

The IUCN Species Survival Commission

Elasmobranch Biodiversity, Conservation and Management

Proceedings of the International Seminar
and Workshop, Sabah, Malaysia, July 1997

Edited by Sarah L. Fowler, Tim M. Reed and Frances A. Dipper



Occasional Paper of the IUCN Species Survival Commission No. 25

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Executive Summary

The Darwin Elasmobranch Biodiversity Conservation and Management project in Sabah was a collaborative project between the Department of Fisheries Sabah and the IUCN Species Survival Commission's Shark Specialist Group, in liaison with WWF Malaysia and the University Malaysia Sabah, and funded by the UK government's Darwin Initiative for the Survival of Species. It used field, market and socio-economic surveys to examine the biodiversity, conservation and management needs of elasmobranchs (sharks and rays) in the rivers, estuaries and coastal waters of Sabah, East Malaysia, during the period January 1996 to July 1997.

The Darwin Project concluded with a three day International Seminar and Workshop (8–10 July 1997), attended by 67 participants from 14 countries. This meeting was held to highlight freshwater and coastal elasmobranch conservation issues in the region and worldwide, to disseminate the result of the project to other Malaysian states and countries, and to raise awareness of the importance of considering aspects of elasmobranch biodiversity in the context of nature conservation, commercial fisheries management, and for subsistence fishing communities.

This Proceedings Volume contains peer-reviewed papers originally presented at the seminar. These include descriptions of the results of the Darwin Project work in Sabah, where an expanding commercial coastal fishery exploits a wide range of shark and ray species, some of which are still to be described by scientists, and where coastal elasmobranchs are an important resource for subsistence and artisanal fishing communities. Sabah's largest river, the Kinabatangan, benefits from legal protection, and fieldwork during the project confirmed that several rare and threatened elasmobranchs still occur and breed there.

Other papers describe similar studies of elasmobranch biodiversity (with particular emphasis on freshwater and coastal habitats), fisheries and trade elsewhere in the Indo-Pacific (Peninsular Malaysia, Philippines, Thailand, Maldives, West Java, Taiwan, India, Australia and Zanzibar). International and regional reviews of

taxonomy, biodiversity, fisheries and trade provide the wider context for these studies, with a species checklist and a review of the importance of regional collections for future taxonomic research providing a basis for more research into fisheries and biodiversity in the region.

Species receiving particular attention in this volume are those recorded from freshwater and estuarine habitats (which are under particular threat and have therefore been the subject of several recent studies by Japanese and Australian research teams) and the whale shark, a highly migratory species which is the subject both of consumptive fisheries and ecotourism activity. This species is considered to have huge additional potential for sustainable ecotourism in the region; another paper summarises the importance of many other species of elasmobranchs as a recreational resource in the Maldives, where dive tourism is a particularly important industry.

Several papers focus on management and conservation, outlining the major threats to shark and ray populations and some of the national and international fisheries management and biodiversity instruments which may be used to promote sustainable use of elasmobranch populations.

The final day of the seminar was dedicated to three workshop sessions on the subjects of 'Future prospects for elasmobranch fisheries and biodiversity', 'Strategies for the conservation and management of elasmobranchs', and 'Carrying forward the Darwin Project'. Workshop participants developed conclusions and recommendations on these subjects, and the workshop report was agreed in outline by the final plenary session, and subsequently refined by correspondence between the participants.

The workshop conclusions highlight the importance of elasmobranchs as top marine predators and keystone species, noting that anthropogenic changes to shark and ray populations are likely to have serious and negative consequences for commercial and subsistence yields of other important fish stocks. The recommendations provide concise guidelines for conservation and sustainable elasmobranch fisheries in the Indo-Pacific and other regions.

Elasmobranch Biodiversity, Conservation and Management in Sabah

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The UK government's Darwin Initiative for the Survival of Species was set up to fund collaborative projects which promote the conservation of global biodiversity. The Darwin Initiative supports unusual projects, which break 'new ground' and would otherwise be very unlikely to receive financial support. Specific aims include raising awareness of biodiversity, involving local people, strengthening links between Britain and partner countries, and acting as a catalyst to generate resources for and interest in further projects. The proposal for the elasmobranch biodiversity project in Sabah arose from the discovery that local fishermen could describe several species of freshwater elasmobranchs not recorded in scientific literature, and in recognition of the largely unreported diversity of elasmobranchs entering coastal markets there. The project was therefore proposed in order to study, for the first time, the biodiversity, distribution and conservation needs of elasmobranchs in the region. In addition to taxonomic and biodiversity studies, it was intended to address the local socio-economic importance of elasmobranchs, the need for fisheries management, protected areas, and education of local people, and to provide the information required by decision-makers to advance elasmobranch conservation. The final international workshop (of which this is the Proceedings Volume) was intended to highlight freshwater and coastal elasmobranch conservation issues worldwide. The Sabah project was carried out in collaboration with the Department of Fisheries, with advice from WWF, and the participation of the Universiti Malaysia Sabah. Work undertaken during the 18 months of the project is described briefly, with reference to other papers in the Proceedings Volume.

