3. SUBREGIONAL REVIEWS

The subregional reviews were submitted by experts from various subregions of the Near East and North Africa, covering all of the major waterbodies in the Region. Their titles are:

- Climate change and ecosystem-based approach to fisheries and marine aquaculture for Mauritania and Morocco, by A. Orbi (INRH), S. Zizah (INRH), K. Hilmi (INRH) and M.Y. Laaroussi (Ministry of Agriculture and Fisheries);
- The ecosystem approach to fisheries and aquaculture for the Southern and Eastern Mediterranean, by M. Belhassen (INSTM);
- The ecosystem-based approach to fisheries and aquaculture for the Red Sea and Gulf of Aden, by M.M.A. Zaid (Al-Azhar University);
- Adapting to climate change: a review on the ecosystem approach to fisheries and aquaculture in the RECOFI region, by H. Negarestan (IFRO).

3.1 Climate change and the ecosystem-based approach to fisheries and marine aquaculture for Mauritania and Morocco

Introduction

Four large upwelling ecosystems border the western boundary of the African continent. In the Atlantic, the economic exclusive zones (EEZs) of the Gambia Morocco, Mauritania and Senegal are part of the Large Marine Ecosystems of the Canary Current.

Upwelling ecosystems provide more than 40 percent of world fisheries catches while representing less than 3 percent of the ocean's surface. Coastal upwellings are induced by winds that cause the movement of cold deep ocean water, rich in mineral salts, to the surface. The source of high biological production, they are nevertheless subject to significant interannual and interdecadal fluctuations (Cury and Roy, 1989; Binet, 1997; Demarcq and Faure, 2000). The Canary Current sustains the highest primary production among the four global upwelling systems; however, its fisheries production is much less than in the Humboldt system (see Table 3.1).

Table 3.1 Primary production and surface occupation of the four upwelling systems in the world

	California	Humboldt	Benguela	Canary
Annual primary production (gC/m^2)	388	269	323	732
Surface (km^2)	$0.96*10^6$	$2.61*10^6$	$1.13*10^6$	$0.81*10^6$
Approximate annual mean total catch (tonnes)	1 000 000	10 000 000	1 500 000	2 000 000

Source: Adapted from Longhurst *et al*., 1995.

These ecosystems are undergoing the effects of climatic change and those of the reorganization of world fisheries, which may lead to significant modifications in their own organization. The management of these ecosystems must be conceived within the wider framework of coastal development in bordering areas. In the Canary Current upwelling system, for example, there is a need to know the frequency of climatic systems variability, acknowledging the significant degrees by which small pelagics fluctuate in this area.

Coastal upwelling along the eastern boundary of the North Atlantic subtropical gyre follows the north–south migration of the atmospheric pressure systems, occurring only in summer at the northern extreme, all year (although more intense in summer) in its central portion, and only in winter south of Cape Blanc (Wooster, Bakun and McLain, 1976 cited by Aristegui *et al*, 2009).

Along most of the Moroccan coast, the subregional upwelling is year round and strongest in late summer (Wooster, Bakun and McLain, 1976; Orbi *et al*., 1998; Makaoui *et al*., 2005). The

oceanography over the Mauritanian shelf (water depths < 200 m) represents a dynamic balance between flow from the north and flow from the south, largely controlled by atmospheric variability (Mittelstaedt, 1991; Hagen, 2001) with the seasonal strengthening of the Azores High and associated north–northeast winds. The trade winds thus intensify south of 20°N in spring and north of 26°N during summer. Between 20 and 26°N (Cape Blanc to Cape Bojador), a strong alongshore wind blows all year round. As a result, the offshore Ekman transport and associated upwelling are permanent between 20 and 26°N, and seasonal during winter and summer south of 20°N and north of 26°N, respectively.

Fisheries and aquaculture in Morocco

Introduction

Morocco, located in the northwest of Africa, has a coastline 3 000 km long in the Atlantic Ocean and 500 km long in the Mediterranean Sea. It has different influences: the Atlantic Ocean, the Mediterranean Sea, the Sahara region, and the Atlas Mountain range. During the last decade, the climate in Morocco has experienced a clear change; it is arid to semi-arid in the majority of the country. It is governed by the North Atlantic Oscillation (NAO). It can be divided into three major subareas (Figure 3.1).

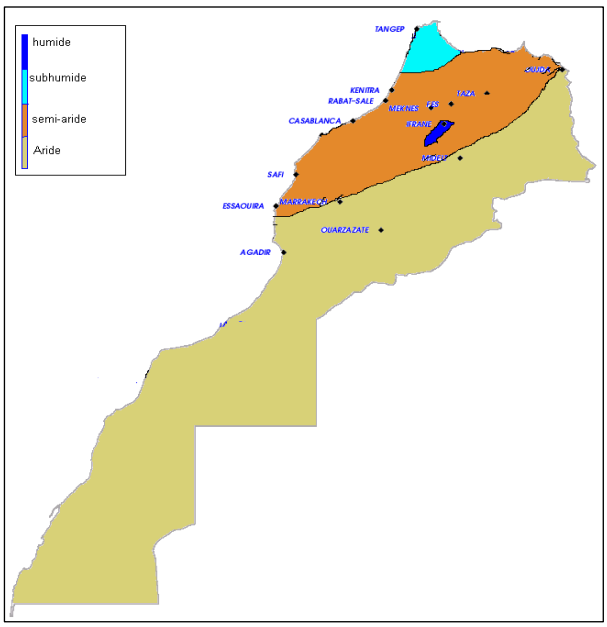

Figure 3.1 Climate in Morocco, 1986–2005

Source: Direction de la Meteorologie Nationale (DMN), Morocco.

Among the major climate change impacts are a reduction in water resources, a reduction in agricultural yields, and a rise in sea levels.

Fisheries sector

Marine fisheries include the following activities:

- High sea fisheries are practised for cephalopods and crustaceans fisheries mainly for frozen products, with vessels of more than 300 Gross Register Tonnage (GRT).
- Coastal fisheries, an activity undertaken by a coastal fleet, are composed of coastal sea bottom trawlers and purse seining and wooden lining vessels.
- Artisanal fisheries use boats of less than 2 GRT for fresh fishing.
- Coastal activities also involve fishing for algae, corals, shellfishes and echinoderms.
- Almadraba tuna is a practised for tuna fishing (mainly bluefin tuna).

- Industrial fisheries involve preserved and semi-preserved food, inland freezing, conditioning food-preserving industries of fresh fish, fishmeal, fish oil and marine algae processing.

The main fish stock resources exploited by the national fleet are pelagic species. Small pelagics fished consist of: sardine (S*ardina pilchardus*), sardinella, mackerel, chub mackerel (*Scomber japonicus*), and anchovy (Figure 3.2). Large pelagics include: bluefin tuna, melva, bonito and swordfish. Small pelagic production represents 70–80 percent, with sardines dominating the catches. However, the contribution of the pelagic production is only 20 percent of the total production value (Figure 3.3). Demersal species are composed of crustaceans, cephalopods, white fish and shellfish.

Seven percent of catches comes from the Mediterranean, 9 percent from the North Atlantic, 30 percent from the central part of the Atlantic, and 55 percent from the South Atlantic (Département des Pèches Maritimes [DPM], 2009).

In 2009, approximately 36 percent of fish products from coastal and artisanal fisheries were used for local consumption, 11 percent for canning, 24 percent for freezing, 27 percent for fishmeal and fish oil industries, 1 percent for salting and 0.6 percent for bait (2008 and 2009 statistics from the Office National des Pêches [ONP]).

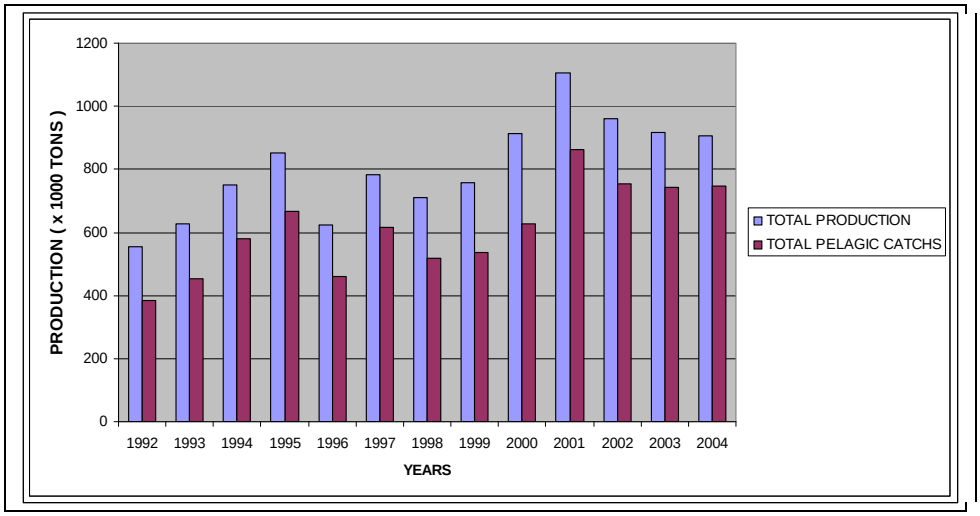

Figure 3.2 Total catch and pelagic catch contribution, Morocco
Source: ONP, various years.

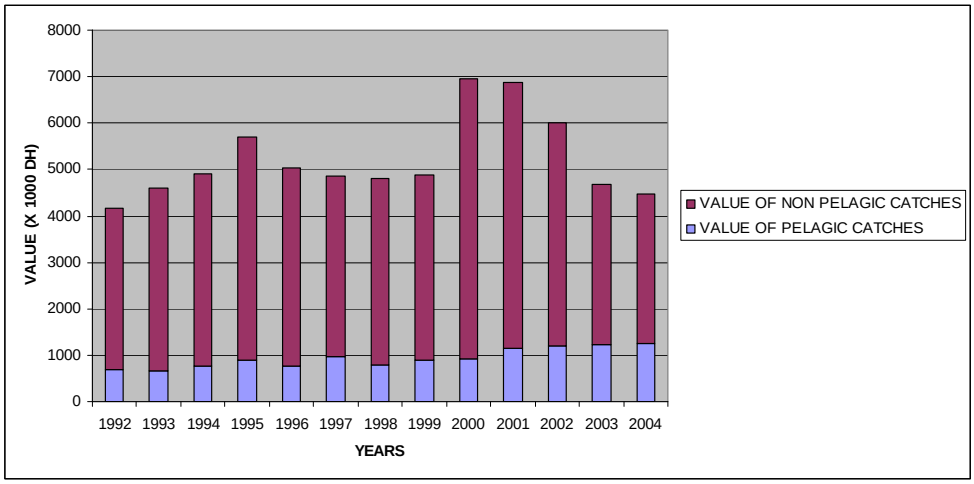

Figure 3.3 Fisheries production value and pelagic contribution value, Morocco
Source: ONP, various years.

Aquaculture subsectors

Marine aquaculture began about 50 years ago when oysters were first bred in the Atlantic Oualidia Lagoon, south of Casablanca, producing approximately 200 tonnes. The first intensive sea fish breeding trials were undertaken in the 1980s on Mediterranean sites suitable for this kind of aquaculture.

Inland aquaculture began in 1924 with the establishment of the fish farming station at the Middle Atlas Lakes. The original purpose of the facility was to promote angling as a sport, by breeding and releasing fingerlings with a high nutritional and economic value, particularly into the Middle Atlas Lakes and various dams and impoundments. After the 1980s, following communities of professional fishers that had settled in these environments, the government redirected its work towards fish breeding for food production using intensive systems, in natural and artificial ponds.

Private enterprise took off rapidly after the 1990s, with the guaranteed support of Morocco's High Commissioner for Water, Forests and Combating Desertification (HCEFLD). A few private aquaculture units are still in operation today and continue to raise eels, trout, common carp and Nile tilapia. Total aquaculture production from 1990 to 2007 did not exceed 2 500 tonnes per year (Figure 3.4).

In 2004, aquaculture production in Morocco was 1 690 tonnes, which only accounted for 0.19 percent of total national fish production. Marine aquaculture output was 788 tonnes, or 47 percent of aggregate national aquaculture production, mainly of European seabass and gilthead seabream, which accounted for 91 percent of total production. These two species were intensively farmed in floating cages in the lagoons, and in open water.

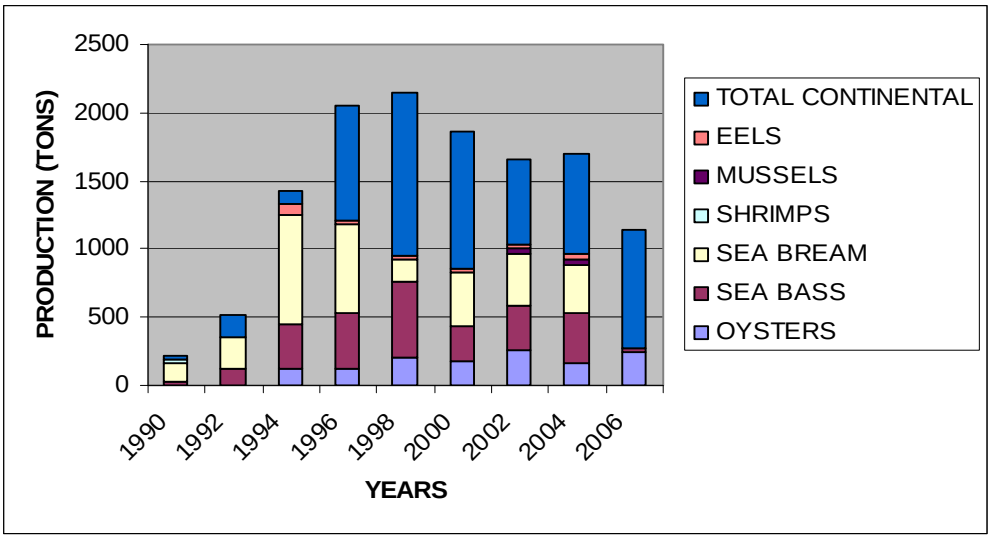

Figure 3.4 Aquaculture production in Morocco

Source: Département des *Pêches* Maritimes, various years.

In 2002, reported domestic aquaculture production was 1 670 tonnes. Seabream accounted for about 22.6 percent, seabass 19.5 percent and cupped oysters 15.2 percent. The production of these three species has remained stable over the past few years.

However, carp production (common carp, grass carp, and silver carp) has fallen by 65 percent below 1999 levels, when production reached 1 400 tonnes. Rainbow trout production is less than 100 tonnes/year. However, 2002 was a good year for Mediterranean mussel production, a commodity that has become increasingly important in recent years.

Importance of the fisheries sector to the economy
The contribution of fisheries to the economy is 2–3 percent of GDP. The sector provides 170 000 direct jobs (1.5 percent of the active population) and 490 000 indirect jobs (source of income for 3 million people). It generated Dh16.3 billion in turnover in 2007 (of which 70 percent was export sales), and 1 million tonnes are produced per year. Morocco has 22 fishing ports, and there are 22 managed landing points. The fishing fleet consists of 344 high seas vessels and 1 835 coastal vessels. The artisanal fleet is composed of 14 225 boats.

After September 2009, Halieutis was adopted by the Government as a new strategy for the fisheries and aquaculture sectors in Morocco. This strategy considers that the fish resource is a sustainable and natural heritage and that aquaculture is a strong growth driver. Fishing ports should be structured and equipped. Inland valorization of catches should be initiated. A controlled flow should be carried out throughout the value chain.

An integrated sectoral approach is suggested to reach competitiveness, sustainability and performance. The strategy is to:

- build and share scientific knowledge;
- develop fisheries on the basis of quota;
- adopt and modernize the fishing effort;
- develop aquaculture;
- dedicate port areas to fishing and effective management;
- enhance the attractiveness of the fish markets;
- structure and revitalize the market around the wholesale markets and retail;
- develop infrastructure and equipment for landing;
- support guidance on industrial growth markets;
- facilitate access to industrial raw materials;
- create three clusters in the north, centre and south.

Tools for the implementation of these objectives are:

- National Committee for Fisheries;
- National Agency for Development Aquaculture;
- Valorization Center of Fishery Products;
- Employment Observatory of the Fisheries Sector.

Generally speaking, aquaculture makes a negligible contribution to Morocco’s national economy.

Fisheries and aquaculture in Mauritania

Introduction
Mauritania is a vast country of the Sahel located between 15°N and 27°N, covering 1 030 700 km^2. Its coast of about 800 km has a rich biodiversity, Arguin Banc serving as an example of a biological reserve. Mauritania has very little aquaculture activity.

The climate of Mauritania is governed by three influences:

- The Azores anticyclone centred over the southwest of the Azores archipelago; the sea breeze from this anticyclone blows permanently onto the north and the northwest coast of Mauritania.
- The Saint Helena anticyclone or monsoon centred on the South Atlantic; it blows from the south or southwest. It is responsible for summer rainfall.

- Anticyclonic cells that settle on the Sahara in winter and migrate north in summer to give birth to the Saharian depression. The Harmattan derived from these anticyclonic cells is cool and dry during the winter and hot and dry in summer.

Taking into account the rainfall and its distribution during the year, Mauritania can be divided into three subclimatic regions:

- In the extreme south, a tropical dry climate (Sahel–Sudan type) characterized by eight dry months (rainfall greater than or equal to 400 mm).
- In the centre, a semi-desert climate (Sahel–Saharan type) characterized by a high temperature range and rainfall between 200 and 400 mm.
- In the north, a climate like the Sahara characterized by lower rainfall. More than 75 percent of the country is desert.

There are four ecological zones: the arid zone, the Sahel (the Sahelian zone covers a strip of 200 km in the south), the Senegal River area (where the potentially largest forest is located on 3 percent of the total area) and the coast (Figure 3.5). According to FAO, the arid climate zone has increased: the 150 mm isohyets have come to settle about the location of the 250 mm isohyets, an expansion of an additional 150 000 km² of desert.

Figure 3.5 Climate in Mauritania

Surface waters are mainly from the Senegal River and its tributaries: the Karakoro River and the Gorgol River. The country has significant groundwater resources: some of the most important aquifers are located in desert areas far from urban centres and potable water remains a crucial problem. Nouakchott is particularly affected by the shortage of drinking-water.

Fisheries sector

Fisheries in Mauritania are synonymous with marine fisheries. The continental and river segment remains very marginal and is confined to the local market. Aquaculture does not exist, with the exception of some experiments that have been undertaken with limited range related to tilapia in the south of the river and oysters in Lévrier Bay. Industrial fisheries account for 90 percent of catch, of which a great part is not actually landed in Mauritania (fishing agreement and free fishing licences of the pelagic species). The landing in Mauritania is about 120 000 tonnes coming from artisanal fisheries (fresh fish), and 20 000 tonnes of fish from industrial fisheries is generally frozen or under ice (Figure 3.6).

More than 72 species of economic value are caught in Mauritania. The main species are:

- cephalopods (octopus, squid, cuttlefish);
- crustaceans (green lobster, pink lobster, tiger shrimp, king prawn, crab, sea urchin);
- demersal fish (hake, sea bream, sole);
- small pelagic species (sardinella, sardines, chub mackerel, mackerel, pelagic squid);
- tunas (swordfish, yellowfin tuna);
- oysters and hardshell clams.

