AQUACULTURE AND AQUATIC RESOURCES

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With 1 figure and 1 table

ABSTRACT. Declining of marine fish populations worldwide have rekindled the interest in marine fish enhancement. Recent technological advances in marine fish culture, provide a basis for stocking hatchery-reared fry, in order to control the declining populations and the fishery yields. The role of aquaculture production for food, fish enhancement as well as production of endangered or threatened species depends on progress in larviculture. The increase understanding of the biological, ecological and technological components of aquaculture systems will enhance aquaculture as a long-term strategy of management and conservation of natural resources.

RESUMO. O declínio das populações de peixes marinhos a nível mundial fez aumentar o interesse na sua produção. Avanços tecnológicos recentes na aquacultura marinha lançaram as bases para a criação intensiva de alevins, por forma a controlar o declínio das populações e os rendimentos da pesca. A importância da produção em cativeiro para fins alimentares, ou melhoramento ou produção de espécies em perigo ou ameaçadas, depende da evolução da larvicultura. O aumento dos conhecimentos das componentes biológica, ecológica e tecnológica dos sistemas de aquacultura farão com que esta se torne numa estratégia de longo prazo na gestão e conservação dos recursos naturais.

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INTRODUCTION

Ocean and freshwater resources appeared to be virtually unlimited after World War II. The increase in exploitation and the application of new technologies allowed for an increase in total fish production from 21,9 million tons in 1948-52 to a peak of 100,3 million tons, including both fishery and aquaculture.

This peak in production was attained in 1988/89, but following that year the world production of animal aquatic living resources (fish, mollusks, crustaceans, etc.) has remained stable at a level of about 100 million metric tones per year. Thirty percent of this value is converted into fishmeal and used as stock feed.

These figures corroborate the work of RYTHER (1969) who, on the basis of the productivity of marine ecosystems, estimated that the potential quantity of fishery products from all the oceans was 200-250 million tons. Today it is obvious that the capture of all existing stocks would irreversibly alter the structure of food web, and RYTHER (*op. cit.*) has therefore proposed an estimated potential production of 100 million tons (Mt) per annum. This figure currently appears to be generally accepted (HJUL, 1973; BAILEY, 1988). And it is reinforced by the consensus that virtually all the established major world fisheries and the most recently discovered and exploited resources (Bering Sea, Falkland Islands, New Zealand and the Antarctic) are already fished at, if not beyond, their sustainable yield (NRC, 1992). Recent studies using two sets of data, the official landings statistics of Food and Agricultural Organization (FAO) and the trophic levels for 220 different species covering those statistics categories, reflect a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish (PAULY *et al.*, 1998). The results of this study indicate that present exploitation patterns are unsustainable.

The human population is expected to reach 6 billion by the year 2000. If the increase in consumption continues at the current rate (annual per capita utilization has doubled since 1950) (NCR, 1992), an annual production of 138 Mt of fish will be needed.

The depletion of marine aquatic resources, caused by 1) over fishing; 2) environmental pollution, particularly for early life stages that are vulnerable to habitat degradation and water quality changes; and 3) the growing demand for fish and other aquatic organisms, has stimulated the development of freshwater and saltwater aquaculture all over the world, not only for food but also to enhance and replenish fisheries.

Production methods in aquaculture are as variable as the number of species cultured and range from those dependent on single operators and single pond production units, to those involving of multinational corporations and intensive rearing systems.

A wide range of production systems are also encountered worldwide due to differences in economic and social systems, which may be more or less dependent on aquatic ecosystems and agricultural systems.

Today aquaculture represents de fastest growing component of the world food supply, and in all its variants forms accounts for around 30% of the total seafood wealth.

An Overview of Aquaculture Production

Aquaculture is an ancestral activity first practiced in the Indo-Pacific region where, according to written accounts, the first work in artificial reproduction in fish took place about 2500 BC.

Aquaculture can take various forms:

1) Extensive culture, where the growth of species corresponds to the natural productivity of the ecosystem, or where the productivity can be slightly increased by the addition of products which act as fertilizers in the aquatic medium. The level of production in extensive culture systems is always low, never reaching more than a few tons of kg/ha/year,

2) Intensive aquaculture, where production can reach a number of tons per ha/year, necessitating a high level of technology and investment. Intensive aquaculture tends to be developed where competition for the utilization of water and of land is imperative.

Basically, the first type is more appropriate as a model for a subsistence economy and the second for an industrial situation.

Aquaculture grown in recent years, reaching a total of around 21 million tons in 1995 (Table 1). - This represents 21% of total production of aquatic resources (FAO, 1997).

Asia is the principal producer, where aquaculture in the region accounts for 88% of global production by weight (BEVERIDGE *et al*., 1997). In the context of world aquaculture output, freshwater culture represents 63% of total production (Fig. 1), where fishes represent 99,1% of the cultivated species. The opposite situation is observed with marine cultures, where mollusks represent the greater part of production (FAO, 1997).

At the present time, 102 fish species, 32 crustacean, 44 mollusk and 5 species of algae are cultivated worldwide.

The role of Aquaculture

Aquaculture can contribute to (HOLT, 1993):

1) Stock enhancement to augment or mitigate natural stocks

2) Aquaculture of food and ornamental fish to reduce exploitation of natural populations

3) Lab culture of threatened or endangered species as live gene banks and
4) Culture of test organisms for monitoring habitat quality

TABLE 1 - Total Aquaculture production by inland and marine waters (Mt).