Trends and Patterns in World and Asian Elasmobranch Fisheries

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International concern over the fate of elasmobranch fisheries has grown recently. This results from two major causes: first, due to their life history characteristics, sharks and rays are prone to overexploitation; second, continued expansion in global catches of sharks and rays seems to be running unchecked. Elasmobranch fisheries remain little known and poorly characterised. This paper presents an overview of fisheries for sharks in the world based on official statistics of FAO, SEAFDEC and various other national and international agencies, and is complemented by an extensive literature review. The paper covers the diversity of world shark fisheries, artisanal and industrial, commercial and recreational, and, where possible, provides information on the most common gears used and the most important species caught. Catch trends for the different regions of the world are presented, together with an analysis of production in each of these regions. Out of the 15 FAO fishing areas, four show decreasing trends in the catches while nine others have increasing trends and two show almost no trend. An analysis of relative production by areas suggests that increases in yield could potentially be obtained in the south-east Pacific and the south-east Atlantic Oceans. Although some industrial fisheries for sharks exist in several countries, most of the catches are actually produced by small-scale fisheries all over the world. Globally, various types of gillnets provide a greater part of the total catch. The bycatch of sharks in other fisheries also accounts for a significant part of the total. Estimates on a worldwide scale indicate that about the same amount of sharks are caught in directed fisheries as are caught as bycatch in other fisheries, mostly longline fisheries for tunas. Sharks are used for food in many countries, and in some parts of the world the hides are used for the leather industry. However, the traditional Chinese shark-fin soup market has expanded greatly in the past 10 years and the high prices paid for dried shark fin are putting pressure on shark stocks around the world. A very controversial novel utilisation of sharks is the production of a shark cartilage pill as a supposedly "magic" cure for cancer. The paper ends with a brief discussion of the needs for management and conservation of sharks around the globe, and the problems faced when attempting to do so.

An Overview of Sharks in World and Regional Trade

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TRAFFIC Network carried out a study of the shark trade in Europe, India, east and southern Africa, South East Asia, East Asia, Oceania and North and South America between early 1994 and end of 1996. The study highlights the fisheries and trade of sharks and shark products in domestic and international trade. The study used a number of different sources of information including FAO data, regional research centres, national fisheries data, national trade data, SEAFDEC, etc., as well as field observations and interviews with traders, fishers, researchers and government sources. The statistical information was found to have a number of limitations. Chondrichthyan fish are caught in targeted fisheries or as bycatch. The former is of a much smaller volume compared to incidental bycatch although it is not possible to accurately compare the two. The trade in sharks includes live specimens, parts and products such as meat, fins, skin, liver oil, internal organs and other edible products such as brain, eggs, ovaries, cartilage, teeth, jaws and other curios, fishmeal, fertiliser and fish oil and bait. Fins are the most valuable parts of a shark, and represent by far the largest proportion of parts and products traded. This study recommends that the principles and standards in the FAO's "Code of Conduct for Responsible Fisheries" that address fisheries research and data collection should be applied by all nations. The collection of data could be much improved, and further monitoring efforts on domestic and foreign vessels should be initiated. Ecologically sustainable management plans are urgently required for the region and Parties to CITES should continue to monitor the work of relevant agencies in improving the collection of data, perhaps through the formation of a CITES marine fisheries working group.

Pilot Fisheries Socio-economic Survey of Two Coastal Areas in Eastern Sabah

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A pilot socio-economic study of two kampongs (villages) in eastern Sabah, one located on an estuary and the other on a reef island, show that a considerable amount of sharks and rays are caught and consumed by artisanal and subsistence fishermen. However, in spite of this, sharks and rays are still considered as low-price catches. Fishing and fishing-related tasks (net mending, boat building, etc.) are the main income generating activities for both kampongs. The role of women is important as food gatherers in both villages.

Elasmobranchs as a Recreational Resource

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Changing patterns of recreation over the last decade have brought changes in attitudes towards elasmobranchs. In particular there is a growing realisation that there are powerful incentives for sustainable (and often non-extractive) recreational utilisation of many elasmobranch resources. There are three large groups of recreational users: 1. Recreational divers. The growth of recreational diving in recent years has been little short of explosive. Divers like to see sharks and rays in their natural habitats and are willing to pay large sums of money to do so. Revenue from shark and ray diving internationally runs into hundreds of millions of dollars annually, as a result of which divers have become a powerful force for shark and ray conservation. 2. Recreational fishers. Fishing is one of the most popular leisure activities worldwide. There is a growing trend among elasmobranch fishers to release catches alive, often after tagging. As a result, mortality in some stocks has been reduced while at the same time information of value to resource managers has increased. 3. Aquarists. Recent improvements in aquarium technology have led to a boom in the display of live elasmobranchs both in big new public aquariums and in domestic tanks. As a result there has been a great increase in awareness of the importance and vulnerability of elasmobranch resources.

