chapter 9

MANAGEMENT OF RESOURCES AND CULTURE PRACTICES

9

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Introduction

The exponential growth of the global population and the associated need to produce enough food impose considerable pressure on the supply of natural food sources, including marine resources. Since the creation of the International Council for the Exploration of the Sea (ICES) in 1902, countries have become aware of the need to cooperate in order to effectively research and manage shared natural resources. Since those days, a vast array of regional fishery management organizations or arrangements have been established. These usually serve as a gateway between the global and national fishery governance levels for implementing the international fisheries legal system, either through "soft law" instruments such as declarations, assertions of principles, codes of conduct, or international plans of action, or through "hard laws" that are legally binding and enforceable. "Hard laws" include international agreements and conventions that stipulate explicit rules governing State conduct over fisheries (Aqorau 2001).

Global experience has shown that unregulated fishing inevitably results in overfishing. Over-exploited fish stocks must be given time to rebuild to sustainable levels and the regional management of the resources should guarantee an integrated approach to maintain populations. Policies should therefore address the causes of overfishing and the related short-term social and economic adjustment costs, without hurting trade or limiting the rightful and sustainable use of the resource.

Social pressure, from fishing communities and consumers alike, has put the management of human activity in context. The effects upon the marine environment and the sustainability of the resource has created a far greater understanding of the links between fishing, aquaculture and ecosystems. The research needed to provide this understanding is extensive and expensive. In the meantime, policy decision-makers must increasingly take into account the environmental dimension of fisheries management and aquaculture policy development. This strategy is a fundamental part of sustainable development in the fisheries sector. As capture-based aquaculture is an overlap between fisheries and aquaculture, the management of the resources and the species involved must take into account the requirements of both practices.

Aquaculture production methods have changed significantly in recent decades. Traditional low-intensive methods with low input levels and relatively small habitat modifications have moved towards modern intensive tank and cage-based techniques. These systems require highly concentrated input levels, significant targeting of species and stocks, and potentially have high impact levels at environmental and social levels.

A common problem in regulating the capture-based aquaculture industry, which is operating in many locations, has been the inadequacy of existing legislation to properly control its expansion. There are potential conflicts of interest with other resource users and activities in coastal areas. Rapid expansion of the sector, coupled with poor regulatory measures, has become a constraint within the industry itself. There is a need for better capture-based aquaculture management; the processes of translating actual or potential impacts into direct environmental costs and into environmental and resources management policies requires development.

Fisheries management

Within the fisheries management process (FAO 1997d), resources management requires considerable information on the biological characteristics, life-cycles, recruitment dynamics, habitat requirements, and fishery interactions for each exploited species. Marine fisheries management should ensure not only that wild populations of these fish are sustained at commercially viable levels, but also that market demands and the economic needs of fishermen are met, while harvest levels are adapted to cope with changing resources abundance. Unfortunately, when little information is available about the status of a stock and its associated fisheries, potential problems tend to be ignored. As a result, most fisheries, both in developing and developed countries, are thought to be either heavily exploited or over-exploited. Many stocks have now been reduced to 10-30% of their original biomass (FAO 2000; ICLARM 1999a,b; Williams 1996).

Some management methods for fish stock assessments are based on catch-at-age data (Coleman *et al.* 1999). The data is used in Virtual Population Analysis (VPA) to reconstruct cohort-specific stock abundance and fishing mortality rates on the basis of past catches. The outcome of the VPA is then used to make annual recommendations for the Total Allowable Catch (TAC). The greatest problem with VPA is that it provides only hindsight information on cohorts that have passed through the fishery, but none on the cohorts that need managing (Coleman *et al.* 1999). Incorrect estimates would not reflect the real condition of the stock, and could lead to management actions that have a negative effect on both the species and the fishing industry. Recruitment forecasting allows management to anticipate problems and to take preventive measures to relieve fishing pressure (Koenig and Coleman 1998).

The cross-disciplinary nature of fisheries management with clear ecological, economic and social dimensions is likely to make solution finding a continuing topic of debate in the coming years. The economic and social aspects of fisheries management can in fact have a severe impact on the choice of management regime and the rigour with which it is imposed (Hall 1999). The conventional management methods used at national and regional level include the following (Jennings, Kaiser and Reynolds 2001):

- Catch controls: these are intended to control fishing mortality by limiting the weight of catch that fishers can take. They include total allowable catch (TAC) or quotas (Q) which are limits on the total catch to be taken from a specified stock (Figure 143), as well as individual quotas (IQ) and vessel catch limits where the TAC is divided between fishing units. Catch controls are amongst the most widely used management regulation. IQs restrict the catches of individual fishers or boats. The sum of all IQs will equal the TAC. If IQs can be bought and sold by fishers than they are known as individual transferable quotas (ITQ). TACs are set to meet the target levels of fishing mortality determined by stock assessment. They may be fixed, or they may change from year to year because fish stock fluctuates and the future is unpredictable. In order to adjust catches from year to year, the government or regulatory authority may buy and sell ITQs.
- Effort controls: these limit the number of boat or fishers who work in a fishery, the amount, size and type of gear they use, and the time that the gear can be left in the water. Effort controls may also limit the size or power of vessels and the periods when they fish. The aim of effort control is to reduce the catching power of fishers and thus reduce fishing mortality. Effort control can be divided into licences, individual effort quotas (IEQ) and vessel or gear restriction. Limited licences restrict the number of boats or fishers in the fishery. Licences can be transferable. Effort quotas limit the amount of

time spent working by a given unit of gear, a vessel, or a fisher. An individual transferable effort quota is a tradable IEQ. Vessel or gear restrictions try to limit the catching capacity of vessel or fishers. These may control the size and the design of pots or nets or the dimension of a fishing vessel, or may ban specific gears that are seen as too effective.

→ Technical measures: these restrict the size and sex of fished species that are caught or landed, the gears used and the times when, or areas where, fishing is allowed. The size of individuals that are landed may be controlled by minimum landing sizes (MLS). Time and area closures can protect fished species at specific phases of their life history. Examples are the protection of juvenile nursery areas or adult spawning grounds. Time closures can protect annual stocks until their production and quality is high, but also lead to market gluts at the start of the fishing season. Time and area closures have been most effective when used in conjunction with other measures such as catch and effort controls.

