Consultancy on Elasmobranch Identification and Stock Assessment in the Red Sea and Gulf of Aden

Final Report

Presented to the:

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Executive Summary

A consultancy on elasmobranch identification and stock assessment in the Red Sea and Gulf of Aden was carried out for SAP/PERSGA by Dr. Ramón Bonfil.

The objectives of the consultancy were capacity building in elasmobranch species identification, capacity building in fisheries stock assessment, preparation of a specialized field identification guide to the sharks and batoids of the Red Sea and Gulf of Aden, and the promotion of the sustainability of the elasmobranch fisheries through the production of formats for data collection, preparation of a curriculum for formal training in stock assessment, evaluation of the main problems in the shark fisheries of the region, and the provision of expert advice for the sustainability of the fisheries and the conservation of the elasmobranch resources.

Two training courses were delivered to a total of 75 staff from 7 member countries, and two training manuals documenting and complementing these courses were prepared.

A 4-day course on Shark and Batoid Identification and Field Sampling was taught by the consultant at the Sub-Regional Research and Training Centre of Aden during April 28-May 1st 2001, to a total of 52 trainees from Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen. The course included theory as well as practical sessions where fresh specimens were identified in the laboratory. The course was used to provide local fisheries enumerators and other regional staff with the specialized skills required for proper identification of shark and batoid species, and knowledge of the methodology used for proper biological sampling of elasmobranchs on the field.

A Training Course in Stock Assessment of Shark and Ray Fishery Resources was conducted at the Sub-Regional Research and Training Centre of Aden, on 27th April – 2nd May, 2002. The course objectives were: 1) To train regional fisheries scientists in the theory of modern stock assessment methods with particular emphasis on sharks and rays; 2) To provide trainees with direct practical experience in the computer-based analysis of data and elaboration of stock assessments using examples of elasmobranch fisheries from the literature; 3) To increase the technical capacity of regional staff as a foundation for the long-term proper management of the resources. Twenty-three participants from Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen attended the course. At the request of the LMR Lead Specialist and in order to promote the better acquisition of fisheries data that is essential for adequate stock assessment work, the instructor also trained the participants briefly in species identification.

Two trips to the region were made by the consultant in the company of the LMR-LS and were used to carry out field surveys of the main fishing points and interviews at relevant governmental agencies in Egypt, Sudan, Djibouti, Saudi Arabia and Yemen. The objectives of these trips were to obtain information from original sources on 1) the structure of shark and batoid landings in terms of species, sex, size and sexual maturity, and 2) information on the importance of elasmobranch fishing in each locality, the type and size of vessels and fishing gears used, major fishing grounds being exploited, and to assess the magnitude of the landings. Fishermen, fishermen representatives, and managers of governmental agencies related to fisheries management, research, and the marine environment, were interviewed with the aim of obtaining further information about the structure and characteristics of the fisheries sector, the existing fisheries management systems, and official statistics on catch and effort for elasmobranchs.

The first trip of the consultancy took place between November 4 and 22, 2000. A total of nine of the most important fishing localities along the coasts of Saudi Arabia (Jeddah and Gizan) and

Yemen (Al-Hodeidah, Hadiboh, Mahfriehem, Zaheq, Bir Ali, Mukkallah and Shukra) were visited.

During the second trip of the consultancy (April 2-May 12, 2001) 20 different localities spanning 5 countries (Djibouti, Egypt, KSA, Sudan and Yemen) were visited. Information on the fishing sector (the characteristics of vessels and gear, fleet size, frequency and duration of fishing trips, average catch per trip, costs of fishing, ex-vessel prices, etc.) was collected through interviews with fishermen and fisheries officers and through direct observations in most localities. In addition, statistical data on shark landings were collected with the cooperation of several persons in Hodeidah, Khokha, and Qusayar in Yemen, and in the Red Sea coast of Egypt.

A total of 247 sharks and batoids belonging to 34 species were sampled during the field surveys. Data recorded for each fish included from one to three different measurements of the size, their sex, and their reproductive status. Whenever available, information about the fishing trips was also recorded. The information gathered through the field surveys evidenced the presence of at least 28 species of sharks and 17 species of batoids for the region. A total of 5 of these species (*Hemigaleus microstoma*, *Aetomylaeus vespertilio*, *Dasyatis* sp. *Himantura fai*, and *Mobula japanica*) were recorded for the first time in waters of the Red Sea and Gulf of Aden. Using information carefully reviewed from the literature the list of elasmobranchs of the region was expanded to a total of 44 shark and 33 batoids species.

One of the main products of the consultancy was the preparation of a Field Identification Guide to the Sharks and Batoids of the Red Sea and Gulf of Aden. The guide was written based on an exhaustive literature review of the subject and the information about species occurrence obtained directly in fish markets and main landing points of the region, and other field data collected during the field surveys. The guide covers the Orders and Families occurring in the region, and individual entries for a total of 44 shark and 33 batoid species. It is fully illustrated and contains an extended bibliography as well as colour plates for most of the species occurring in the area, mostly taken during the field surveys in the region. Through personal negotiations of the consultant, FAO's SIDP will print and publish the guide as part of FAO's series of field identification guides. As a complement to the training in species identification and the work of the guide four small reference collections of identified elasmobranchs were created and deposited in research laboratories or fisheries offices in Egypt, KSA, and Yemen. Together, these collections include a total of 26 different species of sharks and batoids. The purpose of these collections is to provide support reference material to local personnel studying the shark and batoid fauna of the region and to foster further training in identification.

A review of the shark and batoid resources of the region and the fisheries for elasmobranchs is presented in this report. Elasmobranch fisheries in the region are heavily centered on sharks; the composition of the catches as evaluated through the field surveys is dominated by *Rhizoprionodon acutus, Carcharhinus limbatus, C. sorrah, C. amblyrhynchos, C. falciformis, Loxodon macrorhinus, Mustelus mosis* and *Sphyrna lewini.* Relevant biological and ecological information for these species is summarized, including when available in the literature, an evaluation of their rebound potential, a relative measure of the capacity of each species to recover from exploitation. Species that grow to smaller sizes tend to have higher rebound potential than their larger relatives, however information based on population dynamics parameters derived from the populations inhabiting the region are urgently needed for better assessment of their real rebound potential and for the elaboration of future stock assessment studies. The structure of the catches indicates that the fisheries catch very large amounts of juvenile sharks of many species. Of particular concern is the heavy fishing of newborn

Carcharhinus limbatus and juvenile *C. sorrah* in nursery areas and the frequent catch of pregnant *C. falciformis*.

The information gathered through the surveys confirms the preponderance of Yemeni fisheries as the most important for shark and batoid exploitation, but also highlights previously unknown shark fisheries in Djibouti, based on Obock and the 7 Brothers Islands.

Severe problems of waste, poor utilization and bad handling and processing of elasmobranchs and particularly sharks, were identified in some parts of the region, particularly in southern Yemen. The most important problem is that fishermen in many parts of the region do not bleed sharks and rays therefore causing breakdown of the naturally high urea contents in their blood into ammonia, which gives the carcasses a bad taste and a pungent odor. The poor handing and the processing of the catches translate into a large amount of waste, a very low product quality, and ultimately the loss of potential increased revenues from the fishery. Finning practices are known to occur in the Yemeni fisheries but remain unquantified.

With few exceptions, the elasmobranch fisheries of the region are characterized by an extremely poor informational baseline, a low degree of organization, a lack of direction and an almost total absence of regulation. These characteristics are common to other fisheries in the region but are particularly acute in the case of shark and batoid fisheries.

There are many problems with the collection of fisheries data in most countries including unreliable estimates of the total catches (landings + discards at sea), a total lack of collection of effort data, no monitoring of the abundance of the species or the location and state of nursery areas, and lack of research of the fisheries biology of the principal species. These problems are particularly serious in Yemen (where landings of elasmobranchs are not even weighed but rather estimated by eye) which is the most important fishing nation and the major player in the shark fisheries in the region. Another major problem in the data collection system of all countries in the region is the lack of species detail in the data for elasmobranch catches, which are not recorded or reported with any degree of species breakdown or even species-group breakdown. This precludes the availability of adequate statistics on the catches of each species. The problems with data collection and monitoring in the region are such that there is no information available to carry out proper evaluations of the state of the stocks and this precludes the sound long-term management of the elasmobranch fisheries. As a consequence, there are no stock assessment studies for any of the elasmobranch fisheries in the region.

A set of wider-scale problems affect the overall fisheries management systems of all countries in the region and preclude most possibilities of advancement of efforts to attain sustainability in the shark and batoid fisheries. These problems range from shortage of human and financial resources for the execution of most of the activities required for adequate fisheries management to the existence of outdated and inefficient legislative and management frameworks. Some of the most acute problems include lack of strength and clarity in the laws for effective management, monitoring, control and surveillance, lack of transparent and controllable resource management and allocation decision mechanisms, lack of stock assessment studies, poor or non-existent capacity for monitoring, control and surveillance, lack of vessel registration and licensing systems for small-scale fisheries, lack of or poor enforcement of fisheries laws, and ineffective sanctions for violations to the law. While these large scale problems in the fisheries sector are not addressed and solved, it will be impossible to make substantial progress in the conservation and sustainable management of the elasmobranch fisheries in the region.

A two-tiered strategic plan for the eventual attainment of the objectives of sustainable management and conservation of the shark and batoid resources in the region is proposed in this report. First, immediate actions should be applied to improve the management of the elasmobranch fisheries, including precautionary measures consistent with the Code of Conduct for Responsible Fishing of FAO. These immediate measures should resolve urgent problems and set the foundation that is required for the eventual implementation of a second set of recommendations, which cannot take place until the problems that plague the fisheries management systems and the fisheries sector at a wider scale are not solved.

Proposed measures that should be implemented without any delay include: placing limits in the numbers of fishing vessels and gears that are allowed in the elasmobranch fisheries in order to prevent further increases in fishing mortality and ease the management of the effort in the future; establishment of temporary caps in the catches of elasmobranchs in each country until proper stock assessments are carried out to indicate what are the sustainable levels of catch; controlling the catch of newborn and juvenile sharks in nursery areas in order to prevent growth overfishing and possible stock collapse; reductions in the catches of the grey-reef shark which is a species of great importance to the eco-tourism industry; the prohibition of finning practices across the region which promote waste and go against the principles of full utilization; the full protection through legislation of endangered species such as the sawfishes and the whale shark; the elaboration of National Plans of Action for the Conservation and Management of Sharks as recommended by FAO; the promotion of better procedures for handling of the elasmobranch catches and in particular the bleeding of sharks immediately after capture; the promotion of better processing of the landings and in particular the production of high-quality dried-salted shark meat which could be sold at better prices domestically and internationally and increase the revenue in the fishery; the conduction of studies to evaluate the amounts of methylmercury and other health-risk heavy metals in the flesh of the sharks and batoids of the region; the establishment of an *ad hoc* Regional Shark Fisheries Management Group working under the principles of coordination and cooperation in the field and resource and information sharing, to plan and begin implementation of regional strategies for cost effective management, monitoring, surveillance and research; and the establishment of levies in the shark and batoid fisheries of the region in order to partially fund the expenses of management of the resource.

The second set of management recommendations requires first an overhauling and strengthening of the fisheries management systems in the region, in order to be feasibly implemented and successful in achieving their goals. These measures include: establishment of effective data collection systems for, a) the total catches (landings + discards at sea) of elasmobranchs on a species by species basis at least for the main species in the landings, and b) effort data for the elasmobranch fisheries that includes the appropriate level of detail in the measures of effort as well as spatial resolution of fishing operations; establishment of at-sea observer programs for the larger vessels operating in the shark fisheries; the initiation of long-term and carefully planned fishery-independent surveys of the abundance of sharks and batoids throughout the region in order to allow the eventual proper conduction of stock assessment studies; the recovery of historical catch and effort data for the shark fisheries through surveys using properly trained local scientists to visit fishing cooperatives and companies and search through their archives for detailed data on shark landings, so that this essential information can be used to support the conduction of the best possible stock assessment studies for the fishery; implementation of a program to substitute with shark longlines the highly-unselective and destructive gillnets used extensively for shark fishing in the region and the eventual prohibition of the latter in the fishery; implementation of mandatory usage of bycatch reduction devices across the entire trawling fleet of the region to substantially reduce the incidental killing of batoids, sharks, and other fragile marine species; fostering of dedicated research in the population dynamics of all the elasmobranch species in the region starting with those of main importance in the catches; the mapping and surveying of shark and batoid pupping and nursery grounds; and the performance of regular stock assessment for elasmobranchs on a species by species basis.

Activities that should be carried as a follow-up of this consultancy are the continuation and expansion of training courses in elasmobranch identification and stock assessment in the region using the materials produced through this consultancy and others as needed, and the conservation and expansion of the reference collections of preserved specimens of sharks and batoids.

List of Acronyms

ANOVA – Analysis of Variance
BRD- Bycatch reduction device
CFC – Coastal Fisheries Corporation (Yemen)
CPUE – Catch per unit of effort
EPC – Environmental Protection Council (Yemen)
FAO – Food and Agriculture Organization of the United Nations
FISHSTAT – Fisheries Statistical Database (FAO)
FMDC – Fisheries Manpower Development Center (Yemen)
FRC – Fisheries Research Centre (Sudan)
FRP – Fiberglass Reinforced Plastic
GAFRD – General Authority for Fisheries Resources Development (Egypt)
GEF – Global Environment Facility
GIS – Geographic Information Systems
GLIM – General linear models
IBM – Inboard motored (vessels)
INFOFISH - Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Product in the Asia Pacific Region
IsDB – Islamic Development Bank
IPOA-Sharks – International Plan of Action for the Conservation and Management of Sharks
IUCN – World Conservation Union
JECFA – Joint Expert Committee for Food Additives and Contaminants
PTWI – Provisional Tolerable Weekly Intake
KSA – Kingdom of Saudi Arabia
LMR-LS – Living Marine Resources Lead Specialist
LMR-WG - Living Marine Resources Working Group
MAW/MFD – Ministry of Agriculture and Water/Marine Fisheries Department (KSA)
MCS – Monitoring, Control and Surveillance
MFA – Marine Fisheries Administration (Sudan)
MFRC – Marine Fisheries Research Center (Sudan)
MFW – Ministry of Fish Wealth (Yemen)
MPA – Marine Protected Area
MSRRC – Marine Sciences and Resources Research Centre (Yemen)
MSS – Marine Sciences Station (Jordan)
NCSFM – National Corporation for Services and Fish Marketing (Yemen)
NGO – Non-governmental Organization
NIOF – Institute of Oceanography and Fisheries (Egypt)
NORAD – Norwegian Agency for Development
RFMO – Regional Fisheries Management Organization
OBM – Outboard motored (vessels)
ODA – Overseas Development Administration (United Kingdom), now DFID, Department for International Development
PCL – Pre -caudal length
PDRY – People's Democratic Republic of Yemen
PERSGA – Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
SAP – Strategic Action Programme
SIDP – Species Identification and Data Program (of FAO)
t – Tonnes (metric tons)
TL – Total length

TOR - Terms of reference
UK – United Kingdom of Great Britain
UNDP – United Nations Development Programme
USA – United States of America
USAID – United States Agency for International Development
USD – United States Dollars
YAR – Yemen Arab Republic
YFC – Yemen Fishing Corporation

Introduction

1.1. PERSGA, SAP and the Need for Sustainable Elasmobranch Fisheries in the Region

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is an intergovernmental organisation devoted to the conservation of the coastal and marine environments in the region. Due to the increased pressures in the marine environment of the region, the Strategic Action Programme (SAP) funded by the GEF and donors within the region such as the Islamic Development Bank (IsDB), is being executed by PERSGA. The SAP is a continuous, consultative and cooperative process among the coastal states of the Region.

The exploitation of shark-like fishes in the Red Sea and Gulf of Aden dates back several decades and in some cases even centuries. The catches have been modest for most part of this century but a considerable increase in landings has been observed since the mid-1970s.

The countries fishing for sharks and rays in the Red Sea and Gulf of Aden share common problems. The principal and most pressing of them is that none of these countries has any kind of control in the form of management measures to make sure that the shark and batoid populations remain healthy for the fisheries to continue on a sustainable basis. Furthermore, there is a general lack of knowledge of how many species of shark and rays are found in the region, which are the main species in the catches, and even what is the real size of the catches and the amount of fishing effort put by the fishermen in the region. Given the trend of increase in the catches of these resources, it is urgent that the countries in the region enlarge their capability to monitor, assess and manage the shark and ray resources they are exploiting.

The upgrading of regional joint efforts to conserve marine biological resources is one of the main goals of the SAP. Due to a pressing need to undertake measures towards shark conservation and fisheries management in the region, during 2000 PERSGA sought the services of the author as a consultant in order to achieve its aims of capacity building of national and regional scientists in elasmobranch identification and shark stock assessment. As part of the contractual agreement, the consultancy was scheduled to include three trips of the consultant to the region, deliver two training courses, prepare training materials, and provide advice for the conservation and management of the fisheries. The present document is the final report for the Consultancy on Elasmobranch Identification and Stock Assessment in the Red Sea and Gulf of Aden.

1.2. Structure of the Report

The present report follows as much as possible the guidelines for the preparation of technical reports provided by PERSGA. The First Chapter introduces the regional and international context in which shark and batoid sustainable exploitation and conservation are set, and provides a summary about the biology and fisheries for sharks and batoids. The objectives of the consultancy are presented in Chapter 2 and the methodology used to carry out the work is given in Chapter 3. The training courses delivered in the region as part of the consultancy, the training materials and the curriculum prepared to complement the courses are presented in Chapter 4 together with the formats designed for data collection and a description of the data acquired during field trips. Chapter 5 includes an in-depth characterization of the fisheries for elasmobranchs in the region and discusses their general situation as evaluated through the course of the consultancy. Finally, Chapter 6 summarizes the main problems for the elasmobranch fisheries in the region and provides a set of recommendations for their sustainability and for the conservation of the local stocks of sharks and batoids. The annexes present a series of tables and larger documents that are germane to the report as well as larger products of consultancy such as the draft identification guide.

1.3. Background

1.3.1. Shark Biology

One of the chief problems faced when dealing with elasmobranch fisheries is that the biological and ecological profile of this group of fishes makes them highly prone to overexploitation. Most shark and many batoid species can be classified as strong K strategists (Hoenig and Gruber 1990). They are long-lived, some species reaching up to 70 years of age. This, together with their comparatively slow growth (Cailliet 1986, Cailliet et al. 1990), results in a late age of first sexual maturation, which ranges between 3 and 35 years depending on the species and stock. Most elasmobranchs have a very low fecundity when compared with bony fishes or marine invertebrates; the range of young produced by a female shark is between 2 and 125 per litter although most commercially important species have only between 6 and 12 young per litter (see Pratt and Casey 1990 for a summary of key life-history characteristics of sharks). In addition, it many shark species do not reproduce every year; in fact it is quite common that a resting period of several months to a year takes place between pregnancies (Smith et al. 1998; Cortés 2000). The combination of all these factors confers sharks and batoids with very low reproductive potentials as compared with other marine resources (i.e. shrimps, sardines, tunas) and means that the productivity and resilience of elasmobranch stocks is comparatively low.
At the community level, the top predator niche occupied by many sharks raises the question of their importance as regulators of other species' densities and keepers of ecosystem balance. Modelling work and empirical evidence suggest that the implications of the removal or severe depletion of sharks can cause unexpected and negative effects in certain ecosystems (Stevens et al. 2000).

1.3.2. Shark Fisheries

Sharks and batoids have been fished and utilized since millennia ago by some cultures, but have only recently gained popularity in the global arena of fishery resources. The increasing trend of overexploited stocks, world population growth and the need for additional sources of food and income and even cultural phenomena have all influenced the growth in elasmobranch exploitation worldwide. An in-depth review of elasmobranch fisheries worldwide is given by Bonfil (1994) whose work was updated by Stevens et al. (2000). These two sources provide the core of the information presented in this section.

Global reported landings of sharks, batoids and their relatives have been increasing steadily since the mid-1950s and according to FAO statistics (FAO 2002) reached a historical record of 856,726 t in 2000. However, the total catch is probably closer to 1.5 million tonnes, due to a large unreported by-catch (Bonfil, 1994). According to official statistics for the last five years, the top ten elasmobranch-fishing nations are in order of importance: Indonesia, India, Taiwan, Pakistan, Mexico, USA, Japan, Spain, France, and Sri Lanka. Of these, some have artisanal, multispecies, and multigear fisheries, while Japan and Taiwan have high-seas fleets, and unfortunately only the USA has management of its elasmobranch fisheries. In fact only four countries worldwide have formal management plans for their shark and batoid fisheries (Australia, Canada, New Zealand, and the USA).

The main groups of elasmobranchs taken in fisheries around the world are carcharhinids (gray or requiem sharks), sphyrnids (hammerheads), and batoids (skates and rays). Unfortunately, little species-specific or fishery-specific data are available from areas with the highest catches, and virtually nothing is known about the status of individual stocks. During the 1940s, several target shark fisheries developed in response to the market for vitamin A from livers; more recently, fisheries have targeted chondrichthyans for their meat, fins, livers, and other products. There is abundant historic evidence of major declines in shark and batoid stocks due to direct or even incidental fishing around the world (Holden 1974; Anderson 1990; Casey and Myers 1998; Baum et al. 2003). Frequently cited examples of collapses due to directed fisheries are the Californian fishery for soupfin (*Galeorhinus galeus*), the Norwegian fishery for porbeagle (*Lamna nasus*), several fisheries for basking shark (*Cetorhinus maximus*) and spiny dogfish (*Squalus acanthias*). Cases of extirpation of batoid fishes from large parts of their distributional range due their incidental catches in bottom trawl fisheries are the common ray (*Dipturus batis*) in the Irish Sea, and the barndoor ray (*Dipturus laevis*) in the NW Atlantic. Bottom trawl fisheries are some of the most impacting fisheries on skate and ray populations due to the high incidental catches they cause, the high mortality of these by-catches, and the fact that they are usually not reported making it difficult to detect the steady reductions in the abundance and range of these batoid fishes.

Sawfishes (family Pristidae) are one of the most threatened groups of elasmobranchs due to fishing and habitat destruction, although quantitative catch data are mostly lacking. They are mainly demersal in shallow coastal, estuarine, and freshwater habitats and are particularly vulnerable to all types of gear. Little is known about the biology of deep-water squalid sharks. However, the low productivity of many deep-water fish in general and the apparent sensitivity of deep-water squalids to fishing (Wilson and Seki, 1994; Graham *et al.*, 1997) suggest that they may be even more vulnerable to exploitation than other elasmobranchs. Pelagic sharks represent a large by-catch of global high-seas long-line fisheries targeting tuna and billfish, and are retained primarily for their highly valued fins. There are currently few regulations for reporting their by-catch in the oceanic zone, which includes mainly blue *Prionace glauca*, oceanic whitetip (*Carcharhinus longimanus*), and silky shark (*Carcharhinus falciformis*). Bonfil (1994) estimated that 6.2–6.5 million of these species are taken annually around the world.

Sport or recreational fisheries for sharks also contribute to the total catches worldwide and can be quite important in some localities. In the USA, which has the largest recreational fisheries, landings of large sharks from the Atlantic coast and Gulf of Mexico were estimated at 8,000 t per year between 1970 and 1986 (Anderson, 1990). Data for 1996 suggest that some 5.4 million sharks were caught by anglers in these waters, of which about 445 000 were retained (Camhi, 1998). While the impact of these catches in isolation is not known, in combination with commercial landings they are likely to have contributed to stock depletion in the area (Musick *et al.*, 1993).

1.3.3. International Context for the Conservation and Management of Sharks

The International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks) developed by FAO (FAO 1999) through consultations with its member countries and a panel of international experts sets the standards and makes recommendations for the sustainable management and conservation of elasmobranchs. The text of the IPOA-Sharks is provided in Annex I. A second publication by FAO (FAO 2000) provides guidelines for the conservation and management of sharks. However, due to the larger size of that document it is not included here. It can be easily downloaded from FAO's web site http://www.fao.org/fi/. The latter document summarizes critical information about the IPOA-Sharks and its implications. This summary is given in the following two sections with some minor editorial modifications.

1.3.3.1. IPOA-Sharks: objectives and background

The overall objective of the IPOA-Sharks is to ensure the conservation and management of sharks and their long-term sustainable use. There are three guiding principles associated with meeting this objective.

- Participation. States that contribute to fishing mortality on a species or stock should participate in its management.

- Sustaining stocks. Management and conservation strategies should aim to keep total fishing mortality for each stock within sustainable levels by applying the precautionary approach.

- Nutritional and socio-economic considerations. Management and conservation objectives and strategies should recognize that in some low-income food-deficit regions and/or countries, shark catches are a traditional and important source of food, employment and/or income. Such catches should be managed on a sustainable basis to provide a continued source of food, employment and income to local communities.

The IPOA-Sharks is a voluntary instrument elaborated within the framework of the Code of Conduct for Responsible Fisheries as envisaged by Article 2 (d). However, all concerned States are encouraged to implement it. The IPOA-Sharks is not a full strategic plan for the world, rather it prescribes a process whereby individual States, relevant sub-regional arrangements through bilateral and multilateral agreements, and relevant regional fisheries management organizations (RFMO), identify national, sub-regional and regional issues and then appropriately develop national, sub-regional and regional 'Shark Plans' to address the issues. Each State and RFMO (and where required each sub-regional entity) should regularly carry out a regular assessment of the status of its shark stocks subjected to fishing so as to determine whether or not there is a need to develop a Shark Plan. FAO recommends that States and RFMOs that implement a Shark Plan should assess its implementation at least every four years for the purpose of identifying cost-effective strategies for increasing its effectiveness. Furthermore, each State and each RFMO was encouraged to have its first Shark Plan prepared for the COFI Session scheduled for February 2001. However, little progress had taken place up to 2002.

FAO, as part of its Regular Programme of activities, supports States in the implementation of the IPOA-Sharks, including the preparation of Shark Plans and provision of in-country technical assistance. FAO will report biennially through COFI on progress of the implementation of the IPOA-Sharks.

Four elements of the IPOA-Sharks include (a) the particular conservation needs of some shark and other chondrichthyan species, (b) the need for maintenance of biodiversity through viability of shark populations, (c) the need for habitat protection, and (d) the management requirements of shark fishery resources for sustainable use. These elements apply variously for different species and relate to the principles of 'ecologically sustainable development' and 'inter-generation equity' in that they should provide ongoing benefits to successive generations of humans.