Review of the Biodiversity of Sharks and Chimaeras in the South China Sea and Adjacent Areas

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The South China Sea and adjacent areas have a rich shark fauna and undiverse chimaeroid fauna, with at least 136 species of sharks and four species of chimaeras. The region is diverse hydrographically, and includes a broad continental shelf with continuity of inshore fauna between the countries fronting it, an ocean basin, and extensive and largely unexplored continental slopes. The low diversity of chimaeroids in the region may be partly explained by sampling error and limited exploration of the local slopes. The shark fauna is peculiar in having relatively low diversity of catsharks (Scyliorhinidae) and deep-slope squaloids, which may also reflect sampling errors such as better representation of important commercial species in the faunal list and poor representation of deep-slope species. The shark fauna has a wide habitat range and has rich oceanic, slope, and shelf components as well as species that bridge two or more of these broad habitat categories. Zoogeographically, the fauna has few regional endemics (17%), and is primarily composed of wide-ranging species (59%) and Western Pacific species (24%). Most of the ecomorphotypes ascribed to sharks occur in the region, which indicates the high diversity of habitats and life history styles of the regional fauna. A working checklist of sharks and chimaeras of the South China Sea is provided.

Review of the Biodiversity of Rays in the South China Sea and Adjacent Areas

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The South China Sea and adjacent areas have a rich ray fauna of at least 103 species, or about a fifth of the world's fauna. The region is physically diverse with extensive and largely unexplored continental slopes. The fauna is in need of further study. Knowledge of the species, some of which may be vulnerable to exploitation, is difficult in the absence of an adequate identification tool. The low diversity of rajoids in the region may be partly due to the limited exploration of the local slopes. The ray fauna is typical of other parts of the Indo-West Pacific where the myliobatoid groups, the stingrays (Dasyatidae), eagle rays (Myliobatidae) and the devilrays (Mobulidae) are particularly diverse. The ray fauna has a wide habitat range including freshwater, oceanic, and continental shelf and slope components, as well as species that bridge two or more of these broad habitat categories. Biogeographically, the fauna is similar to the shark fauna in having few regional endemics (17%), and is primarily composed of wide-ranging species (54%) and Western Pacific species (29%). However, unlike sharks, the proportion of Indo-West Pacific endemics (45%) greatly exceeds the proportion of very widespread species (10%). Most of the ecomorphotypes ascribed to rays occur in the region, indicating a high diversity of habitats and life history styles of the regional fauna. More than half the species are rajabenthic.

New Records of Elasmobranch Species from Sabah

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This paper presents an annotated checklist of new records of elasmobranch species from Sabah (including both marine and freshwater species); the result of the 18-month elasmobranch biodiversity project funded by the UK Darwin Initiative for the Survival of Species. The high number recorded (34 species of shark, 35 species of ray), with 25 new records for the region (14 shark and 11 ray species), and a record of at least one undescribed species of shark, reflects the rich fish biodiversity in this part of the world. Furthermore, this number does not include several records that have only been determined to level of genus. New records were made throughout the study period, with several species seen only during the last few months of the project. In addition, surveys carried out during the study have provided additional information and added to the knowledge of scientists studying some of the elasmobranchs. These results have indicated that there is considerable scope for more detailed work in the area. Other papers in this volume present information on species recorded from rivers and estuaries and on elasmobranch fisheries in Sabah.

Importance of Biological Collections for Future Taxonomic Research in the Indo-West Pacific

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The Indo-West Pacific has the richest fish fauna of any of the world's major faunal regions. It is extremely complex biogeographically, with several genera being represented by pairs of sister species, often sympatric, from the Pacific and Indian Oceans. Much of the region is faunally unexplored, and the extent of new deepwater taxa is likely to be large. Well organised and maintained regional specimen collections and strategic collecting of reference specimens are essential if we are to adequately define the composition and structure of this fauna. The various benefits of such collections, and recommended procedures for their establishment, are discussed in the light of Australian experiences.

