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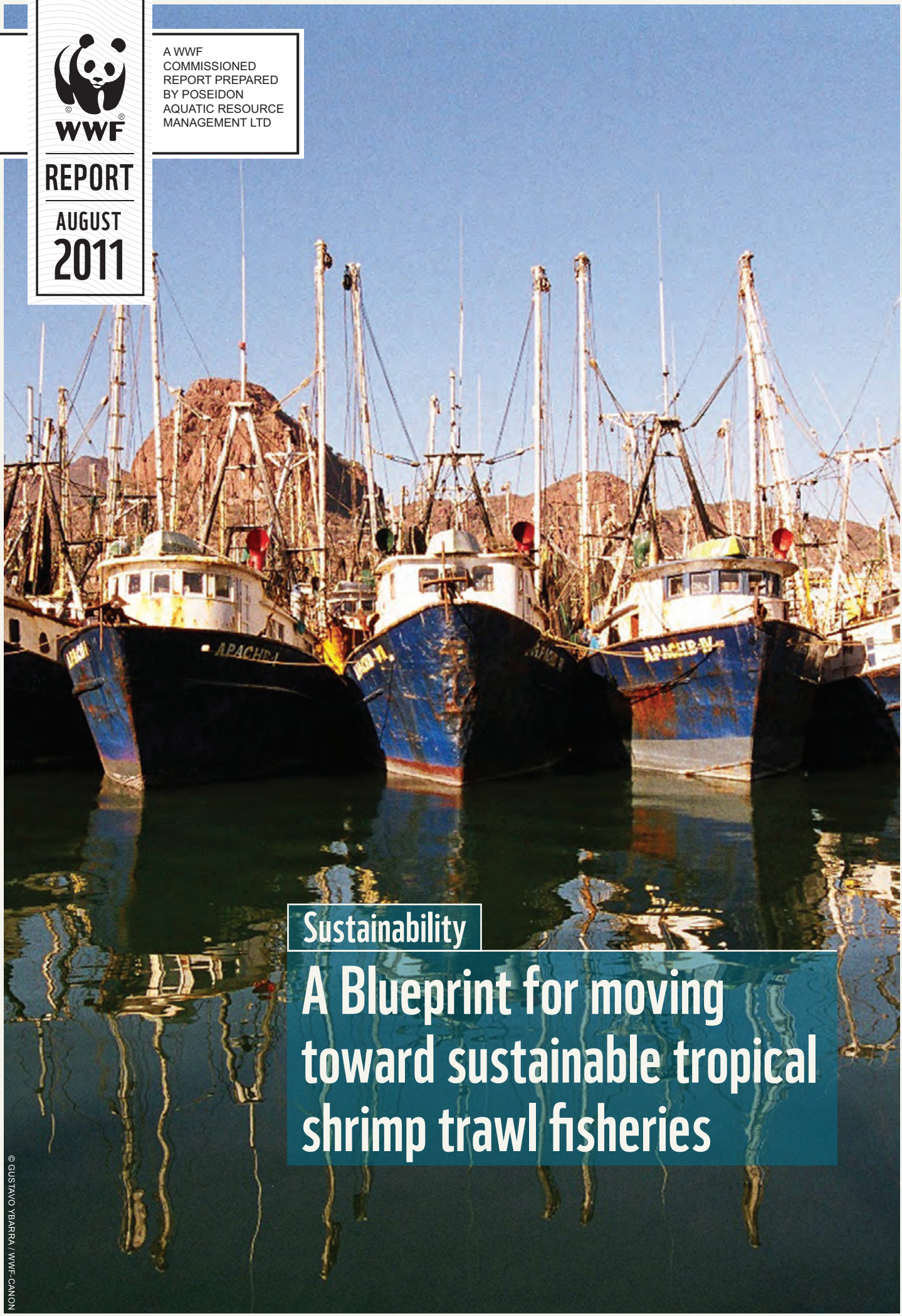

Sustainability

A Blueprint for moving toward sustainable tropical shrimp trawl fisheries

- Foreword -

Whilst there is widespread agreement that bottom trawling for tropical shrimp presents an urgent conservation problem, the complexity of these fisheries, both environmental and socio/economic, has often thwarted effective conservation efforts.

The purpose of this WWF–commissioned report is to address this complexity by providing a set of management guidelines that, if adopted, will serve as the foundational measures from which lasting sustainability can later be achieved.

The management guidelines presented here should not therefore be viewed as a definitive WWF vision of what should constitute sustainability in tropical shrimp trawl fisheries, nor should full adoption of these guidelines necessarily mean a fishery will be sustainable. For this, there are many areas that need to be fully addressed, such as issues of habitat protection, habitat restoration and strengthening protection to endangered, threatened and protected species, for example.

However, it is WWF's hope that these generic guidelines, when regionally applied, will provide an important pathway to help tropical shrimp trawl fisheries adopt better management practices that will eventually allow them to operate in a fully sustainable manner.

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Leader, WWF Smart Fishing Initiative

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Abstract

This report provides a global review of tropical shrimp trawl fisheries, focusing on the fleets involved, catch and stock trends, governance and management arrangements, and the positive and economic drivers of current performance. It examines the many problems in such fisheries with regards to environmental, economic, and social sustainability, and uses case study information to highlight both good and bad practice. This case study information is then used to benchmark tropical shrimp trawl fisheries against the Marine Stewardship Council standards, and a blueprint for sustainable tropical shrimp trawl fisheries is presented which is underpinned by the key lessons learned.

ACRONYMS & GLOSSARY

ABARE	Australian Bureau of Agricultural and Resource Economics
AFMA	Australian Fisheries Management Authority
B_0	Unexploited Biomass
BAP	Bycatch Action Plan
BED	Bycatch Exclusion Device
B_{Lim}	Biomass Limit
B_{MSY}	Biomass exploited at Maximum Sustainable Levels
BRD	Bycatch Reduction Device
BRPL	Research Institute for Marine Fisheries (Indonesia)
BRS	Bureau of Rural Sciences (Australia)
CANAINPESCA	Cámara Nacional de la Industria Pesquera y Acuícola (National Fisheries and Aquaculture Industry Chamber, Mexico)
CARICOM	Caribbean Community and Common Market
CIFT	Central Institute of Fisheries Technology (India)
CIMFR	Central Institute of Marine Fisheries Research (India)
CNCP	Confederación Nacional de Cooperativas Pesqueras (National Confederation of Fishing Cooperatives, Mexico)
CONANP	Comisión Nacional de Áreas Naturales Protegidas (Mexico)
CONAPESCA	Comisión Nacional de Acuacultura y Pesca (National Commission of Aquaculture and Fishery, Mexico)
CPUE	Catch Per Unit of Effort
CRFM	Caribbean Regional Fishery Mechanism
CRPMEM	French Guiana Regional Fisheries Committee
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CSP	Centre de Surveillance des Pêches (Centre of Fisheries Surveillance, Madagascar)
DARD	Department of Agriculture and Rural Development (Vietnam)
DEWHA	Department of the Environment, Water, Heritage and the Arts (Australia)
DKP	Dinas Perikanan Provinsi (Provincial Fishery Department, Indonesia)
DNAP	National Directorate of Fisheries Administration of the Ministry of Fisheries (Mozambique)
EAFM	Ecosystem Approach to Fisheries Management
EBCD	Environment Protection and Biodiversity Conservation Act 1999
EC	European Commission
EDF	Environmental Defence Fund
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPBC	Environmental Protection and Biodiversity Conservation Act 1999 (Australia)
ETP	Endangered, Threatened, and Protected

EU	European Union
$F_{0.1}$	The fishing mortality rate at which the marginal yield-per-recruit (i.e. the increase in yield-per-recruit in weight for an increase in one unit of fishing mortality) is only 10 per cent of the marginal yield-per-recruit on the unexploited stock.
$F_{current}$	Current fishing mortality.
FAC	Fisheries Administration Commission (Mozambique)
FAO	Food and Agriculture Organization of the United Nations
FDF	Department of Fisheries (Nigeria)
GACPM	Groupement des Aquaculteurs et Pêcheurs de Crevettes de Madagascar (Shrimp Aquaculturers and Fisher Group)
GEF	Global Environment Facility
GFEU	Gear Fishing Effort Units
GT	Gross Tonnage
HCR	Harvest Control Rule
h	Hour
hp	Horse Power
HPPI	Association of Indonesian Shrimp Catching Companies (Indonesia)
IBFM	Incentive Based Fisheries Management (Mexico)
ICES	International Council for the Exploration of the Sea
IIP	Instituto de Investigação Pesqueira (Fisheries Research Institute, Mozambique)
INP	National Fisheries Institute (Mexico)
IQ	Individual Quota
IRD	Institut de Recherche pour le Développement (Research and Development Institute; Madagascar)
IT	Information Technology
ITE	Individual Transferable Effort
ITFR	Individual Transferable Fishing Rights
ITQ	Individual Transferable Quota
IUCN	International Union for Conservation of Nature
JTED	Juvenile and Trash Excluder Device
m	Metres
M&E	Monitoring and Evaluation
MAC	Management Advisory Council
MAEP	Ministère de l'Agriculture de l'Elevage et de la Pêche (Ministry of Agriculture, Livestock, and Fisheries, Madagascar)
MAERH	Ministère de l'Agriculture de l'Elevage et des Ressources Halieutiques (Ministry of Agriculture, Growth, and Aquatic Living Resources, Madagascar)
MARD	Ministry of Agriculture and Rural Development (Vietnam)
MCS	Monitoring, Control, and Surveillance
MEY	Maximum Economic Yield

MMAF	Ministry of Marine Affairs and Fisheries (Indonesia)
MoA	Ministry of Agriculture (India)
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MPEDA	Marine Products Export Development Authority (India)
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NOAA	National Oceanic and Atmospheric Administration
n/a	Not Available
NGO	Non-Governmental Organization
NIOMR	Nigerian Institute for Oceanography and Marine Research
nm	Nautical Mile
NMFS	National Marine Fisheries Service (US)
NORAD	Norwegian Agency for Development Cooperation
NORMAC	Northern Prawn Fishery Management Advisory Committee
NPF	Northern Prawn Fishery (Australia)
NPFI	Northern Prawn Fishery Pty Ltd (Australia)
OEFC	l'Observatoire Economique de la Filière Crevettière (Economic Research Centre for the Shrimp Industry, Madagascar)
PIRSA	Department of Primary Industries and Resources, South Australia
PNG	Papua New Guinea
PNRC	Programme National de Recherche Crevettière (National Shrimp Research Programme, Madagascar)
REBYC	Reduction of Environmental Impact from Tropical Shrimp Trawling, through the Introduction of Bycatch Reduction Technologies and Change of Management (UNEP/GEF/FAO project)
rpm	Revolutions per minute
SARDI	South Australian Research and Development Institute
SEAFDEC	South East Asia Fisheries Development Centre
SFP	Sustainable Fisheries Partnership
SFR	Statutory Fishing Right
SGWCPFA	Spencer Gulf and West Coast Prawn Fishermen's Association (Australia)
t	Tonnes
TAC	Total Allowable Catch
TED	Turtle Excluder Device
TTED	Trash and Turtle Excluder Device
TST	Tropical Shrimp Trawl
UN	United Nations
UNEP	United Nations Environment Programme

UNIMA	Groupe Unima (Madagascar fishing company)
US	United States of America
VMS	Vessel Monitoring System
WWF	World Wide Fund for Nature
ZMC	Zonal Management Conserve (Zonal Management Area, Madagascar)

EXECUTIVE SUMMARY

Background to tropical shrimp fisheries and current problems

Some 1.3 million t of tropical shrimp are caught annually throughout the world. An approximate estimate[1] is that 419,000 trawlers from 65 countries catch shrimp, generating employment for around 900,000 fishers. On top of this, there are hundreds of thousands of coastal/artisanal fishers using a variety of fishing gears, including small trawls, trammel nets, bag nets, and seines. This group is responsible for catching less than 5 per cent of the total annual shrimp catch, but can have significant impacts on sustainability.

Shrimp trawling is considered one of the most unselective and damaging fishing methods in the world. Bycatch of commercial and non-commercial species may significantly outweigh catches of target species. This, along with the impacts of bottom trawls on the benthic environment, can result in significant negative impacts on marine ecosystems.

Fishing fleets have expanded at rapid rates in the last 30 years or so, with the result that the shrimp catch per unit of effort (CPUE) in most fisheries is in decline.

Fleets of different sizes and fishing methods access most tropical shrimp fisheries. This often results in conflicts between fishers from different groups. A particularly worrying sign that appears to have received little emphasis in studies to date, and which may in part be a reason for increased levels of conflict, is the growth in artisanal fisheries which often catch smaller-sized shrimp from inshore breeding and nursery areas. While much of the management attention and concern to date has been focused on the activities of larger industrial shrimp fleets, the activities of artisanal groups are having a severe impact on both shrimp stocks and the economics of offshore vessels. The focus on managing larger vessels in the absence of similar management efforts for inshore fisheries is a significant shortcoming.

In many countries, governments focus on food security and the political risks of limiting access on the one hand, and long-term environmental, economic, and social sustainability issues on the other. Short-term objectives have typically been chosen, with a reluctance to control access to the shrimp resource and to adapt management initiatives that focus on limiting bycatch. Markets have consequently developed for bycatch species, which may include food for coastal populations and, in some cases, inputs to fishmeal used as feed in the aquaculture sector. As this report shows, short-term focus is ill founded and contradicts the rationale for supporting long-term sustainability of the resource in the interests of food security and benefits to coastal communities.

Positive developments

There are a few limited examples of what can be considered well-managed tropical shrimp trawl (TST) fisheries. The most widely cited examples of best practice come from Australia, where such fisheries are managed relatively well and many best practice lessons can be drawn. TST fisheries in French Guiana are also well managed. Other examples of improved practices in TST fishery management and stakeholder interaction can also be drawn from positive initiatives in the US, Madagascar, Mexico, Suriname, and Mozambique. Positive developments in these countries focus on effort control, bycatch reduction, and in some cases the ecosystem approach to fisheries management (EAFM); however there remain significant problems and room for improvements in these fisheries. Positive developments have also been taking place with regards to the establishment of sector partnerships (e.g., between government and the private sector, between NGOs and the private sector, and between links in the supply chain) which are greatly assisting with identifying and putting into place improved practices for greater sustainability.

The purpose and methodology of this report

This report seeks to (1) identify and understand the critical problems found in tropical shrimp trawl fisheries and their causes, and (2) create, based on examples of best practice and potential solutions, a "blueprint" which can support a transition of TST fisheries to more sustainable practices.

The report follows on from a workshop convened in July 2008 by WWF in Darwin, Australia, which brought together both external experts and WWF staff to "brainstorm" sustainability issues in global TST fisheries and identify opportunities to drive these fisheries towards substantially improved management regimes.

[1] Extracted from national data provided in Appendices to this report

The present study involved an extensive review of fishery practices adopted in tropical shrimp fisheries. It was informed by work undertaken by the UN Food and Agriculture Organization (FAO), most notably Gillette (2008), and the outputs from the UNEP/GEF/FAO Reduction of Environmental Impact from Tropical Shrimp Trawling (REBYC) project. The work also draws heavily on inputs from WWF fishery officers, government officials, private sector companies, and other individuals who, through a detailed questionnaire prepared by the consultants, provided information on existing practices, management systems, and governance in 11 countries (Australia, Suriname, French Guiana, India, Indonesia, Madagascar, Mexico, Mozambique, Nigeria, the US, and Vietnam). Outputs were also elaborated through country visits to India, Indonesia, Madagascar, and Vietnam, and through a review of other available literature.

Based on the review and fishery case studies, this report provides a benchmarking of TST fisheries using the Marine Stewardship Council's sustainability assessment framework together with an extra principle. The MSC framework assesses fisheries against performance indicators for three main principles — the status of stocks; impacts on the ecosystem; and management conditions — while the extra principle includes economic and social considerations. While prepared for TST fisheries as a whole rather than for the individual fisheries reviewed as part of this study, the benchmarking exercise suggests that very few shrimp trawl fisheries would pass an MSC assessment process based on current performance, and that significant steps need to be taken across most performance indicators in many, but not all, countries.

Conclusions

In reviewing the case study fisheries around the world, this report presents a wide range of detailed information, and draws a number of conclusions:

- The Coral Triangle region accounts for 44 per cent of the total tropical shrimp catch, with Indonesia and Vietnam accounting for 60 per cent of this region's total. The Indian subcontinent accounts for 32 per cent of the total catch, with India accounting for 88 per cent of this region's total. The Americas[2] account for 16 per cent of the total catch, and West and East Africa and the Middle East account for the remaining 8 per cent.
- Industrial trawlers over 18 m in length account for a large proportion of the total catch in both Africa and the Middle East, while in the Indian subcontinent and in the Americas, semi-industrial vessels of 12–18 m dominate the catch. Total catch in the Coral Triangle region is dominated by small-scale trawlers of around 8–12 m in length.
- Very few individual countries show downward trends in overall catch, the exceptions being Senegal, Thailand, and the US. However, the CPUE in most countries shows a decline, which in some cases is very significant. These trends are a reflection of increased numbers of boats and increased numbers of trawls used.
- Very few shrimp stocks appear to be stable. Examples of stocks harvested to optimal levels include fisheries in Australia, the US, and two stocks in Mexico (Pacific and Atlantic brown shrimp). All other stocks, including most stocks in Mexico, are experiencing strong declines.
- In fisheries with open access regimes (e.g., India, Indonesia, Vietnam, Mexico, Nigeria, and Guyana) fishing effort may need to be cut by at least 50 per cent in order to restore fisheries to sustainable levels.
- The ratio of shrimp to other species in landed catch[3] weight ranges from 1:8–15 in multi-taxa fisheries (e.g., Indian subcontinent (India, Pakistan, Myanmar, and Bangladesh), Coral Triangle (Indonesia, Vietnam, Thailand, Malaysia), Venezuela, West Africa, and the Middle East), to 1:5–7.5 in fisheries with selectivity problems but with improved bycatch performance (many countries in the Americas (Colombia, Costa Rica, Cuba, Mexico (Pacific), and the US (penaeid trawlers)), to 1:1 in some well-managed fisheries and fisheries where bycatch is significantly reduced through effective introduction of selectivity devices (such as Australian fisheries and some others (e.g., Suriname (Atlantic seabob), Madagascar (seasonal)).
- TST fisheries can, in many cases, result in significant impacts on ecosystems in the form of bycatch of endangered, threatened, and protected species and trawling impacts on benthic environments.
- Governance arrangements in different fisheries include a range and mix of top-down centralized administration (e.g., in Thailand, Madagascar, Mozambique, Iran, Saudi Arabia, Guyana, Suriname, and Australian Commonwealth fisheries), delegated provincial and district powers (e.g., Indonesia, Vietnam, and

[2] All countries in North, Central, and South America.
[3] Excludes discarded bycatch.

US and Australian states), and co-management with a range of small-scale and company-led inputs to governance. Within this range, very few fisheries show strong overall levels of governance.

- With respect to management systems, many fisheries remain largely open-access. However, various input, output, and technical controls have been used or are currently in use. Input controls include: buy-back schemes (Australia) and decommissioning (French Guiana) to reduce capacity; fishing input rights based on changes to fishing gear such as headrope length (e.g., Australia and Mexico); removal of unused licences (e.g. the US) or licences held by those infringing regulations (e.g., Indonesia); and seasonal and area restrictions (a number of countries). Output controls include: Total Allowable Catches (TACs; selected fisheries in, e.g., Indonesia, Mozambique, French Guiana, and the US); individual boat quotas (e.g., Mozambique and Madagascar); minimum landing sizes; average mean sizes (e.g., Australia); and fish bycatch restrictions. Technical measures used in some countries include: minimum mesh sizes; headrope length; and Bycatch Reduction Devices (BRDs).
- Increases in farmed shrimp production and associated global declines in shrimp prices, coupled with rising/fluctuating fuel prices and worsening catches per unit of effort, have made the financial position of many shrimp trawl vessels very precarious. Potential solutions include: branding and market benefits if fisheries can move towards or demonstrate sustainability (such as MSC certification, which some TST fisheries are presently going through); transfer of effort to other fisheries (on the assumption that these other fisheries are also not being overexploited); and altering the balance of target species, including increasing dependency on other retained species.
- Other business drivers which negatively impact on sustainability include: augmenting low crew wages through the sale of bycatch species (e.g., Nigeria, Colombia, and Indonesia), which leads to a reduction in selectivity, reduced and illegal mesh sizes, and a failure to apply BRDs and Turtle Excluder Devices (TEDs); and fuel subsidies, which are applied in many countries[4] and perpetuate retention of inefficient capacity in the fleet. Positive business drivers include fuel savings through gear changes that allow for increased margins to reward best practice. One example of this is skipper and crew wage premiums for catching larger-sized shrimps (Madagascar).

A blueprint for moving toward sustainable TST fisheries and recommendations to assist with implementation

The final section of this report presents a blueprint to achieve sustainable TST fisheries, focusing on four key objectives:

- Creating a management framework which ensures the setting of appropriate harvest control rules that support the sustainability of the target species and make adequate provision for safeguarding the supporting ecosystems
- Providing a system of strong compliance and facilitating industry participation in all aspects of decision-making
- Creating a monitoring and evaluation framework to assess results of blueprint implementation
- Facilitating the development of positive business drivers linked to improved fishing practices and market incentives.

A number of results are articulated under each of these objectives, with specific activities proposed to help to bring these results about. The types of indicators that could be used to demonstrate that activities have been successfully undertaken are also indicated.

To take the outputs of this work forward, the consultants recommend that fisheries administrators and other relevant stakeholders review the lessons learned and conduct a gap analysis of current performance against these lessons and the blueprint. This is likely to require additional work to compare the performance of fisheries in individual countries against the blueprint.

[4] A recent study showed that, of the 34 largest shrimp-producing nations, 19 had fuel subsidies (Gillette, 2008).

The blueprint presented in this report is generic and applicable to all TST fisheries. In order for implementation to be successful, it should in all cases be reviewed by local stakeholders and amended as appropriate. This is critically important for four reasons:

1. To ensure that the blueprint adopted for any one country/fishery is specific to the needs of that country/fishery
2. To ensure that stakeholders in the country/fishery have the opportunity to participate in finalizing the blueprint, thereby generating a sense of ownership of it
3. To ensure that adaptation of the blueprint in a particular country/fishery can include the specification of a detailed and appropriate timeframe, with responsibilities assigned for all actions
4. To ensure that appropriate resources (financial and staffing) are carefully assessed and identified for all necessary improvements.

1 INTRODUCTION

This report was prepared by Poseidon[5] on behalf of WWF. It follows on from a July 2008 workshop convened by WWF in Darwin, Australia, which brought together both external experts and WWF staff to "brainstorm" global tropical shrimp trawl (TST) fisheries and identify opportunities to drive these fisheries toward substantially improved management regimes.

The present study involved an extensive review of fishery practices adopted in tropical shrimp fisheries. It was informed by work undertaken by the FAO, most notably Gillette (2008), and the outputs from the UNEP/GEF/FAO Reduction of Environmental Impact from Tropical Shrimp Trawling (REBYC) project[6]. The work also draws heavily on inputs from WWF fishery officers, government officials, private sector companies, and other individuals who, through a detailed questionnaire prepared by the consultants (Poseidon country surveys), provided information on existing practices, management systems, and governance in 11 countries (Australia, French Guiana, Suriname, India, Indonesia, Madagascar, Mexico, Mozambique, Nigeria, USA and Vietnam). Outputs were also elaborated through country visits to India, Indonesia, Madagascar, and Vietnam, and through a review of other available literature.

Following this short introduction, the report is divided into three main sections, supported by considerable additional information which can be found in the Appendices.

Section 2 presents extensive background data and information on TST fisheries around the world. This focuses on the types of fleets involved, trends in catches and stock status, governance and management systems being applied, and positive and negative economic drivers affecting sustainability.

Section 3 "benchmarks" TST fisheries using the Marine Stewardship Council (MSC) standards plus an additional principle as assessment tools. This benchmarking exercise highlights the many problems exhibited in TST fisheries, as well as some positive developments in a number of developed and developing countries.

Section 4 provides a blueprint for sustainable tropical shrimp trawl fisheries. The blueprint is presented in the form of a logical framework with accompanying explanation/notes, and is underpinned by a number of lessons learned from the preceding sections that we feel are essential requirements for sustainability.

The intention of the blueprint is to provide an aspirational framework for fisheries managers and practitioners to assess, benchmark, and improve performance. This generic framework can be applied to all TST fisheries, but needs to be refined by stakeholders in each particular country/fishery to meet their specific circumstances and requirements.

[5] www.consult-poseidon.com

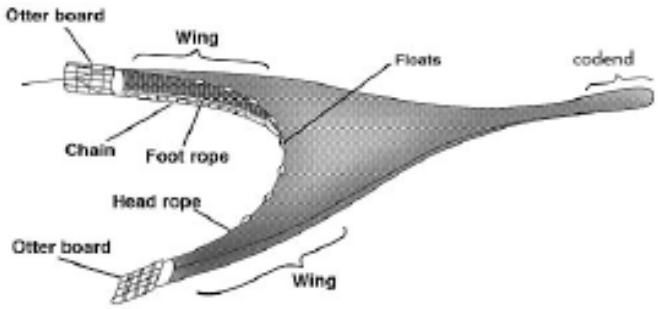
[6] Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management, Project Number UNEP GF/2731-02-4469 & GF/4030-02-04, FAO EP/GLO/201/GEF. The main objective of this multi-year global programme is to reduce discards in TST fisheries by introducing appropriate fishing technologies. Other objectives include the reduction of overall bycatch by shrimp trawlers, in particular the capture of juveniles of commercially valuable species, and a better understanding of the impact of shrimp trawling on marine habitats.

2 BACKGROUND TO TROPICAL SHRIMP TRAWLING

2.1 Description of the fishery

The predominant fishing gear used to catch shrimp is the otter trawl, which consists of a cone-shaped net kept open horizontally by two otter boards (Figure 2–1). The vertical opening is maintained with floats and/or hydrodynamic devices (kites) on the upper edge (floatline) and weights on the footrope. The trawl is designed and rigged to have bottom contact during fishing (see Section 2.5.4). The footrope may be a chain or weighted rope, and may be equipped with rubber discs, bobbins, or spacers to shield the lower leading margin of the trawl from ground damage while maintaining ground contact. Sometimes a "tickler" chain is used in advance of the footrope. Each trawler may tow from one to four nets. Using more than one net is increasingly popular as it improves the rate of catch and therefore fuel efficiency. The spread of the trawl (mouth opening) depends on the number of trawl nets used (more trawls= smaller individual spread); the total spread is probably around 50 m.

Figure 2-1: Shrimp otter trawl



Other critical components to the fishing method are the mesh size in the codend, the trawl wings, whether gear attachments are applied to reduce bycatch, and the tow time. The range of minimum mesh size applied is from around 20 mm to 60 mm. Smaller meshes retain more fish and shrimp, including juvenile shrimp and trash[7] fish. Longer tows also add to the catch volume in the net, thereby reducing gear selectivity. Various devices have been developed to reduce bycatch, such as Juvenile and Trash Excluder Devices (JTEDs), Bycatch Reduction Devices (BRDs), and Turtle Excluder Devices (TEDs). These are placed in critically important areas of the net to allow or improve the escapement of juvenile fish, non-target fish, and other species. Other adjustments can be made to trawl gear to allow trawls to be lighter. Usually developed by trawler companies and fishing boat owners, these include the design of the otter boards (with a focus on lighter weights to reduce drag) and elimination of tickler chains.

Fishing can take place at a variety of depths and distances from the coast. Shallow water fisheries range from 1 m to 120 m, while deepwater fisheries generally range from 300 m to 750 m. Coastal artisanal vessels usually operate in shallow water within 2–3 nautical miles (nm) of shore, small-scale trawlers up to 6 nm offshore, and semi-industrial and industrial boats between 2 nm to 300 miles offshore. Some national management systems define operational demarcation zones, but these are not necessarily respected. Fishing for white shrimp (e.g., banana prawns) predominantly takes place during the day when shrimp are most active, or at night during the full moon. Brown shrimp (including tiger prawns) are generally caught at night. Tow times vary depending on the main focus of the target species: boats seeking to concentrate on shrimp and minimize bycatch typically tow between 45 minutes and 1 hour, while those targeting more fish and/or smaller-size shrimp species may tow for up to 4 hours.

[7] Broadly used term for fish species that by virtue of their small size or low consumer preference have little or no value (FAO).

The following tropical shrimp target species are covered in this report[8]:

- Atlantic seabob (*Xiphopenaeus kroyeri*)
- Blue endeavour prawn (*Metapenaeus endeavouri*)
- Blue shrimp (*Litopeneaus stylirostris*)
- Brown shrimp (*Parapenaeosis atlantica*)
- Brown shrimp (*Farfantepenaeus aztecus*)
- Brown tiger prawn (*Penaeus esculentus*)
- Caribbean pink shrimp (*F. duorarum*)
- Caribbean red shrimp (*F. brasiliensis*)
- Giant tiger shrimp (*P. monodon*)
- Grey shrimp (*P. kerathurus*)
- Grooved tiger prawn (*P. semisulcatus*)
- Indian white shrimp/Red-legged banana prawn (*Fenneropenaeus indicus*)
- Kadal shrimp/Indian banana shrimp (*M. dobsoni*)
- Kiddi shrimp (*Parappenaeus stylifera*)
- Kuruma shrimp (*Marsupenaeus japonicus*)
- Pink shrimp (*P. notialis*)
- Pink shrimp (*F. duorarum*)
- Pacific brown shrimp (*F. californiensis*)
- Red endeavour prawn (*M. ensis*)
- Speckled shrimp (*M. monoceros)*
- Red-spot king prawn (*Melicertus longistylus*)
- Western king prawn (*Melicertus latisulcatus*)
- Whiteleg shrimp (*P. vannamei*)
- White shrimp (*P. merguiensis*)
- White shrimp (*L. setiferus*)

Trawling for tropical shrimp is actively carried out in as many as 65 countries, divided into six regional groupings (Table 2-1). The table shows that:

1. 1.3 million t of tropical shrimp is caught annually
2. 44 per cent is taken in the Coral Triangle region; Indonesia and Vietnam account for 60 per cent of this region's total, and Australia's catch is quite small relative to the other Coral Triangle countries
3. 32 per cent is taken in the Indian subcontinent, with India accounting for 88 per cent of the region's catch
4. 16 per cent is taken in the Americas[9]; Mexico, Brazil, and the Guianas account for 66 per cent of the region's total, with other significant TST activities occurring in the US, Venezuela, Peru, and Panama
5. West and East Africa and the Middle East account for the remaining 8 per cent of global catches, with major producing countries being Nigeria, Cameroon, Mozambique, Madagascar, Iran, and Saudi Arabia.

[8] The number of different tropical shrimp species caught runs into the thousands, but those not listed here would form a minority of the retained species.
[9] Defined as all countries in North, Central, and South America.

Table 2-1: Average tropical shrimp catches by region and country (t; 2000–2007)

CORAL TRIANGLE	
Indonesia	239,240 (18%)
Vietnam	102,971 (8%)
Thailand	77,364 (6%)
Malaysia	73,472 (6%)
Philippines	45,599 (4%)
Australia	22,610 (2%)
Cambodia	11,163 (1%)
Papua New Guinea	1,008
Singapore	322
Solomon Islands	12
Total	**573,761 (44%)**

INDIAN SUBCONTINENT	
India	374,517 (29%)
Myanmar	23,588 (2%)
Pakistan	22,106 (2%)
Bangladesh	3,444
Total	**423,655 (33%)**

MIDDLE EAST	
Iran	7,261 (1%)
Saudi Arabia	7,003 (1%)
Kuwait	1,773
Bahrain	1,738
Yemen	1,485
Oman	489
Iraq	60
Total	**19,808 (2%)**

AMERICAS	
Mexico	65,523 (5%)
Brazil	34,416 (3%)
Guyana	20,533 (2%)
US	18,727 (1%)
Suriname	12,181 (1%)
Venezuela	11,174 (1%)
Peru	7,420 (1%)
Panama	6,642 (1%)
Chile	4,639
Nicaragua	3,650
Ecuador	3,407
French Guiana	2,883
Colombia	2,755
Costa Rica	2,319
Guatemala	1,871
El Salvador	1,740
Honduras	1,500
Cuba	1,361
Trinidad and Tobago	830
Haiti	634
Belize	225
Dominican Republic	65
Uruguay	35
Jamaica	29
Total	**204,559 (16%)**

WEST AFRICA	
Nigeria	25,075 (2%)
Cameroon	9,595 (1%)
Senegal	4,300
Angola	2,276
Benin	2,274
Gabon	2,118
Sierra Leone	1,424
Ghana	1,282
Congo	820
Côte d'Ivoire	459
Gambia	363
Guinea-Bissau	269
Guinea	155
Liberia	103
Total	**50,513 (4%)**

EAST AFRICA	
Mozambique	12,450 (1%)
Madagascar	12,125 (1%)
Tanzania	1,795
Eritrea	447
Kenya	392
South Africa	134
Total	**27,323 (2%)**
Global Total	**1,299,619**

Source: FAO Fishstat. The percentage of global production is indicated in brackets if the figure is 1 per cent or more of the total.

2.2 FLEET STRUCTURE

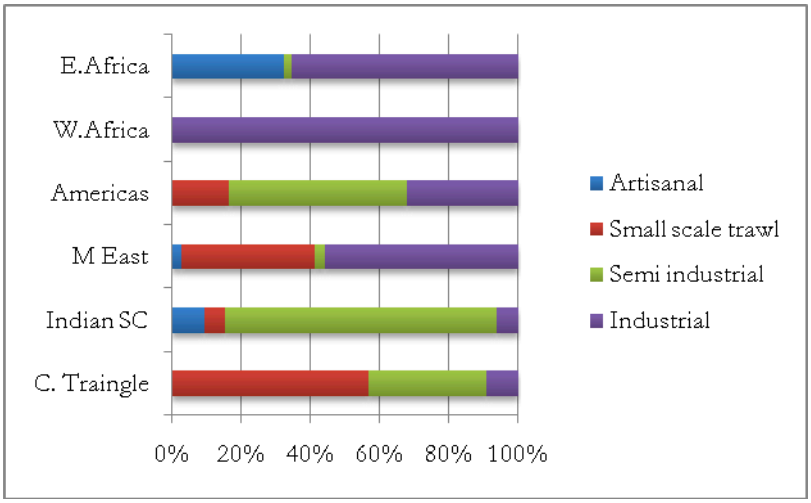
Vessel groupings and definitions may differ between countries, but broadly fall into the following:

- **Industrial trawlers:** usually upwards of 18 m in length, with engine sizes from 300–1,500 hp and onboard freezers; fishing long trips and operating between 5 and 55 days at sea
- **Semi-industrial trawlers:** usually 10–18 m in length, with engine sizes from 90–250 hp and limited onboard storage; usually icing shrimp but occasionally with freezing capacity; operating short trips between 1 and 5 days at sea
- **Small-scale trawlers:** usually around 8–12 m in length, with engine sizes from 33–90 hp; operating trawls in shallower waters and close to shore
- **Artisanal boats:** usually with small outboard engines or sails; using a variety of fishing nets including gill and tangle nets, seines, traps, push nets, and small meshed trawls.

The distinction between industrial, semi-industrial, and small-scale trawls is not only one of size, but more often one of ownership structure. Industrial vessels usually form part of a company corporate structure, often working together under the umbrella of a trawler owners' society. Semi-industrial trawlers may be company owned or operated by individuals; they may be part of a trawler owners' society or may operate independently. Joint venture and foreign ownership is a common feature among many of the developing country industrial trawler fleets. National or local businessmen may own semi-industrial trawlers. The relationship between industrial trawler groups and national, provincial, and district government is usually quite strong, yielding both positive and negative influences, as this report will later highlight. In cases where rights-based systems have been established, semi-industrial trawlers gravitate increasingly into the company-owned sector. Small-scale trawl and artisanal fishers are usually poorly organized, lack a group organizational structure, and often use local figureheads or village leaders as spokespersons. The connection between these groups and district fisheries authorities is usually extremely weak.

Based on the literature review and country surveys completed for this report, it is estimated that there are as many as 10,100 industrial trawlers, 5,800 semi-industrial, and 190,000 small-scale trawlers globally, together with a large number (in the hundreds of thousands) of multi-gear artisanal vessels. An estimate of catch distribution by vessel type in each region is shown in Figure 2-2, while national fleet segments and gear applications are summarized in Box 2-1.

Figure 2-2: Tropical shrimp catch distribution by region and vessel type



Legend: E.Africa: East Africa; W.Africa: West Africa; Americas: North, Central, and South America; M.East: Middle East; Indian SC; Indian subcontinent; C. Triangle: Coral Triangle.

Sources: Catch data (FAO Fishstat), fleet data, Poseidon country surveys, literature review.

Box 2-1: Characteristics of principal national TST fleets

India has 29,000 semi-industrial trawlers (12–17 m) as well as an industrial fleet of 73 trawlers. Semi-industrial fishing is concentrated in the states of Kerala (southwest India), Orissa, and West Bengal (northeast India), while industrial trawling takes place in Gujarat (northwest India). Small coastal boats are also active in all locations, using a combination of stake and bag nets. The semi-industrial boats making up the bulk of the fleet have engine sizes of 85–150 hp and carry one shrimp net. All semi-industrial and industrial boats are required by law to fish beyond 12 nm from shore. Around half the west coast boats also target deepwater shrimp as an alternative fishery during lean fishing periods. Some boats carry larger mesh bottom trawl or semi-pelagic gear to allow a switch to finfish species when shrimp catches are lean. Some of the larger boats also carry try nets.

Indonesia has a dedicated shrimp fleet of 90 national industrial trawlers fishing specifically in one province, Papua (Arafura Sea and Mareoke). Foreign trawlers are also licensed to fish in the same fishery, with reports on the active number ranging from 200 to 330 (Malaysian, Philippine, and Thai). Most trawlers carry two nets, but some carry up to four. There are also thousands of artisanal, small-scale trawlers, and semi-industrial boats targeting shrimp within the archipelago, but exact numbers are unknown. These boats use a variety of fishing methods including trawls, which are banned in areas other than the Arafura Sea, and inshore trammel nets. A trawl fishery also started in East Kalimantan in 2009. Details of activity in this district are unclear but are believed to include both national and foreign (Malaysian/Philippine) vessels.

Vietnam has 29,000 shrimp trawlers divided into two groups: otter trawls (90 per cent) and beam trawlers (10 per cent). The vessels also fall into two categories: small-scale trawlers with engine size <90 hp (97.5 per cent) fishing in coastal waters (but officially fishing beyond 6 nm from shore) and semi-industrial vessels with engine sizes >90 hp (2.5 per cent), fishing beyond 24 nm from shore. Smaller boats are single-rigged, but most trawlers comprise twin-riggers. Both fishing groups are unlikely to respect demarcation zones with frequent alleged transgressions into coastal waters. Trawling is concentrated in two main fishing grounds: the Gulf of Tonkin (provinces with large fleets are Quang Ninh and Hai Phong) and southeast waters of the Exclusive Economic Zone (EEZ; provinces with large fleets are Ba Ria-Vung Tau, Tien Giang, Ben Tre, Bac Lieu, Cau Mau, and Kien Giang).

The Philippines has banned trawling in some areas since the 1980s. However, there are 20 trawlers described as fully dependent on shrimp as well as 445 trawlers that also target demersal and pelagic species in separate fisheries. Important shrimp fishing grounds are Samar Sea, Lingayen Gulf, San Miguel Bay, and Manila Bay.

Mexico has 2,212 industrial offshore shrimp vessels, using either two nets (Pacific side) or four nets (Atlantic side). These account for 57 per cent of the shrimp catch. There are as many as 102,000 artisanal vessels, which catch 43 per cent of the total shrimp landed. The artisanal fleet has tripled in size in the past 17 years.

Nigeria has a fleet of 156 industrial trawlers between 23–30 m in length. The trawlers fish beyond 5 nm from shore and use 2–4 nets. Within 5 nm from shore, there are many coastal artisanal canoes using conical nets which are towed in shallow waters (5–15 m) to catch prawn (*Nematopalaemon hastatus).*

Suriname has 31 licences in the penaeid/marine shrimp sector and 20 in the Atlantic seabob sector, following recent reductions (2010). Vessels are between 18–22m in length and use twin-rig. Penaeid shrimp trawlers are demarcated to fish in depths greater than 30 m. Atlantic seabob trawlers operate in depths between 18–30 m, and vessels are predominantly foreign-owned (Japanese, Korean) with Guyana-based skippers.

French Guiana has 53 licences available for penaeid/marine shrimp and 23 vessels of around 24 m, each using two 22 m trawls. These are twin rig vessels built in Florida with average age of around 20 years. Vessels must stay outside the 30 m depth contour.

Madagascar has a fleet of 70 industrial trawlers (23–30 m and 250–500 hp), 64 of which fish on the west coast and six on the east coast. Fishing takes place in depths of 2–30 m, confined to four zones (including one off the east coast). There has been an uncontrolled expansion of artisanal vessels of 3–4m in length operating in the fishery. Consequently, the catch of industrial trawlers has fallen to from 8,400 t to 3,000 t, with only 21 industrial vessels operational in the west coast fishery in 2008. The artisanal fleet is reported to catch 3,400 t, and the semi-industrial trawl fleet 400 t.

Mozambique has 43 industrial, 49 semi-industrial, and 15,250 artisanal vessels fishing in shallow waters, and seven industrial vessels fishing in deep waters. Trawlers use 1–4 nets. Artisanal catches range from 100–400 t (1–10 per cent of the total shrimp catch weight), semi-industrial catches are 400 t, and industrial catches are around 6,500 t. Industrial vessels are not allowed to trawl within 3 nm from shore, and semi-industrial vessels must operate beyond 1 nm from shore.

Iran has 39 industrial trawlers (27 m, 750 hp) fishing with two trawls, 870 wooden dhows (1 m, 100–220 hp), and 1,500 fiberglass boats (7m, 25–45hp).

Australia has 10 distinctive fisheries, with a total of 1,182 participating vessels comprising a combination of semi–industrial vessels (upwards of 13 m) and industrial vessels (up to 29 m) falling under individual and corporate ownership. Despite the size categories, most vessels are considered to be "industrial" as they freeze their product and stay at sea for 1–4 months at a time. Two fisheries fall under Commonwealth jurisdiction, the Northern Prawn Fishery and the Torres Strait fishery, and account for 52 and 70 vessels, respectively. The largest state fisheries are the Queensland East Coast prawn fishery and the New South Wales prawn fishery, with 478 and 304 vessels, respectively. There are also small Gulf-type

fisheries, a notable example being the Spencer Gulf fishery with 39 vessels. Trawlers carry 2–4 nets per vessel, depending on the specific management system applied.

The US has 3,500–4,500 fishing vessels in two fisheries, the Gulf of Mexico and the Atlantic (South). Atlantic fishing vessels are generally of a small semi-industrial size, whereas Gulf of Mexico vessels can be larger. Vessels move in and out of the fishery based on resource abundance and product prices.

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000), other national reports.

2.3 CATCH TRENDS

An examination of catch records by region (Figures 2-3 to 2-7) shows some contrasting trends. Very few fisheries show growth in catches (although some do, such as Saudi Arabia, Cameroon, Peru, Vietnam, and Brazil). In some cases growth reflects a rapid expansion of catch by artisanal as opposed to industrial vessels (Madagascar and Mexico), with corresponding reductions in catches by the other groups. However, very few countries show any downward trends in overall catch, the exceptions being Senegal, Thailand, and the US.