Species conservation. Some species of shark need 'special protection' (or 'special management'). This is because some species of shark have particularly low productivity, naturally small populations (rare), a spatially small distribution range, or a distribution range within regions of high anthropogenic impact where they might be threatened or have their populations severely depleted. Such species may need special protection through management action such as prohibition of their capture, prohibition of specific fishing gears, or closed areas to their capture or use of specific fishing gears.

Biodiversity maintenance. Biodiversity is the variety of living organisms in all their forms and defined in terms of genetic diversity, species diversity and ecosystem diversity and the interrelations between genes, species and ecosystems. The number of species and within-species genetic variability of shark and other chondrichthyan species is naturally low compared with those of many other taxonomic groups. The loss of species, the loss of individual populations within a species, or loss of genetic variation within a species or population, and consequential loss of ecological processes reduce biodiversity and benefits to human kind. Loss of biodiversity can be caused by increased mortality, loss or degradation of habitat, change of environment, and changes in competition with other species, resulting from the introduction of exotic or genetically altered species or from other ecological changes.

Habitat protection. Anthropogenic activity such as fishing, aquaculture, ecotourism, dredging, mining, catchment area clearing, dumping, nutrient enrichment, pollution, or introduction of exotic organisms can lead to broad-scale degradation of a species habitat range or loss of critical habitat such as nursery, pupping and mating areas or migration lanes of a species. Special habitat protection or habitat restoration programmes might be required where a species abundance or range has been reduced as a result of habitat loss.

Management for sustainable use. Sustainable use requires an understanding of the biophysical and ecological systems and requires maintaining stocks at, or restoring to, levels above those capable of producing maximum sustainable yields. The concept of sustainable catch has to be viewed within the constraints that ecosystems are in dynamic equilibrium and shift between different states depending on natural oscillations in the environment such as El Niño, on anthropogenic stress such as fishing and other activities impacting ecosystems, and, possibly, on climate change. Managing shark resources for sustainable use involves controlling fishing mortality through limiting fishing effort and/or catch and through biological controls such as legal minimum lengths, prescribed mesh-sizes or hook sizes of the fishing gear, closed seasons and closed areas.

1.3.3.2. Precautionary approach and IPOA-Sharks

The precautionary approach requires fisheries managers to be cautious when the state of a resource is uncertain, such as when fishery data are insufficient or unreliable. When faced with such uncertainty, managers are required to ensure that exploitation is conducted at a minimal level. The precautionary approach has been embodied in two important international initiatives: the 1995 United Nations Agreement on Straddling and Highly Migratory Fish Stocks and the 1995 FAO Code of Conduct for Responsible Fisheries.

The low productivity of shark stocks in general, the particularly low productivity of some species of shark, and naturally small population size or rarity of some species of shark implies that the precautionary approach is most applicable to this group of fishes. Their stocks can often be rapidly depleted to very levels and be slow to recover from the effects of overfishing. Controls should be implemented early during the developmental phases of fisheries taking sharks and other chondrichthyan species.

1.3.3.3. Implementation of the IPOA-Sharks

The IPOA-Sharks sets the required steps that should lead to the sustainability and conservation of elasmobranch resources. However, the capacity to implement all its recommendations depends on the particular context of each country and region. As a framework document it provides and ideal situation that is currently impossible to implement in full in the PERSGA region due first to the existing problems in the fisheries sector of the region outlined below (see section 5.1 and particular 5.1.3.6) and secondly due to the costs implied in such an implementation. Nevertheless, the spirit of the IPOA-Sharks and its recommendations have been kept closely in mind throughout the execution of this consultancy and especially during the drafting of recommendations for the sustainable management of the shark and batoid resources of the PERSGA region.

Ultimately, the information gathered through the consultancy -both in terms of literature review and original data obtained through the field surveys- and presented in this report can serve as the basis for the preparation of the shark-plans at the national and regional level that the IPOA-Sharks makes reference to.

2. *Objectives of the Consultancy*

The objectives of the consultancy are expressed in very general terms under the TOR as capacity building of national and regional scientists in elasmobranch identification and in shark stock assessment. Using the remaining text of the TOR and based mainly on the list of tasks specified therein, the objectives of the consultancy can be more explicitly defined and classified in three major headings as follows:

2.1. Capacity Building

The region lacks properly trained personnel for the monitoring, stock assessment and management of elasmobranch fisheries. One of the main aims of PERSGA and SAP through this consultancy is capacity building of national and regional scientists in elasmobranch identification and stock assessment. This includes two sets of activities under the present consultancy:

2.1.1. Teaching of formal training courses in:

- Elasmobranch species identification and sampling methods
- Stock assessment of shark and batoid fishery resources

2.1.2. On the Field Training – Practical training in shark identification and sampling methodology of local personnel accompanying the consultant during field surveys on his visits to the region.

2.2. Promotion of Sustainability in the Fisheries

There is an urgent need to advance the sustainable management of elasmobranch fisheries among the member countries. As part of PERSGA's efforts towards this objective, the consultancy had the following goals:

2.2.1. Preparation of training materials

- A manual for identification of sharks and batoids and sampling methodology
- A manual for stock assessment of shark and ray fishery resources

2.2.2. Development of a curriculum for formal training in stock assessment
2.2.3. Design of Formats for Data Collection
2.2.4. Recommendations for Fisheries Management and Monitoring

2.3. Preparation of a Regional Identification Guide and Creation of Reference Collections

The lack of appropriate and updated literature to support the identification of the sharks and batoids taken by the fisheries in the region is one of the main factors that make it at present impossible to generate adequate fisheries and biological data by species or species groups. Such types of information are fundamental to the eventual assessment of the resources and the recommendation of management measures based on the best available science. For these reasons a specialized guide for the rapid identification of elasmobranchs in the region is one of the basic priorities and most important objectives under the consultancy.

3. Methodology

3.1. Capacity Building

In order to address the needs for capacity building in the region, two approaches were taken. The first was the preparation of training courses and the related manual to document the courses and provide materials for further training by local staff in the countries of the region. The second approach was the direct training of the local staff that accompanied the consultant and the LMR-LS during the field surveys that covered most of the countries in the region.

The groundwork for the first training course (elasmobranch identification and field sampling methods) involved the design of the course and the preparation of the synopsis, lectures, audiovisual materials used during lectures, and the design of the practical sessions for the identification of fresh elasmobranchs. The lectures were structured based on the parallel research that was being carried out for the preparation of the identification guide which constituted the backbone of the training course. Given the broad spectrum of literacy of the trainees, the lectures delivered by the consultant in English were semi-simultaneously kindly translated *viva voce* into Arabic by the LMR-LS to ensure maximum comprehension. The experience accumulated during the field surveys and the photographic material obtained therein were utilized for the teaching of the theoretical and practical sessions.

The second course (stock assessment methods with special reference to elasmobranchs) required an involved process of planning and researching of the lectures using the experience of the consultant and the most prominent text books and research articles, most in the personal library of the consultant. The lectures were supported with audiovisual materials as well as with good old blackboard-based teaching. The practical exercises were all designed with an emphasis in modern numerical methodologies and for this reason they were all carried out in personal computers.

The participants to the two courses were determined through a process of consultation between the LMR-LS and the corresponding national LMR-WG members of each country.

On-the-field training consisted in showing the staff of various national agencies the main characteristics that distinguish each group of sharks and batoids and the key diagnostics for separating species of similar appearance especially those in taxonomic groups with a large number of species. The trainees were also taught how to properly take the different meristics of sharks and batoids that can be used during biological sampling, including how to sex them and how to assess their relative age (newborns, juveniles, adults) and sexual maturity.

3.2. Promotion of sustainability in the fisheries

The sustainability of the elasmobranch fisheries of the region was promoted through a series of approaches aimed at providing the tools and advice that are needed to establish a pattern of positive and objective-oriented change. These involved the preparation of training materials, the design of formats for data collection, the development of a curriculum for formal training, and the conduction of an in-depth analysis of all the information accumulated during the consultancy. The latter was used to prepare a review of the status of knowledge about the elasmobranch resources and the fisheries that depend on them, and the drafting of the recommendations for the sustainability of the fisheries included in the present report.

The two training manuals were developed in conjunction with the respective training courses through home-based research and work Readers should refer to the previous section for details about their preparation.

The development of a formal curriculum for training in stock assessment and fisheries science was based on careful consideration of the knowledge base required by a stock assessment scientist. This was partially based on the personal experience of the author as a fisheries scientist and a shark expert but relied largely on a review of most important text books in stock assessment and literature and an analysis of the *syllabi* of some of the best graduate programs in fisheries from universities in the UK, Canada and the US.

Several formats for data collection were designed from scratch as a means to provide the local staff with clear and useful material to start and maintain programs of data collection. The format for the collection of data from biological sampling of the catches was developed from similar formats designed by the author through his career and used for many years in the collection of data for the fisheries in Mexico (Bonfil et al. 1988). A complete set of formats for the surveying of the small-scale fisheries sectors of each country by local consultants was designed by conducting a careful list of all the information that is usually required to perform and in depth analysis of a fishery. The formats were designed in a spreadsheet program to facilitate printing or direct data entry in electronic format whenever feasible.

The analysis of the status of the fisheries and the recommendation of management and other measures aimed at the sustainability of the fisheries were -together with training and the elaboration of the identification guide- at the core of the goals of the consultancy. Several methods were used to gather the information needed for this goal. First, while the consultant was still working at FAO headquarters in Rome an extensive literature search was carried in FAO's specialized Fisheries Department Library to obtain FAO reports and other works related to the region and its fisheries (particularly for elasmobranchs). This yielded a large good deal of information that was used at several stages of the consultancy and particularly for the writing of section 5 of the present report.

The second approach involved a series of field surveys during two trips that covered all the member countries of the region except Somalia (on advice from the LMR-LS and due to political instability and problematic issuance of visas) and used to directly collect from original sources as much information as possible on the fisheries for sharks and batoids, and other fisheries catching elasmobranchs incidentally. These trips often included the former and/or current LMR-LS, and one or two local staff from the country that was being visited. These surveys included interviews with research personnel and management authorities, visits to main landing points, fish markets and a trip to an actual fishing ground with fishermen (in Djibouti), exploratory fishing in coastal lagoons to identify possible shark nursery areas, collection of biological samples in fish markets and landing points, assessment of the species composition of elasmobranch landings, identification and photographic documentation of the species, gathering of information on fishing operations through interviews of boat skippers, and the search for historical data on landings whenever access to the internal records of fishing companies and cooperatives was granted. All the data that was gathered through these field surveys was entered into an electronic database built by the consultant. These data were analyzed and integrated into the review of the elasmobranch resources of the region presented further below.

A second set of surveys of the small-scale fishing sector of each country was planned to recover detailed data on the catch and effort per fishing unit in directed and incidental fisheries for elasmobranchs, socio-economic data of the fishing communities, information on utilization and marketing of elasmobranchs, a registry of fishing localities and landing points, a registry of fishing organizations, the number of fishing vessels and gear per locality and category, the structure and organization of fisheries management at the national level, existing fisheries management regulations, MCS, access to fishing, and research. These surveys and the set of formats needed, were designed with the intention of being used by local consultants in a coordinated short-time data collection effort. However, due to financial constraints, SAP was not able to implement this phase of the work.

Finally, the information gathered through the field surveys carried out by the consultant and the LMR-LS was complemented with information from the literature. Information about the fisheries of the region was mainly based on the report of Hariri et al. (2002). This SAP report is the result of the effort of a group of experts to provide the most comprehensive information about the status of marine resources in the region. For the purpose of this consultancy it was assumed that information not contained in the aforementioned report was non-existent in the member countries. Nevertheless, additional literature research was carried out to try to obtain historical information. This involved accessing many working documents in FAO’s Headquarters library. Other recent reports from the private library of the consultant and containing ancillary information about the elasmobranch resources and fisheries of the region were also used.

All of the above information was integrated and analyzed to produce the review of the elasmobranch resources and their fisheries, and the strategic plan for their sustainability presented below.

3.3. Identification guide

The preparation of the Identification Guide to the Sharks and Batoids of the Red Sea and Gulf of Aden was based on two approaches. The first task was an exhaustive literature review carried out while at the Species Identification and Data Programme (SIDP) of FAO and elsewhere to locate specialized works used to define the list of shark and batoid species reported in the area. This list was expanded and purged through the information on species occurrence obtained directly from the landings of the fisheries and other field data during the field surveys. The writing up and layout of the draft of the guide was performed by the consultant using desktop publishing software. As an activity outside of the contractual commitments of the consultancy, the author obtained an offer from SIDP to print and publish the guide as part of FAO's series of field identification guides. The draft of the guide and all the materials including an introduction written by the LMR-LS were sent to SIDP for final desktop publishing and publication.

As a complement to the training in species identification and the work of the guide, small collections of fixed specimens were created and left to the care of different local agencies in three countries of the region. The purpose of these collections is to provide support reference material to local personnel studying the shark and batoid fauna of the region and to foster further training in identification.

4. Results

The presentation of results follows the structure of the list of objectives and goals of section 2. In cases where the results are sizeable documents, only brief descriptions are provided and the bulk product is presented in an annex. The baseline information about the fisheries of the region which was collected during the field surveys is given together with the rest of the analysis of data from the literature in the discussion. Likewise, the recommendations for the management of the fisheries have been structured in the conclusions and do not appear in this results section.

4.1. Training Courses

Capacity building through focused training was one of the main objectives of the consultancy. To this end, two regional specialised training courses were expressly prepared and taught by the consultant.

4.1.1. Course on elasmobranch species identification and sampling methods

A regional course on identification of shark and batoid species and sampling methods was given to a total of 52 trainees from all member countries. The four day course was taught at the Sub-Regional Training Centre in Aden between April 28 and May 1st, 2001. The aim of this course was to train regional fisheries enumerators and other fisheries staff in the identification of sharks and rays of the Red Sea and Gulf of Aden. Theoretical sessions in English with simultaneous translation into Arabic were given every morning and part of every afternoon. The lectures were supported by computer-based audiovisual presentations especially prepared for this course according to the course synopsis given in Annex II. Practical sessions for identification of fresh specimens and training in practical techniques for the study of basic shark biology and anatomy were given in the laboratory during part of every afternoon. For this purpose, more than 60 fresh specimens including 14 shark and 7 batoid species of the region were used. These specimens were kindly collected at fish markets and landing sites by Mr. Murtada Ahmed in Hodeidah, and by Mr. Hashem Al-Saqqaf in Aden.

All trainees received a copy of the 1st draft of the identification guide to the sharks and batoids of the region (see section 4.6) that was being prepared simultaneously to other activities of the consultancy. It is recommended that once the guide is finalized and distributed by FAO, SAP makes sure to ship a copy to each of the participants. The list of trainees is given in Annex III.

4.1.2. Fisheries stock assessment with particular reference to sharks and batoids

A Training Course in Stock Assessment of Shark and Ray Fishery Resources was conducted at the Sub-Regional Research and Training Centre in Aden, on 27th April – 2nd May, 2002. The synopsis of the course is given in Annex IV.

The course objectives were

1. To train regional fisheries scientists in the theory of modern tock assessment methods with particular emphasis on sharks and rays
2. To provide trainees with direct practical experience in the computer-based analysis of data and elaboration of stock assessments using data on elasmobranch fisheries from the literature
3. To increase the technical capacity of regional staff as a starting point for the long-term proper management of the resources

Twenty-three participants from Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen attended the course. The list of names and institutions is given in Annex V.

Training in the role of stock assessment in fisheries science and its relation to resource management was given as an essential first step to understanding the broader context of fisheries work. The objectives of fisheries management and their direct link to different goals were reviewed stressing the importance of having clear and explicit management objectives; key concepts in fisheries science were introduced.

Using a series of slide presentations prepared by the instructor, participants were introduced to the global context of fisheries for sharks and rays and the international trends and patterns of elasmobranch exploitation and management. They were trained in the diversity of shark life histories and alerted about the relationship between this and the vulnerability of elasmobranchs to high levels of exploitation. In order to emphasize this topic, an overview of historical cases of shark fishery collapses was given. This was capped with a review of the assessment methods and management regimes currently applied to shark and ray fisheries in different countries around the world.

Trainees were taught the importance of mortality estimation and the different methods available for its direct and indirect calculation. They were shown some of the simple assessment methods that are based in mortality and other biological characteristics. This included methods that link adult mortality with net recruitment to the adult stock as well as demographic or life-table analyses of populations. A practical computer exercise using the software developed by Show (2000) gave participants the opportunity to perform by themselves a series of demographic analyses and the calculation of rebound potentials for a selection of seven shark species that spanned the diversity of life histories of commercially fished elasmobranchs.

To train participants in basic stock assessment models that can be applied to elasmobranchs, they were taught the theory behind population growth and its relation to surplus production models. The models of Schaeffer, Fox, and Pella-Tomlinson were presented in detail. In order to emphasize the applicability of surplus production models to elasmobranch fisheries, early misconceptions about their applicability were explained and examples of how surplus production models are being currently used in real shark fisheries were outlined.

As an essential part of the course, trainees were taught the principles of parameter estimation and the standard statistical techniques for fitting fishery models to data. They were also trained in the importance of data contrast for successful parameter estimation and the importance of the assumptions made for the relationship between CPUE and abundance data. By performing a practical exercise, trainees learned how to build a spreadsheet model to analyze catch and CPUE data and how to perform stock assessment using the surplus production model of Schaefer by applying this to published data for the school shark fishery (*Galeorhinus galeus*) of Southern Australia.

To train participants in more elaborate stock assessment methods, they were taught the delay-difference model of Deriso-Schnute and the yield-per-recruit model of Beverton and Holt. They were also introduced to Bayesian methods as a modern and powerful statistical technique to assess uncertainly and to integrate diverse types of information into the model-fitting procedure. They received hands-on experience in the above methods and procedures through a practical exercise in which they had to fit the delay-difference model to the same data used in the previous practical exercise, using Bayes method to obtain estimates of uncertainty.

Training in advanced (age-structured) stock assessment models included virtual population analysis and catch-at-age methods. The participants also received training in the suite of tools available for shark and ray fisheries management, including MPAs, gear and season restrictions, input and output controls and others.

The level of participation and learning of the trainees was assessed through a series of evaluations. These included a written team-report for each practical exercise and a final individual quiz intended to evaluate the trainee's understanding of the main concepts and principles taught during the course.

At the request of the LMR Lead Specialist and in order to promote the better acquisition of fisheries data that is essential for adequate stock assessment work, the instructor also trained the participants briefly in species identification. This was achieved using a slide presentation that illustrated the ways to identify the main groups and species present in the region and the usage of the Field Identification Guide to the Sharks and Rays of the Gulf of Aden that is currently under final preparation by the instructor and the LMR-LS and that will be published jointly by FAO and PERSGA/SAP.

4.2. On-the-Field Training

Two trips were made by the consultant to several localities along the coasts of the Red Sea and the Gulf of Aden in order to collect information about the elasmobranch fisheries of the region (see 4.2.3 for details). Both offered a unique opportunity to provide further practical training to additional staff from the region in the identification of sharks and batoids and on the methods for biological sampling. A total of 21 staff in 6 different member countries received on the field training; the list of their names and institutions is given in Annex VI.

The main advantage of this practical training is that it allowed for more interaction between the consultant and each of the trainees as compared to the time and attention that each of the 52 course attendants was able to receive. During these *ad hoc* training sessions, several activities covering practical subjects were carried out depending on the opportunities offered by the field conditions and the tasks that were being accomplishes as part of the field surveys at each site. These main activities include: the main characters distinguishing the species that were encountered were highlighted; the proper ways to take the different kinds of measurements used for identification in shark and batoids were demonstrated together with the different sizes that can be used for size frequency analysis depending on the taxon and the condition of the catch at landing (i.e. beheaded, with or without caudal fin); the proper way to determine the life-stage of individual sharks and rays through the analysis of sexual development and relative body size; the proper way to obtain data for the determination of the size at first sexual maturity (such as measurement of the clasper length in males); the techniques for fixation, preservation, logging and storage of specimens for reference collections; ways to record data about the fishing trip when landings data are being collected; and even techniques for dissection and analysis of internal reproductive tracts in males and females.

4.3. Training Materials

Training manuals to be disseminated and used around the region as reference material and as sources of possible locally organized training courses have been prepared during the consultancy. The two manuals are derived from the respective training courses mentioned above; both were prepared by the author and delivered to the LMR-LS a few weeks after the end of each course.

4.3.1. Manual for elasmobranch identification and sampling methods

This illustrated manual presents information on the diversity of sharks and batoids, the terminology used for the study of their external anatomy, a description of the most useful characters for identification, and the classification of the major groups of sharks and batoids. The manual summarizes the main characteristics of the Orders of sharks and batoids found in the Red Sea and Gulf of Aden and lists the Families present in the region under each order. The proper ways to measure the different lengths and the weight of sharks in the field as well as the measurements required for estimation of sexual maturity in males are described and fully illustrated. Additionally, a sample format for the recording of biological-sampling data is given.

A more complete presentation of the elasmobranch fauna of the region including all known species and their identification characteristics was purposely not included. This is covered in full by the regional identification guide being published by FAO. Ideally, SAP should make sure that the identification guide and the present manual are widely distributed in the region as companion publications. The draft of the manual as sent to SAP is presented in Annex VII.

4.3.2. Manual for stock assessment with particular reference to elasmobranchs

A manual documenting the material presented during the lectures of the stock assessment course in Aden was prepared as a complement to the course. This 66-page document was structured in draft form as a training course report and delivered to SAP at the end of 2002. However it is in reality a training manual documenting in full detail the background, principles and theory, equations, and advantages and disadvantages of modern quantitative methods for the study of populations dynamics and stock assessment of fishery resources. A strong emphasis is given to the application of these methods to sharks and batoids, and whenever possible the examples used are based on shark or batoid fisheries. The manual also includes the practical exercises that were assigned to the trainees during the practical training lessons in the computer lab of the Sub-Regional training Centre. The draft of the manual is given in Annex VIII. This manual, if published in final form, should be distributed to each of the participants and to a wider user base in all the fisheries institutions of the region.

4.4. A curriculum for formal training in stock assessment

As part of the activities of the consultancy and in addition to the two formal training courses prepared and taught by the consultant in the Aden Regional Training Center (Shark Identification and Sampling Methodology, and Stock Assessment with Particular Reference to Sharks and Batoids), PERSGA requested the preparation of a curriculum for formal training in stock assessment. The following paragraphs detail all the basic and advanced topics that should be covered in such a curriculum to guarantee the adequate training in stock assessment in the region.

The preparation of this curriculum assumes that candidates will already have a bachelor's degree in natural sciences, preferably in marine biology or a closely related field.

Module 1. Fisheries Sampling and Statistical Methods

Objectives – To obtain the basic knowledge and skills for designing and developing sampling programs for fisheries data and fisheries biology of elasmobranchs. Also, to enable the processing of information through formal statistical techniques, the carrying out of adequate analyses and the derivation of the corresponding results and conclusions from the data to be used in the monitoring and assessment of elasmobranch fisheries.

Topics

- Probability and basic statistics – Probability; population and sample; descriptive statistics and statistical distributions.
- Sampling design – Systematic sampling; random sampling; stratified sampling; sub sampling or two-stage sampling.
- Regression – Correlation and linear regression; multiple regression; non-linear regression.
- Analysis of variance and related techniques – One way ANOVA; two way ANOVA; multivariate analysis.
- Other statistical techniques – General Linear Models (GLIM); Principal component analysis (PCA); Bayesian statistics.
- Gathering of fisheries data
    - Total catch – Definition of stock and choice of sampling unit; sampling of landings, bycatch, discards and drop-outs.
    - Effort – measures of effort; consideration of changes in fishing power, gear and fishermen's skill.
    - Methods for biological sampling – sampling for length composition; bias from gear selectivity; sampling structures for estimation of age and growth; sampling for sexual maturity and related reproductive data.
    - Measures of abundance – CPUE and its dangers; fishery-independent abundance surveys.

Module 2. Elasmobranch Biology

Objectives – To provide the necessary understanding of biology of sharks and rays and the particular life-history characteristics that make them more susceptible to overfishing.

Topics

- Species diversity – Overview of major taxa of sharks and batoids and their general characteristics.
- Distribution and general ecology – Relationship between body shape, habitat and ecology of major taxa of sharks and batoids.
- Life history
    - Reproduction – Sex determination; sexual maturity; fecundity; gestation period and length of reproductive cycle; birth season and areas.
    - Age determination – Methods and techniques for elasmobranch ageing; validation and verification.
    - Growth – Growth models and parameter estimation; growth rates; back-calculation; age-length keys.
    - Feeding – Predator-prey relationships; cannibalism; stomach contents analysis; indexes used in stomach contents analysis.

Module 3. Population Dynamics and modelling

Objectives – To give an in-depth understanding of the theories and laws governing the dynamics of wild animal populations and the numerical techniques available for their analysis.

Topics

- Theories of population control – regulation; balance; top-down and bottom-up control.
- Predation and competition – Simple predator-prey models; predatory pits; simple competition models; co-evolution of predatory-prey systems.
- Estimation of population size - direct counts and ratio methods; removal and virtual methods.
- Biomass dynamics and ecosystem compartment models – Logistic population growth; Gompertz model; Ecopath and EcoSim.
- Mathematical modelling – benefits and pitfalls; approaches and techniques in population model building.
- Introduction to programming and simulation models – Visual Basic and spreadsheet modelling; simple balance models; population structure; individual based models.
- Models and data – parameter estimation and hypothesis testing; experimental design models.
- Optimization and dynamic programming.
- Statistical detection of environmental forcing.

Module 4. Fisheries Stock Assessment and Management

Objectives – To provide a solid understanding of the different models and techniques available for the evaluation of the status of fish stocks with particular reference to methods suitable for elasmobranchs and tropical fisheries situations. To introduce concepts and tools for fisheries management.