An Annotated Checklist of Elasmobranchs of the South China Sea, with some Global Statistics on Elasmobranch Biodiversity, and an Offer to Taxonomists

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An annotated checklist of the sharks and rays of the South China Sea is described, together with some global statistics on the status and use of elasmobranchs. For each of the 156 recorded species, the checklist contains scientific names, synonyms, common names, global distribution, distribution in the area, status of threat, human uses, key references on taxonomy, identification, reproduction, population dynamics, and a list of people who have contributed information. The checklist is a direct printout from FishBase, a global database on finfish, developed at ICLARM in collaboration with FAO, the California Academy of Sciences, and many other partners, and supported by the European Commission (see www.fishbase.org). The goal of FishBase is to further the conservation and sustainable use of fish by bringing together the knowledge of taxonomists, fisheries experts, and conservationists, providing tools for analysing and updating this knowledge, and making it available to concerned people. How a closer link between FishBase, taxonomists and country experts can benefit the specialists, as well as elasmobranch conservation, is discussed.

Elasmobranch Fisheries in Peninsular Malaysia

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This paper presents information on the status of elasmobranch fisheries on the east and west coasts of Peninsular Malaysia. Approximately 19 species of shark and 20 species of ray have been reported in the waters off the east coast, and fewer are reported in the waters off the west coast of Peninsular Malaysia. Information on the biology and habitats of these species is limited. Landings data from 1982 to 1994 indicate that more sharks were caught on the east coast, but rays were found to be more abundant on the west coast. Both sharks and rays were caught mainly by bottom trawl nets. Demersal resource surveys conducted by fisheries research vessels using bottom trawl nets indicated that catch rates of sharks were higher in water deeper than 30m, while catch rates of rays were higher in water of less than 30m.

Status and Trends of the Elasmobranch Fishery in Sabah, Malaysia: A Brief Overview

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No abstract

Taiwan's Shark Fishery – An Overview

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Between 1985 and 1995 the annual landing of sharks in Taiwan ranged from 39,000 to 74,000t, some 7.3% of the world's total shark catch. Of Taiwan's shark landings 85% are from deep-sea fisheries, caught on the high seas or in other countries' Exclusive Economic Zones. Three major fishing grounds are the waters around Papua New Guinea, Indonesia and Mozambique. In addition, the bulk of Taiwan's remaining shark catch was bycatch from tuna longliners and trawlers. The major species landed are silky shark, oceanic whitetip shark, shortfin mako, thresher sharks, hammerhead sharks, blue shark and silvertip shark. Two major bases for coastal and offshore shark fishery in Taiwan, Chengkaung and Nanfang Ao, together landed 4,518t of shark (85% of Taiwan's total coastal and offshore shark landings). The dominant shark species are bigeye thresher, pelagic thresher, scalloped hammerhead, smooth hammerhead, sandbar shark, oceanic whitetip shark, silky shark, dusky shark, spinner shark, blue shark, shortfin mako and tiger shark. The major fishing methods are bottom longline and drift net. The price of sharks caught in coastal waters ranged from US\$0.7/kg for blue shark to US\$7/kg for whale shark. The sharks were utilised completely, i.e. meat, skin, stomach, intestine and fins for food, and liver and cartilage for medicinal use.

Elasmobranch Diversity and Status in Thailand

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The first work to be published on sharks and rays in Thailand was by Fowler (1934). Several studies have been published since. At least 145 species in 34 families of 13 orders have been reported in Thai and adjacent waters. The Thai elasmobranch fauna consists of one species of chimaera, 74 sharks and 70 batoids. Predominant are the ground sharks (Carcharhiniformes) with 49 species in five families, and stingrays (Myliobatiformes) with 45 species in six families. Eighteen elasmobranch species are known from the deep sea, 15 species are oceanic, 108 are coastal and 10 inhabit or penetrate into freshwater.

Four pristid sawfishes are considered to be locally endangered, and 43 species are threatened, especially the two freshwater stingrays, *Himantura chaophraya* and the Mekong River endemic *Dasyatis laosensis*. The main threats to Thai elasmobranchs are habitat loss and overexploitation. Sharks (2,200–4,600t annually) and rays are mainly caught as bycatch of otter-board trawls and gillnets. Major uses are as food, shark fin products and hides. Minor uses are the production of ornamental items and curios, and game fishing. Populations of whale sharks, mantas and other sharks off the southern coasts of the country can be used sustainably through dive tourism.

Elasmobranch Fisheries in the Maldives

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The elasmobranch fisheries in the Maldives are reviewed. There is little local demand for elasmobranch products other than crude liver oil, used for treating wooden boats. Export demand has driven the three major shark fisheries: 1. An offshore longline fishery for pelagic oceanic sharks. This fishery produces mainly salt-dried shark meat (for export to Sri Lanka) and dried shark fins (for export to East Asian markets). The fishery has expanded in recent years. There is a problem of conflict with local tuna fishermen (who maintain that oceanic shark fishing diminishes pole and line tuna catches) and there are concerns about the long-term sustainability of the resource. 2. A multigear fishery for reef sharks. This fishery also produces salt-dried meat and dried fins for export. The resource has been heavily exploited in recent years. This has led to conflicts with the important tourism industry, since reef sharks are a major attraction for visiting divers. It is estimated that about US\$3 million is spent on reef shark and ray watching annually. 3. A vertical longline fishery for deep demersal sharks. This fishery produces high-value squalene-rich liver oil for export to Japan. The resource has been overexploited and the fishery has collapsed.

