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Cover photographs:
Top image: A double rigged shrimp trawler with nets and otterboards hanging outboard. Courtesy of the National Oceanic and Atmospheric Administration (United States of America).
Bottom-left image: Fishing vessels in Thailand. Courtesy of the author.
Bottom-right image: Shrimp being readied for market. Courtesy of the National Oceanic and Atmospheric Administration (United States of America).

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by
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Preparation of this document

Following the publication of a recent FAO study which showed that tropical shrimp trawl fisheries have high discard rates and account for over 27 percent of total estimated discards in all the marine fisheries of the world, the FAO Fisheries and Aquaculture Department commissioned a global review of shrimp fisheries. After completing a preliminary literature review and some in-country work, it was decided to examine shrimp fishing in a sample of ten countries, representing various geographic regions, as well as a variety of important shrimp fishery conditions: large/small fisheries, tropical/temperate zones, developed/developing countries and good/poor management. The ten countries selected for the study were: Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago and the United States of America. Fifteen topics related to shrimp fisheries were studied in each of the ten countries. Country studies were prepared and written with the assistance of national experts. The results of the studies are consolidated by topic and combined with specialized reviews.

This technical paper, containing both the global analysis and country reviews, is divided into two parts. Part 1 summarizes the results of the global study on the development and current status of shrimp fisheries, with a focus on direct and indirect social, economic and environmental impacts. Part 2 consists of the case studies of the countries reviewed. Finally, it includes some recommendations, using the FAO Code of Conduct for Responsible Fisheries as a reference. This report was initially reviewed internally by the FAO Fisheries and Aquaculture Department and then externally by several shrimp fishery specialists with a final review conducted by Serge M. Garcia.

Abstract

This report summarizes the results of a global study on the development and present status of shrimp fisheries, with a focus on direct and indirect social, economic and environmental impacts. The study reviews the current situation, problems and issues, as well as the solutions found and the trade-offs made. Important topics related to shrimp fisheries are examined in ten countries representative of geographic regions, together with their various significant shrimp fishing conditions. The ten countries selected are: Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago and the United States of America. The results of the country reviews are combined with specialized studies on important topics related to shrimp fisheries to produce the major findings of the overall study.

The recent world shrimp catch is about 3.4 million tonnes per year, with Asia as the most noteworthy area for shrimp fishing. World production of shrimp, both captured and farmed, is about 6 million tonnes, of which about 60 percent enters the world market. Shrimp is now the most important internationally traded fishery commodity in terms of value. In many tropical developing countries, it is the most valuable fishery export; the employment aspect is also significant. The economic importance of shrimp needs to be reconciled with considerable concern about the environmental impacts of shrimp fisheries.

Observations are made about many aspects of shrimp fisheries. These include: the development of shrimp fishing; structure of the shrimp fisheries; target species; catch/effort; economic contributions; trade; bycatch; fuel; biological aspects; impacts on the physical environment; impacts of large-scale shrimp fishing on small-scale fisheries; management; enforcement; research; data reporting; and the impacts of shrimp farming on shrimp fishing.

A major conclusion of the study is that there are mechanisms, instruments and models to enable effective mitigation of many of the difficulties associated with shrimp fishing, taking a precautionary and ecosystem approach to fisheries. The inference is that, with an appropriate implementation capacity, shrimp fishing, including shrimp trawling, is indeed manageable. In many countries, however, weak agencies dealing with fisheries, lack of political will and inadequate legal foundations cause failures in the management of shrimp fisheries. The report makes specific recommendations in a few key areas: the management of small-scale shrimp fisheries, capacity reduction; and access to the fishery.

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Foreword

A global review of shrimp fisheries was overdue for several reasons. Shrimp and prawns are an extremely interesting group of resources, with complex life cycles, occurring everywhere from tropical estuarine ecosystems to shallow shelves, continental slopes and deep seas, as well as the open ocean; they provide thought-provoking opportunities for comparison. They are also one of the most important internationally traded fishery products, and one of the few that can be considered a "commodity", with a value of US$10 billion (or 16 percent of world fishery exports), which generates substantial economic benefits, especially for many developing countries. They contribute substantially to the livelihoods of poor vulnerable communities, particularly as a source of cash.

Their "discovery" by industrial fisheries raised immense economic hopes in the 1960s, followed by concern as overcapacity and economic problems increased. Many of the fisheries could be considered as a metaphor of the global fishery crisis, with their long trail of sectoral, cross-sectoral and ecosystem issues. Overfishing is rampant, but no collapse has been reported, despite heavy fishing pressure. Attempts to control fishing efforts have been largely defeated by fishers' inventiveness and technological progress. Conflicts between artisanal and industrial fisheries, exploiting two different phases of the life cycles for penaeids are widespread, raising – sometimes violently – the issue of allocation between endowed modern exploitation systems and vulnerable coastal communities. To make things worse, the explosive development of shrimp culture has exacerbated conflicts related to the use of wild broodstock and postlarvae and to significant competition on the global market.

On the environmental side, shrimp is strongly influenced by climatic drivers, but also often affected by coastal habitat degradation, such as the destruction of mangroves by aquaculture or of seagrass beds by illegal trawling in coastal areas. Coastal shrimp ecosystems have experienced a decrease in their average trophic level from which, shrimp, as prey, has probably benefited (resisting to collapse). Exploiting high-biodiversity ecosystems, specialized industrial shrimp fisheries capture large quantities of bycatch, consisting to a large extent of "trash fish". Having limited storage capacity, these fisheries have been the world champions for discarding and, despite significant improvements in the last decade, still contribute about 25 percent to world discards. Little progress has been made in many countries to manage these multispecies fisheries more efficiently. Of the bycatch species, turtles have caused major problems; shrimp fisheries are an example here of the difficulty and also of the success in introducing bycatch reduction devices (BRDs). Last but not least, the use of trawls leads to an ecological impact on the superficial fauna and on the benthos, the extent and reversibility of which remain controversial.