Topics

- World fisheries and policy issues – Major fisheries of the world; overview of elasmobranch fisheries; characteristics of fisheries development; the role of stock assessment and the objectives of fisheries management.
- Biology of exploited populations – Patterns of behaviour of exploited populations; surplus production theory; the importance of spatial structure in fisheries.
- Surplus production models – Schaeffer model; Fox and Pella-Tomlinson models; advantages and disadvantages of surplus production models; applications to elasmobranch fisheries.
- Estimation of Mortality – natural, fishing, and total mortality; instantaneous and finite rates; catch curves; tag-recapture methods; indirect estimation methods.
- Demographic and yield per recruit models – life tables; matrix models; rebound potential; Beverton and Holt yield per recruit model.
- Partially age-structured model – Deriso-Schnute delay difference model.
- Age-structured fishery models – Virtual population analysis; catch-at-age analysis; stock-synthesis model.
- Multispecies fisheries and ecosystem approaches– Problems for multispecies assessment and the need for ecosystem management; multispecies surplus production models; multispecies-VPA; ecosystem models based on trophic dynamics (Ecopath and EcoSim).
- Length-based approaches – Length frequency analysis and its caveats; ELEFAN; MULTIFAN.
- Fisheries Management – input and output controls (TACs and other tools); open access vs. resource ownership; Marine Protected Areas; jurisdictional and institutional framework; monitoring and enforcement; adaptive policy design; economic and social issues in policy design; product certification and eco-labeling.

The preceding curriculum can be further enhanced with specialized courses in:

- Advanced statistics
- Risk assessment
- GIS (Geographic Information Systems)
- Programming languages
    - Visual C
    - AD Model Builder
    - WinBugs

4.5. Surveys by consultant

Two field surveys were carried out in the region by the consultant to gather information on several areas relevant to the work of the consultancy. The full details of each of these trips can be found on Bonfil (2001a, b). Logistic details about the sites visited and activities performed are summarized in section 3.2 of this report. A brief presentation of the most relevant results is given here.

4.5.1. Elasmobranch species present in the region

A total of 28 shark and 17 batoid species were recorded during the two surveys (Table 4.1). All of these species were recorded in the commercial catches of the region either at fish markets or landing points. The only exception is the longcomb sawfish *Pristis zijsron* which has severely decreased in abundance in the region. However, three rostra obtained by local researchers a decade ago were identified in the headquarters of the MAW/MFD in Gizan and two preserved specimens are on display at the Marine Museum in Hurghada. The list of species directly recorded in the commercial catches will probably increase as data collection expands in the region with the aid of trained personnel and the availability of the identification guide.

Table 4.1 Updated list of sharks and batoids occurring in the Red Sea and Gulf of Aden

Species known to exist in the Red Sea and Gulf of Aden

	Sharks	Recorded by RB Nov 1999	Recorded by RB Apr-May 2001
1	*Alopias pelagicus*	X	X
2	*Alopias vulpinus*		
3	*Alopias superciliosus*		X
4	*Apristurus indicus*		
5	*Carcharhinus albimarginatus*		X
6	*Carcharhinus altimus*		
7	*Carcharhinus amblyrhynchoides*		
8	*Carcharhinus amblyrhynchos (=wheeleri)*	X	X
9	*Carcharhinus amboinensis*		
10	*Carcharhinus brevipinna*	X	X
11	*Carcharhinus dussumieri*	X	X
12	*Carcharhinus falciformis*	X	X
13	*Carcharhinus leucas*		X
14	*Carcharhinus limbatus*	X	X
15	*Carcharhinus longimanus*	X	X
16	*Carcharhinus melanopterus*	X	X
17	*Carcharhinus plumbeus*	X	X
18	*Carharhinus sealei*	X	
19	*Carcharhinus sorrah (=spallanzani)*	X	X
20	*Carcharias taurus*		
21	*Centrophorus atromarginatus*		
22	*Centrophorus granulosus*		
23	*Centrophorus tessellatus*		
24	*Deania calcea*		
25	*Echinorhinus brucus*		
26	*Eridacnis radcliffei*		
27	*Galeocerdo cuvier*	X	X
28	*Halaelurus boesemani*		
** 29	*Hemigaleus microstoma*	X	X
30	*Hemipristis elongatus*	X	X
31	*Heterodontus ramalheira*		
32	*Heterodontus* sp. A		X
33	*Iago omanensis*	X	X
34	*Isurus oxyrinchus*	X	X
35	*Loxodon macrorhinus*		X
36	*Mustelus mosis*	X	X
37	*Nebrius ferrugineus*	X	X
38	*Negaprion acutidens*		X
39	*Rhincodon typus*	X	X
40	*Rhizoprionodon acutus*	X	X
41	*Sphyrna lewini*	X	X
42	*Sphyrna mokarran*		
43	*Stegostoma fasciatum*	X	X
44	*Triaenodon obesus*		

	Rays, skates and mantas (batoids)	Recorded by RB Nov 1999	Recorded by RB Apr-May 2001
1	*Aetobatus flagellum*		
2	*Aetobatus narinari*	X	X
3	*Aetomylaeus milvus*		
** 4	*Aetomylaeus vespertilio*		X
5	*Anoxypristis cuspidata*		
6	*Dasyatis kuhlii*		
** 7	*Dasyatis sp.*		X
8	*Gymnura poecilura*		X
9	*Heteronarce bentuviai*		
10	*Heteronarce mollis*		
** 11	*Himantura fai*		X
12	*Himantura gerrardi*	X	X
13	*Himantura imbricata*		
14	*Himantura uarnak*		X
15	*Manta birostris (ehrenbergii?)*		
16	*Mobula eregoodootenkee (=diabola?)*		
17	*Mobula tarapacana*		
** 18	*Mobula japanica*		X
19	*Narcine oculifera*		
20	*Pastinachus sephen*		X
21	*Pristis pectinata*		
22	*Pristis zijsron*	X	
23	*Rhina ancylostoma*		
24	*Rhinobatos halavi*		X
25	*Rhinobatos punctifer*		X
26	*Rhinobatos salalah*		
27	*Rhinoptera javanica*	X	X
28	*Rhynchobatus djiddensis*	X	X
29	*Taeniura lymma*		X
30	*Taeniura meyeni (=melanospilos)*		X
31	*Torpedo panthera*		
32	*Torpedo sinuspersici*		
33	*Urogymnus asperrimus*		X

** **New records for the region**

Species with uncertain records in the region (need confirmation)

Sharks
1 *Carcharhinus macloti*
2 *Carcharhinus obscurus*
3 *Carcharodon carcharias*
4 *Squatina squatina*
5 *Squatina africana*

Rays, skates and mantas (batoids)
1 *Aetobatus ocellatus*
2 *Aetomylaeus maculatus*
3 *Aetoplatea tentaculata*
4 *Dasyatis pastinaca*
5 *Himantura jenkinsii*
6 *Mobula kuhlii*
7 *Mobula thurstoni*
8 *Rhinobatos cemiculus*
9 *Rhinobatos granulatus*
10 *Rhinobatos obtusus*
11 *Rhinobatos schlegelii*
12 *Rhinobatos thouin*
13 *Rhinoptera jayakari?*
14 *Rhynchobatus australiae?*
15 *Taeniura grabata*

Five species of elasmobranchs were recorded for the first time from the Red Sea and Gulf of Aden. These are the small shark *Hemigaleus microstoma,* the eagle ray *Aetomylaeus vespertilio,* the stingrays *Dasyatis* sp. and *Himantura fai,* and the manta ray *Mobula japanica.* More new records for the region are likely as sampling effort by personnel trained in identification expands.

4.5.2. Biological sampling

A total of 249 sharks and batoids belonging to 34 species were sampled during the field surveys. Data recorded for each fish included from one to three different measurements of the size, their sex, and their reproductive status. Whenever available, information about the fishing trips was also recorded. Additional information for each sample included the location and date where each one was taken.

An electronic database was created with this information and a printed version is appended in Annex IX. The electronic database is in the possession of the SAP and constitutes the starting point for a larger regional database. This should be expanded through additional sampling and used to derive relationships that relate total length, fork length, precaudal length and length to the origin of the second dorsal fin. These relationships can prove to be very useful tools for future estimation of all sizes from sampling of only one size and are essential when specimens to be sampled are landed incomplete. An expanded database will also allow to properly estimate for each of the most important species biological parameters that are needed for stock assessment. These include size at birth, size at first sexual maturation for each sex, litter sizes, and mating and pupping seasons. A brief analysis of some of this information is presented under the species accounts of section 5.1.2.

4.5.3. Surveys of nursery areas

The characterisation of shark and ray nursery areas is part of the key information needed for the recommendation of conservation and management measures for elasmobranchs in the region. It is well documented that many species of sharks and batoids use inshore protected water bodies (coastal lagoons, estuaries and bays) as pupping and nursery areas (Snelson et al. 1984; Williams and Schaap, 1992; Simpfendorfer and Milward, 1993). Human activity around these coastal water bodies can have detrimental impacts on the recruitment of sharks and batoids to the breeding stocks. Examples of detrimental human activities are heavy direct fishing of newborns/juveniles, industrial or urban development, clear-cutting of the mangroves that give shelter to the newborn elasmobranchs and their preys, pollution, and increased navigation.

Given that there are virtually no documented reports about the existence of nursery areas for fishery resources in the region (Hariri et al. 2002), during the second field trip to the region an attempt was made to survey a few coastal lagoons and bays to evaluate their importance as nursery areas for sharks and batoids. These water bodies were chosen from an analysis of environmental and morphological information of the coast that was available to the consultant. The choice of sites was also constrained by logistic factors including time available for this work and the remoteness of the sites from other areas that needed to be visited during the trip. Two areas in KSA were surveyed. However, field observations at other localities throughout the region indicated the existence of areas that serve as nursery grounds for some elasmobranchs including species of commercial importance.

The areas surveyed were a coastal lagoon north of Tuwal and to the east of Al Qadimah, and the larger enclosed bay known as Kur Akharrar south of Mastorah. Surveying of the former of these coastal areas was not possible for logistic reasons outside of our control. However, the officer in charge of the coast guard at Thuwal, Mr Salih Al-Shihri, indicated that this site and Kur Akharrar were indeed areas where newborn sharks were commonly found. With his aid we identified an alternative site in the nearby reef flats of Thuwal which was reported as a nursery area for reef sharks by an experienced local fisherman. The survey consisted of a gillnet set of 3 hrs just before dusk using the boat and gear of the above mentioned local fisherman (a 500 m monofilament gillnet of 1 m height and 3 cm mesh size). The survey of this site failed to produce evidence of its role as a shark nursery ground. Only a blue-spotted ribbon-tail ray (*Taeniura lymma*) and a reticulated whipray (*Himantura uarnak*) were recorded.

Surveying of Kur Akharrar was done using the boat and gear of a local fisherman from Mastorah (gillnet similar to the one specified above). A 4 hr set starting just before dusk was done in the north eastern shallow part of the lagoon in front of a mangrove growth where local fishermen indicated that newborn sharks occur. No fish were recorded. Nevertheless, information from at least three different sources confirmed that the lagoon is used as a pupping/nursery ground by a 'blacktipped' shark species which is usually found later during the summer months.

Additional information on nursery grounds or the presence of newborn sharks was recorded in different countries during the rest of the trip. Newborn sickle-fin lemon sharks (*Negaprion acutidens*) were observed at Suakin, Sudan, where there seems to be a nursery ground for this species in nearby mangrove areas. Newborn and young-of-the-year blacktip sharks (*Carcharhinus limbatus*) and early juvenile scalloped hammerhead sharks *(Sphyrna lewini*) inhabit areas nearby Djibouti and are often landed at this city's beach by gillnet fishermen seeking mackerel. This suggests the existence of nursery areas for both species in the vicinity of Djibouti. More than one tonne of newborn blacktip sharks and juvenile spottail sharks (*Carcharhinus sorrah*) were observed at Mokha while they were being shipped to the Hadhramut region and in one of the processing plants (Qusayar) in this eastern Yemeni region more than 10 t of these newborn and juvenile sharks were being processed. These blacktip and spottail sharks were reportedly fished in the coasts of Eritrea and Somalia. Judging by the size of the landings, several important nursery areas for these species exists in the coasts of Eritrea and Somalia and are being heavily exploited by fishermen. Additionally, large quantities of newborn milk sharks (*Rhizoprionodon acutus*) were observed in the fish markets of Gizan and Jeddah suggesting the existence of nursery areas for this species in the coastal waters of KSA. Young-of-the-year silvertip sharks (*Carcharhinus albimarginatus*) were observed in the fish market of Jeddah. The origin of these sharks could not be established but their presence suggests nursery areas in the region for this species.

4.5.4. Fisheries statistics obtained from local agencies and other sources

Attempts to obtain statistics on the landings of elasmobranchs from original national and local sources were made throughout the surveys. These efforts were not very successful as there is a disturbing lack of adequate data gathering programs throughout most of the region. This evidenced the shortcomings of the data collection systems of some countries discussed in section 5.1.3.4.

The limited data obtained were kindly facilitated by fisheries officers at several localities. These included, for Hodeidah, monthly shark landings by gear and type of boat Jan-Sep 1999 (Tab. 4.2), and daily records of shark products landed during 23-26 April 2001 (Tab. 4.3). Total shark landings for 2000 by port for the Yemeni Red Sea coast (Tab. 4.4), daily shark landings for Khokha Aug 2000-Mar 2001 (Tab. 4.5), daily shark landings and prices during Feb – Jul 2000 and by month during Jan-Mar 2001 for Mokha (Tabs. 4.6 and 4.7), and historical data on shark products during1977-90 and 1997-2000 for the cooperative at Qusayar were also obtained (Tab. 4.8).

Table 4.2 Shark landing statistics (Kg) by month, gear and type of boat for the Yemeni port of Hodeidah, Jan-Sep 1999

Date	Catch	Total number of landings	Fishing Gear/boat Type
Jan-99	7150	42	Gill net/Houri
Feb-99	12100	47	Gill net/Houri
Mar-99	19440	52	Gill net/Houri
May-99	29283	145	Gill net/Houri
Jun-99	9283	470	Gill net/Houri
Jul-99	17100	45	Gill net/Houri
Aug-99	16440	94	Gill net/Houri
Sep-99	13170	52	Gill net/Houri
Jan-99	9400	28	Gill net/Sambuq
Feb-99	13100	51	Gill net/Sambuq
Mar-99	8800	22	Gill net/Sambuq
Apr-99	1475	41	Gill net/Sambuq
May-99	24640	124	Gill net/Sambuq
Jun-99	24640	94	Gill net/Sambuq
Jul-99	14720	55	Gill net/Sambuq
Aug-99	9700	32	Gill net/Sambuq
Sep-99	32650	39	Gill net/Sambuq
Subtotal			**263,091**
Jan-99	8100	131	Long line/Houri
Mar-99	4700	225	Long line/Houri
Apr-99	7200	432	Long line/Houri
May-99	13250	375	Long line/Houri
Jun-99	3250	375	Long line/Houri
Jul-99	5100	224	Long line/Houri
Sep-99	9310	215	Long line/Houri
Jan-99	9750	33	Long line/Sambuq
Feb-99	12300	42	Long line/Sambuq
Mar-99	10720	34	Long line/Sambuq
Apr-99	9500	67	Long line/Sambuq
May-99	26500	105	Long line/Sambuq
Jun-99	21100	155	Long line/Sambuq
Jul-99	6700	81	Long line/Sambuq
Aug-99	22320	71	Long line/Sambuq
Sep-99	4900	35	Long line/Sambuq
Subtotal			**174,700**
Aug-99	4100	335	Truck delivery
Total	441,891		

Table 4.3. Daily shark landings (kg) at Hodeidah, Yemen

Date	Catch in number of sharks	Catch in weight	Fresh fins	*Total estimated catch in weight*	*Estimated individual weight*
23/4/2001	153	5,019	534	16,886	32.8
24/4/2001	184	4,393	478	15,004	23.9
25/4/2001	471	4,210	331	11,566	8.9
26/4/2001	75	4,161	438	13,894	55.5
	883	17,783		57,350	20.1

Table 4.4. Shark landing statistics (tonnes) by port for the Red Sea coast of Yemen, 2000.

Landing site	Catch
Mokha	7.1
Zipap	8.4
Ras Eisa	---
Al-Saleif	2.3
Al-Khubah	43.4
Khokha	41.7
Al-Hodeidah	475.8
Total	578.7

Data on Red Sea shark landings at Suez 1991-1999 as well as on gear quantities by region for 1999, were obtained in Egypt (Tabs. 4.9 and 4.10). Additional statistical data on shark landings for the Red Sea coast of KSA by type of fishery as well as by region during 1995-1998 and by region and month for 1998 were obtained from the official Saudi fishery statistical books (Ministry of Agriculture and Water, 2001; Tabs. 4.11-4.13).

All these data provide some insights into the characteristics of the fisheries mainly in terms of the relative importance of landing sites, types of gear and boats, and the magnitude of the landings at different intervals of time. In Hodeidah, the landings by gillnet boats are almost double those of longliners (Tab. 4.2). The data also show that although recent landings of sharks at Hodeidah amount to about 4.3 t per day, when the additional landings of fresh fins are also considered (after conversion to live weight) the total daily landings of sharks climb to about 20 t per day (Tab. 4.3). This difference is attributable at least partly to the purchase of fins by Yemeni boats from coastal fishermen in Djibouti (7 Brothers Islands; Bonfil 2001b) and possible Eritrea and Somalia, although it is not known if fining and discarding of carcasses occurs among Yemeni fishermen. The role of the port of Hodeidah as the most important landing site for sharks in the Red Sea coast is corroborated by the statistical data which also suggest Khokha and Al-Kubha as important landing sites for sharks in Yemen (Tab. 4.4).

Table 4.5. Shark landing statistics (Kg) for the Yemeni port of Khokha. Monthly estimates are from raising the number of sampled landings to the total number of landings recorded

Date	Catch	Number of sampled landings	Total number of landings
1-Aug-00	383.74		
3-Aug-00	161.70		
5-Aug-00	98.18		
7-Aug-00	46.80		
17-Aug-00	313.20		
25-Aug-00	52.80		
August-00	2912.45	401	1085
1-Sep-00	333.20		
8-Sep-00	283.66		
12-Sep-00	565.00		
15-Sep-00	503.20		
18-Sep-00	147.00		
25-Sep-00	387.20		
Sep-00	8073.37	189	720
1-Oct-00	37.50		
Oct-00	148.40	141	558
8-Nov-00	363.37		
11-Nov-00	231.00		
15-Nov-00	340.00		
18-Nov-00	105.55		
22-Nov-00	60.00		
25-Nov-00	65.33		
Nov-00	5243.62	152	684
1-Dec-00	364.57		
3-Dec-00	290.40		
6-Dec-00	28.00		
9-Dec-00	660.85		
16-Dec-00	147.60		
20-Dec-00	189.75		
25-Dec-00	95.33		
Dec-00	4909.08	201	798
6-Feb-01	214.60		
10-Feb-01	624.61		
17-Feb-01	960.00		
Feb-01	6486.47	309	1114
1-Mar-01	115.50		
3-Mar-01	700.50		
8-Mar-01	40.00		
15-Mar-01	110.00		
18-Mar-01	38.50		
21-Mar-01	624.00		
29-Mar-01	167.38		
Mar-01	7150.74	274	1091
Total estimate	34,924		

Table 4.6. Statistics of shark landings for the Yemeni port of Mokha

Date	Catch	Price YR	Date	Catch	Price YR
27-Feb-00	194 Pieces	154000	1-Jun-00	5 Pieces	5000
28-Feb-00	1 + stack	10200	4-Jun-00	stack	130000
29-Feb-00	stack	4400	6-Jun-00	24 Pieces	22000
3-Mar-00	4 Pieces	20000	7-Jun-00	stack	7960
5-Mar-00	2 Pieces	3500	10-Jun-00	stack	4810
6-Mar-00	stack	80000	11-Jun-00	1 Piece	500
7-Mar-00	stack	100500	12-Jun-00	stack	3800
8-Mar-00	stack	15000	13-Jun-00	stack	27500
9-Mar-00	stack	22100	17-Jun-00	stack	13500
11-Mar-00	27 Pieces	28300	12-Jun-00	stack	98450
12-Mar-00	16 Pieces	50000	22-Jun-00	stack	14100
13-Mar-00	5 Pieces	100000	25-Jun-00	436 Pieces	21800
21-Mar-00	1 Piece	15000	26-Jun-00	30 Pieces	9200
24-Mar-00	1 Piece	4000	27-Jun-00	41 Pieces	10000
5-Apr-00	1 Piece	10000	28-Jun-00	137 Pieces	84740
12-Apr-00	2 Pieces	21000	29-Jun-00	296 Pieces	28900
13-Apr-00	10 Pieces	----	8-Jul-00	35 Kg	1760
14-Apr-00	1 Piece	----	9-Jul-00	43 Kg	88700
15-Apr-00	1 Piece	4000	10-Jul-00	203 Kg	113950
16-Apr-00	1 Piece	4000	11-Jul-00	23 Kg	67700
19-Apr-00	25 Pieces	150000	12-Jul-00	92.5 Kg	256550
24-Apr-00	13 Pieces	17200	13-Jul-00	35 Kg	104250
25-Apr-00	10 Pieces	4450	14-Jul-00	1.5 Kg	6750
1-May-00	1 Piece	600	15-Jul-00	272.5 Kg	296030
2-May-00	20 Piece	1000	16-Jul-00	447.5 Kg	70600
4-May-00	35 Pieces	121000	18-Jul-00	93.5 Kg	60420
7-May-00	1 Piece	3000	19-Jul-00	88.5 Kg	325030
8-May-00	2 Pieces	3000	20-Jul-00	166 Kg	293710
10-May-00	5 Pieces	5000	21-Jul-00	612 Kg	200695
11-May-00	6 Pieces	5800	22-Jul-00	823 Kg	151710
12-May-00	5 Pieces	9200	23-Jul-00	134 Kg	274500
13-May-00	3 Pieces	2000	24-Jul-00	134 Kg	274500
14-May-00	2 Pieces	500	25-Jul-00	212 Kg	91880
15-May-00	18 Pieces	80000		**3,416**	
16-May-00	1 Piece	1000			
17-May-00	11 Pieces	17500			
18-May-00	2 Pieces	3000			
19-May-00	8 Pieces	3500			
20-May-00	13 Pieces	7500			
21-May-00	10 Pieces	2500			
22-May-00	6 Pieces	12200			
24-May-00	6 Pieces	12900			
25-May-00	18 Pieces	5450			
26-May-00	23 Pieces	7500			
28-May-00	1 Piece	2000			
29-May-00	11 Pieces	1430			
31-May-00	2 Pieces	600			

Table 4.7. Monthly estimates of landings for the Yemeni port of Mokha

Date	Catch (Kg)	Price YR	Number of recorded landings	Total number of landings
January-01	410	1,230,000	120	602
February-01	344	1,376,000	167	1363
March-01	102	306,000	192	1177

Table 4.8. Shark Production of Qusayar Fishermen Co-operative Society –Yemen- Hadhramut Governorate.

Year	**Reported landings (tonnes)**	Fresh Meat (Kg)	Dried Meat (Kg)	Wet Salted Meat (Kg)	Salted Meat (Kg)	Frozen meat (Kg)	**Dried Fins (Kg)**	**Wet Fins (Kg)**	*conversion from wet fins*	*conversion from dry fins*	*Estimated live weight from fins (tonnes)*	*Estimated live weight from fresh meat (tonnes)*
1977	1,558	145,350	----	135,385	6,250	4,833	------	96,365	*2,141*		*2,141*	*269*
1978	2,051	160,300	----	1,709,965	70,758	10,367	------	99,185	*2,204*		*2,204*	*297*
1979	2,196	168,699	-----	1,882,062	43,873	5,683	-----	95,668	*2,126*		*2,126*	*312*
1980	3,160	274,747	-----	2,719,115	33,972	446	-----	131,490	*2,922*		*2,922*	*509*
1981	2,524	171,000	----	140,000	-----	81,800	77,000	58,000	*1,289*	*3,720*	*5,009*	*317*
1982	2,012	134,000	-----	1,753,000	---	10,000	------	115,000	*2,556*		*2,556*	*248*
1983	1,334	81,000	-----	1,143,000	-----	17,000	------	90,000	*2,000*		*2,000*	*150*
1984	2,189	165,238	102,303	1,661,681	49,885	128,497	404	74,121	*1,647*	*20*	*1,667*	*306*
1985	1,967	238,787	528,746	987,020	13,827	123,143	18,005	55,544	*1,234*	*870*	*2,104*	*442*
1986	2,505	726,610	254,421	1,249,885	21,415	161,199	------	83,686	*1,860*		*1,860*	*1,346*
1987	3,420	999,817	--------	2,155,372	5,508	88,530	------	147,052	*3,268*		*3,268*	*1,852*
1988	33,915	33,914,574	-----	1,828,199	64,738	47,987	----	88,803	*1,973*		*1,973*	*62,805*
1989	2,711	1,261,000	----	1,292,000	2,000	51,000	----	101,000	*2,244*		*2,244*	*2,335*
1990	1,904	1,321,286	----	536,730	----	3,615	----	37,930	*843*		*843*	*2,447*
1991												
1992												
1993												
1994												
1995												
1996												
1997		640,221						106,522			*2,367*	*1,186*
1998		1,526,910						231,580			*5,146*	*2,828*
1999		1,086,370						120,352			*2,674*	*2,012*
2000		1,018,130						183,317			***4,074***	***1,885***
2001/1		109,234						140,214			*3,116*	*202*

Source:- Mr. Hasan Muhaimdan-Chairman of Qusayar Fishermen Cooperative Society. Letter to Dr. K.I.Hariri dated 5th May, 2001.

There are however several problems with the statistical data from Yemeni fisheries. In some cases (i.e. Tab. 4.6), the data are not given in weight (either estimated or measured) but only in numbers of sharks or numbers of ‘stacks’ of sharks, without additional useful information that allows the estimation of the catch in weight (trying to use the monetary value of each entry to estimate catch in weight is not possible because the sizes of the sharks are not known and different species and sizes of sharks attain different prices, depending mostly on whether their fins are large or small, of high demand of low demand). Clearly, this method of recording renders the data of no use for stock assessment or even statistical purposes. Problems of this kind should be corrected must be corrected as soon as possible.