A Review of Australian Elasmobranch Fisheries

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There are three main directed shark fisheries in Australia: a south eastern fishery for *Galeorhinus* and *Mustelus*, a Western Australian fishery for *Furgaleus*, *Mustelus* and *Carcharhinus obscurus* and a northern fishery for *C. tilstoni* and *C. sorrah*. The combined annual landings from these three fisheries is about 7,000t, which is worth some AUS\$25 million. Each of these fisheries is subject to a range of management measures. There is also a small eastern fishery for *Orectolobus*. Sharks and rays comprise a substantial bycatch in several fisheries, notably the northern prawn, tuna longline and south east trawl. Targeted sportfishing for sharks is highest on the east coast, but catches are relatively small. About 1,200 sharks are caught annually in shark control programmes on the east coast of Australia.

Shark Fisheries in the Philippines

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This report contains details of the production, fishing grounds, fishing gear and marketing of sharks in the Philippines. Except for piked dogfish *Squalus acanthus*, sharks were generally a bycatch of some major fisheries in the late 1960s to early 1980s. Since the early 1980s shark meat has been used for fish balls while the fins are dried and sold to local hotels and restaurants. Piked dogfish is a target species due to the demand for squalene oil. The whale shark *Rhincodon typus* is also fast becoming a target species, for both local and export markets. The average annual production from sharks for the past 20 years was 5,882t. The West Sulu Sea, Lamon Bay and Visayan Sea are the three most important shark fishing grounds in the Philippines. Although there has been no thorough study, several reports have shown that at least 20 species of sharks are reported to occur in Philippine waters. Trawl and handline are the major gears catching sharks. Japan is the primary importer of shark liver oil, while the fins and meat are exported to Hong Kong. The prevailing price of shark meat in the local market ranges from PhP20.00 to PhP60.00 per kg, depending upon the size of the shark. Dried shark fins fetch a price of PhP1,800.00 to PhP2,000.00 per kg, while the buying price for dried hide is around PhP10.00 to PhP15.00 per kg. Shark fisheries in the Philippines are still continuing to expand.

Fishery and Trade of Whale Sharks and Manta Rays in the Bohol Sea, Philippines

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Reports suggest that fishery and trade of whale shark *Rhincodon typus* and manta ray *Manta birostris* in Philippine waters have been operational for several generations, especially around the Bohol Sea. Concern is growing about the sustainability of such a fishery, and the possibility that both species may become extirpated in the wild. This led to a KKP (Kabang Kalikasan ng Pilipinas or World Wide Fund for Nature–Philippines)-funded research on the catch volume and trade of the fishery during the 1997 season, leading to the development of a conservation strategy for these animals. Methods of data collection included site visits to coastal villages involved in whale shark and manta fisheries, market surveys, fishers' interviews and daily landing site enumerations. Initial study sites were Pamilacan Island in Bohol, Balite and Looc in Catarman, Manuyog in Sagay and Talisayan in Misamis Oriental. Fishery profiles and activity patterns related to whale shark and/or manta fisheries in these sites are presented. During the study, 31 fishery sites were operational or had recently been operational. Traditional fishing grounds were not limited to areas within the Bohol Sea, but extended as far as the seas of Sulu and Mindanao. The fishery is flourishing, with fishing effort (number of persons and number of boats) increasing. Products traditionally marketed dried were fins, skin and meat, while the rest were given or thrown away. These are now also sold fresh. The demand has also expanded from local and/or inter-island to national and international markets. Data collected suggest that the whale shark and manta ray populations in the Bohol Sea are threatened. Conservation measures through a fishery ban, however, were unwelcome to most hunters. Some of the reasons given by hunters opposed to the ban were economic dependency on the fisheries, seasonal opportunity, inexhaustible supply of the resources, and religious concepts. Management strategies employing Integrated Conservation and Development projects, ensuring conservation of the species as well as protection of fishers dependent on the fishery, are recommended.

Development of Shark Fisheries and Shark Fin Export in Indonesia: Case Study of Karangsong Village, Indramayu, West Java

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Indonesia has a long-established shark fin export trade. Rocketing market prices for shark fins in Hong Kong in 1987 were reflected in Indonesia. Many new fishermen and traders joined the shark fishing and shark fin trade. Competition intensified and the domestic market price of shark fins increased sharply. The paper describes the development of the shark fishery in Karangsong Village, from the 1960s when nylon nets were used and shark flesh was salted for sale, to the introduction in the 1980s of motorised fishing vessels, use of ice, fish market developments in larger cities and the growth of longlining. The pattern of involvement of traders in the industry over this period is outlined. Boat owners started longlining for sharks and increased their profits (40%–50% of which came from shark fins) in the 1980s. The fishery grew rapidly with increased demand for shark fins in 1987. More traders became boat owners and offered incentives to skilled shark-fishing captains. The economics of this developing fishery are described.