Given both the economic and ecological importance of shrimp resources and the numerous concerns associated with shrimp fishing, it is surprising that it has been almost two decades since the last attempt was made to examine the major issues associated with shrimp fishing in the world. At a time when conventional governance is questioned and a shift to an ecosystem approach to fisheries (EAF) has been adopted, global shrimp fisheries are an excellent example of what should have been avoided but, also, in some areas, of what can be achieved with fishers' collaboration.

It is important that necessary future action be based on complete and reliable knowledge. The *Global study of shrimp fisheries* contributes to this knowledge by examining available information on fisheries: the main issues, research achievements and gaps, as well as the management solutions and difficulties encountered in various parts of the world. The document gives several perspectives on the many areas of controversy, placing them, where appropriate, in the framework of the FAO Code of Conduct for Responsible Fisheries and

EAF. It should not be surprising that, by doing this, the review offers more open questions than definite answers.

I believe that this compilation and the reflections it contains will be particularly useful for the next generation of scientists and managers who will try to tackle the issues raised, with the additional benefit of new tools from slowly emerging modern governance.

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Acronyms and abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACP	African, Caribbean and Pacific Group of States
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
ASIC	Australian Seafood Industry Council
ASMFC	Atlantic States Marine Fisheries Commission
BED	Bycatch exclusion device
BRD	Bycatch reduction device
CARICOM	Caribbean Community
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNP	*Carta Nacional Pesquera* (National Fisheries Chart, Mexico)
CNRO	*Centre national de recherches océanographiques et des pêches* (National Oceanographic and Fisheries Research Centre)
CONAPESCA	*Comisión Nacional de Acuacultura y Pesca* (National Aquaculture and Fisheries Commission)
CPUE	Catch per unit effort
CRFM	Caribbean Regional Fisheries Mechanism
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSO	Central Statistical Office
DANIDA	Danish International Development Agency
DFO	Department of Fisheries and Oceans
DKP	*Departemen Kelautan dan Perikanan* (Indonesian Ministry of Marine Affairs and Fisheries) (see also MMAF)
DPRH	*Direction de la pêche et des ressources halieutiques*
EAF	Ecosystem approach to fisheries
EBM	Ecosystem-based management
EEZ	Exclusive economic zone
EJF	Environmental Justice Foundation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FMP	Fishery management plan
FMSEU	Fisheries Monitoring Surveillance and Enforcement Unit
FRDC	Fisheries Research and Development Corporation
GAPCM	*Groupement des aquaculteurs et pêcheurs de crevettes de Madagascar* (Madagascar Shrimp Fishers' and Farmers' Cooperative)
GBRMP	Great Barrier Reef Marine Park
GDP	Gross domestic product
GEF	Global Environment Facility
GJ	Gigajoule
GMFMC	Gulf of Mexico Fishery Management Council

GSA	Gulf of Mexico and South Atlantic
GSP	Generalized System of Preferences
G(R)T	Gross (registered) tonnage
HMS	Highly migratory species
HP	Horsepower
ICES	International Council for the Exploration of the Sea
ICLARM	International Center for Living Aquatic Resources Management
IHHNV	Infectious hypodermal and haematopoietic necrosis virus
IIED	International Institute for Environment and Development
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUCN	World Conservation Union
JTED	Juvenile and trash excluder device
LPUE	Landings per unit effort
LTPY	Long-term potential yield
MAFCONS	Managing Fisheries to Conserve Groundfish and Benthic Invertebrate Species Diversity
MCSU	Monitoring, Control and Surveillance Unit
MMAF	Ministry of Marine Affairs and Fisheries (see also DKP)
MSC	Marine Stewardship Council
MSY	Maximum sustainable yield
NAFO	Northwest Atlantic Fisheries Organization
Nei	Not elsewhere included
NFC	National Fisheries Company
NGO	Non-governmental Organization
NIOMR	Nigerian Institute for Oceanography and Marine Research
NITOA	Nigerian Trawler Owners Association
NMFS	National Marine Fisheries Service (United States)
NOAA	National Oceanic and Atmospheric Administration
NOM	*Normas Oficiales Mexicanas* (Mexican Official Standards).
NORMAC	Northern Prawn Fishery Management Advisory Committee
NPF	Northern Prawn Fishery
NRC	National Research Council (United States)
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
OIE	World Organisation for Animal Health
OPEC	Organization of the Petroleum Exporting Countries
PAAF	Public Authority for Agriculture and Fish Resources
PICES	North Pacific Marine Science Organization
PL	Postlarvae
PNRC	*Programme national de recherche crevettière* (National Shrimp Research Programme, Madagascar)
QDPI	Queensland Department of Primary Industries and Fisheries
SAGARPA	*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación* (Mexican Agriculture, Livestock, Rural Development, Fisheries and Food Secretariat)
SEAFDEC	Southeast Asian Fisheries Development Center

SEMARNAT	*Secretaría del Medio Ambiente y Recursos Naturales* (Environment and Natural Resources and Fisheries Secretariat)
SFR	Statutory fishing right
SMC BRD	Square-mesh codend bycatch reduction device
SSA	Southern Shrimp Alliance
TAC	Total allowable catch
TED	Turtle excluder device
TPWD	Texas Parks and Wildlife Department
TSV	Taura syndrome virus
UNEP	United Nations Environment Programme
USCG	United States Coast Guard
VAT	Value-added tax
VMS	Vessel monitoring system
WASI	Wild American Shrimp
WECAFC	Western Central Atlantic Fishery Commission
WWF	World Wide Fund for Nature

Executive summary

As the debate over the economic and social costs and benefits associated with shrimp fisheries increases in intensity, FAO has recognized that it has an important role in the discussion process. Although this role could take several forms, it is likely that at this point, FAO's most appropriate contribution would be a description of situations, problems and issues, as well as solutions and trade-offs that have been made.

