

chapter 8

SOCIAL AND ECONOMIC IMPACTS



■ Introduction

Markets have been the driving force behind the development of the capture-based aquaculture industry. Market requirements are determined primarily by consumers' tastes and customs, as is the case for bluefin tuna capture-based aquaculture. The preparation of the traditional Japanese "*sashimi*" fostered the high demand for this high quality species, hence the development of its capture-based aquaculture.

All businesses must keep good records to be profitable and successful: capture-based aquaculture is no exception. Good record keeping is essential to understand the successes, failures and profitability of any venture. High profitability, coupled with high market demand, have ensured the development of this activity. However, the increase in capture-based aquaculture is bringing about a number of very important and diverse socio-economic effects, not all of them beneficial.

The selection of species to be cultured is driven by their acceptability in local, national or international markets. Capture-based aquaculture systems can be completely different, depending on cultural, economic, ethnical opinions and local traditions. Cultural and ethnical heterogeneity, as well as economic differences, are partly reflected in the organization of the fishing and farming activities, and in the technologies used.

In Asia, capture-based aquaculture activities may be constrained by the lack of appropriate technologies and limited investment. For example, the capture-based aquaculture of groupers is typically small scale and artisanal, while that for tuna is high-tech and requires considerable investment. The latter type of culture is normally invested in by international companies in partnership with local operators.

Socio-economic considerations differ, according to the species and the country. The capital requirements of grouper farms are low and family or community orientated, yet the income can have a significant influence on the local/rural economy. There may be several incomes generated in the local economy, from the "seed" catchers to the feed suppliers and the merchants. Tuna farming, when operated by international companies, has significantly lower impacts on the local economy, since the "seed" fish are taken on the high-seas and the products are sold on international markets. The income from tuna operations tends to be localized as wages, while the real profits are made by international companies.

The exploitation of a common resource does not always benefit society at large. It can create conflicts between fishermen, farmers and other resources users (e.g. tourism and shipping), and the risk of the concentration of the benefits into a few hands is often compounded by a lack of appropriate regulatory framework. Impacts, be they positive or negative, are not always predictable because capture-based aquaculture is a novel activity with little past history, and the characteristics are species-specific. It is thus very difficult to have a perspective of the entire socio-economic spectrum. Conflicts with other competing resource users, and with other sectors, are unpredictable in the short term, and there is a need for specialized sector research (marketing, environmental, socio-economic, etc.).

■ Economic issues

Capture-based aquaculture products are seen by many to fill distinctive niches in the seafood market, being of high value and high quality. These products will complement, but sometimes also compete with, those supplied from the wild fisheries or other aquaculture systems. In the short- to medium-term, the main factor that will determine the development of capture-based aquaculture is the ability to build up and maintain high value markets (Figure 137). However, environmental restrictions (sites, “seed” availability), environmental degradation from waste products, diseases, and competition for limited resources may all constrain such developments in the case of some species.

Capture-based aquaculture can contribute significant positive social and economic functions at a regional level, particularly in those regions with depressed and marginal economies that are characterized by high rates of unemployment and emigration, and with a generally low standard of living. The economic benefit depends on the country and the species being farmed, as indicated below.



Figure 137. Tuna being sold in the Tsukiji (Tokyo) fish market (Photo: P. Miyake)

The economic value of tuna capture-based aquaculture in the Murcia region of Spain now represents eight times that of all regional fisheries. This evolution is due to a very rapid response to Japanese market demands, and the development of strong partnerships with Japanese companies (de Monbrison and Guillaumie 2003). New markets in the USA and Europe had been developed in 2001; exports to Europe were said to be up by 50%, to America by 76% and to Asia by 3%. Bluefin tuna farming in Croatia is managed by 6 commercial companies using 9 lease sites. The economic benefit from capture-based aquaculture to the fishery sector is worth approximately € 50 million.

In Australia the tuna industry started in 1990 and has now developed into its largest farmed seafood sector, with a harvest in 2000/2001 of 9 005 tonnes, worth A\$ 263.79 million (Clarke 2002). However, its long-term sustainability in Australia is largely dependent on a reduction of its reliance on imported frozen bait fish for tuna feed. At present, 45 000 tonnes of bait fish are used annually, of which about two thirds are being imported, primarily from the USA and northern Europe. Continuous quality improvement is compromised by the need to use a wide variety of bait fish of different composition and quality. Other problems include quarantine restrictions on the use of some feeds to certain times of the year, and fluctuations in the availability and price of bait fish (www.sardi.sa.gov.au). As a result, the feeds used constitute one of the highest operating cost factors.