The Status of Shark Fisheries in Zanzibar

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The conservation and management of chondrichthyan fishes (sharks, rays and chimaeras) is a concern, particularly of sharks. There are limited population data, making status assessment difficult for Zanzibar. Sharks form a major food source for Zanzibar's growing human population. Some species are of conservation concern, several are considered vulnerable to extinction. Threats come from unregulated fishing, and increasing commercial demand for sharks. Although fishing practices are still traditional, catches are declining. While external factors may be partly responsible, it is possible that the traditional fishery is unsustainable. Marine fisheries laws have recently been revised, but need further revision to provide sufficient protection for marine species.

The paper summarises the status of shark fisheries in Zanzibar. Basic information on shark fisheries obtained from a literature review, interviews, informal discussions and observations at landing stations and fish markets, indicates the pattern of seasonal catches. The common species caught by the fishermen are listed, some of which are threatened by overexploitation. Fisheries laws and regulations exist, but adequate monitoring of fisheries is lacking. Steps to improve the current position are outlined.

Preliminary Report on Taiwan's Whale Shark Fishery

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This study collected information on catch and distribution of whale sharks *Rhincodon typus* around Taiwan by interviews with 32 captains of harpoon vessels and 58 owners/operators of set-nets. The main fishing methods for whale shark in Taiwan are harpoon and set-net, with gillnet and longline playing a minor role. Ilan had the highest annual catch rate for set-nets with 2.35 animals per set-net per year. Miaoli had the lowest catch rate with 0.83 animals per set-net per year. The average estimated annual catch per year was: Ilan, 61.1; Hualien, 46.8, Taitung, 25.3; Pingtung, 14; Hsinchu, 5.17; Miaoli, 3.33; Penghu, 2. The annual catch by set-nets was estimated to be 158 individuals. The estimated total catch for harpoon fisheries in Hungchung, Taitung and Ilan were 33.6, 62.4 and 17.8, respectively. The total annual catch for harpoon fisheries in Taiwan was estimated to be 114 individuals. Whale sharks seem to have an extremely low reproductive capacity and high vulnerability to over-exploitation. Creation of a successful management system for whale shark fisheries will require further research into the species' life history, population structure, behaviour, migration patterns and genetics.

Freshwater and Estuarine Elasmobranch Surveys in the Indo-Pacific Region: Threats, Distribution and Speciation

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The tropical Indo-West Pacific is the world centre of chondrichthyan diversity, with a varied marine and freshwater fauna. The inshore marine fauna, from the intertidal to 50m depth, and the freshwater fauna is especially rich, and comprises approximately 245 species of elasmobranchs and no chimaeroids (which occur on the tropical slopes in the Indo-West Pacific). This includes about 41% sharks and 59% rays, with approximately 86% endemism. The elasmobranchs that occur in fresh water include approximately 12% of the total inshore-freshwater fish fauna. This includes a poorly-known category of marginal species (6% total) which occur in estuaries and river mouths and have a limited penetration of fresh water, and an inadequately-known category of euryhaline and obligate freshwater elasmobranchs (8% total). Euryhaline and obligate species include sharks of the genera *Carcharhinus* and *Glyphis* (family Carcharhinidae), sawfishes of the genus *Pristis* and possibly *Anoxypristis* (family Pristidae), and stingrays of the genera *Dasyatis* (fringetail stingrays), *Himantura* (whiprays), and *Pastinachus* (cowtailed rays) (family Dasyatidae). The shark genus *Glyphis* is endemic to the tropical Indo-West Pacific and, as with many other regional freshwater elasmobranchs, is poorly known. A tentative checklist of tropical inshore and freshwater elasmobranchs of the Indo-West Pacific is presented in the paper. Threats to the survival of freshwater elasmobranchs in the area include biological limitations of elasmobranchs in general and freshwater elasmobranchs in particular, coupled with human-induced problems including over-exploitation and habitat modification and destruction.

Outline of Field Surveys for Freshwater Elasmobranchs Conducted by a Japanese Research Team

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Field surveys for freshwater elasmobranchs were conducted in South East Asia (November 1976–February 1977), South America (August–October 1980), West Africa (December 1985–February 1986), Oceania (August–September 1989, August–September 1990), Mexico and Central America (July 1993, December 1993–January 1994), and Thailand, Laos, India and Bangladesh (November 1996, March 1997; another survey was planned for August–September 1997). Two species of sharks (Carcharhinidae), six species of stingrays (Dasyatidae), and at least eight species of river stingrays (Potamotrygonidae) were examined. Over 200 specimens were collected and examined for a variety of research projects.