Figure 2-3: National shrimp catches: Indian subcontinent

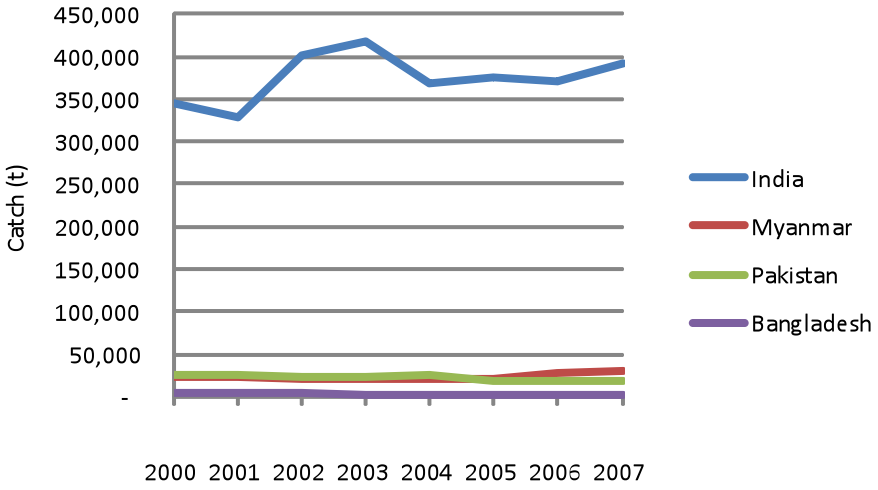


Figure 2-4: Principle national shrimp catches: Coral Triangle

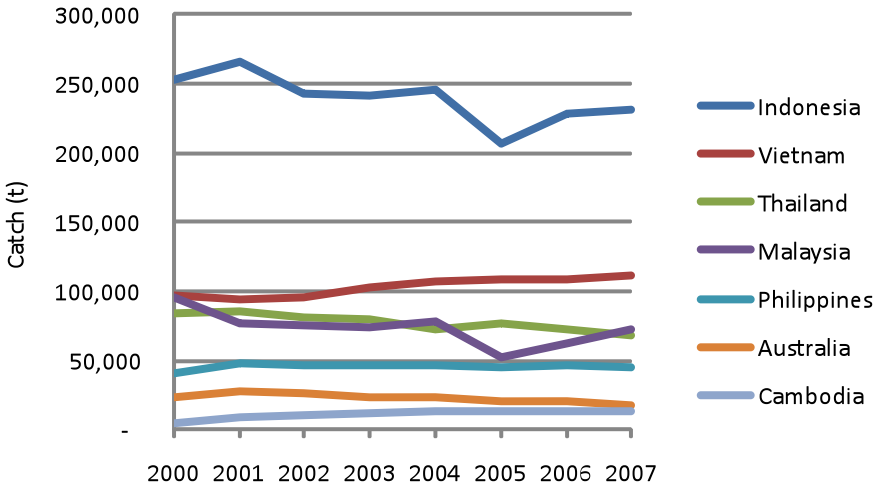


Figure 2-5: Principle national shrimp catches: Americas

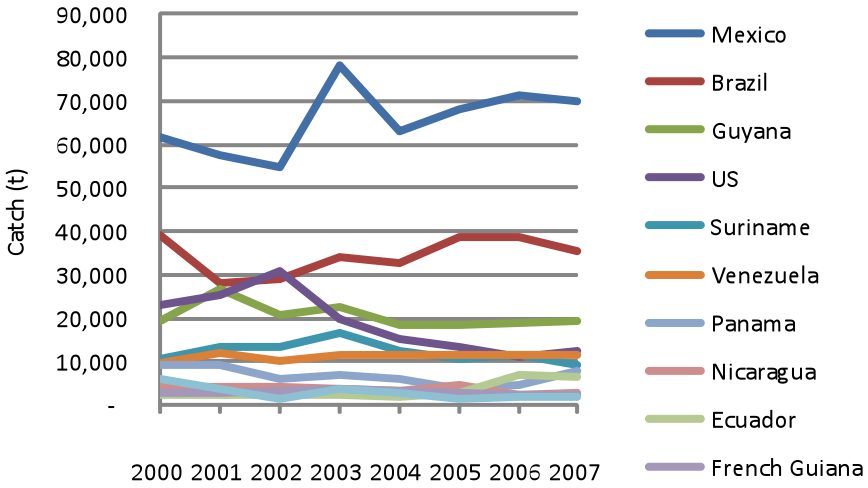


Figure 2-6: Principle national shrimp catches: East and West Africa

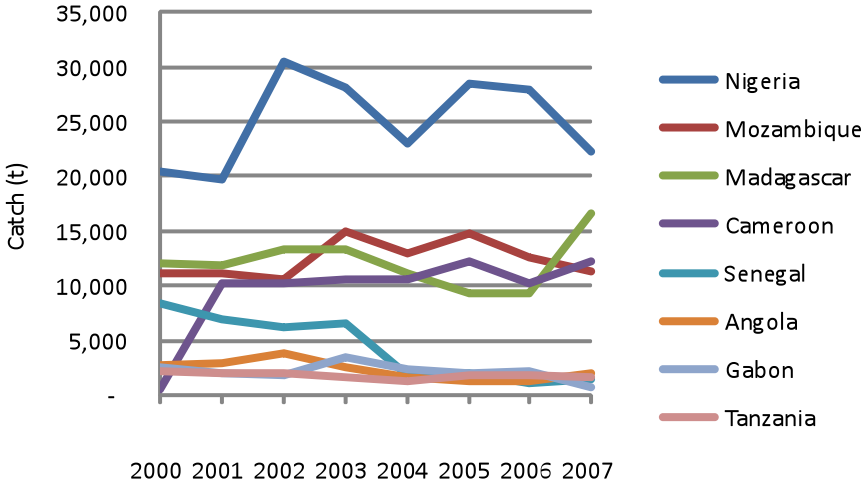
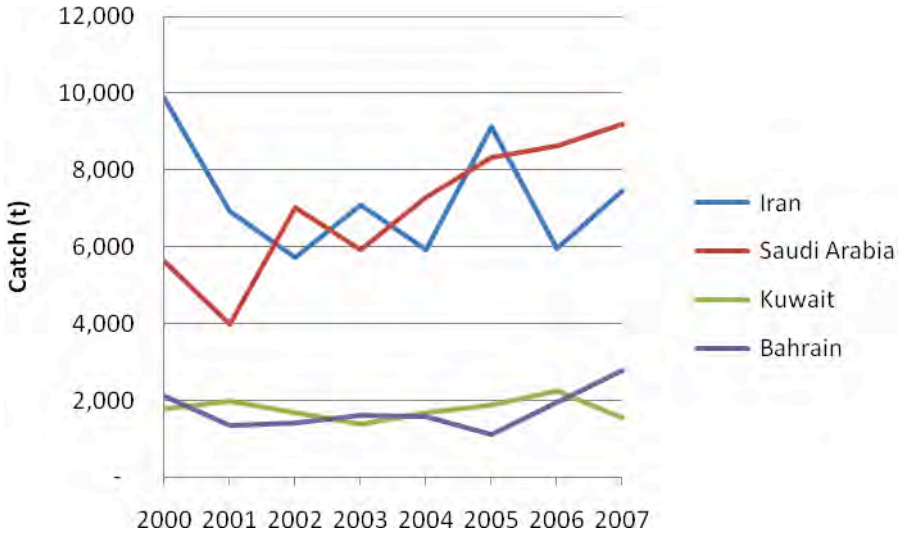


Figure 2-7: Principle national shrimp catches: Middle East



A summary of CPUE trends (Box 2–2) shows consistent reporting of declines in all developing countries, with partial recovery in only one country (Mozambique).

These trends are a reflection of increased numbers of boats and an increased number of trawls used. In some cases, the number of boats has declined in response to lower CPUEs, due to boats leaving the fishery (Madagascar). The only countries with constant or even improved CPUEs are those that have implemented a series of fishery management measures and have some controls on access (Australia and the US). However, the systems in both these countries have had to be supported by restructuring programmes (including national and state buy-back schemes), which reduced capacity in the number of vessels by 68 per cent over a period of 30 years in the case of Australia's Northern Prawn Fishery (Case Study A.1), and by 25 per cent over 12 years in Texas, US[10]. The most recent Australian buy-back scheme was implemented on the condition that the fishery moved from a Statutory Fishing Rights (SFR) Gear Units System based on headrope length to an SFR based on Individual Transferable Quotas (ITQs). The SFR Gear Units System had also been successful in removing 43 vessels since 2000.

[10] http://www.ccatexas.org/cca-texas-helps-complete-shrimp-license-buyback-program/

Box 2-2: Summary of CPUE trends in national TST fisheries

- **Australia**: The Northern Prawn and Spencer Gulf fisheries have stable catches. Both have experienced concerns about effort creep and have responded in specific ways to deal with these (rights-based capacity exchanges linked to headrope lengths (Northern Prawn Fishery), and closed seasons/limited fishing periods).
- **US**: Generally improving CPUEs since the mid- to late 1980s.
- **Mozambique**: Following a CPUE decline in shallow water stocks, concerted efforts have been made to reduce fishing effort using closed seasons, particularly for the industrial fleet. The declining trend has since been reversed. CPUE levels for deepwater pink prawns have been remarkably consistent since 1992.
- ***India***: Declining stocks, with CPUE for all species falling from 80 kg/boat/h in the 1980s to 30 kg/boat/h (2009). Shrimp make up 15 per cent of the total catch, with variations between areas (25 per cent in Kerala; 7 per cent in Orissa). This percentage dependency remained constant between 1980 and 2009.
- ***Indonesia***: Decreasing trend in recent years in the Arafura Sea, with the CPUE decreasing from 500 kg/gross tonnes/year two decades ago to 250–300 kg/gross tonnes/year.
- ***Vietnam***: Uncontrolled access to fisheries in all principal shrimp fishing provinces (Quang Ninh, Hai Phong, Ba Ria-Vung Tau, Tien Giang, Ben Tre, Bac Lieu, Cau Mau, Kien Giang,) with acknowledged reduction in catch/day.
- ***Mexico***: Industrial fleet catch has fallen by 40 per cent in 10 years, from 6.4 t/vessel/year to 3.6 t/vessel/year.
- ***Cambodia***: Shift in fishing gears towards more modern and efficient methods; decreased CPUE from 20 kg to 5 kg/night.
- ***Nigeria*****:** Very pronounced/prominent declining stocks.
- ***Guianas***: The Caribbean Regional Fisheries Mechanism (CRFM) conducts scientific workshops to monitor stock status, and each time concern has been raised that fishing effort has been too high, particularly in Guyana, and that there is a risk of overfishing.
- ***Madagascar***: Gradually declining CPUE, but major fall in shrimp catches in 2005. Catches down from 150 t/vessel/year to 100 t/vessel/year.
- ***Bangladesh***: Shrimp CPUE (kg/vessel/day) has steadily decreased since the early 1990s.
- ***Kuwait***: High level of effort and low CPUE seem to indicate that the stock has been overexploited since 1993.
- ***Trinidad and Tobago***: Fully or overexploited shrimp stocks and over-capitalization in the trawl fishery.
- ***Philippines***: Twenty-four trawling grounds existed from the mid 1950s, with catch rates between 200–400 kg/h. By the mid-1970s, catch rates had fallen to 10–15 kg/h, forcing the government to ban trawling in some areas (Ingles, pers. comm., June 2010.)

Legend: Red/italic text: declining CPUE; orange/underlined text: recovering CPUE; green/normal text: CPUE maintained at reasonably good levels. **Source:** Poseidon country surveys.

2.4 STOCK ASSESSMENT

Table 2-2 provides a summary of the biological status of different shrimp stocks, based on information from individual fishery stock assessment reports. It also gives the main indicators of stock status and reference points against which status is assessed. This is generally a comparison of stock biomass, catch, effort and/or catch rates, and biological targets as applicable.

Table 2-2: National tropical shrimp stock assessments

Country	Species	Comments
Australia (Northern Prawn Fishery)	(1) Red-legged banana prawn (*F. indicus*) (2) Brown tiger prawn (*P. esculentus*)	(1) Stable catches and species biology provide no evidence of overfishing. (2) Spawning biomass not overfished. Maximum Economic Yield (MEY) target applies across multiple species (Larcombe and Perks, 2008).
Australia (Spencer Gulf)	Western king prawn (*M. latisulcatus*)	Relatively stable catches since 1987/1988. Nominal effort (hours fished) reduced to around 40% of the 1978/1979 peak. Mean harvested prawn size larger in recent years than in 1978/1979 (Hooper *et al*, 2007).
US (Gulf of Mexico)	Brown shrimp (*F. aztecus*); pink shrimp (*F. duorarum*); white shrimp (*L. setiferus*)	Exploitation much reduced due to economic factors, supported by some capacity reduction. Recruitment and stock abundance improved since mid- to late 1980s, but some localized recruitment overfishing (Louisiana); otherwise fully to underexploited (Nance, 2009).
India	Kadal shrimp (*M. dobsoni*); kiddi shrimp (*P. stylifera*); kuruma shrimp (*M. japonicus*); Indian white shrimp (*F. indicus*); grooved tiger prawn (*P. semisulcatus*)	All fisheries overexploited at 0.6–0.75 B_{MSY}; however, scientists stress that 0.5 B_{MSY} is overzealous in tropical fisheries due to high fecundity, fast growth rates, and continuous spawning. Some issues of recruitment overfishing (CIMFR). Perceived target is 0.6 B_{MSY}. Scientists have advised states of a need for a 50% reduction in fishing effort.
Indonesia (Arafura Sea)	Red endeavour prawn (*M. ensis*); grooved tiger prawn (*P. semisulcatus*); white shrimp (*P. merguiensis*); red-legged banana prawn (*F. indicus*)	Increased fishing effort and destruction of fish habitats. TAC based on 0.88 B_{MSY}, but always exceeded. Absence of data makes it impossible for scientists to set informed TACs. Last stock assessment done in 2001 (BRPL).
Vietnam	White shrimp (*P. merguiensis*); grooved tiger prawn (*P. semisulcatus*); red endeavour prawn (*M. ensis*)	Shrimp trawl fishery heavily exploited; fishing effort in 2004 should have been reduced by 12–44% to achieve Maximum Sustainable Yield (MSY) and by 46–61% to achieve MEY (Thanh, 2006).
Mexico	*Pacific Coast:* Blue shrimp (*L. stylirostris*); Pacific brown shrimp (*F. californiensis*); white shrimp (*L. setiferus*) *Gulf of Mexico:* Brown shrimp (*F. aztecus*); whiteleg shrimp (*L. vannamei*); pink shrimp (*F. duorarum*); Atlantic seabob (*X. kroyeri*); Caribbean red shrimp (*F. brasiliensis*)	Catches steadily decreasing since 1997 (10%/year in the Gulf of Mexico and 6%/year in the Pacific). White shrimp is a critical concern, blue shrimp a high concern, and brown shrimp harvested to optimal levels. Overall, in the Gulf of Mexico, the stock status of brown and seabob shrimp is moderate, while the stock status of pink and whiteleg shrimp is poor due to their declining trends and depleted biomass. (INP, 2008). Overfishing, vulnerability to environmental changes, and habitat deterioration and destruction have an inherent importance on population dynamics. Conservation International identified the need for a 50% reduction in capacity.
Mozambique	Red-legged banana prawn (*F. indicus*); speckled shrimp (*M. monoceros*); lesser quantities of kuruma shrimp (*M. japonicus*), western king prawn (*M. latisulcatus*), giant tiger shrimp (*P. monodon*), grooved tiger prawn (*P. semisulcatus*) *Deepwater fishery targets: Haliporoides triarthrus*; *Aristaemorpha foliacae*, *Aristeus antennatus*, *Plesiopenaeus edwardsianus*, *Penaeopsis balssi*	Fishing mortality approximately at the target level for *M. monoceros*, but higher than the target level required for *F. indicus* and, because catches are mainly comprised of this species, it follows that trawling effort was 18% higher than the target effort of 220,000 standardized trawl hours. Efforts made to reduce fishing effort by establishing closed seasons, particularly for the industrial fleet. CPUE has since shown improvement (Ministry of Fisheries,, 2004–2008, 2009). Also now considering recruitment overfishing issues from artisanal fisheries. Estimated that there should be 40% fewer boats operating in the shallower water (as opposed to deep sea) industrial fishery (Ministry of Fisheries).

Suriname/ Guyana	Atlantic seabob (*X. kroyeri); Penaeid shrimp*	Number of attempts made over the last ten years by national and international scientists at the bi-annual scientific workshops to monitor stock status. Each time concern has been raised that fishing effort has been too high, particularly in Guyana, and that there is a risk of overfishing. However stock status in both countries, and for both main species, is not well known, although declining CPUE suggests problems.
Nigeria	*Shallow water (7–15 m):* Pink shrimp (*P. notialis*); grey shrimp (*P. kerathurus*); giant tiger shrimp (*P. monodon*); brown shrimp (*P. atlantica*) *Deepwater (15–60 m): Parapenaeus logirostris* (largely unexploited)	Declining CPUE and overfishing of principal targeted shrimp stocks (Nigerian Institute for Oceanography and Marine Research (NIOMR).
Madagascar	Red-legged banana prawn (*F. indicus*); speckled shrimp (*M. monoceros*); grooved tiger prawn (*P. semisulcatus*); giant tiger shrimp (*P. monodon*); kuruma shrimp (*M. japonicus*)	Stocks were at MSY in 2004; growth in fishing effort (change to quad trawls) required a subsequent reduction. Management measures taken by the industrial fleet, but CPUE now declining as a result of high levels of juvenile shrimp caught in nursery areas by coastal fishers. (Caverivière *et al*, 2008).

Legend:

Not overfished/Not subject to overfishing	CPUE stable but additional management actions required to sustain levels	Heavily overfished

Sources: National and regional research institutes, other experts (indicated).

The table shows that:

- Very few stocks appear to be stable. Examples of stocks harvested to optimal levels include fisheries in Australia, the US, and two stocks in Mexico (Pacific and Atlantic brown shrimp). All others, including most stocks in Mexico, are experiencing strong declines in recruitment, some to critical levels.
- Stocks are generally overexploited in countries where there has been a policy of open access.
- Effort reduction measures (fleet reduction through buy-out schemes, tradable SFRs, closed seasons) have allowed some fisheries to establish stable yields.
- Fisheries with open access regimes (India, Indonesia, Vietnam, Mexico, Nigeria, and Guyana) need to cut fishing effort by at least 50 per cent in order to restore fisheries to sustainable levels.
- Recruitment overfishing (Madagascar, Mozambique) is an issue that needs to be factored into any stock assessment. Unregulated fishing in coastal waters, mangroves, and estuaries usually causes this type of overfishing.

Stock assessments for other retained and bycatch species are rarely available. Fisheries scientists trace declines in fish populations through intermittent bycatch surveys, though the exact dimensions of the fish stock depletion are unclear. Examples of such feedback include the Arafura Sea (Indonesia), Mozambique, and Mexico. India has a robust survey system of retained species sampling, which has allowed monitoring of the impact of trash fish extraction. The survey system has noted declines in catches of demersal (as opposed to pelagic) species, especially, ribbonfish, pomfrets, and croakers, by up to 40 per cent. These stocks are estimated to be around 0.75 B_{MSY}.

In many cases, other fisheries (e.g., artisanal fishers targeting fish species) are also experiencing declines in fish stocks. This leads to increasing conflict between fishers and severe social unrest. Examples include the Philippines, Nigeria, and Mexico.

Even in Australian fisheries, there may be limited information on bycatch species for some fisheries. In such cases, the management authority undertakes a risk assessment to determine the level of interaction and impact caused by shrimp trawls.

2.5 CATCH COMPOSITION AND BYCATCH RETENTION

2.5.1 Fish species

Table 2-3 highlights the catch composition of shrimp and other retained species (hereafter collectively called "fish") in national TST fisheries. The table does not reflect the actual levels of discards or the degree of selectivity of specific national fleets.

Shrimp fisheries that land shrimp and other species can be grouped as follows:

- Multi-taxa fisheries, which report shrimp:fish catch ratios of 1:8–15 (Indian subcontinent: India, Pakistan, Myanmar, and Bangladesh; Coral Triangle: Indonesia, Vietnam, and Thailand, Malaysia; Venezuela; West African countries; and the Middle East)
- Shrimp fisheries with selectivity problems but with improved bycatch performance[11], which report shrimp:fish catch ratios of 1:5–7.5 (many countries in the Americas: Colombia, Costa Rica, Cuba, Mexico (Pacific), US, and the Guianas (penaeid trawlers))
- Transitional fisheries[12], which report shrimp:fish ratios of less than 1:3 (Mexican (Gulf of Mexico) and some Madagascan fisheries)
- Well-managed shrimp fisheries or those where bycatch is significantly reduced through effective introduction of selectivity devices; in some cases these report that bycatch has fallen to one-third of the pre-BRD/TED and hopper level,; the shrimp:fish ratio for retained other species is usually in the region of 1:1 or less (most Australian fisheries and some others: Suriname/Guyana Atlantic seabob, Madagascar (seasonal)).

Catch volumes reflect an increasing dependency on demersal fish as a component of the catch. This is usually the result of fish caught as a bycatch but, in some cases, fish dependency increases significantly. Interactions include a large variety of species including croakers (Sciaenidae), pompanos (Carangidae), goatfishes (Mullidae), lizardfishes (Synodontidae), mojarras (Gerridae), threadfins (Nemipteridae and Polynemidae), tooth ponies (Leiognathidae), flounders (Bothidae), rays (Dasayatidae), catfish (Siluridae), snappers (Lutjanidae), tonguesoles (Cynoglossidae), grunts (Pomadasidae), barracudas (Sphyraenidae), shark, squids, octopus, cuttlefish, hairtails, ribbon fish (Trichurus), crabs, slipper lobster, lobster, mussels, and scallops. In many cases individual species may account for more than 5 per cent of the total catch[13]. Trawl catches of pelagic species are minimal.

[11] Significant improvements emanated from BRD initiatives undertaken as part of the UNEP/GEF/FAO REBYC project (Hermes, 2009).

[12] Fisheries demonstrating a marked improvement in selectivity, but with additional measures to be implemented that can further improve selectivity towards a well-managed shrimp fishery.

[13] 5 per cent is a selected indicator used by the MSC to assess main species interdependencies: *Both scoring guidepost (SG) 60 and SG80 use the qualifier 'main retained species'. 'Main' in this context is intended to allow consideration of the weight, value or vulnerability of species caught. For instance, a species that comprises less than 5 per cent of the total catch by weight may normally be considered to be a minor species, i.e., not 'main', in the catch* (MSC, 2010).

Table 2-3: Shrimp dependencies and principal bycatch characteristics of national fisheries

Country	Catch (t)		Shrimp:Fish ratio	Other species		Fish catch composition	Fish discarded or retained
	Shrimp	Other fish		>5% of total catch	<5% of total catch		
India	374,517	663,000	1:14 (Kerala) 1:5 (Orissa)	Ribbon fish, croaker, pomfret, silverbellies, mussels, whelks	Up to 50 fish species, gastropods, bivalve molluscs	Marketable (65%) Juvenile (35%)	Mostly retained; very small amount of non-edible bycatch discarded at sea (crabs and invertebrates)
Indonesia	6,702 (domestic trawl only)	100,000	1:15 (shrimp trawl only)	Croakers (38%), juvenile shrimp, flounder, rays, giant threadfin, squid, octopus, selaroides, snapper	Many additional species	Marketable (30%) Juvenile (60%)	Juvenile fish discarded
Vietnam	102,971	350,000	1:8 (otter trawl; 90%) 1:3 (beam trawl;10%)	Juvenile shrimp, crabs, cuttlefish, squid, trash fish	Many additional species	Trash fish (90%)	No discards
Mexico	65,523	390,000	1:6 (1:9 Pacific Coast; 1:3 Gulf of Mexico)	187 fish, 83 crustacean, and 31 mollusc species. Commonly caught species: *Syacium* spp (halibut, "lenguado"), *Lutjanus campechanus* (red snapper, "huachinango"), *Pristipomoides aquilonaris* (Wenchman, "voraz"), *Upeneus parvus* (dwarf goatfish, "chivo"), *Eucinostomus* spp, *Synodus* spp, *Trichurus* spp., *Cetengraulis* spp, *Cynoscion* spp, *Balistes* spp, *Arius* spp, *Haemulon* spp, *Pristipomoides* spp; *Squilla empusa* (mantis shrimp, "cucaracha"), *Calappa sulcata* (crab, "cangrejo"), *C. flammea* (crab, "cangrejo"), *Portunus* spp (crab, "jaiba", or "cangrejo")	n/a	n/a	n/a
Philippines	45,599	n/a	n/a	Demersal fish, cephalopods, sharks, rays	n/a	Marketable Juvenile	No discards
Nigeria	25,075	200,000	1:9	Juvenile shrimp, croakers (Sciaenidae), soles (Cynoglossidae), silver fish/hairtails (Trichiuridae), big eye grunts (Haemulidae), barracudas (Sphyraenidae), snappers (Lutjanidae), catfish (Ariidae)	n/a	Marketable (booming domestic trades in bycatch)	No discards
Australia	22,610 *NPF (2008):* Banana: 5,816; tiger: 1,03; endeavour:	Most retained species below 5% of total	1:<0.01–0.1	—	Slipper lobster (*Thenus* spp), finfish, scampi (*Metanephrops* spp), scallops	n/a	n/a

Country	Catch (t)		Shrimp:Fish ratio	Other species		Fish catch composition	Fish discarded or retained
	Shrimp	Other fish		>5% of total catch	<5% of total catch		
	217; king: 7 *Spencer Gulf:* 3,000	catch			(*Amusium* spp), squid (*Photololigo* spp)		
Guyana	20,533		1:0.4 (seabob trawl) 1:5 (shrimp trawl)	Commercial size finfish: demersal roundfish (around 5% or less), bangamry (*Macrodon ancylodon*), rockhead (*Larimus brevicep*)	Demersal fish (catfish, trout, butterfish, sharks and rays, sole, flounder), pelagic fish (netley, herring)	Marketable (10%) Trash fish (30%)	Trash fish discarded penaeid shrimp fisheries have discard rates of 80%
US	18,727	90,000	1:5	Red snapper			
Mozambique	12,450	62,250	1:5, 1:2 in early season	Sciaenid (*Otolithes ruber*), tiger toothed croaker, IUCN Red-listed elasmobranchs	n/a	n/a	Large quantities discarded due to lack of storage space on vessels
Madagascar	3,400	1000	1:0.28 (was 1:1–1:6 pre-BRD)	*O. ruber* (Sciaenidae), *Pomadasys hasta* (Haemulidae), *Nemipterus bleekeri* (Nemipteridae), *Saurida micropectoralis* (Synodontidae)	79% marketable, around 800 t from 3000 t shrimp;	Historically 66% discarded, now 21% of fish caught, after BRD (200 t)	180 t marketable fish given to fishers' cooperative to facilitate dialogue
Suriname	12,181	35,000	1:0.4 (seabob; Atlantic shrimp not known)	As per Guyana	As per Guyana		As per Guyana
Cambodia	11,163			Fish and squid	n/a	Marketable Juvenile	No discards
Iran	7,261	56,000	1:8	n/a	n/a	Small (10–25%) Juvenile (40–60%)	No discards; trash fish landed for fish meal

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000). Note: Information not provided where data are not available (n/a).

Fish species may be retained or discarded depending on a number of factors, but usually local demand for food and aquaculture feed and the ability of vessels to retain quantities of other caught species are influential factors. Other critical problems are found when crews extract revenues from bycatch. A disincentive for bycatch retention is the lack of hold space. However, the evident problem is that as shrimp catches decline in poorly managed fisheries, the available hold space increases and is then utilized for marketable-sized finfish. Examples of bycatch retention and discarding are highlighted in Box 2–3.

Box 2-3: Summary of bycatch selectivity characteristics in national TST fisheries

Australia: An assortment of BRD/BED and bycatch mitigation methods is applied. Bycatches are defined as commercial species (slipper lobster, squid, and selected finfish species (Northern Prawn Fishery)) and non-commercial species (e.g., blue swimming crabs). As a result of BRDs and TEDs, the Northern Prawn Fishery has seen a reduction in bycatch from 1:30 to 1:10 (Brewer *et al*, 2007). The Spencer Gulf fishery prohibits the landing of any finfish as well as blue swimming crabs; the latter (and some finfish) are separated on deck and returned to sea using a separate bag and on-deck hoppers.

India: (Kerala and Orissa): Almost no discards, with use of very small meshed nets to retain all species. Thirty-five per cent of fish taken comprise trash fish. Commercial species are also small and before the age of maturity. No BRDs applied to date, but legislation to include BRDs is contained in the forthcoming Marine Fisheries Regulation Act. Ground-breaking effort into hard and soft BRDs undertaken by the Central Institute of Fisheries Technology (CIFT). 100% grants are available from Marine Products Export Development Authority (MPEDA) for the introduction of TEDs. There is some discussion about developing surimi machines to optimize the use of trash fish.

Indonesia (Arafura Sea and Mareoke): BRDs are applied, but skippers and crew from some companies remove them up until 10 days before returning to port, and the crew retains the white fish catch for sale to supplement their income. However, field evidence suggested that this practice is actively discouraged within some trawl companies and strict codes have been established to prevent such practice. There is some discussion about developing surimi machines to optimize the use of trash fish.

Vietnam/Bangladesh: No BRDs are used. Large quantities of juvenile fish are caught (up to 50 per cent by volume). These are sold as trash fish for aquaculture feed. The remaining quantities of fish are sold to the domestic market. Vietnam uses a minimum mesh size of 20–30 mm, Bangladesh 45 mm.

Mexico: BRDs are applied, leading to a 45 per cent reduction in bycatch.

Nigeria: BRDs are used by up to 80 per cent of the fleet. Three types of BRD are used with different design. The minimum mesh size is 44 mm. Fishers are paid low wages (typically around US$45/month), so supplement their wages from retained catch. There is a thriving canoe trade taking fish from trawlers for sale onto the domestic market. Almost no fish are discarded and there is a market for all sizes of fish, including juveniles. A similar practice is evident in **Colombia**.

The Guianas: French Guiana and Suriname have achieved significant success with the recent introduction of BRDs. In French Guiana the use of trash fish and turtle excluder devices has been particularly successful.

Mozambique: BRDs are used but bycatch accounts for 50–80 per cent of the catch depending on the season. Industrial trawlers, which account for 90 per cent of total national catch, are less likely to retain bycatch because it takes up valuable freezer space. Fishers are actively exploring ways to reduce bycatch, e.g. leaving a gap between the footrope to allow escape of soles.

Madagascar: The rate of bycatch decreased after the introduction of BRDs. Twenty-one per cent of bycatch is discarded, with the rest landed for commercial sale or given to local fishery cooperative members (see Table 2-3).

Venezuela: Reportedly has the highest fish to shrimp dependency in any of the multi-taxa fisheries, and probably the least selectivity. Shrimp only accounts for about 5 per cent of the total catch, and the shrimp fleet lands 35 per cent of the national fish catch. Up to 80 per cent of the quantity discarded is juveniles, and the remainder is non-commercial species.

US: BRDs are used but discards can be as high as 83 per cent and 57 per cent from the Atlantic and Gulf of Mexico shrimp trawl fisheries, respectively. Bycatch of red snapper has posed an acute problem: in the 1980s and 1990s, bycatch of juvenile red snapper by shrimp trawl fisheries in the Gulf of Mexico was identified as the reason why commercially valuable red snapper could not recover from overfishing.

Iran: Bycatch is landed, with juvenile fish and non-commercial fish (e.g., sharks; 45–60 per cent of total catch), used as fish meal and the remaining fish (25 per cent of total catch) sold for human consumption.

Trinidad and Tobago: The artisanal fleet targets fish and shrimp collectively, which has caused considerable conflict between domestic fishing groups. Industrial trawlers retain 40 per cent of their fish catch for sale on the domestic market; the remaining 60 per cent comprises juveniles and non-commercial species.

Kuwait: Ninety-eight per cent of bycatch is discarded. Bycatch includes juveniles and adult finfish, sharks, rays, crustaceans, sea snakes, turtles, soft corals, molluscs, and echinoderms.

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000).

2.5.2 Juvenile shrimp

Reference was made inTable 2-2 to recruitment overfishing. In the past it was generally assumed that, due to high fecundity, shrimp are difficult to overfish; however, this is not the case. Examples of recruitment overfishing in shrimp fisheries are highlighted in Box 2–4.

Box 2-4: Examples of recruitment overfishing in national shrimp fisheries

Madagascar: Some 200,000 fishers established themselves in the coastal belt adjacent to Madagascar's most prolific fishery (Ambaro Bay, Zone A). The use of mosquito nets in the mangroves — which catch a total of 3,000 t shrimp per year, with an average size of 0.6 grams — has led to dramatic reductions in the country's national catch. The result is that CPUE levels in this zone are too low to make industrial fishing sustainable. This fishery traditionally supported 65 industrial vessels. The small-sized shrimp are sold in domestic markets, and feudal landlords or influential middlemen support their activities. (B. Couteaux (UNIMA) pers. comm., 2009).

Mozambique: Of the 16,500 sets of coastal fishing gear, 25 per cent are beach seines; and of 15,250 boats, 3 per cent are motorized (2002). Drag nets and scoop nets are operated by one or two people in shallow water. The "purses" of all nets are frequently lined with mosquito mesh in order to minimize catch loss. Estuarine creeks, channels, and river mouths are frequently fished as they harbour high concentrations of prawns at certain times. The coastal fisheries operate throughout the year, although officially there is a closed season for shrimp. Coastal artisanal fishers maintain that theirs is not a shrimp-directed fishery, but rather fish-directed with a shrimp bycatch, so they cannot stop fishing or they would have nothing to eat. Almost the whole catch is retained, unless the organisms are very small (<2 cm). There is generally no attempt made to preserve catches, which are sold soon after landing. Shrimp catches comprise 1–10 per cent by weight of total artisanal catches, depending on the area and season. Extrapolations of artisanal catches of juvenile shrimp indicate that, in some areas, such catches are of a similar order of magnitude to industrial catches; however artisanal catches are not incorporated into annual stock assessments (Ministry of Fisheries, 2009).

India: Fishing by artisanal fishers using bag and stake nets is reported to be increasing and is endemic to most regions. These boats fish between the coastline and 5 km from shore.

Indonesia: Following a 1982 government ban on shrimp trawling in many areas, trawling was restricted to the Arafura Sea. However, no restrictions were applied on access; consequently the fleet grew from 90 to 300+ vessels. Illegal fishing inside the 10 km isobath has led to recruitment overfishing (Purbayanto, pers. comm., 2009).

Vietnam: Fishing is banned within 6 nm of the coast, but frequent violations take place within the zones by artisanal fishers and illegal trawling activity. Vietnamese trawlers are also using mesh sizes below the minimum, with the result that small shrimp are caught (Thuy and Symington, 2008).

Mexico: The country has an open access regime, with a 100,000 strong artisanal fleet targeting juvenile shrimp in coastal waters as they migrate to the offshore grounds.

Nigeria: Large quantities of prawn (*Nematopalaemon hastatus*) caught by coastal/artisanal small-scale fishing gear used within 5 nm from shore (B. Solarin, FAO national correspondent, pers. comm., October 2009).

US (Louisiana): Louisiana has no control on access and places a heavy focus on support for coastal communities. The absence of management measures provided by other state and federal regulations has meant that localized stocks (within 3 nm from shore) are vulnerable to recruitment overfishing (C. Dorset, Ocean Conservancy, pers. comm., October 2009).

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000).

There is often a particular danger of recruitment overfishing associated with coastal artisanal fisheries. Key issues include:

- Artisanal fishers can account for up to half the total catch of shrimp in some countries. In these cases they intercept juvenile shrimp before their gravid (pregnant) stages and have a very serious impact on recruitment.
- Artisanal fishers may or may not deliberately target shrimp, but in many cases local markets have developed for this product.
- Artisanal fishers are usually poorly organized and fall under control of middlemen who supply credit and other inputs. There is often no formal professional organization with which management authorities can engage.
- Artisanal fishers usually fall outside the control system. Their activities are rarely checked and they are active during closed seasons.

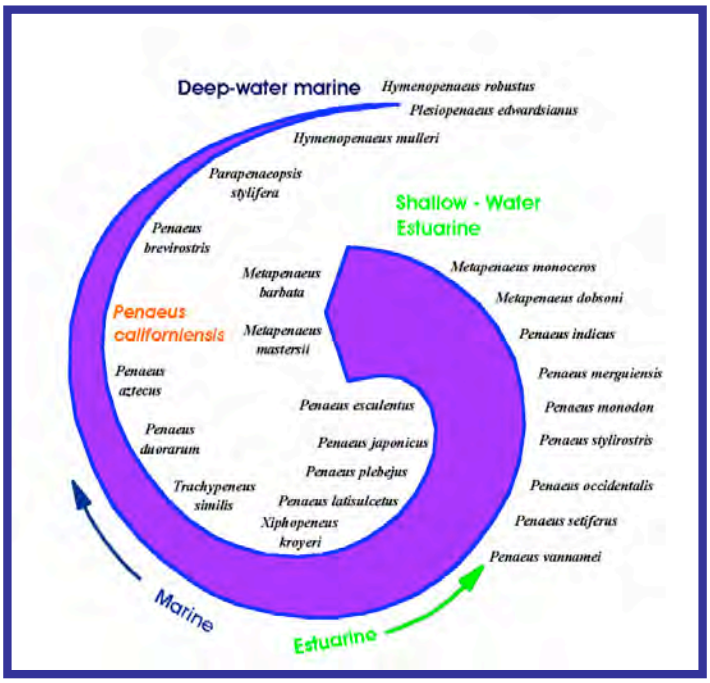
However, artisanal fisheries are not solely to blame for recruitment overfishing. Issues associated with industrial fisheries include:

- Trawling activity may take place inside designated non-trawl or sensitive inshore zones. These areas are the spawning and grow-out areas for the shrimp before spawning.

- Shrimp may be caught by small-meshed nets, as a consequence of targeting multi-taxa compositions.
- The lack of BRDs can lead to greater catch volumes of all species including small shrimp.
- The length of towing time also affects bycatch and small shrimp retention.

Figure 2-8 shows the time that some penaeid species spend inside coastal areas, illustrating the attraction of artisanal and larger trawlers to inshore fishing grounds.

Figure 2-8: Time spent inside of coastal lagoons during the lifecycle of some penaeid species



Source: Dall *et al* (1990).

2.5.3 Other threatened species

TST fisheries interact with a number of other species, including turtles, sharks, sponges, jellyfish, and syngnathids (e.g., seahorses). These include interactions with Endangered, Threatened, or Protected (ETP) species, as defined either by national legislation or an IUCN designation as vulnerable, endangered, or critically endangered. Local populations of both ETP and non-ETP species may be considered as threatened when interactions are sufficient to cause population depletion or "cascades". Species not considered particularly vulnerable to shrimp trawl activities include most dugongs and whales. However, high levels of localized activities in some waters may affect these species and their habitats as well.

Specific findings on non-fish species interactions, both before and after the introduction of BRDs, are highlighted in Box 2-5. It should be noted that the examples cited represent specific cases of identified problems, usually through observer programmes. In many cases there has been an extensive focus on turtles but not other species. Furthermore, in many cases observer programmes do not exist. As such, fishery-independent records are not very comprehensive. It is however recognized that apart from turtles, shrimp trawling may cause a problem for sea snake, syngnathid, sponge, jellyfish, and shark populations.

Box 2-5: Examples of ETP and other species interactions in national shrimp fisheries

Australia: Prior to the introduction of TEDs, the Northern Prawn Fishery reported 780 caught turtles in 2000, of which 96 were released alive. Current mortalities are reported at 0–1 per cent (Brewer *et al*, 2007). Sea snake and sawfish interactions are also problematic. The Popeye Fishbox BRD has reduced catches of the former by 43 per cent (Milton *et al*, 2009). The effects of trawling on sawfish populations, particularly *Pristis mircrodon*, continue to be the subject of research in the fishery. A particular problem is that sawfish are prone to entanglement in trawl nets due to the numerous teeth along their rostrum (Fry, 2009).

The Spencer Gulf fishery records interactions with Port Jackson sharks, but these have a high survival rate because of low stress levels. There is some debate over the impact of repetitive capture. Sponge and syngnathid interactions are also problematic. Some syngnathids are ETP species. These interactions take place close to sea grass beds, or in periods of high water clarity or seaweed drift.

India: TEDs have been provided to 3,000 boats in Orisssa, where there are two large turtle rookeries. These TEDs, funded by MPEDA, are being deployed with the support of WWF/CIFT as part of a participatory management plan. Adoption is slow and enforcement is lacking. When applied, the TEDs have been modified to suit fishers' concerns, most especially to limit the loss of commercial species. Early trials have shown that commercial catch losses are reduced to less than 7 per cent, and turtle catches eliminated.

Vietnam: TEDs have not been introduced; the fleet of 29,000 shrimp/multi-taxa trawlers catches 0.5–10 marine turtles/trawler/annum.

Indonesia: A WWF observer programme recorded an average 11 turtles caught per trawler in one 55-day campaign. TEDs are now applied, resulting in fewer interactions. Other reported species encounters include sea snakes (around 20/day/trawler) and jellyfish swarms.

Mexico: Following introduction of TEDs, turtle bycatch was reduced by up to 98 per cent. However, TED regulations (and all elements of the turtle protection law) are not necessarily well enforced, and it is known that at least some of the industrial fleet avoids using TEDs. Major concerns relate to catches of totoaba (*Totoaba macdonaldi*), indigenous to the northern half of the Sea of Cortez. Formerly abundant and subject to an intensive fishery, the totoaba has become rare, and is listed on the IUCN Red List of Threatened Species. Further concerns relate to interactions with vaquita (*Phocoena sinus*), a rare porpoise; area closures for shrimp fleets are in place at the Upper Gulf of California to address this.

Mozambique: The country reports 2,000–5,000 turtle encounters annually.

Madagascar: An observer programme recorded 42 turtle mortalities in 2002, before the introduction of TEDs. Jellyfish swarms and syngnathids (during periods of clear water) were also witnessed (but not reported) by Centre de Surveillance des Pêches (Centre of Fisheries Surveillance; CSP) observers.

Suriname/Guyana: Fisheries report occasional interactions with turtles as part of a WWF and Department of Fisheries data collection programme.

US: Debate now focused on repetitive trawl capture as it is revealed that turtles drown.

Nigeria: Interactions with turtles, sea snakes, and jellyfish swarms reported.

Kuwait: Interactions with turtles and sea snakes reported.

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000).

2.5.4 Benthic interactions

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, and 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. 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 seabed 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.

Most shrimp trawl grounds comprise mud or soft sediment — and, as described in Section 2.1, the normal process of otter trawling is designed and rigged to have bottom contact during fishing. The footrope/tickler chain ideally just skims the sediment (with no penetration beyond the first 2–3 cm), although the trawl doors will cause deeper furrows (probably up to 20 cm) because of their weight (350–900 kg each). There are however some reported interactions with seagrass beds (Cambodia), which are known habitats for juvenile fish and other sensitive organisms. Deeper-water trawls also require extra weight (up to double that of shallower water) to reduce trawl gear buoyancy during sinking.

Some "low risk" distinguishing features are the coverage of the fishery area and the season length. Some trawl grounds represent less than 15 per cent of the total fishery area. Both the Spencer Gulf and Northern Prawn fisheries in Australia are associated with low coverage as well as limited fishing seasons: 60 days in for the Spencer Gulf fishery, and 4 weeks and 4 months for the Northern Prawn Fishery (see Case Study A.1 and A.2).

Another significant feature is the weight of the gear. As highlighted in Box 2–6, many fisheries have worked to lighten this through light-weight gears (trawl doors), changing the angle of the door, removing the tickler chain, attaching floats to the head rope, and using larger-meshed gear in the trawl wings and codend. These initiatives reduce seabed penetration significantly, and also had a marked effect on reducing drag, leading to considerable fuel cost savings.

Box 2-6: Examples of gear selectivity, bycatch reduction, and fuel savings initiatives related to benthic interactions in TST fisheries

Australia's Spencer Gulf fishery (Case Study A.1): An initiative by the Spencer Gulf and West Coast Prawn Fishermen's Association (SGWCPFA) comprises: changing the angle of the trawl boards (too acute an angle would result in digging); not using tickler chains; the position of the headrope in front of the footrope; and leaving adequate space between the dropper and the footrope. Seabed analysis identified the absence of some species (bearded mussel (*Trichomya hirsutus*), southern hammer oyster (*Malleus meridianus*), and razor clam (*Pinna bicolour*)) from common trawl sites. This is believed to be in response to trawling; however non-trawling-related changes to salinity and anthropogenic disturbance may also be contributory factors. The low coverage of trawl gear over the area of the Gulf (8 per cent) resulted in categorization of benthos impact from trawling as low risk.

Madagascar (Case Study A.3): A UNIMA/WWF partnership has worked to remove tickler chains, install lightweight plastic doors, introduce larger mesh sizes to reduce drag and prevent congestion in the net, and promote short trawl times (1 hour – 1 hour 20 minutes) to reduce build up of bycatch. These initiatives resulted in a 31 per cent saving in fuel costs, with seabed penetration reported as low. In one benthic impact case study, the Institut de Recherche pour le Développement (IRD) measured seabed impacts before and after adoption of new systems over a 5- and 18-month period. The analysis showed that reduced penetration of the seabed by up to two-thirds (from 20 cm to 8 cm) resulted in very little subsequent evidence of trawl activity after 5 months. Furthermore, as the tickler chain skimmed the surface (2–3 cm), there was very little evidence of trawl activity. The trawl area within the zone was between 43 per cent and 61 per cent.

Shrimp Round Table (US) (Case Study A.4): The Ocean Conservancy and the Sustainable Fisheries Partnership (SFP) are working in the Gulf of Mexico to bring together shrimp fishers, seafood buyers, and other fishery experts in order to reduce the environmental impact of the shrimp fishery, improve and strengthen management, and make the fishery more sustainable, while assisting fishers in improving quality through the transition to cleaner, more fuel-efficient fishing gear[14]. Technology improvements have been developed that reduce bycatch by more than 30 per cent and reduce fuel consumption by up to 39 per cent.

Indonesia: Companies have voluntarily reduced the weight of trawls by reducing the length of net from 30 m to 26 m, increasing the mesh size in the codend from 30 mm to 45 mm, reducing the weight of the trawl door from 500 kg to 350 kg,

[14] http://www.youtube.com/watch?v=E-2V1qe7pnY

and reducing the propeller speed from 1,200 rpm to 900 rpm.

India: Support has been provided for the development of low-intensity trawl activity in Kerala. A significant push has been in promoting the use of larger mesh size (moving from the statutory minimum to 45 mm), shortening tow times to reduce the build-up of bycatch, and adding square mesh panels to the codends. The adoption of these practices, by albeit a small minority of fishers, has led to improved quality, efficiencies in sorting times, and minor savings in fuel costs (around 2 per cent).

Source: Poseidon country surveys.

2.5.5 Ecosystem interactions

Major and unpredictable changes may occur in food chains if the abundance of key species is reduced through fishing. This impact is similar whether the removal results from targeted catch or bycatch. One aspect of this issue is the removal of shrimp predators by trawling, which can result in profound changes in the food chain such as increased abundance of shrimp. This has been observed in both tropical and coldwater shrimp fisheries.

Seabirds and dolphins are known to consume discarded bycatch from shrimp fishing. This may improve the reproductive rate of these animals, but may also lead to difficulties if they become dependent on the discards or are injured in the process of taking the bycatch.

The impact of increased carrion (in the form of discards) on bottom detritus feeders and microbial fauna is not well known, although information on temperate fisheries is generally better than that for tropical fisheries. The oxygen depletion that may occur when discards sink to the sea bottom in shallow, poorly circulated inshore areas may cause effects on the benthic community.

2.6 GOVERNANCE SYSTEMS AND JURISDICTIONAL MANAGEMENT

Fisheries governance can take many forms. The range of governance systems applied in TST fisheries is summarized in Table 2-4 and expanded upon below.

Table 2-4: Summary of governance systems in principal shrimp-producing countries

Country	Central/national administration	Provincial/state administration	Co-management	Private company
India	✓	✓		
Indonesia	✓			✓
Vietnam	✓	✓		
Thailand	✓			
Mexico	✓	✓	✓	✓
Australia	✓	✓	✓	
Guyana	✓			✓
US		✓		
Madagascar	✓		✓	✓
Mozambique	✓			
Suriname	✓			✓
Iran	✓			
Saudi Arabia	✓			

Source: Poseidon country surveys.