Table 4.9. Total catch (tonnes) of cartilaginous fishes from Egyptian Red Sea waters

Year	Total Catch
1991	81
1992	32
1993	89
1994	68
1995	137
1996	122
1997	180
1998	135
1999	182

Table 4.10. Monthly catch (tonnes) of Cartilaginous fishes by fishing ground recorded in the landing sites during 1999

Fishing Ground	Gulf of Suez				Aqaba Gulf	Red Sea (outside Egyptian waters)	
Landing Site	**Ataqa**	**Al-Salakhanah**	**Al-Tour**	**Hurghada**	**Sharm Al-sheikh, Dahab and Noweba**	**Ataqa**	**Baraneis**
Jan		3	3		4		
Feb		4	4		2		
Mar		5	4		4		
Apr	6	4	5		2	4	4
May	2	5	5		2	4	4
Jun	2	3	2		3	2	1
Jul		3			6		
Aug					4		
Sep	4		6		4		
Oct	12				4		
Nov	19	1	4		3		
Dec	10		5		4		
Total	55	28	38	0	42	10	9

Table 4.11. Total shark catch (tonnes) from the Red Sea - KSA by type of fishery

Year	Traditional	Industrial	Total
1995	325	44	369
1996	273	40	313
1997	428	20	448
1998	442	20	462

Table 4.12. Shark catch (tonnes) from traditional fisheries by region in the Red Sea KSA

Year	Tabouk	Madienah	Makkah	Gizan	Total Catch
1995	41	20	104	160	325
1996	36	17	81	140	273
1997	12	6	266	144	428
1998	7	4	180	251	442

N.B. Catch of the industerial fishery is not included in this table

A further limitation of most of the catch statistics mentioned above (with the possible exception of Egypt) is that they span a period of time that is too short compared to what is known to be the period of exploitation of sharks in the region. This is especially true for Yemen where only data for the years 1999-2001 were obtained. The only exception is the data from Qusayar which spans the period 1977-1990 and 1997-2001. However, this data has also some problems on inconsistency among different columns. Likely, some errors were made while copying the information, but this can only be resolved when and if further efforts to recover historical information on the shark landings are made (see discussion and conclusions below).

Table 4.13. Monthly catch (kg) taken by fishing gear and region in KSA during 1998

	Gizan Region		Qunfuzah		Tabouk & Madienah	Total
	Trawl		Trawl	Purse Seine	Handline	
Month	Sharks	Rays	Sharks	Sharks	Sharks	
Jan	1559	605			303	2467
Feb	1991	282			297	2570
Mar	2753	310			502	3565
Apr	1769	431			936	3136
May					844	844
Jun					659	659
Jul					760	760
Aug	2877	247			1373	4497
Sep	2639	93			704	3436
Oct	2355	179		72	594	3200
Nov	1916	687	80		2815	5498
Dec	1586	188	24		1027	2825
Total	19445	3021	104	72	10814	33456

The magnitude of the shark landings reported for Qusayar places serious doubts on the accuracy of the data from other ports, particularly Hodeidah, which is host to a much larger fleet of vessels fishing for sharks than Qusayar. Available data indicate that yearly landings in Hodeidah are of about 475 t (Tab. 4.4), but this compares poorly with the yearly landings of between 1,700 and 5,200 t/year estimated for Qusayar excluding the odd year of 1988 when some 33,000-63,000 t were reported (Tab. 4.8). It is likely that the data on Table 4.4 do not include raised estimates from the landings of shark fins in Hodeidah but only the landings of whole sharks. If the former are also considered (at a rate of a 20 t/day landed there, as estimated above and 200 fishing days per year) the estimated total yearly landings in Hodeidah could be of about 4,000 t, more in line with those reported for Qusayar but still falling short of expected values if we consider the Qusayar estimates as valid. In any case, the total shark catches attributed to Yemen could be of at least 10,500 t/year and could be even substantially larger as the present calculations do not consider other important landing sites in the coast of the Gulf of Aden. In contrast, the best available estimates of total shark landings for Yemen indicate catches of a peak of 6,500 t in 1993 and current catches of around 5,000 t (FAO 2002), and record catches of 11,000 t and 8,000 t in 1995 and 1996 respectively (estimates based on official export data on dry fins). Evidently, obtaining reliable estimates of the total catches of sharks for Yemen is a particularly difficult task.

The above problems in the quality of the statistical data for shark catches are especially worrying because Yemen is the main player in the shark fisheries of the region. Overall, it is clear that the system of recording fisheries data in Yemen needs to be updated and improved with urgency.

In addition to the data detailed above, the cooperative representatives at Qusayar and Bir Ali, Yemen, indicated that they have detailed records on shark landings per boat and per fishing trip for several years back (at least since 1977 for Qusayar and from 1972 for Bir Ali, although there are some data gaps for some years) and they offered access to such data. Unfortunately this information is not in electronic format but only in paper forms written in Arabic. Thus, for this information to be used it requires a lengthy process of translation and entry into a computer database.

4.5.5. Information gathered though field interviews during second survey

A considerable amount of ancillary information related to the fisheries for sharks and batoids was recorded during the second survey to the region. This information was obtained through direct observations and through interviews with fishermen and cooperative managers. It provides additional qualitative and quantitative data that helped shape part of this report. The information, record by record is attached in Annex X.

4.6. Surveys by local personnel

The surveys by local personnel could not be fully implemented due to the reasons explained in section 3.2. Very limited data were received and only from Sudan and Somalia. These data, regarded of no use for the purposes of the present consultancy due to their incompleteness, are in the possession of the LMR-LS.

4.7. Formats for data collection

Two types of formats for data collection were developed as part of the work of the consultancy. The first is a format for the collection of data from biological sampling at markets and landing points (Fig. 4.1). This is intended to be used on the field as a standard format by fisheries researchers collecting information on the size, sex, and reproductive status of sharks and batoids. It includes entries for collection of information on the fishing trip and the sampling event.

The second is a set of formats to recover complete information on the fisheries sector of each country and particularly about the shark and batoid fisheries. This set of formats was intended to be used by the local consultants, however as explained above this was not possible but the formats remain and should be used as soon as resources are made available so that an updated assessment of the fisheries sector in each country can be made.

This set of includes formats for recovery of data on:

- Catch and effort per fishing unit in directed and incidental fisheries for elasmobranchs
- Socio-economic data
- Utilization and marketing of elasmobranchs
- A registry of fishing localities and landing points
- A registry of fishing organizations
- Number of fishing vessels and gear per locality and category
- Structure and organization of fisheries management at the national level
- Fisheries management regulations, MCS, access to fishing, and research

The formats are presented in Annex XI.

4.8. Regional Identification Guide and Reference Collections

A Field Identification Guide to the Sharks and Rays of the Red Sea and Gulf of Aden was prepared following the format of FAO identification guides as requested by SAP. This guide contains accounts for a total of 44 shark and 33 batoid species. The guide includes an introduction contributed by the LMR-LS Dr. Mohammed Abdallah, and separate sections for sharks and batoids on: technical terms and measurements, list of families and species occurring in the area, guide to Orders and Families in the region, and guide to species in the region with individual entries. The guide is fully illustrated and contains an extended bibliography and colour plates of most of the species occurring in the area, mostly taken during the field surveys in the region.

PERSGA

Sampling Data Log-Sheet for Sharks and Rays

Regional Organization for the Conservation of Environment of the Red Sea and Gulf of Aden

Name of recorder ____________________ **Type of boat** ____________________

Date ____________________ **Type and amount of fishing gear** ____________________

City/town ____________________ **Number of days fishing** ____________________

Name of locality or boat ____________________ **Approximate fishing grounds** ____________________

Sample number	**Species name**	Second dorsal-fin length D2L	Pre-caudal length PCL	Fork length FL	**Total length TL**	**Weight W**	whole (w) or gutted (g)?	**Sex** (m) (f)	**Relative age**: Newborn (N) Younf of year (YY) Juvenile (J) Preadult (PA) Adult (A)	**Clasper length**	**Samples taken**	**Observations**

Figure 4.1. Format for collection of data on biological sampling of elasmobranchs.

The final draft of the guide was delivered to SAP as agreed under the TOR. However, through personal negotiations of the consultant, the Species Identification and Data Programme (SIDP) of FAO has agreed to publish the guide as an individual stand-alone volume. All the materials for the final desktop publishing are in the possession of FAO and it is expected that the guide will be printed and distributed before the end of 2003. It is important to stress that the publication and distribution of the guide by FAO is not part of the scope of the consultancy but a bonus benefit to PERSGA. Given the size of the final draft of the guide, it is not included in the present report, but appended as a separate appendix at the end of the annexes (Appendix I).

As a result of the work carried out for the preparation of the identification guide and also as a complementary tool to the guide, several small reference collections of fixed specimens were prepared by the consultant with the aid of the former and present LMR-LS. These reference collections of identified sharks are deposited in four localities of three member countries as follows: one in the MAW/MFD headquarters in Gizan, one in the Regional Training Centre in Aden, one in the General Authority for Fisheries Resources Development, Suez Branch, and another in the General Authority for Fisheries Resources Development, Hurghada Branch.

In all cases, the specimens were properly labeled. Data written in the labels included scientific name, sex, length, locality, date and name of the person identifying the shark. All specimens were fixed in 10% formalin (a 10 % solution of concentrated [40%] formaldehyde). Whenever possible depending on local availability of materials, they were transferred to a 70% solution of alcohol for permanent preservation.

The details of the species and specimens included in each reference collection are listed below.

Gizan: *Carcharhinus amblyrhynchos* (= *C. wheeleri*; 2 specimens), *C. limbatus*, *C. melanopterus, C. sorrah, Hemigaleus microstoma, Loxodon macrorhinus* (2 specimens), *Rhizoprionodon acutus* (4 specimens), *Himantura uarnak, Urogymnus asperrimus*.

Aden: *Alopias pelagicus*, *A. superciliosus*, *Carcharhinus albimarginatus*, *C. amblyrhynchos* (= *C. wheeleri*; 2 specimens), *C. limbatus*, *C. leucas*, *C. melanopterus*, *C. plumbeus*, *Hemigaleus microstoma*, *Loxodon macrorhinus*, *Rhizoprionodon acutus* (3 specimens), *Sphyrna lewini, S. mokarran, Triaenodon obesus, Gymnura poecilura, Himantura uarnak, H. gerrardi, Rhinobatos halavi, Rhynchobatus djiddensis, Rhinoptera javanica, Pastinachus sephen.*

Suez: *Loxodon macrorhinus, Mustelus mosis, Rhizoprionodon acutus*, *Rhinobatos punctifer.*

Hurghada: *Carcharhinus sorrah, Iago omanensis*, *Loxodon macrorhinus, Mustelus mosis, Rhizoprionodon acutus, Rhinobatos halavi, R. punctifer.*

5. Discussion

5.1. Achievement of Objectives

The main objectives of the present consultancy as presented in section 2 (capacity building, promotion of sustainability in the fisheries, and preparation of an identification guide to the sharks and batoids of the region) were fulfilled in their entirety and in the case of the identification guide, carried out beyond the original goal.

The lines below briefly outline these achievements and when pertinent the problems encountered during the execution of the present consultancy in relation to objectives and specific goals.

5.1.1. Capacity building

The training courses for regional staff delivered during the execution of the consultancy and the field training of staff during field trips have set very important groundwork. Together, they provide a solid basis for the future implementation of management measures for the sustainability of the shark and batoid fisheries in the region. Both courses were specially developed for this consultancy and were thoroughly prepared to ensure maximum benefits to the trainees. Through these two courses, a total of 75 fisheries staff and scientists from all member states were trained in specific areas of relevance to elasmobranch fisheries and fisheries science.

The course on species identification and field sampling techniques was a highly attended and very successful training exercise that provided theoretical and practical experience to fishery enumerators, researchers and other staff on the most important techniques for the often difficult identification of sharks and batoids. The course was general in the tools provided but very specific in its theoretical and practical focus on the species of the region. The 52 trainees now have the capacity to continue their own practical training and should be able to eventually identify any species found in the catches with ease. However, given the nature of species identification in general and particularly the difficulties with elasmobranch species which often have subtle diagnostic characters, self motivation, dedication and care will be required for the trainees to become experts.

The 52 trainees constitute a sizeable potential for helping to alleviate the problem of lack of species-specific data in the fisheries of their own countries. These trainees can and should fulfill two roles: help fisheries agencies develop a thorough list of the most important species of elasmobranchs in the catches of their own countries that is based on a one year sampling of the landings, and serve as trainers of the existent and future staff in charge of fisheries data collection. This activity will be critically complemented with the availability of the new guide for the identification of sharks and batoids of the region which is currently being finalized for publication (see below).

Stock assessment capacity building was addressed in the second training course. The 23 scientists and fishery officers that attended the course received purpose-tailored training in the essential concepts and principles of fish population dynamics and the theory behind modern stock assessment models. An emphasis was given to the application of models to elasmobranch case studies and the use of examples based on this group of fishes. These trainees have received the basic training in the subject but further and longer training in fisheries science, computer usage, statistical and mathematical analysis will be required to ensure that they can lead the development of adequate stock assessment programs in their respective countries.

A further 21 staff from various agencies in Egypt, Sudan, Djibouti, Saudi Arabia and Yemen received practical training on shark identification and fisheries sampling methodologies while assisting the consultant and the LMR-LS during the various visits to the main fishing localities of their countries. Although limited in time and number of trainees, this approach offered an extra opportunity to provide basic training to some personnel that were not able to attend the first course given at the Regional Training Center in Aden. The advantage was that more time and attention was devoted to each trainee as compared to a class with over 50 students.

5.1.2. Promotion of sustainability in the fisheries

The goals set for the consultancy under the objective of promotion of sustainable elasmobranch fisheries in the region were achieved in their entirety or are achieved in the present final report. The training materials that were prepared in tandem with the training courses constitute resources that if harnessed will improve the level of expertise and thus provide a backbone for sustainability of the fisheries in the region. These material if used properly could allow the trainees, other staff, or local consultants to organize further training courses at the local level.

The curriculum for formal training presented in section 4.2.2 above should be used to complement the groundwork set by the training courses and materials. Together, these achievements should help create a strong base of capable fisheries staff at several levels, from efficient enumerators to scientists in charge of the design and execution of stock assessment projects in support of fisheries management decisions. However, for this to become a reality it is imperative that the curriculum be put in practice by the provision of the courses outlined in the curriculum and by offering scholarships to local staff for graduate and postgraduate studies that address the curriculum.

The formats designed for the collection of baseline data about the elasmobranch fisheries of the region and for the routine biological sampling of the landings constitute another achieved goal that will promote the sustainable management of the fisheries if used correctly. Although the gathering of the baseline information about the small-scale fisheries sector that drives the elasmobranch fisheries of the region was originally conceived as a task to be carried out by local consultants during the work of the present consultancy (so that the author of this report could analyze that information and include it in the report), this was not possible due to financial difficulties that prevented SAP from hiring the local consultants. These formats should be used as soon as it is feasible to obtain the information that is needed for the full and updated characterization of the fisheries. The biological sampling formats can already be used by local enumerators for the routine gathering of information of the main species as outlined in the preceding sections.

The final goal of recommendations for fisheries management and monitoring is achieved in the final section of the present report. These recommendations are in line with the situation of the current fisheries management systems and take into consideration the limits and capabilities of the existing institutions and legal frameworks. Most of the recommendations address precautionary management measures and are based on the premises outlined at the end of section 5.2.3.6.

5.1.3. Preparation of a regional identification guide and creation of reference collections

The draft regional guide to the identification of the sharks and batoids of the Red Sea and Gulf of Aden was completed and delivered to the LMR-LS as specified in the TOR. The completion of this guide fulfills several important goals. The background and field work undertaken for its preparation served to provide the most updated list of shark and batoid species of the region. By this means it increased the scientific knowledge of the elasmobranch fauna of the region, and *inter alia* produced five new species never before recorded in the region.

The most important contribution of the guide however, is to provide an essential and much needed tool that if used wisely will help alleviate the problems of data collection that afflict the elasmobranch fisheries of the region. By solving the problems of identification of species, this tool will enable the proper recording and reporting of data on a species by species basis. It will in addition facilitate the execution of specific population dynamics studies of the main species found in the elasmobranch fisheries of the region. For all these reasons, the guide constitutes one of the most valuable products of the consultancy.

Although the TOR only specified delivery of a draft guide, the author brokered and secured a generous offer from the SIDP of FAO to publish the guide as one of the FAO Species Identification Guides for Fishery Purposes. The guide was prepared in final form by the consultant with the aid of the LMR-LS rather than just a draft and has been delivered to SIDP. It is expected that the guide will be printed and distributed at the end of 2003 by FAO. This additional achievement will not only save considerable financial resources to SAP and PERSGA, but will mean that this valuable tool will be available for use in the immediate future.

The creation of small reference collections of preserved specimens in four different points along the Red Sea will complement the release of the identification guide and will strengthen regional capacity for the identification of the local elasmobranch fauna. These small collections are meant as a starting point but should be expanded by the local staff with the aid of the identification guide. Their safekeeping and proper maintenance (by making sure that their labels are not confused or lost, and that the specimens are permanently and completely covered in formalin) should be an important responsibility of the personnel in the fisheries stations where the collections were deposited. They should be made available to other staff, scientists, and students in the region to promote the better understanding of the elasmobranch fauna of the region and to underpin the training of staff and the correct reporting of species-specific fishery data.

5.2. Characterization of the Elasmobranch Fisheries in the Region

The shark and batoid fisheries of the Red Sea and Gulf of Aden are characterized in the lines below using two chief sources of information. First, past and recent literature sources were used for an in-depth review of information about the resources and the fisheries. Secondly, this was enhanced and updated with data directly recorded from the field and original sources by the author with the assistance of the LMR-LS and local personnel though surveys carried out in all the member countries (except Jordan and Somalia) during the course of the consultancy. This characterization is divided into major headings and when appropriate the information is presented on a country by country basis.

5.2.1. Diversity of elasmobranchs in the region and species composition of the catches

5.2.1.1. Diversity of sharks and rays in the region

Knowledge about the sharks and batoids occurring in the Red Sea and Gulf of Aden was incomplete and outdated before the execution of the present consultancy, and there is still some more detailed work to be done. The studies of several specialists provide a foundation to build a list of species but some of these works are outdated and in many cases provide only a partial geographical or taxonomical coverage of the chondrichthyan fauna. There are also several guides to the commercial fish fauna of particular countries (MAF 1986; MFW 2001) but these are often incomplete or inaccurate.

Gohar and Mazhar (1964) listed a total of 38 elasmobranch species (23 sharks and 15 batoids) for the NW Red Sea. Careful analysis of this list shows that several of these species have since been synonymised and others have been found to be misidentifications. Compagno (1982) updated and expanded the list of sharks of the Red Sea to 26 species. Goren and Dor (1994) summarized previous lists and included 34 sharks and 30 batoids for the Red Sea but detailed analysis of their data shows that some of these species are mistaken reports carried over from the literature sources on which the authors based their work. Additional records for the elasmobranch fauna of the region were taken from Wray (1979), Compagno and Randall (1987), Baranes and Randall (1989), Randall (1995), Randall and Compagno (1995), and de Carvalho et al. (2002). Finally, various guides to marine fauna generated by FAO were used to derive information pertaining to some of the shark and batoid species reported in the region (Fischer et al. 1984; Sommer et al. 1996; Carpenter and Niem 1998, 1999; Compagno 2001).

The information from the reports listed above was cross-checked and purged to derive an updated list of species for the region. This list was then validated and expanded with the species identified by the author during two field surveys in the region. Through this two-tier approach it was possible to produce a list of species known to occur in the region with reasonable confidence and a second list of species which could not be either corroborated to occur or eliminated for some justifiable reason. The latter are thus considered dubious records in need of confirmation.

The final updated list of sharks and rays for the region is presented in Table 4.1 above. It includes a total of 44 species of sharks and 33 of batoids recorded with certainty in the region or in waters just bordering the Gulf of Aden and thus very likely to be present in the Gulf of Aden. This list includes five new records of species previously unknown to occur in the region (1 shark and 4 batoids). The fact that these new records were found in only two surveys of the region suggests that there are still more new occurrences to be detected through longer-term surveys and routine sampling of the landings by trained personnel. A total of 5 shark and 14 batoid species are here listed as uncertain to occur in the region and need confirmation through reliable identification and collection.

5.2.1.2. Species composition of the catches

A preliminary assessment of the species composition in the fisheries of the region was performed based on the data obtained through the field surveys described in section 3.2 Eight species of sharks are predominant in the elasmobranch catches of the region (Table 5.1): *Rhizoprionodon acutus*, *Loxodon macrorhinus*, *Carcharhinus sorrah*, and *Mustelus mosis* are in order of importance the most commonly landed sharks that grow to less than 1.5 m TL, whilst *Carcharhinus falciformis*, *C. limbatus*, *C. amblyrhynchos* (= *C. wheeleri*) and *Sphyrna lewini* are the most commonly landed sharks that grow to larger sizes (more than 2 m TL). Batoids are in general much less important than sharks in the landings with some local exceptions. The most commonly landed are *Rhynchobatus djiddensis*, *Rhinobatos halavi*, *R. punctifer*, and to a lesser extent *Mobula japanica*. The main species of sharks and rays taken in the fisheries vary from country to country as detailed below based on direct observations of the landings made in each country. The very limited data taken in Sudan were complemented with the findings of Elhassan (2002).

<u>Egypt (Gulf of Suez and Hurghada)</u> – Although a large part of the catch is made up of small sharks and batoids taken mainly as bycatch in bottom-trawl fisheries, there is a considerable stock of dry fins of large sharks in the port of Suez, suggesting that directed shark fisheries are taking place somewhere in the Egyptian Red Sea coast. The most important species in the bycatches of bottom trawlers and deep-water (ca. 400 m) small-scale longliners are: *Rhizoprionodon acutus*, *Loxodon macrorhinus*, *Mustelus mosis*, *Rhinobatos punctifer*, *Iago omanensis*, and *Rhinobatos halavi*.

<u>Saudi Arabia</u> – Most of the elasmobranch catches in this country are incidental catches of reef and bottom-trawl fisheries but a wide diversity of shark species sometimes in considerable quantities can be found in the fish markets of Jeddah and Gizan. The most important in terms of

the volume and number of individuals landed are *Rhizoprionodon acutus*, *Loxodon macrorhinus*, *Carcharhinus sorrah*, *C. limbatus*, *C. amblyrhynchos*, and *Triaenodon obesus*.

Table 5.1. Species composition of shark landings in the region as estimated from direct sampling and observations during two field surveys in the region. Batoids not taken into account as they represented a very small part of the landings with only local exceptions. Main species shaded in gray.

	Species	KSA	Sudan	Djibouti	Yemen	Egypt	Total	%
1	*Rhizoprionodon acutus*	35			80	52	167	0.18
2	*Carcharhinus falciformis*	6			117		123	0.13
3	*Carcharhinus limbatus*	18		8	79		105	0.11
4	*Loxodon macrorhinus*	23	1		3	55	82	0.09
5	*Carcharhinus sorrah*	21			40	2	63	0.07
6	*Carcharhinus amblyrhynchos (=whe*	11	6	26	10		53	0.06
7	*Mustelus mosis*				1	43	44	0.05
8	*Sphyrna lewini*	2	1	1	36		40	0.04
9	*Carcharhinus leucas*			1	29		30	0.03
10	*Iago omanensis*					27	27	0.03
11	*Triaenodon obesus*	20	5		2		27	0.03
12	*Sphyrna mokarran*	3			20		23	0.02
13	*Carcharhinus brevipinna*				18		18	0.02
14	*Carcharhinus plumbeus*				17		17	0.02
15	*Carcharhinus melanopterus*	9		1	5		15	0.02
16	*Carcharhinus sealei*				15		15	0.02
17	*Alopias pelagicus*				14		14	0.02
18	*Isurus oxyrinchus*				13		13	0.01
19	*Carcharhinus dussumieri*	10					10	0.01
20	*Hemigaleus microstoma*	2			5	1	8	0.01
21	*Galeocerdo cuvier*				8		8	0.01
22	*Negaprion acutidens*		4		3		7	0.01
23	*Carcharhinus longimanus*				5		5	0.01
24	*Nebrius ferrugineus*	4			1		5	0.01
25	*Alopias superciliosus*				2		2	0.00
26	*Hemipristis elongatus*	1			2		3	0.00
27	*Rhincodon typus*	1			1		2	0.00
28	*Carcharhinus albimarginatus*	2					2	0.00
		168	17	37	526	180	928	1.00

<u>Sudan</u> – Due to the very limited data obtained directly in Sudan during the field survey, the information is mostly based on data provided by I. Elhassan (pers. comm. 2001). Although there is a moratorium for directed shark fishing in Sudan since 1998 some limited fishing continues to be carried out and the shark bycatches in other fisheries continue to be landed. Data from Sudanese fish markets and foreign vessels caught fishing illegally for sharks in Sudan indicates that the most frequently landed species are, *Carcharhinus amblyrhynchos*, *C. sorrah*, *C. melanopterus* and *C. limbatus*.

<u>Eritrea</u> – Data from Marshall (1996a) indicates that the most frequently caught species are *Carcharhinus limbatus, C. albimarginatus, C. amblyrhynchos, C. melanopterus, Galeocerdo cuvier, Triaenodon obesus, Sphyrna lewini,* and *S. mokarran*.

<u>Djibouti</u> – The directed shark fishery of Djibouti (see below) lands mostly *Carcharhinus amblyrhynchos, C. leucas,* and *C. limbatus.* Bycatches of small-scale gillnet fisheries are mostly *C. limbatus*, *Sphyrna lewini* and *Carcharhinus melanopterus.*

<u>Yemen</u> – The Yemeni shark catches being by far the largest in the region include almost all the species recorded in the region. However, the dominant specise in the catches are *Carcharhinus limbatus* (both as adults and in extremely high numbers as new-borns), *C. falciformis, Rhizoprionodon acutus, Carcharhinus sorrah, Sphyrna lewini* and *Carcharhinus sealei* (locally in the Socotra Archipelago).

Somalia – Marshall (1996b) reports personal communications that suggest *Carcharhinus melanopterus, Alopias sp. Sphyrna sp., Isurus oxyrinchus,* and *Negaprion acutidens* as the most commonly landed species in Somali shark fisheries. However, there is still much to be researched about the shark fisheries of Somalia and not knowing how reliable the information used to build this list is it should be taken with a lot of caution.