Almost all of the landings in Mauritania are made up of noble species such as cephalopods, black drum, sea bream and sole. The amount landed in Mauritania is mainly made up of: 25 297 tonnes of frozen cephalopods; 7 915 tonnes of frozen demersal fish; 5 073 tonnes of frozen pelagics; 1 101 tonnes of frozen shellfish; 80 000 tonnes of fresh fish and cephalopods.

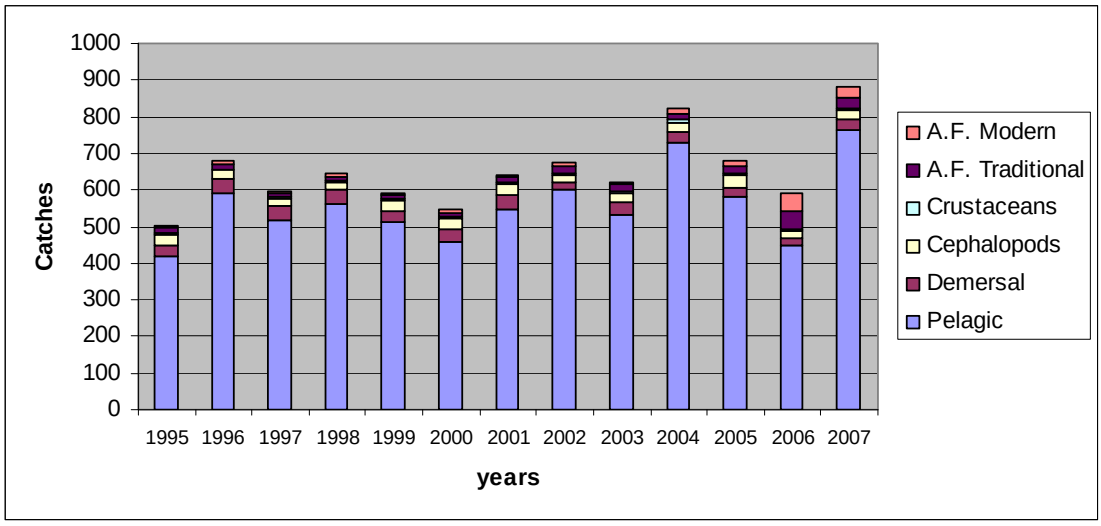

Figure 3.6 Fisheries production in Mauritania

The fishing resources in Mauritania are very diverse and are made up of continental, river and marine resources, which compose the main part of the resources. The main species by type are highlighted in Table 3.2.

Table 3.2 Main fishing resources

Main demersal species	Main pelagic species	Main continental/river species
Cephalopods	Small pelagics	Tilapia
Finfish	Tuna and similar	Danton
Shellfish		Mullet
Hardshell clams		Sardines

In addition, Mauritania has an important stock of algae, which remains unknown and unexploited. The stock of the hardshell clams is currently under evaluation and experimentation for exploitation purposes. The new estimates would be three times more important than what was estimated in the 2003 evaluation.

Aquaculture subsector
There is no aquaculture activity in Mauritania.

Importance of fisheries to the economy
The contribution of fisheries to the economy of Mauritania (including the fisheries agreement between Mauritania and the EU) accounts for 6–10 percent of GDP; it provides 25–30 percent of revenue to

the State budget and generates approximately 30 000 jobs (at sea and inshore), or 36 percent of modern sector employment in the country (strategy for sector development). The overall volume of exports has been declining for several years and many high-value species are in a state of overexploitation (e.g. octopus and shrimp). The incursions of illegal fleets in prohibited areas, the use of prohibited or insufficiently selective fishing gear, intensified competition between artisanal fisheries (increased capture from about 21 000 tonnes in 1995 to 35 000 tonnes in 2005) and industrial fisheries not only threaten the marine environment but also the industry itself and, thus, the livelihoods of those working there.

Mauritania adopted a new strategy for fisheries for 2006–08, with a clear strategic objective of combining the optimization of the sector within the nation's economy with a sustainable management of the resources and a safeguarding of maritime environment (e.g. risks related to industrial activities in port areas, with maritime transport, and oil exploitation offshore).

The choice of the four strategic issues around which the strategy is articulated demonstrates a solid comprehension of the existing links between economic issues and environmental sector. These issues relate to:

- improvement of governance in fishing;
- improvement of the littoral and environmental governance;
- acceleration of the process of integration of the fisheries sector in the nation's economy;
- capacity building of governance in the sector.

The project of the maritime environment code worked out in 2006 is focused on prevention and mitigation against the various types of marine pollutions and takes into account risks relating to hydrocarbon accidents through the preparation and the actualization of the POLMAR plan (emergency national plan in the event of accidental pollution by hydrocarbons).

Understanding of possible climate-change impacts in the subregion

The vulnerability of fishery- and aquaculture-dependent communities and regions to climate change is complex, reflecting a combination of three key factors: (i) the exposure of a particular system to climate change; (ii) the degree of sensitivity to climate impacts; (iii) the adaptive capacity of the group or society experiencing those impacts.

Vulnerability varies greatly across production systems, households, communities, nations and regions. Developing policies and strategies to address climate-change impacts on fisheries and aquaculture depends on identifying vulnerable places and people and understanding what drives their vulnerability. This requires vulnerability assessments at multiple scales and taking into account multiple interacting drivers.

Acoustic surveys have been conducted each year since 1995 on board of the research vessel *Dr Fridtjof Nansen* during the recruitment period. Between 1996 and 1997, the stock decreased by one order of magnitude (Figure 3.7) from more than 5 million tonnes of sardines to less than 0.5 million tonnes (Strømme *et al*., 2004, 2008). The winters of 1995 and 1996 were characterized by a negative NAO index gradient between Iceland and the Azores associated to a weakening of their centre of pressure, which resulted in a less intensive upwelling activity (Benazzouz *et al*., 2006).

Results obtained by Machu *et al*., (2009) show that variability in the sardine stock is partly controlled by the environment via the plankton communities together with the volume of the spawning ground, which fluctuates at seasonal and interannual time scales.

However, other experiments show that sea surface temperature (SST) records from Moroccan sediment cores, extending back 2 500 years, reveal anomalous and unprecedented cooling during the

twentieth century, which is consistent with increased upwelling (McGregor *et al.*, 2007). The evolution of SST from 1995 to 2000 is demonstrated in Figure 3.7.

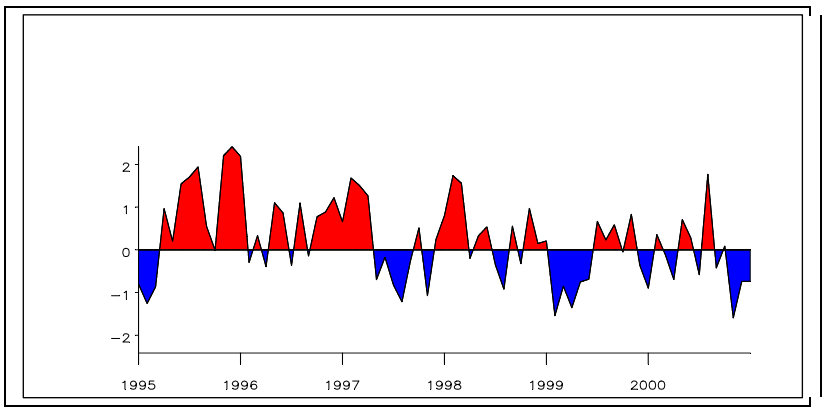

Figure 3.7 Evolution of sea surface temperature anomaly off Cape Blanc (20 °50'N, 17 °30W), 1995–2000

Upwelling off northwest Africa may continue to intensify as global warming and atmospheric CO_2 levels increase. During the past ten years, three major events occurred south of the Moroccan coast (26 °N–21 °N) which are generally accepted (by scientists and policy-makers) to be related to the impacts of climate change (Figure 3.8):

- sardine stock collapse as a natural event (1997);
- sardinella migrating to the north;
- important decline in sardine stock in 2006 (fish with lesions common in 2005).

Biomass estimates of sardines between 16 °N and 29 °N from acoustic surveys by the *Dr Fridtjof Nansen* during November 1995–2003 indicate that there was a biomass decrease in 1997. From acoustic abundance estimation by latitudes from 1995 to 2003 (Figure 3.9), it is apparent that in 1997 there was a decrease in the biomass abundance.

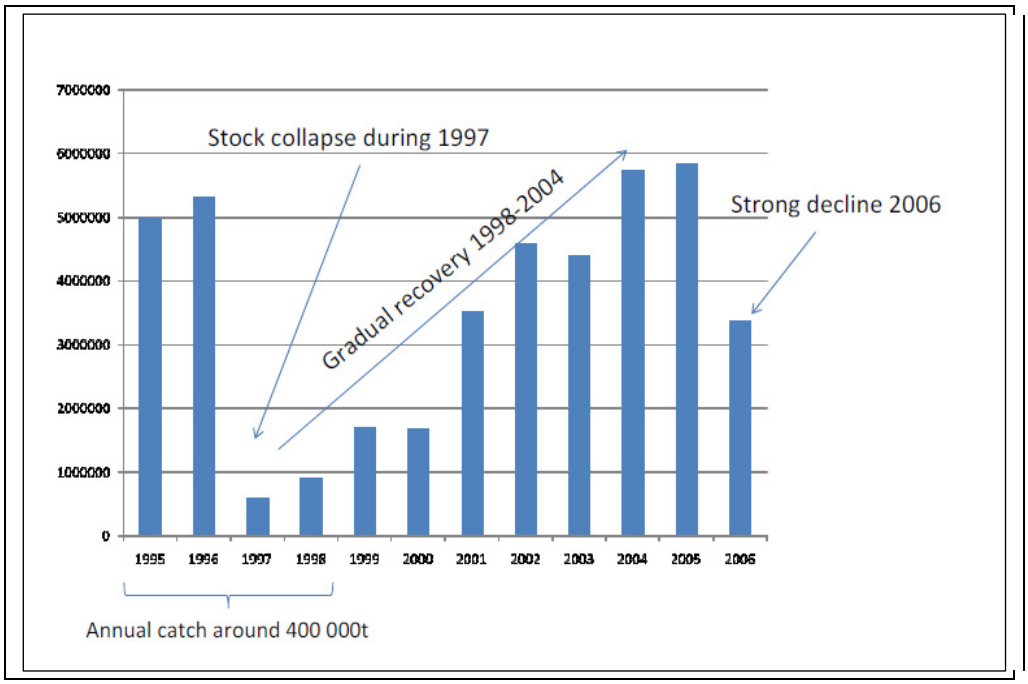

Figure 3.8 Biomass estimation of sardine stock by *Dr. Fridtjof Nansen*
Source: Strømme *et al.*, 2008.

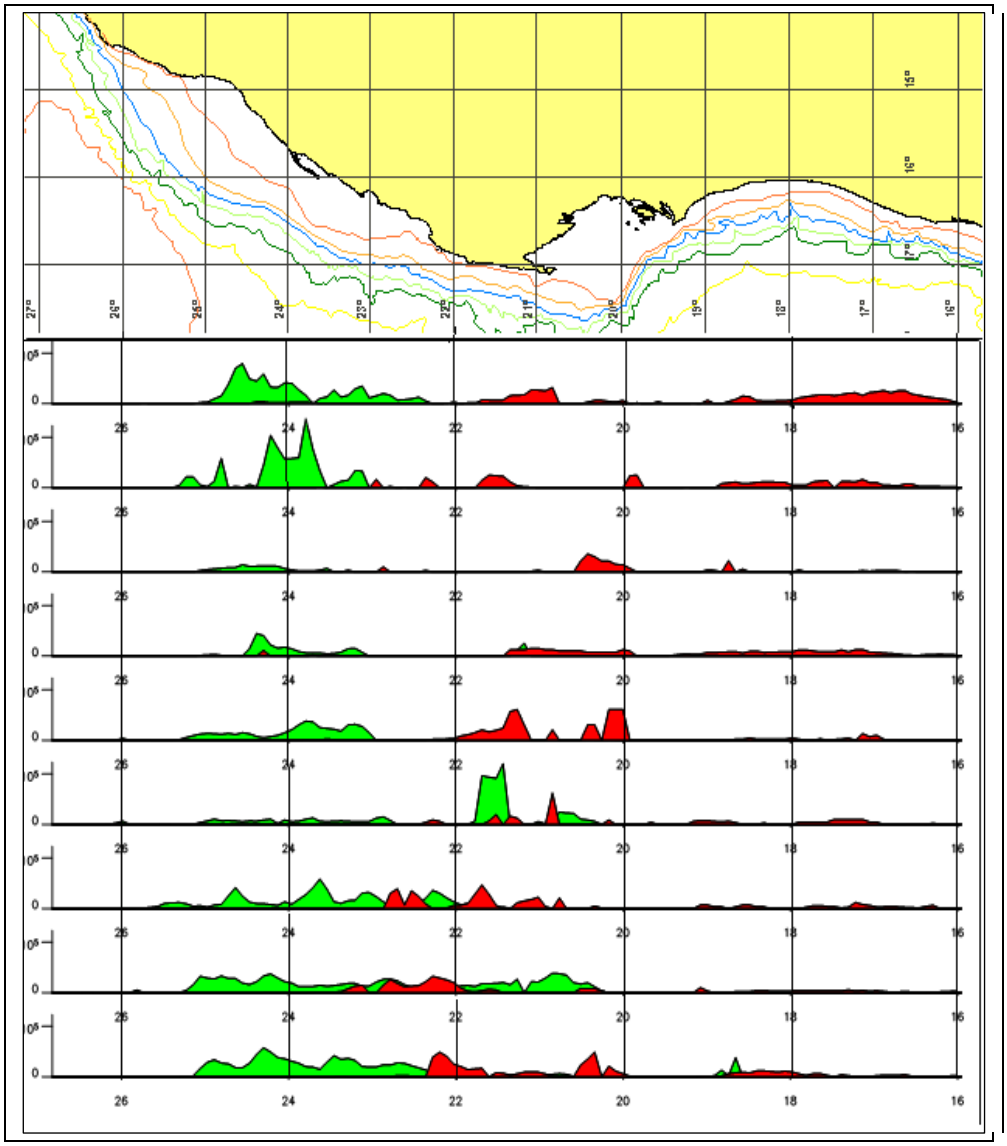

Figure 3.9 Biomass estimation of sardines by *Dr Fridtjof Nansen*
Source: M. Ostrowski, personal communication.

A third event found during the 2005 acoustic survey were some fish with common lesions. Neither bacteria nor viruses were responsible for these lesions. To date, scientists have not solved the enigma of these lesions (see Figure 3.10).

Figure 3.10 Fish with lesions common in 2005

Recommendations

Morocco, in 2009, and Mauritania, in 2006, launched new strategies for their fisheries sectors based on ecological well-being and human well-being. Unlike Mauritania, Morocco integrated aquaculture as a main feature in its strategy. However, in both countries, the economy is highly vulnerable to climate change (Figure 3.11).

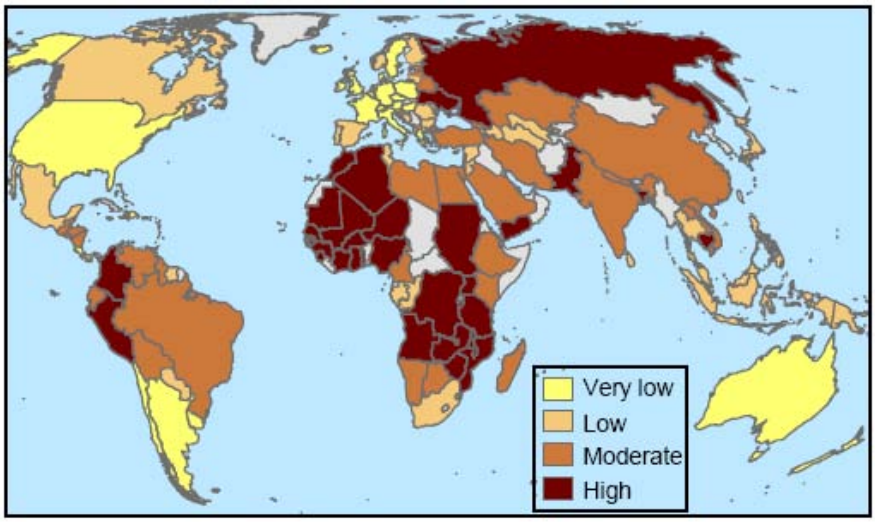

Figure 3.11 Vulnerability of national economies
Source: Allison *et al*., 2005.

It is recommended that a detailed vulnerability study be carried out, with a focus on:

- the nature and degree to which both fisheries production systems and coastal poor populations are exposed to climate change;
- the degree to which national and local economies are dependent on fisheries and, therefore, sensitive to any change in the sector.

These elements will allow both governments to measure the ability or capacity of a system to modify or change to cope with changes in actual or expected climate stress.

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3.2 The ecosystem approach to fisheries and aquaculture for the southern and eastern Mediterranean

Introduction

In the Southern and Eastern Mediterranean Sea, fisheries and aquaculture fishing have had significant effects on livelihoods, employment opportunities and foreign exchange earnings in the countries of the region. In view of overfishing, environmental degradation and anthropogenic impacts on ecosystems, it is essential that some form of effective management plan be drawn up, based on an accurate and relevant scientific approach, to provide for adequate environmental management of the region.

Moreover, the Mediterranean, especially its southern and eastern rims, is likely to be more affected by climate change than most other regions of the globe in the twenty-first century. The temperature increases in the Mediterranean are likely to be above 2 °C and, because of the ecological and socioeconomic characteristics of the areas, the impact will be more marked than in many other regions of the world. The Mediterranean has thus been qualified as a "hot spot for climate change" (Giorgi, 2002). The most vulnerable areas of the Mediterranean are the North African ones bordering desert areas, the major deltas (e.g. the Nile Delta), the coastal zones, as well as socially vulnerable areas and those with rapid demographic growth (IPCC, 2007).

The impacts of the rise in temperature, drop in rainfall, increase in number and intensity of extreme events, as well as a possible rise in sea level, could thus overlap and exacerbate the pressures caused by anthropogenic activities that are already exerted on the natural environment. Through the crucial issue of the scarcity of water resources, the impacts of climate change are fraught with consequences for the fishery and aquaculture subsectors in the twenty-first century, particularly in terms of production and water quantity and quality. In order to minimize the economic losses and damage as much as possible, several adaptation options must be thought out and implemented.

This paper provides a review of the fisheries and aquaculture subsectors in six countries from the southern and eastern Mediterranean. It explains the major trends in these subsectors, highlights their importance to the national economies, and emphasizes the need for a management framework in a context of climate change.

Description of the subregion

The subregion from Algeria to the Syrian Arab Republic is located on the southern and eastern sides of the Mediterranean (Figure 3.12) and is surrounded by Europe to the north, Africa to the south, and Asia to the east. It is about 5.5 million km^2; the coastline extent is about 7 400 km and the continental shelf area is about 230 000 km^2.