Top-down, centralized administration — where policy, as well as other functions such as licensing, compliance, and research coordination, is determined at a central level — is applied in many countries (Thailand, Madagascar, Mozambique, Iran, Saudi Arabia, Guyana, Suriname, and Australian Commonwealth fisheries). In some cases, inspection may be directly attached to a central ministry; in others, it may be a semi-autonomous

agency or delegated to another organization such as the navy. Compliance uses many mediums including port inspectors, at-sea inspections, Vessel Monitoring Systems (VMS), and observers. Research operates centrally with, on occasions, locally based research centres. Funding sources include industry levies, donor support, or the central government. An example of a full cost recovery system is the Australian Commonwealth system, where the cost of managing the Northern Prawn Fishery is funded through fishery management levies which equate to approximately 3 per cent of annual Gross Value Production, equivalent to AUS$2.3 million. These monies are allocated for research, compliance, observer schemes, Management Advisory Committees, data management, log books, licensing, and administration. The specific cost component for research is AUS$866,000 (1 per cent of revenue) and for compliance is AUS$586,000 (0.7 per cent of revenue). Examples of different central government management planning are presented in Box 2–7.

Box 2-7: Examples of central government management planning in the shrimp sector

Advanced governance

Australia's Northern Prawn Fishery (NPF) falls under the responsibility of the Australian Fisheries Management Authority (AFMA; industry research and environmental organization of the state governments). AFMA has a central administration base in Canberra, with a team of 130 personnel with responsibility for 27 fisheries. The Bureau of Rural Sciences (BRS) has responsibility for some fishery research; however, the majority of fishery research is managed through the Fisheries Research & Development Corporation. AFMA is responsible for compliance. The Northern Prawn Fishery Management Advisory Committee (NORMAC) is responsible for assessing the performance of the fishery against a predefined Management Plan and the Harvest Strategy. This Committee and its defined functions preserve independence from outside political influences. NORMAC advises on changes to the management system, and actions are implemented through the Management Plan. An annual report is prepared and submitted to the minister for approval. The members of NORMAC are drawn from AFMA. The industry pays a levy, which funds the functions of AFMA, the research, and a proportion of the compliance functions. The fishery is required to comply with set action plans:

- NPF Management Plan
- Bycatch Action Plans
- NPF Harvest Strategy
- Integrated Scientific Monitoring Program
- NPF Strategic Ecosystem Data Plan, 2004
- NPF Five-year Strategic Research Plan (2001–2006)
- Compliance risk assessment and Action Plan.

The plans are developed against set objectives where the ecosystem approach to fisheries management (EAFM) is a priority.

The industry is organized through an industry company, Northern Prawn Fishery Industry Pty Ltd (NPFI). The NPFI has joined with AFMA to implement a co-management project whereby the company is responsible for making recommendations directly to AFMA in a number of areas, including fishery budgets, research priorities, and fishing season lengths. The NPFI liaises with NORMAC members on relevant issues as required to ensure its recommendations comply with the above plans.

The Australian Commonwealth takes responsibility for fisheries that transcend several state boundaries or are offshore. Its fisheries are required to respect national guidelines, most specifically as an Ecologically Sustainably Managed Fishery under part 13 and 13(A) of the Environmental Protection and Biodiversity Conservation (EPBC) Act 1999. The Department of Environment (DEWHA) plays a critical role in evaluating the fishery's environmental credentials. All fisheries from which product is exported must undergo assessment to determine the extent to which management arrangements will ensure that the fishery is managed in an ecologically sustainable way. Wildlife Trade Operation approval is established subject to meeting criteria on fishery conservation, reduction and mitigation of bycatch, and interactions with ETP species. Each fishery is required to have a Management Plan that lays down the system parameters to control capacity, effort, selectivity, and bycatch mitigation. Harvest control strategies are set based on these parameters and stock assessment.

Developed governance

US Federal Gulf of Mexico and South Atlantic shrimp fisheries fall under the management of two separate Federal Management Councils covered under the Magnuson-Stevens Fishery Conservation and Management Act. Each Council is responsible for shrimp fisheries falling under federal jurisdiction (from 3–9 miles out to 200 miles, according to specific state jurisdictions). The National Marine Fisheries Service (NMFS) is responsible for research and compliance, with some activities shared with state bodies. A distinction between the US and Australian system is that the US does not focus on an ecosystem-based management approach. Some critical issues such as turtle bycatch reduction are addressed, but bycatch reduction is largely driven by avoidance of valuable recreational fisheries as opposed to management mitigation measures driven by all ecosystem impacts.

The Councils formulate a Fisheries Management Plan and follow pre-defined guidelines. The Management Plan also requires the production of a fishery impact statement which assesses, specifies, and analyzes the likely effects, if any,

including the cumulative conservation, economic, and social impacts, of the conservation and management measures.

In the case of the Gulf of Mexico, the Council consists of 17 voting members: the Regional Administrator of NMFS (or his/her designee), the directors of the five Gulf state marine resource management agencies (or their designees), and 11 members who are nominated by the state governors and appointed by the Secretary of Commerce. Appointments are 3-year terms with a maximum of three consecutive terms. In addition, there are four non-voting members representing the US Coast Guard, US Fish and Wildlife Service, Department of State, and the Gulf States Marine Fisheries Commission. The Council meets five times a year at various locations around the Gulf coast. Prior to taking final action on any proposed rule change, public hearings are held throughout the Gulf. Public testimony is also heard during the meeting at which final action is scheduled. Proposed rule changes are then submitted to NMFS for further review and approval before implementation.

NMFS is currently exploring the possibility of increasing emphasis on ecosystem impacts as a conservation impact statement.

Developing governance

Mozambique: Some important structures have been created in terms of the Fisheries Act, including the Committee for Co-Management of Fisheries, which is the main forum for participatory management. Access to marine resources is controlled by the National Directorate of Fisheries Administration (DNAP) of the Ministry of Fisheries, which issues licences and quotas. Licence rental fees are charged, with DNAP having a policy of full cost recovery since 1996. DNAP convenes the Fisheries Administration Commission (FAC), which comprises all stakeholders including representatives from management, compliance, research, product quality, small-scale fisheries, and industry. The Commission meets quarterly to discuss management of the prawn fishery, and makes recommendations regarding the setting of TACs and quotas. A Management Plan, whose formulation was supported with technical input from Australia and Norway, was finalized in December 2009.

Mexico: Responsibility for fisheries management falls under the Comisión Nacional de Acuacultura y Pesca (National Commission of Aquaculture and Fishery; CONAPESCA), which has a set of national conservation measures in place including gear restrictions (minimum mesh sizes and maximum headrope length). Management Plans (Planes de Manejo) are new instruments aimed at providing guidelines and strategies to manage fisheries, including the shrimp sector. In 2007, the ecosystem-based management approach was introduced as a required component of the planning process, though there is no evidence of supporting risk analysis or bycatch management strategies in place at present. The National Committee for Fisheries and Aquaculture negotiates management and ordinance policies and, among other things, determines the lengths of closed seasons with fishers and fleet owners. The Committee comprises CONAPESCA and the National Fisheries Institute (INP). Academic research experts may also be invited to attend; however there are neither industry representatives nor NGOs on the Committee.

Madagascar: Responsibility for fisheries management falls under the Ministère de l'Agriculture de l'Elevage et des Ressources Halieutiques (Ministry of Agriculture, Growth, and Aquatic Living Resources; MAERH), which formulates policy in consultation with the industry and directs the Centre de Surveillance des Pêches (Centre of Fisheries Surveillance; CSP) to implement a control strategy. A management system is in place, which involves restrictive access, effort controls, zoning, technical measures, and control systems (VMS and observer coverage). The industry pays a levy of 8 per cent of annual revenue, of which 80 per cent is redirected to fisheries research, development, and compliance. A formal management consultative body (Zonal Management Conserve, ZMC) exists to discuss management planning, but initiatives are largely industry driven. The ZMC comprises GACPM (shrimp association), MAEP (Ministry of Fisheries), CSP (control agency), PNRC (Stock Assessment Research), and OEFC (Economic Research Centre for the Shrimp Industry). MAEP is subject to political influences, which threatens the independence and integrity of the governance structure. Many industry management decisions have been advanced under the auspices of the industry body (Groupement des Aquaculteurs et Pêcheurs de Crevettes de Madagascar; GACPM), or by specific companies such as UNIMA. However, lack of political will and the inadequate mandate given to ZMC has prevented action in dealing with the growing impact of artisanal fishers in some fishing zones. Consequently, industrial shrimp vessels have been forced to withdraw from the fishery.

Under-developed governance

Guyana: Legal systems are in place and Guyana has a stated policy objective of promoting sustainability for its fisheries resources. However, policy decisions often go against scientific advice, such as restricting the number of shrimp licences granted. The Guyana Fisheries Department is under-funded with associated problems of low morale. There is no effective fishery management and control structure in place. The relevant authorities do not act on contraventions so there is little incentive for compliance. Guyana has no VMS (as opposed to neighbouring Suriname). Licensing fees are paid but these only cover administration costs.

No research plans are in place. Representatives from both Fishery Departments periodically participate in the annual CRFM stock assessment workshop and are party to the debates that take place in these workshops as well as the advice given by international scientists on how the management basis of the seabob fishery might be improved. No apparent attempt has been made to follow the advice, to improve on the data collected relating to this fishery, or to identify and instigate relevant research.

Indonesia: The Ministry of Marine Affairs and Fisheries (MMAF) is responsible for implementation of policy at national

level, and the licensing and management of all vessels over 30 GT and fisheries beyond 12 nm from shore. This includes all dedicated shrimp trawlers. National fisheries policy objectives focus on increasing production and fisheries development. In 1982 Indonesia banned shrimp trawlers in all regions except the Arafura Sea, due to widespread concern about the damage caused to fish stocks. MMAF is responsible for licensing offshore and foreign trawlers. Revenues charged to national boats represents around 2 per cent of vessel sales. There is no available information on fees charged to foreign fishing companies.

MMAF introduced a series of fishery management measures for shrimp trawling as early as 1975 (mesh size and capacity limits), TACs in 1999, and additional bycatch restrictions in 2000. However, shrimp trawlers are reported as widely ignoring these restrictions while actions by MMAF and the Indonesian navy appear to be sporadic, usually in response domestic pressure to eliminate illegal fishing. Indonesian management experts advocate policies of effort restriction and closed seasons, bycatch management, and community participation, but there is no political will to implement these. MMAF now has a reported strategy of not reissuing licences to vessels perceived as non-compliant, but this is highly subjective and is also undermined at a higher political level. MMAF has no formal management/consultative committee, and management decision-making is very top down. The Association of Indonesian Shrimp Catching Companies (HPPI) supports a policy of effort reduction and seasonal closures, but is frustrated by the proliferation of illegal and foreign trawl activities. The conclusion from the experts and studies undertaken is that there is much wishful thinking about what policies should be introduced in Indonesia, but no political will to implement them.

Source: Poseidon country surveys.

Delegated provincial and district powers apply in some countries (Indonesia, Vietnam, the US, and Australia). In Vietnam and Indonesia, management and control responsibilities fall under national, provincial, and district authorities: national management applies beyond 12 nm (Indonesia) and 24 nm (Vietnam) from shore, but provincial management applies within these limits or, in the case of Indonesia, district management applies between 0–4 nm from shore. This means that shrimp fisheries could fall under the responsibility of multi-jurisdictional management. Artisanal fisheries would generally fall under district control, small-scale trawl under provincial control, and offshore fisheries under national jurisdiction. This is also the case in the US, where semi-industrial trawling takes place inside state jurisdiction, 9 nm in the case of Texas and Florida, and 3 nm for the other states, including Louisiana. Australia's state shrimp fisheries fall within 12 nm from shore. Where these occur (Spencer Gulf, Exmouth, Queensland East Coast, and New South Wales) management falls under the responsibility of separate State Departments of Primary Industry. Examples of different systems are outlined in Box 2–8.

Box 2-8: Examples of delegated provincial government management planning in the shrimp sector

Advanced governance

The **Australian Spencer Gulf fishery**, while subject to the State Fisheries Act, conforms to Commonwealth guidelines. The State Fisheries Act provides the means to undertake these operations including the setting of a Management Plan, an outline of goals, objectives, and strategies, and the setting of performance indicators for target species sustainability and ecological risk minimization. The Fisheries Council of South Australia is drawn from industry, the state fisheries management body (Department of Primary Industries and Resources, South Australia PIRSA), South Australian Research and Development Institute (SARDI), recreational and indigenous interests, and an NGO. The Council's primary objectives are (a) the implementation of proper conservation and management measures and (b) the protection of aquatic habitats and adherence to the ecosystem approach to fisheries management. In this context, fisheries performance is peer-reviewed by the Department of Environment (Department of the Environment, Water, Heritage and the Arts; DEWHA) as determined by conditions laid down by the 1999 EPBC Act. The fishery's performance is judged against a Management Plan which lays down management goals, strategies, activities, and indicators; details are provided in Case Study A.2.

Under-developed governance and multi-jurisdictional fisheries

India: The Ministry of Agriculture (MoA) is responsible for preparing the core Fisheries Acts, with Harvest Control Rules (HCRs) identified. It is also responsible for managing fisheries beyond 12 nm from shore, unless delegated to the state authority. In the case of the shrimp sector, MoA delegates responsibility for the semi-industrial trawl sector to state fisheries, but retains responsibility for the 73 industrial trawlers. The state authorities are also responsible for artisanal fishers.

National (and state) legal frameworks are in place, but there is very limited implementation of HCRs other than the closed seasons. BRDs have not been introduced up to now, and there is continual political debate about a 47-day closed season. Political influences and a heavily unionized stakeholder structure prevent management measures from being imposed.

Even were these measures to be imposed, state ministries lack the manpower to implement controls. As an example, one of the largest districts, Quilon in Kerala, has four fishery inspectors to check 1,200 shrimp trawlers. Sanctions are implemented with nominal fines of Rs.5,000–25,000 (US$100–530), but offences are continually repeated. Consequently, there is no compliance because of inadequate resources and very low fines.

The strength of the Indian system lies in its two core research institutions, the Central Institute for Fisheries Technology and the Central Marine Fisheries Research Institute, which have both produced appropriate and ground-breaking advice for the policy makers. Another influential organization is the Marine Products Export Promotion Authority, which is now promoting full traceability against the background of the European Commission (EC) Illegal, Unreported and Unregulated fishing Regulation.

The national Shrimp Trawlers Association is responsible for fishers. However, its members or representatives are not involved in any of the numerous management committees that have been created. Consultative processes exist but these tend to be retrospective, creating highly politicized interactions. Advisory management committees (17 since 1980) have produced logical HCR and capacity reduction recommendations (buy-back), but these have not been heeded at the central government level.

Some initiatives are taking place on co-management, but these are not particularly strong in the shrimp sector. NGOs (including WWF) support these activities and are especially important in the context of promoting participatory management as part of their TED/CIFT partnership. Credit support is provided in some states (Kerala) with the support channelled through the Matsyafed cooperative. This system reduces the dependency on middlemen.

Some changes are taking place with the production of a new Fisheries Management Regulation Act, which includes provision for the ecosystem approach to fisheries management.

Vietnam: The Government of Vietnam operates its fisheries systems through a central organization, the Ministry of Agriculture and Rural Development (MARD), and delegates responsibility for fisheries management for inshore fisheries (within 24 nm from shore) to the Department of Agriculture and Rural Development (DARD). In the context of shrimp fisheries, fisheries are managed by multi-jurisdictional activities. MARD is responsible for the semi-industrial fleet, while DARD is responsible for the management of small-scale trawl and artisanal fisheries (primarily in four provinces: Ben Tre, Tra Vinh, Kien Giang, and Ba Ria Vung Tau). MARD has a number of core policy objectives which are required to be followed at the provincial level. However, as is the case in many countries, Vietnam has a stated objective of increasing employment opportunities and living standards, as well as a policy commitment to scientific management and decision-making as a precondition for sustainable management practices. In practice, its activities focus only on employment generation and supporting open access to its fisheries. The concept of employment generation is also heavily enshrined with the Provincial Peoples Committee, which is the consultative body for fisheries management issues at the provincial and district level. Vietnam has as a core policy on the prevention of fishing (of any fishery) within 3 nm from the coastline and a series of national technical measures, but enforcement of the measures falls well short of what is required (i.e., small mesh sizes and no BEDs). Specific problems identified in all fisheries include: growth in coastal communities and use of destructive fishing gears; inadequate human resources at government level; open access and over-capitalization; fuel subsidies; no effective management or compliance; and weak fisher community structures. The administration lacks the political support to be able to implement management decisions and lacks the capacity to understand the longer-term goals of sustainable fishery resources. Consequently, the resources are heavily exploited, requiring a substantial reduction in fishing effort (Table 2-2), and ETP species mortalities are probably one of the highest of any of the Coral Triangle countries.

Indonesia: Dinas Perikanan Provinsi (Provincial Fishery Department; DKP) undertakes provincial fisheries management responsibilities within 12 nm from shore. Linkages between DKP and MMAF remain strong, but a primary constraint is that DKP is funded through the provincial government and so competes with other provincial departments for revenues. Consequently, DKP uses income from permits to fund its operations. This has allowed the proliferation of many different fishing methods, including the restoration of artisanal trawl fisheries under provincial jurisdiction. Nevertheless in some districts and provinces, the fishers' organizations, the Panglima Laot Lhok (local community structure), have managed to prevent shrimp trawling in coastal waters. Trawling usually proliferates in communities where these organizations are weak.

Source: Poseidon country surveys.

Co-management systems are beginning to emerge in some fisheries. The Indonesian example demonstrates the power of communities where the activities of shrimp trawlers impinge on the well-being of coastal communities. These issues are largely preventative at the local level, and when single management demarcations exist. Such actions are not applied at the multi-jurisdictional level where artisanal fisher livelihoods appear threatened by shrimp trawlers (examples include Nigeria, Trinidad and Tobago, and the Philippines), or where industrial fisher livelihoods are threatened by coastal fishers targeting immature shrimp (Madagascar and Mozambique). In the case of the Philippines, artisanal fishers place artificial obstacles on known trawl grounds as a disincentive to trawling.

A good example of co-management in industrial fisheries can be seen in Australia's Spencer Gulf prawn fishery. The SGWCPFA applies a real-time management decision-making process through the *Committee at Sea*. Catching of prawns up to a target limit reference point, catching a high volume of gravid females, or interactions with bycatch species (i.e., blue crab, leather jackets, or syngnathids) result in fishers taking a collective decision to move on. In some cases high bycatch hot spots have been designated as voluntary closed areas. In addition to independent observer coverage, SGWCPFA also provides its own observers (crew members from other vessels) to

record catch and bycatch data. The quality of the information provided has been independently validated as sufficiently robust. Australia's Northern Prawn Fishery is implementing a similar observer scheme, in particular in recording bycatch of ETP species and implementing "move on" provisions in small prawn areas. The Northern Prawn Fishery co-management trials also include industry taking responsibility for logbook and data management functions (following up over-due log book returns, data integrity and verification, reconciling log book data with seasonal landings data, and creating data summaries) and advising AFMA on commercial and operational matters (season start and end dates, spatial and temporal closures, gear trial areas, in season management arrangements, and fishery budgets).

Mexico is an example of a country with a strong cooperative structure. The government has recently introduced a community quota system (i.e., allocating community quotas to artisanal fishers through fisher cooperatives) as a forerunner to a more elaborate scheme. The scheme, though supported by strong logistical support from government (data collection and catch recording), also demonstrates an increased level of community participation and a significant reduction in the level of non-compliance.

Company-led governance may also exist where there is government inaction, or where rights-based fisheries systems are an established part of the fishery. Examples include Madagascar (UNIMA), Suriname (Guinana Seafoods), and Guyana (Noble House)[15], where individual companies have taken unilateral actions to reduce bycatch and improve the operational efficiency of their vessels (see Case Study A.7). This, against the background of broad inaction by regulatory authorities, often succumbs to political interference. However, there remains an important role for government in these fisheries because of interaction with other fisheries groups. In Madagascar, the company's initiatives have to a large extent been undermined because of a government failure to control growth in the artisanal fishery, which is catching large volumes (around half) of shrimp in juvenile stages. This has resulted in the collapse of the offshore fisheries adjacent to artisanal fisher activity. A similar problem is occurring in the Guianas, with non-licensed shrimp trawlers fishing illegally for Atlantic seabob. Details of initiatives made by various individual companies are highlighted in the case studies.

A small number of partnership initiatives, usually with NGOs, have also been established. Examples of these are provided in Box 2–9.

[15] Guinana Seafoods and Noble House are part of the Netherlands Heiploeg BV group of companies.

Box 2-9: Examples of development initiatives between industry, donors, and NGOs

UNEP/GEF/FAO REBYC project: Implemented by UNEP, executed by the FAO Fisheries Department, and co-funded by the Global Environment Facility (GEF), FAO, and the 12 participating countries, this global project had a total budget of US$9,150,000 and a duration of six years (June 2002–June 2008). Its main objective was to reduce discards in TST fisheries by introducing appropriate fishing technologies; other objectives included the reduction of overall bycatch by shrimp trawlers, in particular juveniles of commercially valuable species, and a better understanding of the impact of shrimp trawling on marine habitats. Overall, the project made important progress towards reducing discards and bycatch, although there were differences in progress among countries.

Outputs included:

- Tests completed on BRDs and decisions on what devices should be promoted/recommended for regulations for some fisheries. Probable bycatch reductions estimated at 30–40 per cent. Revised or new legislation adopted in some countries, and legal reviews in others.
- Recognition of the need for a wider fisheries management approach reinforced, including effort controls through closed seasons/areas and limits on number of trawlers.
- Extensive technical regional (and global) collaboration established and cooperation initialized, and steps taken towards harmonization of bycatch reduction at sub-regional level (Nigeria/Cameroon/Gulf of Guinea countries; Mexico/Latin America and the Caribbean; South East Asia Fisheries Development Centre (SEAFDEC)/Southeast Asia).
- Increased knowledge of bycatch composition and quantities.
- Cooperation between governments (officials and researchers) and the shrimp trawl industry/private sector established or strengthened in countries where it existed pre-project.
- Awareness of the importance and usefulness of BRDs and enhanced knowledge of possible technical solutions among relevant national institutions and administrations as well as within the fishing industry.
- An FAO manual/guide on BRDs published ("A Guide to Bycatch Reduction in Tropical Shrimp Trawl Fisheries");
- Training materials on JTEDs developed (by SEAFDEC) and set-up of a project website.

NORAD/Government of Mozambique: The Norwegian Agency for Development Cooperation funded a consultant for the preparation of a highly credible Management Plan (Ministry of Fisheries, 2009). This is the only one of its kind outside of Australia and the US.

WWF/Environmental Defence Fund (EDF)/CONAPESCA/INP/other NGOs (Mexico): This major precedent in cooperation between government, international NGOs, local NGOs, and funders focuses on Incentive Based Fisheries Management (IBFM) in Mexico. Funded by the Walton Family Foundation, this project started in 2008 by creating a working group with the main task of evaluating national capacity and enabling environment for implementing IBFM. In 2009, the project established a quota system for the artisanal shrimp fishery in Sinaloa State, Gulf of California. Along with an extensive effort by the federal government (CONAPESCA) and the Sinaloa state government in establishing an accurate record of artisanal fishers in the shrimp fishery, the project established the required inputs for the first steps toward a successful IBFM system: a calculation of TAC, establishment and allocation of quota, and a third-party monitoring system in every port of arrival. In 2010, the project consolidated the quota system in Sinaloa and may expand to the artisanal shrimp fishery in Sonora State. It is expected that in the medium-term the industrial fleet will participate in the quota management system.

WWF/UNIMA sustainability partnership (Madagascar): UNIMA's trawling operations have a strong focus on sustainability best practice. The main issues addressed are: trawl nets and BRDs/TEDs designed to reduce bycatch (driven at least in part by fuel efficiency and cost saving opportunities) and carbon emissions; responsible effort reduction strategies and partnerships (closed areas, voluntary reductions in active vessel numbers); co-management discussions with artisanal fisher groups in cooperation with WWF and development agencies, including donating a percentage of fish caught to fishers' cooperative members; participation in WWF turtle catch recording programmes; and implementation of UNIMA crew best practice programmes. WWF focuses on using its influence to promote UNIMA's responsible/sustainable fishing practice to strategically important retail outlets, and to leverage the better practices that the company has developed within the trawling and other business lines to other companies globally. The resulting benefits are: (1) promote more sustainable business practices and demonstrate that such practices can generate financial and market benefits; (2) demonstrate the role that private companies can play in protecting the natural environment and in enabling social and economic development; (3) encourage wider adoption of sustainability in the business models and financing of private sector activities; and (4) demonstrate that partnerships can achieve faster, more credible, and more substantive progress towards sustainable business.

Shrimp Round Table (US): The Rountable is a partnership between a Texas seafood company, the Ocean Conservancy, and the EDF to improve the shrimp fisheries in the US Gulf of Mexico and South Atlantic[16]. Best Management Practices developed include: changing trawl doors, generating a 28 per cent fuel savings; introducing BRDs that reduced bycatch by 50 per cent; and reducing crew workload. The current focus is on minimizing impacts on wider shrimp habitats and

[16] http://www.youtube.com/watch?v=E-2V1qe7pnY

bycatch reduction strategies.

WWF/CIFT/Forest & Wildlife/state fisheries (India): TED trial runs of 0.45 minutes – 1 hour have been undertaken in Dharma and Paradeep, Orissa, in partnership with semi-industrial trawlers. Bycatch and turtle interactions were measured, and gear was adjusted to suit fisher's concerns about fish loss.

WWF-US: Using the MSC-certification process as a tool to create economic incentives for sustainable fishing, the WWF-US Fisheries Program has over ten years experience facilitating MSC certification of small-scale and community-based fisheries. WWF first partners with major seafood businesses to gain their commitment to sourcing MSC-certified products, then evaluates the sustainability of their source fisheries and collaborates with fishers, seafood industry leaders, and governments to help the source fisheries meet the MSC standard.

The MSC pre-assessment process helps identify barriers to sustainability, while the full assessment process rewards responsible fisheries in the marketplace and incentivizes change in similar fisheries around the world. If after pre-assessment a fishery is found to not yet meet the MSC standard, WWF-US uses the results to engage stakeholders in the design and implementation of a fishery improvement project that will move the fishery toward the MSC standard.

The three-pronged approach consisting of company outreach, MSC certification, and fishery improvement projects is changing seafood markets from both ends of the supply chain. With assistance from WWF's global network and partnerships with local NGOs, these MSC-based efforts have generated conservation successes in over 40 fisheries worldwide. WWF-US is presently working with the respective in-country network offices to guide two shrimp trawl fisheries through the MSC process.

On the basis of the above examples of applied governance across a range of countries, some specific summary points can be made:

(1) Policy objectives are provided in many countries. These usually provide for reference to sustainable management of resources, but where economic development/employment generation/food security is a stated as an objective along with sustainable fisheries management, economic development takes priority. No attempt appears to justify the fact that a long-term focus on sustainable fisheries management reduces the risk to coastal community preservation and supports food security.

(2) Only one country, Australia, has endorsed ecosystem-based management as a core management principle.

(3) Implementation of objectives is achievable only when there is a Management Plan with set objectives, goals, defined results, activities, and monitoring indicators assigned.

(4) Management councils/committees need to be established with all relevant stakeholders, including fishers from all groups, national and provincial/state administrations, research organizations, compliance organizations, and NGOs. Such organizations should report against the established objectives, goals, and activities, with performance judged against the indicators.

(5) Management Plans preserve the independent integrity of actions and are the best mechanism to avoid political interference.

(6) Management Plans need to be assessed and monitored. This requires an independent peer review process.

(7) Cost recovery systems are in place in some developed (Australia) and some developing country fisheries (Madagascar, Mozambique). These are proven to work effectively, and form the basis for institutional strengthening (licence administration, compliance, and research).

2.7 MANAGEMENT SYSTEMS

Fisheries management tools are often grouped into:

- **Input (or fishing effort) controls**: such as the number and size of fishing vessels (fishing capacity controls), the amount of time fishing vessels are allowed to fish (vessel usage controls), or the product of capacity and usage (fishing effort controls)
- **Output (or catch) controls**: such as Individual Transferable Quotas (ITQs) which limit the tonnage of fish or the number of fish that may be caught from a fishery in a period of time
- **Technical regulations**: relating to fishing gear (such as mesh size) or area or time restrictions that restrict access to an area by fishers in some way.

This section considers the use of such measures in TST fisheries.

2.7.1 Input controls

Reference has already been made to the lack of any access control in many shrimp fisheries. Fishery managers with the foresight to establish restrictive access are very rare, including in developed economies. Failure to implement access control has ultimately required the use of different capacity reduction schemes to address excess levels of fishing effort and fleet capacities. Examples of these are discussed in more detail below, with specific details of input management controls applied to different TST fisheries summarized in Table 2-5.

Buy-back schemes to reduce capacity were applied in Australia's Northern Prawn Fishery on three successive occasions (mid-1980s, 1990, and 2006/07), removing 250 vessels over 25 years, while in Texas, US, a buy-back scheme applied over a period of 19 years decreased fishing effort by an estimated 48 per cent. The Texas scheme was funded from public finances. The early Australian schemes were primarily funded by a loan repaid by industry levies, while the federal government wholly funded the latest scheme on the condition that the fishery move to a system of ITQs. Mexico is the only other country known to have applied a buy-back scheme, however this bought out latent capacity and was undermined by subsequent re-entry of trawlers.

Gear Statutory Fishing Rights (SFRs) based on headrope length are applied in Australia's Northern Prawn Fishery, with the precedent followed in Madagascar. Implemented to provide a flexible restructuring tool when reductions in effort and/or capacity are required, the scheme works on the basis of gradually reducing the headrope length of the entire fishery, requiring the industry to purchase additional entitlements within the sector or reduce their own company fleet capacity (see Box 2–10 for details). The scheme proved successful in Australia with the removal of 48 vessels and a 50 per cent reduction in headrope length over two successive compulsory reduction schemes. However it has not been successful in Madagascar because the initial allocation of gear SFRs was inadequate to cause sufficient reductions in capacity. The lack of capacity reduction, coupled with increases in effort by the artisanal fleet, has not resulted in corresponding medium- to long-term increases in CPUE. Mexico has an established headrope restriction of 13.5 m, but these are not tradable and were introduced to prevent increases in multi-trawl configurations.

When reductions in effort are applied with substantial reductions in capacity supported by gear SFRs (to eliminate technical creep), substantial increases in CPUE are achieved (Figure 2-9).

Box 2-10: Gear Statutory Fishing Right system applied in Australia's Northern Prawn Fishery

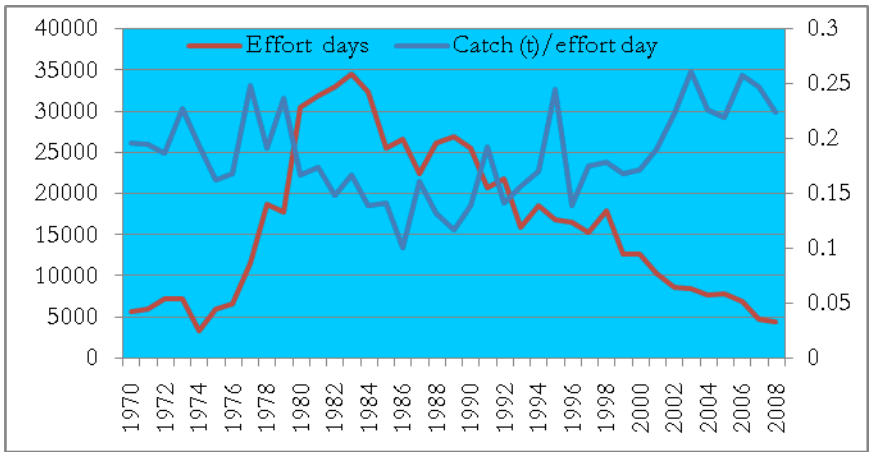
Entry to the Northern Prawn Fishery is through the holding of SFRs, which are recognized as being a form of property right created by statute. Under the NPF Management Plan, operators must hold both a Class B SFR (for the vessel) and the appropriate number of gear SFRs for the length of headrope they wish to use. A gear SFR currently represents 7.481 cm of operational headrope for operators towing twin gear and 6.732 cm of headrope for operators towing quad gear or tongue nets. There is a minimum holding of 100 gear SFRs for each Class B SFR. In this way, the SFRs control fishing capacity by placing limiting both the number of trawlers and the amount of gear permitted.

There are currently a total of 52 Class B SFRs and 35,479 gear SFRs issued for the fishery, all of which are fully transferable and may be bought, sold, or leased. Persons who are granted SFRs under the Management Plan (the owners of the fishing concessions) are able to lease them to other parties who then become the holders of those SFRs for the term of the lease. In those instances the SFR holder has a leased interest in the fishing right, with the interest expiring at the expiration of the lease.

The number of total gear units allocated does not change. However, the value of all gear units can be adjusted (upwards or downwards) in response to biological and/or economic parameters in the pursuit of the fishery's MEY target. This is done through increasing or decreasing operational headrope length on a proportional basis.

Source: A. Jarrett, NPFI, pers. comm.

Figure 2-9: Effort and catch per day (t) in the Australian Northern Prawn Fishery (tiger prawn)



Source: NPF Industry Pty Ltd (2008).

Surrender of fishing rights: In 2008 companies voluntarily surrendered fishing licences in Madagascar from 75 to 70 vessels as a response to an immediate requirement to reduce effort, and a failure of the government to introduce punitive SFR reductions. The current expectation is that the fleet may reduce in size to 20 vessels in response to rapidly declining CPUE.

Removal of latent fishing rights: At the time of writing, the US federal government was seeking to eliminate latent licences in the federal fishery to prevent effort expanding, if and when economic conditions improve. The federal fishery reports 526 latent licences.

Removal of licences as a result of bad practice: Indonesia's MMAF reports a policy of removing licences for vessels with a record of non-compliance. It is not clear how effective this scheme is, and there are reports that decisions taken were undermined by political interference.

Diversification of fishing activities: The Vietnamese, Nigerian, Mozambican, and Indian governments encourage diversification to other species, or to deeper-water prawns. This does not appear to have reduced capacity, but in some cases has reduced fishing effort for short periods.

Seasonal prohibition is a further mechanism to reduce active fishing effort[17]. The closures are usually set when female prawns are gravid or when juvenile prawns are in the fishing grounds. Intermediate closed periods (4–6 months) are applied in Madagascar, Australia's Northern Prawn Fishery and Spencer Gulf fishery, Mozambique, and Mexico, while shorter periods (around 1–2 months) are applied in India, Indonesia, the US, and Vietnam.

Fishing demarcation zones are established in a large number of countries. These are used to (a) partly separate different fisheries, and (b) to protect inshore areas from trawl activity, including sensitive habitats such as seagrass beds. These demarcations apply in India, Indonesia, French Guiana, Suriname, Vietnam, Australia, Nigeria, Mozambique, Madagascar, Cambodia, and Cameroon. The range of specific demarcations shows very little consistency in definition: some fisheries allow trawling from the low tide mark, others from the 5, 10 or 25 m isobath; some fisheries allow trawling within 2 nm from shore, others from 2–3nm and beyond.

Trawl bans have been instigated in three countries in response to the impact on other fisheries and pressure from coastal communities: Indonesia from 1982, the Philippines from 1984, and Venezuela in 2009. In the cases of the Philippines and Indonesia, these bans are being abused in some areas.

[17] Seasonal prohibition could also be classified as a technical control measure. However, on review of its applications, it is to a large extent used partially to protect gravid females and juveniles, but fishing seasons are increasingly reduced as a means of supporting a system of effort control.

2.7.2 Output controls

Examples of applied output management controls are discussed below, with specific details for different TST fisheries summarized in Table 2-5.

Total Allowable Catches (TACs) have been introduced as a management tool in Indonesia, French Guiana, Mozambique, and for one species in the US (royal red shrimp (*Hymenopenaeus robustus*)[18]). Industry and management authorities have ignored the Indonesian catch quota since its inception, and scientists state that they have no basis on which to make annual assessments of changes to the TACs. Mozambique's TACs apply to the industrial fishery, but are seldom reached and, if reached, it is likely that the TAC would be increased to accommodate specific companies. TACs are used successfully in Australia's Spencer Gulf prawn fishery as a tool to prevent overexploitation of the spawning stock during the spawning period. TACs/individual boat quotas (see below) have recently been introduced in Mexico and applied to the artisanal fishery, but not as yet to industrial vessels. The divisions are quite controversial given the growth in the artisanal sector, from 20 to 50 per cent of the catch from 2000 onwards. TACs are about to be introduced as a management tool in Australia's Northern Prawn Fishery in conjunction with individual transferable quota (ITQ) SFRs.

Individual boat quotas (IQs) are applied in Mozambican and Madagascan industrial and semi-industrial fisheries. There is strong resistance to IQs from the industrial fishery largely because (a) they have seen their segment catch shares diminish, and (b) they perceive that there is little incentive to transfer quotas as CPUE is falling. The Madagascan companies have theoretically had IQs in place for some time, but have had no incentive to apply them because of reduced catches and reduced profitability. There is no incentive to purchase IQs when CPUE levels are falling. ITQs are to be introduced into Australia's Northern Prawn Fishery, with allocations reportedly to be based on existing gear SFRs. The government sees the ITQ system as preferable to the existing gear SFR system as it will purportedly facilitate more autonomous adjustment than the gear SFR system; however, the industry is opposed to this change.

Mexico has introduced a pilot community quota scheme for artisanal fishers. The scheme has the support of extensive logistics for data collection (184 landing sites) and inspection. TACs are set for bays and lagoons. The quota system may be extended to the industrial trawl sector over the next two seasons, but it has been important to demonstrate control of the artisanal sector in order to secure the support of the industrial sector. The pilot study has shown a marked increase in compliance.

Minimum landing sizes are used as a tool in only two shrimp fisheries: the Louisiana State shrimp fishery (US) and in Vietnam. In both cases, there appears to be little evidence that the regulation is applied.

Average mean sizes are used in real-time fisheries management measure in Australia's Spencer Gulf fishery. Harvest strategy decision rules permit a "mean size" dependent on fishing period and the strategy to be applied; in November and December, the mean is <250 prawns/7 kg, while in March under a standard strategy, the mean is <220 prawns/7 kg. If the mean size is below this, the *Committee at Sea* will change to another fishing area — and if it is consistently below the benchmark, the fishery will close.

Bycatch retention is used as a means to ensure sufficient bycatch is landed in some fisheries to bolster the supply of fish for domestic food security. Such measures are reported in Madagascar, French Guiana, Mozambique, and Nigeria.

Australian fisheries have implemented **bycatch exclusion** regulations to ensure that certain species are not targeted. These usually relate to fish species (sharks, skates and rays, barramundi, threadfin salmon, jewfish, queenfish, and others).

[18] While not one of the main target species in this fishery, royal red shrimp is protected by catch control triggers as a precautionary measure.

Table 2-5: Examples of input and output management controls applied in the shrimp sector

Country	Effort/input controls				Output controls			
	Restricted access licensing	**Days at sea/seasonal closures**	**Fishing gear units**	**Vessel operational demarcations/ No trawl zones**	**TACs**	**IQs and user rights**	**Min. shrimp landing size**	**Fish bycatch restriction (% total)**
India	Maximum vessel number set for each province. Previously a large number of entries facilitated through fuel subsidies.	Monsoon trawling ban (Kerala: June 14 – July 31; Orissa: April–June). Implemented by all coastal states (47 days). Turtle season trawl exclusion in Orissa (November–April; depending on the monsoon).	✓	Trawlers restricted to beyond 12 nm, but Orissa applies a dispensation to allow trawlers to fish from 5 km.				
Indonesia	Open access but some more recent limitations on reissuing licences. Vessels fish 280 days per year with trips of 40–60 days.	45-day trawling ban during monsoon.		Trawling only permitted in the Arafura Sea, in a defined area (east of the 130° longitude line and beyond the 10 m isobath line). Trawl bans applied elsewhere.	Yes, but not enforced.	Individual company quotas based on vessel GT, but system not transparent and vessel landings not comprehensively checked.		
Vietnam	Licences granted on the basis of submitting a number of supporting documents such as vessel inspection and registration papers; small licence fee levied proportional to engine size.	Closures around March to July every year depending on the area.		>90 hp vessels must trawl offshore (from 24 nm) in zone 3; <90 hp can trawl in zone 2 (6–24 nm from shore).			Yes, but not enforced.	
Mexico	Restrictions on access to industrial fisheries, but some re-entry/re-capitalization. No	Fishing season modified according to the results of biological research. *Pacific Coast:*	Maximum legal size of headrope for artisanal "Magdalena I"	Area closures established to protect juvenile shrimp in coastal waters (up to 15	First TAC estimation for artisanal Pacific coast shrimp	Allocation for artisanal fishery, with community quotas divided		

Country	Effort/input controls				Output controls			
	Restricted access licensing	**Days at sea/seasonal closures**	**Fishing gear units**	**Vessel operational demarcations/ No trawl zones**	**TACs**	**IQs and user rights**	**Min. shrimp landing size**	**Fish bycatch restriction (% total)**
	restrictions on artisanal access until 2009.	September to February. *Gulf of Mexico* May to August and mid-May to October in two different areas. Closed season extended to all fisheries.	system (13.5 m).	nm from shore) and lagoons in the Yucatan peninsula; trawling forbidden in waters of less than five fathoms. Enforcement has been rather lax.	fisheries done in 2009 (INP); TAC and quota allocations made in the past for artisanal fleets in Campeche (Gulf of Mexico).	between cooperatives.		
Philippines				Trawl ban implemented for some areas, but not enforced.				
Nigeria	Open access, with restriction in shrimp trawler size of <23.2 m overall length and 130 GT.			Delimitation of a non-trawling zone of 5 nm.				70%; regulation concerning minimum sizes at sea.

Country	Effort/input controls				Output controls			
	Restricted access licensing	**Days at sea/seasonal closures**	**Fishing gear units**	**Vessel operational demarcations/ No trawl zones**	**TACs**	**IQs and user rights**	**Min. shrimp landing size**	**Fish bycatch restriction (% total)**
Australia	Limited entry, and historic support for buy-back (industry/ government co-funded). Implementing new boat replacement polices aimed at limiting and reducing capacity (NPF).	Restricted fishing seasons *NPF*: Banana prawn: 6–10 weeks from March/April to early June; tiger prawn: 1 August to 28 November plus time of day closures. *Spencer Gulf:* Open periods restricted to 60 nights in full moon periods, generally outside spawning season. Limited spawning season fishery in December (10 days).	Gear SFRs (maximum headrope length). Twin rig only for some fisheries.	No trawl zone inside 5 nm from shore; does not apply on Queensland east coast where fishing allowed up to low tide mark. Spencer Gulf: waters greater than 10m depth, permanent voluntary closures, fishing closures dependent on prawn sizes and catches.	*NPF*: TAC proposed from 2010 *Spencer Gulf*: Catch limit mean reference points (set in kg/h), period quotas (especially during spawning season).	Tradable gear SFRs linked to headrope length[19]. ITQs introduced from 2010/2012.		
Guyana	Government issuing additional seabob fishing licences against both industry and scientific advice.	6-week closed season (September/October), but not consistent with scientific advice (April–June) when females are gravid.						
French Guiana	Yes	No	2x 22 m trawls per boat.	No trawling inside 30 m.	Yes, 4,108 t.			All bycatch landed.

[19] No more than 53,844 gear statutory fishing rights are in force. A prawn trawl net with an operational headrope of a length calculated by dividing the total length of operational headrope specified in the determination by 53,844 (measured when the rope is taut); and (ii) a prawn trawl net with an operational footrope of a length calculated by multiplying the length of operational headrope worked out under sub-paragraph (i) by 1.15 (measured when the rope is taut).

Country	Effort/input controls				Output controls			
	Restricted access licensing	**Days at sea/seasonal closures**	**Fishing gear units**	**Vessel operational demarcations/ No trawl zones**	**TACs**	**IQs and user rights**	**Min. shrimp landing size**	**Fish bycatch restriction (% total)**
US	Federal licensing requirement but access rights to 16,000 vessels, when 3,500-4,500 are active.	Royal red shrimp quota opens 1/1 and closes when quota ends; 45–90 days seasonal closure in Texas. Other seasonal restrictions may apply.			Yes, for royal red shrimp.		Louisiana: minimum size limit on white shrimp.	
Mozambique	Restrictive access. No cap on deepwater licences.	6-month closed season instituted, from September to March.		Not allowed to fish within 3 nm from shore or <10m water depth; semi-industrial trawlers not allowed within 2 nm from shore.	TAC for industrial fleet (shallow and deepwater) but not semi-industrial or artisanal fleet.	IQ allocated to companies.		Obligatory 2:1 bycatch: prawn ratio.
Madagascar	Restricted access to zones A, B, C, D divided between industrial and artisanal fishers.	Fishing season from 1 March – 30 November; east coast fishery open all year. Night fishing prohibited up to 14 April.	SFRs based on headrope length.	Voluntary restrictions include: night fishing ban during first 45 days of fishing seasons in 2005 and 2006; not using tickler chains in front of the body of the net (a widespread practice in the past); alternation between day and night fishing during the season.		Tradable SFRs linked to headrope length[20]. Vessels allocated fishing rights for 20 years, which are transferable between operators. Licences and engine units may be sold or rented, but no one company can own more than 40% of the licences. Engine unit values fixed and		Each kg of landed shrimp be accompan-ied by at least 0.5 kg of fish.

[20] No more than 53,844 gear SFRs are in force. A prawn trawl net with an operational headrope of a length calculated by dividing the total length of operational headrope specified in the determination by 53,844 (measured when the rope is taut); and (ii) a prawn trawl net with an operational footrope of a length calculated by multiplying the length of operational headrope worked out under subparagraph (i) by 1.15 (measured when the rope is taut).

Country	Effort/input controls				Output controls			
	Restricted access licensing	**Days at sea/seasonal closures**	**Fishing gear units**	**Vessel operational demarcations/ No trawl zones**	**TACs**	**IQs and user rights**	**Min. shrimp landing size**	**Fish bycatch restriction (% total)**
						agreed annually. Possible to transfer values from semi-industrial to industrial, but weighted at a penalty of 1.5:1. Maximum of 90 m set for new vessels.		
Cambodia				Trawling prohibited between the shore and the 20-m isobath (up to 10 km offshore).				
Venezuela				Trawl ban implemented from 2009.				
Iran		Approx. 6-week fishing season in each province; opening and closing based on maturity and body length of shrimp and percentage (20%) of remaining stock.	✓					

Source: Poseidon country surveys.