5.2.2. Fisheries biology of the main species

Information about the biology of the eight most important species in the catches is variable, mostly sketchy and in some cases non-existent. Some of the species with worldwide distribution have been relatively well studied in other regions but most of the species with local distribution have never been researched. There are a lot of risks involved in using data on life-history traits based on other populations of the same species, as geographical differences are known to occur among different populations of sharks (Cortes and Parsons, 1996). The information provided below should be only used as an indication of the potential life-history characteristics of each species and as a relative indication of the differences between them.

Carcharhinus falciformis (silky shark)

This is a coastal and semi-oceanic species of worldwide tropical distribution. It feeds on pelagic and demersal fish as well as cephalopods and crustaceans. Reaches a maximum size of about 330 cm (in the Western Atlantic) but Pacific and Indian Ocean specimens seem to grow to smaller maximum sizes. Sexual maturity in the Western Atlantic is attained at 215-225 cm TL or about 10 years of age in males, and at about 230-250 cm or about 9-12+ years of age in females (Branstetter 1987; Bonfil et al. 1993). In the southwestern Indian Ocean females are reported to mature at 248-260 cm TL (Bass et al. 1973) although females as small as 216 cm TL have also been reported (Stevens 1984). Silky sharks are viviparous with a gestation period of about 12 months, a 2-year reproductive cycle and a maximum litter size of 12-14 young. The young have nursery areas in shelf waters and move offshore as late juveniles to join tuna schools.

This species shows seasonal concentrations off the coast of Eastern Yemen that are known and targeted by fishermen. Limited sampling during the surveys indicates that all life-stages of this species from newborns to adults occur in waters of the region and all are caught in the fisheries (Fig 5.1). Specimens landed in Qusayar included several pregnant females of 220-225 cm TL and mature males of 220-240 cm TL.

The life-history parameters of silky sharks translate into a rebound potential of 0.043, which is a medium-low value when compared with other shark species (Smith et al. 1998). This highlights the fact that careful controls should be placed in the exploitation of this species. Better estimates of the rebound potential in the region need to be based on age, growth and reproductive studies of local populations.

Carcharhinus limbatus (blacktip shark)

A coastal and off-shore species of worldwide tropical distribution. Mainly a fish eater also feeding on cephalopods and crustaceans. Maximum reported size is about 255 cm, but specimens of up to 280 cm TL were measured in Hodeidah by the author. Off South Africa females mature at 7 years of age and 151-179 cm PCL, males at 6 years of age and 146-150 cm PCL (Dudley and Cliff 1993; Wintner and Cliff 1996). Gestation lasts about 12 months and maximum litter size in South Africa is 11 young. In the Gulf of Mexico females mature at 6-8 years old and 150-

162 cm TL, males at 4-5 years old and 130-136 cm TL (Branstetter 1987; Killam and Parsons 1989).

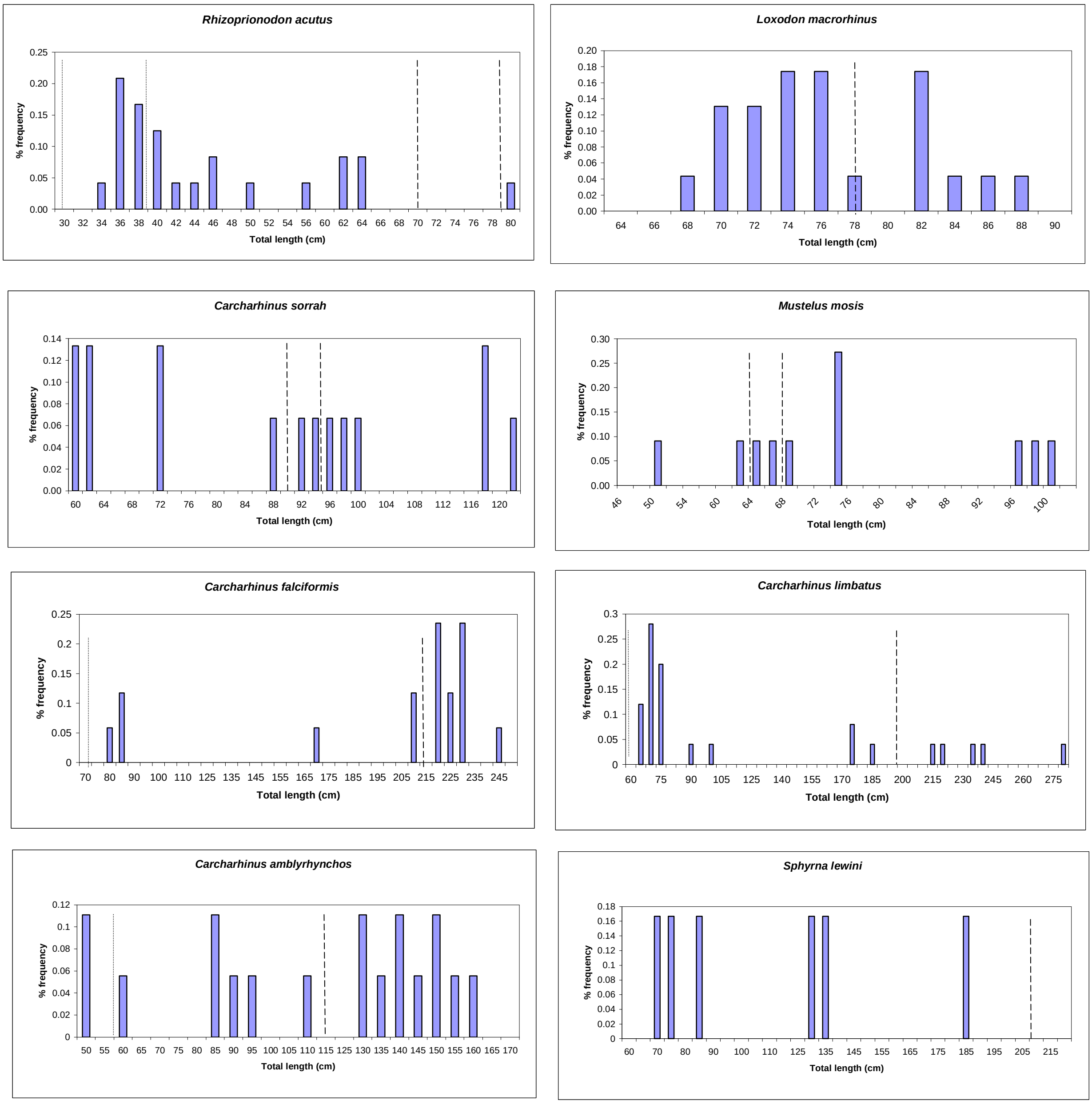

Figure 5.1. Size structure of landings of the top eight most important shark species in the fisheries of the region as estimated from the field sampling campaigns of the consultancy. For each species, fine-dashed lines represent the published size of birth (or range) while the coarse-dashed represent female size at maturity (or range).

Specimens of all life-stages of blacktip sharks are found in the catches of the region, with an emphasis in newborns and early juveniles (Fig 5.1). Nursery areas remain poorly known by researchers and fisheries authorities and need to be mapped and researched. However, nursery areas in Eritrea, Sudan, Djibouti and probably elsewhere are well known by fishermen and are being targeted by them at an alarming rate (Bonfil 2001b). The danger of recruitment collapse is imminent unless urgent measures to protect nursery areas of this species both in the Red Sea and in the Gulf of Aden are put in place.

Blacktip sharks grow relatively fast and do not take as long as other large sharks to attain maturity, at least judging on age and growth studies in other regions. As a result this species has a rebound potential of 0.054 which is of a medium value in relative terms (Smith et al. 1998). Although this species should be able to sustain slightly higher exploitation rates than other large sharks in the region, there is cause for concern about the sustainability of the fishery given the out of control fishing of nursery areas and the uncertainty about the age and growth and reproduction of the local populations. Studies oriented to investigate the fishery biology of this species should figure high in the list of priorities for research.

Carcharhinus amblyrhynchos (= *Carcharhinus wheeleri*; grey reef shark)

This is a common coastal shark found throughout the Indo-Pacific region, usually associated to inshore or offshore reefs. They feed mainly in teleost fishes, some cephalopods and a few crustaceans. Western Indian Ocean populations were until recently thought to be a different species due to minor local pigmentation and morphological differences. They are viviparous with maximum litter size of 4 pups and a one-year gestation cycle. Maximum size in the Western Indian Ocean is reported to be 193 cm TL; males mature at around 110-130 cm and females at about 120 cm TL, with size at birth around 65-75 cm (Compagno 1984). In Hawai'ian waters males mature at 120-140 cm TL and females at about 125 cm TL; maximum litter size is 6 pups and size at birth around 60 cm TL (Wetherbee et al. 1997).

In the Red Sea and Gulf of Aden grey reef sharks of all relative ages (Fig. 5.1) are caught with a variety of gears and at all life-stages. It is the most common shark catch in the region and with the exception of Egypt (probably due to limited sampling) it was recorded in the landings of all the member countries.

Hawai'ian grey reef sharks have been aged to a maximum of 18 years and age at maturity has been estimated at 7 years (Radtke and Cailliet 1984). The estimated rebound potential of this species is the same as the blacktip shark (0.054; Smith et al. 1998). However the age estimates are not validated and the biological information is not based on parameters derived from populations within the region. Exploitation should therefore proceed with caution and studies of the reproductive biology, age and growth, of the local populations should be carried out in the short term.

This species has a great value as a source of eco-tourism in the region as it is the most commonly sighted shark around the abundant coral reefs of the Red Sea. Shark diving world-wide attracts a great deal of adventure-seeking tourism and the much greater value of gray reef sharks alive as generators of foreign revenue for the region (in the form of air transportation, food and lodging costs, and diving tour and equipment) than their one-time value as landed dead fish should be taken into consideration for the management of the resource.

Sphyrna lewini (scalloped hammerhead)

A coastal-pelagic species of circumtropical distribution often found in large schools around sea-mounts. Scalloped hammerheads feed mainly on cephalopods and small pelagic fish. This species displays a good deal of plasticity in population parameters worldwide. Maximum size is between 370 and 420 cm, maturing at around 140 to 212 cm and with litters of up to 31 embryos. Off Taiwan the males mature at 198 cm TL and about 3.8 years old (assuming that two growth bands are deposited each year) whilst females mature at 210 cm TL and 5 years of age and reproduce every two years (Liu and Cheng 1999). However in the Gulf of Mexico males mature at 180 cm TL and about 10 y of age and females at 250 cm TL and possibly 15 y of age (Branstetter 1987). In the Mexican Pacific coast females of 335 cm are 18.5 years old and males of 244 cm are 8.8 years old. In the Western Atlantic Ocean off Brazil females mature at 240 cm TL and males at 180-200 cm TL. Off the KwaZulu-Natal coast of South Africa females attain 243 cm PCL, males 230 cm PCL, and both sexes mature at around 160 cm PCL. Young scalloped hammerheads are often found in deepish bays where they are vulnerable to trawl gear.

Scalloped hammerheads are fairly common throughout the Red Sea and Gulf of Aden and were found in the catches of all member countries except Egypt (likely a function of limited sampling in that country during the field surveys). The limited sampling of length frequencies carried out during the surveys shows that a lot of juveniles are landed in fisheries around the region. However, large catches of adults which could not be sampled for length and thus do not appear in Figure 5.1 were observed in Qusayar and Hodeidah (Annex X field notes). Fecundity in this species might be higher than previously reported in the literature: a pregnant female of 310 cm TL landed in Qusayar had a total of 47 embryos.

Needless to say, specific studies on the reproduction, age and growth of this species is needed as the basis for long-term management measures. This is especially true in lieu of the great disagreement and controversy between age and growth studies of this species in which either one or two growth bands are assumed to be deposited each year leading to grossly dissimilar estimates of age at first maturity and longevity.

Based on the growth studies of the Gulf of Mexico cited above, it is thought that the scalloped hammerhead has a very limited rebound potential of 0.028, one of the lowest among carcharhinid sharks and the lowest for the species of the region for which this parameter is known (Smith et al. 1998). Although this value is much dependent on the estimates of age and they might change depending on which of the two alternative growth models is accepted, this uncertainty is enough reason to place a cap on the catches of this species until population dynamic studies germane to the local populations and including validated age estimates are carried out.

Rhizoprionodon acutus (milk shark)

A small coastal species found in both coasts of tropical Africa and throughout the Indian Ocean into the Eastern Pacific Ocean. Eats mainly fish but also some cephalopods and brachyuran crabs (Salini et al. 1990). It is fairly common in coastal fisheries throughout its range but despite its importance this species has been neglected and little research on its biology is available. Maximum size is reportedly up to 178 cm TL but it rarely exceeds 110 cm. Litter size is up to 8 young and gestation is about a year; males mature at 68-70 cm and females at 70-81 cm TL (Compagno 1984). Size and age at maturity is reported to be 65 cm and 3.5 years in India (Krishnamoorthi and Jagadis 1986).

The milk shark is the most abundant shark in the catches of the region and probably throughout its range. It is found in great quantities wherever it is landed from the Gulf of Suez to Southern Yemen. Its absence from Sudan and Djibouti during the field surveys of the consultancy is likely only an artifact of limited sampling in those countries. Although all life-stages of this species can be found in great numbers in the landings the catches are heavily centered on juveniles and newborns (Fig 5.1). This is likely causing growth overfishing and is a reason for concern regarding possible failure of recruitment to the breeding stock in the near future.

There is no estimate of the reproductive rate of this species or of its rebound potential due to the lack of detailed studies of its age and growth. However, it is reasonable to assume that its biology is similar to that of species in the same genus. Small carcharhinoid sharks tend to have short life cycles, grow relatively rapidly and attain sexual maturity in a few years. If this is assumed valid, the milk shark is possibly the species with the largest rebound potential in the region. A similar species of the same genus, the Atlantic sharpnose shark *R. terraenovae* has a rebound potential of 0.84, one of the highest among sharks (Smith et al. 1998). A possible high rebound potential in milk sharks might explain its ability to sustain large catches in numbers across the region. It should not be forgotten though, that elasmobranchs are still more fragile and less productive than most teleost fish and caution should be exercised in the management of this species.

Loxodon macrorhinus (sliteye shark)

This is a little known but fairly common inshore small shark of continental and insular shelves and restricted to the Indian and Eastern Pacific Oceans. Despite its abundant in the catches of small-scale fisheries throughout its range, information about this species is so rare that not a single paper that focuses on its biology has been published in the last 30 years. Maximum size is reported to be 91 cm TL; males mature at 62-66 cm and females at 79 cm TL (Compagno 1984). Size at birth is about 40-43 cm but litter size and gestation cycle are not known. There are no estimates of longevity or age at maturity for this species and the length of the complete gestation cycle is unknown.

Similar to the milk shark, it is very abundant wherever it is landed and is probably fished throughout the Red Sea as suggested by its presence in landing points in Suez, Sudan, Saudi Arabia and Yemen. Judging from the sampled catches mostly juveniles and adults are taken in the fisheries (Fig 5.1).

There is little data to judge what the life-history characteristics of this species are and it is risky to make guesses about its rebound potential. It is possible that similar to other small carcharhinid sharks, this species might have a short life cycle and a relatively high rebound potential but this is unknown. Studies on the reproductive biology and the age and growth of this species should figure high in the list of priorities in the region.

Carcharhinus sorrah (spot-tail shark)

A small shark common in shallow inshore waters and especially around coral reefs in the Indian and parts of the Eastern Pacific Oceans. Eats mainly bony fishes and some octopi. Growing to a maximum length of 160 cm, males mature at 106 cm and females at 110-118 cm TL; litter size is 3-6 pups and birth size is 45-60 cm. In northern Australia size at birth is 52 cm, males mature at age 2 and 90 cm and females at age 2-3 and 95 cm, maximum fecundity is 8 young per litter (average about 3.1), maximum age is 7 years, and the entire reproductive cycle takes 1 year (Stevens and Wiley 1986; Davenport and Stevens 1988).

It is relatively common in the catches of the region and judging from its occurrence in the catches of Egypt and Yemen (including Socotra), it is probably caught throughout the region; it is certainly known to be fished off Sudan (I. Elhassan pers. Comm. 2001). Limited length frequency sampling in the region suggests that most of the catch is composed of adults (Fig 5.1) but this is a result of limited sampling. The extremely large quantities of newborns of this species that are being landed in Yemen along with newborns of blacktip sharks (Bonfil 2001b) are a cause for concern and should be addressed through protection of nursery areas. As in the case of blacktip sharks, researchers and managers must catch up with fishermen in terms of knowledge about the location and seasonality of these nursery areas and work together with them for their sustainable utilization.

There are no studies of age and growth and the reproductive biology of local populations of spot-tail sharks and none of the rebound potential for the species. Using the Australian data on population parameters, the rebound potential can be estimated using the methodology of Show (2000) for two different scenarios. One uses the maximum age reported above, and the second a maximum age of 9 years more in line with the age corresponding for the largest females found in Australian waters. The resulting rebound potentials are 0.117 and 0.210 (Tab. 5.2) and are among the largest for any shark for which rebound potentials have been estimated (Smith et al. 1998). Despite this optimistic results studies on the fisheries biology of this species should receive due attention in a research agenda for the elasmobranchs of the region to derive rebound potential values (and therefore relative ability to sustain exploitation) that are relevant for the local populations.

Table 5.2. Estimated rebound potential for *Carcharhinus sorrah* based on life-history parameters from Australian populations (Stevens and Wiley 1996; Davenport and Stevens 1988)

Species Name	*Maximum reproducing age* w	*Age at maturity* alpha	*Adult natural mortality* M	*Average litter size (female pups)* b	*intrinsic rebound potential* r_{2M}
Carcharhinus sorrah	7.0	2.5	0.624	2.0	0.117
Carcharhinus sorrah	9.0	2.5	0.488	2.0	0.121

Mustelus mosis (Arabian smoothhound)

A little known demersal species of inshore and offshore waters of the Western Indian Ocean. Viviparous, with 6-10 pups per litter, feeds on molluscs, crustaceans and small bottom fish (Compagno 1984). Grows to a maximum size of 150 cm TL, males are mature at 63-67 mc and females at 82 cm TL. The length of gestation and of the entire reproductive cycle, the size at birth as well as the age and growth of the species remain unknown.

It is mostly caught in the northern Red Sea where it is an important part of the bycatches. Judging from the limited length frequency sampling, the landings are made up of adult sharks (Fig 5.1) which is a good trend, but this should be corroborated with further sampling. There are no studies on the basic population dynamics parameters of the species and this should to be addressed if management is to be based on sound science. For the moment, it is reasonable to expect that the population biology of the Arabian smoothhound will follow the general trend of other species in this genus which tend to grow rapidly and attain maturity relatively soon. Two other smoothhound species were shown to be the elasmobranchs with the highest rebound potential (0.12 -0.13) among 27 shark species (Smith et al. 1998). While there is no replacement for sound science in which to base management decisions and dealing with elasmobranchs precaution is always advisable in exploitation, this species represents probably the least concern among the main species caught in the fisheries of the Red Sea and Gulf of Aden.

5.2.3. Overview of the fisheries

With few exceptions, the elasmobranch fisheries of the region are characterized by an extremely poor informational baseline, a low degree of organization, a lack of direction and an almost total absence of regulation. These characteristics are common to other fisheries in the region but are particularly acute in the case of shark and batoid fisheries.

Several attempts to develop the elasmobranch fisheries and to re-vamp the monitoring and management systems of the fisheries sector around the Red Sea and Gulf of Aden have taken place since the 1970s or are currently taking place (i.e. the UNDP-FAO Red Sea Project, the FAO IV-Fisheries project, the GEF Socotra Biodiversity Project). Unfortunately, the attention given to elasmobranch fisheries continues to be insufficient to guarantee their sustainability and a lot remains to be done to bring them into a phase of stability and permanence.

The first and most comprehensive overview of the fisheries resources of the Red Sea and Gulf of Aden was conducted by Sanders and Morgan (1989) who synthesized and augmented the findings of the long-term Red Sea Project that UNDP and FAO conducted in the region during 1979-1984. An updated review of the marine resources of the region was recently prepared by the SAP of PERSGA (Hariri et al. 2002). Unfortunately, the former report contains extremely limited information about sharks and batoids, probably as a reflection of both the limited state of exploitation of these resources prior to the writing of that report and the historical lack of attention to these less traditional and less popular resources. The latter review contains some useful information but still reflects a pervasive lack of attention to shark and batoid fishery resources.

At least up to the late 1980s most of the fisheries sector around the Red Sea and Gulf of Aden was little developed and most countries were unable to satisfy their needs for fish supply through their own fisheries, having to complement these with fish imports. The only notable exception was Yemen (then the People's Democratic Republic of Yemen or PDRY), a proof of the early preponderance of this country as the lead fishing nation of the region. The PDRY was the only nation with significant industrial fisheries as the rest of the countries surrounding the Red Sea and Gulf of Aden relied largely on small-scale fleets for the exploitation of their resources, although Egypt had already a small industrial trawling sector. There was little mixing of fleets and fishermen exploited resources only within their national waters, a situation that has clearly changed since then. Sanders and Morgan note since then the general lack of adequate time series of detailed landings and effort statistics in the region.

As detailed below, this has changed little in most countries at least for the elasmobranch fisheries. In general, it is evident that little interest remains devoted to these resources and their fisheries in the region. The level of data available in the literature and even from direct sources through management authorities and in the field is extremely poor, a problem that will continue to hamper any future efforts to control and manage the fishery. Steps to resolve this should include dedicated and extensive searches of historical data indicative of past levels of exploitation along with censuses of the amount of people, vessels and gears involved in the elasmobranch fisheries. This information in addition to research into the operational modes and main fishing grounds of the fisheries, surveys of elasmobranch nursery areas and close regulation and monitoring of fishing in these essential habitats will be necessary as first steps towards sustainable exploitation.
The particular aspects of the shark and batoid fisheries in the region are discussed below.

5.2.3.1. Fishermen and fishing craft

Although there is some scattered data about the historical and current number of fishermen, vessels, and gears involved in fishing for sharks and batoids, there is a worrying lack of complete and sufficient data in the whole region. In particular, fisheries authorities do not have access to current information with which to shape management decisions. The particular situation for each country is outlined below.

Egypt – During the early 1980s, the Egyptian small-scale fishery sector in the Red Sea included about 1,300 fishermen (at least 350 on foot fishing from shore) with an estimated 230 motorized boats and about 78 sail-powered boats (Moharram 1983). Fishermen were roughly distributed 27% in Hurghada, 23% in Quseir and surrounding villages, 20% in the Sinai coast, and 30% in the Gulf of Aqaba (mostly on foot). Recent (1997) data indicate that there now about 9,000 small-scale fishermen and 820 boats in the Red Sea of Egypt (Hariri et al. 2002). This is nearly a seven-fold increase in the number of fishermen and more than two and a half-fold increase in the number of boats. There are however no estimates of how many of these fishermen and boats participate in direct elasmobranch fisheries and whether they do this year-round or on a seasonal basis. Interviews in the area indicate that there are no directed fisheries for sharks in the Gulf of Suez although sharks and batoids are frequently landed as bycatch of trawl and longline fisheries (Bonfil 2001b).

Sudan – The small-scale fisheries sector of Sudan is reported to be extremely low, with only 209 fishermen and 460 boats (Hariri et al. 2002). As in the case above, data seem suspect given the larger number of boats than fishermen reported and the extremely low number of fishermen reported. There is no indication about the number of fishermen or vessels involved in shark fishing, which although temporarily banned since 1998 is reported to still take place illegally (I. Elhassan pers. comm. 2002). During this consultancy 105 motorized boats and 50 sail boats were counted at Suakin (Bonfil 2001b). Alternative figures by the Sudanese Marine Fisheries Administration indicate some 1,170 full-time fishermen, 181 OBM boats, 132 IBM boats, and 122 sailing boats (Elhassan 2002). However, the accuracy of these figures is yet to be determined.

Eritrea – Shark fishing in Eritrea is in record since the 1950s and 1960s but little historical and current information is available. Apparently, shark fishing using longlines was started by Yemenite immigrants or local fishermen of Yemeni lineage (Sanders and Morgan 1989). Surveys carried out by FAO in 1992 indicated that some 2,615 people and about 636 boats were involved in small-scale fisheries although at least 1/3 of the fleet was not operational (Marshall 1996a). An unknown number of sambuqs and houris were involved in shark fishing with gillnets (200-400 mm mesh size) and longlines from October to May.

Djibouti – Total fishermen population (all small-scale) was estimated at less than 230 in 1983 (Sachithananthan 1983). Recent reports (1996) indicate that only 270 small-scale fishermen and 90 boats exist (Hariri et al. 2002). Previously unreported directed fishing for sharks takes place with at least 7 boats from Obock using gillnets and longlines. Fishing takes place in the Seven Brothers Islands and the coast north of Obock (Bonfil 2001b) but there are no complete estimates of the size of the shark-fishing fleet or number of fishermen.

Saudi Arabia – Latest estimates (1997) of the small-scale fisheries sector in the Red Sea coast indicate a total of 4,100 fishermen and 5,428 boats (Hariri et al. 2002). Partial surveys during

2001 indicate at least 585 small-scale fishing boats in the Farasan Islands, 110 boats in Ummloj, 100 in Al-Hurjh, (Bonfil 2001b). The above data are suspect since 33% more boats than fishermen are reported. Moreover, there is no indication of the numbers of boats or fishermen participating in shark fisheries or taking important bycatches of elasmobranchs in their activities. Clearly, a better survey of this sector is needed in Saudi Arabia.

Yemen – The size of the Yemeni fishing fleet has historically been the most important in the PERSGA region and continues to be so. Limited historical data for Yemen's Gulf of Aden small-scale fisheries is given by Chakraborti (1984a). Observations in some localities indicated a minimum of 1,584 fishermen and 463 boats (219 sambuqs and 244 houris; Table 5.3).