In general, the region is under the influence of the Mediterranean climate, characterized by mild wet winters and warm to hot, dry summers. Because of its latitude, the Mediterranean Sea is located in a transitional zone where both mid-latitude and tropical variability are important and compete against each other.

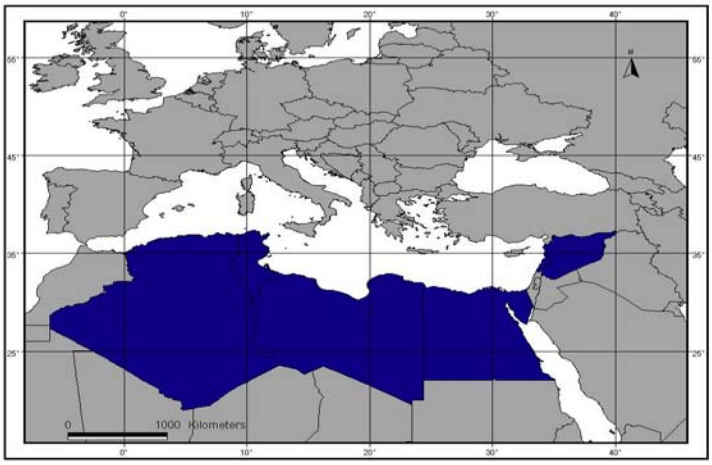

Figure 3.12 Study area, comprising six countries from the southern and eastern Mediterranean

The southern and eastern Mediterranean Sea is characterized by limited water productivity owing to its low nutrient concentrations. However, it hosts one of the richest biodiversities in the world. The freshwater resources are under increasing pressure in terms of both quantity and quality. This is particularly the case for five out of the six countries in the subregion, with the exception of Egypt, where the Nile River supplies the country with important water quantities. The subregion is characterized by the emergence of highly populated societies. Because of the demographic pressure and exploitation of land for agriculture, the subregion presents important anthropogenic effects on the environment. Currently, approximately 140 million people live in these countries. For most of the countries, urbanization is an ongoing process that is changing the socio-economic structures of this region. All these trends are likely to produce contrasts and conflicts in a condition of limited available resources.

Resources and production

Marine fisheries

The fishing activity throughout the southern and eastern Mediterranean has a long tradition. It is characterized today by the dominance of an artisanal (coastal) sector, a timid growing of an industrial sector, and by a large dispersion of fishing and marketing along the coast. The fisheries of the subregion are based on relatively poor resources and often exploited by individuals with low-cost vessels and simple gear. In certain localities of the subregion, fisheries provide an important source of employment and income.

According to the data compiled by FAO on the basis of reports from national authorities and other sources (e.g. regional fishery organizations), Mediterranean fisheries capture production experienced a sharp increase from the 1950s onwards, with a relative stabilization since the 1990s (Figure 3.13). Recent statistics from 2007 show that capture production was about 350 000 tonnes. Algeria, Tunisia and Egypt were the top producing countries (Figure 3.14).

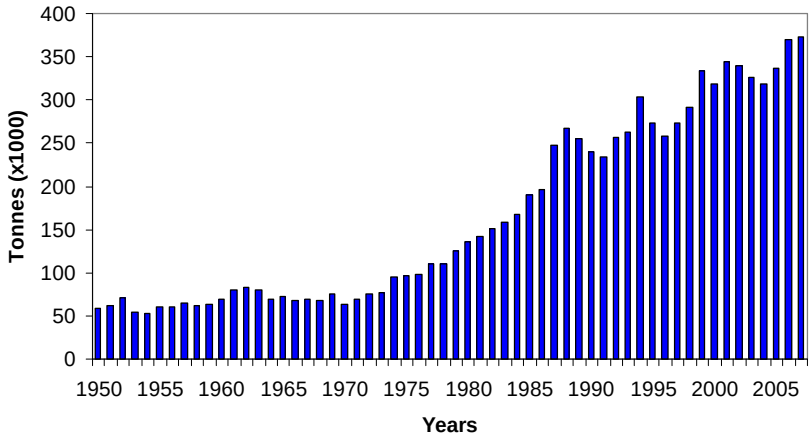

Figure 3.13 Subregional marine capture production

In most countries throughout the region, it is difficult to estimate the state of the stocks because of the absence of surveys to monitor fishing effort. Only inferences based on catch trends are possible. It can reasonably be assumed that, if catches have shown limited increase, it is because of overfishing rather than reductions in the fishing effort. On the whole, it seems unlikely that any underexploited stocks have been left in the region, although some small pelagic stocks can increase suddenly from time to time, possibly owing to temporary environmental conditions. Relatively rich trawling grounds are found in the Gulf of Gabés in Tunisia, the Gulf of Sirte in the Libyan Arab Jamahiriya and off the Nile Delta in Egypt.

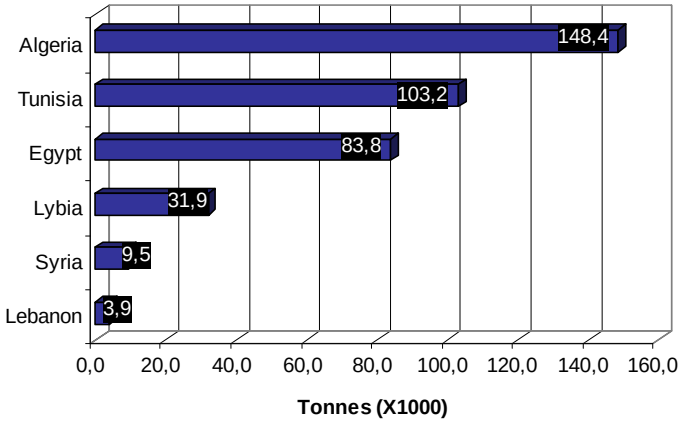

Figure 3.14 Marine capture fisheries: countries production in 2007

Inland fisheries

The present status of inland capture fisheries gives an estimated production of 249 000 tonnes in 2007, while it reached 320 000 tonnes in 2002 (Figure 3.15). Egypt, with about 8 716 km^2 of inland waters, including rivers, lakes, reservoirs and brackish-water lagoons, is the main producing country, representing on average more than 97 percent of the total inland capture production in the subregion. The most economically important species are tilapia species, usually caught by trammel, cast and gillnets.

Figure 3.15 Subregional inland capture production

Aquaculture

There are some similarities between the subregion countries concerning the farmed species and the farming techniques. However, there are significant differences in aquaculture quantities produced by countries. Egypt is the only country that has developed substantial aquaculture activities. Since the end of the 1990s, aquaculture production has substantially increased, with an annual growth rate of about 16 percent (Figure 3.16). Recent statistics from 2007 indicate an aquaculture production of about 650 000 tonnes. Egypt remains by far the largest producer, representing on average more than 97 percent of the total production of the subregion, based almost exclusively on inland aquaculture.

In Egypt, aquaculture is currently the largest single source of fish supply accounting for almost 63 percent of the total fish production of the country with over 98 percent produced from privately owned farms. The majority of fish farms in Egypt can be classified as semi-intensive, brackish-water pond farms. This type of farming suffered a dramatic reduction in numbers during the early 1990s as a result of the competition for land and water from the expansion of land reclamation activities for agriculture. Intensive aquaculture, in earthen ponds, is now developing rapidly to overcome the reduction in the total area available for aquaculture activity. Warm-water freshwater species represent the majority of aquaculture production in Egypt (Figure 3.17) and are almost totally consumed domestically. Production has steadily increased and today contributes significantly to national food security and limits the import of fish. The main constraint for this activity is the limited availability of freshwater (conflicts with agriculture and requirements for domestic water consumption). In order to overcome these constraints, the country is trying to increase the stocking density in this form of fish rearing.

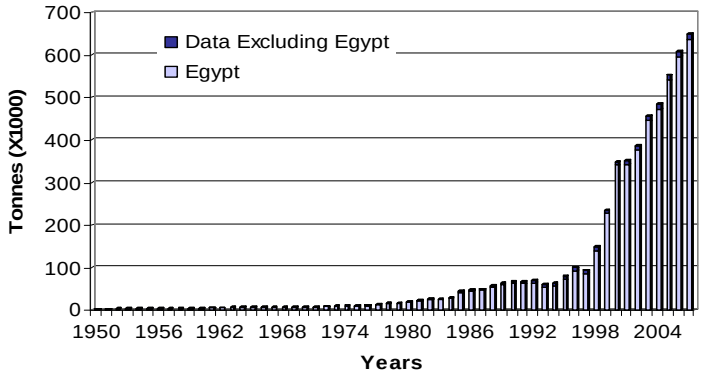

Figure 3.16 Subregional aquaculture production

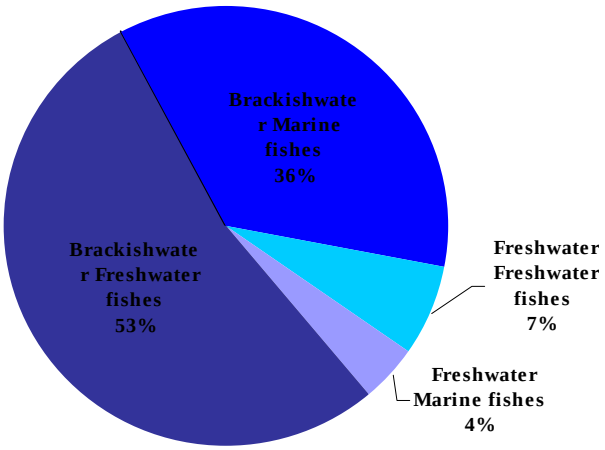

Figure 3.17 Egyptian aquaculture production by species category, 2007

In Tunisia, despite the substantial potential that has been identified (20 000 tonnes/year), aquaculture is not being developing as expected by the public authorities. Current production levels are about 3 400 tonnes, accounting for almost 3 percent of Tunisia's total fish production. Both marine and inland species are currently being farmed. Inland aquaculture produces an annual average of 500 tonnes of freshwater fish. In marine aquaculture, the European seabass and the gilthead seabream are produced.

In Algeria, aquaculture production, estimated at 405 tonnes in 2007, is essentially derived from inland fisheries. It consists mainly of freshwater species (common carp and Chinese carp) that have begun to find a market in areas where they are produced. In order to develop integrated aquaculture with agriculture in the Sahara, the authorities have experimented with broodstock and fingerlings of Nile tilapia, which has been very encouraging.

Aquaculture was initiated in the Libyan Arab Jamahiriya by culturing a variety of freshwater fish species. Owing to the limited resources of freshwater, dams and small lakes have been used for the semi-intensive culture of several species of carps imported from China (common, grass, bighead and silver carps) and catfish. Farming experiments have been successful, with good growth rates obtained for most species. Nile tilapia was introduced in the early 1990s. This species, well accepted on the local market, showed a rapid increase in production, utilizing water from agriculture irrigation channels. Mariculture began in the early 1990s with the development of the culture of the European seabass, gilthead seabream and mullet, raising the overall total production to 240 tonnes in 2007.

Syrian aquaculture is practised exclusively in freshwater. Specifically, it concerns warm freshwater fish culture. The main freshwater fish produced commercially are common carp and tilapias. The prevailing production systems are pond culture, cage culture and culture-based fishery in barrages. Aquaculture accounts for 47 percent of total fish production (8 425 tonnes out of a total of 17 881 tonnes in 2007), at an estimated value of USD24 million.

Total fish production

Since the mid-1990s, capture fisheries and aquaculture have supplied the subregion with more than 500 000 tonnes of fish per year (Figure 3.18). In 2007, the subregion's fisheries and aquaculture production reached 1 300 000 tonnes, with aquaculture accounting for 49 percent of this total. This is in line with the world trend, with aquaculture accounting for 47 percent (FAO, 2008) of food fish in 2006.

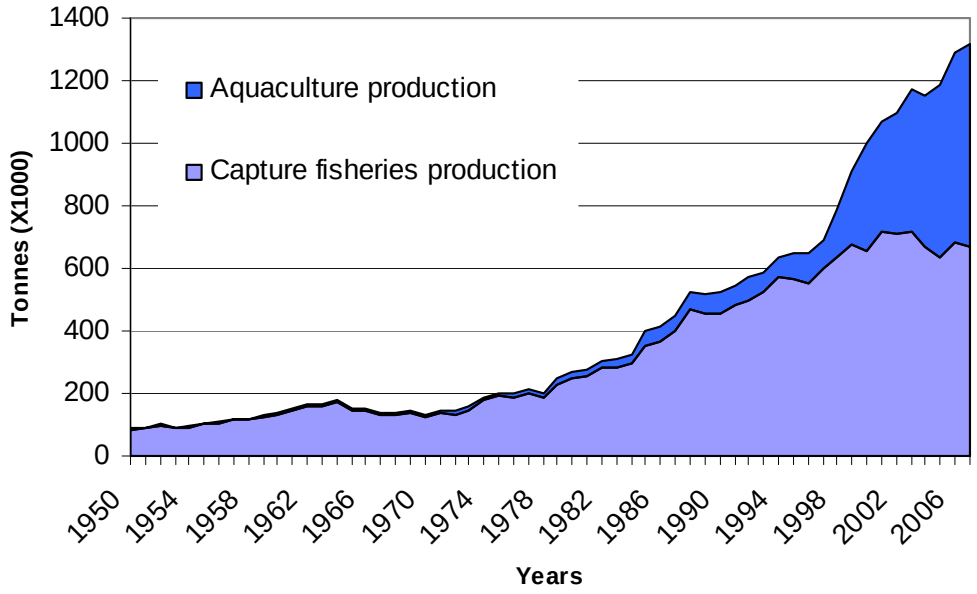

Figure 3.18 Total fish production for the southern and eastern Mediterranean subregion

Utilization and trade

Fish consumption

Fish and seafood consumption varies widely among the countries and remains relatively low by world standards (Figure 3.19). Egypt remains by far the largest consumer, and since the 1990s has accounted for more than 600 000 tonnes of fish and seafood production used for direct human consumption. An increase in demand could be met from higher aquaculture landings of fish. Factors contributing to increased consumption in some countries like Tunisia and Lebanon include economic expansion and development of tourism, while demographic expansion in Egypt, Algeria and the Libyan Arab Jamahiriya could explain the increase in consumption.

Table 3.3 Fish and fishery products apparent consumption, average 2003–2005

Country	Production	Non-food uses	Imports	Exports	Food supply	Population	Per capita supply
	(tonnes in live weight)					(thousands)	(kg/year)
Algeria	127 540	21	26 395	2 349	151 566	32 368	4.7
Egypt	876 733	188	253 262	5 996	1 123 851	71 556	15.7
Lebanon	4 648	9	27 017	246	31 410	3 965	7.9
Libyan Arab Jamahiriya	46 467	0	11 748	3 275	54 964	58 000	9.5
Syrian Arab Republic	16 773	0	26 763	128	43 407	18 392	2.4
Tunisia	106 064	3	36 153	18 935	123 280	9 996	12.3

The average per capita supply in the subregion is only 8.75 kg annually; the Syrian Arab Republic and Algeria rank lowest in this regard (Table 3.3). Egypt, which has the highest per capita food fish supply in the subregion, remains below the world average value, established since 2002 at about 16 kg/year (FAO, 2008).

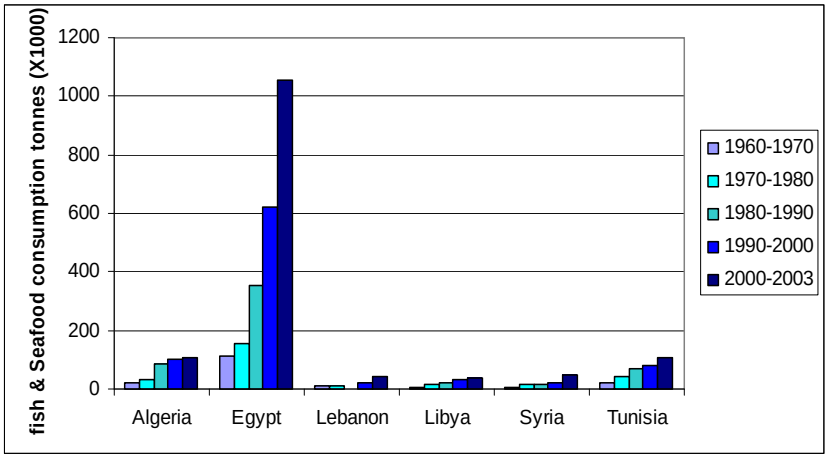

Figure 3.19 Average decennial fish and seafood consumption by country

Fish trade

In 2007, aquaculture and fisheries production in the subregion provided approximately 1 300 000 tonnes representing 44 percent of the total production by Mediterranean countries. Aquaculture produced more than 600 000 tonnes at an estimated value of USD1 239 million. The creation of wealth for the fisheries and aquaculture sector, and hence its contribution to national GDP, is difficult to ascertain. Where one has such information, this is generally close to 1 percent (e.g. Egypt, 1.7 percent; Tunisia, 1.2 percent).

In general, the subregion does not contribute substantially to international fish trade, although some countries, such as Tunisia, are major exporters of high-value fish, some cephalopods and crustaceans to European markets and Japan. The exports of fish and fishery products in the region reached USD185.6 million in 2006 (Figure 3.20), representing 0.2 percent of world exports. Tunisia alone accounted for 86.4 percent of the exports by the subregion.

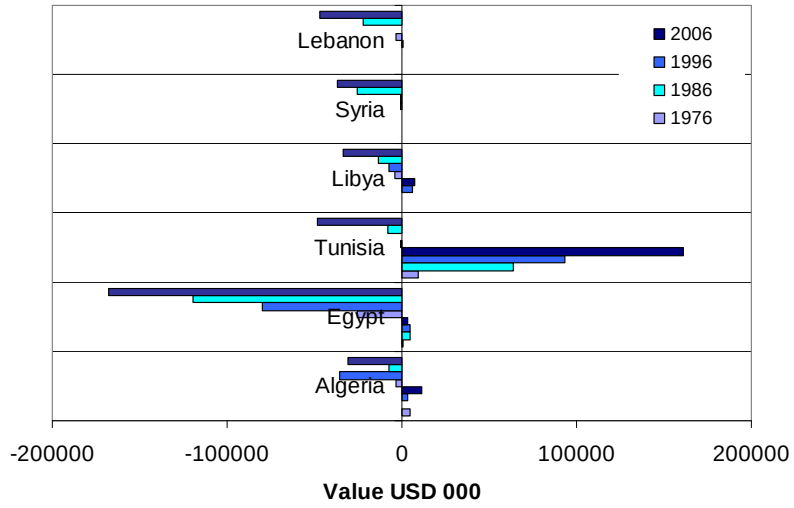

Figure 3.20 Fishery imports and exports, by country

Employment

Fisheries and aquaculture, directly or indirectly, play an essential role in the livelihoods of thousands of people in the region. In the period 2000–2005, an estimated 450 000 people were directly engaged, part-time or full time, in primary production of fish either in capture from the wild or in aquaculture. The contribution of fisheries to the workforce in the region could not be assessed. The data that are

available revealed that the ratio of the number of fishers to the workforce is generally less than or equal to 1 percent, with an average of 0.9 percent in Member Countries of North Africa (e.g. Tunisia 1.05 percent).