It is simply not possible in a short study to examine shrimp fisheries in all countries where they are located. Accordingly, the present study of shrimp fisheries examines important aspects of shrimp fisheries in ten countries. These countries represent the various geographic regions as well as the variety of important shrimp fishing conditions: large/ small fisheries, tropical/temperate zones, developed/developing countries and good/ poor management. The ten countries selected for the study are Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago, and the United States of America.

Sixteen topics were identified for close examination: the history and development of shrimp fishing; the structure of shrimp fisheries; the target species of shrimp fishing and fisheries catch and effort; the economic contribution of shrimp fishing; trade aspects; bycatch issues; the profitability of shrimp fishing; energy input aspects; biological aspects; impacts on the physical environment; impacts of shrimp fishing on small-scale fisheries; management; enforcement; research; data reporting; and the impacts of shrimp farming on shrimp fishing.

TRAWL GEAR

A major characteristic of most large-scale shrimp fishing is the use of trawl gear. Although the number of shrimp trawlers in the world is not known, it was estimated that in the late 1990s there were about 140 000 trawlers of all types in the world's fisheries. There has been considerable interest in developing an alternative to shrimp trawling. Nevertheless, no substantial progress has been made in replacing trawl gear and, after nearly a century, it remains the main producer of important commercial shrimp species. Because of the lack of promising, industrial-scale alternatives to shrimp trawling, most shrimp gear technology efforts in recent decades have been channelled into improving trawl gear and techniques, rather than developing new industrial shrimp fishing technologies.

SHRIMP SPECIES

Slightly less than 300 species of shrimp are of economic interest worldwide; of these, only about 100 comprise the principal share of the annual world catch. Six shrimp species groups account for 83 percent of the global shrimp catch. The most important single species in the world by weight is the akiami paste shrimp (*Acetes japonicus*).

PENAEIDS, CARIDEANS AND SERGESTIDS

Unlike most previous global reviews of shrimp fisheries, the present study attempts to cover the fisheries for the three major groups of shrimp: penaeids, carideans and sergestids. One of the reasons for this approach is that many of the controversial topics associated with shrimp fishing transcend the boundaries between the three groups. It should be recognized, however, that there are major differences among the penaeids, carideans and sergestids that should be borne in mind when considering the results of this study.

SHRIMP CATCHES

The recent world catch of shrimp is about 3.4 million tonnes per year. Asia is the most important area for shrimp fishing; China, together with four other Asian countries, accounts

for 55 percent of the world catch. Globally, about 60 percent of shrimp production in the world comes from fishing, while 40 percent is from farming.

BYCATCH

Shrimp fishing, especially trawling in tropical regions, produces large amounts of bycatch, which is one of the most controversial aspects of the fishing; much of the management attention associated with shrimp fisheries is focused on reducing bycatch. The term "bycatch" is relatively clear in industrial shrimp fisheries of developed countries, but becomes increasingly irrelevant in the progression from large-scale fisheries in the developed world to small-scale fisheries in poor tropical countries – where almost all components of the catch have some economic value and may therefore become a target.

WHY WORRY ABOUT BYCATCH?

Bycatch, particularly when discarded, is a serious concern for a number of interconnected reasons that are not specific to shrimp fishing. First, the lack of identification of the animals killed and rejected (many of which are vulnerable or threatened emblematic species), impedes a proper assessment of their status and trends and any direct management, which raises the risk of depletion or outright extinction. Second, bycatch creates interactions with other fisheries targeting the same species, complicating assessment and management. Third, bycatch, like directed catch, affects the overall structure of trophic webs and living habitats. Finally, the discarding of killed animals raises the ethical issue of wastage of natural production.

DIFFICULTIES IN ESTIMATING THE AMOUNT OF BYCATCH

There are widely differing estimates for the amount of bycatch in the various shrimp fisheries, partly resulting from the different definitions of bycatch, different systems of measurement and the low level of actual monitoring. Even in relatively regulated fisheries in developed countries, it is not simple to estimate and subsequently compare levels of bycatch in a straightforward manner.

TOTAL GLOBAL CATCH BY SHRIMP FISHERIES

Developing a reliable estimate of the total global catch of all species (shrimp and non-shrimp) from every shrimp fishery is beyond the scope of this report. Relatively few regions have reliable data on total species captured (shrimp, finfish and other marine invertebrates). In addition, spatial and temporal variations of species associated with shrimp habitats and differences in fishing operations prevent even a rough approximation of the total global catch of shrimp fisheries.

THE FAO DISCARDS STUDY

Bycatch that is discarded is especially troublesome. A recent FAO study (Kelleher, 2005) indicated that shrimp trawl fisheries are the single greatest source of discards, accounting for 27.3 percent (1.86 million tonnes) of estimated total discards. The aggregate or weighted discard rate for all shrimp trawl fisheries is 62.3 percent and is extremely high compared with other fisheries.