Table 2-6: Examples of technical measures applied in the shrimp sector

Country	Minimum codend mesh size	BRDs/JTEDs/other bycatch mitigation systems	TEDs	Closed areas
India	35 mm, but 8–10 mm used by most fishers.		Compulsory in Orissa only because of proximity of trawl grounds to rookeries.	Closed areas in states like Orissa, Gujarat, Tamil Nadu.
Indonesia	25 mm; 45 mm for foreign trawlers.	Work funded by GEF under auspices of SEAFDEC to introduce JTEDs in the process of introduction.	TEDs are a legal requirement.	
Vietnam	20 mm for boats with <33 hp engines ; 30 mm for boats with >33 hp engines.		Promotion programmes exist, but no real evidence of application.	Marine protected areas, 15 presently in the planning stage but not necessarily related to the preservation of juvenile shrimp.
Mexico	37.5 mm; maximum legal headrope size for artisanal "Magdalena" system (13.5 m).	Mandatory	Mandatory for all vessels >10 t.	
Nigeria	44 mm, but considering 60 mm to minimize bycatch.	Square mesh window; square mesh codend; 90 degree or gentle codend.	Required since September 1996 but still not fully implemented. Grid types include bent rod.	
Australia	45–60 mm	Permitted BRDs (square mesh codend/panels, fisheye specifications, Radial escape, and Popeye Fishbox (NPF)). BRD and crab separator bag (Spencer Gulf) and use of on-deck sorting hoppers.	Used in all fisheries except Spencer Gulf where there are no turtle interactions. TED application accompanied by an extensive crew training programme.	Gazetted/"green zone" areas of prospective high bycatch interactions, seagrass beds, all areas <5 m in depth in some (but not all) areas, and voluntary closed areas.
Guyana		TEDs required by law; BRDs not compulsory, but successful trials leading to widespread adoption.		
French Guiana	45 mm		Trash and Turtle Excluder Device (TTEDs)	Less than 30 m depth
US		BRDs applied and continually under development. Major issue with red snapper selectivity. Construction and installment manuals provided (http://sero.nmfs.noaa.gov/sf/BRDs.htm).	Applied and continually evolving. Current concerns about large-sized turtles and repetitive capture.	Tortugas Shrimp Sanctuary, Texas Flower Gardens, and the Florida Middle Grounds.
Mozambique	60 mm	No; some skippers may rig their gear in order to reduce bycatch of soles, e.g., by leaving a gap		

Country	Minimum codend mesh size	BRDs/JTEDs/other bycatch mitigation systems	TEDs	Closed areas
		between the footrope		
Madagascar	25 mm, but industry applies 50	Applied since 2003.	Applied since 2003 (70 mm).	
Cambodia	40–50 mm (non-gazetted)			No trawl zones
Suriname	45 mm for all trawlers	BRDs not compulsory, but the result of ongoing trials leading to widespread adoption and will be made compulsory by law.	Required by law.	Zone from the coastline to the nominal 18 m isobath line for seabob Zone from the coastline to the nominal 30 m isobath line for marine shrimp.
Cameroon	25 mm			

Sources: Poseidon country surveys, UNEP/GEF/FAO (2000).

2.7.3 Input versus output controls

The Australian government (primarily the Australian Bureau of Agricultural and Resource Economics; ABARE) has done substantial work to review preferred management options for the Northern Prawn Fishery. An ABARE paper published in 2004[21] provides a comprehensive analysis on future management options for the fishery, centred on economic efficiency considerations. This fishery was the recipient of a government-funded buy-back scheme, but also had successfully applied a gear SFR scheme (Box 2-1010). The ABARE research, along with separate work to evaluate the costs and benefits of the ITQ system, identified strengths and weaknesses of the different input and output control schemes; these are summarized in Table 2-7.

[21] Rose and Kompas (2004).

Table 2-7: Strengths and weaknesses of effort management and individual quota schemes

Strengths	Weaknesses
Input controls (Individual Transferable Effort; ITE)	
Generally self adjusting, such that in times of high catchability (i.e. abundance) CPUE increases, and catches for a given effort input are larger. Reverse occurs in periods of low catchability.	Constant and strong incentive for operators to substitute the managed input/s with alternative unrestrained inputs to increase their relative fishing power[23].
Real effort reductions have occurred through the reductions/sale of SFRs, with resultant loss in real effort.	Normal effort creep through better knowledge/knowledge sharing, improved technology, etc routinely undermines management and complicates assessment and management processes.
As catch volumes are not capped, effort based systems are less prone to high-grading and/or discarding behaviour.	Inevitable structural adjustment programmes and alternate management policies to ratchet back effective fishing effort are costly to government and industry.
Are more likely to be more effective than output controls where CPUE is relatively stable in comparison to seasonal variation in stock abundance (as is the case for tiger prawns)[22].	Delays inherent in processes to introduce new input based management controls (policy development, legislative processes, consultation etc) may enable effort substitution strategies to be applied at much the same time as new management constraints are introduced.
Are generally more acceptable to fishers, perhaps because individual operators believe they can catch more fish with a given effort level through superior fishing knowledge and/or efficiency.	Governments have been reluctant to introduce cuts in effort as recommended by scientists.
Output controls (ITQ)	
Provide a more accurate match between actual fishing mortality of target species (landings plus discards/high grades) and the desired fishing mortality as determined by stock assessment processes.	May encourage high-grading and discarding of smaller or less valuable prawns subject to the cost of fishing and the price differential between different size/grade prawns.
ITQ management should encourage industry to maximize the economic returns from their available quota share through fishing at least cost, and at optimal times for sizes/grades that will maximize market returns. Minimizes likelihood of competitive and inefficient race-to-fish behaviour.	The need to closely monitor catches at the individual boat (quota) level, and across the fleet in aggregate, may contribute to high monitoring and compliance costs[24]. This results in very high control costs where fleets are in large numbers. For example, company quotas were introduced in Indonesia but abandoned because of the inability to monitor uptake. *Mexico's IQs system, applying to artisanal boats, is heavily resourced by fishery data collectors and inspectors. This is not accompanied by a formal system of cost recovery.*
Quota transferability encourages flow of quota to more economically efficient operators optimizing the economic return for a given amount of product.	
Having a defined share of the TAC under a strong property right should encourage operators to fish responsibly to maximize returns and protect their investment.	Pre-season surveys and/or stock assessment work to enable a relatively accurate estimate of recruitment and/or available biomass, and hence TAC, for the following seasons are likely to be costly.

Sources: Cobalt Marine Resource Management (2009), Rose and Kompas (2004); amended according to additional observations.

2.7.4 Technical measures

Different technical measures used in shrimp fisheries to improve selectivity and reduce bycatch (and so reduce waste and threats to vulnerable or endangered species) are discussed below, with specific details for different TST fisheries summarized in

[22] Rose and Kompas (2004), p3.

[23] Rose and Kompas (2004) note that the first Northern prawn fishery ITE system based on A units increased the costs and decreased the efficiency of fishing. At the same time substantial effort reductions under this system failed to reduce effective effort by similar amounts due to input substitution (i.e. using more gear to compensate for reduced vessel power).

[24] If the risk of high-grading under current economic circumstances for the Northern prawn fishery is relatively low this will mitigate against excessive monitoring and enforcement costs. There remains a risk of unreported landings outside the quota system which would require additional monitoring resources.

Table 2-6.

Almost all countries apply **minimum mesh sizes** in the trawl wings and codends. However, codend mesh sizes range from 20 mm to 60 mm. Countries applying small mesh sizes are those that are more reliant on trash fish bycatches, namely Vietnam (20–30 mm), Indonesia and Cameroon (25 mm), India (35 mm), and Mexico (37.5 mm). Nigeria more recently increased its mesh size to 44 mm and is considering an increase to 60 mm. Most other fishery codend mesh sizes range from 45 mm to 60 mm.

A **headrope length** restriction is applied in only two countries: Australia and Madagascar[25]. It is used as an input control measure, but is an important additional technical constraint in that it reflects the size of the total individual number of trawls used. It could therefore be used as a technical control measure.

Bycatch reduction devices (BEDs/BRDs/JTEDs) to eliminate fish and other bycatches from the catch are applied in most fisheries, but there are exceptions, notably India, Vietnam, and Mozambique. Indonesia applies a BRD rule, but this is partly ignored. Resistance to devices is reported where there is a fear of loss of company revenue from bycatches (India), where crew remuneration comes partly from revenue derived from bycatch (Nigeria, Indonesia, Colombia), where there is a policy focus on trash fish (Vietnam), and where there is general misunderstanding in its application (Mozambique). A large number of other countries are also about to apply the Popeye Fishbox, which in trials in Australia's Northern Prawn Fishery has reduced small-sized bycatch by up to 48 per cent and sea snake bycatch by up to 87 per cent.

Box2-11: Examples of TED application

TEDs are reported to be applied effectively in Australia, Belize, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Madagascar, Mexico, Nicaragua, Nigeria, Pakistan, Panama, Suriname, and Venezuela.

Lessons learned from TED application emanate from the **US**, where there is strong BRD/TED compliance. Ninety-seven per cent of turtles caught in TED nets escape; however, TEDs reduce the shrimp catch by 10 per cent (NMFS). TEDs can be ineffective as a result of: (i) improper installation; (ii) inexperience of the crew; and (iii) variation in trawling conditions. Some countries, most notably the US and Australia, have applied extensive training programmes to industry to facilitate the introduction of TEDs. Training in the application of BRDs, TEDs, and JTEDs form the basis of the UNEP/GEF/FAO REBYC project.

TEDs were introduced to **Australia's** Northern Prawn Fishery in 2001. In 1999, 96 turtle mortalities were reported and 780 marine turtles were released alive; in 2007, no mortalities were reported and 55 turtles were released alive. This is a substantial reduction which has been confirmed by observer programmes. **Madagascar**, following a similar policy to Australia, introduced TEDs in 2003, and the capture of turtles fell from 42 in 2005 to two in 2008. Both Madagascar and Australia apply observer programmes that record bycatch data (fish, invertebrates, and ETP species).

Countries where TEDs are statutory in legislation but not effectively applied include Indonesia, Trinidad and Tobago, and Mozambique.

In some countries, TEDs are said to be unusable because the vessels are too small (Cambodia).

JTEDs have been developed by SEAFDEC, funded under the UNEP/GEF/FAO REBYC project, aimed at eliminating trash fish in some Coral Triangle TST fisheries (Indonesia, Philippines, Thailand, and Malaysia). SEAFDEC participated in sea trials and coordinated a number of workshops and training-of-trainer exercises in Indonesia.

Temporary and permanent closed areas are usually established to protect habitats, e.g., seagrass beds and coral reefs, areas where juvenile fish and prawns are prevalent, areas where there are known fish aggregations/hot spots (as opposed to prawns), or areas with a high interaction with ETP species (turtles, syngnathids, sea snakes, dugongs). Examples of networks of extensive closed areas are provided in two case studies (Australia's Northern Prawn Fishery and the US Gulf of Mexico fishery). Closed areas are used as a management tool in a number of other countries, including Mexico and India.

In most cases VMS is a requirement for semi-industrial and industrial vessels. It is not applied to artisanal vessels, which tend to have high incidences of failing to comply with demarcation zone boundaries (India, Vietnam).

[25] There are reports (Hermes, 2009) that Iran also applies a gear measure restriction.

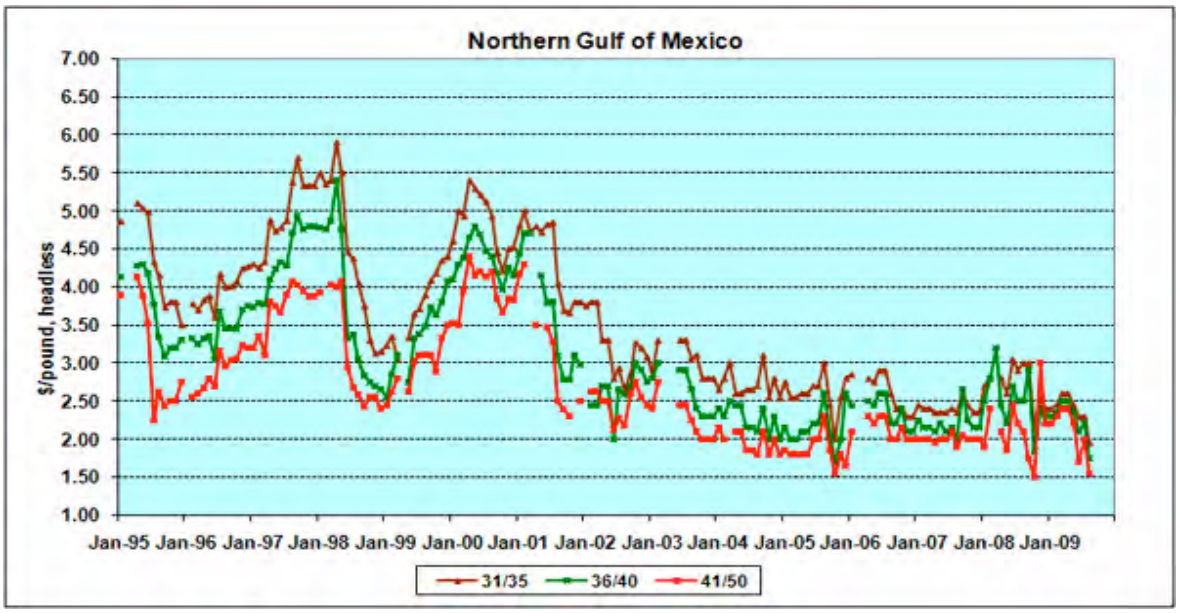
2.8 BUSINESS DRIVERS AND CURRENT PRACTICES

Business drivers are an integral component of a fishery sector's behaviour, providing both negative and positive reactions to changes in costs and earnings. The principal business drivers are market share and accessibility, vessel turnover and profitability, wages and salaries, fuel costs, and gear efficiencies.

2.8.1 Market share, accessibility, and prices

All TST fishery segments evaluated in this report are witnessing a significant loss in market share as a result of the growth in aquaculture production and competition from other capture fisheries, most notably the high volumes of Argentine gamba (deepwater shrimp) and other coldwater shrimp species. This has led to a global decline in wild-caught shrimp prices: an example of price trends for one fishery is shown in Figure 2-10, and is typical of many shrimp fisheries. Nevertheless, wild-caught shrimp usually commands a 20–30 per cent price premium over its aquaculture competitors.

Figure 2-10: Price trends by size grade in the US Gulf of Mexico shrimp fishery (1995–2009)



Source: http://coastal.msstate.edu/shrimp%20landing%20prices.html

Several positive solutions to market competition are available:

Sustaining or improving market share by promoting sustainable products. Mozambique, Madagascar, Suriname, and two Australian TST fisheries, for example, are presently going through the process of MSC certification. GACPM, the Madagascan shrimp producers' organization, sees the transition as essential to sustain the product's competitiveness and product niche. One leading European importer was of the view that price premiums in the region of 10–15 per cent could be obtained as a result of MSC certification. The notable area of concern to the fishery sector is that non-certified products, or evidence of unsustainable fisheries, could cause European and North American buyers to change sources of supply. In this context one European seafood importer is in the process of switching its supply source away from India (Macfadyen and Huntington, 2009).

A key competitive edge can certainly be gained by satisfying the growing demand for sustainably caught products. Many seafood retailers in the US, Europe, and, to a lesser extent, Japan (i.e., the three main markets for shrimp products) have made commitments to sourcing sustainable products. Many seafood retailers and wholesalers now use MSC or alternative certification standards, information sources such as published data from regional fisheries management organizations, or their own audits to evaluate their suppliers' performance and sustainable fishing practices. Examples of trends linked to sustainable fisheries and main shrimp markets are highlighted in Box 2–12.

Box 2-10: Market focus on seafood sustainability

The Netherlands Retail consortium has a commitment to sourcing sustainable fish products by 2011. The Netherlands is the largest shrimp consumer/capita in Northern Europe. Heiploeg (Netherlands), the leading EU buyer of tropical shrimp, buys Chinese crayfish and Indian shrimp from fisheries that might be considered partly "small-scale", as well as shrimp from Indonesia and Bangladesh. The company reported that: "We have stopped buying raw materials from certain sources due to a variety of reasons, including environmental concerns, but none of these were from small-scale fisheries… However we are now considering dropping Indian trawled shrimp due to a variety of reasons, environmental and ecological care included. We have just replaced the Indian shrimp in some retail products with south American shrimp (Suriname)" (Heiploeg, pers. comm., September 2009).

Major **European retail outlets** in Germany (Aldi, Costa, EDEKA, LID, Metro real, Netto, and REWE Grossverbraucher-Service), Belgium (Delhaize), France (Carrefour), and the UK (Asda, Sainsbury's, Marks & Spencer, Tesco, and Waitrose) have similar commitments to MSC and sustainability. By way of example, one UK-based importer/processor/wholesaler supplying leading retail chains and the food service sector stated that: "Detailed self-audit questionnaires have to be completed by every supplier or potential supplier. References must be given to any statements they make. Scientific information on fish stocks is required along with catch data and independent advice. Also catch records, traceability to vessels, vessel legality and registration details, etc. We require bycatch volumes including unwanted bycatch and where national catch records don't require record of bycatch (wanted or unwanted) we seek to have suppliers implement catch records that do include them." (Anonymous, pers. comm., 2009).

The US's largest retailer, **Wal-Mart**, is committed to sourcing 100% MSC-certified seafood by 2011 (fresh & frozen). **Other US retailers** (Kroger, Supervalu, and Giant Eagle), as well as the US's largest food service distributor (Sysco) have also committed to work with WWF to develop sustainable seafood sourcing strategies.

MEL Japan, a leading Japanese certification scheme, was launched at the end of 2007 to "make provision for informed decisions by purchasers whose choice can be relied upon to promote and stimulate the sustainable use of fishery resources". The MSC has also set up its Asian headquarters in Japan and is participating in a leading advertising campaign aimed at promoting sustainably sourced product.

Sources: Macfadyen and Huntington (2009), MSC.

It should be noted that the aquaculture industry is also developing equivalent certification standards in response to growing environmental concerns. To date these standards have not developed as quickly as those available for the capture sector. However, as aquaculture standards for groups such as the Aquaculture Stewardship Council and GlobalGap become finalized and gain credibility, any market advantage that may be gained through certification of capture fisheries may be eroded.

Withdrawing from the fishery and transferring activities elsewhere. This option is seldom used; one exception is US shrimp fisheries, which have seen a marked downturn in participation and a switch to non-shrimp fisheries. This has resulted in a marked reduction in effort and has allowed the Gulf of Mexico and South Atlantic fisheries to remain within safe biological limits.

Other business practices which may be thought of as less positive resulting from increased market competition and declining prices include:

Altering the balance of target species, including increasing dependency on other retained species, e.g., squid, cuttlefish, deeper-water shrimp, and demersal species, including smaller shrimp. This is a path followed by many developing country fishing groups leading to less selective fishing practices in the hope of retaining other species. The focus is on both export markets (cephalopods) and domestic markets (demersal species and small shrimp).

Developing a market for small shrimps. Artisanal fishers are typically successful in selling fresh or dried juvenile shrimp in market stalls. Such markets exist in East Africa, India, and some Coral Triangle countries (e.g., Vietnam and Indonesia).

Applying shadow pricing practices. Many industrial vessels are owned by joint venture partners. Prices on offer by the joint venture partner may be deliberately low so as to preserve the profitability of the parent company and to reduce related export tariffs. The national company, however, sees falling prices as poor business practice, which could promote a change in company production practices, and act as a disincentive to investing in improved selectivity and cost-saving practices.

2.8.2 Wage and salary remuneration systems

A positive business driver can be to reward skippers and crew with wage premiums for catching larger-sized shrimps. This practice is followed by some companies in Madagascar and occasionally elsewhere, including some Sorong-based forms in Indonesia. An example cited by one company (PT Alfa Kurnia) was that in response to a declining CPUE, crews focused on smaller shrimps and bycatch. The former were difficult to sell, while the latter

utilized storage space. The company adopted a price reference scheme, where small shrimp earned one-third of the reference price and large shrimp earned three times the reference price. This reward system resulted in retention of selectivity devices, when other companies would discard them, and a more careful targeting of trawl sites and use of try nets to minimize bycatch. Boats targeting bycatch would result in the sacking of skippers and crew. The company also cited that this new practice reduces crew sorting times.

A negative driver is that in some countries (Nigeria, Colombia, and again Indonesia), crews are paid a minimal wage (e.g., US$20/month in Nigeria) and are forced to make up their wages through the sale of bycatch species. This leads to a reduction in selectivity, promoting reduced and illegal mesh sizes, no application of BRDs and TEDs, and a focus on less efficient trawling practices that promote a build-up of fish in the codend. The result is also a heavy build up of trash fish.

2.8.3 Changes in cost structures

Positive drivers in terms of cost efficiencies have been generated as a result of falling margins, following a decrease in shrimp prices allied to substantial increases in the price of fuel in 2007 and 2008. As fuel costs can account for 39–45 per cent of total operating costs, many fishing companies have adopted a series of measures aimed at improving fuel efficiencies. These have included new more efficient propellers, lighter gears (trawl doors/shorter wings), increased mesh sizes, shorter tows, and removing tickler chains. These have in some cases resulted in fuel savings of 30–35 per cent. In other cases, companies have evaluated their carbon emissions leading to a number of changes in operational practices (UNIMA, 2008). Examples of cost-saving initiatives were identified by this study in Australia, Madagascar, Indonesia, and the US.

A critical negative driver, and one that is all too common, is the provision of fuel subsidies. These are applied in many countries, and perpetuate retention of inefficient capacity and can discourage initiatives such as those presented above. A recent study showed that, of the 34 largest shrimp producing nations, 19 had fuel subsidies (Gillette, 2008). Fuel subsidies are reported in the principal producing countries of India, Vietnam, Mexico, and Mozambique. Fuel subsidies have been removed in Indonesia's industrial fisheries (including the shrimp trawl sector), causing companies to lay up some of their more inefficient vessels.

A hypothetical example of positive drivers and elimination of negative drivers and how this may affect the costs and earnings profile of a small-scale trawler is shown in Figure 2-11. The example shows that profitability can be improved through improved practices.

Figure 2-11: Hypothetical implementation of positive drivers and elimination of negative drivers in a small-scale shrimp trawler (India)

	Current costs and earnings, (US$)	Assumptions	Changes to costs and earnings with proposed business drivers (US$)
Shrimp	25,381	Shrimp price premium (MSC premium (15%), average size increase premium (22%)) + 37%; reduction in catch weight by 15%	29,556
Marketable fish	24,625	Larger fish caught, with loss in revenue from reduced juvenile target species by 50%	17,048
Trash fish	750	Zero trash fish	0
Total earnings	50,756		46,604
Variable costs:			
Fuel & oil	**23,088**	Fuel cost reduction (30%), but loss in fuel subsidy (5%)	**17,316**
Wages	**9,333**	25% of the benefit from fuel savings transferred to crew wage premium paid for larger average size selection	**10,776**
Food & water	956	No change	956
Ice	1,643	Reduction of fish volume by 50%	822
Maintenance	2,101	No change	2,101
Misc	1,280	No change	1,280
Total costs	38,401		33,251
Gross cash flow	12,355		13,353
Depreciation	3,155	rpm/gear change (replacement only) + 25%	3,944
Net profit	**9,200**		**9,409**

Source: Core date extracted from Indian shrimp trawl, CIFT, 2008; Note: Shrimp revenues will improve as CPUE increases.

2.9 SOCIAL ISSUES

Conflict between fisher groups is widespread, with mixing of fishing activities through incursions by larger fishing boats into inshore areas and movement of small-scale vessels further offshore. Such conflicts are typically a symptom of overfishing and, in the most extreme cases, have resulted in piracy and murder. Conflict resolution can be achieved through regular inter-group dialogue, eradication of targeting juvenile shrimp, and introduction of VMS.

3 BENCHMARKING ASSESSMENT OF TROPICAL SHRIMP FISHERIES

3.1 ASSESSMENT METHODOLOGY

The July 2008 workshop convened by WWF in Darwin, Australia, identified a number of characteristics of successful and sustainable fisheries:

- An effective governance structure in place
- Transparent and accountable management process, including co-management with NGOs and other stakeholders, with a culture of adaptive management
- Strong industry leadership including presence of apex bodies and councils
- Economically viable with the financial ability to support restructuring
- Effort and input controls in place, and some form of limitation of access
- Effective monitoring and compliance systems applied in a cost-effective way
- An understanding of the resource and its status, and the ecosystem and its vulnerabilities
- Target and reference points existing in an established framework so that it is possible to assess limits and management performance.

Many of these characteristics are inherent requirements of existing fishery certification schemes. The Marine Stewardship Council (MSC) fishery assessment standards, for example, are consistent with these characteristics but organize them under three component principles for sustainable fishing: the state of the fish stock, the impact of the fishery on the associated ecosystem, and the performance of the management system. Called the Principles and Criteria for Sustainable Fishing, the MSC standards can be considered robust given that they are based on the FAO Code of Conduct for Responsible Fisheries and the FAO Guidelines on Eco-labeling, and that WWF as well as many private sector fishing, processing, wholesaling, and retail/food service sector companies are active supporters. The design of the MSC Principles, as well as the components and performance indicators, has evolved over a number of years through consultation with experts in stock assessment, marine ecosystems, conservation, and the social and legal aspects of fisheries, as well as industry, environment groups, and consumer and regional interests. Only three shrimp fisheries, all coldwater, have been awarded MSC certification to date, with MSC fishery assessments underway in a number of other tropical and temperate shrimp fisheries.

Some fisheries management specialists, however, express the view that the MSC bar is set relatively high and almost all shrimp fisheries would struggle to reach it, and that because only relatively well-managed, sustainable fisheries are likely to achieve MSC certification, the real impacts of certification on poor practices in most of the world's shrimp fisheries are likely to be limited (I. Cartwright, 2008[26]). The view taken in this analysis is that fisheries require standards to aspire to and the design of mechanisms to support the achievement of these standards. However, it is also realistic to understand that the successful application of the MSC standards will take time to implement, and will need to be adapted to suit specific circumstances. The fact that a number of tropical shrimp fisheries are close to achieving MSC accreditation suggests that the goals of achieving sustainable fishing are within reach.

This report therefore uses the MSC Principles and Criteria for Sustainable Fishing as a benchmark framework to assess the performance of TST fisheries, together with a fourth principle, the economic and social framework, which ensures that negative economic and social drivers are not in place to prevent necessary restructuring (Box 3–1). The economic and social standards were developed based on a review of the key drivers identified in the previous section of this report.

Together, these four principles are used as an assessment tool for lessons learned and actions (discussed in the opening section of Section 4) of this report, which help to identify common deficiencies based on the case study information.

[26] Gillette (2008).

Box 3-1: Principles and category definitions for sustainable TST fisheries used in the benchmarking exercise

MSC component P1: Sustainability of the target stock	MSC component P2: Impact on the ecosystem
P 1.1 Management outcomes P 1.2 Harvest strategy P 1.3 The precautionary approach and effective harvest strategy	P 2.1 Retained non-target species P 2.2 Discarded species P.2.3 ETP species P 2.4 Habitat P.2.5 Ecosystem
MSC component P3: Governance and policy performance	**P4: Economic and social framework**
P 3.1 Governance and policy P 3. 2 The fishery-specific management system	P 4.1 National and international price drivers P 4.2 Input cost drivers P 4.3 Remuneration and working systems P 4.4 Conflict resolution

Sources: MSC Fisheries Assessment Methodology (2010), present study findings.

The remainder of this section presents a brief synopsis of the Principles, components, and Performance Indicators and Scoring Guideposts used in the benchmarking exercise, together with the resulting assessment of TST fisheries based on the case studies presented in this report.

3.2 MSC ASSESSMENT

3.2.1 Principle 1: Sustainability of the target stock

A fishery must be conducted in a manner that does not lead to overfishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery.

P 1.1: Management outcomes

Performance indicator P 1.1 addresses the sustainability of the target species and considers the tools, measures, and strategies that are being used to manage the impact of the fishery on the target species. Target species are defined as those that are usually 20 per cent or more of the total catch weight.

Box 3-2: Management outcomes categories and assessment

Primary guideposts
Stock status (Category P 1.1.1) requires that the target stocks are at a level which maintains a high productivity and has a low probability of recruitment overfishing. This requires that the stock is above the point where recruitment is impaired and fluctuating around a target reference point. Default limit reference points are defined as being 0.50 B_{MSY} or 0.2 B_o[27]. **Reference points** (Category P 1.1.2) requires that limit and target reference points are set for the stocks. These should be set above the level at which there is an appreciable risk of impairing reproductive capacity and that there is no danger that genetic changes in the stock would reduce reproductive capacity. **Stock rebuilding** (Category P 1.1.3) is where there is some evidence of stock rebuilding where the stock has been depleted, i.e. that strategies are in place and there is evidence (modelling or by extrapolated evidence) that recovery will be achieved within specified time scales.
Assessment
CPUE in most of the fisheries examined in this report is declining. Only Australia, the US, and brown shrimp in Mexico exhibit sustainable characteristics. 0.5 B_{MSY} is used as a limit reference point to establish effort controls in these countries. Mozambique applies $F_{0.1}$ for its main species along with a target effort trawling level (expressed in standardized fishing hours). There is no evidence that 0.5 B_{MSY} is applied as the default limit reference point elsewhere, and the broad consensus is that current levels of fishing effort are twice what they should be. India applies 0.6 B_{MSY} on the grounds that tropical conditions produce lower levels of vulnerability (high fecundity, growth rates, etc). However, the current level of exploitation is 0.75 B_{MSY} without any mechanism (TACs/effort control) to implement exploitation controls. Recruitment overfishing is reported in a large number of countries where artisanal vessels are targeting juvenile species.

[27] Unexploited biomass

Moreover, because closed seasons are short (with the exception of Australia and Iran), it is highly likely that some fisheries target stocks in peak spawning periods, and as such significantly exceed 0.5 B_{MSY}. The result, as witnessed in many fisheries, is that the target species dependencies are falling, with a heavy emphasis on multi-taxa fisheries. However, a comment made by Indian scientists is that spawning within tropical waters has no seasonal boundaries for some major species, making it difficult to decide on the length of closed seasons.

In many cases, the suite of targets and limits relating to exploitation rate, recruitment index, and size at first capture are not available and there is a need for good accurate recording of data as a "surrogate" "consistent with B_{MSY}". Australia, the US, India, Mexico, Mozambique, and Madagascar report having limit reference points, but these are exceeded in the latter four countries.

Mozambique represents an example of stock rebuilding where the stock has been depleted, primarily through the use of extended closed seasons, with evidence from modelling and extrapolated evidence that recovery is being achieved within specified time scales. The scale of closed season extension is from 6 to 7 months (40,000 effort hours).

P 1.2: Harvest strategy

Performance indicator P 1.2 assesses the harvest strategy's ability to manage the impact on target stocks so as to achieve the primary guideposts for the target species. This requires assessment of the plausibility of the strategy and the tools to control exploitation. These measures should demonstrate a substantial likelihood of success.

Box 3-3: Harvest strategy categories and assessment

Primary guideposts
Harvest strategy (Category P 1.2.1) requires that there is a robust and precautionary harvest strategy in place, such that harvest strategy objectives will be achieved. This requires that monitoring systems are in place to determine that the harvest strategy is achieving its objectives (i.e., the status of the resource, determined from average catch rates observed on surveys, as well as the distribution by age and sex). **Harvest control rules** (HCRs; Category P 1.2.2) are required to be consistent with the harvest strategy, and act to reduce the exploitation rate as the limit reference points are approached. This also requires that HCRs account for uncertainties such as environmental variables, and requires that the most appropriate management tools are in place to ensure effective control of fishing activities. **Information monitoring** (Category P 1.2.3) ensures that relevant data is collected (age, size at maturity, fecundity, stock productivity, fleet composition, fishing effort, etc) and collated with sufficient frequency. **Assessment of stock status** (Category P 1.2.4) requires that there is an adequate assessment procedure for the stock, whereby the stock status is evaluated against the specified reference points.
Assessment
HCRs are lacking, or lacking application in many countries, the most critical problem being unfettered open access. In some cases, fisheries have reached such a critical level that trawling has been banned (Venezuela). Australian fisheries have developed the most sophisticated system of HCRs, focussing on input and output controls as well as real-time at-sea decision rules, supported by in-season fishery independent surveys and real-time monitoring of stocks. A wide set of performance indicators are used in a well-developed decision-making framework to determine fishing strategies (conservative, standard, maximum), along with output controls. Different Australian fisheries apply different HCRs, but principle components are restricted access, capacity and fishing effort limits (gear headrope length), and closed seasons that focus specifically on fishing effort as well as protected species during vulnerable stages (i.e. pre-spawning and nursery stages). The Australian SFR system was broadly followed by Madagascar, but largely undermined by recruitment overfishing in other fisheries and insufficient application of effort reduction as recommended by the scientists. TACs and ITQs are a relatively recent phenomenon in Australian shrimp fisheries, and have also just been introduced as a management measures in Mexico. TACs may exist as a legal measure elsewhere but are not applied with sufficient vigour, and in some cases lack a sound scientific basis for their application (e.g., Indonesia). Closed seasons are also used as a partial system of effort management in Australia, the US, and Mozambique, but not to any great extent elsewhere. In many cases closed seasons are extremely short (confined to monsoon months) and may be insufficient in length to protect pre-spawning females, or to provide substantive benefits in terms of effort reduction. Vessel demarcation zones are used in many countries, but frequently ignored. A common theme is restricting industrial trawl activity to vessels >10 m but allowing for access by other groups in inshore waters. The latter has lead to recruitment overfishing. In many countries, the precautionary management approach would suggest that fishing effort is reduced by at least 50 per cent for industrial trawlers, that small-scale trawl fisheries are limited to deeper depths (>5 m) than at present, and that artisanal fishing for shrimps is eliminated. A system of HCRs would have to be established in many countries, based on such a strategy including capacity reduction, effort hours, closed seasons, gear SFRs, TACs, and, probably, implementation

of real-time management decisions supported by strong co-management systems.

Implementation will have to be supported by a more robust system of data collection and established performance reference points. This will require appropriate and periodic biomass and recruitment surveys, the deployment of observers on trawlers, and an accurate system of catch recording.

3.2.2 Principle 2: Impact on the ecosystem

Fishing operations should allow for the maintenance of the structure, productivity, function, and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

P 2.1: Retained non-target species

Performance indicator P 2.1 addresses the sustainability of the retained species and considers the tools, measures, and strategies that are being used to manage the impact of the fishery on the retained species. Retained species are species that are not targeted by the fishing method yet retained by the fishery under assessment, usually because they are commercially valuable or because they are retained as part of the management rules. Retained species are defined as main retained species if above 5 per cent but below 20 per cent of the total weight of the catch. Minor species are those that are below 5 per cent of the total weight of the catch, but may be considered as part of the evaluation if perceived to be particularly vulnerable to the type of fishing activity (e.g., elasmobranches may be vulnerable because of their low fecundity).

Box 3-4: Retained species categories and assessment

Primary guideposts
Retained stock status (Category P 2.1.1) requires that the fishery does not pose a risk of serious or irreversible harm to the retained species (other than the target species) and does not hinder recovery of depleted retained species. This requires that the main retained species are within biologically based limits. **Management strategy** (Category P 2.1.2) requires that there is a strategy in place for managing retained species that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to retained species. This requires that measures are in place that are expected to maintain the main retained species (i.e., where above 5 per cent of a specific species as a proportion of the total catch) at levels that are likely to be within safe biological limits. **Information monitoring** (Category P 2.1.3) requires that information on the retained species is adequate to determine the risk posed by the fishery and the effectiveness of the applied management strategy. This will require the collection of sufficient information to assess species statistics with respect to biologically based limits.
Assessment
In almost all TST fisheries, non-prawn bycatch is far greater than the target catch. Australia provides the only exception where in the case study fisheries, retained species are under 5 per cent of the catch. Retained species can be divided into marketable fish and trash fish. This assessment was unable to identify how many of these species are reported to be overexploited. In most cases the status of retained species is unknown and there is limited or no recording of bycatch. *Otolithes rubber*, a Sciaenidae indigenous to East Africa, is reported to be in decline in Mozambique, reflected by a decline in mean length of trawled species. However, in neighbouring Madagascar, the same species is not perceived to be overfished. Indian fisheries have seen a 40 per cent decline in targeted finfish fisheries (croakers, pomfrets, silver bellies, and ribbon fish). CIFT stock assessment identifies non-selectivity/trash fish as the cause of this decline. The implication is that countries not applying BRDs (India and Vietnam) are likely to experience significant problems with a decline in retained species, as well as shrimp catches. Policies on retained species exist in some countries (India, Indonesia, Mozambique, Madagascar, and Nigeria) as a means of supplementing domestic supplies to support food security. However, this control measure is not monitored or enforced. Australian HCRs prevent the retention of finfish species as a means to facilitate improved selectivity. Recording of retained species occurs where there are logbooks and observer programmes. However, there is rarely any systematic analysis of the data. In some cases, the data collected by observers are not transferred to the scientific community. Trawling companies in Madagascar, Guiana, and Suriname also hold historical data on bycatches that could be incorporated into stock assessment.

P 2.2: Bycatch species

Performance indicator P 2.2 addresses the sustainability of bycatch species and considers the tools, measures, and strategies that are being used to reduce the impact of the fishery on bycatch. Bycatch species as far as the MSC is concerned are defined as organisms that have been taken incidentally and are not retained because they

have no commercial value, or because they are not retained as part of the management rules to promote selectivity of at risk species.

Box 3-5: Bycatch species categories and assessment

Primary guideposts
Bycatch species stock status (Category P 2.2.1) requires that the fishery does not pose a risk of serious or irreversible harm to bycatch species or species groups and does not hinder recovery of depleted bycatch species or species groups. The main bycatch species should be within safe biologically based limits, or if outside these limits, there are mitigation measures in place that are expected to ensure that the fishery does not hinder recovery and rebuilding. **Management strategy** (Category P 2.2.2) requires a strategy in place for managing retained species that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to bycatch populations. This requires that measures are in place that are expected to maintain the main bycatch species at levels that are likely to be within safe biological limits, or to ensure that the fishery does not hinder their recovery. **Information monitoring** (Category P 2.2.3) requires that information on the bycatch species is adequate to determine the risk posed by the fishery and the effectiveness of the applied management strategy. This will require the selection of bycatch risk assessment species indicators, to allow the focus on collection of sufficient information to assess species statistics in respect to biologically based limits.
Assessment
Some fisheries have no bycatch as all species are retained. Where bycatch/discards are occurring, these may include small finfish, non-edible species, and elasmobranchs. Finfish bycatches are mitigated using BRDs, but in some cases, fish do not swim out through these. Red snappers and leather jackets are known to sit in the net, but more recent bycatch reduction systems have been applied (such as the Popeye Fishbox) to facilitate escape. Coastal sharks and rays are perceived to be problematic in many countries, but bycatches are not recorded accurately. Endangered bycatch species in Mexico include the bluntnose stingray (*Dasyatis say*), Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), southern stingray (*Dasyatis americana*), cownose ray (*Rhinoptera bonasus*), silky shark (*Carcharhinus falciformis*), bonnethead (*Sphyrna tiburo*), bancroft's numbfish (*Narcine bancroftii*), scalloped hammerhead (*Sphyrna lewini*), and smooth butterfly ray (*Gymnura micrura*). Pre-2001, 50 species of sharks and rays were caught in Australia's Northern Prawn Fishery. Shark catch was reduced by 17.7 per cent and ray catch by 36.3 per cent through BRD and TED use and improved fishing practices. Catches of large sharks and rays were reduced by 86 per cent and 94 per cent, respectively. Australian Commonwealth Government policy requires that Bycatch Action Plans (BAPs) are prepared by the respective fishery Management Advisory Councils (MACs), with HCRs implemented. It should be noted that BAPs require specific at-risk species to be identified, so that monitoring is undertaken of these to determine the impacts of the action plans. Other countries focus on the use of BRDs and JTEDs, but the application of these is very variable. Some countries, particularly the higher-producing countries of India and Vietnam, do not have any form of bycatch mitigation measures in place. In some cases fishers themselves may develop their own strategies, e.g., through identifying fish hot spots which they will avoid. Recording of bycatch species data occurs where there are log books and observer programmes. However, there is rarely any systematic analysis of the data. In some of these cases, the data collected by observers are not transferred to the scientific community.

P 2.3 ETP species

Performance indicator P 2.3 addresses the sustainability of the ETP species encountered by the fishery and considers the tools, measures, and strategies that are being used to reduce the impact of the fishery on the ETP species. ETP species are those that are recognized by national legislation or by binding international agreements. These species may be taken accidentally or threatened as a result of the fishing activity.

Box 3-6: ETP species categories and assessment

Primary guideposts

ETP species status (Category P 2.3.1) requires that the fishery complies with the international (IUCN) and national requirement to minimize damage to ETP species. The fishery should therefore not pose a risk of serious or irreversible harm to ETP species and should not hinder their recovery.

Management strategy (Category P 2.3.2) requires that the fishery has in place precautionary management strategies, along with accompanying measures, to meet the national and international requirements, ensure that the fishery does not pose a risk of serious or irreversible harm to ETP species, ensure that the fishery does not hinder their recovery, and ensure that ETP species mortalities are minimized.

Information monitoring (Category P 2.3.3) requires that relevant information is collected to support the management of fishery impacts on ETP species in the context of supporting strategy development, management effectiveness, and measuring the outcomes on the ETP species.

Assessment

The principal bycatch issue for shrimp trawlers is interaction with marine turtles. Many trawling areas interact with turtle migration corridors. These interactions have necessitated the introduction of TEDs, which prompts turtles to swim through escape bars. These have been very successful when introduced, but their successful introduction comes with a strong requirement for fisher training. Australia and the US provide regular training courses, as well as literature on the setting of TEDs.

WWF-India also provides technical support and training programmes in many turtle hot spot areas. However, industry resistance remains, which is usually the result of a lack of training available to fishers and, in many cases, minimal enforcement. TED introduction is being facilitated in some cases with the support of grants. MPEDA in India provides 100% support in the application of TEDs. One shrimp main buyer, Heiploeg BV, has also provided TEDs to their main suppliers. Large sharks are also able to escape from TEDs.

Sea snakes, syngnathids, and jellyfish swarms represent other IUCN/national focus species for protection. The scale of sea snake interaction is not widely reported. The Arafura Sea fishery identifies around 20 snakes recorded per day. Some success has been achieved with these species as a result of the introduction of the Popeye Fishbox in Australia's Northern Prawn Fishery.

Syngnathids are usually found in coastal areas or adjacent to coral reefs. Closed areas are a means to deal with these interactions but thousands of syngnathids may be taken in some fisheries. It is unlikely, however, that these interactions will result in a risk of serious or irreversible harm, but Australian BAPs are increasingly focussing on this problem.

Very little information exists on ETP species interactions. Observer programmes record the interactions with turtles, but seldom focus on other species. Some of Australia's fisheries apply trained fisher observers to record other species interactions, as well as turtles and elasmobranches.

P 2.4: Habitats

Performance indicator P 2.4 addresses the sustainability of habitats (seabed, sea grasses, and coral reefs) and benthic assemblages and considers the tools, measures, and strategies that are being used to reduce the impact of the fishery on these habitats. The assessment relates to the habitats within which the fishery operates, usually within a defined bioregional area. Serious harm may occur if the habitats and abundances are distorted or do not recover in the short- to medium-term.

Box 3-7: Habitat categories and assessment

Primary guideposts
Habitat status (Category P 2.4.1) requires that the fishery does not cause serious or irreversible harm to habitat structure considered on a regional or bioregional basis, or on a temporal or spatial scale. This would mean that the fishery would not reduce habitat structure or impair its recovery. **Management strategy** (Category P 2.4.2) requires that measures are in place to ensure that there is no serious or irreversible harm to habitat structure which would impair the bioregional basis and function of habitats. **Information monitoring** (Category P 2.4.3) requires that information is adequate to determine the risks posed to habitat types by fishing gears, including the likely impact of other variables (latitudinal affects caused by salinity, rainfall, and temperature fluctuations), and to measure the effectiveness of management measures.
Assessment
Most shrimp trawl grounds comprise mud or soft sediment. Targeted research reports investigating fishery impacts on the benthos and related ecology have been undertaken in Australia's Northern Prawn Fishery, Madagascar, and India. Studies in these trawled waters suggest that in areas where there are highly focussed trawling impacts, benthic taxa and communities analyzed appeared to recover relatively quickly from trawl effects. In the case of Madagascar and Australia's Northern Prawn Fishery, impacts of trawling are contained to a relatively small area of the fishery due to the concentration of vessels on the most productive grounds, an extensive system of permanent and temporary fishery closures, and significant areas of the fishery that are not suitable for trawling. These fisheries also use light gears. Indian fisheries, while using light gear, are more widespread. However, continually trawled areas have lost benthic assemblages, with impacts being especially felt by gastropods and bivalve molluscs. There have been no assessments of grounds fished by heavier gears. In many cases, the Indian benthic habitats receive little respite, and the weights of gear could impair benthic recovery. Deepwater trawling is also likely to have greater impact on the benthos since the gear is heavy to counter buoyancy on descent. The most effective strategy is to reduce the coverage of gears on specific sites, to reduce gear weight, and to avoid fishing in vulnerable habitats (sea grasses, coral reefs, or high-intensity shellfish beds). Research into benthic impacts is sporadic, and needs strengthening in all fisheries. Little work has been done in this area, even in some of the countries classified as "developed" (e.g., the US).

P 2.5: Ecosystem

Performance indicator P 2.5 addresses the impacts of the fishery on the broader ecosystem elements such as trophic structure and function of community composition. Issues of concern would be the threat of trophic cascades (i.e., decreased diversity of species low in the food web), depletion of top predators caused by depletion of key prey, reduced rate of recovery as a result of severely truncated size composition, gross change in species diversity of the ecological community (e.g., loss of major species or changes in species evenness and dominance) caused by direct and indirect fishing (e.g., discarding), and changes in the genetic diversity of species caused by selective fishing and resulting in genetically determined changes in growth and reproductive outputs.