Figure 143. Fishing bluefin tuna for capture-based aquaculture in the Mediterranean (an example of quota regulated fisheries) (Photo: F. Ottolenghi)

National and regional fishery management

According to the Code of Conduct for Responsible Fisheries (FAO 1995), conservation and management measures, whether at local, national, sub-regional, or regional levels, should be based on the best scientific evidence available and designed to ensure the long-term sustainability of fishery resources. The measures used should promote a rational exploitation, possibly below MSY, while maintaining the availability of the resource base for present and future generations. Within fisheries under national jurisdiction, States should identify the relevant domestic parties having a legitimate interest in the use and management of fisheries resources and seek their cooperation in achieving responsible fisheries.

For stocks exploited by two or more States (either transboundary, straddling or highly migratory fish stocks) there needs to be cooperation to ensure effective conservation of the resources and management of the fisheries. This should be achieved by the setting up of bilateral, sub-regional or regional fisheries organizations or arrangements. A sub-regional or regional fisheries management organization or arrangement should possibly include States under whose jurisdiction the resources occur, as well as States which have a real interest in the fisheries even though the resources are outside their national jurisdiction. States and sub-regional or regional fisheries management organizations and arrangements should ensure that the laws, regulations and other rules governing their implementation are accepted by all parties (FAO 1995).

Many regional fishery bodies foresee a two-tiered structure; in this concept a scientific entity, either a subsidiary or an independent body, provide scientific advice to the regional fisheries management organization. Indeed, there are two different approaches to developing scientific advice. One approach is based upon a "science secretariat", with has its own independent staff. The Oceanic Fisheries Programme (OFP), the IATTC (Inter-American Tropical Tuna Commission), the NAFO (Northwest Atlantic Fisheries Organization) and others utilize this system. However, the majority of the Regional Fisheries Management Organizations rely on a "multinational approach", where scientists from different national institutes of the Member States meet regularly to develop and agree on scientific advice as instructed by the management body.

The source and availability of staff is the key feature that distinguishes science secretariats (independent staff) from multinational approaches (national scientists) and that may influence the nature of the advice, because compromises are most likely to occur at an early stage in the second approach. The ICCAT (International Commission for the Conservation of Atlantic Tunas), the GFCM (General Fisheries Commission for the Mediterranean), CITES (Convention on International Trade in Endangered Species) are examples of such "multinational" scientific approach that are widely utilized. This approach tends to predominate, because Member States prefer an approach that has low up-front costs and secures their individual, immediate and direct involvement in the fishery's scientific research and subsequent input to management (Ward, Kearney and Tsirbas 2000).

In both cases, the monitoring and state of the resources can be compromized where important fishing nations are not parties to the Regional Fisheries Management Organization or arrangement. Difficulties may also occur where fishing activities outside the jurisdiction of an authority take targeted or incidental catches of species that are under the responsibility of the administration, as is the case of some highly migratory stocks, e.g. bluefin tuna in the Mediterranean and North Atlantic.

Bluefin tuna management – an example for capture-based aquaculture

Two examples of the regional management of capture-based aquaculture, both of tuna, are provided in this section of the report; regional organizations with a remit that includes tuna are listed in Table 78.

The southern bluefin tuna and the CCSBT

The first example is provided by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), which has the responsibility for the management of the stock. Since 1985, Australia, Japan and New Zealand have met to negotiate annual global quotas for southern bluefin tuna (Figure 144). Since 1994, these negotiations have been under the auspices of the CCSBT (1994) and involve the setting of an annual TAC and the negotiation of national allocations (quotas) within that TAC. Each year, discussions on allocation are preceded by a scientific meeting involving scientists from the three Member countries, who exchange scientific data and provide an assessment on the state of the stock. Increased scientific effort has been warranted, given the massive decline in catch but it took several years to reach agreement. Since 1990 there has been a strict annual quota of 11 750 tonnes (Haward and Bergin 2001) of which each Member has been allocated a constant share (Japan: 6 065 tonnes; Australia: 5 265 tonnes; New Zealand: 420 tonnes). The Republic of Korea and Taiwan Province of China became active in the CCSBT in 2001 and 2002 respectively; for the 2003-4 season they were each allotted catch limits of 1 140 tonnes, while the limits for the other countries remained the same. This compares with the peak output of the southern bluefin tuna fishery of 81 000 tonnes in 1961, before stringent quota reductions were applied to prevent stock collapse. The southern bluefin tuna population today is thought to be so severely depleted that the Convention for International Trade of Endangered Species (CITES) has listed the species as “critically endangered” in its “Red List” of endangered species.

