

Southeast Asian Fisheries Development Center

Aquaculture Department

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Coastal aquaculture: Environmental issues

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COASTAL AQUACULTURE

Environmental Issues

Total world production through aquaculture, FAO reports, is expected to attain 22 million tons by the turn of the century, and a substantial portion of this is derived from coastal aquaculture. The term "coastal" includes the shoreland influenced by the sea, the water column, and the seabed extending to the edge of the continental shelf. The term "coastal aquaculture" covers land-based and water-based brackishwater and marine aquaculture practices.

The rapid expansion of coastal aquaculture in some regions has caused ecological impacts which in turn affected the health and the socioeconomic life of the people in the area. Aquaculture has generated pollutants into the natural environment drawing concern not only for the negative effects outside the industry but also for the industry itself.

Item One: Ecological Impacts

Enrichment of benthic ecosystems

The release of soluble inorganic nutrients (nitrogen and phosphorus) from intensive fish and shrimp farming has the potential to cause nutrient enrichment and increase in primary production of a body of water. It has also been suggested that the release of dissolved organic compounds together with other components of the diet such as vitamins could influence the growth or toxicity of particular species of phytoplankton. There have been many instances of mass mortality of farmed fish caused by the occurrence of harmful algae.

The sediments from organic fish farm and bivalve wastes have enriched plant and animal life in the vicinity of the aquaculture operation. Effects have ranged from a reduction in diversity and increase in opportunistic, pollution-tolerant species to the complete absence of these lower forms of animal life. The release of hydrogen sulfide gas, together with hydrogen sulfide dissolved in the water has been held responsible for a deterioration in the health of farmed fish (increased stress, reduced growth, gill damage, and even mortality) and loss of production. A high level of enrichment leading to what has been termed souring of sites has been reported from a number of fish farms in several countries. For example, it has been estimated that 30% of oyster and mussel farms in France are periodically abandoned or relocated because of the accumulation of biodeposits. These are clear examples of how production can exceed the capacity of the site to assimilate the amount of waste generated and how ecological change can limit the long-term viability of a site.

Interaction with the food web

The large scale, extensive cultivation of bivalves can interact with the marine food web in two ways: by the removal of phytoplankton and organic detritus and by competing with other planktonic herbivores. For example, it has been demonstrated that the culture of 50,000-60,000 oysters reduced the amount of both living and non-living minute organisms by between 76 and

95%. It is therefore possible that the establishment of bivalve farms in coastal embayments could reduce the natural productivity of these sites.

Bivalves grown by suspended culture methods will compete with other planktonic herbivores. For example, it was found that in the Ria de Arosa of Spain mussels have replaced copepods as the main pelagic grazing organisms. In addition, the culture structures provided a substrate for the crab *Pisidia longicornis*, the larvae of which also competed with copepods as a planktonic herbivore.

Oxygen consumption

Aquaculture production can be limited by the availability of oxygen. In addition to the oxygen demand by the cultured species, wastes and biodeposits released by a farm have a high biochemical oxygen demand. Organic wastes increase the consumption of oxygen and can result in oxygen depletion of the bottom water. A reduction in the concentration of dissolved oxygen in water passing through cage farms has also been reported. In general, however, large-scale depletion of oxygen in coastal waters is unlikely. While the small, short-term reduction in the concentration of oxygen in water passing through cage farms is important to the farmer, it is probably not ecologically significant.

One possible exception to the above is in low-energy coastal environments such as the deep basins of some fjords and inlets. In such locations, the retention of deep water within the basin for a period of time (months to several years) results in a natural depletion of oxygen. The deposition of waste would increase the oxygen deficit. This potential problem has been recognized in several countries. In Norway, for example, only low level of aquaculture production is allowed in fjords with deep isolated basins and this is restricted to the shallow, relatively well flushed nearshore areas.

Disturbance of wildlife and habitat destruction

All forms of aquaculture have the potential to affect wildlife. Human activity can disrupt important breeding colonies and feeding grounds, while the aquaculture facility itself can attract predatory species. For example, in Germany predators have increased as a result of pond farming. However, there have been few detailed studies of the ecological effects of aquaculture operations on wildlife.

'BOY, YOU HAD ME WORRIED FOR A MOMENT THERE—I THOUGHT YOU SAID THREE TO FIVE YEARS!'



Stirling Oliphant - Denver Post 1969

The impact of some forms of aquaculture on wildlife habitat in the Philippines is the documented destruction of 200,000 hectares of mangrove. In Thailand, an estimated 25% of the mangrove resource has been lost as a result of aquaculture development.