Management

Ecosystem approach to fisheries

The fisheries and aquaculture sector provides significant incomes to the countries of the subregion in terms of food supply, employment opportunities and livelihood benefits for millions of people. In addition, the export of fisheries products represents an important source of foreign exchange earnings, contributing to national GDP. However, throughout this subregion, fisheries are threatened by overfishing, environmental degradation, anthropogenic ecosystem impacts in the form of species introductions, pollution and habitat fragmentation. There have been profound changes in land use of the coastal areas. Urban expansion is one of the most significant of such changes. In addition, the modernization and intensification of agriculture and the damming and modification of rivers flowing into the sea are having profound consequences for the system.

There is broad agreement at the international policy level that the EAF (FAO, 2003) is the appropriate and necessary framework for fisheries management, which flows from and is consistent with the Code (FAO, 2001). The EAF is defined as an approach that "strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries". It addresses both human and ecological well-being and merges two paradigms – that of protecting and conserving ecosystems and that of fisheries management, which focuses on providing food, income and livelihoods in a sustainable manner.

Most of the countries of the subregion have enacted management measures to control fishing, mainly aimed at protecting and conserving fisheries resources, including legislation, licensing of fishing vessels and regulating the characteristics and use of fishing gear. Some of them, e.g. Tunisia, are well advanced in identifying specially protected areas and/or adopting temporal closures to protect, in part, certain species during their reproductive period. An updating of the legislative frameworks is needed to improve the coherence among the countries and to reflect international agreements and instruments, including the Code (GFCM, 2005, 2007). It is also important that the legislation in these countries should incorporate implementation of the EA. It is a matter of concern that there is reported to be a low level, or even absence, of stakeholder involvement and consultation in fisheries management in these countries, and in the Mediterranean in general (CIHEAM, 2003).

The productive fisheries in the subregion are based on inland fisheries, particularly in Egypt. Indeed, inland fisheries management requires an EA, particularly in the catchment areas of large lakes and river systems, like the Nile River. The values and benefits of inland fisheries can be increased if such fisheries are protected through more effective governance and management. There are considerable opportunities to safeguard and enhance existing inland fisheries that can provide food security for millions of people, and to realize the potential for developing underexploited stocks. It is crucial to integrate these fisheries in natural resources management plans covering all stakeholders that affect the quality or quantity of the water resources throughout the catchment basin concerned.

Ecosystem approach to aquaculture

According to production trends, aquaculture will probably exceed fisheries turnover in the medium to long term. In a country like Egypt, inland fish production has steadily increased and today contributes significantly to national food security and limits the import of fish. In order to prosper, aquaculture will have to address some serious growth and cross-cutting issues related to its impact on the environment. The main issues facing subregional inland aquaculture development include competition for freshwater and suitable sites. The limited availability of freshwater (conflicts with agriculture and requirements for domestic water consumption) leads to increases in the stocking density in this form of fish rearing. In addition, there is a lack of intersectoral development planning, especially between

agriculture and aquaculture. Countries facing these constraints are turning to fish culture in existing inland waters and coastal marine waters to avoid the use of arable land.
Marine aquaculture is facing common problems in all the countries, such as a progressive saturation of available sites (both for extensive and intensive aquaculture), high competition in coastal areas (especially with tourism development), and market saturation and restrictions (particularly due to European Union import regulations).
The implementation of an EAA, defined as "a strategy for the integration of the activity within the wider ecosystem in such a way that it promotes sustainable development, equity, and resilience of interlinked social and ecological systems", will permit the development of aquaculture, taking into account the full range of ecosystem functions and services, in the context of other sectors, policies, and goals, and improve human well-being and equity for all stakeholders.

Implementation of the EA in the subregion will require the development of institutions that can deliver such an approach, taking full account of the needs and impacts of other sectors.

Climate-change impacts

Climate change is a threat to the sustainability of capture fisheries and aquaculture development. Its impacts occur as a result of a gradual warming at the global scale and the associated physical and biological changes, as well as the consequences of the increased frequency of extreme weather events. Such changes will require adaptive measures in order to exploit opportunities and to minimize negative impacts on fisheries and aquaculture systems.

Impacts on water resources
One of the greatest potential impacts of climate change on human society is through its effect on water resources. The Mediterranean is already a region experiencing moderate to high water stresses, and climate change has the potential to exacerbate these stresses further. For the period 2031–2060, it is projected that runoff will decrease substantially in North Africa and the Near East (Arnell, 1999).

One measure of national water resource stress is the ratio of water used to water available, and countries using more than 20 percent of their total annual water supply are generally held to be exposed to water stress. Using this measure, all countries around the Mediterranean are expected to see an increase in water stress. The sole exception may be Egypt, where river runoff from the Nile River may actually increase owing to floods in the Central African Nile springs. Some countries have conducted studies to understand the impact of such changes on their countries. The Government of Algeria estimates that a 1 °C rise in mean annual temperature would lead to decreases in precipitation by 15 percent and in influx of surface waters by 30 percent. Subsequently, water demand would exceed available water resources by 800 million m^3 (Government of Algeria, 2001). The Government of Lebanon estimates that, by 2050, climate change could be responsible for nearly doubling the water shortage to 350 million m^3 of water (Khawli, 1999).

Impacts on sea-level rise
Model projections of regional sea-level patterns show very little agreement. For the Mediterranean, the values range from 1 to 2 cm of regional sea level rise per 1 cm of global sea-level rise (IPCC, 2001). This is because of the low tidal range in the Mediterranean combined with the limited potential for wetland migration. The Southern Mediterranean seems to be the most vulnerable region where flooding impacts can occur, particularly in deltaic countries (such as Egypt). Fisheries communities located in the deltas will be particularly vulnerable to sea-level rise and the associated risks of flooding, saline intrusion and coastal erosion.

Impacts on biodiversity
Climate change over the past 30 years has produced numerous shifts in the distributions and abundances of species. Increased temperatures will also affect fish physiological processes and the seasonality of particular biological processes, altering marine and freshwater food webs, with unpredictable consequences for fish production. This will result in both positive and negative effects

on fisheries and aquaculture systems in terms of production and marketing costs, and changes in the prices for fishery and aquaculture products. The impacts of climate change on the Mediterranean environment will relate particularly to marine biological diversity (animal and plant), via a displacement northwards and in altitude of certain species, extinction of less mobile or more climate-sensitive species, and emergence of new species. Fishing yields are expected to drop as a result of the accumulated conditions related to temperature, rainfall and the behaviour of animal and plant species.

The future impacts of climate change on fisheries and aquaculture are still poorly understood. The key to minimizing negative impacts and maximizing opportunities will be understanding and promoting the wide range of creative adaptive measures and their interactions with existing policy, legal and management frameworks.

Conclusions and recommendations

To diagnose the health of the resources in the Southern and Eastern Mediterranean subregion, there is a need to develop appropriate models to evaluate its potential and recommend management policies. Moreover, the lack of accurate data in the subregion, mainly in the eastern rim, has been a constraint to such approach. A special effort must be made to collect the data, to make them available to the researcher and management communities, and to improve the quality of these data in order to make any real progress in this area.

In the subregion, there is a potential for increased production from inland waters, which could be realized through improved management of existing stocks, utilization of unexploited stocks and increased exploitation of reservoirs. Expansion of culture-based fisheries and aquaculture provides a vast potential for growth in production. To realize this potential, there is a need to improve the information base for management, infrastructure, support services and training as well as prevent environmental degradation.

The subregion appears as the most threatened area in the world by climatic change. To minimize the negative impacts of such change on fisheries and aquaculture systems, adaptive measures are required although the countries have limited level of services, technological and economical resources, which are likely to result in very restricted adaptation capabilities to environmental and climate changes. The adaptive capacities of fisheries and aquaculture production systems could be increased by applying existing good governance and management principles and approaches. Such approaches include the EAF and the EAA, which involve practices of adaptive and precautionary management based on appropriate social, economic, political and institutional incentives.

A common understanding of the EAF and EAA concepts is developing, and an effort is now being made to incorporate the principles of the EAF and EAA in policies at the national level. However, there is still much to do to make these principles operational in the practical management of fisheries. In particular, they have to be socially acceptable and based on strengthened institutions at the local and national levels.

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3.3 The ecosystem-based approach to fisheries and aquaculture for the Red Sea and Gulf of Aden

Introduction

The RESGA subregion has always been a vital maritime trade route linking the Near East with the other continents of the Old World. Over the course of the past few decades, the oil industry and marine transportation of oil has increased in significance in the subregion, placing it frequently at the centre of the geopolitical strategies of industrialized countries. At the same time, an increasing interest in the subregion's living marine resources and their habitats has developed both at local and international levels. Early studies on the subregion's living marine resources can be dated back to the collections of flora and fauna, particularly fish, made by the Swedish naturalist Peter Forsskal in 1761–62. Most recently, projects funded by the GEF and other donors aim to help in the conservation and sustainable management of the biodiversity of the subregion.

The Red Sea is a long narrow basin approximately 2 000 km long, with an average breadth of 280 km. Being a semi-enclosed body of water, it is characterized by high water temperatures and high salinity. There are no major river inflows, and the water lost through evaporation far exceeds precipitation. The loss of water through evaporation is replenished through the inflow from the Gulf of Aden through the Strait of Bab-al-Mandab. Primary productivity is relatively low owing to poor surface circulation in the absence of strong wind systems. Productivity is greatest in the south, where it is stimulated by the inflow of nutrient-rich Indian Ocean water. The north of the Red Sea is divided into the Gulf of Suez, a shallow sea less than 100 m deep, and the Gulf of Aqaba, a deep rift basin reaching 1 800 metres in depth. The two gulfs are similar in size and shape. The geographical separation of the Red Sea from the Gulf of Aden is via a 100 m-deep sill about 125 km north of Bab-al-Mandab.

The RESGA subregion is surrounded by seven countries, each with different historical and cultural backgrounds (Figure 3.21). However, owing to the relatively recent need for resource sharing recognized at the global level, the surrounding countries have initiated a form of unity under the umbrella of the Arab League known as the PERSGA. The goals and agenda of this organization, generated during the Jeddah Convention (1982), concentrate on the sustainable use of the available living marine resources in the area. However, the lack of fundamental basic information about the existing marine resources, differences in the degree of development between those countries, and the lack of intergovernmental coordination have been the main setbacks facing the achievement of the goals.

The PERSGA, in close collaboration with relevant regional and international organizations, began implementing activities and programmes to deal with the various threats facing the coastal and marine environments in the subregion. The most significant threats included: environmental degradation, non-sustainable use of living marine resources, maritime traffic, oil production and transport, urban and industrial development, and the rapid expansion of coastal tourism (PERSGA, 2001).

The Red Sea is globally renowned for its unique and attractive marine and coastal habitats with high species diversity. For example, the coral community within the RESGA is composed of more than 250 species of stony corals. This is the highest diversity in any part of the Indian Ocean (Pilcher and Alsuhaibany, 2000). Of these, 6 percent are believed to be endemic (Sheppard and Sheppard, 1991). These habitats are under variable anthropogenic pressures, especially adjacent to urban and industrial areas, port facilities, major shipping lanes and in the vicinity of coastal tourist developments (PERSGA, 1998). The widespread destruction of coastal and marine habitats is a major transboundary concern in the subregion, with impacts of habitat and community modification considered severe for the Red Sea's living marine resources (PERSGA, 1998).

The Red Sea has a number of unique marine habitats, including seagrass beds, saltpans, mangroves, salt-marshes and the unique coral reefs. The Gulf of Aden is a region of oceanic upwelling, resulting

in high productivity of fish resources, particularly in the eastern part of the Gulf. The fisheries of the RESGA are of considerable socio-economic importance to the member States of the PERSGA, in terms of national food security and income generation for rural communities. Fisheries resources are exploited by artisanal subsistence fishers, local commercial fisheries and foreign industrial fisheries targeting invertebrates, demersal finfish and pelagic finfish. Many species cross national boundaries and are essentially shared stocks.

The objective of the present work is to present an overview of the current status of fisheries in the subregion and to analyse the possibility of applying the concept of responsible fisheries in the area through addressing practically all the ecosystem considerations and to identify the possible impact of climatic change on the sustainability of fisheries in the area.

Map of the Red Sea and Gulf of Aden Region and its surrounding countries.

Figure 3.21 Map of the Red Sea and Gulf of Aden subregion

Status of fisheries in the subregion

Fishing in the RESGA subregion is dominated by small-scale, artisanal activities. As is the case throughout the world, such fisheries are by their nature notoriously difficult to monitor, owing to the large number of small craft and fishermen, and the wide range of landing sites used. Reliable data are therefore often very difficult to obtain on a national basis, and comparisons of equivalent data between countries are difficult to undertake with precision. One of the problems facing national administrations in the subregion in trying to collect accurate data on artisanal fisheries is the mobility of the fleet, with a large number of boats moving to different areas at different times depending on the weather, availability of fish and market outlets. The present section summarizes the available information about the status of fisheries in the subregion with special emphasis on some countries that have more transparency and availability in their information sources.

The fisheries of the RESGA are of considerable socio-economic importance in terms of national food security and income generation for rural communities, with the exception of Jordan, which has minimal fisheries in the Red Sea. Fisheries resources are exploited by artisanal subsistence fishermen, local commercial fisheries and foreign industrial fisheries targeting invertebrates, demersal finfish and pelagic finfish. Many species cross national boundaries and are essentially shared stocks.

According to the published data from the area, the subregional artisanal fleet operating in the RESGA area comprises at least 54 500 fishermen and about 15 500 vessels of different types ranging from the smallest (*hori*) to the large fishing boats (*balanse*). Most vessels are locally made of wood, 6–7 m in length with petrol outboard motors of 8–20 hp. A fleet of larger artisanal vessels of 10–15 m operate with 50–150 hp inboard diesel engines. Artisanal fishermen use a range of gear, including longlines, handlines, gillnets, trawls, trammel nets, tangle nets, set nets, traps and spears. Figure 3.22 presents the artisanal profile of the subregion.

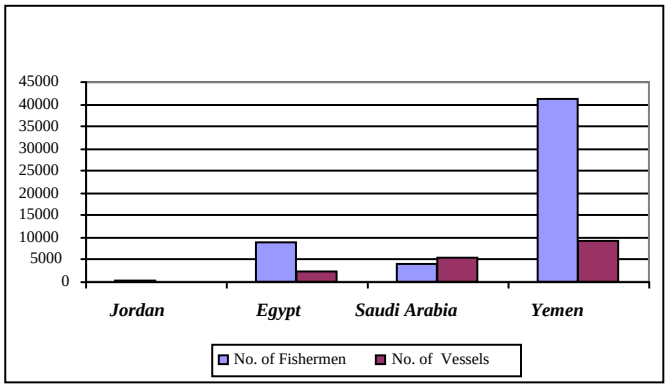

Figure 3.22 Artisanal fisheries profile of the RESGA subregion
Source: PERSGA, 2006.

According to the data collected from the subregion the industrial fleet consists of about 12 057 fishermen and 1 600 industrial vessels. Industrial vessels utilize purse seine, trawl, longline and vertical dropline gear. Figure 3.23 represents the industrial profile of the subregion. Owing to the nature of the Red Sea, the industrial fishery vessels have a rather limited chance in the north except for the Gulf of Suez, while the vessels of Saudi Arabia and Yemen prefer to operate in the southern waters and even extend their range to reach the Indian Ocean. In the Gulf of Aden, large industrial fisheries using "distant water" factory trawlers based in the area exploited demersal and small pelagic fish resources in the past, but because of lack of profitability have not functioned for some time. The situation in Somalia remains uncertain with informal reports of fishing companies undertaking operations and also substantial illegal fishing, particularly outside of the Gulf of Aden by foreign operators.

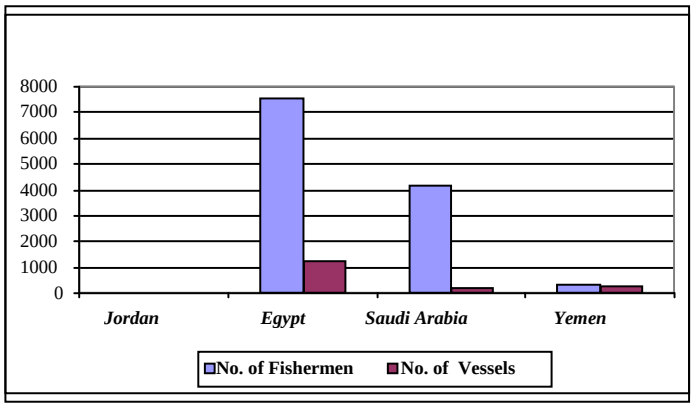

Figure 3.23 Industrial fisheries profile of the RESGA subregion
Source: PERSGA, 2006.

The four countries included in this review (Egypt, Jordan, Saudi Arabia and Yemen) represent about 96 percent of the subregional sector production. According to the available information about these countries, the artisanal and industrial fisheries produced about 30 269 tonnes of invertebrate species and 261 842 tonnes of finfishes in 2007. These figures indicate a considerable increase in the

subregion's production from 236 094 tonnes to 297 058 tonnes in the period from 1998 to 2007 (Figure 3.24). Yemen accounted for 56 percent of total production of invertebrates, Saudi Arabia 22.7 percent, while Egypt accounted for only 5.7 percent. Important commercial invertebrate species include penaeid shrimps in the Red Sea and cuttlefish and rock lobsters in the Gulf of Aden.

In 2007, Yemen accounted for 58.5 percent of the subregion's finfish production, followed by Saudi Arabia at 24.1 percent, then Egypt by 17.3 percent, while Jordan represented only 0.05 percent of the subregional total. Pelagic finfish catches are dominated by sardine, Indian mackerel, Spanish mackerel and yellowfin tuna. The demersal catch is dominated by species of snapper, jack, emperor, lizardfish, grouper, seerfish, rabbitfish and seabream.

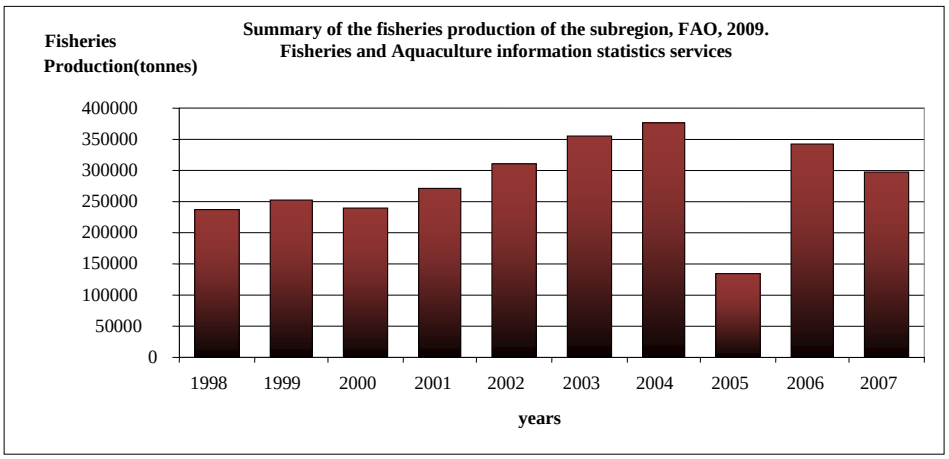

Figure 3.24 Summary of fisheries production in the RESGA subregion
Source: FAO, 2009.