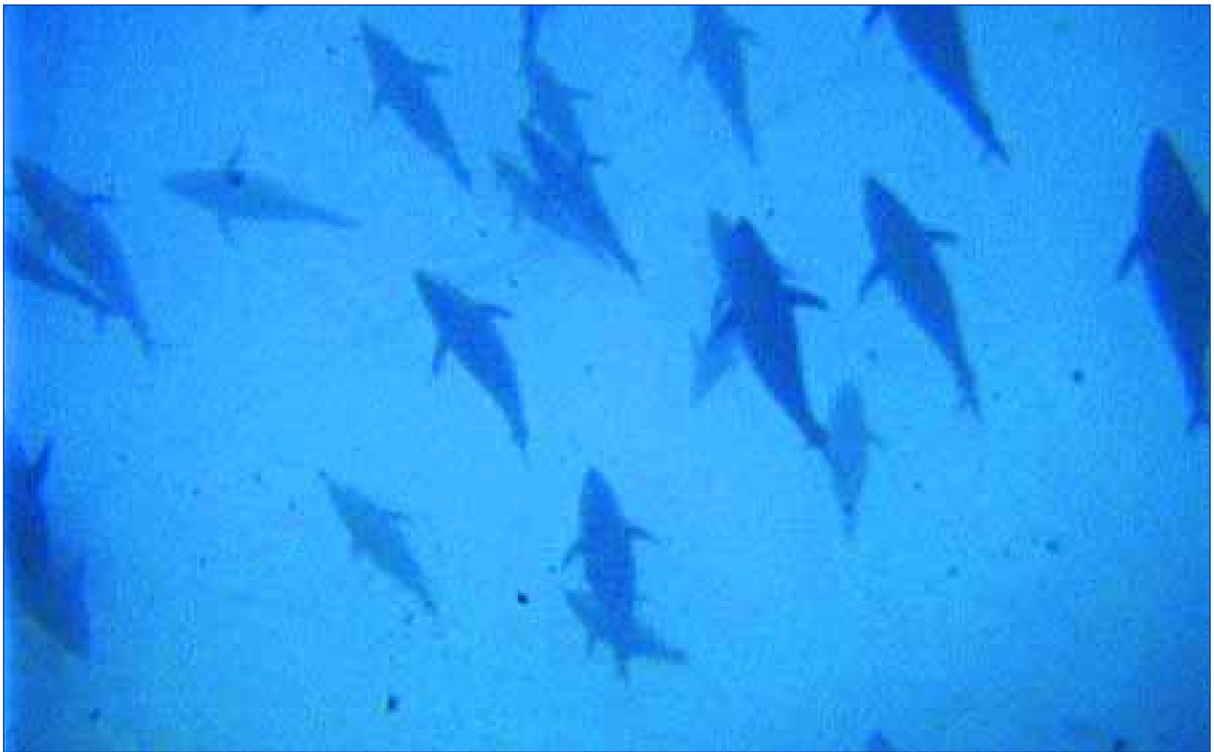

Figure 144. Southern bluefin tuna *(Thunnus maccoyii)* (Photo: L. Mittiga)

CCSBT has also introduced a trade information scheme to track the point of origin of southern bluefin tuna. This proposal had been mooted for several years, following the introduction of a similar scheme by ICCAT. In addition, a southern bluefin Statistical Document Programme (SDP) was launched in June 2000 (Haward and Bergin 2001). It includes the principle that “there is no waiver” of the requirement that all imports of southern bluefin tuna into the territory of a

Member of the CCSBT shall be accompanied by a CCSBT Southern Bluefin Statistical Document. The scheme is also based on the principle that the programme will conform to "relevant international obligations". One of the interesting elements where information is required is for capture-based farmed tuna, thus taking into account the significance of farmed southern bluefin tuna in Australia. As in other schemes, an official of the each vessel's flag State, or its "delegated entity", endorses the Southern Bluefin Statistical Document that accompanies the landing of the fish. Data obtained from the programme is then forwarded to all Members twice a year. Members then check export statistics against the data provided to them from the CCSBT Secretariat.

It should be noted that, following the explosion of tuna capture-based aquaculture, the quota of one Member (Australia) was year by year completely utilized by the farming industry until the CCSBT imposed a cap on the maximum amount of juvenile catch to be taken for this purpose. The southern bluefin tuna collected by the fishery and transferred to the capture-based aquaculture system are monitored by the Federal Fishery Management Authority (that administers the wild fishery), which estimates the total live tuna collected for farming by each operator and deducts it from its TAC.

The northern bluefin tuna and the ICCAT

The second example is provided by the Atlantic and Mediterranean[1] large pelagic fisheries that are under the competence of the International Commission for the Conservation of Atlantic Tunas (ICCAT), which was established in 1969 with the aim of coordinating international research and management of highly migratory tunas and billfish in the Atlantic and adjacent waters. ICCAT is currently composed of 32 members and is endowed with a Standing Committee on Research and Statistics (SCRS) that provides scientific advice to the Commission, The SCRS conducts stock assessments of Atlantic tunas and billfish and coordinates multinational research activities related to these species. The stock assessments, upon which the Commission bases its decisions, change from year to year in response to improved methodologies and revised statistics.

ICCAT's primary stated bluefin management goal is to maintain Atlantic bluefin tuna populations at levels that will allow the Maximum Sustainable Yield (MSY). The MSY is an estimate of the greatest average catch that can be removed from fish stocks year after year, without reducing the stock's ability to sustain these maximum catches in subsequent years (Buck 1995). In an effort to achieve this aim, ICCAT recommended a number of management measures for the Western Atlantic bluefin fishery, which included harvest quotas, per trip catch limits, and a minimum size limit (currently 6.4 kg).

In 1981, ICCAT decided to manage the Eastern and Western Atlantic bluefin tuna stocks as discrete populations, setting a conventional boundary at 45°W. This two-stock hypothesis is supported by the presence of small to large specimens on both sides of the Atlantic, the occurrence of spawning in the Gulf of Mexico and the Mediterranean at different times of the year, and morphometric differences between fish from different areas. Analysis of conventional tagging data, which show a low fish-mixing rate with most tags recaptured in the area of release, also gives support to the existence of two separate groups of bluefin tuna in the North Atlantic (Arnold *et al.* 2003). Several electronic tagging programmes have been initiated recently; these include experiments with "pop-up" satellite-detected tags carried out in Europe between 1998 and 2000 (Arnold *et al.* 2003) and in Canada and New England since 1997 (Lutcavage *et al.* 2003). Additional research is needed for a better understanding of tuna biology, including the

1 In the Mediterranean, large pelagic fisheries are also under the competence of the General Fisheries Commission for the Mediterranean (GFCM). GFCM and ICCAT have established a Joint Working Party to monitor the status of tuna and tuna-like species.

movements of reproductive habitat and spawning site fidelity. There is also a need for a genetic survey of the bluefin tuna and its Mediterranean and Atlantic distribution to understand if mixing occurs between the two stocks; some results are already available, and various studies are currently in progress (Magoulas 2002; Pla 2002).

In 1981, ICCAT initiated a stock recovery plan for the Western Atlantic bluefin population. The Commission recommended that the scientific monitoring quota should be as low as possible for the Western Atlantic and this was set at 1 160 tonnes for the 1982 fishing season in the Western Atlantic but was increased to 2 660 tonnes for 1983 (Buck 1995) and remained at this level until 1992. Between 1993 and 2001 the quota, which is revised at two-yearly intervals, ranged between 1 995-2 500 tonnes. Current catches from the western stock are modest, but the stock is still considered as over exploited (Tudela 2002b). ICCAT also developed a management regime for the eastern stock and the MSY was set at 29 500 tonnes for the Eastern Atlantic and the Mediterranean, with quotas (TACs) allocated on a State by State basis. The 1998 stock assessment for the Eastern Atlantic bluefin tuna, as analysed by the SCRS, showed that breeding population levels had declined alarmingly.