Freshwater and Estuarine Elasmobranchs of Australia

P.R. Last

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Only a decade ago, the freshwater and estuarine elasmobranch fauna of Australia was considered to be insignificant in size and diversity. Surveys funded by Australian and Japanese agencies in the 1990s have significantly changed this impression. At least 7 species from the families Carcharhinidae, Pristidae, Rajidae and Dasyatidae, are now thought to be obligate within these habitats, while many others breed or occur seasonally in estuaries. Our understanding of their biology remains poor and this may have serious conservation consequences. The undescribed Bizant river shark, *Glyphis* sp., which is known from only two specimens taken more than 15 years ago, may now be extinct. The freshwater sawfish, *Pristis microdon*, appears to be restricted to freshwater. This species, which is Australia's largest freshwater fish, is taken in the dry season from waterholes by gill nets and its numbers appear to be declining. So serious is this situation, that this species may be eliminated from the region before its biology is understood. Similarly, an undescribed skate *Dipturus* sp. confined to two Tasmanian estuaries is the world's only known obligate estuarine skate. Once again, little is known of its life history but its small population and extremely restricted range make it highly vulnerable to extirpation. Conservation issues applying to Australian elasmobranchs also apply elsewhere in the Indo-Pacific.

Elasmobranchs Recorded from Rivers and Estuaries in Sabah

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Sabahan villagers and fishermen have traditionally known that elasmobranchs (sharks, rays and sawfish) occur in several large rivers in Sabah. However, prior to the initiation of this study, no species had ever been recorded during scientific surveys, or reported in the literature. As a result of this study, there are now definite records from Sabah rivers of two shark species: *Glyphis* sp., (provisionally named the Borneo river shark) and the bull shark, *Carcharhinus leucas*, and three batoids: the giant freshwater stingray *Himantura chaophraya*, and the sawfishes *Pristis microdon* and *P. zijsron*, (although the latter is known only from a saw). Local fishermen also confidently described other species of fresh or brackish water elasmobranchs, which are yet to be seen by scientists. As a result of these findings, it is hoped more can be learned about the biology of these species, which is presently very poorly understood. Additionally, strategies for the conservation and management of critical freshwater, estuarine and near-shore areas should be better developed and supported.

Growth and Mortality of the Basking Shark *Cetorhinus maximus* and their Implications for Management of Whale Sharks *Rhincodon typus*

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New methods were used to reanalyse previously published length-frequency data on basking shark *Cetorhinus maximus* and thereby resolve an earlier controversy about the growth rate of this fish. These methods confirm earlier suggestions of a slow growth (von Bertalanffy $K > 0.06/\text{year}$, for an asymptotic length of 10m), and correspondingly low natural mortality ($M > 0.07/\text{year}$), as appropriate for a fish with a record length of 9.7m.

Given what is known of the inverse relationship between asymptotic length and K in hundreds of fish species (including sharks), the above results imply that whale sharks *Rhincodon typus* should exhibit, for an asymptotic length of 14m, K and M values of about 0.03 and 0.05/year, respectively. Such slow growth and the high longevity this implies should make whale sharks even more sensitive than basking sharks to human-induced mortality, thus arguing against exploitation by fisheries. Also, ecotourism schemes will have to be careful to avoid becoming a source of indirect mortality.

International Elasmobranch Management and Conservation Initiatives

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A reported steady increase in the international trade in shark products (particularly fins, but also cartilage, meat, teeth, skins, jaws and oil) in the early 1990s led to concern that species were being heavily and potentially unsustainably exploited by fisheries. This issue was debated at the 9th Conference of the Parties to the Convention on International Trade in Endangered Species (CITES) in 1994, and a Resolution agreed. The Resolution noted the lack of specific management or conservation measures for sharks at a multilateral or regional level. It directed the CITES Animals Committee to compile and review existing data on the biological and trade status of shark species subject to international trade, and to prepare a discussion paper on these data prior to the 10th CITES Conference in 1997. Parties to CITES, FAO and other international fisheries management organisations were also asked to establish programmes to provide biological and trade data. This paper describes the work undertaken as a result of this Resolution, which resulted in several important new international initiatives on the monitoring and management of elasmobranchs. Some other selected regional and international natural resource management instruments and organisations which are or may be used for the collection of data on shark fisheries and/or to promote shark fisheries management are also outlined (these have been updated following the presentation of the original paper in Sabah in 1997). The potential use of and synergy between fisheries and wildlife legislation for shark fisheries management and species conservation at international and regional level is noted.