Reported catches from the RESGA area continued their steady increase during the period from 1950 to 2005 reaching a relatively high rate of increase in the last ten-year period. The comparison of data collected from different sources showed that some of this may be from improved reporting practices, but irrespective of the cause, this is a relatively substantial increase when compared with other FAO statistical areas. Applied fisheries research and stock assessment throughout the subregion have been neglected in the past two decades. In most countries, no stock assessment has been undertaken since the cessation of collaborative research programmes conducted in the 1970s and 1980s. Consequently, most national authorities do not have reliable recent resource information regarding stock status, population parameters, estimates of potential biological yield or comprehensive and reliable catch and effort statistics even for the commercially important stocks. Such information is required in order to develop rational management plans, monitor the effectiveness of management strategies and assess the socio-economic value of the fisheries.

A more realistic evaluation of the fisheries of the PERSGA region, conducted by Tesfamichael and Pitcher (2006) using multidimensional scaling, showed that all countries have similar values ethically and economically, and in the technological field all countries have similar values except Egypt, which has lower sustainability. The main differences are in the ecological and social fields. Eritrea and the Sudan have the best scores ecologically. In the social field, Egypt has the best score, then Yemen followed by the Sudan, Eritrea and Saudi Arabia. The west and east coasts of the Red Sea scored the same in all fields except for ecology, where west coast fisheries scored better than those of the east coast. The economic sustainability evaluation of industrial and artisanal fisheries is similar, but the artisanal sector does better in ecological, technological and ethical fields. Surprisingly, the industrial sector rated higher in the social evaluation.

The difference between countries is not as obvious as it is between artisanal and industrial. In fact, the fishing operations of the artisanal fisheries, in terms of boats, facilities, gear and fish storage, are similar in all Red Sea countries. However, there are differences in other aspects. For example, per capita fish consumption is highest in Yemen, followed by Egypt, while the lowest per capita consumption is in Eritrea and the Sudan. It was predicted that Eritrea and the Sudan would be the countries to benefit most from expanding the fishing industry in the Red Sea. However, these countries seem to utilize their resources least and they also have the highest ecological sustainability status. This is reflected also in the comparison between the west (Egypt, Sudan and Eritrea) and east (Saudi Arabia and Yemen) Red Sea fisheries, and there are some reports that other Red Sea countries fish in Sudan and/or Eritrea legally or illegally. Sheppard (2000) stated that, due to lack of efficiency and proper market structure, Red Sea fisheries have been sustainable, with some exceptions such as the Egyptian shrimp fishery in the Gulf of Suez.

The marine aquaculture in the area is mainly limited to Saudi Arabia and Egypt. In Saudi Arabia, aquaculture production, although still small in comparison with wild capture fisheries, is growing rapidly, with production doubling from 2 960 tonnes in 1996 to 5 600 tonnes in 2000, with a further increase to 8 018 tonnes in 2001. This represents about 14 percent of fish production in the country. There were 149 farms in operation with the majority of production coming from freshwater aquaculture, primarily tilapia species. However, marine aquaculture is expanding rapidly, particularly shrimp farms on the Red Sea coast in the region of Jizan and the Tihama Plains. Other marine species in commercial or pilot-scale production include grouper (*Epinephelus coioides*), seabream (*Sparus auratus*), rabbitfish (*Siganus caniculatus*) and mullet (*Mugilidae* spp.). There is also interest, at a feasibility level, in the culture of lobster, molluscs, seaweed and ornamental fish. In Egypt, projects concerning marine aquaculture on the Red Sea coast have not been successful and most of the land allocated for them is still not developed. The reason for this is that the funds allocated by banks for such projects is negligible.

The economic contribution of the fisheries sector to the national economy differs from one country to another. In Jordan, the commercial fisheries sector is small and contributes less than 0.01 percent of GDP. Aquaculture production from intensive farms is increasingly important from a socio-economic point of view in rural areas, particularly in some areas of the Jordan Valley. In comparison with the oil industry, the contribution of the fishing industry to Saudi Arabia's economy is very small. While Saudi citizens own and operate traditional and industrial vessels, the sector is heavily dependent on immigrant workers, with more than 50 percent of these workers coming from Bangladesh and India. In addition to commercial food production, fishery resources also support a significant recreational fishing industry, particularly on the Red Sea coast. The fishing industry has a relatively minor direct role in the economy of Egypt, but nevertheless, domestic fish production makes a valuable contribution to the national food supply and to the traditional way of life, in which fish consumption plays an important part. In addition, it is a significant source of food for the tourist industry. In some cases, fishermen (especially in the Red Sea) sell their catch directly to restaurants or hotels. The fishing industry is also important for the livelihoods of more than 65 000 fishermen and other people employed full time in related activities. The fisheries sector is considered to be third in order of importance in Yemen's economy.

The value of the biological resources, including fisheries, to the prosperity of the subregion, particularly among the coastal populations, has long been recognized. The contribution of fisheries to GDP is relatively small (less than 1 percent), except in Yemen, where this sector accounts for 15 percent of GDP (FAO, 2005). Nevertheless, fisheries, particularly artisanal fisheries, provide food and employment for thousands of the subregion's inhabitants. For example, in Yemen, more than 220 000 people depend on fishing as their principal source of income. The fish resources of the Red Sea are regarded as an important source of domestic protein for coastal communities. Marine fisheries have potential for further development, for example, in Djibouti, where the potential contribution to GDP could rise substantially from 0.1 percent to approximately 5 percent (FAO, 2005). However, realization of that potential will depend on the continued upgrading of infrastructure and development of export markets.

Implementation of the ecosystem approach in the subregion

Despite the fact that the EAF is internationally recognized as a management tool, the implementation of such a principle in the RESGA subregion could be impossible in view of the many anthropogenic and traditional habits that control the behaviour of the fisheries community in this area. The main reason for this is the lack of coordination and trust between the authorities and the fisheries community. The great bulk of the fishers in this area prefer to work alone on a day-to-day basis and not to be connected to any organization or controlling system. Such behaviour contributes greatly to the lack of accurate information about the fisheries in most of these countries. Even those who assert that they have accurate data about their catch cannot provide evidence of their accuracy.

Many attempts have been made by the governments to reach the fisheries community. The most successful one was through the establishment of a NGO at several landing sites or in cities that have an aggregation of fishers. Such organizations contribute greatly to the community; however, being controlled by the fishers themselves, they did not reach the fully mature stage required to understand the importance of the ecosystem to their working future.

In most of the subregion, the real contribution to the current approach is coming from the environmental protection and nature conservation authorities. However, the principle of "rules are meant to be broken" is still applied in many areas where fishing in restricted areas is the favourite task for many fishers. This is clear in the tendency of the fishers of some countries to fish in closed areas or when the fishing season is closed.
It seems that the development of managerial skills in the area will play a very effective role in the implementation of an EAF. The messages delivered to the fisheries communities within the subregion must convince them that the application of ecosystem-based fishery management is likely to:

- contribute to increased abundance of those species that have been overfished;
- contribute to the stability of employment and economic activity in the fishing industry;
- help in the protection of marine biodiversity on which fisheries depend;
- help in deciding the limits of the sea to provide resources and the ability to stay within those limits, in addition to defining the acceptable levels of change in marine environments due to fishing.

The variations in the degree of fisheries management in the region may conflict with the application of the ecosystem-based principle. However, awareness raising regarding the importance of how different ecosystems affect the structure and abundance of fisheries could be considered as the first step towards implementing such an approach.

The efforts contributed by the regional organization (PERSGA) in the fields of habitat and biodiversity as well as living marine resources must be invested in this direction. The recognition of the importance of the present ecosystems in the RESGA area from the fisheries point of view must be explained in a more simple and understandable way. Instead of concentrating on the conservation of the marine ecosystem from the point of view of the ecological authorities, it is necessary to obtain the support of the fisheries community as well. In this way, those accused of destroying the ecosystems will become partners in the process of sustainability in usage.

Despite the fact that the EBFM approach is not applicable in the current situation across the subregion, the possibility of applying this approach in the area in the future would increase if the planning for it were considered by the different authorities within each of the neighbouring countries and conducted under the umbrella of the regional organization. The suggested plan to apply the principle and reach the goals of EBFM should first support the movement of recognizing the distribution of ecosystems within the area and their contribution to the fisheries within the subregion.

Accordingly, it is suggested that the problems must initially be addressed at the country level, where authorities can consider the benefits gained by the multiple users of the ecosystem. This will open the door to a wide range of objectives, frequently ignored in the past, and must be considered in the process of selecting optimal fisheries management measures and strategies. Normally, dealing with such inevitable subjects generates a large number of conflicts between different stakeholder groups. These need to be reconciled and resolved if management is to be successful and the overall societal goals achieved. These conflicts are normally solved through meetings at ministerial level and result in new laws or regulations defining the boundaries and duties of each of the stakeholders. Once the conflicts within the country have been solved, the main concept of EBFM can be introduced at a higher level (e.g. the regional level) through the regional organization (PERSGA), that has already included the sustainable use of living marine resources in its agenda.

The impact of fisheries on ecosystems in the subregion

The impact of the fisheries on the ecosystems in the area is poorly documented in most countries. However, fishing usually affects other components in the ecosystem in which it occurs. For example, there is often bycatch of non-targeted species, physical damage to habitats, food-chain effects and other factors, and in recent years there has been a growing realization of the impact of fisheries on the different marine ecosystems (FAO, 2003).

Coral reef, seagrass and mangroves are the main ecosystems found on the coast of the RESGA countries. Despite the fact that most of these ecosystems have some form of protection or are located within protected areas in these countries, many illegal fishing practices persist in these areas. The impact of such fishing practices are summarized in the following points:

- the reduced abundance of individual species within coral reef ecosystems, for example the case of losing large predators (groupers) as a result of selective fishing or removal of target species, which negatively affects other species that depend on it as prey;
- destruction of a certain habitat type (damage to corals by anchoring) that exposes the prey to the predator as a result of losing shelter;
- the use of unsustainable fishing techniques resulting in deterioration in the recruitment of certain species and reduction of the possibility to restock or recover;
- catching of non-target species as bycatch and their disposal;
- the extent of competition between fisheries and species of concern such as marine mammals, turtles, seabirds and sharks. This includes consideration of both “direct competition”, which involves reduction (by consumption or utilization) of a limited resource but with no direct interactions between the competing species, and “indirect competition” in which the competitors may target different resources but are linked because of a food-web effect;
- the reduction of biodiversity owing to targeting groups of species to the maximum limit, especially on offshore reefs or reefs around islands, which results in changes in the community structure;
- altering the trophic levels in the ecosystem by removing certain trophic categories, resulting in the evolution of a mono-specific type ecosystem;
- the effects of habitat modification. This includes consideration of effects such as trawling, damaging benthic habitats, perhaps having an indirect negative effect on fish stocks;
- changes in the ecosystem state (e.g. mangrove cutting, collection of corals and marine animals) that result in a less productive/desirable state of the ecosystem;
- indirect impacts resulting from the use of old and corroded fishing boats spilling fuel and oils into the marine environment.

Suggested steps towards the implementation of the EAF in the RESGA subregion

Like most of the successful plans implemented in the RESGA area, the EAF must be carried out in steps and according to a regionally studied action plan. The suggested action plan should include the following components.

Environmental inventory
This includes an assessment of the present living marine resources in the coastal area at a country level using standard and internationally recognized methods of assessment. The collected data should be verified and as accurate as possible. Such data can be easily obtained in certain countries; however, in others, the personnel needed for data collection may need training. The regional organization should take responsibility for training in the standard methods of collecting data in those countries.

Environmental assessment
This concerns assessing and evaluating the sources and causes of environmental problems as well as their magnitude and impact on the marine environment. Emphasis is placed on:
levels and effects of marine pollutants;
studies of coastal and marine activities and their socio-economic effects;
environmental degradation.

Environmental assessment is undertaken to assist national policy-makers in managing their natural resources in a more effective and sustainable manner, and to provide information on the effectiveness of legal and administrative measures taken to improve the quality of the environment.

Environmental management
The regional programme includes a wide range of activities in the field of environmental management. Such activities are:

- the subregional integrated coastal zone management plans;
- marine pollution contingency plans;
- establishment and management of specially protected areas;
- raising the capacity of national institutions and experts to participate fully in the programmes.

However, the results of carrying the environmental assessment should indicate the needs for special environmental management actions. These actions need to be addressed on both the national and regional levels. One of the most relevant programmes is the sustainable management of living marine resources in the RESGA region.

Improve environmental legislation
It is well known in the countries of this area that implementation of any programme needs to be supported by law. So, the preparation for the new management scheme for the living marine resources in countries in the area should be accompanied by a set of legislation that creates harmony in the relations between the countries in this field. Some of the countries (Egypt, Saudi Arabia, etc.) have their own environmental laws; however, they are concentrated on the protection of the environment not the sustainable use of it. On the other hand, the management of the fisheries sector belongs to a different part of the administration – causing a great deal of conflict between parties within the same government.

Institutional arrangements
The main role of the regional organization when adopting the action plan comes from its power to bring the governments to agree to let the organization act as the permanent secretariat of the action plan and to agree on the mechanisms to be used for the periodic review of the progress of the agreed workplan and for approving new activities and the necessary budgetary support.

Financial arrangements
In addition to its previous institutional role, the regional organization must:

- ensure governments' contributions towards the costs associated with the implementation of the action plans;
- work towards generating enough funds from international donor organizations to finance the plans;
- control the flow of funds and ensure that they are channelled through specially established trust funds to which the governments participating in the action plan make annual contributions.

Understanding of possible climate-change impacts in the subregion

The IPCC (2007) projects that atmospheric temperatures will rise by 1.8–4.0 °C globally by 2100. This warming will be accompanied by rising sea temperatures, changing sea levels, increasing ocean acidification, altered rainfall patterns and river flows, and higher incidence of extreme weather events. The productivity, distribution and seasonality of fisheries, and the quality and availability of the habitats that support them, are sensitive to these climate-change effects. In addition, many fishery-dependent communities and aquaculture operations are in regions highly exposed to climate change (Allison *et al*., 2009).

It is well documented that the Red Sea has the highest temperatures and salinities observed in the world's oceans. The extremely high evaporation rate leads to formation of salinity fronts, on which temperature fronts tend to develop. Although these fronts are poorly studied *in situ*, satellite observations hold promise given the largely cloud-free conditions over the Red Sea (Belkin, Cornillon and Sherman, 2008). The only known events where the Red Sea surface water temperature has exceeded 28.5 °C occurred in 1969 and again after the strongest El Niño of the last 50 years in 1998–99.

Developing policies and strategies to address climate change impacts on fisheries and aquaculture depends on identifying vulnerable places and people and understanding what drives their vulnerability. This requires vulnerability assessments at multiple scales and taking into account multiple interacting drivers. This could be achieved through intensive study of:

- the exposure of a particular system to climate change;
- the degree of sensitivity to climate impacts;
- the adaptive capacity of the group or society experiencing these impacts.

Improved management of fisheries and of marine ecosystems can undoubtedly play an important role in adapting to the impacts of climate change. Most of the improvements that are needed do not require new science or understanding; they require patient development of acceptable, effective, responsive social institutions and instruments for achieving adaptive management.

In the RESGA subregion, climate change is an additional pressure on top of the many (fishing pressure, loss of habitat, pollution, disturbance, etc.) that the marine environment already experiences. This means that the impact of climate change must be evaluated in the context of other anthropogenic pressures, which often have a much greater and more immediate effect. Conversely, it is evident that fish stocks will be more resilient to climate impacts if the stresses relating to other factors, such as overfishing and pollution, are minimized (Brander, 2005).

Although our knowledge of the processes by which climatic and environmental factors affect fish at individual, population and ecosystem level remains far from complete, we are already able to observe changes at all these levels – changes that can be confidently ascribed to climate change. Globally recognized changes in distribution of fish and plankton are particularly striking because they are more

rapid than the changes occurring in terrestrial fauna and flora (Francis, 1990). In addition, some very basic biological research on the physiological and population constraints for individual species would help in defining biogeographic boundaries and, hence, in making projections of future distribution shifts (Sharp, 2003).

The lack of evidence of the relationship between climate changes and fisheries landings in the RESGA area is due to the following reasons:

- lack of accurate data or records about the landings;
- the tendency to provide information showing increasing fisheries production as a sign of successful fisheries management by governments;
- the use of different and misleading systems in recording the data;
- the presence of too many anthropogenic activities that can be accused of or blamed for stock depletion;
- the lack of transparency and coordination at regional level;
- the common belief that global warming is a God-intended action or that it is a part of natural cycle.

Much of the research conducted in the area on the local and national levels has not recognized anthropogenic climate change as a possible effect on fish production. However, a closer look at the available data suggests that there is a link between fish production and climate – this points out the need to include the effects of global warming as a possible impact in the near future. The revising of the scientific data and results reported in the area (Head, 1987; Sanders and Morgan, 1989; Hariri *et al*., 2000; Tesfamichael and Pitcher, 2006) suggests that shifts in climate could have noticeable effects on some, if not most, major commercial fish stocks in the area.

The main indicators of the climate changes impacts that should be taken into consideration at both national and regional levels include:

- Changes in production: This includes the natural increase or decrease in the production of the region without any interference from other factors (e.g. increase in number of fishing boats, fishermen).
- Changes in fish population processes: This could be monitored on the small scale (local or national) where impacts of climate change on biological production are ultimately the sum of processes that act on individual organisms. The processes, whose response to environmental variability can be studied in exquisite detail, are growth, reproduction, mortality and behaviour.
- Changes in the environmental factors: This includes monitoring of the environmental factors that could affect the biology of the fish, such as changes in the physical-chemical properties of the sea water (pH, temperature, salinity, etc.).
- Decline in total biomass of fish: This can be good evidence if preceded by a decline in mean weight-at-age. Decline in growth rate provides valuable advance warning of reduced surplus production, which can result in a decline in stock biomass.

The questions that need to be answered concerning this region of the world are:

i. Are we really going to be affected by global warming?
ii. Is it too late to react?
iii. What policy processes nationally and regionally do fishery and aquaculture agencies need to engage with to finance and implement adaptation?
iv. How can climate-change adaptation and management be effectively incorporated into fishery and aquaculture development and management planning?

