Ismael Serageldin, Chair of the Consultative Group on International Agricultural Research (CGIAR), "On land, we have learned to produce food by cultivation. But in the sea, we still act as hunters and gatherers."

To raise the sense of urgency, we are again reminded about the need to feed a growing world population. The FAO projects that, by 2010, there will be a shortfall of 16 million tonnes in the supply of fish and fishery products to meet demand. As the North Atlantic Salmon Conservation Organization (NASCO) says, "By the year 2025, the demand will have increased from 100 million to 165 million tonnes."

The crisis is also recognized by industry, as mentioned by Aquaculture Production Technology, a specialized Israeli company: "The only way to bridge the gap between reduced capture fisheries output and increased world demand is through aquaculture." A closer look at the proposed solution of aquaculture raises doubts as to its long-term viability. It is noticeable that to convince society of the importance of learning to cultivate fish, the promoters of aquaculture have their best arguments in the experience of farming communities worldwide, who have been doing it for millennia. The harvest of wild fish and other aquatic produce such as crabs and frogs, collected from rice paddies after the first heavy rains, continues to be key for food security and animal protein intake for many farming communities in lowland areas of Asia. Aquaculture, however, starts when human action controls or enhances the rearing of fish, crustaceans or mollusc. The raising of carp within complex agricultural rice systems in China is perhaps as old as rice culture itself. Rice farmers in Kerala, India, have for centuries managed a polyculture system based on rotational cultivation of rice and shrimp called *chemmeen kettu*. Equally, 300 years ago, the Japanese learnt to favour the growing of seaweed for their diet.

These low-external input aquaculture systems, which are often referred to as 'extensive aquaculture' by the formal sector, do not compete with other uses of the aquatic environment, but rather complement them by helping to close nutrient cycles. For example, in many countries, particularly in Asia, farmers have developed systems in which wastes-poultry, animal and plant wastes-are thrown into fish ponds to encourage the growth of organisms which fish feed upon. Wastes are then returned to the field as fertilizer. The main fish species in these systems are carp and, more recently, tilapia. These systems still thrive today through local initiative and NGO rural development programmes. Rice farmers are continuously adapting fish culture to their needs, such as pest and weed control.

Farmers' innovations have helped enhance nutrition and increased income. In Indonesia, fish can help raise incomes from paddies, because fish income does not have to be shared with the landlord. The results of the introduction of fish in complex agricultural systems may be spectacular even from a purely economic point of view.

Malawian experience

Malawian farmers have been able to totally transform their farm management through aquaculture in the marginal wetlands, associated with vegetable cropping. After seven years, these farmers came to earn more from the gardens and ponds than from their croplands and homestead, and it has been calculated that, for every dollar invested in the wetlands, seven were generated. The importance of such aquaculture for food security is reflected in the fact that 85 per cent of aquacultural production in the South is consumed locally.

The new prophets of aquaculture intend to reproduce the Green Revolution production model in aquaculture. Industry, multilateral development banks and UN agencies proclaim it as the 'Blue Revolution.' Although occasionally referring to the benefits of traditional aquacultural practices, what they propose is entirely different: the monocropping of high-value species to supply international markets. Will a model based on the Green Revolution that failed to meet the needs of the resource-poor and increased genetic erosion in agriculture, do any better underwater?

Though half of marine aquacultural production is actually made up of marine algae and seaweed, mainly kelp, this article focuses exclusively on fin fish. In the last 10 years, aquaculture production has more than doubled, to one-fifth of total world fish production. Given that one-third of all fish catches are turned into fish oil and fishmeal, aquaculture provides a quarter of the fish used for direct human consumption. Impressive as this growth may look, it reflects mostly the activity of a single country, China.

Asian developing countries are the centres of production and, in 1995, China alone accounted for 63 per cent of total world aquaculture. The other main producers are India, the Philippines, Indonesia, Thailand, Bangladesh and Taiwan. Among developed countries, Japan and the US are the main producers, followed by France, Italy and Norway.