Since 1998, the rising demand for bait fish (sardine, mackerels, squids, etc.) in the Italian market has caused sharp price increases for frozen mackerels for bait (75%), frozen squids (40 to 110%, depending on the size and the quality) and sardines (80%) (Miyake *et al.* 2003). In Spain, gilt sardine accounted for less than 5% of the landings in 1993; by 1999 the percentage had risen to almost 35%, mainly because of capture-based aquaculture, and gilt sardine prices doubled in 5 years (de Monbrison and Guillaumie 2003). Production and investment costs are also rising; the cost of boats for fishermen and equipment for farmers can also affect profitability, but these must be evaluated against the increases in prices for the products produced. However, the Japanese market for premium tuna products has been slowing down since 2001, and this will have an impact on new investments (de Monbrison and Guillaumie 2003).

The expense of feeding is also the main problem in yellowtail capture-based aquaculture. Since the 1980s, Japanese yellowtail farmers have had a difficult time as production costs have increased with the rising costs of feed, due to the drastic decline in the volume of sardines caught in Japanese waters, a poor supply of Japanese amberjack juveniles (“*mojako*”), and the stagnant Japanese economy. At the same time, the more valuable greater amberjack (*Seriola dumerili*), and yellowtail amberjack (*Seriola lalandi*) were becoming more attractive to fish farmers, and the number of “*mojako*” stocked for aquaculture started to decline in 1995. Yellowtail culture is today facing difficulties and farmers are trying to introduce new species to make capture-based aquaculture more profitable. Greater amberjack aquaculture has been growing rapidly, and this species has now become a rival to Japanese amberjack. Because of its high flesh quality, the greater amberjack usually commands a much higher price than cultured Japanese amberjack in wholesale markets, and the yellowtail amberjack is highly sought after as a “*sashimi*” ingredient (Nakada 2000). This has established the yellowtail amberjack as a valuable new cultured species in South Australia and other locations.

Japanese amberjack fry are cultured in Japan from the size of 4-5 g, and their price in 1998 was ¥ 15 000/kg. Farmers had been able to maintain annual production at 140 000-160 000 tonnes until 2000 but the number of farms had decreased from its peak of 3 991 in 1977 to 1 815 in 1996 (Nakada 2000). Recently, the domestic supply of “*mojako*” showed a significant decrease, and a few million juveniles were once again imported from the Republic of Korea. The price of greater amberjack juveniles ranges from ¥ 2 500/kg to ¥ 10 000/kg. Via Hong Kong, Japan has imported wild juveniles caught in China and Viet Nam since 1986. However, the importation of wild fry, fingerlings, or juvenile fish has been a source of disease; the Japanese aquaculture industry spent ¥ 13.9 billion for the medication used in fish culture during 1997. In 1998, the average production cost for a Japanese amberjack adult was ¥ 750/kg, while its market price was ¥ 1 050/kg.

A cost analysis for the years 1992-1997 is shown in Figure 138; according to Nakada (2000) the gross profit was not as good as in previous years. The cost of juveniles increased as a proportion

of total expenditure; feed costs also increased because of a drastic decline in the sardine resources around Japan. Though not shown in Figure 138, total production changed little during the period, even though the number of the fish farmers declined.