BYCATCH OF JUVENILES OF COMMERCIAL FISH SPECIES

A fundamental bycatch issue in both warm- and cold-water shrimp trawl fisheries is the catch of juveniles of important commercial fish species. This is significant in several fisheries, including: the bycatch of cod off Norway; rockfish off Oregon; red snapper and Atlantic croaker in the Gulf of Mexico; king mackerel, Spanish mackerel and weakfish off the southeast United States; and plaice, whiting, cod and sole in the southern North Sea.

BYCATCH OF SEA TURTLES

The bycatch of sea turtles by warm-water shrimp trawling is a contentious issue. The subject has generated considerable publicity and subsequent management action has had a major effect on most of the large shrimp fisheries in the tropics. The means to reduce turtle mortality are well known, but they come with a price.

BIOLOGICAL RESEARCH ON SHRIMP BYCATCH

Biological research on shrimp bycatch has consisted of determining bycatch quantities, species composition and impacts on the bycatch species and on the ecosystem. Shrimp bycatch studies appear to be most advanced in Australia. Two Australian studies are especially relevant and provide an indication of what has been achieved in shrimp bycatch research. Important areas for future research are: recovering seabed fauna after depletion; examining ways to assess the sustainability of the harvest of bycatch species; and measuring the recruitment, growth, mortality and reproduction of vertically dominant large seabed organisms.

BYCATCH MANAGEMENT

A variety of measures has been used to reduce bycatch in the various shrimp fisheries. These include: a complete ban on trawling; bans on fishing in areas and/or periods when bycatch is known to be high; reduction of overall fishing effort; and, most commonly, modifications to fishing gear, mainly through the use of bycatch reduction devices (BRDs) and other modifications to the trawl net. Other measures used to reduce bycatch are catch quotas, discard bans and limits in the shrimp-to-bycatch ratio. Measures to make better use of bycatch are also considered to be part of shrimp bycatch management; several large shrimp bycatch initiatives are at least partially based on the concept of bycatch enhancement. Included in bycatch enhancement are improvements in bycatch handling and marketing, as well as product development.

LESSONS LEARNED IN BYCATCH MANAGEMENT

Several authors comment on the lessons learned from successful efforts to manage bycatch, including: the setting of targets/requirements and allowing innovation; the importance of follow-up evaluation; the importance of bycatch management plans; the role of fisheries extension; and avoidance of having to "reinvent the wheel".

BYCATCH CHALLENGES

There have been some remarkable reductions in shrimp bycatch from large- and medium-scale shrimp fisheries. The situation appears manageable, and it is likely that further reductions in bycatch levels could be made, albeit with some sacrifices by fishers. One of the main challenges is to determine the acceptable levels of bycatch, taking into consideration the costs and benefits of reaching these levels. The objective of reducing bycatch in many small-scale shrimp fisheries of developing countries is challenging and perhaps even unattainable. Economic incentives do not favour bycatch reduction, and enforcement of any requirements for bycatch reduction can be extremely difficult.

ECONOMIC BENEFITS OF SHRIMP FISHING

Information on simplistic indicators of benefits from shrimp fishing is presented for ten representative shrimp fishing countries: contribution to gross domestic product (GDP), shrimp consumption, employment, gross value of the catch and value of exports. Comments are made on the availability and reliability of the indicator data. Information on resource rent appears to be important, but has been estimated for only a few of the world's shrimp fisheries.

TRADE

World production of shrimp, both captured and farmed, is around 6 million tonnes, about 60 percent of which enters the world market. Shrimp is now the most important internationally traded fishery commodity in terms of value. Annual exports of shrimp are currently worth more than US$10 billion, or 16 percent of all fishery exports. Although over 100 countries export substantial quantities of shrimp, the international shrimp markets are concentrated in just three areas: the United States, Japan and Europe. Three current issues affecting the shrimp trade are especially important: the United States trade measures relating to turtle conservation, United States anti-dumping tariffs and ecocertification of shrimp fisheries.

FUEL ISSUES

The three most important fuel issues for shrimp fisheries are the relatively large amount of fuel expended for the amount of food obtained, the impact of rising fuel prices on the economics of shrimp fishing, and the use of fuel subsidies. Fuel use by shrimp trawling is large compared with other fisheries, but other types of shrimp fishing such as stow nets are much more energy-efficient. A wide range of measures have been taken to reduce the impacts of fuel price increases on shrimp fishing. These can be placed in two general categories: measures that reduce fuel use and those that increase profitability to compensate for fuel cost increases. A recent study showed that, of the 34 largest shrimp-producing nations, 19 countries had fuel subsidies and seven had no subsidies; there was no information for the remaining eight countries.

PROFITABILITY

In examining shrimp fishing in ten countries, one of the main features to emerge is the current low profitability of many commercial shrimp fishing operations. The typical situation consists of rising costs (mainly fuel) and falling revenue from shrimp sales (resulting to a large degree from competition with lower-cost farmed shrimp) in an environment where there is overcapacity. A number of measures to improve the current situation of poor profitability have been implemented or recommended. The most important measures are: increased attention to fuel costs, fleet reduction, market promotion, subsidies and import barriers. The boldest move to improve the profitability of domestic shrimp fishing in recent years has been the initiative in the United States to restrict the import of farmed shrimp on the basis that it has been dumped on the market.

RESOURCE RENT

Resource rent can be defined as the difference between the revenue from a fishery resource and the costs of exploiting it, including capital costs. In a broader sense, if non-monetary costs and benefits are taken into account, rent can be considered as the net economic return from a fishery to society. Good management regimes tend to increase rent; others, especially open access, can dissipate it. Unfortunately, information on the amount of resource rent available appears to have been estimated for only a few of the world's shrimp fisheries.