The species produced vary according to the kind of water and the regions. Worldwide, the bulk of the production is still from low-value freshwater species that are raised in integrated agricultural systems: carp and, to a lesser extent, tilapia. The farming of this latter species has recently expanded very quickly in Asia and Africa.

Aquaculture species

In 1992, worldwide production of tilapia reached 473,000 tonnes, mainly from China, Indonesia, the Philippines and Egypt. The production of various carp species is higher still. In 1995, worldwide production of the silver grass and common carp was 6.7 million tonnes. Although carp are also important in some European countries, particularly Hungary, developed countries tend to cultivate more value-added fish species in their freshwaters. In the US, the main species is catfish, while trout is appreciated in the us, Europe and Japan. Brackish waters, a mixture of sweet and marine water with intermediate salinity, are found in such places as mangroves, estuaries, lagoons and swamps.

They account for 7.1 per cent of fish aquacultural output, centred on high-value species. In developing countries, there has been a wide expansion of export-oriented shrimp aquaculture, while in European-Mediterranean countries, these areas hold the production of oyster and high-valued carnivorous marine fin fish species, such as striped sea bream and sea bass. If traditional integrated aquaculture activities in Asia are left aside, in the North and South, aquaculture is focused on high-value species (molluscs, crustaceans, marine fish and salmon) that together account for 31.5 per cent of world production, equal to 61 per cent of the total market value. It is these areas where the promoters of the Blue Revolution have invested their resources.

The most serious impact of the Blue Revolution aquaculture is that, rather than increasing global catches, it may very well lead to lower total productivity of our seas. Most intensive aquaculture operations take place in shallow waters, which compete with other possible uses. Plentiful sunlight and nutrients in these zones contribute to the position of shallows as the world's most diverse and productive types of marine ecosystems, including sea grasses in temperate zones, and mangroves and coral reefs in tropical areas. Such systems harbour the juvenile stages of most fish species, including oceanic fish, which sustain both traditional and industrialized fishing activities.

The intensive, high-density cultivation of fish and shellfish has environmental effects similar to those of intensive breeding of livestock or poultry. First and most evident is the accumulation of organic matter, both in the form of unconsumed feed and faeces. When aquaculture activities are conducted directly in the marine or brackish environment, this accumulation may well lead to a process of eutrophication, with associated depletion of oxygen near the sea bottom or throughout the water column, and a proliferation of unicellular algae, some of which may be toxic. Compounding these problems is pollution by pesticides and antibiotics, used intensively when animals are raised in such high densities. The result is a serious loss of local biodiversity. This has particularly occurred in sheltered waters, such as with salmon in Norwegian and Chilean fjords, with the raising of oysters and mussels in lagoons and estuaries, and with the raising of shrimp in ponds.

When aquaculture employs the construction of special installations, such as ponds, the impacts are even more pervasive. The most extended example of intensive aquaculture, and that which has been promoted most aggressively by international development banks and institutions is shrimp aquaculture. Farming shrimp and prawn, or 'pink gold', for the lucrative markets in the North, is the most prominent example of the social and environmental consequences of intensive aquaculture practised on a big scale. It has grown quickly in Southeast Asia, Ecuador and Central America. In 1990, Asia alone accounted for 80 per cent of the world total, covering 820,000 hectares, which produced 556,000 tonnes. Principal markets remain Japan, the US and Europe, with a total market value of nearly US$ 7 billion.

Shrimp culture is one of the main causes of the destruction of mangroves. In Thailand, 40 per cent have been destroyed and the clearing for pond construction is only one part of the story. Although there are hatcheries for shrimp larvae, when this supply is not sufficient, larvae are fished from wild mangrove systems using fine-mesh nets that also sieve out big quantities of other marine organisms.

Problems with aquaculture

Shrimp aquaculture is not only conducted in mangroves, but also on agriculture lands close to water bodies. Besides the displacement of farmers and rice culture, the high needs of fresh and salt water lead to a drying of underground water sources, with a subsequent penetration of saline water. Such deterioration means that the average life of aquaculture farms is only three to five years before being abandoned, leaving behind salted, polluted land of no further agricultural use.