Box 3-8: Ecosystem categories and assessment

Primary guideposts
Ecosystem status (Category P 2.5.1) requires that the fishery is unlikely to disrupt the key elements underlying the ecosystem structure to a point where there would be serious or irreversible harm. This refers to issues such as disruption to trophic interactions. **Management strategy** (Category P 2.5.2) requires that there are measures in place that prevent damage to the ecosystem to the point of irreversible harm. **Information monitoring** (Category P 2.5.3) requires that there is adequate information to identify the ecosystem (e.g., trophic structure and function, community composition, productivity pattern, and biodiversity). This requires that the main functions of the components (target and other retained species, bycatch, habitats) in the ecosystem are known.

Assessment
It is difficult to draw conclusions on the impacts of the various fisheries on the ecosystem from the selection of case studies, largely because necessary information for such an assessment is not available and has not been collected. What is evident is that there are declines in both shrimp and fish stocks. Shrimp are low in the food chain, and these declines will impact on their main predators, larger fish and elasmobranches, and other species such as cetaceans. Declines in fish populations are also evident as and when trash fish are extracted. There would not appear to be any evidence of trophic cascades, but these declines will most certainly impact on species dependent on the food chain. Nevertheless, research by CIFT (India) had measured a 9 per cent decline in trophic levels in what is perceived as one of the heavier exploited fisheries. Countries where stocks and fleets exhibit similar characteristics to India are likely to be experiencing similar problems.

3.2.3 Principle 3: Governance and policy performance

The fishery is subject to an effective management system that respects local, national, and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

P 3.1: Governance and policy

Performance indicator P 3.1 assesses the framework in which the management system operates. A fishery management system's legal and/or customary framework is considered to be the underlying supporting structure, be it formal or informal, that incorporates all the formal and informal practices, procedures, and instruments that control, or have an impact on, a fishery. This includes policies and practices of both government and private sectors, including (but not limited to) implementing agencies (e.g., fisheries agencies, conservation agencies), fishery business groups (e.g., catch sector cooperatives, industry associations), fishing vessel owners, indigenous groups, local civil society or community groups, and so on. The government sector includes all applicable government systems, the courts, and the relevant parliamentary and regulatory bodies. The management system is not limited to government legislation, nor to industry or customary practice, but is the complex interaction of all such elements, controls, and practices that are used in a fishery and result in "hard" (law) or "soft" (accepted practice) controls over actual "on-water" catching practices.

Box 3-9: Governance and policy categories and assessment

Primary guideposts
Legal and customary framework (Category P 3.1.1) requires that a management system is in place, with an effective legal framework, to support the achievement of sustainable fisheries in accordance with MSC Principles 1 and 2; that observes the legal rights created explicitly for those that are dependent on fishing for food or livelihoods; and incorporates an appropriate dispute resolution framework. **Consultation roles and responsibilities** (Category P 3.1.2) requires that the management system has effective consultation processes that are open to interested and affected parties. Organizations involved in the management process are clearly identified and their functions, roles, and responsibilities are understood. The consultation process must take account of relevant information from the main affected parties including local knowledge to inform the management system. **Long-term objectives** (Category P 3.1.3) requires that the management system has clear long-term objectives to guide the decision-making that are consistent with MSC Principles and Criteria, and incorporates the precautionary approach. Fisheries policy objectives should focus on long-term stock sustainability, and not just satisfy short-term food security or other market demands (e.g., fish meal or fertilizer). **Incentives for sustainable fishing** (Category P 3.1.4) requires that the management system provides economic and social incentives to encourage sustainable fishing (and does not operate with subsidies).
Assessment
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 and lack of political will cause failures in the management of shrimp fisheries. In all cases evaluated, the legal foundations for legislation appeared to be strong, with adequate facility for dispute resolution. In many cases, fishers' groups have capacity to make representations but are excluded from whatever dialogue there is on policy. In some countries where policy is weak, some private companies even participate in sustainable fishing initiatives. A critical problem, however, is that some groups lack representation (e.g., traditional fishers), or are at the same time impossible to control because of the sheer number of fishers involved. Long-term objectives exist, and in many cases provide for sustainability, but this priority is greatly outweighed by growth and social objectives (e.g., reference to food security). Consequently there is little regulation on entry into the sector, and

long-term economic and social objectives that would result from a stronger emphasis on sustainability are being outweighed by short-term gains. Even in the US, Louisiana prefers to advance a policy similar to that pursued in many developing countries: preservation of fishing communities. Other countries (India, Indonesia, and Vietnam) openly advocate expansion on production. In some cases (Indonesia), the motivation for short-term expansion includes the collection of revenues for national, central, and district institutions. However, Australia is one country that clearly advocates the EAFM approach to fisheries management above all else. Some others appear to be moving towards EAFM (the US, Mexico, Mozambique, and Nigeria). The issue of subsidies is covered under Principle 4 below.

P 3.2: Fishery-specific management system

Performance indicator P 3.2 addresses the objectives of the fishery management system applied as opposed to the strategies and measures that implement these objectives.

Box 3-10: Fishery management system categories and assessment

Primary guideposts

Fishery-specific objectives (Category P 3.2.1) requires that the fishery has clear, specific objectives designed to achieve the outcomes expressed by MSC Principles 1 and 2, and are implicit within the management system.

Decision-making process (Category P 3.2.2) requires that there are decision-making processes (informal or formal) that result in measures and strategies to achieve the fishery-specific objectives.

Compliance and enforcement (Category P 3.2.3) requires that monitoring, control, and surveillance systems are in place and are effective, that sanctions for non-compliance exist and are applied, and that fishers comply with the management system as well as have input into strengthening the management system.

Research Plan (Category P 3.2.4) requires that a research plan exists and provides the management system with inputs in a reliable and timely manner that support the achievement of the objectives.

Monitoring and management performance evaluation (Category P 3.2.5) requires that there is a system for monitoring and evaluating performance of the fishery-specific management system against the objectives.

Assessment

Australian fisheries management plans go beyond mere reference to the EAFM approach, to implementing measures that relate to objectives, goals, and compliance with pre-set reference points. These are applied in the form of fishery-specific management goals and BAPs. The strength of the Australian system lies in the structure of its management system: Management Committees or Councils, drawn from primary stakeholders (fishers, scientists, fishery management and compliance representatives, NGOs, and processors). A similar model is followed in the US, but with a weaker objective and output-orientated structure compared to Australia. A critical component of the committee/council structure is that it creates a body that is provided with the responsibility for determining management decisions and cannot be influenced by political interference. This, in the case of Australia, is further supported by a peer review structure, through an independent organization (DEWHA). Mozambique is the first of the developing countries to implement a comprehensive Management Plan (presently in its draft stages), but the plan contains far-reaching proposals aimed at capacity reduction, dealing with the vexed question of juvenile overfishing, closed seasons, improved compliance, and a strengthening of scientific assessment (Case Study A.6).

In other country cases, there exists only one possible example of existing structures evolving into management councils (i.e., Zonal Management Conserves in Madagascar), but in this grouping, management functions are limited. In other cases, where industrial fishing vessel owners are organized into associations (India, Indonesia, Mexico, and Nigeria) there are informal (non council) linkages between industry and government but no examples of all the main players coming together, notably, all the different fishery groupings, fishery and compliance managers, fishery scientists and economists, and environmental NGOs. Mexico has a management council, but this is exclusive to industry stakeholders and NGOs. In Suriname there is a seabob working group that informs management authorities. It would seem that there is a clear reluctance of the majority of fisheries administrations to divest responsibility for fisheries management to a council. Decision-making processes are thus top down, and usually exclusive. Politicians and trade unionists can heavily influence decisions with no heed to advice from supporting central institutions. An example of this is found in India, where the national supporting framework is very strong but there is no political will to carry out its advice.

The performance of national, state, and district fisheries administrations is very mixed. The advanced administrations demonstrate strong management and compliance capacity. Australian fisheries are also linked to full cost-recovery from the fishery sector. Weaker organizations demonstrate no will to implement management decision making, even when those within the organizations are fully aware of what is required. The ability to implement decision-making is undermined by (a) political interference resulting in a failure to implement management systems, (b) lack of funding dedicated to implementation, (c) lack of internal capacity, and (d) physical remoteness from fisheries.

Fishery compliance is weak in all the case study developing countries considered in this study. Very few controls are applied to artisanal fishers, observer coverage where it exists is insufficient, and there is insufficient attention to training

programmes. Specific initiatives such as the UNEP/GEF/FAO REBYC project are worthy of note, but it is evident that there are questions about sustainability post-project completion. Common offences committed are fishing inside demarcation areas, lack of support for TEDs and BRDs, and on some occasions (e.g., India) failure to adhere to mesh size restrictions.

In contrast, co-management is applied in Australian fisheries, which ranges from the example of the Spencer Gulf's *Committee at Sea* implementing real-time management decisions usually to mitigate against catching small shrimp or bycatch interactions, to fisher participation on data collection and observer schemes (Spencer Gulf and also the Northern Prawn Fishery).

3.2.4 Principle 4: Economic and social framework

This analysis incorporates a fourth principle: an economic and socio-economic framework that relates to the key drivers of change that are outside the realm of traditional fisheries management control systems. These do not form part of the MSC assessment process but, as already identified, good and bad practice drivers have evolved in various fisheries, the negative elements of which seriously jeopardize the achievement of sustainable fisheries.

Box 3-11: Economic and social categories and assessment

Primary guideposts
P 4.1 National and international price drivers: Requires that pricing systems are transparent and provide reward for mature target and other retained species, as opposed to juvenile and immature fish species. This requires market regulation to prevent the sale of immature fish. Shadow pricing occurs where foreign companies undertake joint ventures with domestic companies. Joint venture companies may sell at below market rates as a means of reducing export tariffs. This also inflates the profits of the foreign beneficial owners, and creates a lower level of profit in the domestic company which can result in lower returns on capital, bad practices, and lower capital investment. **P 4.2 Input cost drivers**: Requires that business drivers are actively in place to promote sustainable fishing but optimal application of costs within the fishing method are evaluated, so as to ensure a good return on investment and provide sufficient margin to contribute, if applied, to management and/or research costs. Price and input cost subsidies discourage efficiencies. **P 4.3 Remuneration and working systems**: Requires that best practice and reward systems are in place that prevent reduced selectivity and high grading. **P 4.4 Conflict resolution**: Access systems reward sustainable fishing practices that lead to reduced conflicts.
Assessment
No TST fleets in developing countries have as yet achieved recognition in terms of economic sustainability. Some have adapted their fishing practices to eliminate juvenile shrimp and focus on larger sizes. The most negative issue encountered is the sale of juvenile shrimp into domestic markets. Shadow pricing also acts negatively in terms of failing to adequately reward national companies for shrimp caught and creates a disincentive to invest in improved practices. Fuel subsidies remain prevalent in a number of major producing countries (India, Vietnam, and Mexico). This creates artificial profitability levels for fishing vessels, encourages overcapacity within the sector, and discourages cost savings such as gear adjustments to save fuel costs. The latter has proved to be a very encouraging development within the sector, since not only does it reduce fuel costs, but has encouraged selectivity, prompted retention of sorting devices, and reduced carbon emissions. Remuneration and working systems in some countries have actively encouraged a focus on retaining non-shrimp species (Nigeria, Colombia, and Indonesia). Some of the practices are beginning to change, but if such systems prevail, it prevents uptake of selection devices. The focus should be to switch savings in fuel costs resulting from low-weight gear adjustments to improved fisher reward systems linked to improved selectivity and larger average sizes of shrimp. Conflicts between fisher groups are widespread and are usually a result of recruitment overfishing by larger-scale vessels. This emphasizes the importance of demarcation areas for non-targeting of shrimp and the application of VMS to trawlers.

3.3 SUMMARY OF PROBLEM ANALYSIS AND CURRENT PERFORMANCE

The management objectives for TST fisheries should be to sustain the health of the target resource (shrimp and low-risk other species, i.e. those not judged to be beyond the point of irreversible harm), ensure that ecosystem impacts are low risk, and ensure that fleets are able to sustain catch levels in order to remain viable. In countries with effectively managed shrimp fisheries, legislation often requires or encourages certain positive features (Gillette, 2008). 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 in response to research findings or changing fishery conditions.

Conversely, the consequences of management inaction are:

- Growth in fleet numbers (including artisanal to industrial) resulting from open access
- Growth in fishing effort without appropriate control mechanisms
- Reduced CPUE for the target species
- Increased reliance on byproducts leading to multi-taxa fishing
- Greater risks for non-target species and the ecosystem as fishing methods are altered to catch a larger proportion of byproducts
- Potential damage to juvenile shrimp which would have previously escaped
- Reduced profits, wages, and employment for fishing vessels
- Bad practices in crew behaviour as wages decrease
- A reduction in investment with resulting implications and problems in terms of crew safety.

The main problems (extracted from the analysis above) facing the development of "sustainable" shrimp fisheries management are considered in Box 3–12. These are categorized in sequence based on cause and effect, linked to a) governance, b) the failure to implement input/output harvest control strategies and technical measures to limit overfishing, and c) bad business drivers. All issues require equal focus, and no one issue can be tackled without considering the others.

Box 3-12: Problem analysis in TST fisheries

Governance

Poor governance, remote and centralized management, poor stakeholder interaction: Poor governance stems from political interference and/or lack of political will, an inability to identify fishery-specific goals, a results-based approach that cannot be deflected by outside influences, exclusion of relevant stakeholders, and remoteness from the day-to-day activities of the fishery.

HCRs not appropriately designed or linked to stock assessment and ecosystem management: Management measures may exist but in many cases are not applied or enforced, with the result that there are increasing negative developments such as reduced selectivity and change to other retained species. Scientific capacity is insufficient in many countries, and often lacks the financial resources needed to assess the state of the fishery. The EAFM to fisheries management is generally not applied which prevents sufficient focus on the non-commercial elements of the fishery. There is insufficient engagement with the industry to explain the benefits in applying specific technical control measures, and politicians also lack the will to implement decisions that will lead to positive results, often pacifying minority or voter interests.

Limited enforcement and compliance: Resources are insufficient in many countries to apply appropriate risk assessments with the result that existing control systems, when applied, are weak. Co-management is either not frequently applied or is not effective.

Input /output harvest control strategies

Open access in all fisheries leading to overfishing and a decline in CPUE: Many TST fisheries are associated with unfettered access, supported by a policy focus on increasing employment and production. Many fisheries now require effort reductions of 50 per cent in order to achieve sustainable levels of production. Only three countries have successfully applied buy-back schemes (Australia, the US, and Iran). It is noteworthy that it took Australia's Northern Prawn Fishery 30 years to achieve the required capacity reduction. While this and other schemes have been successful, they require a high financial commitment from government and industry, and have had to form part of a package that allows for other systems to be implemented post buy-back to provide for autonomous adjustment. A critical problem for sustainability in many fisheries has been the failure to control access and expansion by the artisanal fishery sector. Failure to deal with the issue has in one case (Madagascar) led to the near collapse of the commercial shrimp sector due to heavy recruitment overfishing.

Lack of supporting effort control measures leading to technical (effort) creep: Many TST fisheries have seen an evolution towards multi-rig trawling. In many cases, technical improvements have lead to an increase in real effort. The solution in some of the well-managed fisheries is to implement rights-based management (SFRs: Australia's Northern Prawn Fishery), and to heavily restrict the number of days fished. In extreme cases, one fishery (Australia's Spencer Gulf fishery) operates for only 60 days per year. Nevertheless, the fishery is successful because of the high catch rates sustained by the effective application of the control systems.

Catch controls not implemented or enforced: Annual or seasonal catch limits are rarely set for target species or bycatch species. This allows for overfishing, targeting of species at vulnerable stages in their life cycle, and significant imbalances in the trophic dependencies and ecosystem. It remains to be seen whether ITQs can be applied successfully in shrimp fisheries as there are presently no working examples from which to test this issue. A critical issue is that unprofitable fisheries are not likely to experience a dynamic trading environment (B. Couteaux, UNIMA, Madagascar, pers. comm.). Another major concern is the ability (or lack thereof) of scientists to produce robust TACs, particularly where recruitment is highly variable.

Inadequacies in the application of technical measures: Fear of loss in commercial catch, lack of training in awareness and application, weaknesses in design, and poor enforcement all lead to abandonment of TEDs and BRDs, and adoption of small mesh sizes leads to significant detrimental effects on juvenile species and possible trophic cascades for commercial and non-commercial species.

Inadequate enforcement: 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.

An increase in reliance on byproducts leading to multi-taxa fishing: Multi-taxa fishing is often a symptom of a failed fishery management regime and a near collapse of the main retained species. It should not lead to a quest to recognize a multi-species fishery. It represents a call for urgency in redressing these issues, since failure to deal with these issues will lead to potential trophic cascades (e.g., India).

Greater risks for non-target species and ecosystems as fishing methods are altered to catch a larger proportion of byproducts: As dependencies increase on other retained species, the impact on invertebrates and benthic assemblages increases, reducing the ability of benthic habitats to recover from trawling.

Negative business drivers

Reduced profits, wages, and employment for fishing vessels: Profits fall as catch volumes decline through overfishing as highlighted by the CPUE reductions in this report. External influences such as negative price trends and high fuel prices

exacerbate the problem.

Bad practices in crew behavior as wages decrease: Resulting pressures on crew remuneration as a result of falling vessel turnover lead to bad practices (less selectivity) and a change of focus towards other commercial species. This also creates additional workloads for crew in sorting, and damage to commercial shrimp catches.

A reduction in investment with potential problems for crew safety: Falling profits lead to low returns on capital and unwillingness to re-invest. Poor equipment maintenance can lead to accidents on board.

Subsidies leading to economic inefficiencies and fleet expansion: Subsidies result in false profits and stimulate further activity and investment (e.g., Vietnam). Greater numbers of fishers lead to a reduction of individual profits for those already within the sector, leading to some of the negative drivers listed above.

4 BLUEPRINT FOR MOVING TOWARD SUSTAINABLE TROPICAL SHRIMP TRAWL FISHERIES

4.1 INTRODUCTION

Improvements to the sustainability of tropical shrimp trawl fisheries are critical given the very significant economic and social benefits that are derived from such fisheries, which must be safeguarded for future generations.

This blueprint for moving towards sustainable TST fisheries is based on key lessons learned from an extensive literature review, and information collected from the Poseidon country surveys and field visits to all major TST fisheries around the world.

The intention of the blueprint is to provide an aspirational framework for fisheries managers and practitioners in these fisheries to assess, benchmark, and improve performance. It is recognized that in most countries, bringing about necessary changes will take considerable time and resources. Nevertheless, it is expected that many concrete actions can and should be taken quickly, so as to improve the sustainability of TST fisheries throughout the world. Certainly an inability to adopt all the recommendations of the blueprint quickly is not an excuse for delaying action on those items that can be addressed in the short- to medium-term.

The blueprint provides a generic framework that can be applied to all TST fisheries; specific parameters will need to be defined to fit individual circumstances and the requirements of different countries/fisheries.

4.2 LESSONS LEARNED

A global review of TST fisheries suggests that sustainable shrimp fisheries can only be achieved when a number of general conditions are in place and fisheries are being governed and managed based on certain standards. These "lessons learned" are presented below and then incorporated into, and used to inform, the blueprint presented in Section 4.3.

Governance

1. Sustainability needs to be a priority. Long-term environmental sustainability is the basis on which long-term social and economic sustainability rests; therefore food security and social and economic sustainability must become long-term outputs from a management plan which prioritizes long-term environmental sustainability as opposed to (short-term) production and growth-led policies.
2. Great care must be taken to ensure management of all different fleet segments (i.e., industrial, semi-industrial, coastal/artisanal) exploiting a resource, so that positive improvements in sustainability in some sub-sectors are not undermined by unsustainable practices in others.
3. Conflicts with small-scale fishers and other groups can be addressed through zonal management accompanied by strict enforcement and improved stakeholder communication forums. VMS is an especially appropriate support mechanism.
4. Government should undertake the role of custodian as defined by the fisheries act, but allow for independent management councils (e.g., Australia, the US).
5. Collaborative and partnership-based approaches to fisheries management between government and industry yield strong results (e.g., Australia, the US, and signs of improved structures emerging in Mozambique), and co-management approaches should therefore be supported and underpinned by appropriate legislation and human and institutional capacity development.
6. Decentralized management for specific fisheries, linked to national guidelines, strengthens the ability to undertake rapid decision-making (e.g., Australia). Remoteness of managers to the fishery leads to an inability to properly identify fishery-specific management priorities, and serves to isolate industry from decision-making (e.g., India, Indonesia).
7. Political stability and strong governance capacity is critical in forming a cohesive fishery management plan.
8. Strong leadership and industry champions in the private sector typically play a crucial role and must be identified and/or nurtured. Industry participation and leadership is an essential part of driving positive management changes. Demarcation of responsibilities must be clear (e.g., Australia, the US, Suriname,

Madagascar).

9. Clear goals and deliverables (results) must be applied to fishery-specific management objectives (e.g., as contained in Australian and Mozambican management plans).
10. Goals should support the ecosystem-based approach to fisheries management to ensure that bycatch and ecosystem issues are accounted for as a component of management measures introduced (e.g., Australia, Madagascar, Mozambique, Mexico).
11. Prevention of overfishing requires a strong focus on a very wide range of potential issues/activities, including educational programmes, market regulation, a switch to selective fishing methods, alternative livelihoods and improved compliance, input controls, output controls, and technical measures.
12. Rights-based management systems (e.g., gear SFRs) which limit capacity and allocate fishing rights to individual operators and/or groups should be made with some provision for transfer between individuals and/or groups. Such allocatory policies provide a realistic option when participation in the fishery is of a size that equates to an adequate compliance infrastructure (Note: Mexico sought to strengthen its compliance and data collection capacity to deal with the change to collective quotas for the artisanal sector). Australia's Northern Prawn Fishery is a good example of operating rights-based management through gear SFRs, which achieved a 46 per cent reduction in capacity over a period of 9 years. Nevertheless, the levels of adjustment required significant support from three successive buy-back schemes, and management measures such as closed seasons allowed for a rapid recovery in CPUE, which provided the economic incentive for change.
13. Quota management systems are not yet tried and tested in shrimp fisheries. These have been successful in achieving fleet rationalization in some non-shrimp fisheries, but usually in cases where fleet numbers are small and profitable, creating the incentive to acquire additional rights from others (e.g., Australia).
14. Management and governance must be based on a risk-based framework. This requires supporting of data and pro-active interaction with the fishery sector to identify key risks (e.g., fleets, locations, areas, species, etc).
15. The performance of fishery management systems needs to be evaluated by a separate department or through an independent peer review authority (e.g., Australia's DEWHA).

Managing fleet capacity, and setting and enforcing harvest control rules

16. Supporting structures must be in place (e.g., for compliance and research) that are commensurate with the size and scale of the fishery concerned so as to ensure that harvest control rules can be defined and enforced.
17. A reasonable degree of compliance with some of the technical measures (mesh sizes, BRDs) typically requires at least some onboard observer coverage. Good enforcement of shrimp fisheries management requirements already occurs in some developing countries (Mexico, Mozambique, Nigeria).
18. The identification of appropriate shrimp stock assessment models (or proxies) is necessary for use in many developing tropical countries so that harvest control rules can be specified.
19. Centralizing research capacity through a regional apex body (e.g., SEAFDEC, CRFM) or centre of excellence (e.g., CSIRO (Australia), CIFT (India)) can generate some efficiencies and counter existing weaknesses in capacities at national level.
20. Bycatch reduction measures can form a useful catalytic starting point to improvements in management measures. Strong focus needs to be placed on shrimp selectivity, and change in gears if other species are to be the target species. The UNEP/GEF/FAO REBYC project has demonstrated that those countries advancing such technologies can more readily transfer experiences to others (e.g., Mexico to Cuba and Colombia; Nigeria to Cameroon).
21. Fleet capacity controls and effort limitation systems need to be addressed at an early stage. The consequences of failing to do so typically require a very heavy subsequent commitment to buy-back schemes (all countries) and results in significant difficulties in removing capacity.
22. Recovery in catch rates is usually rapid following a significant reduction in effort.
23. Alternatives to buy-back schemes can include a package of measures including licence removal for non-compliance, licence auctions, and other adjustments based on financial incentives or legislation.
24. The concept of multi-taxa trawling is counter to sound management of shrimp fisheries. A focus on other

species is a symptom of the problem of overfishing which needs to be correctly addressed with the application of appropriate management measures, including a focus on BRDs and separator panels, so as to allow the sustainability of other retained species. Income derived from trash fish is so small (e.g., 1 per cent of total revenue in Indian fisheries) that its loss will generally not impact on the economics of fishing operations.

25. Ongoing training processes and the production of clear guidelines must accompany the application of harvest control rules and supporting input/output/technical measures on their application (e.g., Australia, the US, SEAFDEC).
26. Temporal and spatial closed areas can and do act as a good mechanism to reduce overall fishing effort, and to avoid juvenile overfishing and protect vulnerable habitats.

Financial support for improvements

27. Budgets must adequately reflect the need for structural adjustment through reduction in capacity, and ensure that the support structures are appropriately funded.
28. Donors and support institutions must provide the necessary assistance in terms of funding and technical advice to allow for the strengthening of management systems and to assist industry in pursuing positive business drivers.
29. Transparent financial partnerships between government and industry (co-funding through cost recovery) must be established and maintained so as to guarantee servicing of the management requirements and ensure widespread participation in management planning and implementation. Fee systems must be transparent and reflect actual needs (e.g., Australia) as opposed to supporting alternative government income streams (e.g., Indonesia).
30. Understanding business drivers is critical to specification of appropriate management policy, e.g., the adoption of gear selectivity technology. This includes demonstration of the application of cost-effective and fuel-efficient technologies, and the elimination of fuel subsidies and bycatch-linked remuneration schemes which perpetuate non-selectivity and inefficiencies at both the individual vessel and fleet level. A much stronger focus on business planning and supporting economic analysis is required than has been the case to date (e.g., the US, India, Vietnam, Mexico).
31. Market drivers are critical to the evolution of positive business outcomes. A focus on sustainable shrimp practices will achieve positive outcomes through support of certification schemes such as the MSC (Australia, Mozambique).
32. NGOs can play an important role in encouraging partnerships within industry, and focusing in a constructive and participatory manner on the ecosystem approach to fisheries management (EAFM) and risk analysis through participation in influential advisory councils.

These lessons learned can be presented schematically as shown in Figure 4-1 to reflect key problems and their solutions. These solutions are then specified and elaborated in the following blueprint.

Figure 4-1: Problem analysis and related solutions for sustainable TST fisheries

Problem	Means/Solutions	Result
• Poor governance, remote and centralized management, poor stakeholder interaction • HCRs not appropriately designed or linked to stock assessment and EAFM • Limited enforcement and compliance	• Governments undertake role of custodian as defined in fisheries acts • Management tasks provided by an independent body • Collaborative and partnership-based approach to management • Industry participation and leadership • Decentralized management • Clear goals and deliverables applied to fishery-specific management objectives • Improved research • Cost recovery	• Acts strengthened to focus on sustainable fisheries • Management councils established • Funding and transparent cost recovery secured • Stock assessment and bycatch risk assessment procedures established/strengthened • Compliance strengthened
• Open access fisheries leading to overcapacity and declining CPUE • Lack of supporting effort control measures leading to technical creep • Catch controls not implemented or enforced	• Economic overfishing in shrimp fisheries addressed by limiting/reducing participation through various input, output, and technical measures	• Limited entry licensing supported by buy-back schemes, licence removal • Gear fishing rights established • Closed seasons in place • Community and individual quotas
• Increased reliance on byproducts leading to multi-taxa fishing • Greater risks for non-target species and ecosystems • Potential damage to juvenile shrimp resources	• Strong focus on adult shrimp selectivity • Focus on bycatch retention linked to commercially sustainable retained species • Focus on BRDs • Closed areas and zoning to protect key areas/species • Gear designs to minimize benthos damage	• Codend mesh size: 45 mm • Minimum landing sizes reduce juvenile catches • Locally conditioned BRDs/JTEDs linked to training and extension for their use • Lighter gears used to minimize benthos impacts (and generate economic savings through lower fuel use)
• Reduced profits, wages, and employment • Poor crew practices as wages decrease • Reduced investment with resulting safety and other problems • Subsidies leading to economic inefficiencies and fleet expansion	• Focus on business planning and necessary supportive economic analysis; understanding business drivers is critical • Use market drivers to effect positive changes	• Removal of harmful subsidies • Introduction of market-based incentives such as certification • Business planning and investment in cost-saving measures with associated environmental impacts

4.3 THE BLUEPRINT

As part of overall guidance for planning for sustainability, it is important to specify an over-riding or high-level objective. The following primary objective is specified as the basis for the blueprint:

"To ensure shrimp resources are managed in a sustainable ecosystem-based manner, to ensure the long-term sustainable livelihoods of fishers and fishing communities."

The blueprint is structured around the following secondary outcomes in support of the objective:

- To create a management framework which ensures the setting of appropriate harvest control rules that support the sustainability of the target species and make adequate provision for safeguarding the supporting ecosystems
- To provide a system of strong compliance and facilitate industry participation in all aspects of decision making
- To create a monitoring and evaluation framework to assess results of blueprint implementation
- To facilitate development of positive business drivers linked to improved fishing practices and market incentives.

Table 4–1 presents the TST blueprint in the form of a logical framework for use by management authorities.

Table 4-1: Log frame matrix providing a blueprint for sustainable TST fisheries

Objective and Outcomes	Outputs	Activities	Objective verifiable indicators[28]
Objective: To ensure shrimp resources are managed in a sustainable ecosystem-based manner, to ensure the long-term sustainable livelihoods of fishers and fishing communities			
1. To create a management framework which ensures the setting of appropriate HCRs that support the sustainability of the target species and make adequate provision for safeguarding the supporting ecosystems	1a. Governance system strengthened	• Strengthen governance policy objectives by giving priority to sustainability and the ecosystem approach to fisheries management • Create fishery-specific Management Advisory Council (MAC) with clearly defined roles • Strengthen the capacity of the fisheries administration to service the MAC • Establish community fisher organizations • Determine the annual real costs of management, research, and compliance for the fishery • Prepare fishery Management Plan	• Fisheries Acts amended • Legislation adjusted to confirm the independence, powers, and duties of the MAC • Fishery managers and MAC participants provided with training on MAC functionality and service delivery • Community organizations strengthened for small-scale trawl and artisanal fisher groups • Long-term financial support systems established • Annual budget efficiency exercises undertaken and approved • Management Plan prepared
	1b. Shrimp biomass exploited at sustainable levels	• Prepare a research plan to generate inputs necessary for the fishery Management Plan • Develop regional centres of excellence for stock assessment and gear technology • Strengthen stock assessment models to ensure consistency and implementation of scientifically acceptable standards (0.5–0.6 B_{MSY}) • Collect fishery-dependent information through landing records (sex and size) • Collect appropriate data to aid assessment	• Research plan prepared with funding provided from each MAC • Regional centre of excellence confirmed with agreed MoUs with national research organizations and the MAC • Stock assessment blueprint established and adjusted for regionally specific fishery characteristics • Environmental risk assessment parameters established for bycatch species • Common data collection systems agreed and established

[28] Log frames usually contain means of verification and assumptions. These would be established as and when the country-specific blueprints are agreed.

Objective and Outcomes	Outputs	Activities	Objective verifiable indicators[28]
	(1b cont.)	• Agree on a set of measures that can support the restructuring of the fishery. These will include: o Removing redundant licences o Industry buy back o Setting gear SFRs o Possible transition to ITQs but taking account of stock assessment needs, management costs, and compliance requirements and associated costs • Establish input management restrictions which are consistent with scientific advice: o Restricted entry licensing o Gear SFRs and rights-based fishery management, i.e., allowing for tradable fishing rights o Closed seasons o Demarcation zones for specific fisheries • Establish output management restrictions: o Fishery-specific TACs o Minimum size limits for shrimp and other retained species • Establish technical measures o Minimum mesh sizes >45 mm o BRDs appropriate for specific species interactions o On-deck hoppers to reduce mortalities for discarded crustaceans and finfish (which may be required by law) o Transition of artisanal fishing methods to alternative selective fisheries • Introduce ongoing training and awareness programmes • Develop spatially and temporally explicit (closed areas) harvest strategies for periods to protect spawning aggregations and environmentally sensitive zones. VMS or strong co-management system must be introduced to support this.	• Activities specified in Management Plans • TST capacity adjustment strategy agreed with government • Financial support for buy back secured • Legislation in place to confirm restricted entry licensing conditions, gear SFRs, a facility to change closed season parameters, reconfirm zonal parameters (that ensure protection of juvenile species), TACs, minimum landing sizes, gear parameters • Training curricula established with ongoing support programmes provided by the regulatory authority

Objective and Outcomes	Outputs	Activities	Objective verifiable indicators[28]
	1c. Fishery impacts on bycatch, byproduct species, and ecosystems minimized	• Establish technical measures: TEDs and other ETP species selectivity devices • Maintain a limit on the amount of gear used in the fishery to minimize benthic impacts • Develop spatially and temporally explicit (closed areas) harvest strategies for an appropriate period to protect environmentally sensitive zones; VMS or strong co-management system must be introduced to support this • Undertake continuous risk assessment to determine the vulnerability of bycatch and byproduct species to overfishing • Continuously develop management measures to avoid interactions with ETP species • Provide a system of education and training for skipper and crews which can extend to a participatory observer scheme • Collect appropriate environmental data to aid ecosystem-based approach	• Activities specified in management plans • Risk assessment species established • Bycatch action plan prepared and published • Closed areas established and gazetted by law • Bycatch reduction devices installed with supporting training for fishers and crew • Gear parameters reviewed to ensure minimal impact on the benthos • On-board participatory observer schemes operational • Training provided • Data required for ecosystem-based approach collected and used to inform management decisions
	1d. Measures introduced to support and control artisanal fishers	• Create community organizations • Secure demarcation zones, but including coastal no-go areas • Empower fishery authorities at district level • Set gear parameters • Establish market control mechanisms to prevent sale of juvenile species	• Activities specified in management plans • Funding support secured (e.g., NGOs and donor organizations) • Definition of a typical district structure and organization, with a clear definition of the attributes and powers of the administrator, the district structure responsible for fisheries administration, and the role of the community organizations • Training of fishery administration and inspection staff at district level • Establishment of the participatory fishery management bodies at district level • Gear application parameters set and promoted at district level
2. To provide a system of strong compliance and facilitate industry participation in decision making	2a. Fishery compliance systems strengthened	• Undertake risk assessment strategies and determine deployment strategies (VMS, observers, reporting in, aerial surveys, marine and land inspection systems established) • Agree budgets and inspection strategies with the MAC • Establish penalty systems • Compliance training • A policy of intervention for the artisanal fishery sector	• Deployment strategies prepared outlining: observer coverage, port inspection coverage, VMS, displacement, and reporting systems • Standard operating procedures specified and in operation • Inspector participation in gear application awareness schemes • Introduction of a system of sanctions envisaging the loss of fishing rights • District inspector participation in community-based management schemes
	2b. Co-management participation secured	• Determine co-management responsibilities based on above and provided for in legislation • Focus on real-time at-sea fisher decision making • Fisher participation and partnerships in stock assessment • Fisher and industry participation in observer and data collection schemes	• Documented co-management responsibilities and supportive legislation • Fisher awareness programme on species interactions • Fisher observer training

Objective and Outcomes	Outputs	Activities	Objective verifiable indicators[28]
3. To create a monitoring and evaluation (M&E) framework to assess results of blueprint implementation	3a. M&E system established	• Agree on indicators • Develop a peer review and M&E plan • Agree on M&E practices that ensure the credibility, impartiality, transparency, and usefulness • Set target output indicators	• Peer review report • M&E plan finalized • M&E processes
4. To facilitate development of positive business drivers linked to improved fishing practices and market incentives	4a. Private sector partnerships, and fishing vessel best practice systems, operating	• Establish sector partnerships between catching, processing, export, import, retailer, and food service sector stakeholders, facilitated by NGOs • Review operational economics and develop business plans which include crew reward schemes for improved selectivity; introduce gear adaptations which reduce fuel utilization and create carbon savings • Establish network within and between countries to share positive experiences of adopting improved business drivers and impacts on bottom line so as to support uptake/replicability in other areas • Remove all negative forms of fishing subsidies.	• MoUs established which provide for a built-in price reward structure for changes towards environmentally sustainable fishing practices • Individual company assessments undertaken • Network system developed through industry partnerships initiative • Subsidies removed

To further elaborate on some of the parameters specified in the blueprint above, additional clarification and explanation is presented below, structured around the key results of the blueprint log frame.

1a. Governance system strengthened

Legal developments in support of sustainability
Legislation embraces all instruments having the force of law, such as acts, regulations, decrees, orders, and local by-laws. It provides the legal framework to support the blueprint through the detail specified in such instruments, and through powers relating to enforcement and sanctions for those infringing the law. Changes to established policy may require associated legislative change, and the implementation of new policy will very likely require an assessment of the extent to which current legislation needs to be changed/strengthened to support the successful implementation of policy.

Not all of the blueprint needs to be supported and "hardwired" into formal legislation if, for example, there are already well-established informal rules and norms which support particular initiatives. Effective implementation of policy may also be best achieved through other means, for example by the use of economic instruments, or support/promotion and ad-hoc programmes that don't necessarily require enforcement by the rule of law. However, legislation may often be crucial, especially in terms of (a) stipulation of powers of enforcement and sanctions, and (b) ensuring that certain rights are enshrined that cannot be eroded through social, economic, and political marginalization.

As with policy, it is very important that all relevant stakeholders are incorporated into the process of developing legislation (both within fisheries and in other sectors), even if the process can be a long one. Only by doing so can it be hoped that conflicts will be minimized and that legislation will have a measure of legitimacy. Processes for legislative development are different in all countries, but better compliance can be fostered by legislation that involves all stakeholders in its development as stakeholders can then claim "ownership" over such laws.

It should be recognized that legislation has the potential to marginalize and create conflict, as well as to provide a framework for implementing policy and managing conflict issues. Importantly, legislation is often not neutral in its impact on different socio-economic groups. This raises the importance of ensuring that legislation is carefully tailored to suit the needs and conditions in individual countries and situations. It may also be appropriate to have an overriding national framework/legislation, and then local community management norms/rules to reflect different situations.

Management Advisory Council
An MAC should be drawn from the principal stakeholders. The Minister would usually make the decision on the appointment of members of the council. Options for the composition of the council could include:

- An independent chairman
- The fisheries manager (from the National Ministry of Fisheries or equivalent)
- Industry champions derived from each subsector (industrial, semi-industrial, small-scale, and artisanal)
- Representatives of the principal buying companies and middlemen
- Fisheries scientist
- Fisheries economist
- A compliance officer
- An NGO

The chairman must be fully independent without any linkage to existing stakeholders. He/she must be able to support the effective implementation of the management plan. It is important he/she and the co-opted industry members possess strong charisma to ensure the support of the wider industry, but are independent of the wider industry and able to work within the operational requirements of the council's terms of reference.

Provision is made to include an economist in the MAC. This is important so as to be able to determine the economic impact that any proposed MAC measure may have on the sector.

The MAC could be decentralized to ensure that regionally specific fisheries are managed at the provincial level, subject to appropriate safeguards from a nominated peer review authority which could be the National Ministry of Fisheries or Environment (or equivalent Ministry).

The MAC should have the following functions:

a) Prepare annual Management Plans including setting of management indicators (stock abundance, CPUE,

stock fecundity, economic indicators)

b) Propose management measures that ensure the Management Plans can be implemented effectively

c) Conduct reviews of Management Plans based on the results from stock assessment and assessment of ecosystem impacts

d) Promote the co-management of fisheries

e) Promote research, education, and training in relation to fisheries and the management of fisheries

f) Determine the fee structure to pay for a research and development fund, the operating expenses for the council, and an independent peer review

g) Prepare or promote codes of practice concerning matters of relevance to fishery authorities and other stakeholders.

Management Plan
The Management Plan should aim to achieve outcomes that are consistent with sustainability objectives for the management of the species and the supporting ecosystem. The plan should:

- Set out the fishery-specific management objectives and implement a strategy for achieving these
- Identify research needs and priorities
- Set out the resources required to implement the Management Plan
- Describe the biological, economic, and social characteristics of the fishery
- Identify the impacts or potential impacts of the fishery on its associated ecosystem or ecosystems, including impacts on non-target species of fish or other aquatic resources
- Identify any ecological factors that could have an impact on the performance of the fishery
- Assess the risks to the ecosystem and set out strategies for addressing those risks
- Set out methods for monitoring the performance of the fishery and the effectiveness of the plan, including performance indicators, trigger points for review or action, and progress reporting.

Management authority staff strengthened
The blueprint will identify clear activities which will require allocation to specific stakeholders. Some key issues that need to be addressed are as follows:

- Small, efficient, and cost-effective units will have to be created to undertake specific tasks
- Tasks will be defined by clear Terms of Reference
- Staff will have to demonstrate a capacity to implement the tasks; this may require needs assessment and capacity strengthening
- Deliverables and timelines will be set for the various tasks to ensure appropriate support to the work of the MAC
- Barriers will need to be identified and constraints unblocked (e.g., legal issues)
- Replicability in tasks must be avoided at all costs (e.g., important to define the relationships between national and regional governance).

It is important in this situation not to re-invent the wheel. MAC service delivery is a composite part of Australian and US fisheries management, and can assist in terms of exchanges or provision of short-term technical support. Australian expertise has been used to support the development of institutional structures in Mozambique and Madagascar, for example.

1b. Shrimp biomass exploited at sustainable levels

Research plan
Each MAC should agree a budget for research, appoint a lead scientist(s), and support an annual research programme as specified in a research plan. The research programme could be implemented by a regional centre of excellence, or by a national research organization with linkages to more regional research work.

Some specific research components will depend on resources available and the suitability of the fishery to different approaches. Research options should include:

- Recording average catch rates observed on surveys, nominal effort (hours fished), and mean harvested prawn size

Then either[29]:

- Deploying a sophisticated approach linked to a suite of dynamic stock assessment models (yield per recruit/age-structured), or
- Establishing targets and limits relating to exploitation rate, recruitment index, size at first capture, which can be used as a "surrogate" "consistent with B_{MSY}".

In each case allowances will need to be made for environmental variables as well as models evaluating the impacts of changes to fishing power (e.g., as and when gear SFRs are deployed). In some cases, there may be a large number of different species, requiring a combination of the above.

Given the cost and complexity of a sophisticated approach, the latter option would appear far more practical for most developing country groupings.

Attributes of successful research specification and delivery include:

- Research delivery time-scales need to be relevant to blueprint needs, with a balance between operational, strategic, and more fundamental research needing careful consideration
- Research findings and policy implications need to be clearly communicated to their target audiences and linked to management action
- By including more stakeholders in research, especially end-users such as fishers and fishworkers, research can become more demand-led and ownership will increase, thereby ensuring that results are more likely to feed back into action
- In targeting research to policy-makers, it should be recalled that policy-makers are not just those in government, but also those making informal policy in the private sector
- Research will be most effective if embedded in a review and planning process ensuring that it is more action-orientated
- Research capacity building is often required in developing countries, but is only sustainable if incentives for retaining that capacity can be addressed.

Fishery restructuring
Most fisheries are likely to require a package of measures for re-adjustment backed by significant political will. Decision-making will be largely dependent on the philosophical direction that a country may wish to pursue, and whether it is more free-market or socially orientated. However, there should be a note of caution with regards to the ability to police the management regime. Output restrictions such as TACs are extremely expensive to police, particularly in remote fisheries or where there are many individual fleet operators. If company structures exist (as per most semi-industrial and industrial groupings), with vessels within these, a system of ITQs is more attractive because these groups can identify the benefits of rationalization, economies of scale, and the likelihood of a fast recovery in shrimp stocks. Buy-back schemes are infinitely preferable, but require significant central government and/or industry outlay and probably longer-term time horizons. Resources may be available in some countries but not in others.

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[29] The modelling approach is used to support research in Australia's Northern Prawn fishery. In contrast, the South Australian Spencer Gulf fishery uses various measurable targets and limits to cater for real time management (Zacharin *et al*, 2007).

Irrespective of the approach taken to buy back, individual transferable fishing rights (ITFRs) (e.g., gear SFRs)[30] are good means of establishing a system of input limitation and capacity adjustment. In some cases where multi-rig trawling has yet to evolve, it will be important to establish such a system. However, ITFRs, if sufficiently punitive, can also achieve significant reductions in capacity.

The order of adjustment should be as follows:

1. Remove redundant licences. This strategy has some advantage in the current climate where uneconomic vessels have been withdrawn from the fishery.
2. Introduce a buy-back scheme. Such as system would need to be centrally government funded. An array of different systems may be applied such as flat rate schemes, tenders, or payments linked to real as opposed to nominal capacity. What cannot be allowed to happen is that a regime change occurs and additional vessels are allowed to re-enter into the fishery after restructuring has occurred.
3. Introduce ITFRs (e.g. gear SFRs) as a supporting or alternative system to buy back. If it is an alternative, governments must accept that calls for reductions in the total SFRs will be extreme, but could be phased in over a period, for example 50 per cent over five years. What cannot happen is governments failing to follow the scientific advice (usually in response to lobbying from fishing companies) and not setting the required reductions.
4. Introduce a system of company or community quotas as an alternative to gear SFRs, where the fleets are sufficiently small in number and compliance can be demonstrated.

Harvest control rules
The management system must contain the following elements:

1. Access to the fishery needs to be controlled, with a licensing regime specifying operating areas and permissible net lengths.
2. Closed seasons should be set which protect spawning aggregations, but also compliment effort control systems. These should relate to the protection of juveniles and gravid females and be meaningful (i.e., should not be set in lean fishing periods).
3. Demarcation zones should be set.
4. The minimum landing size should be reviewed for target species to prevent juvenile overfishing.
5. All of the above should be supported by continuous awareness schemes undertaken by the regulatory authority.

1c. Fishery impacts on bycatch, byproduct species and ecosystems minimized

The management system must contain the following elements.