STOCK ASSESSMENT

Stock assessment in the shrimp fisheries of the world ranges from simple trends in catch per unit effort (CPUE) to extremely complex stock assessment and simulation models. Assuming that surreptitious increases in capacity are understood and accounted for, CPUE trends have the advantage that they are simple, easy for developing country managers to use and readily understood by fishers and the general public. The more sophisticated models are able to integrate many different types of information on shrimp resources, to give potential yields from a fishery and to be used for projections. Despite the limitations of using CPUE to gauge the conditions of shrimp resources, the reality is that many, if not most, shrimp fisheries in developing tropical countries are heavily dependent on CPUE trends for their management and are likely to continue to be so in the foreseeable future.

PHYSICAL IMPACTS OF SHRIMP FISHING

The effects of shrimp fishing on benthic habitats can be divided into several categories: alteration of physical structure; sediment suspension; changes in chemistry; and changes to the benthic community, resulting in changes to the ecosystem. The degree to which shrimp fishing, specifically trawling, alters the seabed and the associated effects on biodiversity have generated an enormous amount of discussion and controversy, echoing and contributing to the more general and controversial debate on trawling. The factors complicating this debate include: the difficulty in clearly separating fishing impacts from environmental variability; lack of information on the original state of some fishing grounds; a lack of agreement on the level and quality of the evidence of impacts; doubts about the reversibility of these impacts; the objective difficulty in assessing the more insidious impact of the overall flattening of the ground and the less visible impacts on the benthic and microbial fauna; and the relative importance attached to the ecological, social, economic and societal costs and benefits of fishing.

IMPACTS OF SHRIMP FISHING ON SMALL-SCALE FISHERIES

Large-scale shrimp fishing interacts in several ways with small-scale fisheries, including: physical interactions; safety at sea; targeting the same resources; interaction through bycatch; habitat disturbance; and market interactions. To reduce the physical impacts of large-scale shrimp fishing on small-scale operations, the most common measure is simply to move the large boats offshore. There is a general feeling among fisheries managers in several regions of the world that the various approaches to reduce negative interactions would be effective if only they were enforced. The irony is that, in developing countries where the conflicts generated by shrimp fishing are the greatest, the required governance and enforcement are the weakest, either because of a lack of capacity in monitoring, control and surveillance, or because the social costs of the measures, if enforced, are perceived as dangerously high.

OBJECTIVES OF SHRIMP FISHERY MANAGEMENT

Management objectives are not always clearly stated and are rarely prioritized. The long-term conservation of the resource is an important management objective in most shrimp fishery management schemes. Maximum economic yield is a further important objective in the management of many shrimp fisheries in developed countries. Maximum sustainable yield (MSY) is also common, with Indonesia as a good example. The reduction of bycatch/discards and physical impacts is becoming increasingly important, especially in developed countries. In addition, conflict reduction plays a significant role as a management objective in shrimp fisheries, especially in developing countries. Achieving an equitable allocation of shrimp resources among the various users is important in the penaeid fisheries because of the movement of shrimp between shallow inshore and deep offshore areas. Maximizing employment is sometimes de facto the most important management objective in some of the poorer countries. Generation of government revenue through licence fees is often an unstated objective in the management of shrimp fisheries in countries ranging in development from Cambodia to the United States.

PRIORITIZING OBJECTIVES

It is difficult to prioritize the incongruous and conflicting objectives that are often set for shrimp fisheries. On a practical level, one situation is especially common – attempting to maximize economic yield in an open access regime. An important objective of open access shrimp fisheries, probably more common in the world than restricted access, is often to maximize employment. This is, however, incompatible with the economic efficiency needed to generate maximum economic yield.

DIFFICULTY IN MANAGING SHRIMP FISHERIES

Compared with other fisheries, warm-water shrimp fishery management is relatively easy as a result of several factors: growth and mortality have been determined for many of the important species; shrimp is highly fecund; and abundance is largely climate-driven. Furthermore, because most warm-water shrimp fisheries utilize more than one shrimp species, it is unlikely that bad year classes will occur in all species in one year. Because of the short life cycle, overfishing is immediately apparent, and if management mistakes are made, they can often be rectified in one year. Specific difficulties are encountered, however, in sequential fisheries (where artisanal fishers take immature shrimp, impacting directly on the recruitment to industrial fisheries), and through strong multispecies interactions with all coastal fisheries.

MANAGEMENT MEASURES

There are a variety of measures available to shrimp fisheries managers. Some of the main management issues and associated interventions are the following.

- Economic overfishing in shrimp fisheries has been addressed by catch limits, limiting/reducing participation, restrictions on gear, stock enhancement, monetary measures and subsidies.
- Growth overfishing has been dealt with by closed seasons, closed areas, mesh sizes and minimum shrimp landing sizes.
- Discards/bycatch have been addressed by BRDs, turtle excluder devices (TEDs) , mesh sizes, other net modifications, gear restrictions, no discards policies, closed areas, limits on bycatch of particular species, unilateral trade measures and awareness raising of fishers.
- Physical impacts and ecosystem damage have been dealt with by gear restrictions, closed areas and fishing effort reductions. Total bans on trawling have been proposed.
- Conflicts with small-scale fishers have been addressed by zonation, BRDs, reduction of large-scale fishing effort, time-sharing of fishing grounds and total bans on trawling.
- Resource allocation between groups of fishers has been dealt with by closed areas, closed seasons, gear restrictions and mesh sizes.
- Habitat degradation of the inshore nursery ground has been addressed by controls on coastal zone development and land reclamation, restricting pollution, and watershed management.