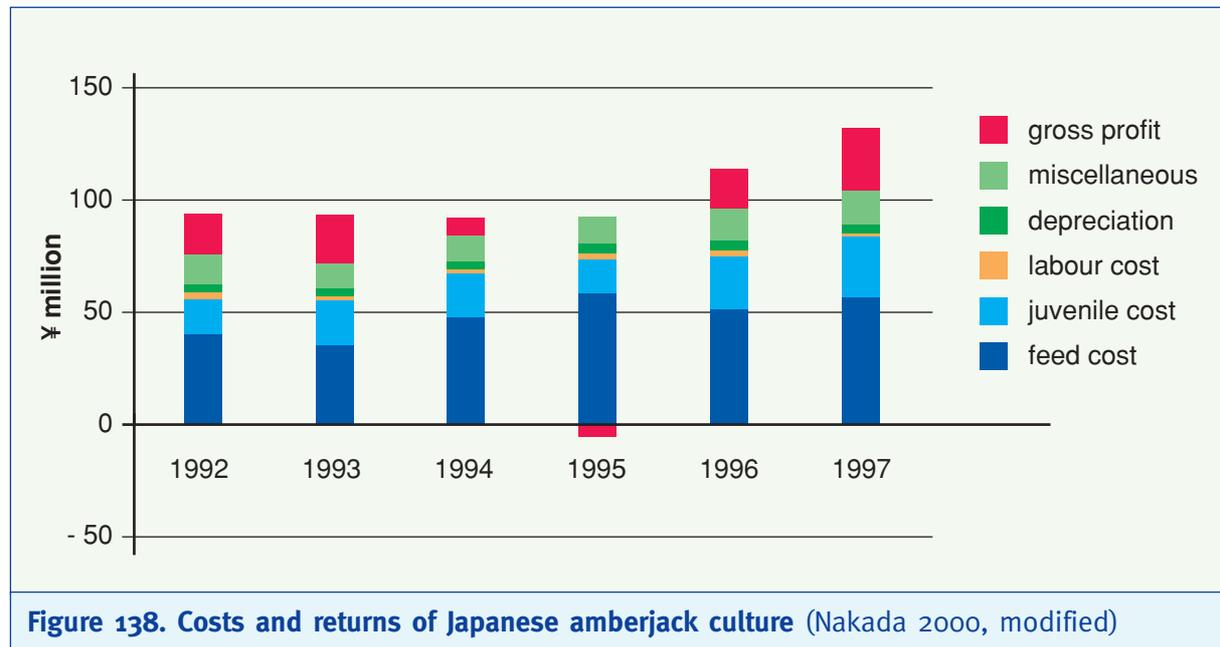


Figure 138. Costs and returns of Japanese amberjack culture (Nakada 2000, modified)

High-density culture is becoming common practice, in order to compensate for falling profits, but it can lead to pollution in the culture areas. It has been established that fish eat less in overcrowded conditions, resulting in poor growth and with an increased susceptibility to diseases. Fish farmers are now trying to use formulated feeds instead of raw fish; when these expensive diets are used, effective feed utilization is essential, but they are more environmental-friendly. In order to overcome their problems, fish farmers are becoming aware of the importance of maintaining good records on stocking density, and carefully compute the daily feed used, based on feeding tables that reflect fish size and water temperature. New technologies, including underwater cameras and counting systems, are used to assess stock numbers and therefore stocking density. Computer programs are extensively used to generate feeding tables and create stock recording systems. The use of formulated feeds (Figure 139) with balanced nutrients has made production of high-quality fish with firm flesh and no fishy odour possible. This practice has also created a new demand for cultured products, for use in “*sashimi*” and other dishes.

As the availability of cultured fish has increased, consumers have become more selective about quality and food safety issues, and farmers have sought to address consumer demand. Currently, a special brand of cultured Japanese amberjack will fetch a higher price than ordinary products. Product quality is obtained by discarding second grade fish and paying special attention to handling systems to maintain freshness. Sales have been expanded in supermarkets and retail fish stores through the marketing of special brands produced by Kagawa and Kagoshima Federation of Fisheries Co-operatives, amongst others (Nakada 2000). Greater amberjack and yellowtail amberjack are becoming more popular than Japanese amberjack because they can be kept for more than three days under refrigeration without losing any of their flavour, colour, and firmness. Currently, the demand for them exceeds supply (Nakada 2000).

Mediterranean production of greater amberjack, mainly in Spain, stopped in 1999. In 1992, young fish were captured and sold directly to farms for about 225 pesetas each and their market value



Figure 139. Feeding a formulated diet to Japanese amberjacks in Japan (Photo: M. Nakada)

was about 1 300 pesetas/kg. Compared with yellowtail production in Japan the profit margin was low, mainly owing to the extensive natural fishery for greater amberjack in the Mediterranean and limited demand (Nash 1995). At present in Spain there are no cage farms producing *Seriola*. Some farms devoted to seabass/seabream or tuna are producing it as a sideline, but these are projects to assess the viability of commercial production. The main limitation for commercial operations is the source of juveniles for on-growing purposes: these always have to come from local wild populations, and are either too scarce or too expensive (€ 2-3 for each 50g young *Seriola*) to be interesting as a source for capture-based aquaculture (A. García Gómez, pers. comm. 2002).

South Australia is beginning to harvest yellowtail amberjack (*S. lalandi*) to satisfy increasing export demands. Australian “*hiramasa*” are used for high quality “*sashimi*” in Japan and the USA, and as a table fish in Europe and Asia. “*Hiramasa*” is the second most popular “*sashimi*” product in Japan after tuna. In 2001, 18 tonnes of yellowtail amberjack, destined for the United States, were harvested. With 23 companies from all over the world showing interest, yellowtail farming could turn into a major new industry for South Australia (Anonymous 2001).