Interaction between escaped farmed stock and wild species

The rapid development of marine cage farming of salmonids in Europe has raised concerns about the impact of escaped fish on natural populations. It has been suggested that farmed fish have been selected for traits which make them suitable for farming (for example, rapid growth and placid behavior) but less well adapted to the natural ecosystem. Thus, escaped fish could initially outcompete native stocks, but then decline, or the offspring resulting from interbreeding could be poorly adapted to the ecosystem.

Farmed fish do escape and the numbers of escapees can be large. Some countries have initiated studies to address this issue and in recognition of the potential problem, Norway prohibits the establishment of salmon farms within 30 km of important salmon rivers.

Introductions and transfers

A number of fish, invertebrate, and seaweed species have been transferred or introduced from one region to another for aquaculture purposes. Transfers take place within the present geographical range of a species and are intended to support stressed populations, enhance genetic characteristics, or re-establish a species that has failed locally. Introductions are movements beyond the present geographical range of a species and are intended to insert totally new taxa into the flora and fauna.

Transfers and introductions may alter or impoverish the biodiversity of the receiving ecosystem through interbreeding, predation, competition for food and space, and habitat destruction. Disease problems have also arisen in the past from such movements as illustrated by the transfer of salmon smolts from Sweden to Norway and Finland, the introduction of infected ova of coho salmon (*Oncorhynchus kisutch*) from the USA, and the introduction of Japanese oysters (*Crassostrea gigas*) to France.

Bioactive compounds (including pesticides and antibiotics)

Bioactive compounds are considered part of overall disease control strategies. However, it is accepted that many bioactive compounds, including pesticides and antibiotics, are used



extensively in coastal aquaculture as the sole means of disease or pest control. Indeed, the success or failure of aquaculture may in certain circumstances depend on the timely use of such bioactive compounds to combat infectious diseases and parasites. In general, the use of such compounds in aquaculture is haphazard, often reflecting the whims of the aquaculturist or disease adviser.

Tom Darcy - Newsday

G E S A M P
(Group of Experts on the Scientific Aspects of Marine Pollution), an advisory body, has come up with the following code of practice for the use of inhibitory compounds in aquaculture:

1. Medically important inhibitory compounds should be banned from use in aquaculture. However, some medically important compounds may need to be used in exceptional circumstances for certain specified diseases.
2. The availability of inhibitory compounds should be restricted to qualified individuals, such as veterinarians.
3. Access to inhibitory compounds should be denied to all laymen and inexperienced personnel.
4. The storage of inhibitory compounds should be in the manner recommended by manufacturers/suppliers.
5. The use of inhibitory compounds should be strictly in accordance with the written instructions from the manufacturer/supplier.
6. The use of pharmaceutical compounds should be by rotation. Thus, the repeated use of single compounds should be avoided.
7. The use of suitable withdrawal periods, after the use of pharmaceutical compounds, is necessary before animals are removed from the aquacultural facility.
8. The deliberate or accidental release of inhibitory compounds into the aquatic environment must be avoided.
9. Unused inhibitory compounds must be disposed of safely.
10. A surveillance program must be adopted to ensure that the code of practice is carried out.

Chemicals introduced via construction materials

Some construction materials release substances into the aquatic environment (e.g., heavy metals, plastic additives). Their presence is unknown to most of the farmers, although awareness is increasing. Frequently, preservatives have been intentionally used assuming that they are relatively harmless to the cultured species. These include antifoulants, of which the broad ecological effects of tributyltin (TBT) is a good example. Plastics contain a wide variety of additives including stabilizers, pigments, antioxidants, UV absorbers, flame retardants, fungicides, and disinfectants. Many of these compounds are toxic to aquatic life, although some protection is provided by their low water-solubility, slow rate of leaching, and dilution. Mortalities in coastal aquaculture have resulted from toxicant leaching from construction materials, and the environmental effects of these toxicants remain largely unresolved.

W. E. D. King

TERRORS of the SEAS

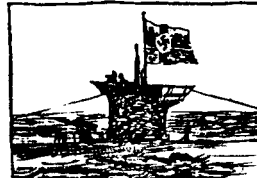
995AD: Leif Eriksson



1718: Blackbeard



1940: the U-Boat



1941: The Bismarck



1987: THE GARBAGE BARGE



May 1987

Jeff MacNelly - Tribune Media Services

Item Two: Implications to Human Health

Much of aquaculture is practiced in coastal waters which are subjected to organic pollution. Toxic algal blooms are common in many parts of the world. Consumption of raw or partially cooked fish/shellfish from affected areas is likely to cause diseases due to pathogens or toxins.