Table 5.3. Number of cooperative fishermen and boats in the Gulf of Aden coast of Yemen around 1983 according to data from Chakraborti (1984)

Locality	Fishermen	Sambuq	Houri	Notes
Al Shokra	-	10	75	Reported about 18.6 t of sharks in 3 months
Mukkallah	650	36	13	Half of sambouks fish for sharks w/longlines, houris fish with gillnets
Ash Shihr	642	138	76	Sambouks operate longlines for sharks; houris handlines
Fukum	292	35	80	30-hook longlines used for sharks
Totals	1,584	219	244	

More recent estimates (1997) based on comprehensive surveys showed about 21,500 fishermen and 2,200 small-scale craft the Red Sea coast, and approximately 19,000 fishermen and 5,400 fishing craft in the Gulf of Aden coast (Saqaff and Esseen 1997). The above figures represented a 250% increase in the number of fishermen in the Red Sea coast since the last data available (undated), while in the Gulf of Aden the number of fishermen grew by 143% and the number of boats by 96% in comparison to data from 1992-93. However the authors of the report highlight that the interviews in which these data are based showed some inconsistencies and that their numbers should be only indicative of the relative size of the fisheries. The largest centers of small-scale fishing activity in order of importance were Hodeidah, Khokha, and Khobah in the Red Sea, and Mukkallah, Foqum, Shihir, and Qusayar in the Gulf of Aden. In addition to this, Nichols (2000) estimated the total number of fishermen around the Socotra Archipelago at about 2,600 and the total number of boats at 1,113 (40 sambuqs, 840 FRP houris and 133 wooden houris). The above information results in a total estimate of 43,100 fishermen and 7,713 fishing boats for Yemen at the end of the 1990s. There is no quantification of the numbers of boats or fishermen involved in the direct fishery for sharks, but the above reports indicate that east of Mukkallah fishermen concentrate in sharks, yellowfin tuna and other pelagic fish with Qusayar the most important shark fishing center, and fishermen in Socotra fishing shark as their prime activity. Most of the 100 sambuqs based in the Gulf of Aden coast are engaged in shark fishing with gillnets and longlines (Hariri et al. 2002). Additional information gathered directly during the consultancy (Bonfil 2001b) indicates that vessels and people involved in directed shark fisheries include:

- Hodeidah: 3,600 fishermen and 300 sambuqs each with up to 2,400 m of gillnet
- Mokha: 20 houris using longlines of 80 hooks
- Bir-Ali: 12 houris using longlines of 120 hooks, and 20 boats with shark gillnets
- Mukkallah: 20 houris using longlines of 34-51 hooks
- Al-Hami: 15 houris with longlines of 40-60 hooks
- Qusayar: 568 fishermen and 30 abris using 900 m of gillnets, surface longlines of 150 hooks and bottom longlines of 120 hooks

From the above figures it is possible to estimate that a minimum of 4,200 fishermen and 417 vessels of various sizes are directly involved in shark fishing in Yemen. If the estimates of fishermen and vessels in Socotra are added (Nichols 2000), the total could rise to 6,800 fishermen and 1,297 vessels.

Somalia – There is no historical information available about fisheries in Somalia except a report by Elmer (1985; in Sanders and Morgan 1989) indicating that most of the fisheries there were small-scale and that sharks were targeted with gillnets. Marshall (1996b) compiled data on the shark fisheries of Somalia and reported a minimum of 200 OBM boats fishing for sharks in the northeast of the country. A total of 269 FRB boats and 806 wooden boats are reported in the small-scale fisheries sector of Somalia but at the same time at least 140 boats are reported not operational. Recent estimates (2000) suggest at least 8,000 fishermen and 522 boats operating in Somali waters and there are indications that shark fishing with gillnets and longlines is the prime activity (Hariri et al. 2002). However, there are no reliable estimates of the total number of boats, fishermen and gear directly involved in shark fishing.

5.2.3.2. Historical and current catches

Lack of reliable information on the catches of sharks and batoids in the region is notorious. Figures reported to FAO indicate that catches have always been of a relatively very low level in the countries of the region with the exception of Yemen (Fig 5.2). However, such statistics might be misleading and at least in some cases an underestimate (see below Yemen and Saudi Arabia). Until recently there was no data in the FAO database on elasmobranch catches for Sudan and there is still no data for Djibouti and

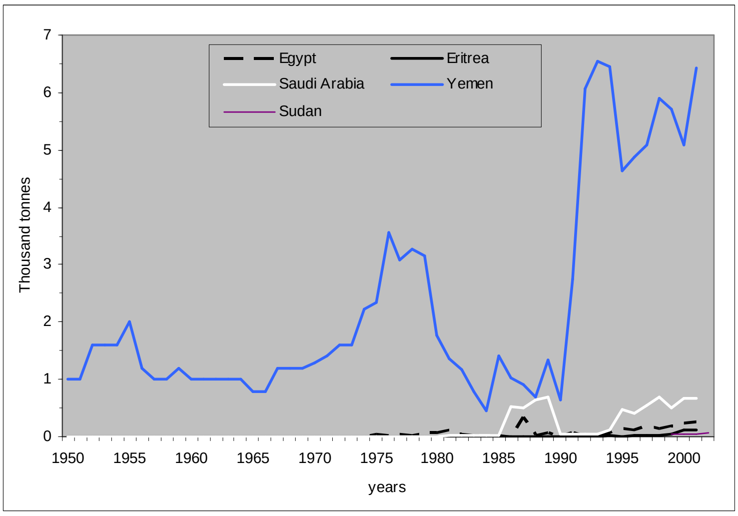

Figure 5.2. Historical catches of elasmobranchs for countries of the Red Sea and Gulf of Aden region according to statistics reported to FAO.

Somalia despite the existence of directed fisheries for elasmobranchs in both countries (Bonfil 2001b; Hariri et al. 2002). The reported current level of shark and batoid catches is of nearly 6,500 t for Yemen, 650 t for Saudi Arabia, 260 t for Egypt (excluding Mediterranean coast), 100 t for Eritrea, and 80 t for Sudan.

According to FAO data, reported catches in Yemen grew very rapidly in the early 1990s from about 1,000 t/y to about 5,000-6,500 t/y where they have fluctuated since then (Fig 5.3). Saudi catches of sharks and rays have never reached 800 t/y but show wide fluctuations likely associated with inconsistencies in the reporting system rather than actual changes in catches, although figures seem more regular since 1995 and suggest a very slight increasing trend.

Reported Egyptian catches of sharks and batoids have remained below 400 t/y but show a clear and rapid increasing trend since 1990, surpassing 250 t in 2001. Reported catches of elasmobranchs in Eritrea are not available before 1994, but they are rapidly increasing and have surpassed 100 t/y since 2000.

The historical data available through FAO can only be as good as the data provided by each country. Knowing the lack of adequate monitoring systems in the region (see below) the above data are probably reflective only of the relative importance of the catches between countries but should not be used as indicators of either trends in the fisheries or the actual level of the catches. Several sources of information suggest that the level of catches of sharks is much higher at least for Yemen and probably for a few other countries. Exports of dry shark fins from Yemen for the period 1995-2000 (K. Hariri, pers. comm. 2001) do not match the reported catches mentioned above (Fig 5.3). A better idea of how inaccurate the available official statistics are is provided by comparing them with historical data on shark landings and shark products of the Qusayar Fishermen Cooperative Society made available during the consultancy (H. Muhaimdan pers. comm. 2001). The landings and production data kept for financial purposes by this one cooperative alone for the period 1977-2000 indicate that their landings are larger than the data reported through FAO for the whole of Yemen. The differences range from 50% to 400% more for the period 1980-1990 (ignoring an odd extremely high figure for 1988; Fig 5.4). Alternative estimates for the total landings of this cooperative based on conversion of their reported dry shark fin volumes to live weight show similar inconsistencies with the FAO data and reinforce the view that the real catches of sharks in Yemen might be at least twice as large as currently reported.

Despite the greater FAO catches since 1997, which might lead to believe the inconsistencies have been resolved, it should be considered that Qusayar represents only part of the landings of sharks in Yemen. If the estimate based on the Qusayar cooperative data for 2000 is added to the conservative estimated catches of 1,200 t in Socotra for the same year (Nichols 2000) and a conservative estimate of 2,250 t for the port of Hodeidah (based on data reported by Bonfil (2001b) for daily shark landings during 4 days in April 2001 and assuming 120 days in a year with similar landings) the total is 7,450 t. Higher estimates for recent catches of up to 7,200 t for Socotra alone are available (see Historical Data below), further evidencing the likelihood of total Yemeni shark catches that are much higher than currently thought.

Data for Somalia are lacking, but Marshall (1996b) provides an estimate of about 130,000 sharks taken per year in the mid-1990s. She goes further to mention that at least 50% of these would be sharks of less than 1.5 m TL. A rough estimate using 5 kg as average weight for sharks less than 1.5 m and 30 kg as average weight for the rest of the catch, results in an overall estimate of 2,625 t/y.

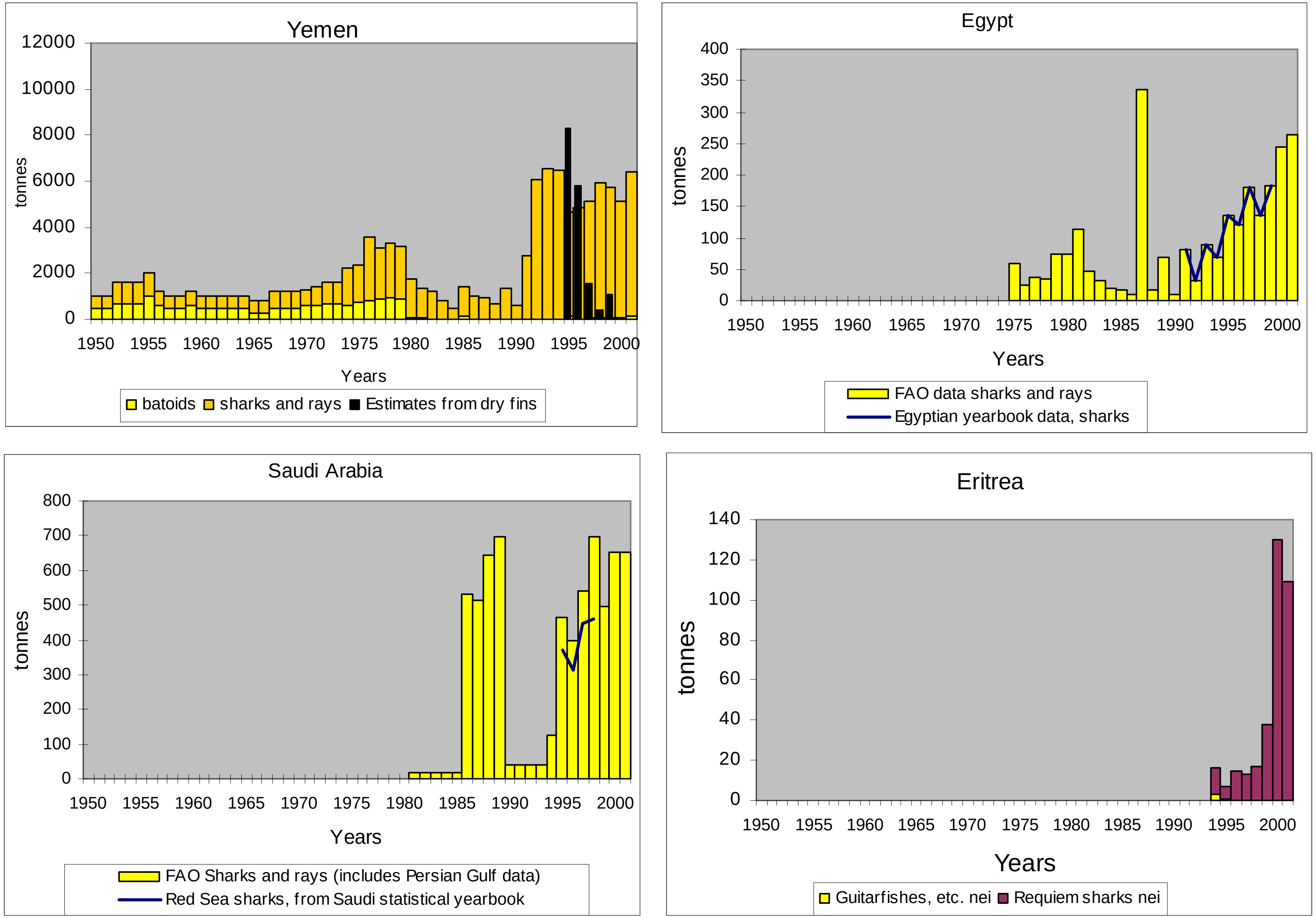

Figure 5.3 Historical catches of elasmobranchs of Yemen, Egypt, Saudi Arabia and Eritrea as reported by FAO and local official sources (see text).

Some historical data (Sanders and Morgan 1989) suggest that catches of sharks and batoids in the Red Sea coast of Saudi Arabia were already as high as 820 t in 1983, much higher than reported by FAO statistics. Recent data from local official statistics for Saudi Arabia and Egypt seem at least to be consistent with corresponding FAO data (Fig 5.3). Nevertheless, a large degree of unreliability in catch statistics is inevitable given the shortcomings of fisheries data collection throughout most of the region.

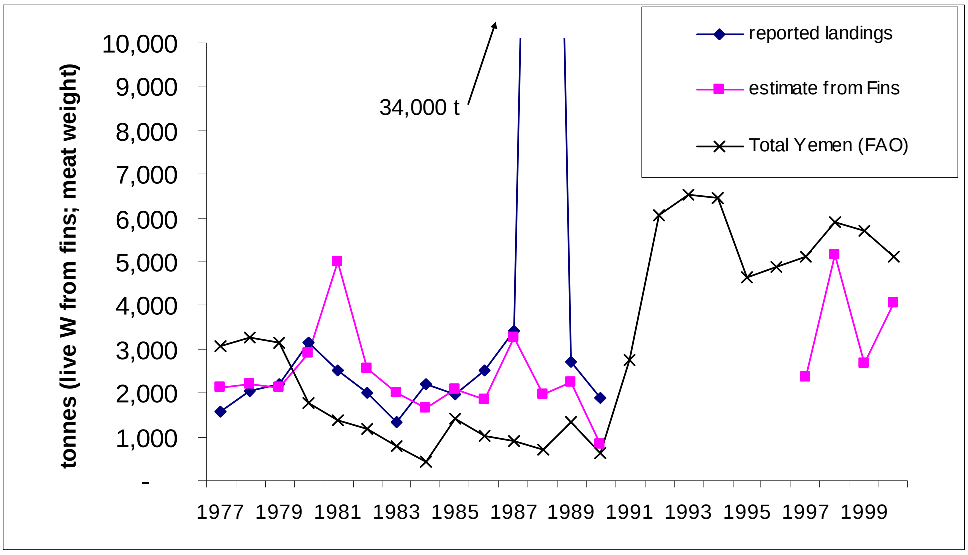

Figure 5.4. Landings of sharks, and live weight estimated from landed shark fins, for the Qusayar Fishermen Cooperative Society as compared to official FAO total elasmobranch landings in Yemen.

5.2.3.3. Utilization and quality control

With few exceptions, utilization of sharks throughout the region leaves much to be desired. Several problems in this regard have been reported in the literature and witnessed during the consultancy (Nichols 2000; Bonfil 2001b; Hariri et al. 2002). The lack of a code of practice for the handing and the processing of the catches translates into a large amount of waste, a very low product quality, and ultimately the loss of potential increased revenues from the fishery. Full utilization of sharks is one of the practices required though the FAO's IPOA-Sharks for compliance with the Code of Conduct for Fisheries that should be promoted across the region as a priority not only to comply, but also because it would generate direct economic benefits to the shark industry in the region.

The first and most important problem is that fishermen across the region do not bleed sharks and rays as soon as they are brought on board their vessels right after capture. Bleeding sharks should be strongly promoted though extension and awareness campaigns and if possible forcefully implemented as part of the regulations for fishing. Cutting the tail of the sharks and rays is the most effective and easy way to bleed them, but cutting the gills through the gill openings is an alternative an equally effective way (Sachithananthan 1983). Not bleeding sharks causes breakdown of the naturally high urea contents in the blood of elasmobranchs into ammonia, which gives the carcasses a bad taste and a pungent odor.

A second and more difficult problem is the shortage or lack of ice facilities on board vessels and on shore in many areas around the region. The proper usage of ice would allow fishermen to keep their elasmobranch catches fresh and hygienic to obtain a better final product that would generate higher incomes. A current practice in many places along the Red Sea and Gulf of Aden is to keep the sharks after capture on board the vessels in the sun and without ice until the catch is landed. Then sharks are processed by gutting them and splitting them in two, salting them and piling them up. The result is a high degree of spoilage of the meat which in some areas gets often infested by maggots and mice (Nichols 2000). The end product is half rotten and of extremely bad quality. Proper bleeding, icing and processing could greatly increase the quality of the product and the revenue in the fishery, but the solution is costly: a large scale program to repair existent but ageing or broken down ice factories and the installation of new ones in areas where they are not available. Long term availability of spare parts and servicing would have to be implemented alongside for the program to have a chance of long term success. The benefits would spill over to other fishery products that are equally suffering of bad handling practices and lack of facilities to keep them fresh.

Proper salting and drying of filets and the utilization of the hides of sharks are two other areas for improvement in the fishery that need to be promoted. Currently the meat of sharks is processed without separating it from the hide, without bleeding the shark at capture, using an excessive amount of salt and without properly placing the product to dry in the sun with sufficient aeration (Nichols 2000; Bonfil 2001b). Well prepared dried-salted filets of sharks can attain much better prices and could even be promoted as an export. The environmental conditions of the region are ideal for this kind of processing and product with the advantage that ice would only be required during the period between capture and landing. Rapid and efficient processing on shore will be required and some training and promotion of this type of processing will also be needed. However the benefits can be substantial.

Along similar lines, the hides of sharks are not being utilized with the consequent loss of opportunity for further revenue in the fishery. Shark hides produce some of the best quality leather which is one of the strongest and most durable leathers available. The major constrain at present for the processing of shark skins in the region is the availability of a steady market for the product.[1] If this problem can be solved, training and promoting of the processing and export of shark hides should be carried out in the region, especially in Yemen where the shark fishery is larger and the problems of utilization and quality control stronger.

5.2.3.4. Data collection and monitoring

The collection of data for elasmobranch fisheries in the Red Sea and Gulf of Aden is deficient and very poorly developed whilst the monitoring of the elasmobranch fishery resources is totally non-existent; both situations need to be urgently improved. There are severe problems in the gathering of catch data. Furthermore, there is a total lack of collection of effort data and no monitoring of the abundance of the species, the location and state of nursery areas, and research of the fisheries biology of the principal species.

[1] Attempts to prepare a market study for shark hides with the help of FAO were made during the consultancy with the hope that Yemeni authorities could establish links with potential buyers and explore the viability of promoting the processing and selling of shark hides in foreign markets. FAO got in touch with INFOFISH (an intergovernmental organization for marketing information and technical advisory services for fishery product in the Asia Pacific region) asking for help with a market study for shark hides. Their response was that a study could be carried out if financial resources could be made available. This response was passed over the former LMR-LS of SAP Dr. Khaled Hariri. Apparently the financial resources were not available but the possibility to carry out the study still exists and could be pursued in the near future.

The first major problem in the data collection system of all countries in the region is the lack of species detail in the data for elasmobranch catches. Data on catches of sharks and batoids are not recorded or reported with any degree of species breakdown or even species-group breakdown. At best, catches of sharks are reported separately from batoids, but there is no detailed data on which of the 28 shark or 17 batoid species known to occur in the fisheries, the catches belong to. Species-specific data on catches are one of the most important pieces of information for stock assessment purposes and are one of the most urgent problems that need to be solved in particular for elasmobranch fisheries (FAO 1999). Species-specific catch data collection for at least the most important sharks and batoids needs to be implemented soon if any stock assessment and meaningful management of the fisheries is expected. An initial first step that can be feasibly implemented is to begin recording species-specific catch data for the 8-12 most important species of each country as defined in the preceding sections. Periodic checks on the species composition of the catches might be required to adjust the list of most important species.

A second and closely related problem is that the systems for fisheries data collection in most countries of the region have been traditionally weak and continue to be so, becoming one of the main obstructions for proper planning and management of the fisheries. Catch data collection is incomplete or non-existent and effort data collection for the elasmobranch fisheries is not taken by any country. There is a better organization of the systems for catch data collection in Egypt and Saudi Arabia, where yearly fishery statistics books are produced by the government, and which generally agree well with FAO statistics. However there are no means to measure the relationship between such statistics and real catches of elasmobranchs and at least in the case of Saudi Arabia there are examples of problems with data collection and reporting in the 1980s.

The situation is worse in Sudan, Somalia and Yemen, and probably in Eritrea (for where little information was available). The lack of organized fisheries and adequate monitoring systems is understandable in some of these countries as they have been torn by war for several decades, but other countries without these problems have also not develop efficient data collection systems. Sudan had no system for collection of fishery statistics in the 1980s (Sanders and Morgan 1989), and presently no catches of shark or batoid are reported from Sudanese sources (Hariri et al. 2002) while at the same time alternative sources confirm the existence of landings in this country (Elhassan 2002; FAO 2002).

The case of Yemen deserves particular mention given that it has by far the largest and most active fishing fleet in the region and is a nation with a long history of shark fishing. FAO and UNDP implemented a large project that attempted to set up an adequate system for fisheries data collection and monitoring in the former PDRY (Chakraborti 1984a). However, this effort did not translate into improvements and to this date there are large deficiencies in the system such that in real terms fishery statistics for Yemen are deemed unreliable (Hariri et al. 2002). Aside possible problems of lack of enough qualified human resources (information on numbers of enumerators working for the MFW is not available) and possibly shortage of financial resources which affect the fishery agencies of many countries, the available resources in Yemen are not used properly. Fishery catches are almost never weighted anywhere in Yemen (Nichols 2000; Hariri et al. 2002), but instead they are crudely estimated or perhaps in some cases made up. Underreporting and non-reporting to fishing cooperatives- an alternative source of data on catches- are known to occur in order to avoid marketing charges and contributions (Nichols 2000).

Monitoring of elasmobranch species abundances trough fishery-independent surveys, mapping and monitoring of main nursery areas, and research on the life-history characteristics of the main species, all essential information for stock assessment and management, are non-existent in any of the countries in the region (Nichols 2000; Hariri et al. 2002). The situation is such that there is no information available to carry out proper evaluations of the state of the stocks and this precludes the sound long-term management of the elasmobranch fisheries.

5.2.3.5. Resource status

5.2.3.5.1. Stock definition and characterization

There are no studies or data about the definition of the stock of any elasmobranch species in the region. The sizes attained by some of the specimens observed during the field surveys suggest to the author that some of the species with cosmopolitan distribution might have regional stocks, something that would be expected. Very large specimens of blacktip (*Carcharhinus limbatus*) and spinner sharks (*C. brevipinna*), as well as relatively small mature specimens of silky sharks (*C. falciformis*) as compared to populations in the NW Atlantic (Bonfil 1997), suggests that the specimens from the PERSGA region might belong to separate stocks. However, it is impossible to do anything more than speculate about the definition of such stocks. It is unlikely that the above species have stocks that are restricted to the PERSGA region given their strong swimming capabilities and in the case of the silky shark its offshore habits. However little more than this can be said.

For some of the smaller and less mobile species and especially those with distributions restricted to this part of the globe, it is likely that they might have local stocks separate from neighboring areas in South Asia or East Africa. This could be the case of species such as *Carcharhinus dussumieri, Iago omanensis, Loxodon macrorhinus, Mustelus mosis,* and *Rhizoprionodon acutus*. However, there is nothing to prove or disprove the above speculations. Much research on the detailed distribution of these species in the region and neighboring areas, studies of their meristics and population genetics, and perhaps even tagging programs will be required to elucidate the structure of the stocks of the sharks and batoids of the region.

5.2.3.5.2. Stock Assessment

There are virtually no stock assessment studies for any of the shark and batoid species in the region. This is mainly a direct result of the lack of the data required for stock assessment that in turn is due to the deficiencies on data collection and monitoring discussed above, more than to a problem of trained personnel to perform the stock assessments. But the root of the problem of adequate data not being available lies not only in the structural and functional problems that exist in most of the fisheries agencies in charge of collection and monitoring, but also in the lack of awareness in those agencies and among the fisheries sector itself about the importance of the elasmobranch resources and the special need these resources have for more careful management their propensity for overexploitation.

The need for stock assessment and related studies is particularly acute for the shark fisheries of Yemen, which are probably responsible for at least 75% of the shark and batoid catches in the entire region. The only attempt for a shark stock assessment in the region focused on the shark fisheries of Socotra Archipelago in Yemen (Saeed 2000). The estimates from this study are unreliable and cannot be of use for management purposes (Nichols 2000; Hariri et al. 2002). The derivation of data used in the study is suspect and not clearly explained, the time series of catch and CPUE used is too short to provide a reliable estimate of the size of the stock and its potential, the approach unrealistically assumes that up to 10 shark species with very different life-history characteristics can be lumped together for the analysis and expected to behave like a single-species stock, and the model implementation (equilibrium surplus production model) is the worse choice of model.

The lack of historical data on the abundance level and the removals of sharks can be partially alleviated by digging out detailed information on landings and effort from individual fishing cooperatives and fishing companies throughout the region. At least two localities in Yemen (cooperatives in Bir-Ali and Qusayar) are known to have detailed records going back to the 1970s and are willing to facilitate the retrieval of this data. This would require a dedicated pair of well-trained fishery officers or consultants to visit each site and carefully record the data in electronic format. Further investigations across the region might highlight the existence of similar data that should be recovered. This information could at least provide a credible index of shark abundance trends for those parts of the region where the corresponding fleets have traditionally fished, as well as an index of the level of catches that could be used to raise numbers to produce estimates of total removals. This approach however would still serve only as a preliminary assessment and the reliability of the analysis would depend strongly of the quality and quantity of data that could be recovered. Still it is the only option available at the moment for attempting to trace the situation of the elasmobranch fisheries.

5.2.3.5.3. Historical data on elasmobranch catch and abundance

There are several scattered pieces of punctual information about abundance of sharks in several locations throughout the Red Sea from experimental fishing and related studies that took place as part of the Red Sea project. Although they are all limited observations in time and place, they possess a relative value because they are the only measures of the abundance levels of elasmobranchs in the region and in some cases of specific species. A brief outline of these data is provided below but it should be considered that in order to use them to complement future stock assessment studies, the original sources should be obtained and carefully studied to qualify the usefulness of each data point and to extract more detailed information from the original reports if this is available.