In many Asian regions, the focus is on the capture-based aquaculture of groupers. Globally the grouper market is not large and the market demand/supply relationship can seriously influence prices, making it very sensitive due to the high exclusivity of the product (Svennevig 2002). Owing to the regional nature of the market, prices can fluctuate wildly, and there is a great need to develop new markets to attain stability to support the sector. According to the NGO TRAFFIC, exports of groupers and wrasses from South East Asia rose from 400 tonnes in 1989 to 5 000 tonnes in 1995. However, exports declined by 22% in the following year. The decline in wild populations of groupers and wrasses was identified as one of the main factors behind the

decrease in exports. TRAFFIC estimated that the main threats to reef fish and their ecosystems in South East Asia come from increasing fishing pressures, aimed at ensuring a constant supply for the live reef fish market, and unsustainable fishing methods, such as the use of cyanide.

Hong Kong is believed to be the largest importer of live reef fish for food in Asia and an important re-exporter to other countries. In 2000, imports of high value live marine fish such as red grouper and Napoleon wrasse (*Cheilinus undulatus*) totalled 5 851 tonnes, corresponding to over HK\$ 552 million, i.e. some US\$ 71 million (GLOBEFISH data). The main suppliers of groupers to Hong Kong are Indonesia, the Philippines, Malaysia and Thailand. In the Hong Kong market, consumers prefer smaller specimens to be served whole rather than filleted; therefore the price of smaller specimens is higher than that of larger fish.

Millions of dollars are being spent on grouper research, with the aim of introducing appropriate practices and reducing production costs for capture-based aquaculture, to make it sustainable. These need to take the fragility of the market into account, should production take off. Investment is also needed on the marketing side to make the industry economically viable (Svennevig 2002).

An example of production costs, revenue and profit of grouper capture-based aquaculture from Thailand is as follows (Boonchuwong and Lawapong 2002): the average annual total production costs per farm were US\$ 5 000, while the gross revenue was US\$ 9 800 giving a net profit of US\$ 4 800 to the farmer, with a 96% rate of return (net profit/total cost). Feed accounted for 57% of culturing costs, whereas “seed” accounted for 24%. Other costs (opportunity, depreciation, repairs, etc.) accounted for 19%.

The most important individually recorded *Epinephelus* species mentioned in FAO data on aquaculture production (FAO 2002a) is the greasy grouper (*E. tauvina*), which is farmed in Malaysia and Hong Kong; production was worth about US\$ 12.4 million in 2000. The second most valuable individually recorded farmed grouper species recorded was the slender grouper (*Anyperodon leucogrammicus*), farmed mainly in Thailand, which was valued at over US\$ 10 million in 2000. The value of the areolate grouper (*Epinephelus areolatus*) reared in Hong Kong was much less (US\$ 1.7 million). The recorded value of farmed orange-spotted groupers (*E. coioides*) was less than US\$ 40 000 in 2000. However, all these figures are put into the shade by the non-specified category “groupers nei”, worth over US\$ 40 million. This category of farmed groupers was reared mostly in Taiwan Province of China and Indonesia.

Capture-based aquaculture in Indonesia is a value adding process, with potential economic benefits to coastal communities. For example, the economic returns to a Moslem community in NE Sumatra (since 1990) have meant that its members can now make pilgrimages to Mecca, thanks to the profits of the grouper businesses. Individual fishermen earn a significant percentage of their annual income from grouper resources (Sadovy 2000). In Viet Nam, the income from grouper fry/fingerling fisheries contributes 10 to 50% to the annual income of fishermen, and a single fisherman’s income from this source can reach as much as US\$ 3 080 annually (Sadovy 2000).

The economics of marketing capture-based aquaculture products in Asia, such as live grouper, functions at two levels, namely local and export. The local level involves the collectors and brokers. Collectors, either in the local area or from the region, are responsible for the collection of fish from the local small-scale farmers for the market. Brokers are responsible for the monitoring and movement of prices, informing farmers, and contacting collectors and wholesalers. The export level consists of marketing involving agencies or network companies. The marketing margin (the difference between the purchasing price and the selling price after

the deduction of sales costs) for exporters is much higher than that for the collectors, even though the sales costs of exporters are higher. Boonchuwong and Lawapong (2002) calculated that the rate of return on total costs was as high as 94.4% for exporters and 49.2% for collectors. Exporters receive the highest returns of all traders involved in the live grouper marketing system, as they must carry all of the risks during the collection and export of the live fish – fish deaths, damage, packaging and other export costs.