		1986	1995
Fish, Crustacean, Mollusks (1)	TOTAL	8 827 247	20 938 326
	Inland Waters	5 819 613	13 773 943
	Marine Waters	3 007 634	7 164 383
Total Aquaculture (2)	TOTAL	12 245 800	27 768 284
	Inland Waters	5 820 894	13 774 481
	Marine Waters	6 424 906	13 993 803

Source: FAO, 1997

(1) Includes all fishes, crustaceans, mollusks, frogs and other amphibians, turtles, sea-squirts and other tunicates, crabs, sea urchins, echinoderms and a miscellany of invertebrates.
(2) Includes species generally not for human consumption (crocodiles, alligators, pearls, shell, corals, sponges).

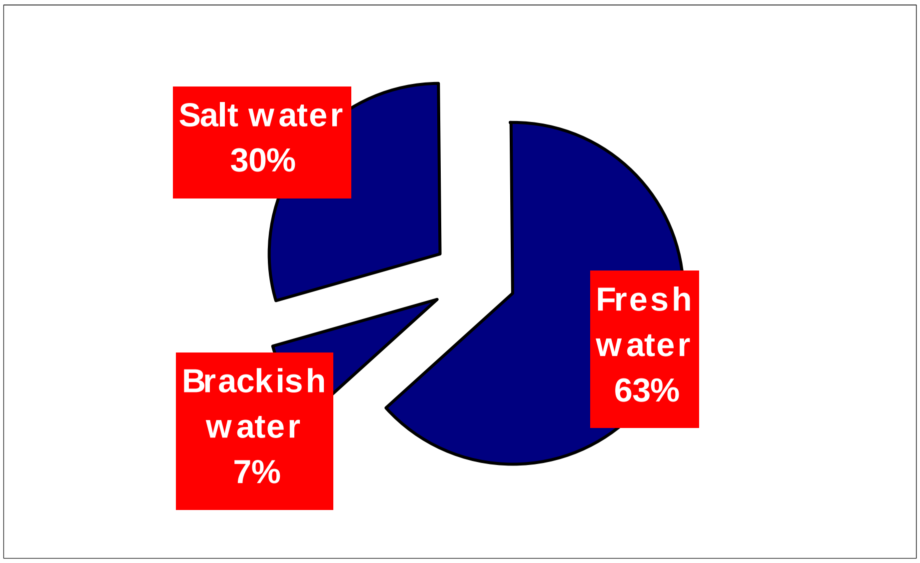

Fig. 1 - Marine, brackish and freshwater aquaculture (FAO, 1997).

Marine stock enhancement is not a new concept. Cod (*Gadus morhua*) larvae have been released into the Atlantic Ocean for nearly a hundred years beginning in the late nineteenth century. The principal technique used was hatchery based, as evident in the history of the Norwegian cod hatchery by Captain Dannevig. However, stock enhancement fell out of favor among fishery biologists after a half a century of hatchery releases produced no evidence of an increase yield (BLANKENSHIP & LEBER, 1995).

In the USA, the last of the early marine hatcheries closed in 1948, following 50 years of stocking marine fishes. Only Norway continued to propagate cod, even intensifying operations after 1950. The British lost interest before the Americans. When it was calculated that 20 million juvenile plaice would have to be stocked each year to increase the annual catch by just 5%, the British hatchery projects turned towards aquaculture for food instead of restocking programs (RICHARDS & EDWARDS, 1986).

However, in recent years, releases of salmon, stripped bass, sturgeon and red drum fry are currently undertaken in the United States, for stock enhancement purposes (NCR, 1992).

Commercial aquaculture production systems may be divided into four categories: 1) flow-through systems: 2) enclosed natural water bodies (enclosures); 3) stagnant water ponds; and 4) recirculating systems. Each can be implemented at different levels of intensification, which interact with the neighboring aquatic environments in different ways (MIRES, 1995). Simultaneous with the development of aquaculture, the protection of aquatic environments has become a major concern, as the intensification of the production systems leads to an increase in suspended organic solids or dissolved matter such as carbon, nitrogen and phosphorous from the fish farm effluents, causing eutrophication.

However, a number of systems to minimize the negative impact of fish farm effluents have been developed. In land-based systems the effluents may be diverted to secondary retention ponds or to cultures of organisms capable of using the residual organic and dissolved components in the effluents. And thus, fish, macrophytes and bivalves can contribute to the purification of the outflow.

In flow-through systems and enclosures this is more difficult to control, however, improvements in the quality of feeds and husbandry management has had a positive effect on the impact of these aquaculture systems.

The mitigation of environmental problems associated with aquaculture may be possible through better knowledge of the biological and ecological factors involved in the culturing of various species, and through engineering and technological solutions that allow new approaches to culture operations.

Recent advances in culture techniques are resulting in profitable aquaculture ventures for more and more species, which can now be raised to marketable size for food consumption. These successes provide support for those who want to culture for stock enhancement. Releases for enhancement include not only populations that are traditionally fished, but also the threatened, endangered or over-harvested ornamental species used for the growing aquarium trade. However a major limitation to the rapid development in this area is the high cost and unreliable production of fingerlings (HOLT, 1993).

Producing live foods (algae, rotifers and brine shrimp) required by marine fish larvae as well labor costs and intensive tank culture costs more than rearing trout or freshwater species. Cost reductions would follow from improvement in larval survival and reduction in the manpower required and in live food requirements.

CONCLUSIONS

Advances in aquaculture technology and in the understanding of the biology of relevant farmed species are essential in order to overcome the major constraints of this activity.

It is possible to reduce the environmental impacts of aquaculture, by establishing the biological, ecological and engineering knowledge base required for decision making.

Larviculture can have an important role in stock enhancement projects, for pilot releases of juveniles of endangered populations as well in for fisheries management.

In addition to providing a means of producing food for human consumption, aquaculture can make significative contributions to fisheries management by development of research in areas not yet well understood, such as the early life stages and adult biology.

Aquaculture, in its *senso lacto* is nowadays an important tool to support regulation and conservation efforts of natural resources.

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