chapter 11

GENERAL CONCLUSIONS AND FUTURE PROSPECTS

11 GENERAL CONCLUSIONS AND FUTURE PROSPECTS

Capture-based aquaculture can be considered the mid-way point between fishing and aquaculture, yet as a commercial activity it constitutes a distinct sector. Its success provides the potential to stimulate research into developing new species for aquaculture, and it has the benefit of existing markets ready for aquaculture production.

It is clear that a very significant proportion (many millions of metric tons) of the total foodfish (finfish, crustaceans and molluscs) aquaculture production reported by FAO is obtained through the on-growing of wild-caught juveniles (for example, in addition to the four species groups considered in this report, the farmed output of milkfish (*Chanos chanos*), mullets, most molluscs, and some marine shrimp is derived from juveniles captured from the wild). However, it is impossible to quantify the total volume or value of the output from capture-based aquaculture accurately because, as yet, the data collected by FAO from its Member States does not distinguish between production from hatchery-reared and wild-caught juveniles.

Most of the production arising from capture-based aquaculture consists of molluscs. Considering finfish alone, the capture-based production of the species groups considered in this report (eels, tunas, groupers and yellowtails) represent a large proportion of the total volume and an even larger proportion by value.

The statistical returns to FAO (FAO 2002a) appear to underestimate production by about 15% for the four species groups covered in this report, when compared with the estimates and reports from other sources (Table 82).

Table 82. Data for the capture-based aquaculture production of eels, groupers, tunas and yellowtails in 2000

Species groups	Estimated data (tonnes)	References for estimated data
Eels	287 815*	Frost *et al.* (2000) www.glasseel.com
Groupers	15 000	Sadovy (2000) Kongkeo and Phillips (2002)
Tunas	20 000	Ikeda (2003)
Yellowtails	136 200	M. Mahita (pers. comm. 2002) and data from the Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, Japan
Total	**459 015**	

* This is comprized of the sum of FAO data (FAO 2002a) and 50 000 tonnes of European eels (Frost *et al.* 2000) that are not specifically recorded in FAO statistics, together with the reported total production of 5 000 tonnes of *Anguilla japonica* in China and *Anguilla rostrata* in Asia (www.glasseel.com).

As indicated above, capture-based aquaculture contributes a significant proportion of total foodfish production through aquaculture, in terms of value as well as volume. For example, even considering the lower production figures reported to FAO, the total value of the capture based aquaculture of the four groups covered in this report exceeded US$ 1.7 billion in 2000 (FAO 2002a). It qualifies to be considered as a separate and distinct entity within the aquaculture sector, not only for its production volume and value, and its market relevance, but also because it has its own specific culture characteristics, which include the facts that:

- in developing countries, capture-based aquaculture constitutes an alternative livelihood for local coastal communities and can contribute significant positive economic returns in those regions with depressed marginal economies. In these countries, capture-based aquaculture is based on international joint ventures, driven by strong market demands and high values. It has a strong economic base, and production can represent eight times the value of the specific regional fisheries;
- capture-based aquaculture has the potential for significant economic multiplier effects, due to the labour intensiveness that is associated with operational and infrastructure requirements. Capture-based aquaculture needs new professionals, thus increasing employment opportunities. In some cases, it has brought about social stability (e.g. Port Lincoln, Australia) with better working conditions and regular incomes. In developing countries it can contribute to poverty reduction and the overall welfare of low-income, resource/asset-poor households;
- new market segments have been created by capture-based aquaculture. In Japan, for example, farmed tuna has filled the gap between two extreme food categories (high quality/expensive and low quality/cheap) and, with its affordable price and high quality, has become very popular. Another example is that farmed groupers are cheaper than comparable wild fish, and they are more competitive in the lucrative live fish market;
- capture-based aquaculture possesses some advantages that can reduce the risks associated with food safety. For example, capture-based farmed species can be "certified" ciguatera-free where control systems are established, so that they can be a safer source of fish for human consumption than wild fish. Consumers are becoming very sensitive to the health hazards associated with capture-based farmed species, as many of these products are normally consumed raw (e.g. "*sushi*", "*sashimi*"). With the application of HACCP, or other food safety assurance programmes, it will become possible for producers to increase their competitiveness in the market by guaranteeing high quality products. In Japan, capture-based farmed yellowtails have a good market image. The same can now be said for eels (through eco-labelling). Both examples are in response to the growing public concerns about food quality. For those capture-based farmed species that at present only enjoy a regional trade, quality will play a key role in the strategies needed to expand the market internationally.