Conclusions

Several issues in the fisheries sector need to be dealt with before the implementation of an EAF/EAA in this subregion; among which:

- The absence of effective controls, surveillance and regulation enforcement in most of the countries has resulted in widespread poaching and habitat destruction by foreign and national vessels.
- The legal framework provided for fisheries management and development is weak in many states. Penalties for infringements are too low to act as an effective deterrent and encourage compliance by fishermen.
- Enforcement is virtually non-existent in most of the subregion. However, some states are acting to strengthen the national legal framework through higher penalties, provisions for habitat/biodiversity conservation and clearly defined powers for management authorities and enforcement officers.
- In all the RESGA countries, national institutional structures lack the administrative and technical capacity to formulate and implement realistic and effective fisheries management policies and strategies.
- A generic problem throughout the subregion is the lack of financial and material resources allocated to those authorities responsible for fisheries research, management and development.

Recommendations

- To ensure the future of the fisheries sector in the RESGA area, it is suggested that all governments in the subregion aim to develop a clear policy for national fisheries within a framework for integrated coastal management.
- Greater harmonization of national legislative frameworks for fisheries and the environment, data collection, research and multisectoral studies, operations and procedures would provide a better basis for cost-effective management.
- The concept of integrated management and coordination between ministries (currently non-existent in most countries owing to the strong sectoral nature of government) must be encouraged.
- Institutional capacity needs to be strengthened in the areas of regulatory policy, fisheries management and environmental conservation.
- Although aquaculture has been seen as a major alternative source of fresh fish supply and is growing rapidly, production from this sector has not grown fast enough to meet increased demand.

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3.4 Adapting to climate change: a review of the ecosystem approach to fisheries and aquaculture in the RECOFI region

Introduction

The RECOFI is a regional fisheries body located in the Near East and covers an area of water including the Persian Gulf, Gulf of Oman and north Arabian Sea. There are eight countries with coastal waters in RECOFI, including Bahrain, Iran (Islamic Republic of), Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (Figure 3.25).

The climate of the RECOFI region is of subtropical nature. Salinity is high compared with neighbouring marine environments, particularly in the Persian Gulf. Freshwater input into the Persian Gulf is low and solely from the Arwand River, which collects water from the Karoun, Euphrates and Tigris Rivers. The Gulf of Oman and north Arabian Sea receive water from the Indian Ocean and the Indus River.

Climate change is a phenomenon that cannot be disregarded. The average world temperature has risen, glaciers are melting, and natural disasters are increasing. Ocean acidification is evident. Drought is occurring in the region.

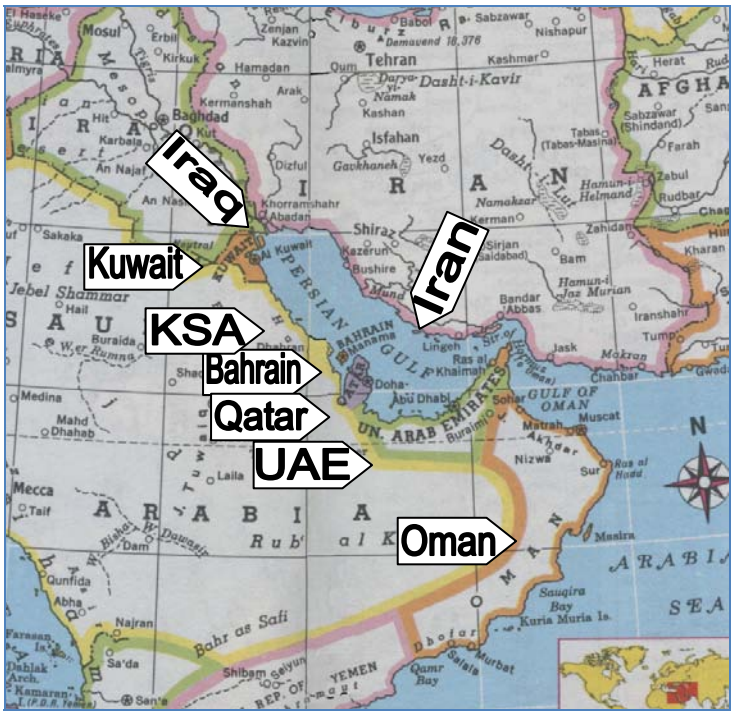

Figure 3.25 Map of the RECOFI region
Source: Hammond, 1978.

Member country fisheries and aquaculture profiles

Bahrain
Bahrain is a flat country with an area of 706 km^2 and 32 islands in the Persian Gulf. There are very few freshwater resources, and so fishing and aquaculture are mainly limited to marine waters. This country used to cover 695 km^2 in 1991, but by land reclamation and dredging, which resulted in some environmental and coral destruction, it has been able to increase its area to 706 km^2. Bahrain's population is 963 000.

In 2001, fish production in Bahrain was 11 230 tonnes, imports were 4 080 tonnes, and fish exports were 5 990 tonnes. Fish imports in 2003 were 3 358 tonnes for a value of USD6 880 000, while

exports in the same year were 7 202 tonnes, valued at USD11 595 000. Crab, finfish and shrimp are mainly exported to Saudi Arabia. Bahrain has 590 km of coastline and a fishing industry that catches mainly shrimp, crab, finfish (mostly rabbitfish, emperors and groupers). There are approximately 2 300 fishing boats, 85 percent of which are made of fibreglass, and 15 percent of wood. The main types of fishing gear are shrimp trawl, gillnet, wire trap (gargoor), and hook-and-line. Shallow-fixed stake nets (haddrah) are mainly banned, as are drift nets but they are still widely used, despite enforcement measures taken by Bahraini authorities.

Although fisheries in Bahrain are not economically important, in the sense that they comprise only 0.4 percent of GDP, they are of socio-economic importance as a result of their role as a main source of employment for many rural areas.

Fisheries in Bahrain are mainly artisanal and are increasing in importance. Fishing increased dramatically in 1996, and has continued to increase since; however, the composition of fish products of Bahrain has changed with a decrease in the shrimp and red grouper (hamour) catches and increases in the crab and finfish catches. It is suggested that some popular species are overexploited.

It is estimated that 7 200 people are directly employed in the fisheries sector in Bahrain, with an additional 2 000 persons indirectly employed. In 2003, fish consumption per capita was 16.7 kg in Bahrain. In 1993, work started on aquaculture, focusing on grouper (*Epinephelus coioides*), rabbitfish (*Siganus canaliculatus*), and yellowfin seabream (*Acanthopagrus latus*). Later, in 1999, culture of sobaity bream (*Sparidentex hasta*) was successfully implemented. Bahraini hatcheries supply fry for local and regional aquaculture (FAO, 2009).

Iran (Islamic Republic of)

The Islamic Republic of Iran is a mountainous country of 1 648 195 km^2 located to the north of the Persian Gulf. More than half of the country is covered with mountains, one-quarter is desert and the rest is agricultural land. Most rivers are small or of medium size, while the Karoun River is the only navigable large river in the Islamic Republic of Iran. There are four main watersheds, which empty into the Caspian Sea, the north RECOFI area (Persian Gulf and Gulf of Oman), Lake Urmia, and central inland lakes.

There are approximately 170 000 persons working in fisheries and aquaculture in the Islamic Republic of Iran. Some 28 000 aquaculturists raise Chinese carp, rainbow trout, and shrimp in the Islamic Republic of Iran. Approximately 13 000 people fish on Caspian Sea coasts, mainly on bony fishes, sturgeons and kilka. The remaining 130 000 people fish in the Persian Gulf and the Gulf of Oman, mainly for tuna, shrimp, demersal and pelagic fish species. The Islamic Republic of Iran has 2 700 km of coastline, 1 800 km of which is located within the area covered by the RECOFI. Fish production of the Islamic Republic of Iran in the RECOFI area was 329 000 tonnes in 2007. Fish consumption in the Islamic Republic of Iran is 7.35 kg per capita and the country is attempting to increase fish consumption among Iranians. The country's fish exports consist of caviar, which constitutes approximately 41 percent of the country's USD81 million in fish exports in 2003. The value of fish imports to the country was USD69 million in the same year (FAO, 2009).

Iraq

Iraq, with an area of 435 052 km^2, has two main regions, flat and mountainous, and a population of 24 million people. Iraq has two main rivers, the Tigris and the Euphrates, which empty into the Arwand River and finally into the Persian Gulf. Iraq has 50 km of coastline in the northwest Persian Gulf. The salt marsh areas of Iraq have been extensively degraded and approximately 90 percent of them have been destroyed. This was caused mainly because of a sharp decline in the inflow of the two main rivers of Iraq into the Persian Gulf, as well as the diversion of the rivers around the marshes causing increased drainage. These salt marshes have been reduced to an area of 1 700 km^2 and are used to support 60 percent of Iraq's fish landings as well as providing a nursery ground for a variety of Persian Gulf fish.

In 2001, approximately 22 800 tonnes of fish was produced in Iraq. In 2003, Iraq imported 1 897 tonnes with a value of USD2 660 000 and exported 17 tonnes with a value of USD97 000. Approximately 20 000 fishermen, 5 000 aquaculturists and 4 500 fish marketers worked in the fisheries industry in 2000. The majority of fish are consumed fresh in Iraq and thus the fish processing sector is not well developed.

The main commercial marine fish species of Iraq are shads (*Tenuolosa* spp.), silver pomfret (*Pampus argenteus*), and different mullet species (*Liza* spp.), and the most important freshwater fishes are cyprinids and *Barbus* spp. Fishing in Iraq is artisanal using trawl, gillnet, cast net and traps. Aquaculture in Iraq is small, is mainly based on Chinese carps and is practised in an area of 7 500 ha with a total production of 2 000 tonnes in 2001 (FAO, 2009).

Kuwait

Kuwait is a flat country with an area of 17 818 km^2 containing no rivers. Kuwait has 195 km of coastline and a population of 2 350 000. In 2001, Kuwait produced 6 000 tonnes of fish. There are 1 400 workers in fisheries and aquaculture, with an additional 2 500 working indirectly in this sector. Some 12 800 tonnes of fish was imported and 640 tonnes exported in 2001. In 2002, the value of fish exports from Kuwait was USD21.2 million and that of imports was USD2.4 million.

Fisheries in Kuwait are mainly artisanal, however, shrimp fishing is practised using both modern and artisanal techniques. Some 90 percent of 3 700 tonnes of finfish are produced by artisanal wooden dhows, while only 45 percent of 2 300 tonnes of shrimp landings are accounted for by artisanal ships. There are 35 industrial trawlers and 33 dhows active in shrimp fishing of Kuwait. The commercially important shrimp species of Kuwait is *Penaeus semiculcatus*, it alone accounts for more than half of the shrimp harvest of Kuwait. There are two processing plants for marine products in Kuwait. The shrimp fishery is managed by imposing a closed season and a no-take zone in Kuwait Bay and 3 miles of coastal waters.

There are an additional 868 fishing vessels targeting finfish as well as 522 intertidal stake nets (hadrah) working in Kuwait (2003 data). The main commercial fish species of Kuwait are silver pomfret (*Pampus argenteus*), hilsa shad (*Tenualosa ilisha*), grunt (*Pomadasys kaakan*), mullets (*Liza* spp.), grouper (*Epinephelus coioides*), seabream (*Acanthopagrus latus*), snapper (*Lutjanuis malabaricus*) and croaker (*Otolithes ruber*). Catches of certain popular species including silver pomfret and hilsa shad have recently decreased. Suggested causes for reduced catch in Kuwait are overfishing and a change in the environment owing to decreased freshwater input resulting from dam construction on the two main rivers of the north Persian Gulf, the Tigris and the Euphrates. The coastal mullet species have also been affected by several occurrences of harmful algal blooms in the region.

Aquaculture in Kuwait includes raising marine seabreams (*Sparus aurata*, *Sparidentex hasta* and *Acanthapagrus latus*), grouper (*Epinephelus coioides*), and brackish-water tilapia (*Oreochromis niloticus*). In 2001, aquaculture production in Kuwait was 195 tonnes. Mariculture is based on cage culture while brackish-water aquaculture is based on agricultural drainwater. Fish fingerlings are mainly imported from Greece, Cyprus, Italy and Bahrain. Fish feed is also imported from the Netherlands and Saudi Arabia.

Shrimp exports have decreased from 90 percent of total catch in the 1980s to 40 percent of total catch in recent years as a result of increased local consumption of shrimp. Workers in the Kuwaiti fishing sector are not all from Kuwait, and the employment provided by fisheries is not regarded as important. However, this sector provides a good opportunity for investment (FAO, 2009).

Oman

Oman has an area of 309 500 km^2 and is located in the Gulf of Oman and the Strait of Hormuz of the Persian Gulf. Oman has a coastline of 3 150 km and a population of 2.6 million. Total fish production in 2003 was 139 000 tonnes, fisheries products imports were 27 000 tonnes and exports were

76 000 tonnes. The value of Oman's fish exports in 2004 was approximately USD103 million and that of imports was USD14 million. There are approximately 35 000 workers in the fisheries and aquaculture sector of Oman, with an additional 6 000 working in dependent industries.

Fisheries are not a major contributor to the economy of Oman. However, it is a significant source of rural activity and employment. In 2004, the total value of fish production of Oman was approximately USD180 million, amounting to 0.6 percent of GDP. Fisheries comprise 2.4 percent of total labour workforce.

The artisanal fisheries industry is made up of 14 000 vessels, which account for up to 85 percent of fishing in Oman, followed by industrial fisheries. Total fisheries production in 2005 was around 150 000 tonnes, consisting of tuna, sardines, emperors, seabreams, groupers, cuttlefish, lobster, shrimp and abalone. The industrial fishing vessels use trawl nets and landed 22 000 tonnes of demersal fish and 3 500 tonnes of pelagics in 2005. They included 31 bottom trawlers and 42 tuna fishers. Some 17 percent of the fish biomass of Oman is present in the Gulf of Oman and the rest is in the Arabian Sea. Lobsters (*Panulirus homarus* and *Panulirus versicolor*) are also fished, mainly by artisanal fishing boats.

Approximately 50 000 tonnes of tuna and other large pelagic fishes, 43 000 tonnes of demersal fish, 50 000 tonnes of sardines and other small pelagic fishes, 233 tonnes of lobster, 57 tonnes of abalone, 12 000 tonnes of cuttlefish, and 500 tonnes of shrimp were landed in 2004. Aquaculture in Oman consists of seabass, seabream and farmed tuna and shrimp. Fish are locally consumed or exported to Europe, Arab and Southeast Asia countries. Oman supplies 60 percent of the Dubai fish market. Fish is an important food item for Omani people, and it is consumed more in rural areas than in cities. The main imported fish items are freshwater fish, salmon, shrimp, and lobster. There are approximately 35 500 workers in fisheries with an additional 3 200 engaged in transporting fish, and 1 300 in fish market jobs (FAO, 2009).

Qatar

Qatar is a flat country, 11 437 km^2 in area, with a population of 600 000 and a coastline of 563 km. In 2001, Qatar produced 8 600 tonnes, imported 4 600 tonnes and exported 2 200 tonnes of fish. Some 4 700 workers are active in fisheries in Qatar. Fishing in Qatar is primarily artisanal, in the past there was an industrial shrimp fishing fleet but the industry shut down in 1993 after a decrease in the species. At present, 98 percent of fish landings in Qatar are finfish, mostly of emperor (*Lethrinus* spp.), grouper (*Epinephlus* spp.), mackerel (*Scomberomorus commerson*) and grunt. There are 515 fishing vessels in Qatar. Fishing methods include gillnet, traps (gargoor) and hook-and-line. Driftnets are illegal but are used. The majority of exported fish is re-exported as 2 100 tonnes of fresh and frozen fish. Imports also increased to 3 820 tonnes in 2001. Qatar had an increase in the catch of grouper and emperor in 2001, with a total catch of 8 863 tonnes. Commercial fisheries in Qatar account for 0.1 percent of its GDP, but owing to its employment capability it is an important sector (FAO, 2009).

Aquaculture includes experimental raising of rabbitfish (*Siganus canaliculatus*) and grouper (*Epinephelus* spp.), but no commercial production. Most landings are consumed locally but some are exported, mostly to Saudi Arabia.

Saudi Arabia

Saudi Arabia is largest country in the Arabian Peninsula, covering more than 80 percent of the peninsula. It is a flat country and is largely covered by desert. The western area is covered by mountains parallel to the Red Sea. There are no rivers with the exception of temporary creeks in Saudi Arabia. It has an area of 1 960 582 km^2, a population of 23 million and a coastline of 2 640 km, of which 580 km is in the Persian Gulf. Although most of the coastal region of Saudi Arabia is located on the Red Sea, the majority of fish production is in the Persian Gulf. In 2003, fish production in Saudi Arabia was approximately 65 000 tonnes. Imports were about 100 000 tonnes, with a value of USD 136 million, and exports were 10 400 tonnes, valued at about USD10.5 million.

Fisheries and aquaculture in Saudi Arabia provide employment for approximately 5 900 people, with an additional 15 000 employed in related activities. The main commercial fish caught in the Persian Gulf are groupers, emperors, scads, mackerel, jacks, shrimp, and kingfish. In 2000, 98 percent of fish production of Saudi Arabia in the Persian Gulf (24 600 tonnes) was contributed by artisanal fisheries. Out of the country's 9 400 artisanal fishing vessels, only 1 800 work in the Persian Gulf; and out of its 183 industrial fishing boats, 34 vessels operate in the Persian Gulf. Saudi Arabia has 1 700 fisheries workers and 7 000 fisheries-related workers in the Persian Gulf. The majority of fisheries workers are from Saudi Arabia, but the workers in fisheries-related activities are mostly non-native. Aquaculture is growing rapidly in Saudi Arabia. Aquaculture production was 8 000 tonnes in 2001. The main fish product is tilapia from brackish-water sources, with 3 900 tonnes in 2001. The culture of shrimp on the Red Sea coast is a growing business in Saudi Arabia. Grouper (*Epinephelus coioides*), seabream (*Sparus auratus*), rabbitfish (*Siganus caniculatus*) and mullet (Mugilidae) are reared in Saudi Arabia, either on a commercial or experimental scale.

Saudi Arabia has three fish-processing plants with modern facilities and a capacity of 100 tonnes. Because stocks of certain popular fish species have decreased and the demand for fish is increasing, the price of most fish products is also increasing. Approximately 14 percent of fish in the Saudi Arabian market are aquaculture products. Most stocks are overexploited. Moreover, some fish species caught in the Persian Gulf have been reduced, such as grouper. In addition to overfishing, illegal fishing (such as fishing of small shrimp by small artisanal boats in shallow waters) and changes in the environmental condition of the Persian Gulf have contributed to the decline. Compared with the oil industry, the input from fisheries to the Saudi Arabian economy is small. The sector is also not very important for job creation because there are few native people working in the sector, but it is significant because of commercial food production and aquaculture as a growing business (FAO, 2009).

Ecosystem approach

The importance of fisheries, marine biodiversity and productive ecosystems in the RECOFI region is clear. Recently the region experienced rapid development in the coastal zone and a loss of potential to sustain coastal populations. An integrated EAF in the region is essential.

Management of fisheries can improve from the current state of open access in many areas and fishing seasons, to a population based totally controlled management that can enhance most commercially important fish species of the region. In this case, the habitat characteristics of each population of a species should be identified and protected. The breeding area, nursery ground and feeding area would be under different management control in order to ensure that enough offspring grow to commercial size for harvest. A fishing ground with a specified season and legal size of fish catch and allowable catch per boat, per day, and per year would be defined, to make sure that no overfishing would happen.