FAO Initiatives for Elasmobranch Fisheries Research and Monitoring

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In November 1994 the Convention on International Trade in Endangered Species (CITES) passed Resolution 9.17, which asks the Food and Agriculture Organization of the United Nations (FAO) and other international organisations to establish programmes to further collect and assemble the necessary biological and trade data on sharks. Current statistics to support the widespread decline of shark catches are scarce, and global statistics show several gaps and inaccuracies. The main problems with existing data are the lack of data for shark bycatch and lack of species detail for catches on a global and national level. Acknowledging the gaps in the information available, and in order to allow FAO to respond to the CITES request, FAO has recently included some shark activities in addition to existing programmes. A special inquiry was undertaken on shark fisheries in the autumn of 1996, and a consultant reviewed all available biological and fishery data on sharks, including those resulting from the inquiry, and prepared a report on the biological status of sharks worldwide. FAO also intends to: (1) review the trade status of sharks and shark parts; (2) commission a study on species identification using DNA analysis; (3) commission the preparation of case studies on shark fishery management; (4) update the shark species catalogue and the technical paper on shark utilisation. In addition, the 1997 Commission on Fisheries meeting at FAO HQ in Rome proposed organising an expert consultation with Japan and US on conservation and management of shark populations. [An Editor's note provides an update on activities since 1997.]

Review of Fisheries and Processes Impacting Shark Populations of the World

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Populations of many species of shark around the world are being affected by harvesting and habitat change. Widespread stock reductions have occurred for targeted and bycatch species of shark in certain industrial fisheries. More localised reductions have occurred closer to shore from the effects of industrial, artisanal, recreational and, possibly, traditional fisheries. Beach protection programmes, designed to reduce the risk of shark attack on humans at bathing beaches, have also reduced numbers. Several countries are beginning to manage usage of their shark resources rationally, but most are not. Whilst stocks of some species are being harvested sustainably, stocks of other species have been reduced to levels where they now require total protection. Other factors impacting shark populations are more difficult to quantify. Industrial, domestic and agricultural development in coastal and catchment areas are affecting inshore nursery areas. Aquaculture, ecotourism, spread of exotic organisms, pollution and environmental disturbance by fishing gear, and, in the long-term, global warming and ozone thinning are probably having more subtle impacts. These anthropogenic non-harvesting influences together are likely to be impacting first on those species of shark reliant on inshore areas for their nurseries; certain migratory species are likely to be impacted in the long-term.

Whale Shark Tagging and Ecotourism

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Whale sharks are becoming increasingly important to the growing dive tourism industry in South East Asia and Western Australia. Seasonal aggregations of whale sharks in specific areas in Asian countries have been recorded by dive operators, who actively promote diving and snorkel trips with these sharks. Whale sharks are also being harvested, apparently on an increasing scale, in the Philippines, Taiwan and Indonesia for their meat, fins, oil and cartilage. At present little is known about their population numbers, migratory habits and behaviour. This paper describes a proposal to use ecotourism operations as a basis for a South East Asia regional effort to assess whale shark populations and exploitation, in conjunction with other studies in South Africa, Mozambique, the Seychelles and Western Australia.

Reproductive Strategy of the Japanese Common Skate (Spiny Rasp Skate) *Okamejei kenojei*

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The reproductive biology of *Okamejei kenojei* is described, based on the examination of 134 female specimens collected from waters off Choshi, Japan. Female skates started to mature at a size of 390mm (total length), when the shell gland formed, and the gonad index ($100 \times \text{gonad weight}/\text{total weight}$) began to exceed 1.0. The female skate possesses egg-capsules in its oviduct throughout the year except in January, when the maximum ovum diameter exceeds 12mm. Observations of three live skates in the Oh-arai aquarium were recorded. One female skate began to lay egg-capsules soon after it was introduced to the aquarium. This skate has produced a total of 291 egg-capsules in seven years. The other two aquarium skates produced 510 egg-capsules in five years and 612 egg-capsules in four years, respectively. The offspring of these skate began to lay egg-capsules between three years and two months and three years and six months after hatching. Female individuals of the species may live at least seven years after sexual maturity without any further growth. This species of skate's reproductive strategy is characterised by rapid sexual maturity, a high rate of fecundity and, once sexual maturity has been reached, direction of energy resources towards reproduction rather than additional growth.

The Role of Protected Areas in Elasmobranch Fisheries Management and Conservation

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Elasmobranchs characteristically show sex and size segregation and as most are active, mobile animals which often have extensive distributions, closed areas will seldom protect all parts of a population. However, closed areas can be used to protect particular segments of the population which are particularly vulnerable, for example closure of inshore pupping and nursery areas as part of fishery management plans, and seasonal closures of shallow mating areas to boat traffic as part of conservation plans. Closure of areas, or protection of species within certain areas, have been used in various ecotourist ventures based on elasmobranchs. Fishery management measures have also used large-scale closures of inshore areas to provide a general refuge for stocks of commercial species and rolling closures have been used to protect pregnant females moving along migratory routes to pupping grounds.

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No abstract