Behind these environmental costs, there is the social price that local communities pay by losing access to both aquatic and mangrove resources. In Bangladesh, for example, shrimp farmers have priority in leasing land, which has deprived local people of their rights to common land and public water bodies. Government regulations to encourage export often worsen the problem. In the Philippines, fishers' unions have protested that bays where they fish have been obstructed by fish pens. Despite this, it is still local fishers who provide most of the fish that is locally consumed.

The instability inherent in such intensive farming systems results in local communities being unable to participate. In the words of Roger S.V. Pullin, the Director of the Inland Aquatic Resource Systems Program of ICLARM, "For stand-alone fish farms, a farmer might expect a total loss or at least serious loss of profits at least once in 10 years and perhaps, on average, twice in 10 years. This would mean bankruptcy for some commercial operators, and life-threatening situations for some resource-poor farmers in developing regions." Later, the inevitable environmental degradation resulting from intensive aquaculture forces operators to change their locations. Both factors have made the sector the domain of capital-intensive operators who do not need to bear the costs of environmental degradation, that is, investors who are able to put their returns into other sectors, or companies able to find new sites for their operations.

Dazzling export figures hide enormous costs for the countries that export shrimp. The annual profits from these operations in the State of Andhra Pradesh, India, are believed to cross millions of rupees. However, according to the Third World Network, the negative impacts on local communities and the environment far outweigh any production gains, when viewed in a wider perspective. Indeed, a coalition of Indian NGOs has challenged the right of the shrimp industry to destroy the rights to livelihood of millions of coastal people. Their actions led the Supreme Court of India to dismantle existing installations and to ban new operations.

Inbreeding

Aquaculture has relied on fish stocks from a narrow centre of origin, with subsequent inbreeding causing impaired genetic performance. A classic example is that of the cultivation of tilapia in Southeast Asia. As Pullin explains, "Some fish were collected from open waters in Egypt in 1962 and shipped to Japan. Some of their descendants were shipped to Thailand in 1965 and they produced a strain that has been widely fanned since then. A few fish of this strain were shipped to the Philippines in 1972 and their descendants have since been farmed there."

In spite of the selection efforts by Filipino farmers, in 1989, their tilapia A turned out to be less efficient than new founder stocks collected from the wild in Egypt. As a solution to this problem, ICLARM launched a programme in the mid-1980s to develop genetic resources for tilapia that has led to the creation of the 'super-tilapia', using Egypt's wild populations.

Genetically impoverished stocks would only be a problem for aquaculturists if it were not that there is no way to avoid the escape of cultured fish into the surrounding environment. This may come as a consequence of bad weather, floods, broken equipment, etc. In fact, fish of cultured origin are sometimes even purposely used to re-stock native populations.

To understand the impact of such escapes and releases, it is necessary to take into account the fact that, particularly in freshwater hydrological systems, populations have adapted to their environment through particular genetic combinations. If large enough numbers of introduced fish inter-breed with wild populations of the same or related species, these particular combinations of environmental adaptation are lost. Small, wild populations are particularly susceptible to this kind of genetic contamination.

A good illustration of the scale of escape in aquaculture systems is salmon. Adult salmon are raised in giant cages floating in the sea, close to the coast. In 1995, the number of salmon known to have escaped from Norwegian salmon farms increased to almost 650,000, from 570,000 in 1994, and, the same year, the proportion of fish of farmed origin in samples from the coastal fisheries was 42 per cent. In the Magagudavic River, Canada, 1995 estimates of salmon caught being of farmed origin were as high as 90 percent. Even if there is no inter-breeding or released fish are sterile, there are other potential effects on wild populations which are often impossible to predict. It is well known that many native populations of Atlantic salmon in Norway are threatened with extinction, from a parasite introduced through genetically resistant salmon populations from the Baltic Sea. The most severe case of extinction caused by an introduced species may be the case of the Nile perch, which led to the loss of nearly 200 unique species of cichilds in Lake Victoria.