MANAGEMENT IN OPEN ACCESS REGIMES

A fundamental problem for many of the world's shrimp fisheries is open access – i.e. the right for the public to participate in a fishery. In general, if there are no barriers to entry, fisheries typically end up producing at the point where total revenue equals total costs or even beyond, when subsidies are provided. The history of shrimp fishery management shows that management interventions that do not control access and/or removals (e.g. catch limits, closed seasons) are usually ineffective at preventing economic overfishing in the long term.

ELEMENTS OF EFFECTIVE FISHERIES MANAGEMENT LEGISLATION

In countries with effectively managed shrimp fisheries, legislation often requires or encourages certain positive features. These include fisheries management plans; bycatch management plans; collaboration among the various stakeholders; provisions for keeping management interventions at arms' length from the political process; ecosystem-based management; and the flexibility to intervene quickly, as a result of research findings or changing fishery conditions. Many of these features are important for fisheries management in general and not strictly specific to shrimp fishery management.

ENFORCEMENT COMPLEXITY

In general, the management of shrimp fisheries is associated with a more complex enforcement environment than most other fisheries, although there is a large range of national conditions. The complicating factors for shrimp fisheries include:

- the use of numerous types of management measures, many of which require enforcement activities at sea;
- large incentives to circumvent restrictions on inshore trawling;
- the fact that many restrictions are counter to the short-term economic interests of fishers;
- some management measures that infuriate fishers;
- the huge problems of enforcing requirements in small-scale shrimp fisheries.

ENFORCEMENT ISSUES

Some important enforcement issues that emerged are the following.

- Poor enforcement appears to stem from insufficient operational budgets, inadequate enforcement infrastructure, weak institutions, political considerations affecting enforcement priorities, and corruption.
- In many cases where there is efficient enforcement, the fishing industry itself has at least some enforcement responsibilities.
- If penalties for non-compliance are harsh enough, then the actual detection efforts do not need to be so great.
- A reasonable degree of compliance with some of the technical measures (mesh sizes, BRDs) requires at least some onboard observer coverage.
- Enforcement of regulations in small-scale shrimp fisheries is often considered too difficult.
- Not all cases of good enforcement of shrimp fisheries management requirements occur in wealthy, developed nations. The importance of a fishery to the national economy and effective national institutions appear at least as important as national wealth.

RESEARCH ON SHRIMP FISHERIES

Much of the past research associated with shrimp fisheries has involved biological research on shrimp in support of stock assessment. Overall, this has been successful – researchers have made considerable progress in gaining an understanding of the life histories and other aspects of the biology of the most important species of shrimp. Currently, much of the shrimp research in the various shrimp fisheries around the world can be placed into several categories:

- ongoing monitoring and stock assessment of fisheries;
- interdisciplinary research involving biology, sociology and economics, addressing issues such as reduction of conflicts and improvement of economic efficiency, e.g. by developing bioeconomic models and determining optimal exploitation strategies;
- gear technology, especially for reducing bycatch and impacts on the benthic environment;
- topics of special concern – impacts on non-target species and effects of trawling on the sea bottom.

MAJOR RESEARCH ISSUES

Several issues related to research that emerged in the study include:

- the identification of shrimp stock assessment models that are appropriate for use in many developing tropical countries – a persistent issue;
- the degree to which the research agenda should be driven by the information required to intervene effectively and achieve important management objectives;
- the need for greater involvement of socio-economic research in small-scale shrimp fisheries, particularly for the development of integrated assessments.

IMPACTS OF SHRIMP FARMING ON SHRIMP FISHING

The main effects of shrimp farming on shrimp fishing are:

- economic impacts in the marketplace;
- the destruction of mangrove forests for shrimp aquaculture operations;
- the capture of shrimp postlarvae and broodstock for farming;
- escapes of cultured shrimp into the wild;
- the "trash fish" issue.

Overall, shrimp farming has had a substantial impact on shrimp fishing activities, from the fishery level to the international level. Interaction in the marketplace seems to have the most effect, at least during the present period of low profitability. The total impact of shrimp farming cannot be quantified, but the net result has been lower prices.

IS SHRIMP FISHING MANAGEABLE?

Single-species tools and models are available for the management of shrimp fishing. This does not mean that shrimp fishery management practices are problem-free. In many countries, weak agencies dealing with fisheries, lack of political will and an inadequate legal foundation cause failures in management. These factors, which can be encountered in all fisheries across the world, are largely responsible for the lack of success, rather than any inherent unmanageable qualities of shrimp fishing gear or practices. This suggests that efforts to improve shrimp fishery management in these countries should pay more attention to such factors as agency effectiveness, awareness raising and the provision of adequate legislation to support rights-based and dedicated access systems, among others.

The findings of this study suggest that shrimp fishing, including trawling, is indeed an activity that can be managed to attain objectives, even though the management of many small-scale shrimp fisheries in developing countries presents an extremely difficult challenge.

SMALL-SCALE SHRIMP FISHERIES IN DEVELOPING COUNTRIES

Opinions on how best to deal with the challenges of small-scale shrimp fisheries and improve their management seem to fall into three categories: a *laissez-faire* approach – i.e. recognizing difficult realities, yet giving low or no priority to the management of these fisheries; a strategy to favour management measures that are to some degree easy to enforce, such as marine-protected areas or total bans; and a comanagement approach, in which communities and government are jointly involved in the management process.

Despite the differences in dealing with the complexities of small-scale shrimp fisheries, many shrimp specialists agree that much more attention should be focused on what is desirable, possible and practical in the management of these fisheries.