However, what is still lacking is a thorough assessment of the sustainability of capture-based aquaculture, given its high complexity and reliance on "seed" material from wild stocks. By focusing on the selected species in this report, it has been possible to extrapolate a general overview of the capture-based aquaculture industry. This activity is influenced by several key factors and careful management is needed, together with further scientific research and other investigations, to ensure its future viability. These factors are highlighted below.

Wild seed supply

The supply of wild "seed" to the capture-based aquaculture industry appears to be unsustainable in the short term and inadequate in the long term. There are several reasons for this:

- the availability of the "seed" resource, determined bycatch per unit effort of "seed" (juveniles and/or adults), appears to be in decline;
- nursery and adult habitats (e.g. mangrove, sea-grass, coral) are increasingly damaged by pollution, destructive fishing practices and other environmental impacts;
- the actual status of stock resources (lack in knowledge of biology, age maturity, recruitment, etc.) remains substantially unknown;
- there is a lack of quality data on catches, biomass, sizes, etc., which is needed to manage the stock successfully;
- overfishing of the target resources occurs during normal fishing activities.

Solutions for these problems must include improvements in the management of each species, further studies on their biology, and specific research on more selective fishing gears. Moreover, there is a need to develop specific policies and legal frameworks for capture-based aquaculture that incorporate and create interactions between the fishing and farming sectors.

Seed transfer

The transfer of the "seed" to the farms creates additional problems, including:

- high mortality rates (through disease, cannibalism, transport stress, etc.);
- high cost (collection areas and farms are often far apart);
- inadequate holding procedures;
- conflicts with other resource users.

New technologies for the transhipment of wild fish to the farms are needed in order to reduce mortalities, while capture-based aquaculture activities must be properly regulated so that they do not adversely affect associated fisheries, or compete with other human activities.

Farm management

The culture (on-growing) systems also have a series of difficulties to overcome which include:

- the use of trash fish causes problems including the fact that the availability of bait fish is unpredictable (seasonally, etc.), and there is an inappropriate assessment of the related environmental impacts, such as bait fish stock depletion, diseases and infections, etc. The use of raw trash fish may not only cause the transfer of disease vectors to the farmed fish but to other fish sharing the same water body. The transfer of human pathogens is also possible;

- the use of inadequate technologies (feeding regimes, lack of specialized formulated feeds, poor mooring systems and cage structures, etc);
- the currently limited research that would establish optimum conditions for on-growing facilities, which in turn would result in the development of better equipment for offshore operations;
- the lack of trained personnel, with many operations being undertaken at an artisanal level, resulting in poor performance and loss of fish.

An important breakthrough will come when specific cost-effective formulated diets are developed for each species, and accepted by the farmers. The substitution of trash fish by compound feeds will lower the dependence on capture fisheries, thus indirectly protecting marine resources. It will also reduce the pollution caused by waste feed, promote a favourable ecological equilibrium, enable diet quality to be controlled, guarantee a more efficient feed conversion ratio (thus reducing handling and feeding costs, although the ultimate economic gain through such improvements depends on the relative unit costs of the alternative feeds, as well as FCR; other factors also need to be taken into account, such as the final consumer acceptability, and therefore value, of the products produced through alternative feeds. These factors are important considerations, because they heavily influence the willingness of farmers to change from current feeding practices), and eliminate the health risks associated with the uncontrolled quality of bait fish.