Perhaps the most pervasive effect of the Blue Revolution is that the rise in production of carnivorous fish (accounting for all the luxury fish raised) and shrimp has translated into a large demand for fishmeal, which has to be obtained from wild fisheries. Worldwide a third of fish catches are devoted to fishmeal.

The rise of, particularly, shrimp production, has introduced new fisheries to tropical countries where they were virtually unknown previously. In Thailand, this has already been translated into 'biomass fishing'. Whereas earlier, the sea bottom was trawled for shrimp, with the rest of the species discarded or sold in local markets, now it is done to extract anything that can be turned into fishmeal.

However, many of these species have been part of the traditional food of coastal communities. As a result of these destructive practices, people are deprived of cheap protein. In Indonesia, demand for prawn feed is making unaffordable previously inexpensive and locally available products such as sardines. In Malaysia, the same phenomenon has resulted in a shortage of fish for the salted fish industry.

No trickle-down benefits

With local communities marginalized, unable to participate in the system, and weighed down by environmental consequences, intensive aquaculture is of no benefit. There is little evidence either to suggest trickle-down benefits from export earnings. From a national perspective, the Blue Revolution results in a transfer of cheap protein from the South into less abundant, more expensive protein to be exported to the North. The economic and monetary crisis in Southeast Asia shows that relying on currency and external markets, rather than ensuring internal production for food security, may be a dangerous gamble.

In January 1996, for the first time in history, genetically engineered salmon was grown in a commercial hatchery in Loach Fyne, Scotland.

The 'AquAvantage Bred Salmon' were genetically engineered for accelerated growth rate with a technology developed by a research team from Memorial University, Newfoundland, Canada. The technology transfer was mediated by the Boston-based firm, A / F Protein.

The application of genetic engineering to fish started in 1982, with the familiar moral justification of the need to feed a future world population. As NASCO puts it, "The predicted demand for aquatic organisms from a rapidly increasing world population will require increasing use of biotechnology in aquaculture."

Developing countries are encouraged to get on the bandwagon as soon as possible. "The ability to produce transgenic fish and shellfish in culture, which grow faster and to a larger size with more efficient utilization of nutrients, is of particular value to developing countries, not only as a source of food, but also as export products," states a World Bank Discussion Paper on Marine Biotechnology and Developing Countries.

It comes down to a question of faith in technology, but before engaging in it, countries should ask themselves whether genetic engineering in aquaculture provides a solution to the real problems.

Failure to address key questions such as the environmental stress on marine ecosystems with their resulting impoverishment, and the progressive marginalization of coastal communities from economic and nutritional livelihood, may result in gene technology compounding the existing crisis.

Behind the promises of the technology, fish genetic engineering is so far very inefficient and random. The most frequently used methodology consists of inoculating the desired genes egg by egg, or embryo by embryo. The idea is that the gene will be incorporated into the egg's genome and then expressed in the transgenic adult.

Tedious work

Injecting fish eggs one by one is tedious and requires skilled operators. The efficiency is low, with the average number of transgenic fish obtained from inoculated eggs usually ranging between 0-13 per cent of those that survive. Much of current research effort is devoted to developing techniques that allow large-scale transfer of genes into fish. Teams around the world are busy trying to develop more efficient mass transformation' methods, such as electroporation, particle bombardment, the use of liposomes and sperm cell vectors, so far with little success.

The reality of fish genetic engineering today is more a question of luck and tricks than a comprehensive understanding of the processes involved. Added to this, even NASCO acknowledges that many genetically modified fish are highly inbred.

Although there is much basic research to be resolved, scientific teams have embraced applied research, and have not disregarded patents in the process. Increasing the economic appeal of aquaculture has provided the motivation to focus on three lines of research into faster-growing, freeze-resistant and disease-resistant fish.

Feed accounts for roughly half the operating costs in fish farming: Growth rates, and food conversion efficiency of cultured fish species, are of utmost interest to aquaculturists. The first fast-growing transgenic fish, a common carp incorporating a mouse promoter gene linked to a human growth hormone gene, was developed in China in 1986.