BENEFITS AND COSTS OF SHRIMP FISHING

In the process of managing shrimp fisheries, some mechanism for balancing the benefits of fishing with the various costs incurred is required. Considering the scarcity and limitations of the data on both shrimp fishing benefits and costs, it seems as if there is not enough information on benefits in most countries to determine whether costs incurred are justified, at least not in a quantitative sense. Although it is recognized that it is extremely difficult to compare benefits and costs for most shrimp fisheries, in effect, they are being compared and trade-offs are being made in the fisheries management process. The subsequent controversy appears to stem partially from a lack of stakeholder consensus on the mechanisms for making trade-offs and on the adequacy of the information used.

AUSTRALIA

The experiences acquired and lessons learned from Australia's large investment in shrimp fishing research and management could be used as a guide, saving fishery managers in other countries much time and expenditure from having to "reinvent the wheel".

RECOMMENDATIONS

Since this has been the first attempt in several decades to review the world's shrimp fisheries, some effort has been made to provide specific recommendations in selected key areas such as the management of small-scale shrimp fisheries, capacity reduction, open access and multispecies issues – in the perspective of the FAO Code of Conduct for Responsible Fisheries and the precautionary and ecosystem approaches.

Introduction

Shrimp resources are highly diversified and support a large range of fisheries. Shrimp fishing takes place in equatorial, subpolar and most intermediate ocean regions. Much of the global catch of shrimp is taken by large industrial fishing operations, but some of the largest shrimp fisheries are based on small-scale fishing, including non-motorized operations. The top ten shrimp-producing nations include both some of the richest and poorest nations in the world. The management of some shrimp fisheries is carried out effectively and illustrates the potential benefits of conventional fisheries management as well as its limits. However, other important national shrimp fisheries are textbook examples of how unmanaged fisheries can dissipate benefits.

Shrimp fishing is exceptional in the amount of controversy it generates. A recent FAO study (Kelleher, 2005) showed that tropical shrimp trawl fisheries generally have high discard rates and account for over 27 percent of total estimated discards in all the marine fisheries of the world, amounting to some 1.8 million tonnes per year. Trawling, including shrimp trawling, has been compared to forest clear-cutting and accused of being the world's most wasteful fishing practice. Garcia (1989) states that shrimp fisheries are the major source of fisheries conflict and problems in the tropical zone.

In spite of the above, it is difficult to deny that shrimp fisheries are vital and produce substantial benefits. About 3.4 million tonnes of wild shrimp are currently caught annually and shrimp is now the most important internationally traded fishery commodity – in recent years, about 18 percent of the total value of all this trade. In many tropical developing countries, shrimp is the most valuable fishery export. The employment aspect is also significant. Several years ago when Indonesia, for example, banned shrimp trawling in its waters, an estimated 25 000 people lost their jobs.

Shrimp fishing is associated with numerous benefits but also with various high costs. A review of the recent shrimp fisheries literature suggests that many of the discussions on the costs and benefits of shrimp fishing have been to some extent polarized to support a particular point of view and there is no comprehensive perspective.

This report summarizes the results of a global study on the development and current status of shrimp fisheries, with a focus on direct and indirect social, economic and environmental impacts.

Development of the study

METHODOLOGY

In mid-2005, FAO recruited the author to undertake a global review of shrimp fisheries and associated issues. One of his first tasks was to identify and articulate the most suitable approach for a study of shrimp fishing on a global basis. Discussions at FAO, together with a preliminary literature review and some in-country work, led to several conclusions concerning the study's methodology and scope. Because of the limited time and means available, it was decided to base the review on a sample of ten countries, representing various geographic regions, as well as a variety of important shrimp fishery conditions: large/small fisheries, tropical/temperate zones, developed/developing countries and good/poor management. The ten countries selected for the study were: Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago and the United States of America (Figure1).

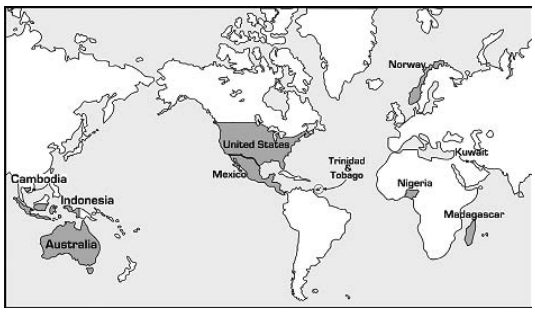
Numerous topics related to shrimp fisheries were studied in each of the ten countries. Specifically, the following 15 topics were identified for close examination.

1. History, development and structure of shrimp fisheries: types of fishing, numbers of vessels, ownership of vessels.
2. Target species of shrimp fishing; catch and effort of fisheries for these species.
3. Economic contribution of shrimp fishing in terms of employment, nutrition and contribution to gross domestic product (GDP).
4. Trade aspects, including amount and value of exports of shrimp from the various fisheries.
5. Bycatch issues associated with shrimp fishing.
6. Profitability of shrimp fishing and information on resource rent.
7. Energy input aspects.
8. Biological aspects.
9. Impacts of shrimp fishing on the physical environment.
10. Impacts of shrimp fishing on small-scale fisheries.
11. Types of management of shrimp fisheries.
12. Enforcement of management measures.
13. Research on shrimp fisheries.
14. Data reporting.
15. Impacts of shrimp farming on shrimp fishing activities.

A key element of the methodology of the study is that the results of the ten country reviews (Part 2 of this report), with respect to these 15 topics, are combined with specialized studies on these topics to produce the major findings of the overall report. Finally, some recommendations are made, using the FAO Code of Conduct for Responsible Fisheries as a guide.