Egypt – During March and April 1982 deep water gillnetting off Quseir (at 100-250 m depth) for 28 days produced 1,602 kg of sharks, which were the most abundant species comprising about 59% of the catch (Bean 1982). Prado and Drew (1991) cite Bean (1981) for exploratory gillnet fishing in Wadi Gimal producing 1.3 kg/net of sharks over coral reefs and 5.2 kg/net over sandy bottom. Moharram (1983) cites the potential for small-scale fisheries in the southern Red Sea coast of Egypt as 1,000 t/y, without details given about the basis for this assessment. Commercial landings in Hurghada in 1977-78 were 7.1% sharks and prices in Quseir for shark in 1982 were LE 0.35/kg, same as parrot fish and more than mackerel (LE 0.20/kg). Moharram (1983) states that shark did not contribute more than 7% of the landed catch of the Red Sea and Gulf of Suez, but that experimental fishing at the time showed sharks to be between 10 and 42% of the catches with gillnets in the southern Red Sea coast of Egypt. Moharram (1983) also summarizes information on experimental fishing in Wadi-Gimal and Quseir during Feb-Mar 1982 with multi-monofilament bottom set gillnets in shallow waters and longlines in deep waters. Three different types of boats ranging between 10 and 5 m length and with inboard and outboard motors were used. Total shark catch in one month (only 15 days of actual fishing) was 4,495 kg constituting between 55 and 59% of the catch depending on the type of boat (average 57%). Average catch was 115 kg of shark and 88 kg of bony fish per boat/day. Sharks over 150 cm were 66% of the catch in weight while smaller sharks comprised 34% (Table 5.4).

Table 5.4. Catch composition of sharks landed at Wadi Gimal experimental camp (Egypt, Red Sea), Feb 15-Mar 15, 1982 (15 days actual fishing). Taken from Moharram (1983)

Length class m	No. of sharks in catch	Total weight kg	Mean weight of sharks kg	Proportion
3 or more	1	283.0	283	6.4%
2.5 - 3.0	2	492.5	246	11.1%
2.0 - 2.5	8	1,069.5	134	24.2%
1.5 - 2.0	18	1,085.5	60	24.5%
1.0 - 1.5	23	588.5	26	13.3%
1 or less	94	907.0	10	20.5%
Totals	146	4,426		100%

Sudan –Experimental gillnet fishing (at 200-400 m depth in front of Suakin) produced 1,290 kg of shark which comprised about 80% of the total catch (Bean 1985a). Very high shark catches were obtained in silt bottoms adjacent to the bottom of the slopes of the reef. A commercial shark fishery was thought to be viable if markets could be developed (Bean 1985a).

Eritrea –Between 1 and 5 t of sharks were landed per year in Eritrea between 1965 and 1972 (Sanders and Morgan 1989). In the 1980s the war discouraged landing of shark and batoid incidental catches which were usually discarded (Guidicelli 1984).

Djibouti – Sachithananthan (1983) reports catches of sharks for 1979-1982 as 4.5-8.3 t/y but mentions that some 1 t/year of sharks were rejected by processors due to lack of markets. Fishermen reported dried meat and fins previously exported to Yemen, Somalia and Eritrea, and Yemeni and Somali fishermen fishing for sharks in Djibouti and taking products to Aden.

Saudi Arabia – Estimates indicate that a little more than 10,000 t of fish were landed by small-scale fishermen in the Red Sea coast of KSA in the mid 1970s, and that during 1983 about 820 t of sharks and rays were landed there (Peacock 1978; Chakraborti 1984b). Exploratory surveys with bottom trawls in the Farasan Bank inner passage produced average catches of about 40 kg/hr of sharks and batoids while demersal gillnet surveys in the same area were dominated by sharks and batoids (about 70% of the total catch; Sanders and Morgan 1989). Handline surveys around the Farasan Bank produced catches with about 9% of sharks and batoids by weight (Peacock 1980). Bottom gillnet experimental fishing in waters 140-200 m deep off Tuwal in 1985 produced catch rates of 10-30 kg of sharks per net per day (Bean 1985b).

Yemen – In the Red Sea coast, the former Yemen Arab Republic increased catches in the mid-1980s due in part from landing of previously discarded species including sharks (Sanders and Morgan 1989). Wholesale fish prices doubled in the mid 1980s and the entire catch was consumed domestically. Comprehensive system of fisheries data collection by interview sampling was 'well established' in the late 1980s. Catches of 400 to 1,400 t of sharks were reported in the mid 1980s, representing between 2.4 and 7.5% of the total catch. Mid-1970s trawl surveys off Hodeidah within 50 m depth, indicated that stingrays were10-14%, guitar fishes 0.2-2.8% and sharks 0.1-0.9% of the total catches (Walczack 1977). Sharks and batoids were discarded from commercial trawlers during the early 1970s.

In the Gulf of Aden sharks were mainly caught as reef-associated species with handlines and longlines (Sanders and Morgan 1989). Sharks too large to be weighed were caught during exploratory fishing with longlines in 1966-67, and only sharks were caught for three days (Losse 1975). Gillnet and longline experimental fishing carried out for 14 months by FAO starting in October 1970 showed sharks to be the main species; biomass estimates from these campaigns (pertaining to the whole Gulf of Aden) indicated 400,000 t of medium/large pelagic fish of which 10% was taken as the potential yield. No specifics are given about the proportion of sharks in the medium/large pelagic group (Sanders and Morgan 1989). Chakraborti (1984a) provides most of the following information. The National Corporation for Fish Marketing (NCFM) had a processing plant for shark fins and mackerel and shark fins were exported. Industrial vessels from the Yemen Fisheries Corporation (YFC) and Coastal Fishing Corporation (CFC) used to send daily radio reports with their catches for the tabulation of statistics by the MFW. Such reports were quite detailed in some cases, including each fishing location and catches by species groups. However the YFC did not report sharks or rays but a large group of 'other fish' (about 1000-2000 t/y) which could contain sharks; the CFC reported shark catches of 2-110 t for 1979-81. Total catches reported for Qusayar were of about 2000 t for 1981-82 (less than the shark data alone made available to the consultant by the Qusayar cooperative; see Bonfil (2001b)). Incidental data shows that shark fishing was a widespread activity, usually pursued with longlines. Data from small-scale fisheries was very poor and probably only about 1/3 of the catch was actually reported to the MFW to avoid taxes and due to preference for immediate cash (cooperatives always took time to pay fishermen). The number of fishermen and boats available in some localities in Yemen's Aden coast in 1983 is detailed in Table 5.3 above. A total of about 21,000 t of fish were reported to be landed by the 13 cooperatives of the PDYR in 1981-82. The species composition is unavailable but judging from the known catches of sharks in Qusayar for those years (from interviews made during the present consultancy) and the data presented by Chakraborti, sharks could have been a substantial part of the catch. Saqaff and Esseen (1997) report that the average catch of a fishing boat in Qusayar is 300-400 kg of dry fins for a 15 day trip. Estimates of shark production are scarce and very uncertain due to the lack of an adequate system for monitoring and reporting of landings throughout the country. Nichols (2000) estimates a yearly production of 1,200 t of sharks by the Socotran fishermen. Alternative estimates for shark catches in Socotra include 4,000-6,000 t/y (Huntington and Al Sakaf 2000, cited by Nichols 2000), 5,520 t in 1998 (MFW), and 7,283 t/y (Saeed 2000). Nichol's estimate above seems low because his assumption of 1 t of sharks per boat/season is equivalent to a very short (25 days) fishing season at the 40 kg/boat/day reported by Huntington and Al Sakaf (2000) or an even shorter fishing season if the 54 kg/boat/day assumed by Saeed (2000) is considered. Alternatively, Nichols is implicitly assuming a shark catch of only 8.52 kg/boat/day (if the 160-day fishing season reported by Saeed is used with the 840 houris and 40 sambuqs Nichols considered in his calculations) which seems much lower than other estimated catch rates above and observations made during the surveys of the consultancy. An alternative but still conservative estimate presented here includes the 840 FRP and 133 wooden houris reported by Nichols (2000) with catch rates of 40 kg/day for a shorter 60 day shark fishing season (based on reports by Huntington and Al Sakaf 2000), plus the reported 40 sambuqs catching 9 t per season each as estimated by Nichols, for a minimum total estimated shark catch of 2,695 t/y (2000 data). Note that this figure pertains only to Socotran based fishing craft and does not account for the catches of outside vessels. Although no recent direct measures of abundance of sharks exist for Socotra, some fishermen report having to travel longer distances to maintain production at prior levels (Nichols 2000).

5.2.3.6. Management systems

An updated review of fishery management systems in the countries of the region is provided by Hariri et al. (2002). Only a brief summary of the most relevant features is provided here.

All of the countries in the region have one or more institutions responsible for the management of the fisheries, fisheries research, fostering the development of and providing services to the fishing sector, and other related marine stewardship activities (Table 5.6). All countries also posses the legal framework for fisheries management in the form of laws related to the management of the fisheries.

Table 5.6. National institutions with functions in fisheries and environmental management. Taken from Hariri et al. (2002).

JORDAN	
Name of Authority	Main Function
Marine Science Station, Aqaba	Fisheries and marine research
Ministry of Agriculture	Policy and management
EGYPT	
Name of Authority	Main Function
Egyptian Environmental Affairs Agency (EEAA)	Monitoring and protection of the marine environment
Egyptian Organization for Standardization (EOS)	Maintenance of standards for domestic products, provides training in compliance with national standards
General Authority for Fish Resource Development (GAFRD)	Fisheries management, development and conservation; enforcement, MCS, data collection, training and extension; aquaculture development
National Institute of Oceanography and Fisheries (NIOF)	Primary research institute for marine fisheries
Ministry of Defence	With Frontier Guard Corp, issue fishing permits and monitor vessel activities, crewing levels etc
Ministry of Health	Examination of agricultural and fisheries foodstuffs in regard to chemical and biological safety levels
Ministry of Scientific Research	Supervises the IOF and its two research stations in Suez and Ghardaqah
Ministry of Supply and Trade	Supervision of fish quality and monitoring landings quotas in Suez, Red Sea and South Sinai Governorate
Ministry of Supply and Trade, Dept of Food Inspection and Quality control	Quality assurance for all agricultural, food (including seafood) and industrial products
Ministry of Supply and Trade, General Organization for Control of Export and Import (GOCEI)	Concerned with Quality control of all agricultural and industrial exports
SAUDI ARABIA	
Name of Authority	Main Function
Faculty of Marine Sciences of King Abdulaziz University	Involved in research activities
Fisheries Research Center, Jeddah	Involved in research activities
MEPA (Meteorology and Environmental Protection Administration)	Jurisdiction for prevention of pollution in the territorial sea including effluent from landfill, pollution monitoring; jurisdiction for oil spill response; responsible for setting standards for the environment
Ministry of Agriculture	Responsible for fishery management, agricultural development, development of groundwater resources and seawater desalination
Ministry of Agriculture and Water: Dept. of Fisheries Affairs	Management and administration: marine fisheries, aquaculture and the marine environment, licensing, regulations, credit facilities for fishermen, imported fishing equipment and research; Responsible for management of national parks; landfills;
Ministry of Agriculture, Sweet Water Conversion Corporation (SWCC), Ministry of Petroleum (Saudi Aramco, oil companies), Ministry of Municipalities and Rural Affairs (Sewage Authority), Ministry of Industry and Electricity (SCECO and industrial cities) and RCJY	Control activities that emit pollutants into the Territorial Sea
Ministry of Defence	Jurisdiction of military activities within the Territorial Sea
Ministry of Industry and Electricity	Responsible for industrial development and electricity generation
Ministry of Municipal and Rural Affairs	Responsible for municipal development, flood water management and disposal of waste
Ministry of Petroleum	Jurisdiction over oil production and marine mineral extraction activities in the Territorial Sea
Ministry of Transport	Responsibility for Marine Navigation in the Territorial Sea
NCWCD	Responsible for management of protected areas
Royal Commission for Jubail and Yanbu	Responsible for industrial development within the two industrial cities; also responsible (under a Memorandum of Understanding with MEPA) for environmental management in those cities
Saudi Coast Guard	Jurisdiction between the border of the Territorial Sea (12 miles offshore) and 10 km inland
Sea Ports Authority	Responsibility for ports

Table 5.6. continued

SUDAN	
Name of Authority	Main Function
Marine Fisheries Administration under the Red Sea State (Ministry of Animal Wealth)	Manages the fisheries sector and controls the observation of fisheries regulations
Ministry of Animal Wealth	In overall charge of animal production and fisheries
Red Sea University, Port Sudan	Marine Research and education
The Marine Fisheries Research Center (MoAW)	Provides scientific information for the management of fisheries resources. Field station at Dongonab and 2 laboratories at Port Sudan. Over the last 15 years, it has been concentrating on pearl system production
The Wildlife Research Center (MoAW)	In charge of providing the scientific background for wildlife
conservation and management	
University of Khartoum, Suakin Marine Laboratory	Biological research and training
University of Khartoum, Faculty of Economic and Social Studies	Research on resources and development
University of Khartoum, Institute of Environmental Studies	Research on environmental issues
DJIBOUTI	
Name of Authority	Main Function
Inter-ministerial coordination, Commission on the Protection of the Marine Fauna and the Sea Bottom	Maritime conservation
Ministry of Agriculture and Hydraulics Direction de l'Elevage et des Pêches (DEP), Directorate of Stock-farming and Fisheries	Fisheries administration and management
Ministry of Tourism Office National du Tourisme et de l'Artisanat (ONTA National Office for Tourism, Arts and Crafts)	Tourism development
Ministry of Transport and Telecommunications, Direction des Affaires Maritimes (DAM, Directorate of Maritime Affairs)	Maritime transport
National Council of the Sea	According to a decree of 5 July this is presided over by the Prime Minister, Policy towards the marine sector
Presidency of the Republic Institut Supérieur d'Etudes et de Recherche Scientifiques et Techniques (ISERST, Institute of Higher Studies, Scientific and Technical Research)	Research and postgraduate training
Primature, Service de l'Aménagement et de l'Environnement (SAE, Service for Management and Environment)	Environmental conservation
YEMEN	
Name of Authority	Main Function
Coastal Fisheries Corporation – MFW	Catching, processing and exporting rock lobster
Environmental Protection Council (EPC)	Council of ministers with responsibility for environmental matters coordinates and monitors environmental protection and conservation policy
Fisheries Manpower Development Center (FMDC) - MFW	Manpower training; extension services,
Marine Science and Resources Research Center (MSRRC) – MFW	Fisheries and oceanographic research
Ministry of Fish Wealth (MFW)	Fisheries management and administration; fisheries legislation, fish quality control
National Corporation for Services and Fish Marketing – MFW	Fish purchase and marketing, services (fuel, ice, cold stores), extension services, market operations, fishing port management, fish storage and processing, management of vessel repair facilities
SOMALIA (since the civil strive these institutions are no longer functioning)	
Name of Authority	Main Function
Ministry of Fisheries and Marine Resources	Development and management of fisheries resources; production, planning, research, marketing, personnel and administration
Ministry of Marine Transport and Ports	Development of maritime transport and the improvement of port facilities; environmental control of coastal areas, including ports, prevention of marine pollution and safety of navigation; implementation of the Maritime Code, other laws and regulations related to the marine environment, and implementation of regional and international conventions
Ministry of Minerals and Water Resources	Two main responsibilities included the development of mineral resources including mining and geological survey, and the development of water resources
Ministry of Tourism	Was in charge of establishing MPAs Legislation, following the Kenyan model, has been prepared for a network of protected areas
National Marine Affairs Committee	Oversees the overall development of the fisheries sector. Committee chaired by Ministry of Marine Transport and Ports and members included following ministries: Minerals and Water Resources, Fisheries and Marine Resources, Foreign Affairs, Education and Defense
National Range Agency (Ministry of Livestock, Forestry and Range)	Was responsible for National Parks

Despite the existence of the institutional and legal mechanisms for fisheries management, a series of problems have been identified. The existence and magnitude of the problems vary from country to country and more details can be found on Hariri et al. (2002). A general but non-exhaustive list includes: shortage of qualified staff, lack of financial resources to increase the existing base of staff, shortage of operating funds for the existing institutions, outdated and inefficient legislative and management frameworks and in particular lack of strength and clarity in the laws for effective management, monitoring, control and surveillance, lack of transparent and controllable resource management and allocation decision mechanisms, obsolete facilities for fisheries management and research, lack of stock assessment studies, shortage or unavailability of fisheries research vessels, poor or non-existent capacity for MCS through patrol vessels and aircraft, lack of vessel registration systems for some sectors or fisheries, absence of licensing systems for small-scale fisheries, unbalanced focus and allocation of resources between industrial and small-scale fisheries sectors, lack of co-management systems and integrated coastal zone management approaches, high illiteracy rate among fishing communities, lack of or poor enforcement of fisheries laws, and ineffective sanctions for violations to the law (fines and jail sentences set too low).

Clearly, the existent management systems in the region are not capable at present to perform their mandate in full. Many of these systems serve virtually a cosmetic role and others are only capable of keeping the fisheries sector of the country running in terms of processing the required paperwork. Under these circumstances it is unrealistic to expect the implementation of an ambitious fisheries management system for the shark and batoid resources of the region that is on par with those in existence in other parts of the world (such as Australia, Canada or the USA).

6. Conclusions

The preceding sections of the report provide the most complete and updated baseline of information about the fisheries for sharks and batoids of the region. The present section outlines the main problems identified for the conservation and sustainable management of these resources in the region, proposes a set of immediate and precautionary actions that should be taken as initial steps towards positive change in the shark fisheries, outlines the route towards long-term sustainability, and suggests activities to follow-up the work undertaken during this consultancy.

6.1. Main Problems Facing the Sustainability of Elasmobranch Fisheries in the Region

Many of the problems affecting the fisheries for sharks and batoids in the region have already been discussed in several of the previous sections. A summary of the main problems identified above is presented here.

The first level of problems occurs at a wider and higher level than the elasmobranch fisheries and involves the general framework for fisheries in the region. In this sense, these problems are independent of, and at the same time directly and indirectly responsible for some of the particular problems affecting the shark and batoid fisheries. Until these problems are not solved, it will be very difficult to move beyond the precautionary measures suggested below, and if not solved, may even prevent some of the proposed precautionary measures from translating into effective improvements in the fishery.

The general problems affecting the fisheries sector in the region include:

1. Outdated and inefficient legislative and management frameworks and in particular lack of strength and clarity in the laws for effective management, monitoring, control and surveillance
2. Lack of or poor enforcement of fisheries laws, and ineffective sanctions for violations to the law (fines and jail sentences set too low)
3. Lack of transparent and controllable resource management and allocation decision mechanisms
4. Fisheries data collection and monitoring systems that are inexistent or inefficient in some countries. This problem is particularly acute in Yemen and Somalia, but problems exist in other countries in the region.
5. Shortage of qualified staff and lack of financial resources to increase the existing base of staff
6. Shortage of operating funds for the existing institutions
7. Obsolete facilities for fisheries management and research
8. Lack of stock assessment studies
9. Shortage or unavailability of fisheries research vessels
10. Poor or non-existent capacity for MCS through patrol vessels and aircraft
11. Lack of vessel registration systems for some sectors or fisheries
12. Absence of licensing systems for small-scale fisheries
13. Unbalanced focus and allocation of resources between industrial and small-scale fisheries sectors
14. Lack of co-management systems and integrated coastal zone management approaches
15. High illiteracy rate among many fishing communities

The particular problems affecting the shark and batoid fisheries in the region include:

1. The importance given and resources devoted to elasmobranch fisheries across the region is insufficient to guarantee their sustainability.
2. With one exception (the temporary ban on shark fishing in Sudan; which is reported as not being very effective), there is a total lack of specific management measures for the conservation of the regional stocks of any elasmobranch species and the sustainability of their fisheries.
3. There is a total lack of explicit and clear objectives for the elasmobranch fisheries in all countries.
4. There is an acute problem of unavailability of reliable historical and current data on the catches of sharks and batoids in most countries. For Djibouti and Somalia in particular, there are fisheries of elasmobranchs but no records of the catches.
5. Yemeni landings of elasmobranchs are almost never weighted, and the method of reporting of landings is suspect.
6. Lack of species definition on the little catch data available for elasmobranchs across the region, compounds the problems for attempts to design and evaluate management measures.
7. Data reported to international agencies like FAO are in some cases inaccurate (reporting no catches of elasmobranchs when they exist) and in all cases do not include detail at the species or group level.
8. Complete absence of data on the historical effort applied to shark fisheries including lack of a reliable and updated inventory of the number of vessels participating and numbers of fishermen depending full-time and part-time on the fishery.
9. Lack of data on the abundance of the resources either through time-series of CPUE or fishery-independent abundance data.

10. Absence of studies on the fisheries biology of the most important elasmobranchs in the fisheries, including lack of knowledge about the structure of the stocks, age and growth, and reproductive parameters.
11. No stock assessments exist for any of the elasmobranchs of the region and there is no information available for the production of stock assessments.
12. The status of knowledge and the general availability of information about the shark and batoid resources of the region are very poor, such that elaborate management decisions like fishing quotas to maintain or rebuild abundance cannot be made at this stage.
13. Large catches of newborn and juvenile sharks are being taken in pupping and nursery grounds without any sort of control, including some of the main species in the fishery and in particular of blacktip shark (*Carcharhinus limbatus*), spot tail shark (*C. sorrah*), and milk shark (*Rhizoprionodon acutus*). This practice can compromise the future recruitment to the reproductive stock and lead to stock collapse.
14. Lack of scientific knowledge of the location and importance of sensitive habitats such as pupping and nursery areas for commercially important elasmobranchs.
15. Unchecked targeting of seasonal concentrations of silky sharks (*Carcharhinus falciformis*) off the south coast of Yemen.
16. Finning of sharks is common practice in some areas, causing a great amount of waste.
17. A strong reliance in gillnets for shark fishing chiefly by Yemeni vessels, is causing the uncontrolled and large destruction of sensitive habitats and species.
18. Bad practices in the processing and utilization of sharks are causing large amounts of waste, poor quality products, and loss of potential revenue and employment. Sharks are never bled after capture causing ammonia to deposit in the flesh, shark processing is minimum (splitting, gutting and salting), and the conditions of the product in holding facilities are often insalubrious. The meat is not properly processed into high quality dried-salted filets but instead let to start spoiling, and the skins are wasted instead of used for the production of leather.
19. There is a lack or shortage of ice in many communities, so fishery products and sharks in particular are not kept fresh, deteriorating the quality of the final product.

6.2. Strategic Plan for Sustainable Management

The management of the shark and batoid fisheries of the region must include a strategy that takes into consideration the limits of the existent management system. In particular it is necessary to apply a step-wise approach that proposes first specific new actions to be implemented in the short-term for improving the management of the elasmobranch fisheries, and later the implementation of longer-term actions that are consistent and well integrated with an overhauling of the current fisheries management systems and institutions, thus strengthening such systems and institutions while achieving important but realistic goals.

This is the strategy presented here. First, a set of measures that should be implemented immediately -some of them of a precautionary nature- is proposed. This is followed by a set of measure that will not function or cannot be implemented while the existing large-scale problems of the fisheries sectors of most nations are not solved. Thus they will have to be implemented at a later stage. However, it is important to emphasize that without the implementation of both sets of measures, the future of the elasmobranch resources and the fisheries that depend on the abundance of these resources will be severely jeopardized.

6.2.1. Phase I. Immediate Management Actions

6.2.1.1. Precautionary measures

The set of recommendations provided in this section intends to prevent further deterioration of the elasmobranch resources and establish controls and measures that will set the ground for the further upgrading of the management and conservation of elasmobranchs in the region that can only take place when the wider problems affecting the management systems of fisheries in general are resolved. These recommendations are designed to solve immediate and urgent problems and in general do not require immense amounts of funding or lengthy research to be implemented. They should therefore be given a top priority and be implemented within a year or two.

6.2.1.1.1. Limiting the number of fishing vessels and gear

Access and effort allocation in elasmobranch fisheries is out of control in the region and in particular among the most powerful fishing nation, Yemen. Although likely to be unpopular at the start, it is imperative to place an immediate moratorium on fishing licenses for crew and vessels (and the amounts of gear each are allowed to use) that could join the fisheries for sharks. Similarly, the building of new boats that could enter the fishery should be discouraged. As long as the amount of effort is not forced to stabilize or decrease the problems of the elasmobranch fisheries will only become more acute. Once proper stock assessment studies have been carried out and only if these show that the elasmobranch resources of the region can sustain increased effort, this moratorium can be lifted.

A possible way to implement caps in effort is by issuing ownership rights that are transferable to all current participants in the fishery and that are linked to a fixed number of vessels, usually one per license holder (i.e. issue individual transferable quotas or ITQs). This measure will help alleviate further increase of the effort while promoting responsible fishing. The process for such an endeavor falls out of the scope of this report, but in broad terms it should involve all the fishermen currently part of the fishery, especially those with a long-standing tradition of shark fishing, as well as representatives from coastal communities that depend on the fisheries. More details for how to implement such a proposal can be found in Morgan (1997) and Nichols (2000) but technical assistance from FAO or other international institutions can be also sought. Finally, the success of this measure depends strongly on the implementation of the measure proposed in 6.2.1.2.

6.2.1.1.2. Establishment of temporary caps for total catches

A temporary cap for the total catches of sharks (landings plus discards at sea) in all countries in the region should be established and closely enforced. This measure can be used alone or in conjunction with a limit on the number of vessels and gear involved in the fishery as outlined above. If implemented effectively, this measure alone can effectively stabilize mortality in the fisheries and serve as a way to avoid further danger of stock collapse in the light of lack of knowledge of the status of the stocks. Once proper stock assessments are carried out in each country or preferably around the region, the catch limits can be revised according to the results of stock assessment.

While the determination of the actual catch limits will necessarily have to be based in the limited information currently available, the temporary nature of the measure, the fragility of elasmobranchs to exploitation and the need for order and control in the fisheries around the region warrant the implementation of this necessary step. Given that this measure is meant to be of a precautionary nature, the catch limits should aim to err on the conservative side. Proposed catch levels for Yemen should be of no more than 5,000 t per year for all shark species, and preferably lower. This is slightly less than the only available catch levels reported for this country in recent years (FAO 2002) while allowing the continuation of the activity. In a similar way, the catches of other countries should be capped at levels close to those reported though their national agencies or FAO.