Fisheries and aquaculture in the RECOFI

Artisanal fisheries are of great importance in the RECOFI region as they include a large number of fishers with small incomes, and in many cases fishing is a family business (Figure 3.26). Modern fisheries of various types are also present in the region – however, not at a high-intensity level. The most noticeable of these are the bottom trawlers of the Gulf of Oman, purse seiners, and a few longliners (Figure 3.27). Aquaculture is limited to land-based shrimp culture, and an extensive cage culture of marine species.

Fisheries trends
Most fishing in the region is done using traditional fishing methods (Figure 3.26). This means many fishermen sharing a small amount of catch. However there is a tendency to change the system and use more advanced methods of fishing (Figure 3.27).

Figure 3.26 An example of artisanal beach fishing in the United Arab Emirates
Source: Alyafeyi, 2009.

Compared with the oil industry, the fisheries sector is not regarded as an economically important sector in the region. However, it is regarded as a source of employment and revenue for rural areas. Socially, it is an old system, and has not changed much from its original structure. There are a number of reasons for an overhaul in the fisheries sector, the most important of which is depletion of the main popular species and the growing demand for fish in the region. This is reflected in growing fish imports in some countries, which will probably be followed by other countries.

Figure 3.27 A pair of modern purse seining vessels, Bandar Abbas, Iran (Islamic Republic of)
Source: H. Negarestan.

As fisheries in the region are still in a developing stage, trends do not yet show the effects of climate change. Trends in fisheries show the managerial success of countries of the region in increasing their catch; captured fish have almost doubled in the last decade (Table 3.4). This increase is unlikely to repeat itself in the next decade as the main resources of fish in the region are currently being fully exploited. This is shown by some species such as silver pomfret (*Pampus argenteus*) in Figure 3.28.

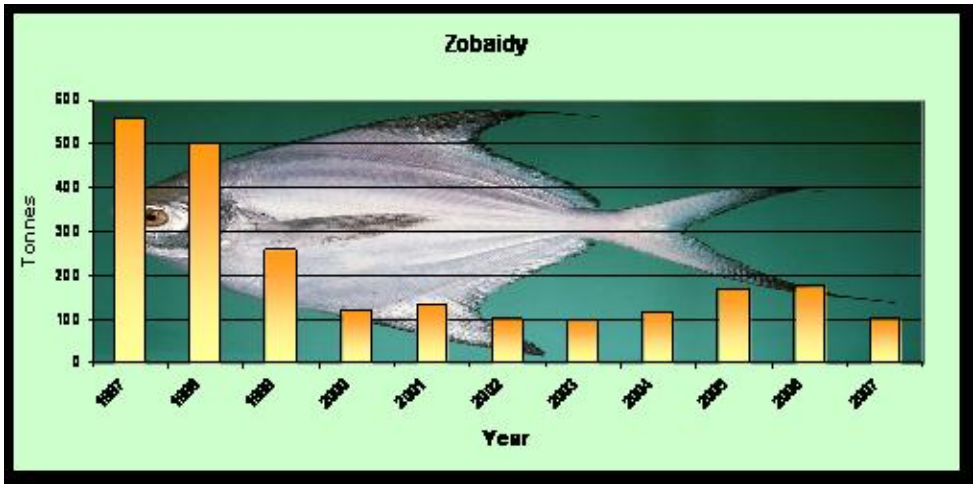

Figure 3.28 Reduced fishing of *Pampus argenteus* in Kuwait
Source: Murad, 2009.

Shrimp are fished from small wooden or fibreglass boats, dhows (Figure 3.29). The trend in shrimp fishing is not similar to fish and it has not increased (Table 3.4). Shrimp have already reached their maximum exploitation potential.

Figure 3.29 A small fibreglass fishing vessel in Bandar Abbas, Iran (Islamic Republic of)
Source: H. Negarestan.

Aquaculture is a rapidly developing industry in the region. It has increased almost five times in the last decade (Table 3.4 and Figures 3.30 and 3.31). It is likely that this industry will continue to increase in the coming decade, if the region can cope with climate change.

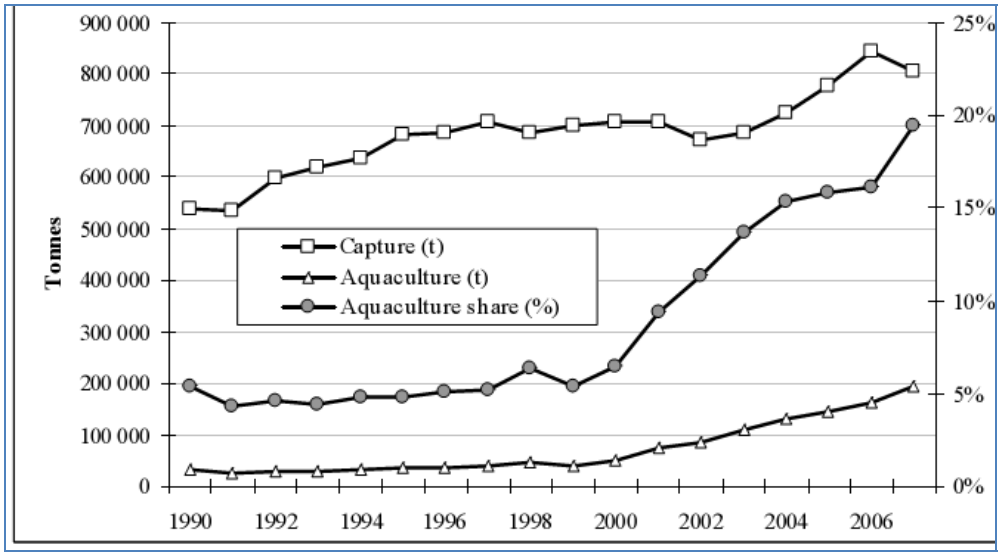

Figure 3.30 Total fisheries production in the RECOFI region (including marine and inland)
Source: RECOFI, 2009.

Table 3.4 Fishery trends of countries of the region, by catch

Country	Marine captured fish		Captured shrimp		Aquaculture		Source
	1997	2007	1997	2007	1997	2007	
	(tonnes)						
Bahrain	7 830	12 222	2 571	2 790	0.5	1.5	FAO, 2009
Iran (Islamic Republic of)	251 380	322 121	7 620	7 450	30 281	158 789	Keymaram, Valinassab & Mojahedi, 2009; FAO, 2009
Iraq	31 302	57 388	–	388	3 400	15 810	FAO, 2009
Kuwait	5 761	2 833	2 066	1 540	204	348	Murad, 2009; FAO, 2009
Oman	118 995	151 744	–	–	–	90	FAO, 2009
Qatar	5 034	15 187	–	–	2	36	Fisheries Department, 2009; FAO, 2009
Saudi Arabia	22 146	42 038	–	–	4 691	18 411	Marine Fisheries Department, 2006; FAO, 2009
United Arab Emirates	114 358	87 000	–	–	2	570	Alyafeyi, 2009; FAO, 2009
Total	453 912	890 533	12 257	12 168	38 580	194 055	

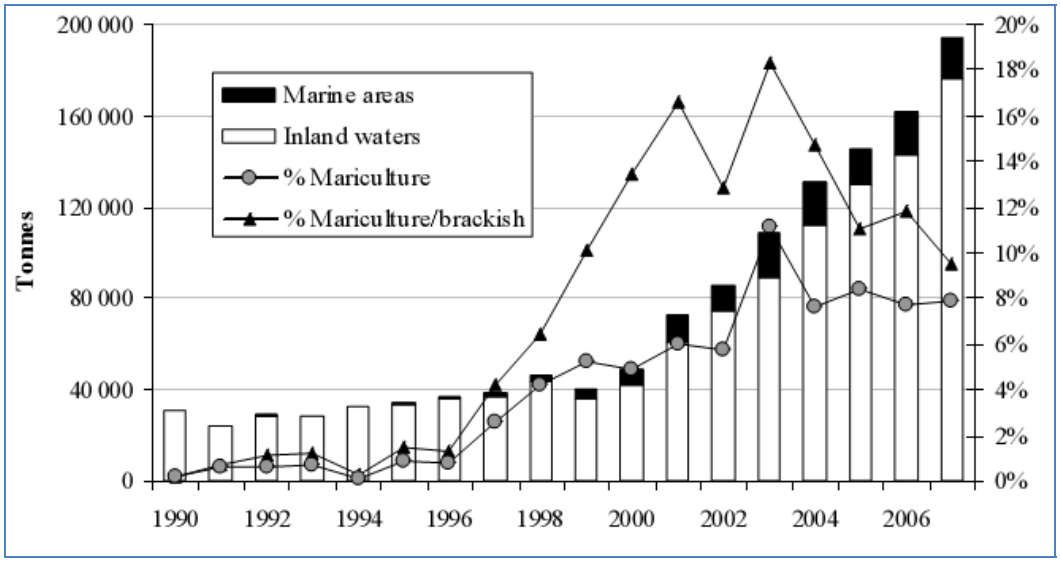

Figure 3.31 Total aquaculture production in RECOFI countries
Source: RECOFI, 2009.

Climate change

Climate change is happening at a growing pace in the world. The RECOFI region was hit by a tropical cyclone called Gonu, causing a large amount of damage. Many areas of the region experience drought. Coral bleaching observations of the region may also be linked to water temperature fluctuations. The *Cochlodinium polykrikoides* harmful algal bloom of 2008 was long-lasting and covered an exceptionally large area. This may have been related to the unusually calm winter in 2008.

When compared with other areas, the RECOFI region has experienced few impacts of four major effects of climate change. However, this may not be the case in the future. The four major effects are:

- temperature change;
- precipitation change;
- sea-level rise;
- extreme events.

Temperature and rainfall changes
The exchange of water between the Persian Gulf and Gulf of Oman is small. In addition, the volume of water that the Persian Gulf receives as freshwater input of the rivers, particularly that of the Arwand River is limited. This river has been reduced as a result of dams and land-based uses, and so a further increase in water temperature and decrease in precipitation may cause serious stress on the populations of commercially important fish species as well as the ecosystems in which they live.

Sea-level rise
Sea-level rise has not significantly affected the RECOFI region. It should be noted that melting of glaciers around the globe is not progressing slowly, and so sea-level rise will affect this region and cause a great amount of damage through loss of land or other damage to the economy, to mangrove forests and other wetland areas, and to the whole ecology of the region.

Extreme events
Cyclone Gonu was a catastrophe, leaving a large amount of damage in its trail, for the first time in the region (Figure 3.32). However, this may not be the last cyclone in the RECOFI region. There are some areas in the world that experience more than two or three cyclones per year.

Figure 3.32 Damage caused by Cyclone Gonu in the Islamic Republic of Iran
Source: Zahmatkeshan and Saadatkhah, 2007.

The “red tide” of 2008 caused many problems for people, fish and other marine organisms. It is unknown whether this will occur again in the future. In 2009, there was a bloom of jellyfish in the Gulf of Oman, causing extensive difficulties for fishers. Without knowing what new invasive, harmful or pathogenic species will migrate to the RECOFI area, it is difficult to prepare. It is necessary to develop mitigation strategies in order to combat these problems.

Fisheries management problems

There are eight countries in the RECOFI region. Fisheries management is practised separately in each country. The present approach to solve fish stock problems is based on concentrating on fishes grouped according to fishing gear. Some species have been given special attention.

The importance of fisheries in the RECOFI region with its rich marine biodiversity and productive ecosystems is clear. In recent decades, the region has experienced rapid development in the coastal zone and a loss of potential to sustain coastal and marine populations of fish. An integrated EAF in the region is necessary. This was the focus of the third meeting of the working group on fisheries management of RECOFI, 20–22 October 2009 in Doha, Qatar.

Results of present management practices
Some popular species are overfished. There are some great fluctuations in short-lived species catch, such as shrimp harvest. Low-income fishers comprise the majority of those in the fishing communities. The sustainability of fisheries is under question. The effectiveness of fisheries management in protecting fish from overfishing is minimal. Illegal and unregulated fishing and trade are out of control. Fishing data deficiencies are a region-wide problem.

Conclusions

Many problems occur as a result of inappropriate management, while other problems occur as a result of climate change. There is a need to change the fisheries management approach in the region, from the present situation to an ecosystem-based approach. In addition, sustainable fisheries for some popular species are under question and need particular attention. There is little evidence that climate change has caused change in the fisheries of the region. However, with the majority of fishers living on low incomes, the RECOFI region is highly sensitive to possible fluctuations caused by climate change in the future.

Aquaculture can be more tolerant of climate change because the system may be more adaptable to change. However, if climate change causes the environment of the region to become more saline, it will present a challenge to aquaculture with regard to finding freshwater.

Recommendations

It is recommended that the countries of the RECOFI region work together in order to build capacity to make a unified road map. This road map would be used for joint work on making strategic plans in order to adopt and mitigate climate change in the next decade. A comprehensive study on possible effects of climate change on the fisheries and aquaculture sector of the region is advisable.

Furthermore, it is recommended that the fishing methods be reviewed and upgraded to less harmful techniques. Fisheries management based on fish habitats with defined fishing grounds, fishing seasons, fish sizes, and limited harvests could result in better fish production in the long run. Unified management in the region can help to bring about better and more profitable fisheries. Aquaculture should be developed and there is room for great development of this sector. However, care is needed to avoid accidental release of exotic species into the coastal waters of the RECOFI region.

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4. EVALUATION OF UNDERSTANDING OF CLIMATE CHANGE, EAF AND EAA

4.1 Pre-workshop questionnaire

The Workshop participants were given a questionnaire prior to attending in order to gain a better understanding of their knowledge of climate change and the EAF and EAA, as well as any initiatives or information dissemination on these topics in their home countries. Eleven questionnaires were returned prior to the Workshop, and the following is an analysis of the results.

Regarding the awareness of climate change, EAA and EAF, more than half of participants who answered the questionnaire were personally aware of these topics prior to coming to the Workshop (Figure 4.1). The depth of knowledge was not known, but none of the Workshop participants were aware of any studies or publications on EAA or EAF in their country (Figure 4.2).

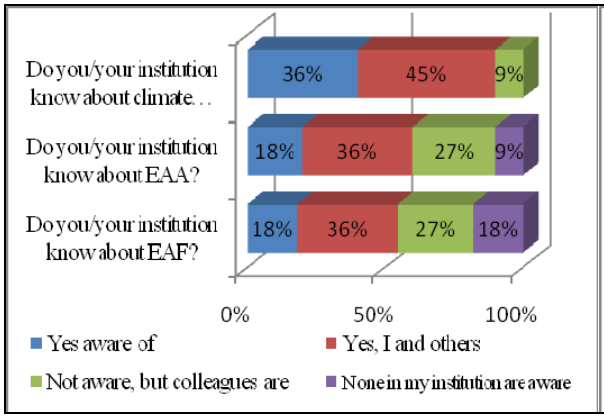

Figure 4.1 Awareness of climate change and the ecosystem approach in the RNEA

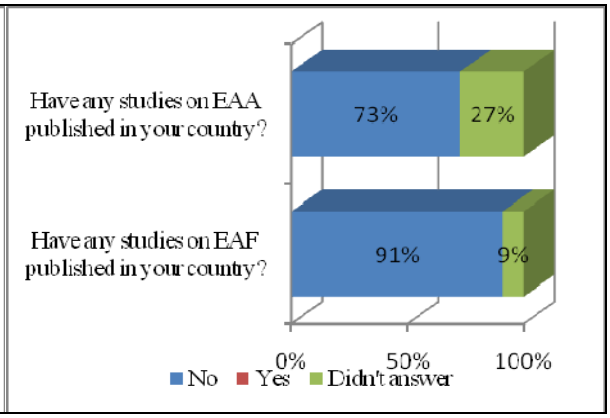

Figure 4.2 Published studies on the EAA and EAF

Government action on adaptation to climate change, as well as the implementation of the EAA and EAF was varied, as detailed in Figure 4.3. While only 27 percent of governments had formally implemented the EAA, 55 percent had implemented the EAF. The disciplines involved in this implementation were mainly fish biology and marine ecology for both. Regarding climate change, 45 percent of governments had taken some kind of action to promote adaptation to the effects of climate change, mainly by the planning, agriculture and forestry, and legislation sectors.

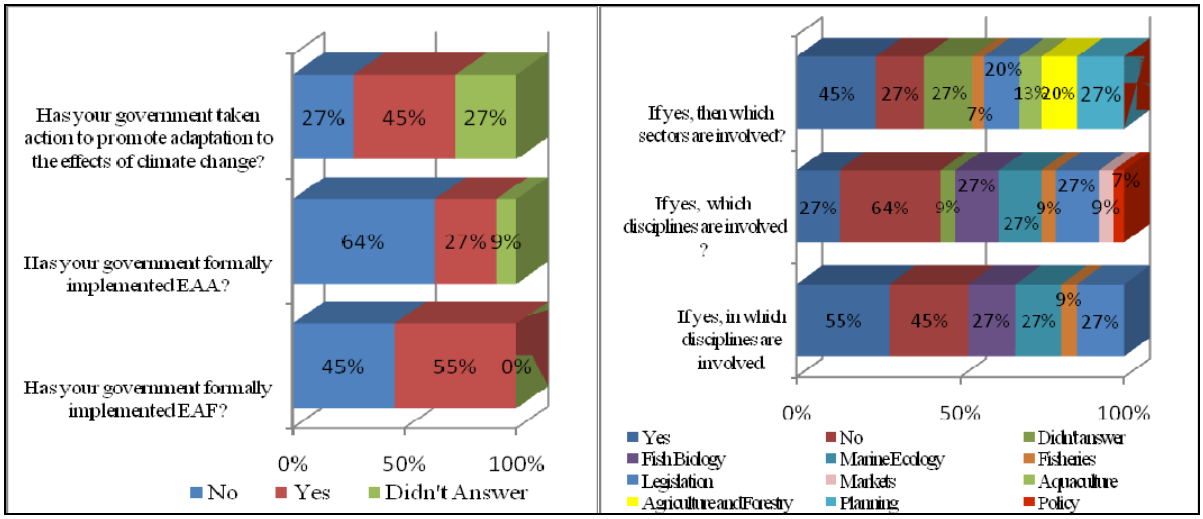

Figure 4.3 Government action on climate change, EAF and EAA

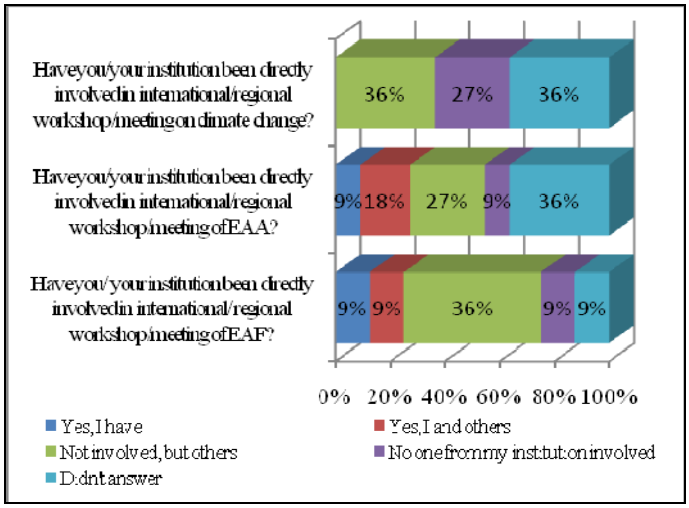

Figure 4.4 Institutional involvement in workshops on climate change, EAF and EAA

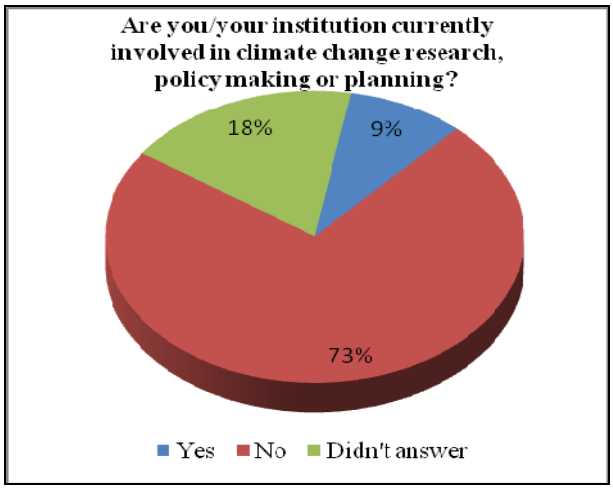

Figure 4.5 Current involvement in climate change

Very few of the participants were directly involved in workshops or meetings on climate change, the EAF or EAA, although many were aware that other colleagues from their institutions were involved (Figure 4.4). Moreover, 73 percent of respondents replied that neither they nor their institution were involved in climate change research, policy or planning (Figure 4.5).