In Italy, European eel culture is carried out on 74 farms which produced 3 100 tonnes in 2000. Their operation depends heavily on “seed” availability; annually there is a requirement for 500 tonnes of elvers or glass eels. “Seed” is collected from the wild and imported (predominately from France) at an increasingly higher cost (1 kg of glass eels, containing 3 000-4 000 glass eels, is equivalent to € 15-41). “Seed” can account for up to 50% of eel production costs (www.regione.emilia-romagna.it/laguna/articolo.asp?id_articolo=510). Since the fall in the availability of glass eels there has been an increase in the average unit cost of eel product, since elvers are often cultured instead of glass eels. The main production costs in eel culture are the costs of elvers (37%), feed (24%) and labour (12%) (Corbari, Mezzani and Rossi 1997). Italian farms produce two market sizes of eel: 130-180 g for Italy and the Netherlands and 300-1 000 g for German consumers. Eel market prices have generally fallen since 1995 (although 1999 saw a 3.2% rise), due to increasing production from North European recirculation systems. Eel production has spread all over Europe, owing to its potential profitability, but consumption remains mainly in the Netherlands and Germany. The market demand for smoked eel in the Netherlands is satisfied mainly from Danish and Dutch farmers, who sell their production directly to processing systems. Other countries, particularly Greece and Spain, have increased eel production for export to North European markets; they have no local market but good culture conditions. In 1998, a Danish laboratory began producing “*kabayaki*” (ready-to-eat eels for Japan), creating a new market for European producers who had been suffering a price decrease in 1996 and 1997. However, the Japanese market has seen prices decline, due to domestic crises and increased production from Chinese farms. Good eel quality is an essential part of a marketing strategy, and producers are increasingly aware that diets and post-harvesting processes contribute to improving the overall performance of the sector (www.aquaguide.com/databank/tesi/capitolo_5.html).

■ Social impacts – employment creation and skill development

Social benefits are often closely related to economic benefits. The development of a new industry has the potential to create jobs. In the case of capture-based aquaculture, these employment opportunities often arise in rural coastal communities where jobs are limited. There is also a relationship with the fishing industry. With the constant reduction in fishing opportunities, another fishery-related industry is a welcome alternative for the existing skilled workforce. The drift of young persons to cities can also be reduced if job opportunities become available in a new dynamic sector that has the potential to generate high incomes.

Bluefin tuna farming has brought some changes to the Mediterranean tuna fishing industry. Tuna fish prices rose for fishermen and completely changed operational procedures (including fishing areas and seasons, as well as fishing operations). There has also been an increasing demand for purse seines, which are used for the collection of live bluefin tuna (Miyake *et al.* 2003). The fishing sector in Croatia has been significantly influenced by the development of bluefin tuna capture-based aquaculture. After Australian emigrants successfully transplanted Southern bluefin tuna fattening techniques the practice developed very quickly. In just one year, purse seine

fishing vessels increased from 19 (1999) to 30, in order to guarantee the supply to tuna farms. The same phenomenon has happened in France, mainly as a consequence of the increasing number of capture-based tuna farms in Spain; from 1995 to 2000 the number of vessels forming the specialized blue-fin tuna fleet increased from 21 to 32 boats (de Monbrison and Guillaumie 2003). The increasing number of purse seine boats (also in other Mediterranean countries) contributes to the modernization of the fleet, better shoal detection efficiency, speed, improved safety, catch handling systems, and crew comfort.

Many fishermen have become active partners in farming activities, either as suppliers or tuna farmers. Some fishing vessels are employed in capturing the small pelagic fish used as feed for caged tuna. In Croatia, trawlers have been fully integrated into tuna farming operations, either for transporting live fish or delivering feed to the farms. Tuna farms offered a very important employment source in the heavily depopulated Croatian islands; 300 farm jobs have been created (Katavic, Vicina and Franicevic 2003b). In the Murcia region of Spain the bluefin tuna industry provides 500 direct jobs. The employees are young – 25-35 years old and the majority are working as divers at sea (de Monbrison and Guillaumie 2003).

The catching cost in Australia (i.e. use/waste of resources) of bluefin tuna for capture-based aquaculture (purse seine system) is lower than high seas long-lining, namely A\$ 3.50/kg versus A\$ 22/kg (B. Jeffriess, pers. comm. 2002). Australian capture-based tuna aquaculture has had a significant economic multiplier effect because of its labour intensiveness (350 direct and 700 indirect jobs) associated with operations, infrastructure requirements and the exporting of fresh chilled and frozen product. In the area where farming takes place, bluefin tuna farming has brought social stability to the tuna industry, as wild tuna fishing forces crews to remain absent from home for very long periods (B. Jeffriess, pers. comm. 2002). Working conditions are better than on the fishing boats (regular hours, regular salaries, weekends on shore).