1. Gear configurations should be adjusted to prevent the build-up of bycatch.
2. Closed areas should be established to protect spawning stocks or areas of high risk to ETP species and environmentally dependent bycatch species.
3. ETP species exclusion devices should be introduced and should not necessarily be exclusive to TEDs, as other interactions are problematic (e.g., sea snakes and syngnathids).
4. Benthic impacts should be evaluated and gear modifications made to reduce impacts. Fishers have been particularly innovative themselves with initiatives in this area. Bottom trawled areas should not be increased and shrimp fisheries should aim for the reduction of their footprint by reducing the area trawled and introducing smarter gear types and technologies.
5. The above should be incorporated into a documented bycatch action which examinines all options (utilize, avoid, or reduce). The action plan requires the need for an environmental risk assessment which will determine bycatch species most at risk. In the event of at-risk species, a number of mitigation measures

[30] Other forms of ITFRs which could be further explored for adoption in TST fisheries are the Boat Units System (Torres Prawn Fishery) and Time Units (Queensland East Coast Trawl Fishery).

should be evaluated and applied as appropriate. These might include trigger limits, closing areas where sensitive interactions are high, or further innovations to BRDs and TEDs.

Box 4-1: Ecosystem approach to fisheries management

EAFM entails taking careful account of the condition of ecosystems that may affect fish stocks and their productivity. It also means taking equally careful account of the ways that fishing activities may affect marine ecosystems. This means, where necessary (e.g., within agreed levels of impact), changing the way in which the fishery operates, adjusting the type of gear used, or imposing closed areas to protect biodiversity or habitats critical to the whole fishery or to the biodiversity of the region. Furthermore, it means taking an inclusive approach to setting goals and objectives for harvested fish and the fish ecosystem, recognizing ecosystem interactions, possibly integrating activities across a range of other users and resource sectors, and respecting the broad range of society's values for the marine environment.

The ecosystem approach aims at environmental and human well-being by:

- Maintaining the natural structure, function, biodiversity, and productivity of natural systems
- Accounting for human needs and values of ecosystems when establishing objectives
- Recognizing that ecosystems are dynamic with attributes and boundaries constantly changing and that consequently, interactions with human uses are also dynamic
- Accepting that natural resources are best managed within a management system based on a shared vision and a set of objectives developed among stakeholders
- Adopting adaptive management procedures, based on scientific knowledge, continual social learning, and recurrent audit and evaluation of the management performance.

In moving towards an ecosystem approach to shrimp fisheries a number of steps should be taken to:

- Delineate the practical boundaries of the shrimp fishery ecosystem inland and at sea
- Identify critical habitats (e.g., lagoons, mangroves, seagrass beds, mudflats, structured benthic environments, spawning –feeding -shelter grounds), their state, and existing threats (agriculture, urbanization, etc)
- Identify the species assemblage and information available on it, predators, and preys
- Identify all stakeholders and catalogue the different values of the ecosystem for them
- Identify potential partners (e.g., in the Ministry of Environment, NGOs, etc)
- Assess, at least qualitatively, the bycatch and habitat damage issue, looking for threats to protected/endangered species
- Identify institutional zones such as reserves and exclusion zones for industrial fishing
- Identify potential external drivers (e.g., climate oscillations, rainfall, market forces, etc)
- Identify potential sources of threats (e.g., pollution sources, competing sectors, urban development, oil industry, and dumping activities)
- Identify patterns of variability and change
- Identify explicit and implicit objectives.

Source: Extracted from WWF working documents.

1d. Measures introduced to support and control artisanal fishers

See comments on both co-management (2b below) and human capacity development (section 4.4).

2a. Fishery compliance systems strengthened

Each fishery will require risk assessment profiling in order to determine the most effective and cost-efficient resource deployment strategies. Some observations are as follows:

- Demarcation zones require VMS (including satellite), or a heavy presence by marine vessels/aerial surveillance where known incursions occur
- Observer schemes are effective, but can be supplemented by participative co-management
- Onshore inspections (of fishing gear) are more cost efficient than at-sea inspections
- TAC systems require heavy resourcing; costs may be reduced through delegating data collection responsibilities to industry organizations
- Where artisanal fisheries are significant, special district inspectors will need to be trained and deployed; this role could be delegated to community-based management and co-management groups and/or NGOs.

2b. Co-management participation secured

Co-management in the wide sense of government partnerships with other stakeholders for the purpose of natural resource management, rather than just the narrower concept of community-based management, is an emerging

trend. The trend is driven by, among other things, an awareness of resource depletion, conflicts both within the sector and between fisheries and other sectors, and the perceived benefits of co-management as an approach. Furthermore, implementation of co-management is now being encouraged, or at least enabled, by decentralization policies in many countries.

Political will is the key to the establishment of co-management mechanisms, a necessary pre-requisite without which co-management initiatives are unlikely to succeed. It must be reflected in policy, legislation, and action specific to the fisheries sector, as well as more generally in government policy and legislative support.

For co-management to be successful, a number of factors must be in place:

1. Decentralization should be provided for in fisheries policy, not just in national non-sectoral policy/legislation, with references being specifically tied to a mention of its importance for co-management.
2. It is better to undertake legal/policy reviews of decentralization of fisheries management/ administration and co-management at the same time to ensure a cohesive and complimentary effect.
3. An enabling environment supportive of co-management is more likely when a wide range of stakeholders are involved in the process to develop the country/fishery-specific blueprint itself. Indeed this could be considered the first step in co-management.
4. The blueprint and its implementation should be supportive of success factors associated with co-management, such as:
   - User rights
   - Institutional strength of local organizations and their leadership
   - Recognition of existing local fisher community organizations as fundamental to the co-management process
   - Local political support
   - Appropriate incentives for local users to engage with co-management
   - The need for formal legislation to back up/codify community rules and resolve disputes.
5. Research may be necessary on how to move beyond pilot approaches to mainstreaming co-management, and on assessing the positive impacts of co-management. Co-management initiatives can also be enhanced and supported through appropriate local level research and better linkages between researchers and policy markers at the local level.
6. Co-management initiatives should ensure that fisheries legislation is supportive of them and of decentralization of fisheries management before commencing.
7. Co-management legislation should contain dispute resolution mechanisms to deal with user conflicts, and to ensure that local rules/regulations do not conflict with national-level legislation and policy.
8. Co-management legislation should specify the extent to which local autonomy in developing management rules/legislation will be accepted.
9. National fisheries legislation should provide for a broad and flexible legislative framework that enables a choice over co-management arrangements and rules, with detailed mechanisms set out in regulations that can be changed if necessary.
10. National fisheries legislation should contain specific reference to co-management, or provide indirect support to key success factors that need legislative support.

3a. Monitoring and evaluation system established

M&E Plan

Monitoring indicators of fishery management performance should be used for the continuous or periodic (typically quarterly, semi-annual, or annual) measuring of the extent to which the activities specified in the policy planning hierarchy are being successfully completed. Generally, managers with responsibility for policy implementation use indicators to assess outputs and progress. Monitoring indicators can then be used to take corrective action on the policy implementation through appropriate feedback mechanisms, i.e., by highlighting that a specific activity is being carried out too slowly. Monitoring indicators can therefore be viewed as process indicators. In terms of policy implementation, they would thus be used to monitor the extent to which the specified activities are being implemented. Typically those responsible for policy implementation would collect monitoring indicators.

Evaluation indicators, on the other hand, are used to measure results/impacts/benefits. They can be considered equivalent to "blueprint impact indicators", and are generally strongly focused on performance (although in certain instances some evaluation indicators can also be process indicators). Usually assessments should be made less frequently, i.e., every 3–5 years. Assessment of blueprint implementation impacts may best be made by external specialists with evaluation experience, rather than by those responsible for policy specification and implementation.

For example, in Australia, the 1999 EPBC Act requires that all fisheries from which product is exported must undergo assessment to determine the extent to which management arrangements ensure that the fishery is managed in an ecologically sustainable way. These Wildlife Trade Operations accreditations are set for three years, and 58 fisheries are listed including shrimp fisheries. Accreditations are based on a number of major themes/issues which are evaluated, and which are closely associated with the MSC Principles:

- Fishery area of interest
- Fishery
- Management system
- External influences
- Interaction with protected species
- Ecosystem impact (e.g., habitat, food chains, etc)
- Target stock status
- Byproduct and bycatch stock status.

Each fishery is subjected to an evaluation organized under the auspices of DEWHA (Australian Department of Environment). The participating Management Authority is required to submit a report highlighting performance against a set of indicators. Each report is then subject to DEWHA review, which involves recruiting an independent specialist as part of the review team. The review monitors performance against a set of output indicators but also makes a number of recommendations for further action. The report is made available to the public for scrutiny.

Importantly, evaluation indicators should also consider the design of the policy planning hierarchy, its implementation, and the results, and be used to help answer a number of important evaluation questions relating to the:

- Efficiency/value for money (assessing the outputs in relation to inputs, looking at costs, implementing time, and economic and financial results)
- Effectiveness (measuring the extent to which the objectives have been achieved or the likelihood that they will be achieved)
- Impact (measuring both the positive and negative, foreseen and unforeseen, changes to and effects on society caused by the policy/strategies/activities under evaluation)
- Relevance and coherence (assessing the extent to which the policy satisfies the needs of the various interest groups and gauging the degree to which the policy goals/strategies/activities at a given time are justified and fit within the global and national/local environment and development priorities)
- Sustainability (measuring the extent to which benefits continue from a particular policy goal/strategy/activity

after its completion).

With increasing emphasis being placed on monitoring and evaluation, and the indicators used to assess policy implementation and its impacts, it is essential that a detailed M&E plan be developed. This plan should contain:

- Detailed information on the indicators
- The frequency and timing separately for a) monitoring and b) evaluation reports
- Specific monitoring and evaluation responsibilities to all relevant parties (i.e., who should be reporting to who)
- The activities required to complete the M&E requirements (e.g., stakeholder consultation, fieldwork, regular reporting)
- Methods and tools to be used to collect information/data necessary for different indicators (i.e. the means of verification)
- Technical issues related to specific indicators and their means of verification
- Dissemination components and techniques.

The M&E plan should also contain detailed information on the feedback mechanisms for monitoring and evaluation outputs to be used to make changes either to blueprint implementation, or the overall design of the blueprint logframe as it pertains to specific countries/fisheries. It might also contain a supervision plan specifying the periodicity and make-up of supervision mission teams.

M&E processes
Monitoring and evaluation practices must ensure the credibility, impartiality, transparency, and usefulness of their outputs. Two key mechanisms can help to ensure that this is the case:

- Wide stakeholder consultation (e.g., with the scientific community, NGOs, governments, etc)
- Installation of IT management systems.

4a. Sector partnerships, and fishing vessel best practice systems, operating

Successful implementation is very likely to depend on the establishment of a) cost-recovery mechanisms, b) public-private sector partnerships, and b) supply-chain partnerships in support of improved sustainability. Establishing such mechanisms can be facilitated by demonstrating the advantages of improved sustainability (e.g., through preparation of business plans), thereby also increasing the potential for funding linked to positive changes.

Business practices and analysis of economic strengths and weaknesses are extremely important in the context of development of best industry practice.

- Market-led initiatives are presently underway using MSC guideposts or alternatives such as Seawatch (Mexico) and other mechanisms to promote sustainability and link initiatives to importers and retailers. WWF-US has funded two MSC pre-assessments in TST fisheries and is in partnership with one producer (UNIMA). The Shrimp Round Table (US) is promoting industry/processor partnerships linked to conservation initiatives. One private sector European importer is presently funding a full assessment of a TST fishery. The benefits from this are likely to result in price increases, but there are overwhelming external pressures from non-TST supplies. Nevertheless, wild-caught shrimp always maintains a high price premium.
- Trash fish inclusion is recognized as not contributing substantially to income (CIFT, India), so is questionable in the context of a business model.
- Other retained species may be important to financial viability, but there is a need to ensure that commercial species reach acceptable adult sizes, and that the market takes account of low volume/improved quality.
- Fuel savings of up to 30 per cent can be achieved through improved fishing techniques (lighter gear and reduced haul times).
- Carbon emission studies can also reveal savings in fuel consumption (e.g. propeller rpm and freezer efficiency).
- Fuel savings can be transferred into improved crew remuneration systems, most importantly crew premiums for larger shrimps.

These issues can be explored on a company-specific basis through business plans, but also the results shared more widely than at present through improved networking between TST companies and sector partnerships.

4.4 IMPLEMENTATION OF THE BLUEPRINT

The implementation of the blueprint is likely to pose significant challenges in many countries. In particular, two areas are worthy of special comment, and some additional advice is therefore provided in support of successful implementation.

Making the generic blueprint country/fishery-specific

The blueprint presented above is generic and applicable to all TST fisheries. However, in order for implementation to be successful it should in all cases be reviewed by local stakeholders and amended as appropriate. This is critically important for two reasons:

1. To ensure that the blueprint adopted for any one country/fishery is specific to the needs of that country/fishery (this is likely to require provision of additional specifics to the generic blueprint)
2. To ensure that stakeholders in the country/fishery have the opportunity to participate in finalizing the blueprint, thereby generating a sense of ownership of it, hence the creation of the MAC.

How can countries/fisheries make the blueprint specific to their needs? The approach taken should be to convene a workshop of all relevant stakeholders (government, private sector, civil society) to review and amend the blueprint presented above. This workshop could be professionally facilitated, and should start by agreeing an overall objective and the four specific objectives proposed. The key anticipated results should then be discussed and agreed before moving to necessary activities in support of these results, and their respective objective verifiable indicators. As noted in the generic blueprint, means of verification should also be agreed.

Of critical importance in the adaptation of the blueprint to any particular country/fishery is that all activities should be allocated a specific timeframe, with responsibilities assigned for their completion. Stakeholder expectations should also be managed carefully from the start of the implementation process so that reasonable goals are identified that are achievable within realistic timeframes. In addition, a central coordinator should be identified to lead the work for a particular fishery so that activities stay on track and stakeholders continue to be engaged in an inclusive and effective manner.

Funding for implementation of the blueprint

A key factor in ensuring that the specified blueprint can actually be implemented is the allocation of appropriate budgets and resources. This is a two-way process in which:

- All activities should be costed with total cost estimates presented via the MAC to the government/state treasury for inclusion in development and operational budgets for the fisheries/aquaculture sector
- Once development and operational budgets have been approved, the list of activities to be conducted may need to be revised, depending on how much funding is available
- Activities and budgets are constantly reviewed by the MAC.

It should be noted of course that an important job of the relevant fisheries ministry should be to lobby for financial resources from government and stakeholders. This can be facilitated by:

- Careful presentation of the actual and potential benefits of the sector to the nation (e.g., income generation and added value, foreign exchange earnings, employment generation, multiplier effects, taxation, food security, as a safety-net activity for the poor, etc)
- Demonstrating that the blueprint is logical and that all activities are essential to achieving the objectives
- Demonstration of the effective and efficient use of previous funds provided to the sector so as to generate maximum value for money.

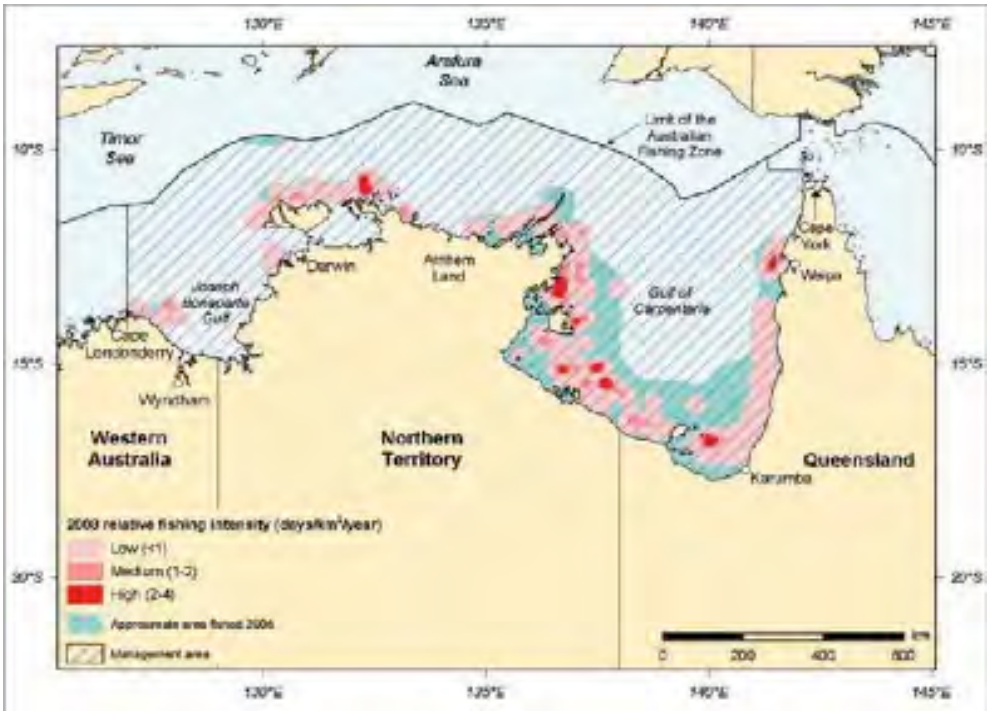
The issue of allocation of resources also requires careful consideration of the timing of budget allocations/release, and a match of the time-bound responsibilities of activities with the timing of the funds to be provided by the government.

In all countries, government resources are scarce. This places great onus on those in the sector to strive to use resources efficiently and effectively, and where possible to select low-cost options over high-cost ones. It also means that fisheries managers should seek to bring in external funding where possible, which can then be used to support implementation of the blueprint (see also comments above under the notes on objective 4a related to partnerships).

APPENDICES

APPENDIX A. COUNTRY CASE STUDIES

A.1: Northern Prawn Fishery, Australia

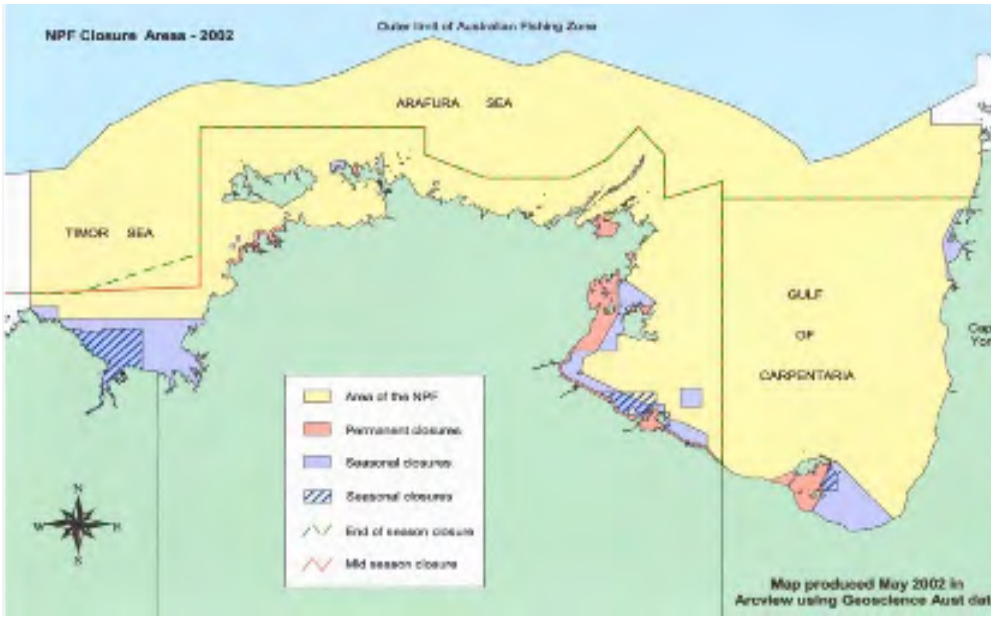
Feature	Description
Target species	Red-legged banana prawn (*Fenneropenaeus indicus*) White banana prawn (*F. merguiensis*) Brown tiger prawn (*Penaeus esculentus*) Grooved tiger prawn (*P. semisulcatus*) Blue Endeavour prawn (*Metapenaeus endeavouri*) Red Endeavour prawn (*M. ensis*) Red-spot king prawn (*Melicertus longistylus*) Western king prawn (*M. latisulcatus*)
Byproduct	Slipper lobster/Bugs (*Thenus* spp.) Finfish (various) Scampi (*Metanephrops* spp.) Scallops (*Amusium* spp.) Squid (*Photololigo* spp.)
Shrimp dependency	99.5 per cent
Management authority	Australian Fisheries Management Authority (AFMA)
Fishing zone	
Fleet segments	52 industrial trawlers.
Management methods	Restricted access with 250 vessels bought out through three successive buy-out schemes since mid-1980s. Input controls, individual tradable gear SFRs: 3,029 metres of operational headrope (twin trawl net configuration) (2007) 2,654 metres of operational headrope (twin trawl net configuration) (2008). These may be transferred subject to AFMA approval. 48 boats removed in 5 years through SFR aggregations. Output controls from 2010/2012. Quota likely based on existing SFR holdings. SFRs accepted as the

property right in the fishery.

Seasonal closures: Banana prawn season from 27 March for 6–10 weeks; tiger prawn season from 1 August to 28 November (2008), comprising a fixed 15 weeks, but a two-week extension may be granted if catch rates are more than 300 kg/vessel/night. Mid-year closures to protect spawners and end-year closures from December to 1 March to protect juveniles.

A daylight trawl closure during the tiger prawn season aims to reduce the capture of gravid prawns, which are more likely to be caught during the day. A total of 2.1 per cent of the fishery management area is subject to permanent closures, with 6.3 per cent subject to seasonal closures. Less than 11 per cent of the total area of the fishery is actually fished.

Permanent and seasonal area closures to help protect nursery areas and sustain the productivity of the fishery; end of season and mid-year closures to reduce the capture of juveniles and gravid tiger prawns.



Cobourg Marine Park contains extensive live coral reefs and seagrass meadows, and is rich in marine life. The conservation values of the park are:

- the diversity of marine habitats
- the occurrence of live coral reefs and extensive seagrass meadows;
- the occurrence of breeding grounds for dugong, turtles, and other marine life
- the occurrence of critical habitat for a variety of marine animals
- the occurrence of nursery areas for marine life in the form of a well- developed benthos
- the presence of endangered species such as dugongs, turtles, and the estuarine crocodile (*Crocodylus porosus*).

History

Mid-1960s: Fishery started.

1970s: Up to 200 vessels operating.

1971: Seasonal closures for banana prawns introduced.

1977: Interim Management Plan developed; first formal multi-stakeholder management advisory committee (NORPAC) formed to provide management advice to government. Limited entry introduced through 3-year moratorium on licences and new vessels entering the fishery.

1980: Controls on vessel replacement relaxed to allow smaller trawlers to replace to “subsidy size” trawlers with no penalty.

1984: Unitization introduced as a response to concerns about fishing capacity and over-capitalization. Adoption of A-units as measure of vessel size and power. B-units introduced to authorize the right for a vessel to fish, and to limit total capacity. Northern Prawn Fishery Management Advisory Committee (NORMAC) formed to replace NORPAC.

1985: First formal NPF Management Plan implemented.

Mid- to late-1980s: Buyback scheme aimed to reduce A-units to 70000 by 1990. Plan was for an initial voluntary buyback followed by a compulsory surrender, however the compulsory component of the scheme was not implemented due to lack of industry support. Voluntary buyback extended to B-units.

The scheme removed approximately 90 vessels.

1987: Mid-season closure (usually May–August) introduced to reduce effort on tiger prawns before they spawn, in response to decline in tiger prawn recruitment. Daylight trawling during the tiger prawn season banned. Vessels restricted to towing two nets (from quad or triple gear). Additional restrictions on boat replacement implemented.

1988: Fishery became solely managed by the Commonwealth under Offshore Constitutional Settlement arrangements.

1990–1993: Buyback scheme refinanced, with amended target of 53,844 A-units by early 1993, achieved through combination of buy back and compulsory surrender (30.76 per cent). Licence numbers reduced from 212 to 137 (132 active trawlers).

1995: Management plan and A and B class SFRs introduced, based on existing effort units in the fishery, to replace class A and B units.

1998: Northern Prawn Resource Assessment Group advise that the effective effort directed at tiger prawns was well above MSY and should be reduced by 25–30 per cent. First Bycatch Action Plan developed.

2000: Fishery moved to gear-based management using headrope length, with A and B units replaced by gear SFRs and B (boat) SFRs.

2000. TEDs became compulsory.

2001: BRDs became compulsory.

2002: 40 per cent effort reduction target met through a 25 per cent reduction in total allowable headrope length and shortening of season (to 134 total days in 2002, 2003, and 2004).

2004: NORMAC established MEY as the overall management objective of the fishery. MSY redefined as limit reference point. NORMAC recommended 25 per cent reduction in gear SFRs.

2005: 25 per cent reduction in total allowable headrope length. Second (tiger prawn) season lengthened, with additional measures to minimize tiger prawn catch in the first (banana prawn) season.

2006: NPF Management Plan 1995 amended to allow for the use of different gear types (notably quad gear) and provide for the collection of prawn broodstock. An AUD$68 million structural adjustment package *Securing Our Fishing Future* removed 43 class B SFRs and 18,365 gear SFRs purchased from the fishery (45 per cent and 34 per cent reduction, respectively). A condition of participation was for the fishery to move to output control management (i.e., individual transferable quotas).

2007: NPF Harvest Strategy Under Input Controls introduced, which aims to maximize profit by changing effort levels using the results of a bioeconomic assessment of the tiger prawn fishery.

2008: 33 per cent increase in total gear in the fishery, resulting in an increase in the value of each gear SFR from 0.5625 cm to 0.7481 cm.

Management Plan

Northern Prawn Fishery Management Plan 1995 (Department of Agriculture, Fisheries, and Forestry 1995; last amended July 2006)

The objectives of this plan are to ensure that:

a) The objectives pursued by the Minister in the administration of the Act, and by AFMA in the performance of its functions, are met in relation to the Northern Prawn Fishery

b) The incidental catch of non-target commercial and other species in that fishery is reduced to a minimum.

The measures by which the objectives of this plan are to be attained include:

- Developing and implementing appropriate management measures (including directions referred to in subsection 17 (5A) of the Act) in relation to the Northern Prawn Fishery
- Implementing an effective program of surveillance for the Northern Prawn Fishery to ensure compliance with this plan
- Promoting research that is relevant to the Northern Prawn Fishery
- Preparing an annual budget of costs associated with managing the Northern Prawn Fishery
- Setting and collecting levies and fees in relation to the Northern Prawn Fishery
- Collecting data that can be used to assess the status of the Northern Prawn Fishery
- Monitoring the impact of catching operations in the fishery on ecologically related species and implementing any practical strategies that are necessary to minimize the impact of those operations on those species
- Developing and implementing a bycatch action plan.

The performance criteria against which the measures taken may be assessed are:

- The status of economic efficiency of the Northern Prawn Fishery
- The status of the biological resources and environmental conditions in the Northern Prawn Fishery area
- The cost-effectiveness of the Northern Prawn Fishery.

AFMA and the Northern Prawn Fishery Management Advisory Committee must, from time to time, conduct assessments of the effectiveness of the measures taken to implement the objectives of this plan by reference to the performance criteria. AFMA must publish an annual report assessing the performance of this plan The following specific plans are prepared:

- FMA. 1995. NPF Management Plan: www.afma.gov.au/fisheries/northern_trawl/northern_prawn/publications/default.htm
- Commonwealth Policy on Fisheries Bycatch, June 2000: www.daffa.gov.au/__data/assets/pdf_file/5812/bycatch.pdf
- AFMA. Bycatch Action Plans – Northern Prawn Fishery: www.afma.gov.au/information/publications/fishery/baps/default.htm
- Integrated Scientific Monitoring Program: observer reports, 2001 – 2005: www.afma.gov.au/fisheries/northern_trawl/northern_prawn/publications/default.htm
- AFMA. NPF Northern Prawn Fishery Strategic Ecosystem Data Plan, 2004: www.afma.gov.au/fisheries/northern_trawl/northern_prawn/publications/default.htm
- AFMA. NPF Five-year Strategic Research Plan (2001-2006): www.afma.gov.au/fisheries/northern_trawl/northern_prawn/publications/default.htm

Governance

AFMA undertakes primary responsibility for fisheries management, with a dedicated senior manager and support staff.

NORMAC

NPF Industry Pty Ltd (NPFI)

Harvest strategy

Commonwealth Fisheries Harvest Strategy Policy. The strategy's control rules operated in 2008.

Tiger prawns: Target reference point: MEY from the tiger prawn fishery as a whole (including byproduct of endeavour prawns) Limit reference point: 0.5 B_{MSY} (half the spawning stock size required for maximum sustainable yield). A maximum of 52 vessels fished during 2008. The fishing effort for brown and grooved tiger prawn fleets is set for a two-year period to maximize profits over a seven-year moving window, based on the results of a bioeconomic assessment conducted every two years. Fishing effort is controlled by modification of area, season, and gear (headrope length). If the limit reference point is triggered, targeted fishing of the species concerned ceases. Standardized fishing effort for the fleet in any one year cannot be less than half of the standardized effort targeted at brown tiger prawns in 2006.

Banana prawns: There are no specific target or limit reference points for banana prawn but these are managed through an escapement policy. The season is limited to 6 weeks, with the possibility of extension to 8 or 10 weeks provided that banana prawn catch rates are maintained (>500 kg/vessel/day) and tiger prawn bycatch is low (<6.6 t/week). The rules are based on historical data which indicates that this approach is likely to result in a sustainable fishery.

King prawns are monitored through logbooks, surveys and seasonal landings. If a consistent decline in abundance is detected over a three-year period, appropriate management measures (including additional spatial closures) will be implemented to reduce fishing pressure.

Scampi status is assessed through examination of trends in total annual catch, vessel participation, catch rates, and size distribution. A catch of 30 t or greater, or participation of eight or more vessels, in a year will trigger a 30 t TAC in the following year.

Harvest strategies to be replaced by TACs/IQs in 2010.

Bycatch work plans

Northern Prawn Fishery Bycatch Action Plan 2007 (AFMA, 2008)

EPBC Act assessments: listed species (Part 13) international movement of wildlife specimens (Part 13A). Current accreditation dated 12 January 2006. Current accreditation (exempt) dated 22 December 2008; expires 9 January 2014.

Key features

Significant emphasis on capacity reduction (buy back and SFRs) with the removal of 250 vessels over 25 years.

Strong industry cohesiveness. NORMAC proactively involved in fisheries management decision-making, with extensive stakeholder interaction and production of harvest strategy (to prevent overexploitation) and bycatch action plans (to provide mitigation measures for bycatch species).

	High-quality stock assessment and bycatch mitigation strategies applied through NORMAC.
	The fishery includes a high proportion of bycatch, interactions with protected species (such as marine turtles and sea snakes), and the potential impacts of trawling on benthic communities. The industry has been involved through crew-member monitoring of bycatch and evaluation of the effectiveness of bycatch reduction measures since 2000. Industry education programmes in the application of TEDs have been effective in reducing marine turtle bycatch and, to some extent, bycatch of other large species. In 1999, 96 turtle mortalities were reported and 780 marine turtles were released alive; in 2007, no mortalities were reported and 55 turtles were released alive. BRDs still under development. The latest approved BRD, the Popeye Fishbox, reduced small-sized bycatch by up to 48 per cent and bycatch of sea snakes by up to 87 per cent in trials. An ecological risk assessment of the fishery was completed in 2009. Because of the low coverage area within the fishing region (10–12 per cent) and seasonal closures, the application of a cohesive closed area policy, and use of TEDs and BRDs, the fishery is judged to be low risk.
	VMS but good level of compliance, with risk assessment strategies applied.
	Peer review process through DEWHA audits.
Problems	Continued heavy emphasis on bycatch mitigation.
	Potential industry concern about change to ITQ management from the gear SFR system that has proven to be effective.
	High management costs (AFMA) for relatively small fishery.
	The fishery is exposed to factors beyond the direct control of operators and fishery managers. Banana prawn stock levels are substantially influenced by rainfall. In addition, prawn price, fuel price, and exchange rate movement have substantially affected financial returns in the fishery.
Actions taken	Continued emphasis on harvest strategies and bycatch mitigation.
	Strengthening focus on market-based mechanisms to reduce capacity (ITQs).
Lessons learned	Ecosystem approach to fisheries management applied successfully.
	Strong focus on stock assessment.
	Significant financial resources required to reduce capacity.
	Adaptive management been successful, gear SFRs have dealt with growth in effort (multi-trawls), with additional benefits secured through gear unit aggregations.
	Strong industry cohesiveness.
	Formation of NORMAC with deliverables on action plans for bycatch mitigation and harvest control. The ecosystem approach to fisheries management proven to be highly effective. Strong support for co-management approaches.
	Effective peer review processes in place to ensure strong management.

A.2 Spencer Gulf fishery, South Australia

Feature	Description
Target species	King prawn (*Melicertus latisulcatus*)
Byproduct	Calamari (*Ibacus* spp.) Slipper lobster (*Sepioteuthis australis)*
Shrimp dependency	95 per cent
Management authority	Department of Primary Industries and Resources, South Australia (PIRSA)
Fishing zone	
Fleet segments	39 industrial trawlers.
Management methods	Restricted night-time fishing (60 days, i.e., no more than 14 nights per month over the dark of the moon), gear restrictions (twin trawl/maximum headline length/minimum mesh size 45 mm), maximum vessel length and hp, BRDs. Gazetted and voluntary closed areas Voluntary gear revisions: • The slight angle of the trawl boards, too acute angle would result in digging • Not using tickler chains • The position of the headrope in front of the footrope • Adequate space between the dropper and the footrope.
History	1967: Trawl fishery began 1976: Restricted access began 1982: First Management Committee and Management plan 1999: Ecosystem approach to fisheries management initiated
Management Plan	The current Management Plan (PIRSA, 2007) aims to achieve outcomes that are consistent with broader government objectives for the management of the marine environment. These include: • The National Strategy for Ecologically Sustainable Development; • The Precautionary Principle, as set out in the Intergovernmental Agreement on the Environment; • The Australian Government "Guidelines for the Ecologically Sustainable Management of Fisheries", which relate to the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* • The National Policy on Fisheries Bycatch. The plan: • Sets out the management objectives and implements a strategy for achieving these • Sets out the resources required to implement the plan • Describes the biological, economic, and social characteristics of the fishery • Identifies the impacts or potential impacts of the fishery on its associated ecosystem or ecosystems, including impacts on non-target species of fish or other aquatic resources

- Identifies any ecological factors that could have an impact on the performance of the fishery
- Assesses the risks to the ecosystem and set out strategies for addressing those risks
- Sets out methods for monitoring the performance of the fishery and the effectiveness of the plan, including performance indicators, trigger points for review or action and progress reporting.

Management goals, objectives, and strategies for the Spencer Gulf Prawn Fishery (2007–2011)

Goal	Objective	Activities
1. Maintain an ecologically sustainable prawn biomass	1a. Spencer Gulf prawn stocks harvested at ecologically sustainable levels	• Maintain a restriction on the number of licences and the total amount of gear in the fishery • Develop spatially and temporally explicit harvest strategies for each fishing period in line with established target and limit reference levels and decision rules • If the stock is determined to be operating below the established limits, the fishery will be managed to promote recovery to ecologically viable stock levels, within agreed timeframes
	1b. Sufficient biological and ecological information exits to inform management decisions	• Collect fishery-dependent information through commercial logbooks • Maintain the fishery-independent prawn survey programme • Assess the status of the stock through quantitative stock assessment • Collect appropriate environmental data to aid assessment • Review and update the strategic research and monitoring plan
2. Ensure optimal utilization and equitable distribution	2a. A fishery exploited for maximum economic value	• Within a framework of sustainable exploitation, develop harvest strategies that match target size with market requirements • When targets are reached, allow for higher exploitation levels to capture economic benefits from the fishery (subject to the constraints outlined under goal 1)
	2b. An economically efficient fleet	• Develop management arrangements that allow commercial operators to maximize operational flexibility and economic efficiency • Undertake economic surveys of the commercial fishery to assess economic performance against a set of economic indicators
	2c. Equitable public access	• Review appropriateness of access arrangements between sectors once within the life of the Management Plan • Develop a mechanism for altering access arrangements should a change be required
3. Minimize impacts on the ecosystem	3a. Minimize fishery impacts on bycatch and byproduct species	• Maintain a limit on the amount of gear used in the fishery • Maintain permanent closed areas • Undertake a risk assessment to determine the vulnerability of bycatch and byproduct species to overfishing from prawn trawling • Develop mitigation strategies for bycatch and byproduct species deemed at high risk of overfishing from prawn trawling • Promote the development of environmentally friendly fishing practices
	3b. Avoid the incidental mortality of endangered, threatened, and protected species	• Undertake a risk assessment to determine the vulnerability of endangered, threatened, and protected species to fishing operations • Improve data recording systems to capture fishing interactions with endangered, threatened, and protected species • Develop management measures to avoid interactions with endangered, threatened, and protected species

	3c. Minimize fishery impacts on benthic habitats and associated species communities	• Maintain a limit on the amount of gear used in the fishery • Maintain permanent closed areas • Promote the development of environmentally friendly fishing gear and fishing practices • Develop strategies for assessment of impacts on habitat and associated species communities
4. Enable effective and participative management of the fishery	4a. Industry delegated greater responsibility in management	• Industry manage the spot survey process and develop harvest strategies (with reference to PIRSA Fisheries and SARDI) • Industry manage all at-sea operations of the fleet • Develop an improved industry decision-making structure to satisfy governance requirements • Develop explicit allocation of prawn resources between sectors • Develop a process for the industry association to review the necessary ecological assessment report for export accreditation.
	4b. Management arrangements reflect concerns and interests of the wider community	• Promote stakeholder input to the management of the fishery, through established co-management processes • Ensure that social and cultural issues are given appropriate consideration when new management strategies are being developed • Communicate management arrangements to the wider community
	4c. Management arrangements are complied with	• Undertake annual compliance risk assessment • Implement a cost-effective compliance and monitoring program to address identified risks • Promote high levels of stakeholder stewardship through established management processes and Fishwatch activities
	4d. Costs of management of the fishery funded by the relevant stakeholders	• Ensure stakeholders are involved in development of management arrangements for achieving management objectives • Determine the annual real costs of management, research and compliance for the fishery • Recover an economic return from commercial licence holders, sufficient to cover the attributed costs of fisheries management, research, and compliance in line with established cost recovery principles

Source: Management Plan (2007).

Performance indicators for assessment of the Spencer Gulf Prawn Fishery

Objecti ve	Performance Indicator	Limit reference point
1 b	Fishery independent surveys	3 surveys completed
1 b	Stock assessment report	Completed
2 b	Economic report	Completed
1 a	Indices of future and current biomass	Neither index is below lower threshold levels
1 a	Recruitment index	>35
1 a & 2 a	Total commercial catch (t)	>1800
1 a & 2 a	Mean commercial CPUE (kg/h)	>80
2 a	% vessel nights with mean size >280 prawns/7 kg	<2%
2 b	Gross Value of Production (GVP)	<0% change
2 b	Management Costs	>10% increase
2 b	Return on investment	<0% change
4 a	Committee comply with harvest strategy	Committee develops all harvest

	decision rules	strategies based on results of surveys and in accord with decision rules
4 c	Fleet complies with harvest strategies	Fleet operates within prescribed open areas and times described in every harvest strategy

Source: Management Plan (2007).

Performance indicators measured for 5-year assessment of ecosystem impacts for the Spencer Gulf Prawn Fishery

Objecti ve	Performance Indicator	Measurement frequency	Limit reference point
3 a & 3 b	Undertake a bycatch risk assessment	Within 5 years	In the development stage
3 a	Develop mitigation strategies for high-risk species	Prior to the conduct of the next risk assessment	Ongoing and awaiting details from bycatch surveys
3 a	Measure the success of each mitigation strategy	Within 1 year of development of the mitigation strategy	Successfully reduced the risk, when known. Investigating other interactions (e.g., ETP species, sponges)
3 a	Measure the effectiveness of mitigation strategies by assessing differences in consecutive risk assessments	5 years after the previous risk assessment	Reduced number of species deemed at high risk
3 b	Develop measures to record interactions with endangered, threatened, and protected species	Within 5 years	Completed
3 b	Develop measures to reduce interactions with endangered, threatened and protected species	Within 5 years	Successfully reduced the risk to some species. Other mitigation strategies to be prepared
3 c	Maintain permanent closed areas	Annual	Completed and ever increasing gazetted sites.
3 c	Develop strategies to assess impacts on benthic habitats and associated communities	Within 5 years	Ongoing

Source: Management Plan (2007), with authors comments based on reported findings.

Actions taken in the event that harvest strategies fail to comply with stock assessment indicators

1. Notify the Minister for Agriculture, Food and Fisheries and participants in the fishery as appropriate.

2. Undertake a detailed review including an assessment of the additional performance measures (tables above) where appropriate. Provide a synopsis of the causes and implications of failure to achieve the minimum desired performance.

3. Where appropriate, consult with key stakeholder groups regarding the need for alternative management strategies and the collection of additional data.

4. Provide a report to the Minister, within three months of the initial notification, on the effects of breaching the performance indicator, including any recommendations on management strategies.

5. Minister or Director of Fisheries to consider recommendations, endorse supported strategies and implement as appropriate.

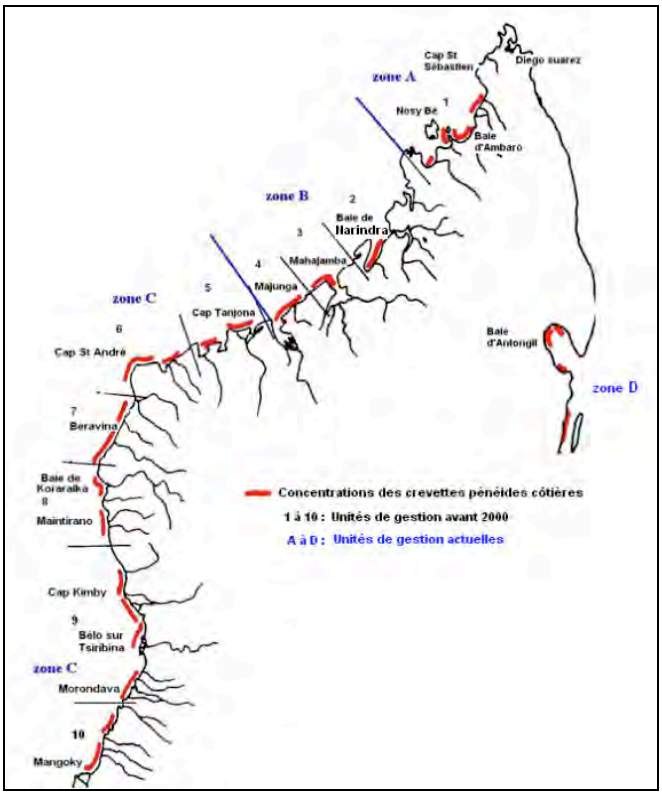
Harvest strategy

The fishery is managed in real-time adaptive mode as the system is dynamic. The fishery manages effort, catch and prawn size on a "quasi-quota" over 5–6 fishing periods with catch and effort "allocated" in proportion to biomass of the stock, annual recruitment strength, the amount of effective spawners (females >42 mm carapace length, the maturation and spawning status, and size composition of prawns

	over grounds.
Bycatch work plans	Risk assessment ongoing. Mitigation measures included temporary and permanent closed areas. *Committee at Sea* responds to bycatch interactions (syngnathids, leather jackets).
Key features	Restrictive entry licensing. Strong stakeholder cooperation through industry association governed by Management Committee. Cohesive fishing industry structure Restricted night-time fishing, gear restrictions (twin trawl/maximum headline length/minimum mesh size 45 mm), maximum vessel length and HP, bycatch reduction devices (Hoppers) Gazetted and voluntary closed areas Voluntary gear revisions: • The slight angle of the trawl boards, too acute angle would result in digging • Not using tickler chains • The position of the headline in front of the footline High quality stock assessments. HCR and bycatch work plans. Limited operational area within fishing zone, including no fishing above 10 m. Gear development and short tows to mitigate against high bycatch. Temporary and permanent closed areas. Advanced system of co-management through *Committee at Sea* with direct participation in real-time decision-making and observer coverage. Peer review process through DEWHA audits.
Problems	Effort creep and review of policy to implement change. Continued need to review bycatch mitigation policies.
Actions required	Continued emphasis on harvest strategies and bycatch mitigation.
Lessons learned	Ecosystem approach to fisheries management applied. Strong focus on stock assessment. Highly effective Fisheries Management Council with clear goals, objectives, activities, and indicators. Real time management actions by fishers to reduce bycatch. High compliance. Peer review process in place to guarantee conformity.

A.3 Shrimp trawl fishery, Madagascar

Main features and statistics of the Madagascan shrimp fishery

Feature	Description
Target species	Red-legged banana prawn (*Fenneropenaeus indicus*) Speckled shrimp (*Metapenaeus monoceros*) Grooved tiger prawn (*Penaeus semisulcatus*) Giant tiger shrimp (*P. monodon*) Kuruma shrimp (*Marsupenaeus japonicas*)
Byproduct	*Otolithes ruber* (Sciaenidae) *Pomadasys hasta* (Haemulidae) *Nemipterus bleekeri* (Nemipteridae) *Saurida micropectoralis* (Synodontidae)
Shrimp dependency	1:0.28 (77 per cent)
Management authority	Le Ministère de l'Agriculture de l'Elevage et de la Pêche (Ministry of Agriculture, Livestock, and Fisheries; MAEP)
Fishing zone	
Fleet segments	Industrial/semi-industrial divided between five companies: Somapêche (20 vessels), Groupe Unima (20), Groupe Réfrigépêche (7), Pêchexport (7), Pêcheries du Ménabé et du Mélaky (5). Coastal/traditional fishery comprising 200,000 migrant workers.
Management methods	Restricted entry licensing. A system of licensed engine units linked to vessel hp. The maximum number of industrial licences is limited by zone: seven in zone A, seven in zone B, 45 in zone C, and six in zone D. The number of semi-industrial licences is limited to two in zone A, three in zone B, and 16 in zone C. BRDs, TEDs, headrope, and backrope specifications, and minimum mesh size (30 mm in the codend). Industry self-imposed BRD mesh size of 70 mm, and codend minimum mesh size of 50 mm. Gear fishing effort units (GFEU) based on headrope length. Unit measured in cm: GFUE is a function of vessel unit X annual set GFUE / 100 = annual individual vessel headrope length. No single vessel can have a headrope length greater than 69 m. Headrope lengths are adjusted. Voluntary gear revisions to promote fuel efficiency.