Capture-based tuna farming now complicates the stock assessment in the Mediterranean area, due to the transhipments of tuna "at sea". In the Mediterranean, owing to the absence of EEZs, the stock has the potential for much greater common ownership, and this gives rise to conflicting data. The main problem is that it necessary to know the characteristics of the fish when they are first caught (size, location, fleet/gear used, and the amount of fishing effort spent in capturing them) (ICCAT 2003). Biological sampling is necessary to understand the age and structure of the populations. Today it is more difficult to know the precize biological composition of a catch, since tuna are not landed to local buyers but are transferred live at sea. There, the counting of the fish is often done by divers equipped with underwater cameras to estimate fish length and the size composition of the catch (giving total weight). However, the results are still crudely estimated.

Capture-based tuna farming has raised other issues, due to the lack of information on growth and conversion rates in cages, data that is required for the BTSD to back-calculate weight at catch. The challenge is to ensure that the tuna catches sold to tuna farmers are reported for both stock assessment and quota purposes. The difficulties related to collating the data received from most of the Mediterranean tuna farms and national authorities in 2001 has led ICCAT to estimate that tuna gain an average of 25% of their body weight during the farming period. This has led to a conversion factor of 0.8 that is applied to farmed products imported by Japan, which is used to back-calculate the weight of the catches before the capture-based aquaculture period.

ICCAT introduced a Bluefin Tuna Statistical Document (BTSD) programme for frozen bluefin in 1993 and for fresh bluefin in 1994. The aim of the programme was to increase the accuracy of bluefin statistics and track unreported fish caught. The programme requires that all contracting parties must report all imported bluefin tuna, and that these records are accompanied by an ICCAT BTSD detailing the weight and type of products by flag of the fishing vessels and area of fishing operations (Miyake *et al.* 2003).

There is general agreement that capture-based aquaculture should be developed within a Best Management Practice framework. For this purpose GFCM and ICCAT established a Joint *ad-hoc* Working Group on Sustainable Tuna Farming Practices in the Mediterranean in 2002. The Working Group is composed of scientists from the GFCM Scientific Advisory Committee and the GFCM Committee on Aquaculture, and of scientists from the ICCAT SCRS.

Table 78. Examples of regional organizations with remits that include tuna (Ward, Kearney and Tsirbas 2000, modified; FAO 2003)

Acronym	**GFCM**
Organization	General Fisheries Commission for the Mediterranean
Founding year	1949
Membership	Albania, Algeria, Bulgaria, Croatia, Cyprus, EC, Egypt, France, Greece, Israel, Italy, Japan, Lebanon, Libya, Malta, Monaco, Morocco, Romania, Slovenia, Spain, Syria, Tunisia, Turkey
Species	All species including tunas and small tunas
Area of competence	Mediterranean Sea, adjacent waters, the Black Sea and the Azov Sea
Main functions	To promote the development, conservation and management of living marine resources; to formulate and recommend conservation measures; to encourage training cooperative projects
Approach to science	Multinational

Acronym	**IATTC**
Organization	Inter-American Tropical Tuna Commission
Founding year	1949
Membership	Costa Rica, Ecuador, El Salvador, France, Guatemala, Japan, Mexico, Nicaragua, Panama, Peru, USA, Vanuatu and Venezuela
Species	Tuna, tuna-like species, dolphin
Area of competence	Eastern Pacific Ocean
Main functions	To gather and interpret information on tuna; to conduct scientific investigations; to recommend proposals for joint action for conservation
Approach to science	Science secretariat

Acronym	**ICCAT**
Organization	International Commission for the Conservation of Atlantic Tunas
Founding year	1969
Membership	Algeria, Angola, Barbados, Brazil, Canada, Cape Verde, China, Côte d'Ivoire, Croatia, Equatorial Guinea, EC, France (St. Pierre and Miquelon), Gabon, Ghana, Guinea Conakry, Honduras, Japan, Korea (Rep. of), Libya, Mexico, Morocco, Namibia, Panama, Russia, Sao Tomé and Principe, South Africa, Trinidad and Tobago, Tunisia, UK (Overseas Territories), United States, Uruguay and Venezuela
Species	Tuna and tuna-like species
Area of competence	Atlantic Ocean including the adjacent seas
Main functions	To study the population of tuna and tuna-like fishes; to make recommendations designed to maintain these populations at levels permitting maximum sustainable catch
Approach to science	Multinational

Acronym	**FFA**
Organization	South Pacific Forum Fisheries Agency
Founding year	1979
Membership	Australia, Cook Islands, Federal States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Western Samoa
Species	Tuna
Area of competence	South Pacific (Central and West)
Main functions	To harmonize fishery management policies; to facilitate cooperation in surveillance and enforcement, processing, marketing and relations with third countries; to arrange for reciprocal access by member countries to their respective 200-mile zones
Approach to science	Multinational

Acronym	**IOTC**
Organization	Indian Ocean Tuna Commission
Founding year	1993
Membership	Australia, People's Republic of China, Comoros, Eritrea, EC, France, India, Iran, Japan, Korea (Republic of), Madagascar, Malaysia, Mauritius, Oman, Pakistan, Seychelles, Sri Lanka, Sudan, Thailand, UK
Species	Tuna and tuna-like species
Area of competence	Indian Ocean and adjacent seas north of the Antarctic Convergence
Main functions	To promote cooperation in the conservation of tuna and tuna-like species and also promote their optimum utilization, and the sustainable development of the fisheries
Approach to science	Multinational