6.2.1.1.3. Limiting the catches of grey reef sharks

Grey reef sharks constitute a valuable resource for ecotourism across their range. Their abundance around coral reefs is well known and appreciated by sport divers. Shark diving has become a trendy and profitable business in many parts of the world (Burgess 1998) to such an extent that shark species that are the focus of shark diving are today more valuable and profitable alive than dead (Anderson and Waheed 2001, Anderson and Ahmed 2002). Shark diving and in particular shark diving around coral reefs to observe grey reef sharks (*Carcharhinus amblyrhynchos*) has taken up in the northern part of the Red Sea and multiple operators in Egypt and Sudan are making profitable businesses in this activity that depends on the chances to see grey reef sharks around their coral reefs.

The expansion of shark fisheries throughout the area is conflicting with the more profitable tourism industry because of the unchecked fishing of grey reef sharks and cases of conflict between fisheries and tourism are already occurring in some areas and particularly in Sudan, where a ban on commercial fishing for sharks has been passed as a result of this conflict (Elhassan 2002). Sudan should be praised for its concern over grey reef shark conservation although the monitoring and surveillance of the ban is reported to be largely ineffective due to lack of capability.

Grey reef sharks should be given some level of protection not only to ensure the conservation of the local populations but to guarantee that the regional economies do not lose on the opportunity to maintain or expand the eco-tourism industry that brings larger revenues than shark fishing through the expenditures of foreign divers in food, lodging, equipment and other related expenses.

Two alternative ways to implement protection of grey reef sharks without affecting the fishing industry more than needed. First is the establishment of a network of localized marine protected areas (MPAs) around well-known coral reefs with abundant grey reef sharks and where no fishing at all should take place. Second is the implementation of species-specific catch quotas for grey reef sharks. Both alternatives have advantages and disadvantages and some nations might decide on one against the other depending on the local context.

The establishment of MPAs has the advantages that it would offer benefits to the entire fish community of each reef, but it will require dedicated surveillance and a good design in terms of the number, size and location of each nod in the network. The possibility of charging entrance fees to the MPA or special levies to the shark diving industry could help fund some of the surveillance costs and perhaps create funds for compensating the fishing industry through adequate mechanisms such as encouragement of responsible fishing practices such as changing their gillnets for longlines. Also, it is likely that the tourism industry and local environmental NGOs will join in efforts to help in the maintenance and surveillance of the MPAs. A possible shortcoming of this measure is that if the network of MPAs is not designed adequately and fishing effort keeps increasing outside the MPAs, grey reef shark populations might not receive enough protection to guarantee the maintenance of their abundance at the needed levels.

A species-specific quota could be a simple way to control the numbers of grey reef sharks that are removed from the population. However it would require some studies to set the quotas at a level that would guaranty large enough numbers of individuals in the population to maintain the attractiveness of the shark diving operations. This measure would also require good monitoring of the catches and strong penalties for running over the quota.

6.2.1.1.4. Controlling the catches of sharks in pupping and nursery grounds

The targeting of shark nursery areas by fishermen is known to occur in Djibouti, Eritrea Somalia, and Sudan (Bonfil 2001b). Yemeni fishermen are particularly knowledgeable of these shark nursery grounds and usually take very large quantities of newborn and juvenile sharks there, particularly newborn blacktip and very young spot-tail sharks. Uncontrolled exploitation of newborn and juvenile sharks is a dangerous fishing practice that leads to growth overfishing and if continued can result in stock collapse (Bonfil 1990).

It is urgent to set controls on the amount of fishing taking place in the nursery areas of the region until further research has been carried out in the stock assessment of the species affected. Several options are available for setting precautionary controls. The first is to set a limit on the catches of newborn and juvenile sharks that can be landed for each species. This would ideally involve estimating what are the safe catches to be allowed but in the light of lack of any population dynamics and abundance information it will be hard to come up with a quantitative answer. Instead a qualitative way is proposed here for the most urgent case of the Yemeni catch of blacktip and spottail sharks. A quick appraisal of the total yearly landings of blacktip sharks under ca. 90 cm TL and spottail sharks under ca. 75 cm TL in all landing points in Yemen should be made by direct observations and detailed interviews. Once this quantity is estimated, half of this amount should be set as the allowed quota for both species, which are often taken together. Close monitoring of the landings and imposition of severe penalties will be needed to make this an effective management measure.

A second approach involves instituting legal minimum sizes at first capture for all species known to be taken in large numbers as juveniles. Precautionary minimum size limits to avoid the take of newborn and very young sharks of such species are suggested in Table 6.1.

Table 6.1. Recommended minimum size limits for catches of species frequently taken as newborns and early juveniles in the

Species	Suggested initial minimum length (to be revised when detailed data on length at birth and maturity is gathered for the local stocks)
Carcharhinus limbatus	94 cm TL
Carcharhinus sorrah	62 cm TL
Negaprion acutidens	107 cm TL
Rhizoprionodon acutus	47 cm TL
Sphyrna lewini	80 cm TL

Note: recommended minimum sizes set at the length corresponding to maximum size at birth + 25% of the difference between size at birth and average of male and female minimum size at maturity, as reported in the literature

The simplest way to implement these minimum sizes would be to prohibit the usage of gillnets with mesh sizes and hanging ratios that will catch a sicklefin shark of 107 cm TL. This quantity can be easily estimated by a fishing gear technician if the maximum girth corresponding to a sicklefin of 107 cm is provided.

6.2.1.2. Prohibition of finning practices

Finning of sharks (the practice of removing the valuable fins at sea and throwing back the rest of the fish) is a wasteful practice that is known to occur in the region. A ban on finning would be in line with the Code of Practice for Responsible Fishing of FAO, and would promote the much needed full utilization of the shark resources in the region. This would add to the revenue of the fishing industry if it is accompanied by the measures suggested in section 6.2.3 designed to increase the full utilization of sharks. Effective monitoring of the landings and severe penalties for infringements will be required for this measure to be effective. The best and suggested way to implement this measure is by prohibiting the landing of fins that are not attached to the carcass of the shark. In cases where on-board processing of sharks takes place, carefully researched ratios of landed processed meat to landed number of fins should be developed and used to regulate and monitor the compliance with the ban.

Finning bans are increasingly being passed around the world and it is likely that in the future a worldwide ban on this practice will be passed. Nations in the region should voluntarily impose such bans.

6.2.1.3. Protection of endangered species

Sawfishes are the most endangered group of elasmobranchs world wide and the three species recorded in the Red Sea and Gulf of Aden are endangered according to the Red List of Threatened and Endangered Species (IUCN 2000). This group of batoids is very vulnerable to fishing because they often occur in shallow areas and coastal lagoons where they are susceptible to capture with a wide range of gear including trawl gear. Several accounts of catches of very large specimens of sawfishes in the past were found during the surveys of the consultancy but fishermen across the region consistently mention their rarity and not a single fresh specimen was seen in the landings during the surveys. There is no doubt that the range and abundance of sawfishes has diminished substantially around the region.

The whale shark is another species under threat, currently classified as vulnerable (IUCN 2000); it is sought for its fins and in some parts of the world like Taiwan, for its meat. Whale sharks are extremely vulnerable to fisheries due to their docile behaviour and their propensity to spend time at the surface grazing on concentrations of plankton. Whale sharks are known to be caught opportunistically in the Red Sea and Gulf of Aden only for their fins. However, whale sharks are a very important species for eco-tourism and diving activities, and are worth much more alive than dead (Anderson and Waheed 2001).

A total protection of all sawfish species and the whale shark through legislation that bans their direct and incidental take in fisheries should be passed by all countries in the region. This measure is needed to protect sawfishes from imminent extinction and to protect the whale shark from depletion and allow the flourishing of more profitable non-consumptive sustainable use based on shark-diving activities. Research oriented to the discovery, documentation and protection of the pupping and nursery grounds of sawfishes should also be urgently promoted.

6.2.1.4. Establishment of a regional group for shark fisheries

A small *ad hoc* Regional Shark Fisheries Management Group should be formed as soon as possible. This group should be established through an informal agreement and be composed by managers, fishery scientists and fishermen's representatives, from all the countries in the region, independently of whether they belong to PERSGA or not. The initial tasks of the group should be to plan and start implementation of regional strategies for cost effective monitoring, surveillance and research. Coordination and cooperation in the field, and resource and information sharing, should be the driving principles. The first activities to be implemented should be those that can be carried out with the available resources and infrastructure (i.e. promoting the bleeding of sharks and more elaborate processing of the products, reporting of catches on a species by species basis, elaboration of plans of action at national and regional level). An important task of the group should also be to seek sources of financing -including national as well as regional and international sources- for the strengthening of activities being already implemented and for the implementation of new ones. A possible source of partial funding from national sources can be through part of the contributions from shark fishing levies proposed in section 6.2.

Initially, modest steps can be taken but in time and pending on the successful securing of funds, the goals and suggested measures should be expanded. FAO, the GEF, the World Bank and other sources of international aid will likely provide technical assistance if and when the group shows that there is commitment and effective work being carried out. In time, this group can develop into a formally institutionalized Regional Fisheries Management Body (RFMB) through which management and research of the regional shark fisheries can be undertaken.

6.2.1.5. Elaboration of National and Regional Plans of Action

The initial steps and groundwork for the elaboration of National and Regional Plans of Action have been carried out during the present consultancy. The current situation of the fisheries, the data gathered and leads to further data that have been outlined, as well as the problems that have been identified should all be used in conjunction with wide-scale consultations at the national and regional level to set the objectives and sets of actions that will be taken to foster the sustainability in the elasmobranch fisheries. In this sense, the formation of the group suggested in the preceding section will be instrumental for the preparation of these plans of action.

6.2.1.5.1. Role of FAO

Help from FAO with technical assistance in the elaboration of the plans of actions should be sought through the appropriate official channels once the group outlined in 6.2.1.4 has been established and is working. According to point 7.2 of the FAO Technical Guidelines for Responsible Fisheries No. 4 Supplement 1 (FAO 2000), the role of FAO in supporting states in the implementation of the IPOA-Sharks is prescribed in paragraphs 29-31 of the IPOA. This opportunity should be used.

6.2.1.6. Improved quality control of products and promotion of full-utilization of elasmobranch resources

A substantial effort should be placed in improving the quality control of elasmobranch products and promoting the full utilization of sharks. Any improvements in the processing and quality control of the shark products will translate into direct economic benefits to the fishing communities. Higher prices can be obtained for high-quality dried-salted shark meat instead of the dark, on-the-skin smelly product that is currently being sold across large parts of the coast, particularly in Yemen. If the product is good enough foreign markets might be reached further augmenting the revenue in the fishery. In addition, the processing and selling of shark hides for the industrial production of leather is a promising area of development in the marketing of the fishery. Technical training on the quality control and processing of sharks is easy to find and FAO will be a first and reliable source of help, both for the salt-drying of the meat and the production of hides. Attainment of the goal of full utilization of shark catches is highly desirable and necessary in order to comply with FAO's IPOA-Sharks.

The governments of the region must begin by establishing extension programs and awareness campaigns to educate fishermen about properly bleeding sharks and rays as soon as they are brought into the fishing vessels (or just prior to, while still in the water, in order to avoid possible contamination of the fish in the hold if blood enters this area and begins spreading ammonia as the urea on the blood breaks down). This is an essential first step for the improved quality of any final product from sharks and batoids, whether it will be fresh or salted in its final form.

Before the utilization of hides for the production of leather can be promoted and implemented, it is necessary to perform a sound market study in the region as well as internationally. A reliable market for the un-processed shark hides (salted and partially dried only) should be secured before the adequate processing of sharks at landing points can be promoted and established. FAO has expressed availability to broker such a market study in South East Asia that can be carried out by INFOFISH. The only constrain at the moment is finding a small amount of money to cover the costs of the study by INFOFISH. If the money is found, a request should be sent to Ms. Helga Josupeit (helga.josupeit@fao.org) of the Fisheries Department.

Promotion of the full utilization of sharks can be a major aid for implementing controls of the fishing pressure presently directed at the local elasmobranch resources. Fishing communities are more likely to accept reductions in catch or caps in fishing effort if these are accompanied with viable alternatives for increased income from their catches. The introduction of these management measures as a single proposal that compensates reduced catches with increased earnings should not be underestimated.

6.2.1.7. Public health issues

Given their high trophic level in food chains, sharks (and to a lesser extent batoids) are well known for being bioaccumulators of naturally occurring heavy metals, which are poisonous for the neurological system of humans. Eating elasmobranch meat might pose a serious threat to human health if the levels of mercury and other heavy metals are over permissible limits. Older fish tend to have a higher concentration of these metals but there is variation from species to species and from region to region (Lyle 1986; Hueter 1995). Nothing is known about the concentration levels of heavy metals in elasmobranchs of the region. However, in June 2003, the Joint Expert Committee for Food Additives and Contaminants (JECFA) released new recommended levels of methylmercury intake (the most common form of mercury found in fish) and reduced them from a Provisional Tolerable Weekly Intake (PTWI) of 3.3 µg/kg-bw to only 1.6 µg/kg-bw, while mentioning that sharks and swordfish are the fish with higher concentrations of this lethal compound.

A study that determines the average levels of heavy metals and particularly methylmercury in the main species of the fishery is necessary and urgent, firstly to protect the health of the coastal communities around the Red Sea and Gulf of Aden, particularly the lower income sectors who are the ones consuming the available dried product, and secondly to validate any possible attempts to develop the handling and processing of sharks in the region for the production and possible exporting of high-quality dried-salted shark meat suggested in the previous section.

6.2.1.8. Establishment of levies in the shark fisheries at the national level

One of the many problems in fisheries management worldwide is the lack of sufficient governmental funds to cover all the expenses of management, research, surveillance etc. Traditional perceptions and attitudes must change if this situation is to be resolved. A trend of user-based cost recovery has started to spread around the best managed fisheries in the world and is an inevitable step if success in management is expected. There are various ways to implement cost-recovery or partial cost-recovery in fisheries, the most successful are based in the granting of ownership rights of the resource to fishers. While implementing such a system is a monumental endeavour, it should be pursued if possible. Alternatively, a fixed levy aimed directly at partial cost-recovery of management can be institutionalized through legislation. In this case, a fixed percent rate of the price paid at landing should be charged; similar or perhaps higher rates should also be charged to exporters of shark fins and other shark products, and perhaps even to middle men involved in whole sale of elasmobranch fishery products domestically. This system should be used to fund as many of the priority recommendations listed in this chapter, but the system will succeed only if the principles of equitability and fairness, transparency, honesty and accountability are incorporated in such a system. Funds levied from shark fisheries should only be used to fund shark fisheries management and research activities. The funds should not be diverted to other governmental expenditures or even to other management of other fisheries.

6.2.2. Phase 2. Recommendations to be implemented in the longer-term

The set of recommendations presented below depend on a substantial improvement of the existing fishery management systems and the capacity of the countries of the region to invest more human and financial resources in them. Thus, these recommendations cannot be implemented in the short term and will necessarily have to wait to be implemented until progress is made in resolving the problems affecting the management systems outlined in section 6.1.

6.2.2.1. Fisheries monitoring

Much improved systems for fisheries monitoring are needed in most of the countries of the region, and with particular urgency in Yemen. Accurate data on total catches (landings + discards at sea) should be obtained together with accurate data on effort at an appropriate level of definition (total number of sets of nets, or total number of hooks per operation). Spatial definition of the fishing operations should also be obtained. However the design of such a system or the provision of detailed recommendations is beyond the scope of the present consultancy. Nevertheless, in terms of the elasmobranch fisheries, a few points should be taken into consideration.

The collection of data on catches of sharks and batoids from the fisheries should be made on a species by species basis. The species that occur in the current catches have been identified in this consultancy and this list should be used to prepare the formats for data collection that will allow the recording and reporting of information on a species by species basis. Without this level of detail in the data, it will be impossible to make meaningful stock assessments for the management of the fisheries.

Given that most of the shark and batoid fisheries in the region are of a small-scale nature, the usage of total censuses for the collection of fishery-related information is not feasible. Programs that implement an approach including frame surveys and geographically stratified random sampling as described in detail in Chakraborty (1984a) are the best alternative and should ideally be the ones implemented.

6.2.2.1.1. Observer programs

A program of at-sea observers should be instituted in the shark fisheries to obtain biological samples for the study of age, growth and reproduction, to record accurate data on CPUE and fishing grounds, to verify and correct the amounts of catch reported by skippers or recorded at landing points, and to monitor the compliance of management regulations such as no-fishing zones like in nursery areas, prohibitions of finning practices, the usage of illegal gear, or fishing for prohibited species.

This program should be implemented only in the larger vessels (sambuqs and abris) that normally carry more than 3-4 crew and that can have the space available for the observers. The costs of food for the observers on-board the vessels should be covered by the vessel as part of the responsibilities of the fishing sector that should go together with the right to fish.

6.2.2.1.2. Fishery-independent surveys

The ability to perform robust stock assessments of any fishery resource depends largely on the availability of time-series of abundance levels. While CPUE has been used for decades as a proxy of abundance, it has been shown in the last two decades that in most cases it is not a reliable indicator of abundance. This is particularly true in the case of elasmobranch fisheries (Walker 1998) where the mobility of some species, the targeting practices of the fishing vessels, and the multispecies nature of the stocks commonly make using CPUE in stock assessment a difficult and unreliable approach.

The best way to guarantee the availability of reliable time series of abundance is by implementing a thorough and regular system of fishery-independent surveys. These surveys can be costly but are extremely important for the ability to provide management advice that is based on sound science. Two approaches can be taken, using research vessels (lacking in the region at present) or hiring of commercial vessels, gear and crew with total control from part of the researchers on the places where fishing is carried out. This system is viable and much cheaper, especially if a system is put in place whereby a standard minimum rate (the average revenue of the boat per fishing trip) is fixed to guarantee returns to the fishermen. The revenue from the catch can be either split between the vessel/crew and the institution, or kept by the institution to partially cover the costs of the program.

A sound statistical design for the surveys should be carefully planned. This should incorporate fishermen's knowledge about the fishing grounds and the habits of the species. Several coordinated surveys of this type will be needed to cover the entire region, and at least one per country. Their design and seeking the sources of financing can be one of the tasks of the regional shark management group. These surveys should be carried out every single year and on a permanent basis, for as long as a fishery exists.

6.2.2.2. Recovery of historical data from original sources

Local staff or consultants should be sent to sift through the records of fishing companies and cooperatives across the region to recover data that could prove valuable in reconstructing the history of the fishery in terms of catches and abundance. The work of the consultancy evidenced a couple of sources of this kind of data in eastern Yemen and it is very likely that similar records exist in other parts of this and other countries of the region. Careful recovery of these data will allow estimating a minimum of the total historical landings in each country and perhaps for most of the region for several years back in time. This information can be used to generate alternative scenarios of total catch based on educated assumptions about discard and misreporting rates. These, when used in combination with stock assessment models within a Bayesian statistical approach can prove very effective to evaluate uncertainty and advise management measures (Babcock and Pikitch 2001; Apostolaki et al. 2002). If historical information on the amount of fishing vessels by category or fishing trips producing the landings can be recovered, it will then be possible to generate CPUE time series at least for some localities.

The careful process of recovery of this information should follow the procedures indicated in the spreadsheet shown below. This spreadsheet has been specifically developed by the author for the recovery of this type of information and a copy of the electronic file is available through the LMR-LS. But even from this printout a similar spreadsheet can be easily created and used for the recovery of the data.

The most important place for implementation of this program is Yemen not only because data are already known to be available (Bonfil 2001b) but because it has historically been the largest fishing nation in the region and in the shark fishery. The personnel employed for this data recovery exercise should be fully able with computers and have a relatively good background in fisheries, as their understanding of what the intention of the exercise is will be essential for judgment decisions during data recovery and entry. The total cost of this project will not be unaffordable if a couple of modest laptop computers and two local consultants are hired for a period of 1 to 3 months per country (even less for countries with less number of fishing localities and companies/cooperatives than Yemen). At a salary rate of $1000 per month, a total of $10,000 USD should cover all the costs for data recovery in Yemen including travel expenses and modest laptop computers (although if these are lent by MFW or EPC the costs would be abated).

6.2.2.3. Changes in fishing gear

6.2.2.3.1. Substitution of gillnets by longlines

Gillnets are the most detrimental fishing gear for the marine environment after trawl nets. They are characterized by being totally unselective of the species that they catch and often cause large amounts of bycatch of non-target species (Northridge 1991; Bonfil 1994). The catches of sensitive or endangered species such as marine mammals and sea turtles are of particular concern, but gillnet also catch a plethora of non-target fish. Additionally, gillnets are highly destructive of coral reefs when used around them. In comparison, well designed longlines can largely reduce the accidental killing of non-target species.

A program for replacement of gillnets by longlines in the shark fisheries and particularly in Yemen should be implemented as soon as financially possible. Several types of longlines specifically designed for demersal or pelagic sharks are available (Prado and Drew 1991; Branstetter 1994). Incentives to the fishing industry and awareness campaigns should be part of such a program for it to be effective. The main problem for implementation of this program will be financial resources, but it is possible that a well-designed proposal –especially if tied to community development objectives such as the improvement of product quality and full utilization of sharks- could be supported by international agencies such as the GEF or the World Bank, or by foreign-development agencies from wealthy countries (USAID, NORAD, ODA).

6.2.2.3.2. Incorporation of BRDs in trawl fisheries

Trawl fisheries are widespread around the region and are probably responsible for the largest mortality of batoids and some shark species, apart from killing large quantities of sea turtles, non-target finfishes and some marine mammals. Shrimp trawling in particular is known to cause the most mortality of non-target species. A region-wide program that incorporates into the fisheries law of each country the compulsory usage of bycatch reduction devices (BRDs) in all trawl fisheries should be pursued urgently. There is a long-standing technical experience on the best types of BRDs for each kind of trawl gear and target species, as well as on the methodologies for finding the best designs for new regions/fisheries. The technical aid of these countries and FAO should be sought for implementing this management measure.

The benefits of incorporating BRDs are not only in helping the environment but also in decreasing the amount of work and sorting time of the cleaner catches. But perhaps the most tangible benefit for the fishing industry will be the possibility of receiving access to otherwise forbidden markets for their products through ecolabeling certification. Many countries such as the USA prohibit imports of shrimp when they come from environmentally unsound fisheries.

6.2.2.4. Research on the population dynamics of the main species

One of the main problems that will hamper the conduction of sound stock assessment studies even in the eventual case of having good catch data and abundance indices is the lack of key population dynamics parameters that are valid for the local stocks of each species. Studies oriented to determining the following parameters for each of the main elasmobranch species and if possible all species in the fishery should be encouraged:

- Size at birth
- Size and age at first sexual maturity for each sex
- Maximum age attained by each sex
- Pupping season
- Length of the gestation cycle
- Length of the entire reproductive cycle (time between two birth events)
- Maximum and average litter size
- Natural mortality rate for major age groups (newborn, juveniles, pre-adults and adults)

This can be easily achieved by promoting the conduction of these studies by graduate students from local universities. A first step would be to pass a request from the fisheries agencies of each country to all the biology departments of the universities in their area offering an exciting topic for the development of graduate theses. A list of the priority species and specific goals of the studies should be appended to the request. In addition, the offering of small scholarships to cover some of the costs of the research or the tuition fees, and an offer to facilitate access to biological samples though arrangements with fishing companies or fish market authorities, will be an excellent way to foster the execution of this strategy.

6.2.2.5. Mapping and surveying of nursery areas

An activity that needs to be urgently carried out is expanded research leading to the mapping of all the important pupping and nursery areas for elasmobranchs in the region. These areas should be characterized in terms of location, size, seasonality and species present as newborns or juveniles, and should then be classified in terms of their importance and the amount of fishing pressure they are receiving. This information will help underpin stock assessment studies and also will enable the setting of sounder limits on the amounts of newborn and juvenile elasmobranchs that can be fished.

Harnessing the vast knowledge of fishermen in efforts to map and study these nursery and pupping grounds would be the best way to approach this task. Monitoring of these areas and the eventual quantification of the average numbers of newborns and juveniles of each species using them will allow a better way to set limits on the allowable catches.

6.2.2.6. Periodic stock assessment

The carrying of periodic stock assessment studies should figure high on the list of long-term tasks of the fisheries management authorities of each nation. The seeds of the required technical knowledge have been planted by the training course and related training materials produced through this consultancy. But the main problem at the moment is the unavailability of any kind of information that can lead to even preliminary stock assessment studies. Implementation of the recommendations outlined in points 6.2.2.1, 6.2.2.2, and 6.2.2.4 will eventually alleviate the crisis of data availability. Once this has been achieved, periodic stock assessment studies on a species by species basis if possible should be carried out in order to underpin management decisions.

Initial approximate approaches can be applied within a few years. Demographic models require only the population parameters listed above that could be already available in 3-5 years from now. This could at least help classify which species are more vulnerable than others and guide some qualitative approaches to management. The recovery of historical information, if successful enough, could allow the application of non-equilibrium surplus production models for stock assessment. Without the eventual performing of periodic stock assessments, the implementation of the recommendations mentioned above will be rendered useless and a waste of resources. Carrying out fisheries stock assessment studies is the only way in which sustainability in the elasmobranch fisheries of the region will stand a chance.

6.3. Follow-up Activities

The activities listed below are directly linked to the objectives and goals of the present consultancy and should be carried out independently of the recommendations listed above.

6.3.1. Continued and expanded capacity building

The needs of capacity building in the region are large and the work started through this consultancy should not be expected to resolve these needs. Further promotion of training of personnel should be an independent goal of all the nations in the region. At the local level, the materials now available should be taken advantage of fully by organizing local training courses in elasmobranch identification by some of the top students that attended the courses. Technical assistance from FAO and other international bodies should also be sought for training purposes. The areas of most urgent training are in numerical analysis of fisheries (stock assessment), statistical analysis and database design and management, fisheries biology, and computer science. Graduate studies abroad in all of the above areas should be strongly encouraged.

6.3.2. Conservation and expansion of reference collections

The reference collections of elasmobranchs created through the consultancy should be transferred to appropriate museums or the collections of universities and research laboratories in the region. Furthermore, they should be maintained and expanded as they represent a valuable resource to increase and expand the knowledge of the shark and batoid fauna of the region. These collections can help resolve problems of identification of students and research staff and can directly and indirectly further the training on elasmobranch identification throughout the region. Periodic invitations to experts in elasmobranch systematics (once every five years or so) can be arranged for them to check the collections and resolve potential problems of misidentification.

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