With the development of equipment suitable for offshore cage locations, better water quality and fish health will result. Such developments will require consequential improvements in feeding systems, larger boats for servicing them, and new techniques for net repair and cleaning and the maintenance of mooring systems. Increased automation, electronic monitoring, and the use of tension leg mooring systems are possible solutions.

Environmental and safety issues

Environmental and safety issues are always high on the list of concerns for aquaculture generally, and particularly for capture-based farming; these include:

- the lack of an adequate, cost-effective environmental assessment system to ensure good site selection. The use of trash fish can create serious problems for water quality. Sites need to have good water circulation; be deep enough for the nets to be used, to minimize sediment build-up; and have good flushing characteristics to prevent eutrophication, etc.;
- existing regulations do not enforce regular environmental monitoring of site conditions, allowing the development of potentially harmful situations from farm pollutants, which may cause the operation to fail;
- the use of trash fish as feed will continue to have considerable environmental impacts; including wastes, oil skims, etc. The development of low-pollution diets for the various species would considerably reduce environmental impacts;
- the choice of aquafeed ingredient sources, and rearing or fattening sites, should include an assessment of the possibility of chemical contamination (e.g. by dioxins and PCBs) to ensure that farmed fish remain safe for consumption.

The negative effects of farm generated pollution represent a cost to the coastal environment and other resources users. Controlling and reducing wastes would be beneficial to the capture-based aquaculture industry. Sustainable practices not only preserve the environment and reduce the potential for conflicts with other coastal users, but also result in products that are perceived by the consumer as safe, thus improving marketability. An integrated and multidisciplinary approach is needed to develop and achieve sustainability. The development of rapid and innovative low-cost environmental impact assessment programmes, together with regular monitoring based on key environmental performance indicators, will be highly beneficial for the capture-based aquaculture industry.

Post-production issues

Harvesting, processing and marketing also need improvement. Existing problems include

- inappropriate or poor harvesting techniques;
- inappropriate or limited food-safety measures to guarantee consumer health;
- lack of knowledge of the effects of contaminated food on human health and its epidemiology (socio-economic and public health consequences);
- the absence of product traceability;
- limited commercial trade and restricted markets due to product type;
- limited product ranges, which leave producers exposed to market volatility;
- high transportation costs for the fresh “live” fish to market.

Strict (but enabling, not restrictive) procedures are needed to grant farming and selling licences, and for establishing inspection systems to ensure hygiene and quality. Such regulations would protect consumers and help producers to increase the competitiveness of their products in the market. There is a need to develop new market strategies and new market segments, because relying on a unique market (such as Japan for bluefin tuna) is becoming risky for capture-based aquaculture operators.

Control over the life cycle

Capture-based aquaculture needs to progress towards the control of reproduction and the ability to breed in captivity, as well as rear the various life stages of the farmed species. Until this final stage is reached (when formerly capture-based products become normal aquaculture products similar to farmed salmon or trout), the application of responsible techniques for capture-based aquaculture must be the rule. Generally, capture-based aquaculture represents the first (but sometimes, as in eel production, very lengthy) step towards true aquaculture. Thus it is essential that governments should explore and develop legal and institutional instruments to:

- recognize capture-based aquaculture as a distinct sector;
- integrate capture-based aquaculture concerns into resource use and development planning;
- set up international agreements, signed by all those countries that share the same resources, for specific actions in the sector;

- improve food quality;
- improve the management of capture-based aquaculture, particularly where the practice is unsustainable;
- actively promote the activity, as it is likely that it will lead to the development of new aquaculture species, thus reducing the pressure on existing wild stocks.