Acronym	**CCSBT**
Organization	Commission for the Conservation of Southern Bluefin Tuna
Founding year	1994
Membership	Australia, Japan, New Zealand
Species	Southern bluefin tuna
Area of competence	Atlantic, Pacific and Indian Oceans where SBT are found
Main functions	To collect, to analyse and interpret scientific and other relevant information on SBT to adopt conservation and management measures including the total allowable catch and its allocation among the Members
Approach to science	Multinational

Acronym	**WIOTO**
Organization	West Indian Ocean Tuna Organization
Founding year	1991
Membership	Comoros, India, Mauritius, Seychelles
Species	Tuna and tuna-like species
Area of competence	Western Indian Ocean
Main functions	To harmonize polices with respect to fisheries; to determine relations with distant water fishing nations; to establish mechanism for fisheries surveillance and enforcement; to cooperate in fisheries development; to coordinate access to EEZs of the Members
Approach to science	Multinational

The southern and northern bluefin tuna populations are examples of capture-based aquaculture target pelagic species. They are highly migratory and, being a shared resource, responsible management requires common rules, which need to be adopted and properly enforced in all the distribution areas of each species. ICCAT, GFCM and CCSBT face many complexities and difficulties in order to improve their management, and specific new rules have to be implemented to deal with the tuna capture-based aquaculture issue. The high economic value of the species and market interests will inevitably make solutions challenging.

Aquaculture management

Marine finfish aquaculture is a relatively recent phenomenon that has experienced the bulk of its growth over the last three decades. Asia is the leading continent, with a long history of small-scale marine farming, a labour-intensive activity that was well integrated with the local environment and within the bounds of available resources. During the last 30 years it has grown into a large-scale food producing industry, which is now focused on earning foreign currency from exports. The rapid expansion of intensive monoculture systems has led to developments in the sector where the focus has been on raising predominantly carnivorous, highly profitable species that demand large amounts of feed, water and fertilizers. This pattern of expansion has been witnessed worldwide. Intensive marine aquaculture, together with the exploitation of other marine resources, the expanding coastal population, urban and agricultural pollution, capture fisheries, tourism, and recreational industries have all increased the pressure on the world's coastal ecosystems.

Nowadays, there is a general realization that for aquaculture to be sustainable, management must not only be aware of the technological issues but also understand the environmental effects, as well as socio-economics issues and markets. Intensive aquaculture, particularly when dependent on fishmeal for the feeding of carnivorous species, is the form of farming most questioned in terms of sustainability (Folke, Kautsky and Troell 1994, 1997; Naylor *et al.* 1998, 2000). Aquaculture is considered a source of potential danger to coastal ecosystems, when it is not managed correctly. Aquaculture management must be included as part of an Integrated Coastal Management (ICM) plan. The concept of ICM was developed in the 1990s, and has been widely embraced around the world. The management of capture-based aquaculture must now be viewed within this environmental concept, and the influence of ICM policies on it are increasing.

A practical consideration for managing aquaculture within the ICM environment is the consideration of environmental carrying capacity, which for aquaculture can be defined as the level of production that a given area (water body) can accommodate without causing significant impacts to the surrounding environment or other resource users (Donnan 2000). GESAMP (1986) defined this capacity as "a property of the environment and its ability to accommodate a particular activity or rate of an activity ... without unacceptable impact".

More specifically, in terms of biological and chemical parameters, GESAMP (1996) defined environmental capacity as:

- the rate at which nutrients are added without triggering eutrophication;
- the rate of organic flux to the benthos without major disruption to natural benthic processes;
- the rate of dissolved oxygen depletion that can be accommodated without mortality of the indigenous biota.

As ICM programmes are established on a long-term basis, there are a few examples of the application (with aquaculture as a factor) that can be used (Table 79).

Table 79. Some ICM programme applications

Country	Legislative	Year	Content
Australia	National Strategy for Ecologically Sustainable Development	1992	Integration of economic, social and cultural ocean uses
	National Strategy for the Conservation of Australia's Biological Biodiversity	1996	
	Australia's Ocean Policy	1998	
Canada	Ocean Act	1997	Precautionary approach and sustainable development for oceans strategy
European Community (EC)	Report on CZM and demonstration programme on 35 ICZM projects (EC 1999).	1999	Need for aquaculture/fisheries policy to be integrated with the environmental policy
Indonesia	Act n. 5/1990 Presidential Decree n. 32/1990	1990	Protection of fish habitats (coral reefs, mangroves, sea-grasses) Management of protected areas
New Zealand	Resource Management Act. Besides, a wide ranging review and report on coastal issues (PCE 2000)	1991	Integrated planning framework for aquaculture

Major international initiatives for ICMs are the adoption of Chapter 17 (oceans and coasts) of the Rio de Janeiro 1992 Agenda 21 (www.un.org/esa/sustdev/agenda21.htm), Articles 9 (aquaculture development) and 10 (Integration of Fisheries into Coastal Area Management) of the FAO Code of Conduct for Sustainable Fisheries (FAO 1995), and, more particularly for aquaculture management, the development of a series of Coastal Zone Management (CZM) systems around the world. The main points contained in the 2002 Johannesburg plan (www.johannesburgsummit.org) are related to the promotion of the "ecosystem approach" for the protection of marine biodiversity, and from the beginning of 2004, a monitoring system which evaluates the marine environment. The main goal for fisheries is the adoption of strategies and measures necessary to generate sustainable fisheries by 2012.

Despite their theoretical advantages, the more comprehensive (National, Regional) forms of ICM are unlikely to offer an effective solution to the immediate needs of improved planning and management in the areas of existing, or rapidly developing coastal aquaculture activities.

National and Regional aquaculture management

There is no single planning or management framework tool that can be universally applied to promote more sustainable coastal aquaculture development. The importance of legal, procedural and planning frameworks designed to facilitate sustainable aquaculture development is emphasized in the Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995). This promises to have a significant impact worldwide on the development of regulatory systems for aquaculture in the coming years. Article 9 of the CCRF deals with aquaculture development and sets out a wide range of relevant principles and criteria. The first principle is that States should establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of responsible aquaculture. FAO has also produced technical guidelines for responsible aquaculture development (FAO 1997b), which are intended to provide general advice to support and implement Article 9 of the CCRF.