This report was initially reviewed internally by the FAO Fisheries and Aquaculture Department and then externally by several shrimp fishery specialists. Serge M. Garcia conducted a final review of the document.

FIGURE 1
The ten study countries



Certain limitations of the study should be acknowledged. It relies to some degree on national fisheries statistics or a form of these statistics given to FAO. In several countries the quality of the statistics is questionable and, in some cases, could be described as indicative at best. Nevertheless, these statistics are the best available and are consequently used in this report out of necessity. It will also be noted that several important shrimp fishing countries are not included in the study. Their exclusion, however, allows inclusion of some countries that may be more representative of global or regional conditions. China is an extreme case – many more months of work would be necessary for the country to be covered adequately. Additional limitations of the study are the following.

- Several national consultants assisted in the work. In some respects, the degree of coverage and the perspectives on the various shrimp fishing topics may have been affected by the backgrounds of these consultants. Efforts were made to "triangulate" some of the key findings, but some bias is likely to remain.
- In some countries, significant documentation related to shrimp fishing is readily available in an international language while, in others, this is not the case. Consequently, the detail of reporting in some of the developing countries included in the study may have been affected.
- Because there are significant interlinked issues in shrimp fisheries, a degree of repetition is inevitable, in order to ensure that each chapter may be read and understood independently of the full report.

OTHER CONSIDERATIONS

Most previous global reviews of shrimp fisheries have focused on a subset of the world's fisheries, usually for penaeid shrimp (Gulland and Rothschild, 1984; Garcia, 1989). There is ample justification for this approach – the three major shrimp groups (penaeids, carideans and sergestids; see Chapter 3, Catches by shrimp species) differ greatly with respect to their biology, the fisheries that catch them, and other factors. Nevertheless, the present study attempts to cover the fisheries for all three groups because many of the controversial topics associated with shrimp fishing transcend the boundaries between the groups. By examining all major types of shrimp fisheries, it is possible to gain greater insight into these sensitive issues. Other justifications for the study being so inclusive are set out below.

- Developments in important aspects of the fisheries for one type of shrimp have often affected other aspects, inter alia, net designs, bycatch reduction devices (BRDs) and enforcement.
- Many of the management issues and the manner in which they have been addressed have common elements across the major groups.
- The available statistics on shrimp harvests in the world are often not disaggregated in sufficient detail to determine the specific contribution from each of the three major groups of shrimp. A quarter of the global shrimp catch in FAO statistics is dedicated to "Natantian decapods" (i.e. shrimp) alone.

It should be recognized, however, that there are major differences between the penaeid, caridean and sergestid fisheries, which should be borne in mind when considering the results of this study.

In order to avoid dispersion, the focus is on marine shrimp fisheries. Shrimp farming is only considered to the extent that it interacts with shrimp fishing. Freshwater shrimp fishing is not included, nor are activities associated with brine shrimp (Artemia).

Some nomenclature also requires clarification. The relationship between "shrimp" and "prawn" causes considerable confusion (Box 1). For simplicity, this report uses "shrimp" as the more inclusive term, to cover prawns as well. The terms "discards", "bycatch" and "fishery" follow the convention of Kelleher (2005).

BOX 1
Shrimp or prawn?

Two authorities on shrimp taxonomy comment on the shrimp/prawn debate.

- Because of confusion in the use of the terms "shrimp" and "prawn", it seems useful to draw some attention to the problem. It is impossible to give a short definition of either name, since in different regions of the world these terms are used for different animal groups and even within a single region usage is not consistent. Both terms originated in the United Kingdom, where "shrimp" is used for members of the family Crangonidae, while "prawn" is used for species of Palaemonidae. However, Crustacea, which do not belong to these two families, are also often termed "shrimp" and "prawn", which is where the difficulty begins (Holthuis, 1980).
- Chan (1998) indicates that the terms "shrimp" and "prawn" have no definite reference to any known taxonomic group. Although "shrimp" is sometimes applied to smaller species, while "prawn" is more often used for larger ones, there is no clear distinction between them and their usage is often confused or even inverted in different countries or regions.

Some references use the cumbersome term "shrimps and prawns" throughout the text but, for simplicity, this report uses "shrimp" except in the case of specific names (e.g. Australia's Northern Prawn Fishery, Kuruma prawn).

- Discards, or discarded catch, are those portions of the total organic material of animal origin in the catch that are thrown away or dumped at sea, for whatever reason.
- Discard rate is the percentage of total catch that is discarded.
- Bycatch is the total catch of non-target animals. Discards are not a subset of bycatch since the target species is often discarded.
- A fishery is defined as a combination of a fishing area plus a fishing gear plus a target species (or group of species). The term "fishery" is considered to be equivalent to the French term métier.

In some countries, because of restrictions on trawling, this fishing technique sometimes assumes other names. In the present report, the definition of "trawl" is that of Nedelec and Prado (1990): a towed net consisting of a cone-shaped body, closed by a bag or codend and extended at the opening by wings. Unless otherwise specified, "trawling" here refers to bottom trawling.

Terms for the various scales of fishing are as defined by FAO (2005f).

- Industrial fisheries. Capital-intensive fisheries using relatively large vessels with a high degree of mechanization, and that generally have advanced fish finding and navigational equipment. Such fisheries have a high production capacity and the catch per unit effort (CPUE) is normally relatively high.
- Small-scale fisheries. Labour-intensive fisheries using relatively small craft (if any), and little capital and equipment per person on board. These are mostly family-owned. They may be commercial or for subsistence, are usually low in fuel consumption, and are often equated with artisanal fisheries.