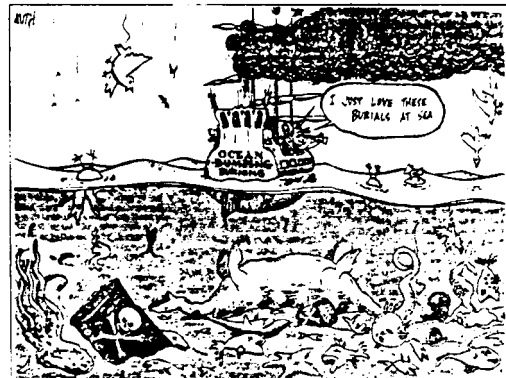
The clear risk of transmission of typhoid fever by bivalves growing in sewage-contaminated water was well-established during the early years of this century and served as the basis for the establishment of shellfish sanitation programs in the UK and in the USA. These programs were based on approved, clean harvesting areas and shellfish self-purification in clean water-holding tanks or "depuration."

Shellfish, particularly molluscs grown in sewage polluted water, are very effective carriers (and concentrators) of infectious hepatitis virus and have on numerous occasions caused infection in humans. On the other hand, excreta of cholera patients (1×10^{13} organisms/day) could contaminate shellfish beds via improperly treated or raw sewage.

The occurrence of toxic species of phytoplankton represents a considerable threat to the economic sustainability of coastal aquaculture development in many countries. A relatively small number of algal species produce a range of toxins, the effects of which include mortality of stock (larval and adult), and human illness and even death.

In some coastal regions, the occurrence of toxic species and toxicity in bivalves is almost an annual event and this has necessitated the establishment of extensive programs to monitor bivalve stocks. For example, most European countries have routine monitoring programs for paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP). The detection of toxins at a pre-determined level usually results in a ban on harvesting which is enforced until the level of toxin in the stock falls below the action level. It is therefore possible to safeguard human health and manage farms to mitigate the effects of toxic events. The duration of closure can, however, affect the economic viability of bivalve culture as a result of loss of markets due to failure to provide the product or loss of consumer confidence in the product (often the result of misinformation). Furthermore, the value of the product can be reduced if harvesting is not permitted before the stock begins to mature sexually and the quality of the meat declines.

Depuration is commonly used to reduce the risk of microbiologically contaminated filter feeding invertebrates being sold for human consumption. Thus, the animals are transferred to tanks with several changes of "clean" water whereupon disease-causing bacteria are supposedly eliminated. The effectiveness of such procedures is possibly illustrated by the virtual elimination of typhoid fever by this route in the industrialized nations of the western world. Yet, problems ensue with the cleanliness of the water used in depuration systems. Firstly, without adequate disinfection systems, depuration may serve to spread pathogens from a few contaminated animals to many others in the depuration system. Secondly, harsh disinfectants, such as high levels of chlorine, may well inactivate many pathogens, but the presence of such chemicals in the water has an adverse effect on the animals. In the presence of some disinfectants the invertebrates close up and, therefore, do not depurate. For effective depuration, it is essential to use systems which encourage the animals to eliminate the bacteria into the water, while ensuring that there is adequate disinfection to kill them.



Item Three: Socioeconomic Considerations



The full socioeconomic benefits of coastal aquaculture development can only be achieved by adopting the principle of sustainable development, which is defined by FAO as: "Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry, and fisheries sectors) conserves land, water, plant, and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable."

Inadequate planning and inefficient management of coastal aquaculture has resulted in serious socioeconomic consequences. Some examples are:

- Large-scale mangrove conversion for shrimp and fish farming in Ecuador and many southeast Asian countries displacing rural communities which traditionally depended on mangrove resources for their livelihood. In addition to the negative social consequences, the cost of disrupting the ecosystem includes coastal erosion, saltwater intrusion into groundwater and agricultural land, acidification, and a reduction in a range of goods and services produced from mangrove forests.
- The economic disaster resulting from the collapse of the shrimp industry due to disease outbreaks in Taiwan province in which shrimp production dropped from 90,000 to 20,000 tons between 1987 and 1989.
- Land subsidence (sinking) in Taiwan province caused by excessive pumping of groundwater for shrimp and eel culture resulting in significant social costs in terms of salinization of underground water and land due to salt water intrusion (which reduce agricultural productivity), reduction of freshwater supply (for agricultural, industrial, and municipal/domestic uses) and damage to transportation and other infrastructure.
- Financial losses to the Norwegian cage-farming industry due to outbreaks of Hitra disease.
- The public health consequences of red-tide outbreaks in areas where shellfish are grown.

The costs related to the deterioration of coastal water quality are not usually borne by coastal aquaculturists. Such costs are often spread onto other users of coastal waters. Likewise, the cost of land subsidence is borne not just by those in the aquaculture industry, but also by others who are engaged in other productive activities which depend on the availability of groundwater.

Action-oriented policies are necessary for an equitable balance between those seeking a simple livelihood, those wanting to make a profit, the quality of the environment and the interests of local people, the wider community and, where appropriate, the international community.