Progress has also been made in the application of the hazard analysis critical control points (HACCP) system in aquaculture (see also the following chapter) and FAO has published general guidelines for seafood quality (Huss 1993). In addition, FAO is currently involved in reviewing the draft Code of Hygienic Practice for the Products of Aquaculture under the auspices of the *Codex Alimentarius* Committee on Fish and Fishery Products. This Code deals with key hygienic factors involved in all aspects of finfish and crustacean farming, from location and layout of aquaculture facilities to end-product specifications and the production of an HACCP system. The Code is advisory in nature and is intended to be used as a guideline for preparing national quality standards and fish inspection regulations by countries that do not possess fully-developed legal regulations (De Fontaubert, Downes and Agardy 1996).

In many countries laws regulating aquaculture are poorly developed and frequently consist only of a few articles pertaining to capture fisheries legislation. However, during the last few years there has been a growing interest in many countries to develop a comprehensive regulatory framework for aquaculture that will protect the industry, the environment, other resource users and consumers (New 1999). While capture fisheries are generally regulated by a single government department, aquaculture is frequently regulated by many agencies under a variety of laws. This means that developing a comprehensive regulatory framework for aquaculture is often a legally and institutionally complex process. Often it involves drafting or amending legislation that addresses a variety of issues, e.g. land use planning and tenure; water extraction, use and discharge quality; fish movement; disease control and notification; pharmaceutical use; and food quality and public health. It also requires the establishment of institutional arrangements to ensure the co-operation and co-ordination of many different institutions with jurisdiction over natural resources, animal and public health, environment, etc.

Although new comprehensive national laws that regulate aquaculture may be desirable in many countries, other options are now being considered. Developing and passing new legislation is a long process and sometimes takes several years, while the rapid development of the sector has created an urgent need for regulation. These options include the enactment of regulations under existing legislation, and non-legally binding agreements such as guidelines and codes of practice. For example the EU has over 250 different regulations that can apply to fish farming.

Capture-based aquaculture transcends both aquaculture and fisheries legislation. As the sector develops there are likely to be greater areas of conflict and more difficulties for this sector, due to increased legislation in both the fisheries and aquaculture sectors. Capture-based aquaculture needs the development of "soft law" instruments, economic incentives and performance bonds, as well as requirements for international and regional collaboration.

Environmental Assessment (EA) – a technical instrument for aquaculture management

Environmental Assessments (EAs) or Environment Impact Assessments (EIAs) could represent a sound technical approach for the development of sustainable aquaculture management systems, and should be compulsory for all new aquaculture developments. In many cases, where international finance or grants are involved, the sponsor will be required to undertake an EA. The EA is normally part of the feasibility study, and is essential to obtain investment funding. The management of each project needs to develop a monitoring system from the EA, in addition to other mitigation measures, in order to ensure the continuing sustainability of the project in environmental terms.

Capture-based aquaculture presents a series of environmental impacts that need an EA and monitoring system, since this would help to prevent conflicts between coastal users, protect sensitive habitats and improve sustainable development of the mariculture industry. At a national level, where an EA regulation exists, licenses for aquaculture sites are more or less mandatory. These are granted only following the presentation of an Environmental Impact Statement/Study, which is the technical basis for local decision makers (who will take into account other factors including public opinion, private sector/producer associations, environmental organizations, various NGOs, etc.). Table 80 shows some examples of EA national legislation worldwide.

An aquaculture proposal has to satisfy several characteristics that take into account all potential environmental hazards: impacts on the ecosystem (water, sediment, habitats, pelagic components,

Table 80. Environmental Impact Assessment Acts

Country	Legislative	Year	Content
Indonesia	Environmental Management Act (EMA)	1982	Environmental protection and management
	Analysis of Impact on the Environment (AIE)	1986	Enabling regulation of EMA
Malta	Policy and Design Guidance for EIA	1994	Technical guidelines for EIA and EIS
Sweden	Swedish Environmental Code	1999	Sustainable development

benthos, other organisms), stock removal, visual impacts (on the visual amenity of the site), odours, noise or vibrations (tourism may decrease due to odours caused by tuna farms, as has happened in Croatia), human health and socio-economic effects.

Mitigation measures have to be included in the EA to prevent or to minimize such impacts. Surveillance monitoring (long-term), site specific monitoring (medium-term) and operation compliance monitoring (short-term) represent important mitigation measures (Figure 145). Management needs to develop contingency plans for the operation, so that if an undesirable impact is detected, alternative operating policies and practices are on hand and the project does not have to cease functioning.

Figure 145. Capture-based Japanese amberjack culture in Japan: monitoring is a tool to assess its sustainability (Photo: M. Nakada)

Aquaculture – specific legislation

In the Mediterranean, there are several legislative instruments governing marine aquaculture activities. For example, Dosdat and de la Pomelie (2000) show that operators in France are regulated by a law that still has to be harmonized with EU directives. Fish farmers have to obtain a permit for the use of maritime public property and an operating authorization, as fish farming is considered by law to be an "activity liable to pollute". The permit lists the species to be farmed, production levels, culture system, location and some other general specifications of the operation. Farmers have to pay a fee that depends on the size of the activity (e.g. € 8.40 per 100 m^2 area, for fish) and not on the actual production value. The authorization consists of an ordinary declaration for a fish production below 20 tonnes per year, and an implemented authorization if this threshold is to be exceeded. This regulation was applied to marine fish farming in 1993. The central document is the Environmental Impact Study (EIS), and the monitoring of aquaculture impacts is undertaken by the Departmental of Veterinary Services (DVS). The most common monitoring scheme for sea-cage farming involves a survey of the benthos (redox potential, benthic fauna, settled organic matter) carried out every six months, a water nutrient analysis (near-shore to the cages) and microbiological monitoring at 3 monthly intervals. Fish farmers have to record every intervention and farming activity (standing stocks, food consumption and ratios, input-output of fish, etc.), accidental mortality and losses, waste management (dead fish, organic matter, fuel) in a report transmitted to the DVS. The use of veterinary products is regulated by EU directive 92/18 (antibiotics, food additives and vaccines) (Dosdat and de la Pomelie 2000).