Prior to the Workshop, 73 percent of participants felt that the EAA and EAF were useful tools for climate change adaptation, while 18 percent thought they were useful but needed improvements (Figure 4.6).

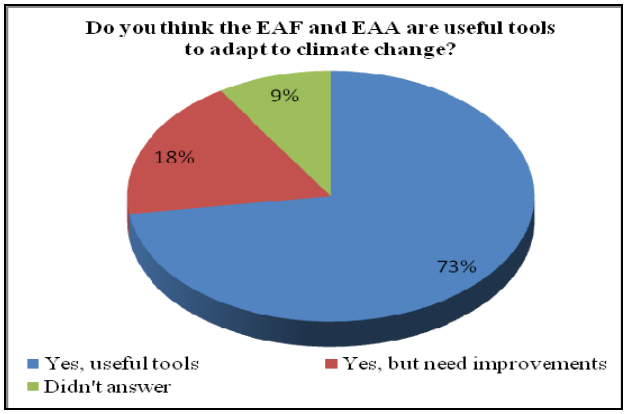

Figure 4.6 Opinions on effectiveness of EAA and EAA for adapting to climate change

4.2 Post-workshop evaluation

Upon completion of the Workshop, participants completed an evaluation questionnaire prior to departure. They were asked questions relating to how the Workshop components served the objectives (Figure 4.7), the quality of the Workshop (Figure 4.8) as well as its value (Figure 4.9) and duration (Figure 4.10). The participants were satisfied for the most part, with the exception of the duration of the workshop, where 54 percent of participants said that the duration of the workshop was insufficient in relation to the workshop components and objectives.

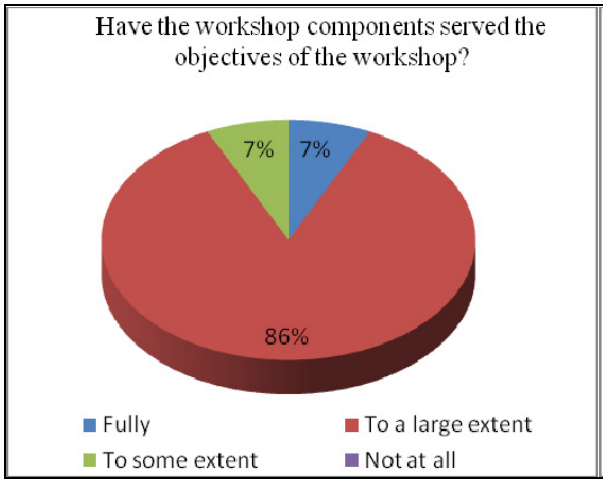

Figure 4.7 Workshop objective achievement

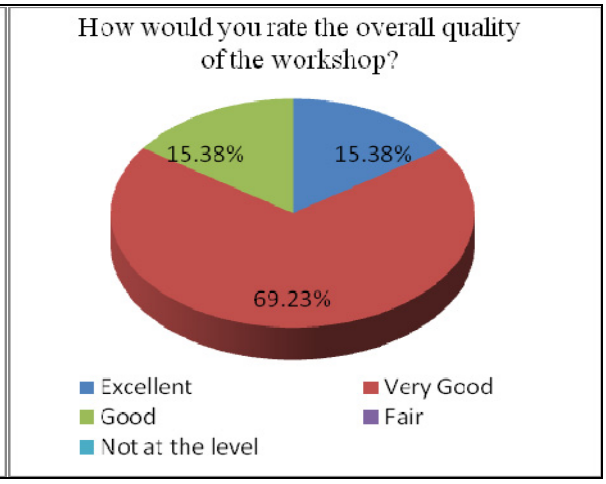

Figure 4.8 Workshop quality

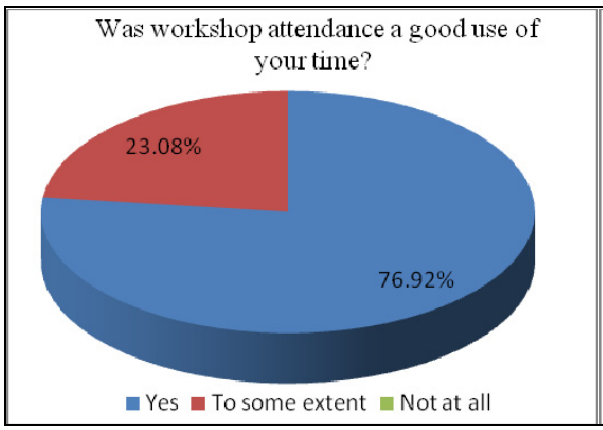

Figure 4.9 Workshop value

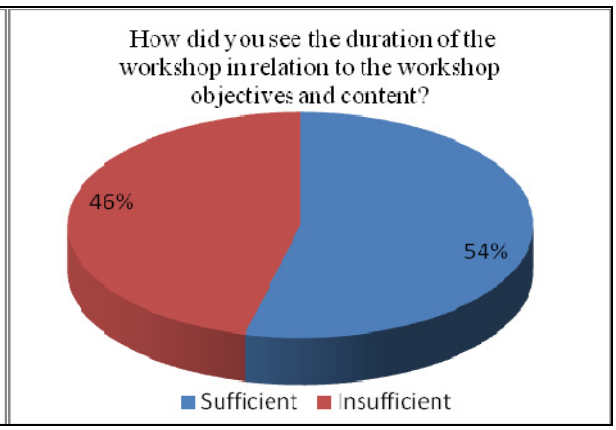

Figure 4.10 Workshop duration vs objectives and content

The final part of the evaluation questionnaire dealt with how the Workshop fared in increasing participant understanding of climate change, EAA and EAF (Figures 4.11 and 4.12). Seventy-five percent of participants said that the Workshop enhanced their understanding of adapting to climate change using the EAA and EAF to a large extent, while the other 25 percent stated to some extent (Figure 4.11). In addition, 50 percent of participants felt that their understanding of climate-change threats to fisheries and aquaculture were much better upon completion of the Workshop, with the other 50 percent responding that it was better. Twenty-five percent of participants said that their understanding of the EAF and EAA was much better, with 75 percent saying their understanding of the EAF was better, and 67 percent saying their understanding of the EAA was better. Only one participant (8 percent) stated that his understanding of EAA was about the same.

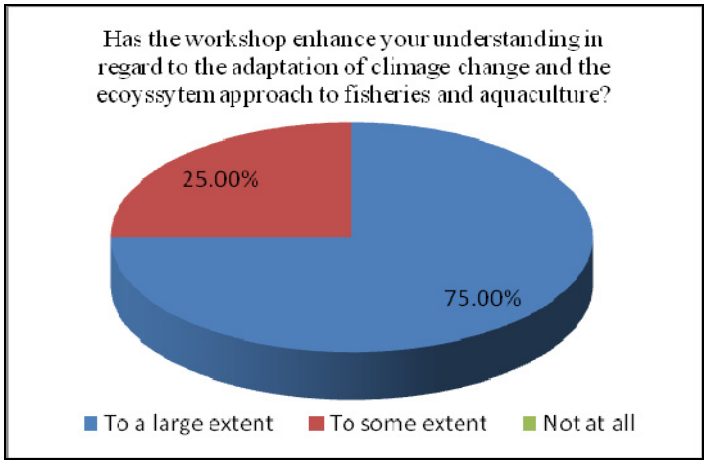

Figure 4.11 Understanding of climate change adaptation, the EAF and EAA

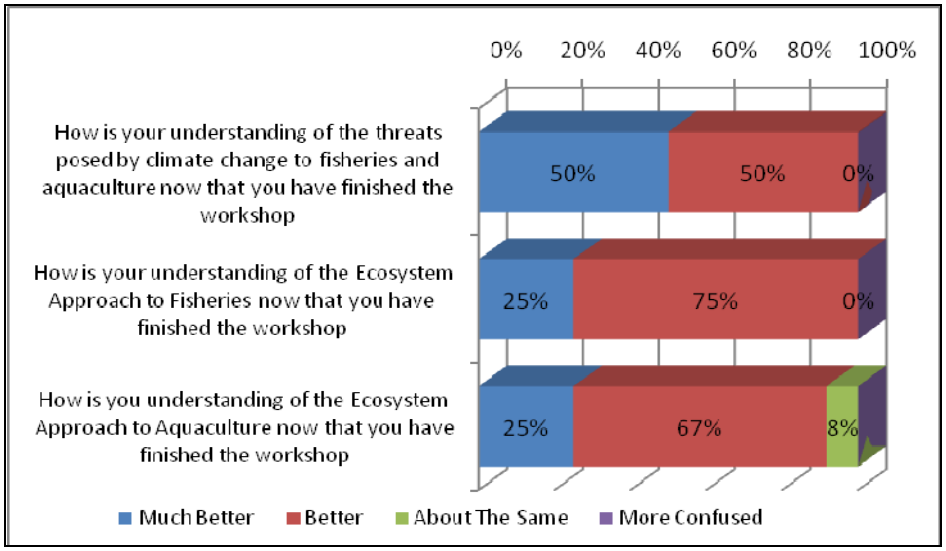

Figure 4.12 Improvements in understanding climate change, the EAF and EAA

The analysis of these results shows that while more than half of the respondents entered the Workshop with an awareness of EAF, EAA and climate change, nearly all of them departed with an enhanced understanding of the issues involved.

APPENDIX I

Finalized agenda

Date	Time	Activity
09/11/09	various	Arrival of the participants
DAY 1 10/11/09	0700–0800	Breakfast
	0830–0900	Registration
	0900–1000	Session 1 – Opening. Chair: Abdel Rahman El Gamal, WorldFish Welcome – Government of Egypt Welcome speech – (on behalf of ADG/RNE of the FAO) Welcome – WorldFish (programme details; housekeeping)
	1000–1030	Group picture and coffee break
	1030–1300 1030–1100 1100–1130 1130–1200 1200–1230 1230–1300	Session 2 –Thematic presentations. Chair: Piero Mannini, FAO Climate change in the Region (Hideki Kanamaru, FAO) Ecosystem-based approach to fisheries (EAF) (Cassandra De Young; Yimin Ye, FAO) Ecosystem-based approach to aquaculture (EAA) (Doris Soto, FAO) Climate change and fisheries (WorldFish/FAO) (Marie Caroline Badjeck and Eddie Allison, WorldFish) Climate change and aquaculture (WorldFish/FAO) (Malcolm Beveridge and Abdel Rahman El Gamal)
	1300–1400	Lunch
	1400–1500	Session 3 – Analysis of country reports. Chair: Malcolm Beveridge Analysis and discussion (Secretariat)
	1500–1530	Break
	1530–1730 1530–1600 1600–1630 1630–1700 1700–1730	Session 4 – Subregional reviews. Chair: Malcolm Beveridge Mauritania/Morocco (Abdellatif Orbi, INRH) Mediterranean (Malika Bel Hassen-Abid, INSTM) Red Sea and Gulf of Aden (Mohammed Abou Zaid, Al Azhar University) The RECOFI (Hossein Negarestan, IFRI)
	1730–1740 1740–1800	Closing session. Meeting of Secretariat
	1900–2000	Dinner for participants staying in Abbassa
DAY 2 11/11/09	0700–0800	Breakfast
	0830–1000	Session 5 – Thematic Working Groups: Identify climate change impacts on fisheries and aquaculture using ecosystem approach. Distribution of post-workshop evaluation form Divide groups and outline tasks Identify likely regional climate change impacts on fisheries and aquaculture and time-scales; summarized as bullet points
	1000–1030	Coffee break
	1030–1200	Session 5 (ctd.) – Thematic Working Groups: Identify climate change impacts on fisheries and aquaculture using ecosystem approach. Summarize as bullet points
	1200–1300	Session 5 (ctd.) Report from thematic working groups to plenary, and discussion. Chair: Cassandra de Young
	1300–1400	Lunch
	1400–1530	Session 6 – Thematic Working Groups: Identify adaptation strategies to climate change impacts for fisheries and aquaculture.
	1530–1600	Coffee break
	1600–1730	Session 6 (ctd.) – Thematic Working Groups: Identify adaptation strategies to climate change impacts for fisheries and aquaculture.
	1730–1800	Meeting of Secretariat
	1900–2030	Workshop dinner

DAY 3 12/11/09	0700–0800	Breakfast
	0830–1000	Session 6 (ctd.) – Report from thematic working groups to plenary, and discussion. Chair: Piero Mannini
	1000–1030	Coffee break
	1030–1330	Session 7 – Thematic Working Groups: Identify regional and subregional capacity to adapt to climate change impacts. Chair: Doris Soto
	1330–1430	Lunch
	1430–1530	Session 7 (ctd.) – Report to plenary on the regional and subregional capacity to adapt to climate change impacts
	1530–1600	Coffee break
	1600–1630	Session 8 – Closure Chair: Secretariat Collection of post-workshop evaluation forms
	1630–1700	Meeting of Secretariat
	1900–2000	Dinner for participants staying in Abbassa

APPENDIX 2

List of attendees

Participants

Mr Salim Al-Ghassani
Director of Fisheries Research Centre/Dhofar
Ministry of Fisheries Wealth
OMAN
E-mail: sagem15@yahoo.com

Mr Hassan Ali Al-Ghazal
Ministry of Aquaculture
SAUDI ARABIA
Tel.: +966 503924799
E-mail: hassanghazal@yahoo.com

Mr Hussain Al-Hindi
Directorate of Marine Resources
P.O. Box 20071
Manama
BAHRAIN
Tel.: +973 843010
E-mail: hjs_100@hotmail.com

Mr Mohammed Al-Kharafi
Marine Living Resources Department of Fisheries
Public Authority of Agriculture Affairs and Fish Resources
P.O. Box 21422, Safat 13075
KUWAIT
Tel.: +965 22254111/22254118
E-mail: drhmurad@paaf.gov.kw

Mr Lefghih Dit Mohamed Yahya Ould Bechiri
Ministère des pêches et de l'économie maritime
MAURITANIA
Tel.: +222 617 6333
E-mail: ouldbechir@yahoo.fr

Mr Essam El Alamy
General Authority for Fish Resources Development
EGYPT
Mobile: +2 0127130597

Mr Mohamed Yassine El Aroussi
Département de la pêche maritime
Ministère de l'agriculture et de la pêche maritime Rabat
MOROCCO
E-mail: elaroussi@mpm.gov.ma

Mr Mohamed Saif Ismail Hasan
Marine Science and Biological Research Authority
Ministry of Fish Wealth
YEMEN
E-mail: mohammedsaif@hotmail.com

Mr Ibrahim El-Hawi
Head of Rural Development and Natural Resources
Ministry of Agriculture
Bekaa
LEBANON
E-mail: hawi_leb@hotmail.com

Mr Ebrahim Abdulla Jamali
Director of Marine Resources Research Center
UNITED ARAB EMIRATES
Tel.: +9 716 7655881
E-mail: eaaljamali@moew.gov.ae

Mr Oussaid Ramdane
Director of Environment and Prevention
ALGERIA
Tel.: +21 433968
E-mail: Oussaid_mustapha@yahoo.fr

Mr Talal Ahmed Rasheed
General Direct Assistance
IRAQ
E-mail: fisheries_iraq2005@yahoo.com

Mr Moheb Ali Sistani
Deputy for Fishing and Fishing Harbours
Chabahar Fisheries General Directorate
Sistan-Baluchesta Province
ISLAMIC REPUBLIC OF IRAN
E-mail: sistani55@yahoo.com

Speakers and organizers

Dr Marie Caroline Badjeck
Post-Doctoral Fellow
WorldFish Center
E-mail: m.badjeck@cgiar.org

Dr Malcolm Beveridge
Director, Aquaculture and Genetics
WorldFish Center
E-mail: m.beveridge@cgiar.org

Ms Lori Curtis
Research Assistant
WorldFish Center
E-mail: l.curtis@cgiar.org

Dr Cassandra De Young
Fisher Planning Analyst
FAO
E-mail: cassandra.deyoung@fao.org

Dr Abdel Rahman El-Gamal
Senior Aquaculture Scientist
WorldFish Center
E-mail: aaelgamal@gmail.com

Dr Gamal El-Naggar
Director
Central Laboratory for Aquaculture Research
E-mail: gnaggar@cgiar.org

Dr Malika Bel Hassen-Abid
Institut National du Science et Technologies
E-mail: belhassen.malika@instm.rnrt.tn

Dr Hideki Kanamaru
Environment, Climate Change and Bioenergy Division
FAO
E-mail: hideki.kanamaru@fao.org

Dr Piero Mannini
Senior Fisheries Officer
FAO
E-mail: piero.mannini@fao.org

Dr Hossein Negarestan
Department of Aquatic Ecology
Iranian Fisheries Research Institute
E-mail: hosseinnegarestan@yahoo.com

Dr Doris Soto
Senior Fisheries Officer (Aquaculture)
FAO
E-mail: doris.soto@fao.org

Dr Yimin Ye
Senior Fisheries Resource Officer
FAO
E-mail: yimin.ye@fao.org

Dr Mohammed Abou Zaid
Professor of Aquatic Animals
Al-Azhar University
E-mail: abouzaid_mohamed@yahoo.com

Observer

Dr Faisal Bukhari
Aquaculture Consultant
SAUDI ARABIA
E-mail: feisalbukhari@yahoo.com

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