	Three- month statutory closed season (including traditional vessels). Operators have themselves extended the closed season to 4.5–5 months per year.
	Fishing season begins on 1 March and ends on 30 November; 50 per cent of total catch caught in the first three months. Closures are implemented for three months from December to February. Night fishing is prohibited up to 14 April. The east coast fishery is open all year.
	All trawlers are equipped with ARGOS or INMARSAT transmitters.
	On-board observers and land inspection (provincial officers) to monitor the fleet activities. Thirty-four observers are deployed on 30–45 days per ship; total of 2,106 hours and 120 trips. They record effort, catch, catch of other retained species, turtle catches, discards, and the type of offences committed.
History	1970: Restrictive entry licensing introduced.
	1995: Industry organization body, GACPM, set up with the support of l'Agence Française de Développement.
	1997: Programme National de Recherche Crevettière (National Shrimp Research Programme; PNRC) created, followed by l'Observatoire Economique de la Filière Crevettière (Economic Research Centre for the Shrimp Industry; OEFC) in 2000. PNRC undertakes stock assessment work under the guidance of l'Institut (français) de Recherche pour le Développement (IRD). OEFC evaluates the economic performance of the fleet.
	2000: Individual company licence units introduced, with government levy (8 per cent). Engine units could be traded as from 2000. Trade between industrial fleet companies, and between industrial and semi-industrial subject to a penalty. Movement from semi-industrial to industrial results in a penalty of 1:1.5. No company can own more than 40 per cent of the engine units.
	2003: Technical measures introduced at industry's instigation: backrope and headrope length, minimum mesh sizes, TEDs, and BRDs. Legal requirement that each kilogram of landed shrimp be accompanied by at least a half a kilogram of fish
	2007: Gear unit effort control system introduced at industry's instigation, following technical advice from Australia. Each company may hold up to 1 million GFEUs.
	2008: In response to declining CPUE, companies reduced fleet size from 75 to 70 vessels. Further reductions expected in fleet numbers, probably by as much as 20 vessels, but with a threat to company participation in the fishery because of marginal economics. Restrictive entry licensing introduced for traditional fishers with fishing boat, fisher and gear licences. Enforcement not implemented due to political malaise.
	2009: Fishing operations cease in Zone A/B because of low CPUE due to coastal fishing activity.
Management Plan	No formal management plan exists.
Governance	Responsibility for fisheries management falls under the Ministère de l'Agriculture de l'Elevage et des Ressources Halieutiques (Ministry of Agriculture, Growth, and Aquatic Living Resources; MAERH), which formulates policy in consultation with the industry, and directs the Centre de Surveillance des Pêches (Centre of Fisheries Surveillance; CSP) to implement a control strategy. This industry pays a levy of 8 per cent of Gross Value Production, of which 80 per cent is redirected to fisheries research, development, and compliance. A formal management consultative body (Zonal Management Conserve; ZMC) exists to discuss management planning, but initiatives are largely industry driven. The ZMC comprises GACPM (shrimp association), MAEP, CSP, PNRC, and OEFC.
Harvest strategy	Formal TACs and IQs in place but not reached because of lower CPUE. Vessels stop fishing when fishing becomes unprofitable.
Bycatch work plans	BRDs and TEDs instigated by industry. TEDs resulted in a 10–15 per cent loss of commercial shrimp. Capture of turtles fell from 42 in 2005 to two in 2008.
	WWF participates in turtle tagging programmes, but turtles now rarely encountered.
	GACPM attempted to instigate a closed area programme with traditional fishers but this failed.
	CSP observers report other species encounters (jellyfish and syngnathids).
Key features	PNRC stock assessment supported by IRD, with support of French government. However, real-time assessments do not take place and analysis is perceived as dated.
	Government does not have any clear sector objectives, but through the industry levy funds: CSP (compliance), sanitation, and economic and biological research. A proportion of CSP funding is earmarked for training traditional fishers.
	Fleet overcapacity. Industry buy-back was sought, and funding secured from the French government, but

resisted by Madagascan government.

Industry advocates greater reductions in GFEU, but some political resistance and reluctance from fellow industry members.

Industry, at its own instigation, has advanced and developed technical controls (BRDs, TEDs, and the GFEU).

Industrial fleet sector needs to be more cooperative in its management actions.

Gradually declining CPUE, but major fall in shrimp catches in 2005. Catches per vessel down from 150 t/annum to 100 t/annum.

Industry reduces operational time on grounds, especially after peak season as economic return is insufficient and high bycatch issues become more problematic.

Inter-company effort transfer exists in theory but not utilized because of declining CPUE.

Vessels are fully compliant (CSP).

Industry, driven by UNIMA, has also developed other gear modifications and trawling practices to increase fuel efficiency. This was in response to the fuel crisis in 2007. Initiatives include reducing the weight of the trawl through removing tickler chains, installing lightweight plastic doors, larger mesh sizes to reduce drag and prevent congestion in the net, and short haul times (1 hour to 1 hour 20 minutes) to reduce build up of bycatch. These initiatives resulted in a 31 per cent saving in fuel costs.

Carbon assessment and reduction of emissions programme introduced to reduce overheads. This resulted on increase carbon efficiency for engines (alternator), new propellers on all boats, and a change in cold storage systems. A cost of €210,000, saved 80 cm^3/year.

Industrial fleet owners/GACPM are seeking MSC accreditation at the time of writing. Concerns are that while recognized as important, multiple retailers are always squeezing margins with no rewards for an ecologically sustainable product. Would like to see greater partnership with WWF and incorporation of the WWF logo on products. WWF and UNIMA have formed a partnership agreement which seeks to promote a more sustainable production focus, better and more secure access to international markets, and the dissemination of good practices more broadly in the private and NGO sectors.

Industry has attempted to engage with coastal fishers, and provides fish to cooperative members as a means to facilitate dialogue, but its efforts have been thwarted due to a lack of enforcement of coastal fishing on the ground.

The African Development Bank is in the process of starting a support programme for the professionalization of traditional fishers' organizations. The programme is delayed because of the current political malaise.

Strategic partnerships

UNIMA focuses on sustainability best practice. The main issues addressed are: trawl net design and BRDs/TEDs to reduce bycatch and to create fuel efficiencies and reduce carbon emissions; focus on responsible effort reduction strategies and partnerships (closed areas, voluntary reductions in active vessel numbers); instigated co-management discussions with artisanal fisher groups in cooperation with WWF, including donating a percentage of fish caught to fisher cooperative members; cooperates in WWF turtle catch recording programmes; and implements UNIMA crew best practice programmes. WWF focuses on using its influence to promote UNIMA's responsible/sustainable fishing practice to strategically important retail outlets; funds specific initiatives such as carbon emission analysis; and assists in accessing funding for UNIMA sustainability research and development. The resulting benefits are demonstrated as: (1) promote more sustainable business practices and demonstrate that such practices can generate financial and market benefits; (2) demonstrate the role that private companies can play in protecting the natural environment and in enabling social and economic development; (3) encourage wider adoption of sustainability in the business models and financing of private sector activities; (4) demonstrate that partnerships can achieve faster, more credible, and more substantive progress towards sustainable business.

Problems

Unfettered growth in traditional fishing active in shrimp nursery grounds using mosquito nets with devastating consequences on offshore CPUE in areas accessible to traditional fishers. Some industrial companies are pulling out of Zones A and B. Traditionally, 84 per cent of the shrimp catch came from zone A.

85 per cent of the shrimp trawl grounds are in the coastal zone (inside 2 nm), creating conflict with other fishers.

Inability of CSP to implement control programme for this sector because of current political malaise.

Traditional fishers working for middle men and landowners in feudal type system; becomes extremely difficult to advance co-management.

Potential concern that government is highly driven by licence revenue accrual, with prospect that

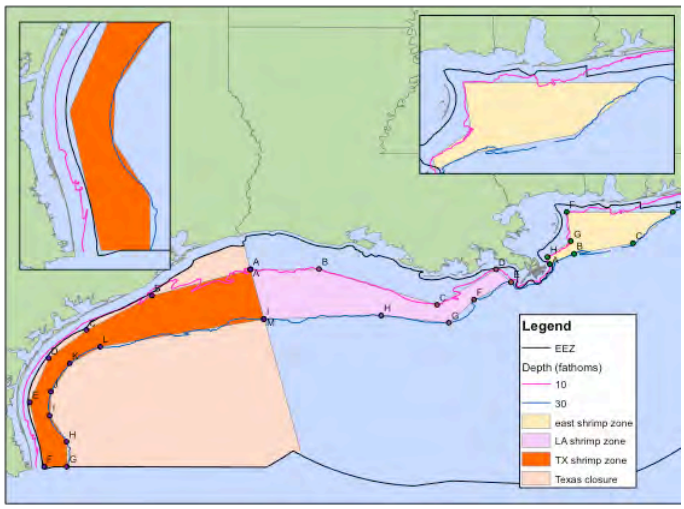
	additional licences could be granted.
	Government generally poor in its response to sustainability and ecosystem-based management.
	The legal requirement to land 0.5:1 fish:shrimp seen as illogical and not ecologically sustainable.
Actions required	Given the damage of rapid growth in the coastal fishery, urgent attention is needed to remove effort from this sector. Focus should be placed on alternative livelihoods, group organization, education, and control.
	The need for greater emphasis on stakeholder management and development of a Management Plan. The plan should clearly set out goals, objectives, and strategies, and the setting of performance indicators for target species sustainability and ecological risk minimization.
	The industry, under the auspices of GACPM, should work towards a more proactive co-management role which would allow it to directly participate in sea trails in partnership with PNRC, and to be encouraged to take real-time management actions in response to changing catch rates and concerns over the composition of the catch (e.g., high quantities of juvenile shrimp or gravid females and interactions with non target species). The Spencer Gulf *Committee at Sea* would be a good role model to follow.
	Establish closed areas that will allow improved recruitment to offshore fishing grounds.
	Review the policy of fishing up to 2 nm from shore, which would allow for some reduction in local conflict, but may also have benefits in terms of stock recruitment.
	Professionalization of traditional/coastal fishers.
	The need for real-time stock assessment and management actions supported by government.
	Improved integration of data collected by observers with subsequent scientific analysis.
	Evaluate the risks and mitigation strategies (if appropriate) for non-target species (jellyfish/syngnathids).
Lessons learned	Every effort should be made to prevent growth in artisanal fisheries on a scale witnessed in Madagascar. The focus should be on alternative livelihoods, group organization, education, and control. The profile of these fisheries needs urgent attention from government and donor organizations.
	Industrial trawler owners should heed the lessons learned from UNIMA's efforts to reduce costs. Large-scale capital adjustments can be made to fishing vessel operations to make them more economically efficient. Such savings could be transferred to business models that can support a change in vessel remuneration systems. Considerable effort is required to change the company/crew psychology of a high focus on bycatch collection.
	Where governance is weak, it may not necessarily be the panacea to devote attention solely to strengthening capacity at government level. Professionalizing fishers in associations such as GACPM could yield considerable benefit. However, this also requires a heavy focus on education to change the psychology of trawler owners towards a focus on ecosystem-based management.
	Heavy focus has in the past been placed on strengthening particular elements of governance, e.g., compliance. While this is extremely important, a much greater emphasis needs to be placed on training government officers in evolving management systems, and how these should be prioritized against a set of other objectives (most specifically economic development and growth). Best management practice should precede these.

A.4 Gulf of Mexico and South Atlantic shrimp trawl fisheries, US

Feature	Description
Target species	Brown shrimp (*Farfantepenaeus aztecus*) Caribbean pink shrimp (*F. duorarum*) White shrimp (*Litopeneaus setiferus*)
Byproduct	Restricted to recreational bag limits
Shrimp dependency	1:4 (20 per cent)

Management authority	National Marine Fisheries Service (NMFS; federal waters), supported by Gulf of Mexico Fishery Management Council[31] and South Atlantic Fishery Management Council. State fisheries (9 nm Texas/ 9 nm Florida/ 3 nm for other states).
Fleet segments	3,500–4,500 vessels in total. 1,389 large industrial fishing Gulf of Mexico federal waters. 1,000 smaller semi-industrial (ice boats) in Atlantic coastal/South Atlantic federal waters. 1,100–2,100 fishing Gulf coastal states.
Management methods	Permit required for all vessels that intend to fish for shrimp in EEZ waters of the Gulf of Mexico and South Atlantic. Restrictions on the number of federal permits, as well as for Texas and Florida, but with movement between state lines. No restricted entry for Louisiana and Alabama. Buy-back schemes operational in Texas, 48 per cent of inshore fishing effort removed since 1995, reducing the bycatch by an estimated 40 per cent. TEDs and BRDs are mandatory in federal and all state waters with the exception of Louisiana, with guidelines and manuals provided. Prohibited areas and seasonal closures. Seasonal closures established to protect young shrimp, and may be from 45–90 days (Texas) Vessels with shrimp trawls or entangling net gear aboard may not exceed the recreational reef fish bag limits. Louisiana has a minimum size limit on white shrimp.

Gulf of Mexico Shrimp Closure Zones



History	1976: Fishery Management Councils formed under the Fishery Conservation and Management Act (now called the Magnuson-Stevens Fishery Conservation and Management Act).
Management Plan	Fishery Management Councils prepare fishery plans which are designed to manage fishery resources from where state waters end out to the 200-nm limit (Gulf of Mexico).
Bycatch work plans	TEDs and BRDs are central to US and most state conservation regulations. TEDs have been increased in size to account for larger average sizes in the last five years. There is also a problem of repetitive capture and fatigue leading to drowning of turtles. BRDs are effective, but not for red snapper which tend to hang in the net. Scientists are attempting to find red snapper hot spots. Red snapper is subject to a rebuilding plan. Shrimp trawlers are allowed limited number of days at 10–30 fathoms in the Northern Gulf of Mexico. As and when these days are reached (i.e., certain number of days in that zone), area closures take effect.
Key features	Strong focus on TEDs/BRDs, implementation and development (http://sero.nmfs.noaa.gov/sf/BRDs.htm). Turtle bycatch mitigation work continues.

[31] http://www.gulfbase.org/organization/view.php?oid=gomfmc

Insufficient focus on other bycatch species. Prohibitions have driven the recreational sector, where the focus is on preserving recreational fish as opposed to other species. Syngnathid interactions are perceived to be a problem. However, Fishery Management Councils are looking at movement towards ecosystem-based management = ECOSYM modelling.

Observer coverage is extremely low (1 per cent).

VMS is not implemented for shrimp vessels but applied to other fisher groupings.

IQs are not implemented for shrimp vessels but applied to other fisher groupings.

Permits are not limited to vessel characteristics (size/hp) or gear rights.

The sector is driven by economics, with exit and entry linked to fuel price and shrimp price values.

Texas reduced the size of its shrimp fleet by 25 per cent through a buy-back scheme. NMFS now seeking to recover unused permits.

Socio-economics and coastal welfare feature significantly in Louisiana, where support for the fishery sector is seen as a substitute for social welfare. The state fisheries are associated with a high degree of recruitment overfishing, with small shrimp targeted in coastal waters.

Prospect of moving to IQ system, once latent licences withdrawn.

Governance issues

The Gulf of Mexico Fishery Management Council consists of 17 voting members: the Regional Administrator of NMFS (or his/her designee), the directors of the five Gulf state marine resource management agencies (or their designees), and 11 members who are nominated by the state governors and appointed by the Secretary of Commerce. Appointments are three-year terms with a maximum of three consecutive terms. In addition, there are four non-voting members representing the US Coast Guard, US Fish and Wildlife Service, Department of State, and the Gulf States Marine Fisheries Commission.

The Council meets five times a year at various locations around the Gulf coast. Prior to taking final action on any proposed rule change public hearings are held throughout the Gulf. Public testimony is also heard during the meeting at which final action is scheduled. Proposed rule changes are then submitted to NMFS for further review and approval before implementation.

When reviewing potential rule changes, the Council draws upon the services of knowledgeable people from other state and federal agencies, universities, and the public, who serve on panels and committees.

Compliance generally strong in terms of bycatch mitigation; however there are problems associated with closed/seasonal areas. Use of VMS would resolve this problem.

Strategic partnerships

Shrimp Round Table: The Ocean Conservancy and the Sustainable Fisheries Partnership (SFP) are working in the Gulf of Mexico to bring together shrimp fishers, seafood buyers, and other fishery experts to explore new and innovative ways to move this valuable and important fishery towards sustainability. The over-arching goals of the project are to reduce the environmental impact of the Gulf of Mexico shrimp fishery, improve and strengthen management, and make the fishery more sustainable while assisting Gulf shrimp fishers in improving quality through the transition to cleaner, more fuel-efficient fishing gear (http://www.youtube.com/watch?v=E-2V1qe7pnY). Technology improvements have been developed that reduce bycatch by more than 30 per cent and reduce fuel consumption by up to 39 per cent. This reduction in fuel consumption will significantly reduce the carbon footprint of the fishery and provide much needed relief to fishers struggling with the rising cost of fuel. The Ocean Conservancy and SFP are also working to engage major seafood buyers to build a market for more sustainable Gulf shrimp. Seafood buyers can be instrumental in implementing key policy reforms in the shrimp fishery, and supporting improvements in the performance of bycatch reduction devices and other fishing gear. Funding is available from research grants, low or no interest loans, and a loan guarantee scheme. Sponsors are also funding specific initiatives within the scheme.

Wild American Shrimp Initiative (WASI): Gulf of Mexico shrimpers are trying to regain market share lost to cheaper farm-raised imports by advertising theirs as a better product. The campaign, financed by the eight states, coincides with a new law requiring that many foods sold in supermarkets be labeled with the country of origin. Shrimpers are promoting their catch as more natural, tastier, fresher and more tender than the farmed imports, which have taken over 87 per cent of the US market. There is no link to any sustainability assessment criteria.

Problems

Individual state jurisdictions mean that the number of active vessels and real effort is not known. There are 526 inactive licences that fall under state jurisdiction.

Policies tend to be driven by short-term responses to economic issues as opposed to ecosystem management (WASI).

The US still supports a fishing vessel structural programme (soft loans).

Insufficient focus to date on ecosystem approach to fisheries management, driven very much by recreational agendas and concentrated on sport fish preservation.

The observer scheme pays insufficient attention to bycatch reduction on non-commercial species.

97 per cent of turtles caught in TED nets can escape. TEDs reduce the shrimp catch by 10 per cent (NMFS), but also do not overcome the problem of repeated capture.

Louisiana's social policy focus undermines the national credibility in shrimp conservation.

Lessons learned

Seasonal closures and bycatch reduction tools would seem to be the most effective mechanisms for management, but other measures (gear management/capacity reduction) are, to a large extent, redundant.

Effective buy-back schemes have been partially successful, but the focus now is to withdraw inactive licences.

Difficulties to see how closed areas can be advocated without VMS applied.

Bycatch reduction and mitigation.

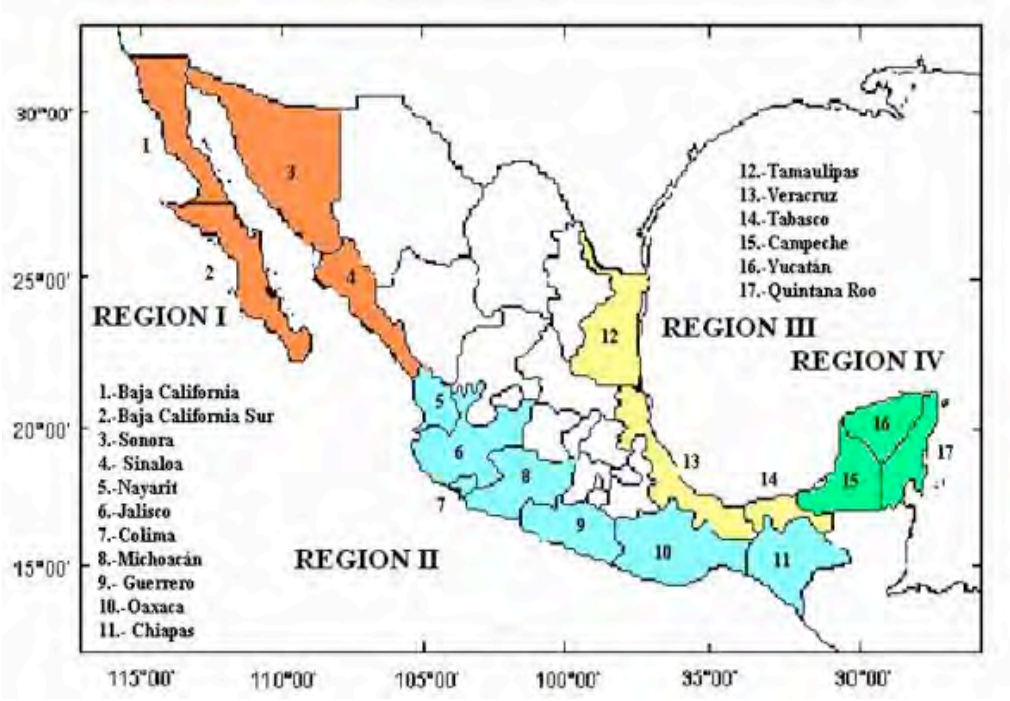
Shrimp Round Table has made very significant advances, with its initiatives covering some 1,100 vessels. The NGO/private sector initiative has been extremely effective to date in marrying economics with bycatch reduction.

A.5 Shrimp trawl fisheries, Mexico

Feature	Description
Target species	**Pacific Coast** Blue shrimp (*Litopeneaus stylirostris*) White shrimp(*L. setiferus*) Pacific brown shrimp *(Farfantepenaeus californiensis*) Other species from the *Sicyonia* and *Trachypenaeus* genus **Gulf of Mexico and Caribbean** Atlantic seabob (*X. kroyeri*) Whiteleg shrimp (*P. vannamei*) Brown shrimp (*F. aztecus*) Pink shrimp (*F. duorarum*) Caribbean red shrimp (*F. brasiliensis*) Other species from the *Sicyonia* and *Xiphopenaeus* genus
Byproduct	187 species of fish, 83 crustaceans and 31 molluscs. Species commonly caught as bycatch are: *Syacium* spp. (halibut, "lenguado"), *Lutjanus campechanus* (red snapper, "huachinango"), *Pristipomoides aquilonaris* (Wenchman, "voraz"), *Upeneus parvus* (dwarf goatfish, "chivo"), *Eucinostomus* spp., *Synodus* spp., *Trichurus* spp., *Cetengraulis* spp., *Cynoscion* spp., *Balistes* spp., *Arius* spp., *Haemulon* spp., and *Pristipomoides* spp. For crustaceans, a *Squilla empusa* (Mantis shrimp, "cucaracha"), *Calappa sulcata* (a crab species, "cangrejo"), *C. flammea* (a crab species, "cangrejo") and *Portunus* spp. (crab, "jaiba" or "cangrejo").
Shrimp dependency	Without BRDs, the average shrimp:bycatch ratio is 1:9 in the Pacific Coast and 1:3 in the Gulf of Mexico and the Caribbean.
Management authority	Commission of Fisheries
Fleet segments	2,212 industrial offshore shrimp vessels, using either two nets (Pacific side) or four nets (Atlantic side). Industrial trawlers account for 57 per cent of the catch (was once 82 per cent (2000)), artisanal vessels for 43 per cent. Three fleets: Region I (Gulf of California) 1,456 vessels; Region II (Pacific coast): 991 vessels; Region III/IV (Gulf of Mexico/Yucatan) 703 vessels. An estimated 102,000 artisanal craft.
Management methods	Buy-back packages have been introduced in the past, but were ineffective as they decommissioned obsolete components of the fleet, and monies stimulated reinvestment and the government subsequently allowed for re-entry. The government is now applying an incentive scheme for artisanal vessels to stop using specific gears, and to acquire new engines, supported by a subsidized credit scheme. The concern is that the scheme is further capitalizing expansion in the fishery, with newer, more efficient equipment and replaced engines remaining in the fishery. CONANP, the Management Authority for the Upper Gulf of California, is supporting the replacement of shrimp drift gillnets by a shrimp trawling prototype. Normas Oficiales Mexicanas (national conservation measures) regulate mesh sizes, types of fishing gear used, spatial-temporal restrictions, and other features. Open and closed seasons are additional management strategies. No restriction on fishing power or its modifications exists either. Gear specifications: 37.5 mm codend mesh size; a maximum legal size of headrope for the artisanal "Magdalena I" system (13.5 m). Seasonal closures (applied to High Seas, estuaries, and bays). Fishing season modified according to the results of biological research. These apply to artisanal vessels for lagoons and estuaries; however there is some non-compliance by this segment in the closed season. Industrial vessels must have VMS. Area closures established for protection of juvenile shrimp in areas like coastal waters (up to 15 nm from shore) and lagoons in the Yucatan Peninsula. Also, trawling is forbidden in waters of less than five fathoms. Some access is allowed to Marine Protected Areas (MPAs) on submission of Environmental Impact Assessments (EIAs). Area closures for shrimp fleets in the Upper Gulf of California for the sake of vaquita (*Phocoena sinus*; a rare species of porpoise) conservation. TED and BEDs are mandatory in the industrial fleet, and for all artisanal trawlers greater than 10 GT. Artisanal quotas, managed through fisher cooperatives, introduced as a pilot in the artisanal sector for Sinaloan artisanal shrimp fisheries during 2009 and 2010, with extensive logistical support to data collection (184 landing sites). TACs are set for bays and lagoons. The quota system will be extended to the

industrial trawl sector over the next two seasons. However it has been important to demonstrate order in the artisanal sector in order to secure the support of the industrial sector. The pilot study has shown a marked increase in compliance.

Location



History

1994: Gear restriction introduced (mesh sizes, closed seasons, closed areas, BEDs, and TEDs). Shrimp Management Plan for shrimp fisheries, updated regularly.

2004: VMS, industrial fleet only.

2007: Ecosystem-based management included as a component of the Management Plan.

2009: EIAs have to be submitted to allow fishing inside sensitive areas (MPAs).

Management Plan

Management Plans (Planes de Manejo) are new instruments aimed at providing guidelines and strategies to manage particular fisheries stated as a particular objective in the recent Sectoral Plan.

The fishery is managed as follows:

- The General Law of Sustainable Fisheries and Aquaculture defines access rights and obligations for users
- The "Ley de Metrología y Normalización" regulates the generation of Official Standards
- The General Law for Cooperative Societies regulates fishers' organizations
- The "Ley General del Equilibrio Ecológico y Protección al Ambiente" protects the environment
- Mexican Official Standards states rules for fishing gears and operations (Mexican Standard for shrimp fisheries NOM-002-PESC-1993 and its modifications decreed in November 2006 and July 2007)
- The National Fisheries Chart provides official statements about stock status and management strategies; strategies are defined by management plans (e.g. the Management Plan for Shrimp Fisheries of the Mexican Pacific Ocean)
- The National Committee for Fisheries and Aquaculture negotiates management and ordinance policies, among other things, determine the lengths of closed seasons, with fishers and fleet owners. This is where co-management occurs.
- Management plans, MPAs, and other special protection areas are also taken into account.

The Committee includes government and industry, but not state or municipal governments or NGOs. Academics are invited to participate.

Ecosystem-based management formerly included from 2007 with new general law of fisheries and aquaculture. It is not yet either defined or implemented.

Governance

Principal institutions: Commission of Fisheries and National Fisheries Institute (INP). The agency responsible for fisheries management, monitoring and enforcement is the National Commission of Aquaculture and Fisheries (Comisión Nacional de Acuacultura y Pesca, CONAPESCA).

INP bears responsibility for, among others, assessment of the status of national fisheries as well as the

evaluation of fishing gear. INP has the function of defining levels of fishing effort applicable to species and groups of species in specific areas and giving guidelines, strategies, and provisions for conservation, protection, restoration, and management of aquatic resources that could affect their habitat and ecosystems. This modification of the Fisheries Regulation gave the National Confederation of Fishing Cooperatives (Confederación Nacional de Cooperativas Pesqueras, CNCP) a binding character that must be considered in the process of decision-making by management authorities.

Major stakeholders include the industrial fishers, most of them grouped under the National Fisheries and Aquaculture Industry Chamber (Cámara Nacional de la Industria Pesquera y Acuícola, CANAINPESCA). Artisanal fishers are usually organized in fishing cooperatives, grouped under the CNCP. However, there are many cooperatives not affiliated to that organization. Many fishers belong to "Social Solidarity Societies" and many "free fishers" do not belong to any group so the representativeness of the CNCP is not as complete as that of CANAINPESCA.

Before the mid-1990s emphasis was put on increasing catches, the National Fisheries Development Plan 1988–1994 set as an objective to reach MSY. In the early 1990s, a change of emphasis began to take shape in part as a result of the international forums held at that time (Mexico was an active promoter of the Code of Conduct for Responsible Fisheries) and fisheries management was incorporated in 1994 in the newly formed Secretariat of Environment, Natural Resources and Fisheries which gave due consideration to the importance of marine resources as part of natural resources. The new Fisheries Plan stated sustainability as a goal and the Precautionary Principle as a guideline. Since the end of the year 2000, at the beginning of the present administration, fisheries institutions were transferred to the (present) Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación) with emphasis seemingly shifting again to "promotion" ("fomento") of the fisheries sector, although sustainability remains an objective but without the inclusion of the Precautionary Principle.

Bycatch work plans

The gear and devices tested include trawl nets of new material with slightly different design and bigger mesh (2"1/4 instead of 2" or 1"3/4 depending on the area), fish eye (double or single), double foot rope and double cover TEDs. The results show that bycatch is reduced (by 25–70 per cent, depending on combination of devices) and the quality of the shrimp catch is improved (i.e., larger size shrimp). The new nets, which are lighter than the old ones, decrease fuel consumption by some 30 per cent. Work onboard, i.e., sorting of catch, has become easier and is quicker. The industry takes a great interest in the new nets considering the reduction in fuel consumption.

Key features

The main shrimp fleets in Mexico are the offshore trawl fleets (Pacific Coast, Gulf of Mexico; 18–25 m, 240–624 hp) and the Magdalena artisanal fleet. Pacific Coast boats fish 9 and 64 m deep, using two trawl nets with a headline of 23–36 m, and 3.81–4.13 cm mesh in the codend. Gulf of Mexico boats fish 9 and 64 m deep, using four trawl nets with a headline of 10.6–13.6 m and 3.81–4.45 cm mesh inshore. The seabob Magdalena fleet comprises up to 80,000 smaller craft, using many gears (including trawl) and fishing in depths of between 5 and 15 m. Mesh sizes are regulated.

Non compliance was 40–60 per cent.

Strategic partnerships

WWF, EDF, and the Commission of Fisheries examination of fuel efficiencies. Draft technical report on test of selective trawling prototypes. Economic studies. Generation of saving scenarios. Carbon trading/reduction.

Problems

Open access continues.

Overcapacity / declining CPUE.

Subsidies: diesel, new engines.

Conflict between industrial and artisanal fishers (violent).

Non compliance of 40–60 per cent.

Juvenile shrimp targeted by the artisanal sector.

Strong resistance from the sector to effort control.

Resistance to IQ system by the industrial fleet against the background of lost fishing opportunities to the industrial sector.

Lack of management of the interactions between the three different types of shrimp fisheries in Mexico (High Seas, bays, estuaries).

Fuel subsidy for all shrimp fishing vessels (industrial and artisanal).

Lax enforcement of closed seasons and other measures.

Lessons learned

The need for greater stakeholder consultation in management planning.

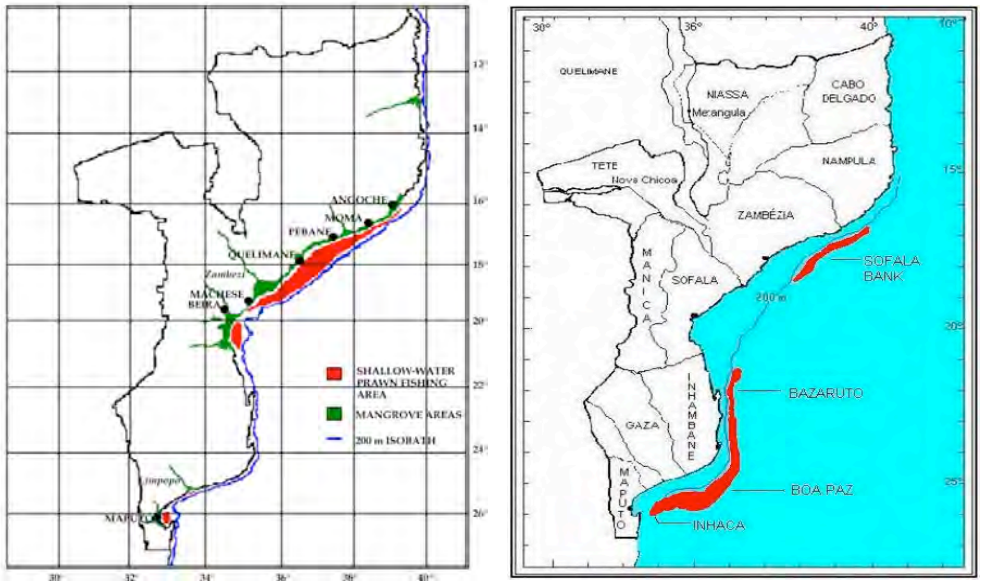
A much heavier focus on bycatch mitigation, and species sustainability within management planning.

The need to establish management controls on inshore fishing activity.

The need to establish management systems that are devoid of political interference.

The system of community quotas and ITQs is very expensive to police, given the size of the fleets. Regional fisher cooperatives may be able to reduce the costs by participating in co-management initiatives.

A.6 Deep- and shallow-water prawn fisheries, Mozambique

Feature	Description
Target species	**Shallow-water fishery** Red-legged banana prawn (*Fenneropenaeus indicus*) Speckled shrimp (*Metapenaeus monoceros*) Lesser quantities of *M. japonicus, Melicertus latisulcatus*, *Penaeus monodon,* and *P. semisulcatus* **Deepwater fishery** *Haliporoides triarthrus* Amounts of *Aristaemorpha foliacae*, *Aristeus antennatus*, *Plesiopenaeus edwardsianus*, *Penaeopsis balssi*
Byproduct	**Shallow waters** *Otolithes rubber* (sciaenid) **Deeper waters** *Metanephrops mozambicus* (langoustine) *Chaceon macphersoni* (crab) *Palinurus delagoae* (deepwater spiny lobster)
Shrimp dependency	1:2–1:5 (25–10 per cent, depending on season) 1:12 for deepwater (crustaceans:other organisms)
Management authority	The Ministry of Fisheries comprises several divisions (but explicitly the National Directorate of Fisheries Administration; DNAP)
Fishing zone	
Fleet segments	43 industrial shallow water and seven industrial deepwater trawlers (9 per cent of the catch) 49 semi-industrial vessels (6 per cent of catch) 15,250 artisanal vessels (3 per cent of catch)
Management methods	Restricted entry licensing for shallow waters, but no cap on deepwater licences. There are no licence limits or catch limits for the artisanal sector (shallow-water), although once the current levels of effort (gear and fishers) are established by census it is intended to cap them at this level. Both the semi-industrial and industrial shallow-water sectors have a cap on the number of licences. The semi-industrial ice vessels (shallow-water) do not have catch limits (quotas). The industrial fleet (including semi-industrial freezer vessels) has an annual TAC for shallow-water prawns (all species combined), which is determined based on input from the Instituto de Investigação Pesqueira (Fisheries Research Institute; IIP). The TAC is allocated to companies as quotas by the ministry at an open consultative forum (the Fisheries Administration Commission; FAC) before the season starts. The FAC is a body comprising representatives from the ministry and industry. It is not clear exactly how the quotas are allocated to each company (number of vessels is a factor), but DNAP maintains that it is an "open" process. DNAP would like to move towards allocating quotas per vessel.

	The deepwater fishery is not managed by a TAC, but quotas are issued for prawns and langoustines.
	Six-month closed season for the shallow-water fishery extending from September to March (the exact dates vary annually based on input from IIP and industry at the FAC); for semi-industrial boats in Maputo Bay, Limpopo, and south of Beira, the closed season is only two months (January–February), while the deepwater fishery operates throughout the year.
	Both deepwater and shallow-water trawl nets have a minimum mesh size of 55 mm.
	No bycatch reduction devices are used, although some skippers may rig their gear in order to reduce bycatch of soles.
	TEDs required by law but not implemented.
	Obligatory 2:1 bycatch:prawn ratio.
	Industrial vessels are not allowed to trawl within 3 nm of the coast, and semi-industrials have to operate beyond 1 nm of the coastline.
	Industrial vessels are required to use VMS; trawlers have to submit summarized catch statistics every 10 days to DNAP, and must submit logbooks annually.
	While the inspectorate is under-resourced in terms of manpower and other logistic support, it is generally acknowledged by both industry and those involved in compliance that adherence to regulations has improved in the last year, since the advent of the Monitoring, Control, and Surveillance (MCS) campaign with its associated use of a patrol vessel and at-sea inspections.
	Scientific observers are placed onboard trawlers, although this activity appears to be limited; trawl logbooks are submitted to the ministry and scientists, and trawler catch reports are submitted every 10 days; trawl landings are monitored by inspectors.
	Artisanal vessels not controlled, and there is a growing problem in the use of mosquito nets.
History	Late 1960s: The industrial shrimp fishery began to develop.
	1976: Mozambique began to control access and effort.
Management Plan	DNAP is in process of finalizing a comprehensive Management Plan for the shrimp fisheries of the Sofala Bank.
	Objective*: The Sofala Bank shrimp resource exploited so as to provide maximum overall net benefits (economic, social, and financial) to society, for poverty reduction, in a framework of the sustainability of the resource in particular and of the aquatic ecosystem in general.*
	This objective can be achieved through the following outputs: (1) reduced fishing effort on the Sofala Bank shrimp resources; (2) strengthened fisheries administration and surveillance capacity to better control the evolution of the fisheries and enforce laws, regulations, and management measures; (3) increased knowledge about the resource and the fisheries in order to follow their evolution, and so that the recommended management measures may be more effective; (4) revision of some aspects of the organization of the three fisheries that exploit the common shrimp resource; (5) reduced operational costs for the various fishing fleets; and (6) increased added value of the exported product.
Governance	Some important structures have been created in terms of the Act, including the Committee for Co-Management of Fisheries which is the main forum for participatory management. Access to marine resources is controlled by DNAP, which issues licences and quotas. DNAP convenes the FAC, which comprises all stakeholders including representatives from management, compliance, research, product quality, small-scale fisheries, and industry. The Commission meets quarterly to discuss management of the prawn fishery, and makes recommendations regarding the setting of TACs and quotas.
Harvest control rules	TACs and closed seasons.
Bycatch work plans	There is a strategy in place for managing the fishery's impact on ETP species, including measures to minimize mortality, but compliance is poor. There is no specific spatial plan to reduce habitat impacts.
Key features	The Ministry of Fisheries comprises several divisions, including DNAP, which controls access to resources by means of issuing licences and quotas, and IIP undertakes biological research to establish biomass and stock status of resources.
	DNAP is in process of finalizing a comprehensive Management Plan for the shrimp fisheries of the Sofala Bank (PGC/BS). Inputs in June–August 2009 were based on the formation of an ecosystem approach to fisheries management. Implementation of the plan and recommended effort controls were anticipated for

the 2010 fishing season.

Actual fishing effort in 2007 was assessed as being about 18 per cent higher than the target effort of 220,000 standardized trawl hours[32]. Note that this was before the six-month closed season was instituted. Overall CPUE for deepwater prawns (dominated by *H. triarthrus*) has remained remarkably constant since 1990.

All three sectors (artisanal, semi-industrial, and industrial) are required to have and pay licences. The freezer semi-industrial vessels are effectively managed as industrial vessels.

There appears to be limited adherence to the requirement for landing twice as much bycatch as prawn: industry pays a levy for this based on their quota allocation, regardless of whether they land the bycatch or not, and consequently there is little incentive to fill up their freezers with bycatch.

Only about 60 per cent of vessels submit logbooks. Although required by law, the VMS system is not fully operational.

TED use has been exempted by DNAP as a result of representations made by industry at DNAP, particularly relating to a lack of knowledge about TEDs.

The administration of fishing is expressed locally in the provinces and districts. The administration of semi-industrial and industrial fishing is exercised by the provincial fisheries administration body, currently integrated into the Provincial Fisheries Directorates. In the districts, any power in terms of licensing and inspecting artisanal fishing has been, as from 1 October 2006, exercised by the district administrator or by the body to which he/she delegates this task in the District Services for Economic Activities.

IIP undertakes annual stock assessments for the shallow-water and deepwater industrial trawl fisheries, and makes recommendations to the ministry on appropriate TAC/quota levels and timing of the closed season. Assessment of the shallow-water industrial fishery is based on a range of data sources, including monthly catch production and vessel characteristics, logbooks, biological sampling, and an annual pre-season recruitment survey (always using the same vessel). The assessment incorporates factors affecting the catch rate and mean weight of the two main species, such as location, seasonal trends, depth, time of day, vessel type, and biological characteristics of these species. Consultants from Australia and Norway are contracted to assist with the assessment, which is essentially a yield- and value-per-recruit assessment incorporating a stock-recruit relationship. In 2007, a target $F_{0.1}$ level of ~2.2 yr^{-1} was determined separately for these two species and for both species combined, and $F_{current}$ at that stage was calculated as 3.5 yr^{-1} for *F. indicus*, 2.2 yr^{-1} for *M. monoceros,* and 3.3 yr^{-1} for both species combined.

Problems

Biomass, and consequently catches and the CPUE, are currently at their lowest levels ever.

The total quota distributed for each annual campaign (9,285 t) exceeds by almost 30 per cent what should have been the TAC of 7,200 t recommended by the research.

TAC restrictions alone are not sufficient to adequately manage the fishery, and are combined with effort control (closed season), although the effective level of effort is not known owing to effort creep.

Non-prawn bycatch is far greater than the target catch, and the majority is discarded. A large variety of species (mainly fishes, but also cephalopods and other crustaceans) and substantial quantities are involved.

For the two main shallow-water target species (*F. indicus* and *M. monoceros*) there appears a conflict relating to stock status, with one species apparently recovering (*F. indicus*) and the other declining.

A commonly discarded fish species (*Otolithes ruber*) was reported to be overexploited in the mid-1980s and there are reported declines in mean length of trawled *O. rubber*. Because of the large bycatch and range of species caught (including large pelagic species and sharks, predominantly in the shallow-water trawls), ecosystem cascade effects are likely.

The system of collecting fishing licence fees by volumes allocated in a factor of pressure to increase fiscal revenue.

The current difficulties ensure that some ship-owners are abandoning the fishery or selling their vessels to the large companies that replace them with vessels that have greater operational capacity.

Loggerhead and green turtles occur frequently in trawls and in artisanal beach-seines; leatherbacks far less frequently. Estimates of numbers (~2,000–5,000) caught by the former sector are questionable, and estimates for the latter are not readily available. It is likely that some Red-listed elasmobranchs are also caught, but detailed information is not available.

There is a fuel subsidy for Mozambican-registered vessels.

[32] IIP use a "standard vessel" based on historic effort levels of a subset of vessels in the fishery. Effort is either raised or lowered for vessels of lesser or greater power.

The performance of the MCS system has not reached the level required. It did not prevent breaches of the law and fishing regulations.

Actions

Reduced fishing effort — first pre-condition for making the objectives viable on time

Components of the management plan are:

1. Withdrawal of fishing effort by the state
2. An initial reduction in the total quota allocated in the industrial fishery, with a corresponding decrease in the number of vessels
3. Extension of the closed periods
4. If deemed necessary, a second adjustment in the total quota allocated in the industrial fishery, with a corresponding decrease in the number of ships
5. Cancelling unused fishing licences
6. Restricting the concentration of quotas in the industrial fishery
7. Negotiating the replacement of vessels
8. Confirmation of the current rule on dispensing with the requirement for a minimum tonnage
9. Introduction of sanctions envisaging the loss of fishing rights
10. Improved control over the industrial and semi-industrial catches through a quota system

Strengthened MCS system (research, fisheries administration and enforcement) — the second pre-condition for making the objectives viable in due time

1. Strengthen the capacity of the fisheries administration
2. Restructuring of the fisheries administration (DNAP) at central and provincial levels
3. Training fisheries administration staff at central and provincial levels
4. Strengthening and expanding data collection concerning the activities of the fleets in the two fisheries
5. Making analyses in order to increase the cost-effectiveness and cost-efficiency of the fisheries administration in general
6. Strengthen inter-sector cooperation concerning the two non-artisanal fisheries
7. Strengthen regional cooperation concerning the two non-artisanal fisheries
8. Review the regulatory framework and the sanctions with regard to these two fisheries
9. Strengthening fisheries inspection
10. Regular aerial and maritime patrols in the Sofala Bank shrimp fishing areas, especially in the areas and seasons of greatest risk, now noted
11. Training fisheries inspection staff at central and provincial levels
12. Put the VMS system into operation, regularly supplying data on fishing activities in the industrial fishery
13. Strengthen and expand inspection from the base ports
14. A policy of intervention for the artisanal fishery sector
15. Definition of a typical district structure and organization, with a clear definition of the attributes and powers of the administrator, of the district structure responsible for fisheries administration, and the role of the community organizations
16. Training of fishery administration and inspection staff at district level
17. Establishment of the participatory fishery management bodies at district level
18. In the particular case of the beach seining fishery, definition of the number of units to be licensed in the district, for the various fishing centres

Greater knowledge provided by research into the shrimp resource and the various fisheries that exploit it

1. Improved gathering of the actual fishing data (catch, effort, biological data)
2. Discards of small shrimps and bycatch in the industrial fishery
3. Use of the bycatch either by the industrial and semi-industrial fleet or through exchanges established with the artisanal fishers
4. Volumes and composition of shrimp catch by artisanal fishing in the various areas

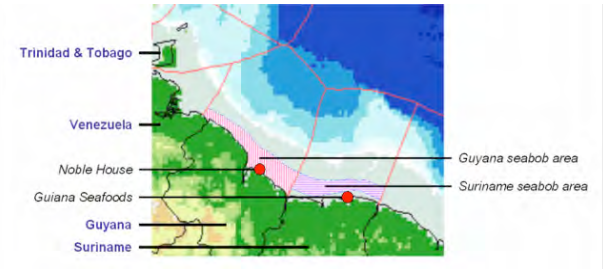
Lessons learned

DNAP demonstrates a strong profile towards good management. However, it is important to realize that in the case of Mozambique, this comes from a strong history of donor support.