The development of new skills has been important for harvesting operations, for example in Australia, where a specialized team of divers crowd the tuna into a small area inside the cage using a sweep net, and then capture the bluefin tuna directly by hand (Figure 140); tuna reach an average weight of 50 kg. This technique is very important and it is essential to have experienced divers who do not stress the tuna too much, as this influences product quality.



Figure 140. Divers are indispensable in bluefin tuna capture-based aquaculture activities
(Photo: L. Mittiga)

Specialized divers are professionals dedicated to tuna capture-based aquaculture. They are fundamental to many farm activities, including inspections of the cages for mortalities, mooring and net integrity, and for transfer after collection and killing procedures.



Figure 141. Specialist employees in a capture-based aquaculture system for Japanese amberjack (Photo: M. Nakada)

■ Value-added benefits

New opportunities arise from the production of capture-based aquaculture operations. However, to take advantage of them, marketing strategies need to consider the availability of the basic resource, in this case the capture-based aquaculture species itself. The possibility of tapping the potential for livelihood improvement through this activity depends on the adoption of appropriate technologies or their transfer or modification for local application, having been tested to determine their economic viability. Lack of technology and high costs are typically considered as the main obstacles for resource exploitation. Appropriate technology needs to be adapted to suit the needs and limitations of each region. A balance has to be found between maximum sustainable production and environmental sustainability that first of all safeguards the livelihoods of the local communities, while providing products that can access existing and develop new markets.

Capture-based aquaculture activities in Asia often employ inappropriate technologies and skills; fish farmers may therefore be forced into using unsustainable practices. The use of wild fry puts stress on fish recruitment for the capture fisheries and on the biodiversity of the capture areas. There is also a lack of fry availability for most of the species used in capture-based aquaculture.

The present use of trash fish as feed leads to various constraints on production, as well as having a negative environmental impact. The currently available “traditional” cage technology also forces the farms to cluster in very sheltered areas (Figure 142).



Figure 142. Artisanal capture-based aquaculture system in Southeast Asia (Photo: S. Fazi. Coastal Resource Management and Sustainable Tourism in Ulugan Bay project implemented by UNESCO/CSI and the Puerto Princesa City Government with the support of UNDP)

The results of these practices are fairly predictable and eventually lead to serious negative environmental impacts, which cause production constraints and diseases or low growth performance, due to non-suitable water quality (high levels of suspended material). The lack of, or expense of new or improved technology deters newcomers from entering the business and restricts the families of landless fishermen from exploiting this livelihood opportunity. Farmers have had to focus on shortcuts in collecting and keeping wild fry, competing with capture fisheries for stocking material. Often, they only benefit from capture-based aquaculture by applying better logistics to the marketing of live and very high-value fish, such as groupers. Frequently, very limited value is added to the product through real growth of the fish biomass, with only 25-30% being added to the sales price (Svennevig 2002).

Focus in Asia has been given to the lucrative live fish market. This is a logical strategy for the farmer, and is the most immediately accessible market segment. Sale prices in this specialized market more than cover the production costs and provide a reasonable return to the farmers. However, this market is not controlled by the farmers, but by the wholesalers, who have the

highest profit margin and little interest in the well-being of their supporting farmers (Svennevig 2002).

Another issue within the grouper “live fish” segment is that the Hong Kong market; though being the target of grouper production for most of the countries in the region; it trades a limited volume – 5 000 tonnes/year. It is therefore predicted that the market will show a “normal” supply/demand collapse when the large RandD effort put into grouper culture becomes fruitful and production increases. This will leave some farmers in a very vulnerable situation, especially those that still only use the present technology and methods of farm management. If they do not diversify the market segment for their products there will always be risks of the market collapsing from increased production.

The impact of capture-based farmed bluefin tuna on the Japanese market has been significant. Products are of the middle quality category, and fill the gap between top (pre-spawning bluefin tuna) and lower (smaller and post-spawned blue-fin tuna) qualities. The availability of capture-based farmed products has expanded the range of products available in Japan, guaranteeing middle quality at a good price. The capture-based farmed tuna have provided the consumer with a fatty meat called “*toro*”, which only rich people could have afforded before (Miyake *et al.* 2003). Farmed tuna are now even sold in supermarkets and used in the popular, but inexpensive “*sushi*” bars. The availability of this new category has forced prices down for both high and low quality tuna meat. The unique tuna markets of Japan, especially for tuna from capture-based aquaculture, is becoming risky for both fishermen and farmers. The high priced “*sashimi*” tuna market in 2002 has been strong, with relatively soaring demand despite the weakness of the Yen that has affected returns on investments. However, Japanese consumers have started changing their consumption habits, choosing less expensive products (de Monbrison and Guillaumie 2003). Competition and substitution with other less expensive tuna species has already been observed in the market, with big eye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) being sold at € 3-6/kg in Japan versus bluefin tuna sold at € 20-40/kg.