Scientific teams from the US have since genetically engineered carp and catfish, while British and Cuban groups have centred their efforts on tilapia and Canadian scientists have focused on salmon and trout. Overtime, and in order to avoid the sensitivities of consumers scientists have increasingly used gene constructs containing only fish genes.

It is Canadian scientists who have achieved the most dramatic results with transgenic salmon growing up to 10 times faster than control groups. This was done by adding the growth hormone gene of a chinook salmon, controlled by an ocean flounder antifreeze gene promoter. It is these fish that have been exported to Scotland.

Transgenic salmon

A further gene construct, based on the Pacific sockeye salmon, created transgenic salmon that were, on average, more than 11 times heavier than non-transgenic controls, with one individual an extraordinary 37 times larger.

However such top growers paid their price by showing cranial deformities an opercular overgrowth. At the age of one year, the deformities became more severe and were followed by death.

The Canadian team is also researching the production of freeze-tolerant fish. The cultivation of salmon, for example, is limited to certain latitudes, because if water drops below zero degrees Celsius, the salmon's cells freeze and the fish dies.

However, some demersal fish species thrive in waters under ice, such as the ocean pout, thanks to a protein that prevents their blood freezing. Canadian scientists had the idea to isolate the antifreeze protein gene from a winter flounder and insert it into the salmon's genome.

Results proved disappointing, with the salmon producing only one per cent of the protein level naturally found in the flounder. It was while doing this experimentation that, by chance, scientists discovered that the antifreeze protein gene promoter activated growth hormone expression.

With fish under high-density cultivation being particularly prone to sickness, the interest in disease resistance is understandable.

For viral infections, there have been several approaches to disease resistance. One of them has been the use of antisense technology, which a Japanese team has used to genetically engineer trout resistance to the necrosis blood virus.

Several approaches have also been undertaken to fight other infections. Canadian teams working on salmon are targeting a trout gene as a bacterial inhibitor. Another approach, undertaken by a team working in New Zealand, is to insert the genes, encoding for biologically active peptides from frog skin.

Although these represent the main areas of research, other points have caught the scientists' attention. A Japanese team is attempting to develop a gene to make freshwater fish tolerant to salt and vice versa.

Another line of research relates to genes involved with skin pigmentation, with the economic motivation for tailoring fish colour to culinary and ornamental tastes.

Compared with plant research, transgenic fish research is still in its infancy and, to a large extent, carried out by public research centres or institutes that have established large teams which cross national borders and have close working relationships with their counterparts. It is yet to be seen whether these relations will survive if technologies are introduced on a commercial scale.

Financing the Blue Revolution

The growth of intensive aquaculture in developing countries, including shrimp aquaculture, has been stimulated by an intensification of loans from multilateral aid agencies. From 1988 to 1993, a third of the money committed to fisheries consisted of aid to aquaculture.

The Ecologist reports that, in 1991, World Bank (WB) loans for aquaculture included US$ 420 million to India, US$ 386 million to China, and US$ 267 million to Argentina. Though the negative effects of intensive aquaculture have become increasingly evident, there has been little change in Word Bank policy. In May 1997, the WB approved a US$ 40 million loan to the Government of Mexico to help finance an aquaculture development project to intensively grow shrimp, tilapia, scallop and abalone. The objective is to increase Mexico's 15 per cent aquaculture contribution to total fisheries production. The Bank has drawn criticism for only consulting local people, after the plans were already drawn up, when little could be changed.

In 1997, the bank also approved a US$ 120 million loan for livestock and aquaculture development in the Heilongjiang Province of China, the aim being to expand fish production by constructing 584 hectares of new ponds, rehabilitating 237 hectares of existing ponds and restocking a 12,000-hectare natural lake.

Superficial knowledge

Our knowledge of marine ecosystems remains superficial and knowledge of both short- and long-term effects of .transgenic fish is necessarily poor and schematic. One certainty we have is that transgenic fish will escape into the rivers and oceans in the same way that their non-transgenic relatives do. In the case of fast-growing fish, their effects on wild populations and ecosystems would depend on whether these fish grow faster because they eat more or because they are more efficient. In the first case, they would present more competition to wild stock. The increased size at a given stage in its life cycle could result in transgenic fish competing with other species of the ecosystem or in its predators not being able to feed from it.