Positive signs are that all the right mechanisms are there to control effort, and actions have been taken without political interference.

Industry reluctance to endorse BRDs and TEDs is a worrying issue. Species appear to on the verge of ecosystem cascades, and there are considerable concerns about turtle and elasmobranch interactions. The imposition of the TED programme (as per US and Australian examples) should have been supported with a heavy emphasis on training.

A.7 Atlantic seabob trawl fishery, Suriname

Feature	Description
Target species	Atlantic seabob (*Xiphopenaeus kroyeri*) *Penaeid shrimp* (known locally, and in the text below, as marine or Atlantic shrimp)
Byproduct	Bangamry (*Macrodon ancylodon*) Rockhead (*Larimus brevicep*)
Shrimp dependency	Seabob: 1:0.4 (71 per cent) Atlantic shrimp: not known
Management authority	Suriname Fisheries Department
Fishing zone	
Fleet segments	20 vessels licensed to catch seabob in Suriname, and 31 marine shrimp vessels (2010).
Management methods	TEDs since 1999, and BRDs in the process of introduction. Suriname implemented VMS for all marine shrimp and seabob vessels. Input management measures are in use in the shrimp trawl sector, and represent the main method of fisheries management, and are tied to licence conditions. These measures include restrictions on: • Licensing, coupled with days at sea restrictions • Maximum engine size • Demarcation zones for specific fisheries based on fishing depth (Suriname's seabob fleet is prevented from fishing within the 10 fathom (18 m) contour, and the marine shrimp from inshore of the 30 m contour). There are no robust data to determine whether the existing fleet licences (31 in the marine shrimp sector and 20 in the seabob sector, following recent reductions in order to be precautionary) represent overcapitalization or not, and so no basis at the present time on which to justify any additional reductions in existing licence numbers Licence conditions for marine shrimp vessels already include a minimum landing size for marine shrimp. However, given the current state of knowledge, it is considered too early to consider quota management or other forms of output management.
History	1960s: Commercial *Penaeid* fisheries commenced. 1996: Seabob fisheries commenced. Since the late 1990s: the CARICOM Caribbean Regional Fisheries Mechanism (CRFM) has convened an annual joint meeting of local and international fishery scientists is tasked with working up available data for the purpose of providing stock management advice.
Management Plan	Policy intent: *To manage, regulate and promote the sustainable utilization of the country's fishery resources for the benefit and safety of all stakeholders in the sector and the nation as a whole.* There is a draft fisheries management plan from 2000, but this was never formally adopted, and more recently a draft seabob management plan has been developed jointly by industry and the government and is awaiting formal ratification. Management of the marine shrimp sector is less advanced.
Bycatch work plans	None
Key features	On balance, industry practice is largely left to the good practice and self-constraint of the industry operators. It is evident that both the industry and government in Suriname are likely to be more

responsive to industry-initiated developments than is the case in Guyana.

The industry holds substantial accurate and detailed data records on the evolution of this fishery through its pack-out records.

Suriname has a tight inspection regime on landing, along with VMS (Guyana has neither). It is also noted that some seabob shrimp trawl sector companies in Suriname are currently supporting (and paying for) MCS activities through the provision of fishing vessels to act as marine platforms for surveillance activities by the Ministry of Defense, and through regular reporting of illegal vessel sightings.

To date there has been very little, if any, sharing of information between fisheries departments in Suriname, Guyana, and French Guiana.

The government of Suriname has signed up to FAO's regional bycatch reduction programme.

The use of TEDs is routinely checked by Fishery Department staff in Suriname (but no equivalent controls are in place in Guyana). WWF Guianas is also particularly active in promoting the conservation of turtles through awareness raising programmes, and promotion of improved practice to artisanal and industrial fishers.

Problems

The draft seabob management plan contains an HCR, but the marine shrimp sector has no such mechanism in place and is overall far less well organized/managed.

No formal stock assessment has been undertaken for either fishery.

MCS activities are poorly planned and not based on risk assessment (of key times, locations, operators, etc).

The 2004 CRFM workshop, using 2003 data from both Suriname and Guyana, recommended that fishing effort should be reduced from an average of 335 vessel-days per month (average of 14 days per vessel per month;3,500 kg of seabob per vessel day) to 210 days for the Suriname fleet (9 days/vessel/month), and reduced from 10,382 (average of 12 days/vessel/month; 1,320 kg of seabob/vessel/day) to 900 vessel-days per month for the Guyanese fleet (also 9 days/vessel/month).

Over the last 20 years, FAO and other international development agencies have been working to build and strengthen fisheries management capacity throughout the region, including Suriname and Guyana. Such efforts have yielded some steady improvement, but such gains have often been undermined by high turnover in staffing and inadequate budgets.

Consultation processes are in place and there is evidence of their effectiveness (notably in the introduction of a closed season), but the quality of information on which decisions are made is poor, and the transparency of decision-making can be questioned.

Lessons learned

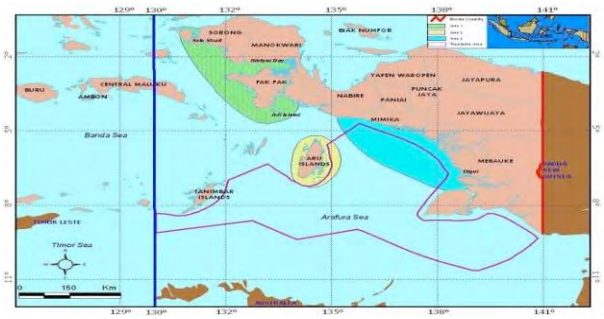
No formal management system in place: the importance of integrating stock assessment with structural and effort control, and integrating these into HCRs should be emphasized.

More stringent use of HCRs is required as a mechanism to protect gravid females and, in the absence of other effort limits, to control effort.

Strengthening of government capacity is needed.

Marked-based incentives, such as the ongoing MSC assessment process for the seabob fishery, have proven to be a significant catalyst of change for the better.

A.8 Arafura Sea and Mareoke, Papua, Indonesia

Feature	Description
Target species	Red-legged banana prawn *(Fenneropenaeus indicus)* and white shrimp (*Penaeus merguiensis*; 35.1 per cent combined) Grooved tiger prawn *(P. semisulcatus*; 23.6 per cent) Red endeavour prawn *(Metapenaeus ensis*; 23.2 per cent).
Byproduct	Flounder, rays, giant threadfin, scad, squid, octopus, Selaroides, snapper, fringed scale sardinella
Shrimp dependency	1:8–15 (8 per cent)
Management authority	Ministry of Marine Affairs and Fisheries (MMAF)
Fishing Zone	
Fleet segments	90 domestic industrial trawlers in the Arafura sea (and Mareoke), from 50–>200 GT. These are based in Sorong , Mareoke, and Ambon. 200 additional foreign boats fishing under access agreements. However, details of the agreements are unclear.
Management methods	Open access, but more recent emphasis on reducing the numbers through non-renewal of licences for bad practice/non-compliance. TAC set at 17,200 t. Companies receive allocations based on vessel GT. Trawling is permitted in waters deeper than 10 m. 25 mm minimum mesh size (Presidential Decree No 1, 1975). Trawlers in the Arafura area required to deploy TEDs (Fisheries Decree No. IK.010/S3.80.75/1982), a BRD required to be installed on the body of the trawl (Fisheries Decree No. 868/Kpts/IK.340/ II/2000). Trawlable area is east of 130° longitude line and beyond 10 m of isobath line (Presidential Decree No. 85, 1982). Trawling has also just been permitted in East Kalimantan. All gear should be <350 GT (Ministry of Agriculture Decree No. 392, 1999). Observers are required by law (for trawlers), but insufficient in number. Around 20 in total.
History	1975: First shrimp trawl management measures introduced. 1982: Trawling for shrimp restricted to the Arafura Sea (Eastern Indonesia), and outside 10 nm in this zone. 1999: TACs introduced. 2000: TED and BRDs made compulsory.
Management Plan	No management plan in place.
Bycatch work plans	There are no workplans. Very little observer coverage: 20 observers for 1,000 trawlers.
Key features	Shrimp fishing conducted throughout the year, July–December in the Arafura Sea (banana shrimp), and in the months of January/February in adjacent Mareoke (tiger shrimp). However, there is no closed season. Trawl ban was initiated in most areas in 1982, but generally circumvented, which includes some allowance for foreign vessel activity. Licensing and registration mechanisms are weak, and subject to political interference. Presently, no new licensed vessels allowed.

Illegal activity and poor statistical/data collection. Association of Indonesian Shrimp Catching Companies (HPPI) members cooperate, but this is 30 per cent of the sector (90 of 300 vessels). There does not appear to be any formal reporting procedure for licensed foreign vessels.

Decreasing trend in shrimp CPUE in recent years. Catch/vessel/day has decreased from 300–350 kg/day two decades ago to the present 250–300 kg/day.

Arafura Sea stock is overexploited and fishing should be reduced to around 50 per cent of 1993 levels. The average size of fish and shrimp is smaller and smaller.

Increase in fuel price caused a 25 per cent reduction in effort between 2008 and 2009. The main casualties being foreign owned vessels fishing under access agreements (BRPL, 2005).

High discard level of industrial shrimp trawlers in the Arafura Sea. Bycatch dependencies increased from 1:10 to 1:15/20, with 60 per cent discarded. 500,000 t fish caught from shrimp trawls, up from 35,000 t.

Very large number of non-trawl vessels active in other parts of the archipelago, using shrimp nets, Danish seine, beach seine, drifting gill net, trammel net, and stowed net. These fish inside the 10 m isobath.

TAC system (Fisheries Decree No. 995/1999) is not supported by robust scientific analysis, and there is only partial recording of the uptake.

Stock assessment is qualitative, and based on 0.8 B_{Lim}. Last stock assessment undertaken in 2001, but CPUE changes measured annually.

Biological impacts of industrial bycatch are significant.

Some appropriate measures to mitigate bycatch problems (mesh sizes, more appropriate BEDs).

Enforcement is intermittent.

Non-target species include: pelagic fish, demersal fish, cephalopods, sharks, and rays. Evidence that small shrimp are caught.

National companies pay wage dividends for larger prawns, and use try nets pre-fishery to ensure larger prawns are caught, but some trawl companies still pay crew remuneration from fish sales. The feedback though is that discards/most other retained species (except squid) are seen as a nuisance.

Turtle interactions reduced because of the application of TEDs.

Fuel subsidy removal for industrial boats combined with an open access system has resulted in the collapse of some fisheries in the country. This policy has brought many fishing companies to the brink of failure, especially those operating vessels larger than 30 GT in the Arafura Sea. The operational fleet is reported to have fallen to around dedicated shrimp 90 trawlers, but with some companies only operating at 75 per cent capacity.

Conflicting administrative responsibilities in licensing (offshore under national jurisdiction, inshore under provincial and district).

At the provincial level, the main management objective appears to be the generation of government revenue and, to a lesser extent, mitigation of conflict.

MMAF applies a licensing system to domestic and foreign trawlers with fees, but fees are absorbed by the Ministry of Finance and not transferred to control or research.

Many of the problems in the management of fisheries in the country relate to enforcement difficulties, and lack of finance to deploy resources.

Recognition of what needs to be done and much positive aspiration, but little political will to implement.

Governance

MMAF responsible for management decision making. The laws are in place but there is no implementation. The ability to implement is hampered by lack of human and financial resources, and political interference. A National Committee for Fish Stock Assessment exists and TACs and individual company quotas are set each year. The scientific basis for the assessment relies on a stock assessment in 2001, along with CPUE data collated from a limited number of fishing companies (HPPI members). MMAF has very limited means of checking the landings data, with 20 observers allocated to 1,000 trawlers in the region.

The government has an increased focus on co-management, but there is questionable ability as to co-responsibility of a large number of trawler companies.

Dinas Perikanan Provinsi (Provincial Fishery Department; DKP) is responsible for artisanal vessels operating inside 12 nm. This organization advocates a system of open access which allows for more and more vessels entering inshore fisheries. DKP has a stronger focus on licence revenue collation.

HPPI is responsible for 30 per cent of the trawler sector. Its membership represents 90 vessels, or the original participants. The fishery has since expanded to 200 trawlers (mostly foreign). HPPI is responsible for the dissemination of regulations to its members, and converses with government. However there is no formal structure, and HPPI would support the creation of a management committee. The organization

	advocates a policy of licence control and seasonal closures as a means to restrict effort.
	Currently, four Sorong-based companies conduct shrimp fishing with trawls: PT. WIFI (Western Irian Fishing Industries), PT. DBU (Dwi Bina Utama), PT. AKFE (Alfa Kurnia Fish Enterprise), PT. IMPD (Irian Marine Product Development).
Strategic partnerships	UNEP/GEF/FAO and Southeast Asian Fisheries Development Centre (SEAFDEC) has developed JTEDs.
Problems	Fleet expanded threefold since 1980. Overfishing with declining CPUE and increased reliance on bycatch species.
	Foreign fishing largely unregulated.
	Some crews receive income from the bycatch, which reduces incentive for greater selectivity.
	Acceptance of the need to manage, but no political will to implement.
	No restrictions on the numbers of artisanal boats entering the fishery, and differences in provincial and national policy goals.
	Centralized administration, too remote from fishing and subject to political interference.
	Inadequate resources allocated to stock assessment.
	Inadequate resources allocated to management, and control and data validation.
	Weak formal management/stakeholder dialogue in place.
	Some discussion on processing (mechanized conversion of trash fish to surimi).
Lessons learned	Need for increasing resources for management, research, and compliance.
	Focus on effort reduction programmes, limited entry licensing, and effort control through seasonal closures and other associated measures (e.g., gear SFRs) required.
	Improved focus on gear selectivity, gear weight, and bycatch exclusion.
	Business structure that rewards crews through bycatch retention reduces selectivity, so need to focus on other business drivers (e.g., fuel savings).
	Improved observer presence to ensure implementation of BEDs and bycatch and catch recording.
	The need for training in gear application, possibly by education from observers.
	Improved data collection methods to gain information on bycatch and related problems, as well to monitor bycatch management measures.
	Greater integration of stakeholders into management planning and means to prevent political interference (i.e., adoption of performance indicators and peer-review process).

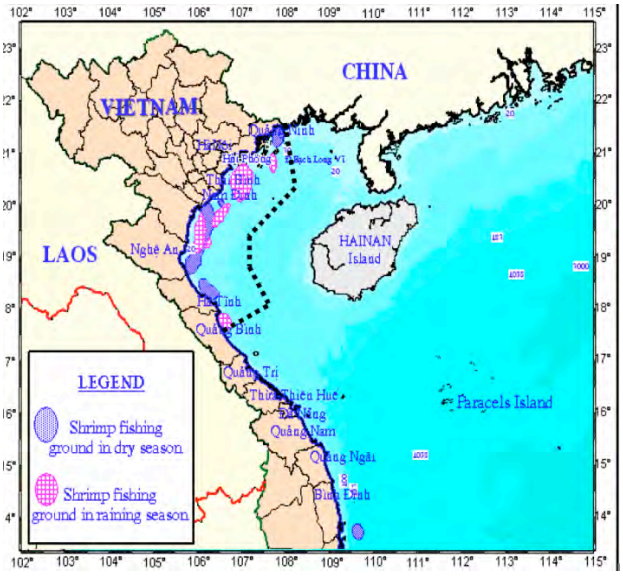
A.9 Kerala and Orissa shrimp fisheries, India

Feature	Description
Target species	**West coast** Kadal shrimp *(Metapenaeus dobsoni*) Kiddi shrimp (*Parappenaeus stylifera*) Kuruma shrimp (*Marsupenaeus japonicus*) Indian shrimp/Red-legged banana prawn *(Fenneropenaeus indicus*) **East coast** Grooved tiger prawn (*Penaeus semisulcatus*) 15 species identified for stock assessment purposes. New development into deepwater shrimp fishing.
Byproduct	Ribbon fish, pomfrets, silver bellies, croaker, threadfins, soles, but up to 400 species caught.
Shrimp dependency	East coast: 25 per cent. West coast: 7 per cent.
Management authority	Maritime States Fisheries Departments under the concerned state ministry and the Ministry of Agriculture under the Union government.
Fleet segments	29,000 shrimp trawlers, mostly artisanal/semi-industrial, 85–150 hp, 12–17 m.
Management methods	Closed seasons: West coast, 47 days, June–August; East coast: 47 days, April–May; 7-month closure of selected turtle corridors in Orissa. Fishery demarcation zones: No trawling within 12 nm from shore, but Orissa condones trawlers operating between 5 nm and 12 nm. Minimum mesh size of 35 mm, but 10–15 mm used. MPAs, but established largely around islands or areas of high biodiversity. Protected species including syngnathids, sponges, 10 species of shark, but largely found in coastal habitats. Compulsory use of TEDs in Orissa. No BRDs presently applied, and to be introduced under amendments to the Fisheries Act, supported by participatory management processes.
History	1897: Indian Fisheries Act. 1972: Wildlife (Protection) Act 1972. 1978: Marine Fisheries Regulation Act. 1980: Maritime States enabled. 1981: Marine Zones of India Act 1981. Several review committees, especially in reviewing the case for closed seasons. Recommendations made but never taken up by national government, refer to further committees. 2009/2010: Marine Fisheries Regulation and Management Act (currently in consultation phase) incorporating ecosystem approach to fisheries management and clarifying roles of national and state government.
Management Plan	Management plans exist but are not implemented. Management committees constituted by scientists from the research and technology institute, academics advise the maritime States Fisheries Departments on the management plans for improvement of the fisheries. Management reference points are provided for establishing limits as thresholds but not applied. Consultation with stakeholders is very limited.
Governance	State fisheries responsible up to 12 nm from shore; national fisheries responsible beyond 12 nm. Vessels over 30 m also fall under the responsibility of the National Ministry. Authority for artisanal vessels, though fishing outside 12 nm, is delegated to the State Ministry.
Bycatch work plans	WWF/Central Institute of Fisheries Technology (CIFT) and Shrimp Trawlers Association working in participatory design of TEDs in Orissa. CIFT developing several BRDs for application to suite fisher-specific needs. These include Juvenile Fish Excluder/shrimp sorting device, Hard BRDs (Rectangular Grid BRD, Fisheye BRD, Oval BRD) and Soft Reduction devices (Radial Escapement Device, Sieve Net BRD, Separator Panel BRD, and Bigeye BRD).
Key features	Four maritime zones. Main shrimp trawl regions are NW (31 per cent), SW (36 per cent),and NE (13 per

	cent).
	Open access regime, but fleet stabilized now with a policy of taking out old boats (>20 years), and some confiscations when caught inside seasonal closed areas.
	Effort has also stabilized as a result of the closed seasons.
	CPUE declining. Total fish catch was 80 kg/h in 1980s, now 30 kg/h. Shrimp constitute 7 per cent (west coast) to 25 per cent (east coast) of total catch. These ratios (shrimp percentages) have remained constant throughout.
	Shrimp stocks, while overexploited (0.6–0.75 B_{MSY}), have a low vulnerability index and are quite robust due to high fecundity, continuous spawning, without any specific peaks identified, high species diversity, low life span, and high growth span.
	Some species compositions affected significantly as a result of heavy bycatch of juvenile (trash fish), e.g., catfish, silver bellies, pomfret, croakers, gastropods, molluscs, threadfins, and other whitefish.
	Day trawlers have significantly higher bycatch ratios, but this group is in rapid decline. Multi-day trawling has a record of being less damaging with lower juvenile bycatch ratios (5–10 per cent). Some adaptations made to gears by a minority of multi-day trawling vessels, and greater use of try nets and alternative semi-pelagic fishing gears (60 mm) to target finfish. These boats also focus on specific shrimp seasons, as and when catch rates are higher.
	Boats increasingly switching gears as a result of target species (shrimp or finfish). Finfish nets have larger mesh sizes, but still retain some shrimp. Semi-pelagic gear also being used.
	The average percentage of juvenile trash fish is around 15 per cent, but income from juvenile trash fish is less than 1 per cent
	. Hence, the need for heavy focus on reducing juvenile fish bycatch.
	Shrimp Trawlers Association agrees focus on bycatch reduction (Gujarat). Members now reducing trawl times to 1–1.5 hours, some adoption of square meshed panels in the codend (60 mm upper net for fish) and 20 mm in the lower net. Square meshed panels reduce resistance from the net and reduce sorting, resulting in improved shrimp and fish quality and some minor savings in fuel costs.
	Some recruitment overfishing inshore throughout coastal area as a result of other gears deployed by coastal fishers, e.g., mini trawls, stake nets, and bag nets which have high catches of juvenile shrimp. Contribution to recruitment overfishing also from semi-industrial boats illegally fishing in inshore waters. These boats are targeting shrimp and pomfrets.
	Benthic interactions have impacted heavily on gastropods, bivalves, etc. Some respite during the closed season, and evidence of fairly rapid recovery.
	Ecosystem impacts are also of major concern. Trophic dependences have been severely affected as total fishery catch increases.
	The area hosts the largest Olive Ridley's turtle rookery in the world with migration across the shrimp trawling areas.
	Existing adaptation of TEDs has resulted in fish losses of around 5–7 per cent, and 0.2 per cent loss in shrimp catch. Turtles and large sharks eliminated from catch. However, only 3,000 TEDs introduced (to around 10 per cent of the fleet). TEDs are provided free to the industry, funded by Marine Products Export and Development Authority (MPEDA). The programme supports the training of fishers; 120 sessions have been held to date, attended by 25–100 fishers per session.
	Some heavy juvenile fish hot-spots are presently being identified to avoid heavy bycatches.
	Fuel price subsidy (3 per cent).
Problems	CPUE continually falling.
	Heavy bycatch of juveniles impacting on whitefish species, with resulting decline in biomass.
	Fishers reluctant to lose any catch.
	Benthic interactions causing problems for some assemblages.
	Ministry of Agriculture heavily influenced by politicians and trade unions, with the result that there is little action taken in implementing HCRs. Expert Committees (17 since 1980) are created at national level and state level, but no actions are taken. Membership of these committees is exclusive, i.e., limited fisher stakeholder involvement and no NGOs. Committee reports consistently recommend a buy-back policy to central government.
	Some proposals to produce surimi machines to optimize trash fish.
Lessons	Need for a strong centralized fishery act with decentralized powers, but removal of political influences,

learned	and creation of a Management (stakeholder) Committee that can implement rules without interference. Need for much focus on participatory management, and linking the outputs of the core institutions to fishers. 50 per cent reduction in effort required (CIMFR advice to Kerala State Fisheries Department). Some extension or revision of closed seasons, especially as a means of supporting effort reduction. Strengthening of enforcement capacity within departments to implement control systems. Rapid introduction of TEDs. Elimination of trash fish catches is essential. BRDs to be made mandatory, with focus on separating out fish from shrimp, either within the trawl or with a focus on two distinct gears, i.e., shrimp bottom trawl and semi-pelagic trawl. Introduction of gear SFRs to prevent expansion in fishing effort.

A.10 Tonkin Gulf, Vietnam

Feature	Description
Target species	White shrimp (*Penaeus merguiensis*) Grooved tiger prawn *(P. semisulcatus*) Red endeavor shrimp *(Metapenaeus ensis*) plus Penaeidae (15 other species), Scyllaridae (3 species), Solenoceridae (1 species), Squillidae (6 species)
Byproduct	Trash fish
Shrimp dependency	Otter trawl (90 per cent of the fleet): 1:8 (12.5 per cent) Beam trawl (10 per cent of the fleet): 1:3 (33 per cent)
Management authority	National Directorate of Fisheries Resources Exploitation and Protection (NADAREP), Ministry of Agriculture and Rural Development (MARD; policy and management beyond 24 nm from shore). Provincial Fisheries Departments, Department of Agriculture and Rural Development (DARD) management inside (within 24 nm from shore).
Fleet segments	Artisanal: 414 beam trawl (using sticks and pipes, with between 1–18 nets); 3,750 otter trawl (1–2 nets) Semi-industrial otter trawl: 13 Industrial: 95 trawlers
Management methods	Open access. Minimum legal lengths (*Metapenaeus intermedius*: 95mm), but not enforced as mean sizes are well below this. Minimum mesh sizes: (20 mm for boats with engine <33 hp; 30 mm for boats with engine >33 hp), but not respected. Vessels over 90 hp cannot operate within 24 nm from shore. Trawling within 6 nm of shore prohibited. No closed seasons.
Fishing zone	
History	Before 1985, almost all fishing boats were otter trawls belonging to stated owned enterprises and used engines of >200 hp. However, due to low economic returns, this sector has declined with a growth in the artisanal sector.
Management Plan	No management plan exists. The current regulations (as above) are defined in MARD, Fisheries law, Circular no. 02/2006/TT-BTS.
Bycatch work plans	BRDs and TEDs are not used.
Key features	The Vietnamese fishery sector is occasionally heavily subsidized: fuel payments equate to US$900–2,400/year for <40 hp to >90 hp (2008), equating to 10–15 per cent of fuel costs per year. Subsidies are also paid to conversion to larger vessels and larger sized engines >90 hp, to promote offshore fishing.

Governance issues	Policies and their implementation concentrate on social aspects (employment) and maximize production rather than any focus on species sustainability and environmental management. The stated focus is that: *Fishing communities are very poor so the government should support them in the short run so that they can conserve fish resources for the long run.* Enforcement of management measures is not applied, and the management measures are ignored.
Strategic partnerships	The Danish International Development Agency is active in the development of co-management initiatives, but little advance appears to have been made towards commercial fisheries initiatives. The MARD focus remains heavily on production increases despite an apparent MoU with the MSC.
Problems	No control on access. The government has been subsidizing the offshore fishing fleet (engine >90 HP). As a result, fishing effort has been increasing and heavily overexploiting coastal areas (due to scare fish resources offshore). Management measures ineffective and no progress towards other alternatives (e.g., closed seasons, restrictive entry licensing). No bycatch reduction with significant impact on other species, including ETP species. No TEDs/BRDs in operation, mesh size at the codend are smaller than regulated and hence the ratio of juvenile and trash fish in the catches is high. 0.5–10 marine turtles caught/trawler/year. The market for trash fish is a major driver.
Lessons learned	A revision of fishery-specific objectives that will focus on species sustainability and avoidance of trophic cascades. The strategic importance of trash fish should be clearly examined. The need for a limited entry licensing system and a significant reduction in fishing effort. Elimination of capacity as opposed to deflecting it to offshore waters. Weak compliance will ensure that effort remains in inshore waters resulting in continuing conflict and juvenile overfishing. DARD implementing management plans in consultation with stakeholders, but illustrating clear and positive drivers for change as a result of the above measures. Introducing educational system for fishers focussing on bycatch reduction and positive business drivers.

A.11 Industrial shrimp trawl, Nigeria

Feature	Description
Target species	**Deepwater(15–60 m)** *Parapenaeus logirostris* (largely unexploited) **Shallow waters (7–15 m)** Mainly brown shrimp (*Parapenaeosis atlantica*) Also pink shrimp (*Penaeus notialis*), grey shrimp (*P. kerathurus*), giant tiger shrimp (*P. monodon*) As reported for Cameroon, the non-native giant tiger shrimp (*P. monodon*) is increasing in abundance.
Byproduct	Croakers (Sciaenidae) Soles (Cynoglossidae) Silver fish/hairtails (Trichiuridae) Big eye grunts (Haemulidae) Barracudas (Sphyraenidae) Snappers (Lutjanidae) Catfish (Ariidae)
Shrimp dependency	1:9 (11 per cent).
Management authority	Federal Department of Fisheries (FDF)
Fleet segments	156 vessels for inshore shrimping; 33 for inshore fishing. 35,000 artisanal fishers. The shrimp trawlers belong to 15 fishing companies.
Management methods	Open access, but restrictions, e.g., in size of a shrimp trawler to less than 23.2 m length overall and 130 GT. BRDs and TEDs applied and implemented. Three BRD options given: square mesh window; square mesh codend; 90 degree or gentle codend. Currently more than 80 per cent of the shrimp trawl nets carry one BRD. 44 mm codend mesh size. No trawling within 5 nm from shore. 70 per cent bycatch restriction. Regulation concerning minimum fish sizes for sale.
History	The use of TEDs on shrimp trawl nets has been a requirement since September 1996.
Management Plan	No management is applied. The ecosystem management approach is about to be introduced.
Bycatch work plans	UNEP/GEF/FAO REBYC project, but no formal management plan in place.
Key features	Overcapacity of the trawl fleet. Declining stocks are very pronounced and prominent. Traditional small-scale fishing gear catches large quantities of prawn (*Nematopalaemon hastatus*) within 5 nm from shore. Small meshes applied and long trawl times, leading to heavy bycatch and fuel inefficiencies. UNEP/GEF/FAO-supported initiatives for BRDs and TEDs in shrimp trawl nets. Companies also introduce cruise targets, i.e., 10–12 t of shrimp and 17–25 t of bycatch; fish caught in excess of this is passed to the crew. Crew remuneration is low (US$20/month) and crew are paid from the sale of bycatch, which runs counter to the bycatch initiative. Bycatch trades provide jobs along the chain to the consumers, especially in rural communities, and also support the need for food security. Export expansion grant is given to augment cost of operation. It has promoted the urge to earn more foreign currency in export trades in shrimps. One of the major/priority projects of the Nigerian Institute for Oceanography and Marine Research (NIOMR) is to conduct a deep-sea resources survey. This is with a view to promote diversification from inshore waters.

Governance	NIOMR responsible for effective marine research and gives data/information for policy formulation. FDF is the administrative arm for policy and enforcement.
	Nigerian Trawlers Owners' Association, an umbrella association of licensed fishing companies, is a major stakeholder in the fishing industry.
	Economic and social support strategies, as well as sustainability, form part of government objectives. Economic and social interests tend to outweigh environmental considerations in implementation.
	There is a high level of government/industry interaction but no formal management council.
	Implementation/enforcement is a joint responsibility of FDF, NIOMR, the navy, and Customs & Immigration Services of the federal government. Most checks are on land; inadequately equipped MCS (e.g., no patrol craft).
	BRDs are not expected and do not remove bycatch completely. However the volume of bycatch is reduced. Bycatch is sold at sea to augment the relatively low crew remuneration. (FDF has zero tolerance for non-compliance in the usage of both TED and BRDs; bycatch trade is not dependent on non-application of the devices).
	Non-compliance issues relate to trawling within 5 nm from shore and non-compliance with the codend mesh size.
Strategic partnerships	UNEP/GEF/FAO REBYC project has improved awareness among all stakeholders for drastic reduction in bycatch.
	Proposed harmonization of regional management measures (Cameroon).
Problems	No system of effort control.
	No closed seasons.
	High number of conflicts between coastal and industrial fishers, with frequent incursions into no-trawl zones by industrial vessels.
	Ecosystem issues exacerbated by indiscriminate dumping of refuse and nylon bags which end up in coastal waters.
Lessons learned	Management planning incorporating the ecosystem approach to fisheries management making allowances for effort reduction through initiatives such as closed seasons.
	A stronger emphasis on gear selectivity and implementation of BRDs.
	Educating fishing companies towards positive business drivers.
	A stronger compliance system linked to established demarcation zones.

A.12 French Guiana

Feature	Description
Target species	*Penaeid* shrimp
Byproduct	n/a
Shrimp dependency	30 per cent
Management authority	CRPMEM (French Guiana Regional Fisheries Committee) Maritime Affaires also involved with formulation of policy.
Fleet segments	23 boats of 24 m. Twin rig, built in Florida, average age 20 years old. Principal companies are: UNIFIEPECH company, and ABCHEE and Fils fishing company.
Management methods	45 mm mesh size (based on a study by Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploration of the Sea; IFREMER)) in 2004 to determine best size to retain market sizes and release juveniles). Use of TTEDs. Closed area less than 30 m depth for trawling. No closed seasons. Use of Neptune doors that reduce drag and impact less on the benthos. One-third of boats actively use these doors and the others have ordered the gear. Without the TTED it would be impossible to use these doors since they are lighter and therefore more affected by the volume of catch in the bag. TTEDs eliminate all large items that cause drag and amplify the selectivity of the bag (aka Sting Rays). Use of restricted licensing; 53 licences available. Restrictions on fishing gear in the form of 2 x 22 m trawls per boat. Compulsory landing of bycatch; all catch unloaded at Larivot dock. TAC of 4,108 t. Also a fish bycatch restriction of 2 kg/day/crew. Restrictions on the transfer of licences for replacement vessels.
History	Has been government support for scrapping. Has been considerable decline in vessel numbers over the years.
Management Plan	Not specifically but very wide range of management methods in places.
Bycatch work plans	Considerable amounts of historical research and ongoing work on bycatch reductions.
Key features	Well-managed fishery, and well resourced as French Guiana is a department of France. Controls at sea show that TTEDs are being used and are proving effective, with a 25–40 per cent bycatch reduction according to rigorous testing using International Council for the Exploration of the Sea (ICES) protocol for the testing of towed gears. Observed reduction ranging from 15–90 per cent. Subsidies: Tax-free fuel, but still more expensive than many other places in the world. No more subsidies for boat building. Subsidy of €1/kg exported to EU to cope with the distance of the market. Research conducted by IFREMER on: • Catches (logbooks, landings) • Bycatch rates of fish sold • Discards • Shrimp/fish sizes • Ecosystem status • Compliance levels with regulations • Spawning stock biomass • Ecosystem modelling.
Governance	TTEDs made mandatory by the industry through the CRPMEM.

	The French Marines and The Maritime Affaires enforce regulations
	As a department of France, the waters of the French Guiana are technically part of EU waters and fall under EU regulations.
Strategic partnerships	Industry contributes boat time to research on bycatch reduction and resource health.
	Industry and NGOs working together.
Problems	Used to be a problem during the months of August and September when boats want to follow the resource inshore within the 30 meters zone. Since three years ago, boats stop fishing during this period and stay in the harbour so as not to get reprimanded and ticketed by the marines responsible for controlling the zone.
Lessons learned	Key role of research and partnerships in improving management.

APPENDIX B: OTHER COUNTRY DATA

Country	Tonnage	Fleet characteristics	Management system	Problem issues
Asia Pacific				
Thailand	77,364			
Malaysia	41,000	4,026 trawlers : Zone B: 2,714 Zone C: 1,054 Zone C2: 258	No trawl zone within 5 nm from shore. Zone B (5–12 nm from shore) allows vessels between 20–40 GT. Zone C (12–30 nm from shore) allows vessels between 40–70 GT. Zone C2 (Beyond 30 nm to EEZ) allows vessels above 70 GT. Codend mesh size according to the Fisheries Act is 38 mm, but enforcement is lacking.	40% of Malaysian landings comprise trash fish. Incidences of shrimp trawlers encroaching into the coastal zone for the resources.
Philippines	45,599	445 trawlers: 3.1–20 GT: 276 21–150 GT: 165 150 GT+: 4		Discard rates are unknown, but are likely to be relatively small as there is a market for most captured fish. MCS very weak.
Bangladesh	3,444	45 industrial trawlers	Shrimp trawlers range in length from 20.5 to 44.5 m. These vessels use outriggers and operate 2–4 nets at a time, using modern shrimp trawl nets with the codend having a mesh size of 45 mm and a headrope length of 15-35 m. Shrimp trawlers must land finfish, which must exceed 30% of the total catch. Licensed vessels must land fishing in designated ports and in the presence of a Department of Fisheries officer. Declaration of marine reserve in the Middle Ground and South Patches of the Bay of Bengal. No catch can be discarded (except marine turtles). All trawlers must use a TED during trawling Suspension of trawler ban in waters <40 m from 10 April 2007 to 21 August 2007.	Trawl fishing has officially been restricted from operating within the 40 m depth contour; however, vessels have been found to be operating in depths as little as 10 m, in order to catch brood shrimps for hatcheries. The CPUE of shrimp (kg/day/shrimp trawler) has steadily decreased since the early 1990s. High levels of discarded finfish were reported, reaching up to 35,000t, approximately 70% of the fish bycatch. MCS focuses primarily on the trawl fisheries.
Cambodia	1,163	1,500 trawlers in four municipalities. Two groups: 30 hp, and 20 m	Open access. The basic fisheries law prohibits trawling between the shore and the 20-m isobath (up to 10 km offshore).	Few legal instruments, no legal mechanism in the fisheries law for limiting fish catches or fishing effort. Illegal fishing in coastal waters.

Country	Tonnage	Fleet characteristics	Management system	Problem issues
			Mesh sizes (non gazetted are 40–50 mm). 150 trawlers (mainly from Thailand) are licensed to fish in the offshore "overlap zones".	Damage to seagrass beds. Trash fish is a major bycatch issue; trash fish (for fertilizer), fish, and squid could be considered together with shrimp as an actual target of trawling. The proportion of trash fish in the trawl catch is increasing. Trawl interactions with turtles and TEDs not practical because of the small size of the vessel. Shrimp gill netters targeting larger prawns. Paucity in biological data, no enforcement. Shift in fishing gears towards more modern and efficient methods, decreasing CPUE from 20 kg to 5 kg per night. Poor enforcement. Significant quantity of unregulated fishing effort from Thailand. Regulatory authorities reluctant to prevent trawling inside 20 m isobath despite constant pressure from other artisanal fishers.
Papua New Guinea	1,008	15	Eight nationally owned prawn companies operate in the Gulf of Papua prawn fishery, and others in PNG Torres Strait fishery. Banana prawn (*F. merguiensis*, *F. indicus*): 50–60%; tiger prawn (*P. monodon, P. semisulcatus*): 10–15%; endeavour prawns (*Metapenaeus ensis, M. endeavouri, M. demani*): 15–20%. Most vessels are twin-rigged with 12 fathoms (24 m) (footrope), except three vessels that are quad-rigged. Aggregate head rope (with mesh attached) for the main nets exceeds 60 m and 1 (one) try net exceeds 6 m head line. The duration per main net shot is 4 hours. The trawl grounds from Iokea to Cape Blackwood shall be closed from 1 December to 31 March. Mesh size 50 mm, fish escape panel at the neck of the codend, consisting of 1 m wide panel of net of 50 mm.	
Americas				

Country	Tonnage	Fleet characteristics	Management system	Problem issues
Brazil	34,416			
Venezuela	11,174	351 trawlers	TEDs applied. The fishing grounds are demarcated into zones with a portion of the fleets authorized to fish in each of them.	The trawl fishery is a combined fishery for shrimp, molluscs, and fish. Shrimp component represents 2.5–6% of the general catch. Of the additional catch, 30–35% is normally landed, the remaining 60–65% (mainly fish, with an estimated 80% of juveniles from species of commercial interest) is discarded.
Panama	6,642			Shrimp fisheries have discard rates in excess of 80%.
French Guiana	2,883			Shrimp fisheries have discard rates in excess of 80%.
Colombia	2,755	Pacific coast: 115 vessels, mainly small boats, 70% of them operating in coastal areas. Atlantic coast: approx 20 m vessels plus other seabob trawlers		Shrimp resources are overexploited. Pacific: Bycatch 7.5:1, 14,664 t of incidental catch (out of which many juveniles) Atlantic: Bycatch 4:1. Bycatch sales used as a bonus to pay crew.
Costa Rica	2,319	73 trawlers ("Florida type" with outriggers)	TEDs mandatory in shallower waters <80 fathoms. VMS.	Bycatch 7.5:1. 80% of finfish discarded. High discard rates, particularly of juveniles, and overfishing.
Cuba	1,361	51 fishing vessels	Shrimp fishing grounds are well demarcated. Fishing closures during recruitment seasons. Other regulations exist for reducing fishing effort and the protection of areas with a known high density of juveniles or large quantities of small size fish.	Bycatch 5.5:1. Significant changes made as a result of the UNEP/GEF/FAO REBYC project. BRDs now mandatory. Historically, 22% of the non-shrimp catch landed for human consumption, the rest reduced to fishmeal or silage. Shrimp bycatch is sold at receiving centres at sea when fishers take multi-day trips, and are fishing away from shore. This allows the bycatch to be sorted o-board and sold for human consumption, as well as for use as animal feed. Fishers were given monetary incentives to exceed prearranged quantities and qualities of bycatch on a daily basis.

Country	Tonnage	Fleet characteristics	Management system	Problem issues
Trinidad and Tobago	830 t: 37% artisanal, 13% semi-industrial, and 50% industrial	84 artisanal trawlers 9 semi-industrial trawlers 21 industrial trawlers	Most vessels operating in coastal waters trawl both day and night; artisanal vessels, 1.8 and 18 m; semi-industrial, 9 and 41.4 m; industrial, 9–77 m. Restricted access to industrial and semi-industrial fisheries. Trawling prohibited on the east coast of Trinidad and within 12 nm of the coast of Tobago. Artisanal trawlers permitted to operate outside 1 nm from the coast; semi-industrial trawlers permitted in depths of six fathoms (1 fathom=1.83 m) or more; industrial trawlers permitted in depths of 10 fathoms (18 m). Stretched mesh size of the codend must be no smaller than approximately 7.5 cm when trawling for fish and approximately 3.5 cm for shrimp. Use of TEDs statutory for industrial and semi-industrial boats.	High incidental juvenile fish catch (90%) associated with artisanal shrimp trawling. This causes major areas of conflict with non-shrimp fishers. Larger industrial or semi-industrial trawlers normally keep around 40 % of their bycatch on board. Shrimp: Bycatch = 1:1; shrimp value more than 4 x fish. Semi-industrial and artisanal vessels deliberately target juvenile shrimp. Fully or overexploited condition of shrimp stocks and overcapitalization in the trawl fishery. Use of TEDs in semi-industrial and industrial trawl fleets has not been well accepted by the industry. Capture of juvenile (pre-spawning) shrimp. Low or negative profits in the fishery. Limited capacity to monitor compliance at sea. Limited catch data. Lack of political will and legal tools to do so. Strong emphasis on subsidies: Registered fishers or vessel owners receive Value Added Tax (VAT) exemption on equipment, engine parts and new fishing vessels. Replacement vessels are eligible for 25 % subsidy subject to a maximum of US$800. Registered vessel owners are also eligible to access subsidies on gasoline and oil, but these are minimal.
Africa				
Cameroon	9,595	65 vessels	Vessels mainly operated by "Time Charter" companies, a form of joint venture with foreign ownership. Two-boat trawling is increasing in shallow waters, targeting mainly fish. 25 mm mesh size currently used. Some consideration of a change to 35 mm (GEF).	The capture of juvenile food fish was a threat to sustainable exploitation of demersal fish resources. Violation of non-trawl zones. Trawling in shallow waters created serious conflicts with artisanal fishers.
Senegal	4,300			Bycatch of fish, including juveniles. Some sold for

Country	Tonnage	Fleet characteristics	Management system	Problem issues
				human consumption, but most discarded at sea. Conflicts between artisanal and trawl fisheries because of inshore activities.
Tanzania	1,795	20 vessels	Foreign-owned outrigger shrimp trawlers. Trawling for shrimp in coastal waters. Trawling banned in December, January, and February, and night fishing (between 6 pm and 6 am) prohibited.	Bycatch of fish, including juveniles. Some sold for human consumption, but most discarded at sea. Conflicts between artisanal and trawl fisheries because of inshore activities. Violation of non-trawl zones.
Ghana	1,282			Bycatch of fish, including juveniles. Some sold for human consumption, but most discarded at sea. Conflicts between artisanal and trawl fisheries because of inshore activities. Violation of non-trawl zones.
Kenya	392	4 industrial trawlers		Strict monitoring regulations as well as a declining stock. 2:1 fish:shrimp.
Gambia	363			Bycatch of fish, including juveniles. Some sold for human consumption, but most discarded at sea. Conflicts between artisanal and trawl fisheries because of inshore activities.
Middle East				
Iran	7,261	39 industrial trawlers (27 m and 750 hp) fishing with two trawls (i.e., twin rig) 870 wooden dhows (16 m / 100–220 hp) 1,500 fibreglass boats (7 m, 25–45 hp)	Fishing season in each province is approximately six weeks, and opening and closing is based on the maturity and body length of shrimp and percentage (20%) of remaining stock.	Shrimp trawler catch composition consists of: 10–17% shrimp; 10–25% small fish; 40–60% juvenile fish. The grid (Grid 80) became mandatory for industrial trawlers. Consequently, gear trials later focused on artisanal fisheries, so far with mixed results, and these trials (using JTED, square mesh window, parallel ropes, and fisheye) are continuing. Aside from legislation for BRD use, shrimp fisheries

Country	Tonnage	Fleet characteristics	Management system	Problem issues
				are also regulated through effort reduction (through buy-back of licences and gear swaps) and controls, research-based imposition of closed seasons and closed areas.
Kuwait	1,773	35 steel-hulled double-rigged Gulf of Mexico-type trawlers 34 dhow trawlers	Limited entry. Specified six-month fishing season (1 September –end-January/February, determined by stocks assessment), allied to a system of effort limitation. Protected areas (Kuwait Bay and the 3 nm coastal zone). Nominal stretched mesh size of 51 mm in the main body of the net and 45 mm in the codend. Typical net specifications are: 57.4-m headrope, 30.5-m footrope. Capacity reduced through buy-out scheme. Plans to introduce TEDs and BRDs within the next two years.	High level of effort and low CPUE seem to indicate that the stock has been overexploited since 1993. High discard rates. Bycatch actually landed is small (1.32–1.61% of the total bycatch caught); more than 98% of the bycatch is discarded. Bycatch includes juveniles and adult finfish, sharks, rays, crustaceans, sea snakes, turtles, soft corals, molluscs, and echinoderms. Heavy reliance in subsidies which sustain profits. No incentives to use BRDs.
Bahrain	1,738	335 traditional vessels ("banoush"), 5–25 m, towing only one trawl.	Nine-month fishing season.	Bycatch of finfish is problematic.
Oman	489		Only traditional fishing methods are allowed, mainly cast nets, involving 500–700 fibreglass boats. The fishing season is 1 September – 31 December.	

APPENDIX C: REFERENCES

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Tropical shrimp trawling

1.3M

The annual catch of tropical shrimp is an estimated 1.3 million tonnes

419,000

Approximately 419,000 trawlers from 65 countries catch shrimp, generating employment for around 900,000 people

15KG

For each 1.8 kg of shrimp caught, as much as 15 kg of untargeted catch is also produced

50%

In some situations, fishing effort may need to be cut by at least 50% to help achieve sustainability

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