■ Impacts and conflicts with other resource users

Capture-based farm installations can be a source of conflict in coastal zones. Conflicts may be direct or indirect; affecting activities such as navigation, tourism and other fishing operations. Conservation of valuable natural resources are dependent on the presence/absence of national/regional legislation. Farms in Italy are not allowed to be located close to *Posidonia* sea beds, but other countries do not always take up their political responsibility to protect and manage these fragile and endangered ecosystems.

Capture-based tuna aquaculture activities in the Mediterranean area have caused friction between the local tuna fishermen that use long-lines and the cage towing operations of capture-based farmers. Since the activity of tug boats towing tuna cages was disturbing the traditional long-line fisheries of Italian, Maltese, Tunisian and Japanese fleets, as well as reducing tuna catches, the Maltese national delegation to the GFCM 26th Session in September 2001 proposed the establishment of a box in the international waters south of Malta that would be closed to purse seine fishing (Tudela 2002c). The artisanal fisheries could not compete for the resource against advanced industrial fleets with large catching capacities, which exploit acoustic and aerial surveillance methods (Tudela 2002a,b).

Bluefin tuna farmers in Croatia have caused problems due to the smell and pollution during the summer season. The uncollected fat skim on the sea surface, which comes from the feeding of

oily trash fish, may spread outside licensed zones, and can have disastrous effects on the beaches used by tourists (Katavic, Vicina and Franicevic 2003b). In France, the biggest fresh tuna market in Europe, five companies specialized in bluefin tuna have had negative impacts on local employment opportunities with a 20% reduction in people employed in the sector. This is due to the tunas being moved to the Spanish farms in Murcia for on-growing instead of being sold to supermarket chains in France (de Monbrison and Guillaumie 2003). In some cases, however, tourism has been used to increase farm profits. There are guided tours to the offshore tuna cages in Port Lincoln (Australia); in Murcia (Spain) sport diving in bluefin tuna cages was allowed until recently, when a diver was accidentally hit by the fin of a tuna (de Monbrison and Guillaumie 2003).

In the developing countries of Asia, capture-based aquaculture could have a positive impact. Hair *et al.* (2002) considered the advantages of using capture-based juveniles to supply the ornamental and live food markets for fish from coral reefs. There has been an increasing interest in using this practice. In this case, capture-based aquaculture has had to overcome problems resulting from overfishing of adults and the use of destructive fishing techniques, in particular sodium cyanide solution. Two sampling techniques, light traps and cast nets, have proved suitable for the capture of live pre-settlement fish, and substantial progress has now been made in applying these methods to the development of artisanal fisheries for ornamental species. Although the capture and culture of postlarvae is unlikely to meet the demand for all the tropical marine fish required by the ornamental trade, it has created important niche markets, for example for eco-labelled specimens which increases the value of the fish caught and reared in an environmentally sustainable manner (Wood 2001), and provides sustainable economic returns from coral reef resources for coastal villagers. The live reef food fish trade, conducted mainly through Hong Kong (30 000-35 000 tonnes/year) had a total wholesale value of US\$ 490 million at the end of 1999 (Chan 2000a). Some difficulties have been experienced as capture-based aquaculture activities have increased (wild-caught groupers may be 30% more expensive than farmed fish), and the supply to the ornamental industry (in particular groupers) has been insufficient to meet consumer demand.

The islands of Bermuda provide an example of conflicts between cultural traditions and the environment. The fishing and capture-based aquaculture industries wanted to increase the quantity of fish that they were allowed to catch, in order to satisfy local demand and increase both market shares and income. However, the tourism industry wanted to decrease fishing quotas because it needs a thriving aquatic life for tourists to enjoy. By the 1980s, the stock of grouper had declined, and tourism had the upper hand. This case appears to be a conflict between ecological concerns (the depletion of the fish resources) and cultural ones (the rights of generations of fishermen and farmers who depend on the fish for survival). When reviewing the economic impact of the ban, it becomes clear that the major reason for it was that the tourism industry was – and still is - significantly more profitable than the fishing industry. Various reef related activities (excluding fishing) yielded approximately US\$ 9 million in 1988, whereas the fishing industry generated only US\$ 2 million in this same period. Thus, “from a strictly cash viewpoint, reef preservation appears to be more than four times more valuable than the pot fishery” (www.american.edu/ted/bermuda.htm).