The above requirements are also needed as part of an HACCP system (see the following chapter) and, although adding to the operating costs of the project, these controls and reporting systems have the potential to add value and assure consumers. The term “environmentally sustainable and responsible aquaculture” is becoming an important “tag” for serious commercial companies.

At both national and local levels there is a lack of standardization. For example the threshold in Ireland is set at 100 tonnes compared to 20 tonnes in France, while in Italy the limit is related to area, not to the production method or density (5 ha for intensive farming). Site choice is also difficult to standardize, due to the local characteristics of coastal zones, which differ greatly from place to place. It is also very difficult to establish a set of effluent standards for open water cage farming systems.

Legislation should aim to regulate fish density, depending on carrying capacity, in order to minimize the environmental effects of fish farming. These effects can be significantly reduced by careful site selection, site carrying capacity assessment, stock density control, and improved feed formulation (artificial feed instead of trash fish). Use of trash fish as fish feed is being regulated in some countries: in Denmark, trash fish has been banned and fish farms have been forced to switch to formulated feeds. Compared with pelleted feed, the use of trash fish leads to a much higher wastage of feed. Research conducted on Hong Kong grouper culture showed that solid wastes could be reduced by 5 433 tonnes (40%) (Chu 1999). Feed wastage is a function of protein intake and the digestibility of the feed (percentage of non-digestible components present), and can be reduced by improved feed technology. For example, ammonia excretion by fish is a function of nitrogen and protein intake (Engin and Carter 2001) and can be kept to a minimum with artificial feed. The levels of nitrogen and phosphorous in feed have decreased, as artificial feed matches more closely the dietary requirements of fish. Modern diets tend to contain more lipids and less binders and carbohydrates. This has resulted in a general reduction improvement in feed conversion ratios (Black 2001).

The application of computer modelling to aquaculture management and monitoring should also be carried out to ensure that the culture activity is environmentally sustainable. A numerical model has been developed that describes the material cycling in Japanese amberjack (*Seriola quinqueradiata*) culture grounds, and has been successfully applied at Yusu Bay in the Bungo Channel, Japan (Takeoka *et al.* 1988). The seasonal change in flux of particulate organic carbon in the bottom layer, which consisted of the remainder of the bait and the faecal matter from yellowtail culture, has been calculated using the data and parameters for Yusu Bay. The results fitted well to the flux values of particulate organic carbon into the bottom layer obtained by sediment trap experiments in Yusu Bay.

Grouper management – an example for capture-based aquaculture

The management of capture-based farmed groupers is complicated by several problems, including shortage of capture-based "seed"; disease transfer resulting from international trade in "seed", high mortality rates in capture and culture, overfishing of grouper adults, etc. Groupers are top predators, sedentary in character and strongly territorial, typically long-lived and slow growing and many assemble in large numbers to spawn. These characteristics contribute to the ease with which over-exploitation may occur, and is engendered by the Live Reef Food Fish Trade (LRFFT). This has already led to calls to include many of the target species in Appendix II or III of the Convention on International Trade in Endangered Species (CITES) (Lau and Parry-Jones 1999). The Nature Conservancy (TNC) has developed a regional strategy in the Asia-Pacific that focuses on developing and applying regional models to sustainable fisheries.

Many different resolutions have been taken to reduce exploitation: the Bahamian government has recently approved the establishment of five no-take marine reserves. All of these sites contain known Nassau grouper spawning aggregations. Although stocks of Nassau grouper in the Bahamas appear to be healthy, these closures (coupled with other research activities) are being implemented to ensure that conservative management measures are taken, as a precaution against stock collapses such as those that have occurred in other locations that once held stocks of this species (Johannes 2000).

Other regulations should be developed to control capture-based grouper "seed". The availability of capture-based grouper "seed" is often insufficient and unreliable (both in quality and quantity) to meet demand; low production in farming is mainly attributed to lack of seed supply (Chao and Chou 1999; Yashiro *et al.* 2002; Agbayani 2002). Disease problems due to the high transfer stress can cause high mortality rates in capture and culture. Sadovy (2000) has compiled information on the status of regulations on grouper "seed" capture and exports that concern capture-based aquaculture (Table 81).

A Southeast Asian survey found that while the quantity of "seed" caught was astonishing, the production level was very low. The major causes contributing to this massive mortality are destructive fishing practices and gears, poor post-harvest handling, poor farming practices and conditions, and a generalized lack of experience or knowledge (Sadovy 2000). This review indicated that there is a substantial fishery, and demand, for fish in the 5-10 cm range, but that the removal of this "seed" could have serious consequences for the future of both adult stocks and the contribution of these adults to the future of the "seed" fishery itself. Given the likelihood that there will be a significant increase in natural mortality for the smallest settling fish, several researchers have already proposed that fisheries for very early post-settlement (or even pre-settlement) "seed" is a way of gaining benefit from a resource that does not affect its long-term sustainability.

It is necessary to consider further directions and initiatives to attain a better use of biological resources and greater socio-economic benefits from grouper capture-based aquaculture. One possible approach for grouper management is, as Sadovy (2000) suggests, the establishment of nursery areas where the capture fishery and culture operations occur. Another possibility is to protect key "seed" settlement areas and nursery habitats, such as mangrove areas and sea-grass environments in river mouths and estuaries, and to ensure "seed" production by safeguarding spawning adults. Marine protected areas may incorporate key settlement and nursery areas.