The case of the freeze-resistant salmon would allow this species to colonize entirely new ecosystems, where they could compete with the existing carnivorous species. Such a scenario leaves open the possibility for thriving and invading large areas, a situation that would be compounded if the genetic character was transmitted to wild salmon populations. A similar story of species advantage disrupting the natural balance would be the danger with disease resistance.

Although, in the long term, the aquaculture industry would be affected by such interactions, the fishing sector would be the first one to note the impact of the release of transgenic fish into the environment. To prevent these problems, scientists argue that it is possible to design transgenic fish which are unable to reproduce, a claim that is far from proven. Even if such modifications were achieved, they could alter the behaviour of the transgenic fish, with a resulting impact on wild populations or ecosystems. The point is not whether such risks are acceptable, but if they are needed at all. Proponents of the Blue Revolution technology, who continuously remind us of the need to feed the world, will affirm that we need to bear the risk. But where is all this leading to?

If the trends of overfishing, intensive aquaculture and genetic engineering are taken to their extreme, the image that comes to mind is that of impoverished marine ecosystems producing large amounts of 'designer' fish, under the control of corporations able to invest in and maintain, such systems. In this brave new world, cultivating the aquatic environment would be a task of industry, and the role of people would be reduced to workers and quiet consumers of more or less sophisticated fish protein. This industrialization of the aquatic environment is, in fact, the very core of The Blue Revolution.

Growing population

It is certainly true that the world will have to feed a growing population, but it is even more urgent that it starts feeding its current population and does it in a way that does not pre-empt capacity to continue in future. Instead of trying to resolve existing problems by developing new answers that will invariably lead more problems, a better solution would be to solve existing problems and look into the available alternative that can nurture the base of life: diversity.

The initial step towards this objective is to review fisheries management. After taking into account both the degree of exploitation of our seas and oceans and its direct and indirect impacts, it seems clear that, under current fisheries practices, the present total catch is unsustainable. Two questions then come to mind. Would it be possible to maintain current harvest levels in a sustainable way? And would it be possible then to even increase it?

The answers to these questions depend on who you ask. The FAO maintains that marine captures may be sustainably increased by 20 million tonnes, if a number of conditions are met, namely, that degraded resources are rehabilitated, underdeveloped resources are exploited avoiding overfishing, and discards are reduced. Other voices propose a radical change in the very heart of fisheries management, including its underlying assumptions.

According to this approach, the main objective of fisheries management should be the protection of marine resources against the causes that lead to their overexploitation. In the long term, such a change would not necessarily mean a decrease of the harvest. In the waters of the EU, it would be possible to obtain a level of catch similar or even larger than the ever-dwindling amounts that the EU member states overfish year after year, if proposed management practices were adopted.

An approach that is concerned with maintenance, over mere conservation, could be defined as a harnessing approach, such as has been the root of the way many coastal communities have managed their fishing grounds for millennia.

Having been plundered for all they are worth, the world's oceans have become impoverished, drained of the rich biodiversity that once fed so many. For an industry desperately seeking to secure supply for continuing demand, the short-term fix of the Blue Revolution is an attractive one, if not the only solution to industry's own survival. Supplying prawns to restaurant tables in Rome, Washington or Tokyo may bring in ready cash, but it is devastating for aquatic ecosystems and the millions of people who depend on them for their livelihood.

Both intensive aquaculture and genetically engineered fish are the last-gasp efforts of a dying industry trying to sustain itself, and should be clearly seen as short-sighted in approach. The sorriest players in all this are the international banks and institutions, who, instead of supporting the sustainable fishing practices of the South, are, instead, lending millions to industry to keep the North supplied with luxury fish. Existing integrated aquaculture systems provide a prosperous alternative to the Blue Revolution, which could be successfully enhanced in the future.

This article, part of ongoing work by Anna-Rosa Martinez, first appeared in Seedling, the quarterly newsletter of the Genetic Resources Action International (GRAIN)