■ Conclusions

For some countries, capture-based aquaculture represents an alternative livelihood for local coastal communities and can have significant, positive economic returns in those regions with depressed and marginal economies. The main limitation to the potential for the development of capture-based aquaculture is the small market volume and the exclusive niches that its products

seek to exploit, e.g. live groupers in Hong Kong. Fresh fish (the main product for capture-based farmed species) fetches significantly higher prices than frozen and the incentives to enter this market are significant (Valdimarsson and James 2001).

The marketing of fresh fish and, in particular, “live fish” is difficult, due to the perishable nature of the product and its very short shelf life. This increases the economic risk for the producer, and the costs of product transportation to the market, e.g. the air-freighting of tuna from Australia or the Mediterranean to Japan. Large volumes of fish need to be marketed close to where they are landed and these markets often do not pay the best prices. However it is in the best interests of producers to investigate and develop markets for new products in the sector.

Economic analysis shows that the key input is feeding (feed comprises up to 70% of operational costs), which is typical for most intensive aquaculture operations. The lack of specific diets for capture-based aquaculture means that production is dependent on the availability of bait fish and, as has been seen in recent years, prices for these fish are rising. Yellowtail farmers have already had a difficult time due to a significant decline in the volume of sardines caught in the waters around Japan. The long-term sustainability of southern blue-fin tuna capture-based aquaculture will, in a large measure, be dependent on a reduction in the reliance of the industry on imported frozen bait fish and the development of efficient manufactured diets. Benefits of capture-based aquaculture have been demonstrated by the tuna farms in the Murcia region of Spain. Their production now represents eight times the value of all other regional fisheries. This evolution is due to a very rapid adaptation to the Japanese market demand, and the development of strong partnerships with Japanese companies.

The structure of the capture-based aquaculture industry may be described at a number of levels in the hierarchy of the system, from the local production scale to the macroeconomic scale of the international trade in capture-based aquaculture species. This incorporates all the aspects related to the profitability of capture-based species culture: “seed” availability, marketing from the local production level to customers (through middlemen, exporters and wholesalers), and market trends and influences. A limit to capture-based aquaculture will be the availability of the “seed” resource. From an economic point of view, a poor supply of “seed” is the greatest risk to production. For example, wild caught farm seed availability for European eels represents 50% of the total production costs at present, and if there is a continuing decline in availability, this will seriously affect the overall operating costs – and the future profitability.

In Asia, there has been a falling market trend (1995-1999) in the consumption of live seafood (Pawiro 2002), especially for high-value species such as grouper. The markets for “luxury food items” such as live fish is determined by the strength of the economy, in particular the level of disposable incomes, and the prevailing exchange rate between the exporting and the importing country.

In the future, the capture-based aquaculture of target species such as yellowtail may expand, for example in Australia, leading to increased competition. Increasing production may lead to a fall in market prices, unless the producers develop new market strategies and new markets. However, to enter new markets, the products from capture-based aquaculture must look for unique selling positions (USP) to identify their products, and to maintain the exclusivity which exists at the moment. All future developments and increases in production must be market led. The future will also depend on the ability of operators to reduce production costs (e.g. with improvements in growth rate, food conversion, disease control, etc.). There are also specific skills gaps that are evident in the sector, including specific knowledge on economics and management, the suitability of individual species for culture, information on the biology and dietary requirements of the species, and the marketing of the selected species and products.

One of the most important factors for the effective development of capture-based aquaculture enterprises is a rational selection of experts to assist in the design and initial operation of each project. All projects must be established in a logical and economically structured manner, with the associated technical, engineering, biological, environmental, marketing, and financial analyses. Only if all of these criteria are met should a project be considered for investment. An aid to proper project development would be the collection of data on existing farm operations where many of the key elements can be identified and costed – SWOT analysis would reveal where the investment is at risk of failure, and improvements can then be added to new or existing projects. The capture-based aquaculture industry needs the right mix of skills and knowledge to achieve its potential. There will be a need for partnerships between the business sector and those involved in education, research and government.

Capture-based aquaculture can have significant economic multiplier effects, due to the labour intensiveness associated with operating and infrastructure requirements, the exporting of fresh, chilled and frozen products, etc. Related activities can generate a significant number of jobs and a very significant income; in some cases capture-based aquaculture has brought social stability (e.g. in Port Lincoln, Australia) with better working conditions. It can also contribute to poverty reduction in developing countries, and enhance the overall welfare of low-income, resource-poor or asset-poor households.

Capture-based aquaculture, like every business, can and will have negative and positive impacts on the local economic and social climate. Positive or negative interactions due to capture-based aquaculture will be more or less marked according to its level of development and the technology used and species cultured. The challenge will always be to try to create a balance that provides a positive answer to the overall equation.