Statistical issues

For more than a decade FAO has been refining the questionnaires that it sends to Member States, to assist them in defining what production activities result in aquaculture output, from a statistical point of view, and what are regarded as capture fisheries production. Since the growth of the tuna fattening industry, some statistical difficulties have been experienced because of the size of the animals caught from the wild for stocking purposes. In 2001, the Coordinating Working Party on Fishery Statistics (CWP) addressed this issue (Fishstat Plus 2002) and decided that in tuna fattening practices the weight of the captured tuna should be recorded as capture fishery production and that subsequent incremental growth in captivity should be recorded as aquaculture production, in order to avoid partial or total double counting. However, while this solution is theoretically correct, there are practical difficulties in weighing the fish twice. This matter therefore is still under discussion and remains to be satisfactorily resolved; until it is, some difficulties in interpreting the statistical data relating to those species of tuna that are fattened in farms exist. Cooperation between FAO and the tuna fattening industry to develop appropriate rates for measuring increments over time, so that the correct proportions of total production can be assigned to the statistical returns for capture fisheries and aquaculture production, is essential. While this matter is a serious problem relating to tuna fattening, there are no similar statistical problems with the other species discussed in this report (eels, groupers, yellowtails) because the animals caught from the wild for stocking into aquaculture rearing units are negligible in weight; in these cases, the total production is recorded as aquaculture. However, similar statistical problems to those experienced with tuna fattening may occur in reporting the output from the on-growing of other species that are stocked from the wild (e.g. cod).

The future

Capture-based aquaculture is an economic activity that is likely to continue to expand in the short term, both for those finfish species currently under exploitation and possibly with others that may be selected for aquaculture in the future. In the case of non-finfish species, such as a variety of bivalves (e.g. mussels), the activity will certainly continue in view of the very large number of gametes released.

However, in the long term, the capture-based aquaculture of selected species of finfish may have to cease, through legislation, if it is viewed as a threat to their fisheries, to natural recruitment in the wild, and perhaps to their very existence. This is why it is critically important that means be found to rear these species throughout their full life-cycle that are economically viable. When that goal is achieved, not only will the future aquaculture production of those species be assured but restocking programmes may be feasible to enhance their capture fisheries.

Researchers worldwide have been working for many years on the reproductive cycles of all of the species dealt with in this report, achieving results that range from a hint of success in the case of eels to partially successful ones in the case of bluefin tunas and selected species of groupers.

The reproductive biology of the species covered in this report varies in complexity. So far, however, in no cases has their "seed material" been produced artificially on a commercial level.

Research activities focused on fully controlling the reproductive cycles of these fish species will therefore continue as long as there is a high consumer demand for them. The importance of these efforts will be emphasized if their capture fisheries are threatened as a result of current exploitation and farming practices. The impact on eel fisheries caused by farming activities is already evident. It is possible that the capture and export of elvers for this purpose may become totally banned; in this case the farming of eels will cease unless economical means of rearing them artificially to the stocking size are by that time available.

While there are opportunities for market expansion for all of the species discussed in this report, there is a proven tendency (e.g. salmon; seabass; seabream) for farm-gate prices to decline as supply increases. Thus expansion will only be feasible if farmers are able to reduce costs. From a technical point of view the main constraint to expansion is "seed" supply. In the case of tuna fattening, future expansion will be constrained by limited fishery quotas. Eel farming is already constrained by the shortage of "seed" and future expansion is likely to be limited by controls over elver capture. Damage to the environment (e.g. by the collection of grouper seed) may also result in controls that will limit expansion. There is enhanced interest in yellowtail farming but, again, the limitation is "seed" suply.

Although the volume of market demand affects the rate of expansion in the farming of the species discussed in this report, the ability to supply that market will depend primarily on the supply of "seed" and on keeping farming costs down. In conclusion, the development of "seed" production in hatcheries on an economically viable commercial scale, and the refinement of grow-out technology to ensure that the fattening phase is environmentally acceptable are the critical issues for the future. Failure to address these matters successfully would have severe consequences for both aquaculture and capture fisheries.