Positive steps to address many of these issues are being taken by the Network of Aquaculture Centres in Asia and the Pacific (NACA) and its partners, the Asia-Pacific Economic Cooperation (APEC), the South-East Asian Fisheries Development Center (SEAFDEC), the Australian Centre for

Table 81. Southeast Asia National Regulations (Sadovy 2000)

Locality	Regulation
People's Republic of China	➔ Limits the number of grouper "seed" fishers and the quantities of grouper "seed" captured ➔ A licence is needed for transporting marine "seeds" and their export is prohibited ➔ There is a management regulation of Guangdong Province for the cultivation of aquatic products in the shallow sea intertidal zone, which applies to those engaged in marine cultivation
Hong Kong SAR China	➔ Culturists must be licensed and operate in one of 26 gazetted culture zones ➔ There are no regulations that apply to the capture of grouper "seeds" or their import or export
Indonesia	➔ There is no management of seed resources
Malaysia	➔ Federal legislation prohibits the use of cyanide for fishing ➔ In East Malaysia there are no special regulations for grouper seed capture. Some regulations may act indirectly, for example some gears that are made of trawl net are subject to trawl mesh size control. Grouper seeds cannot be imported for culture ➔ In West Malaysia the fishing of "seeds" is not allowed during November and December; it is only permitted during the peak season from January to April. No export of seeds smaller than 15 cm is permitted
Philippines	➔ It is illegal to use cyanide or any other poisonous substance for fishing ➔ Scissor nets are illegal ➔ Fyke nets have been banned ➔ The Fisheries Code of 1998 (Republic Act 8550) prohibits the export of "seed" of milkfish and prawns but its application to groupers is not clear. This Code regulates gear/structures and operational zones for fish capture and culture ➔ Transportation and export of fish and fisheries products requires permits from the Quarantine section, including a health certificate from the Fish Health section of BFAR
Taiwan Province of China	➔ In Penghu Island, fisheries are not permitted to catch any grouper seed of <6 cm ➔ The use of cyanide for fishing is illegal
Thailand	➔ The use of push nets and fyke nets is limited. Push nets and trawlers should not be used within 3 km of the shore and the mesh size of trawlers should be ≥2.5 cm
Viet Nam	➔ Government regulations prohibit export of groupers <500 g (Ministry of Fisheries) ➔ There is no limit on export volumes. For export a health certificate from a provincial office, Fisheries Resources and Environment Conservation Sub-Department is needed, and requirements of the importing country satisfied

International Agricultural Research (ACIAR), and the WorldFish Center (formerly known as ICLARM), etc. 1998 saw the establishment of the Asia-Pacific Grouper Network (APGN); this organization aims at aquaculture development, in order to:

- reduce the current reliance on capture-based "seed" for aquaculture, as the capture of wild juveniles is sometimes carried out using destructive fishing techniques that can have significant impact on the long-term status of the stock;
- provide an alternative source of income/employment for coastal populations currently engaging in destructive fishing practices;
- protect endangered reef fish from the pressures of illegal fishing practices, through the development of sustainable aquaculture;
- develop new aquaculture livelihood options and investments that will generate economic benefits for a diversity of stakeholders and employees.

Since 1996, all the above mentioned organizations have set up workshops, with the aim of establishing a regional mechanism for research cooperation that supports the sustainable development of capture-based aquaculture in the Asian region. Emphasis has been placed on technology transfer and management strategies for the benefit of farmers and coastal populations.

Conclusions

The complex interactions of capture-based aquaculture with fisheries and aquaculture pose many difficulties. There is a need to develop specific rules that complement existing regulations in order to improve management practices. Management schemes for capture-based aquaculture need innovative instruments and concepts. Overfishing, bycatch, gear selection, etc., are common problems concerning resource removal. Environmental impacts (waste, eutrophication, etc.) are problems that are shared with other aquaculture systems. However, in addition, capture-based aquaculture practices have their own specific characteristics, such as "seed" importation, the transhipment of live fish in open seas, the unloading of catches, food quality, unspecific diets for feeding (mostly trash fish), etc. Other complexities are species-specific; some examples are the towing-cage transportation of tuna, the wastage of "seed" arising from unnecessary mortalities during harvest, transport and culture, and the problems linked to the export/import of capture-based "seed".

Most of the concerned management authorities (either at national, sub-regional, or regional levels) having to deal with capture-based aquaculture systems are working to assess the dimension of the issue, in efforts towards identifying adequate responses. For example, at a regional level, ICCAT and GFCM are considering potential solutions to integrate northern bluefin tuna capture-based aquaculture within a coherent management framework in the Mediterranean area. As an example of actions at a national level, the Japanese Coastal Fishing Grounds Rehabilitation and Development Law, enacted in 1974, creates fish shelters to attract fish to new fishing grounds and promotes the release of fry into coastal waters for culture-based fisheries. A fishing rights system authorizes local cooperatives to manage the fisheries in coastal waters, and a special license is required to collect and sell the fry of yellowtails, to prevent overfishing.

With regard to the management of groupers, one possible approach is, as Sadovy (2000) suggests, the establishment of nursery areas where the capture fishery and culture operations occur. Another possibility is to protect key "seed" settlement areas and nursery habitats, such as mangrove areas and sea-grass environments in river mouths and estuaries, and to ensure "seed" production by safeguarding spawning adults. Protected marine areas may incorporate key settlement and nursery areas.

For all capture-based farmed species it is important to study not only the biological characteristics (spawning capacity, behaviour, etc.) of both the wild and farmed fish and to carry out specific research, but also to understand all of the impacts and monitor all the parameters related to these practices, particularly the social, economic, and environmental parameters. The need to develop policies and a legal framework for capture-based aquaculture is now widely recognized. As capture-based aquaculture is a practice which is constantly developing (mainly for high commercial market value target species), care should be taken to create or amend the comprehensive regulatory framework to ensure that the sector develops in a sustainable manner. In particular, legal and institutional instruments should continue to be explored and developed, *inter alia*, to:

- recognize capture-based aquaculture as a distinct sub-sector;
- integrate capture-based aquaculture concerns into resource use and development planning;
- improve food safety and quality to safeguard consumers, and meet the standards of importers;
- improve the management of capture-based aquaculture, particularly where the practice is potentially unsustainable (e.g. due to overfishing, bycatch, food wastage, the use of trash fish, and the relationship between the consumption of raw fish and consumer safety).

Specific actions might best be taken through international agreements or arrangements among the countries that share the same resources. Related measures could include acceptable capture methods for "seed" and market-size fish, seasonal or other bans to protect specific size classes or species, and restrictions on numbers and sizes taken. For the responsible management of capture-based aquaculture, it would also be advisable for governments to consult and permanently interact with private farmers, in order to identify factors that may be inhibiting sound management and development; the principles set out in the CCRF and the Draft Code of Hygienic Practice for the Products of Aquaculture could provide useful guidance.