

PART 2
SHRIMP FISHERIES IN SELECTED
COUNTRIES

Shrimp fishing in Australia

AN OVERVIEW

Australia is greatly involved in shrimp²¹ fishing and its associated activities. Shrimp fishing occurs in the tropical, subtropical and temperate waters of the country, and ranges in scale from recreational fisheries to large-scale operations using vessels of up to 40 m in length. Australia also produces shrimp from aquaculture and is involved in both the export and import of shrimp in various forms. Many Australian shrimp fisheries are considered to be extremely well managed and a model for other countries to emulate. Moreover, the availability of recent information on Australian shrimp fishing and management issues is excellent.

DEVELOPMENT AND STRUCTURE

The main Australian shrimp fisheries can be roughly divided by area and management responsibility.²² Ten major shrimp fisheries are recognized in the national fisheries statistics (ABARE, 2005). Summary details on these fisheries are given in Table 20. The nomenclature of the main species of Australian shrimp is given in Table 21.

Some of the more significant or interesting Australian shrimp fisheries are described below.



TABLE 20

Main shrimp fisheries in Australia

Fishery	Species listed	Main method	Fishing units
Commonwealth Northern Prawn	Banana, tiger, endeavour and king prawns	Otter trawling	96 vessels
Commonwealth Torres Strait Prawn	Prawns	Otter trawling	70 vessels
New South Wales Ocean Prawn Trawl	Eastern king prawns	Trawling	304 licence holders
Queensland East Coast Otter Trawl	Tiger, banana, red spot, king, endeavour, eastern king, bay prawns	Otter trawling	478 licence holders
Queensland River and Estuary Trawl	Banana, bay and tiger prawns	Beam trawling	160 licence holders
Western Australia Shark Bay Prawn	King, tiger and endeavour prawns	Trawling	27 licence holders
Western Australia Exmouth Prawn	King, tiger and endeavour prawns	Trawling	13 licence holders
Western Australia Nickol Bay Prawn	King and banana prawns	Trawling	13 licence holders
South Australia West Coast Prawn	Western king prawn	Trawling	3 licence holders
South Australia Spencer Gulf Prawn	Western king prawn	Trawling	39 licence holders

Sources: ABARE, 2005.

²¹ Although the term “prawn” is more often used than “shrimp” in Australia, “shrimp” is used in this chapter to be consistent with other chapters and international usage. (See Box 1 for information on the use of shrimp versus prawn.)

²² Most of the larger offshore fisheries in the country are managed by the Australian Commonwealth, while most of the coastal and inshore fisheries fall under the jurisdiction of the Australian states or territories.

TABLE 21
Main shrimp species in Australia

Scientific name	Common name in Australia
<i>Penaeus merguensis</i>	White banana prawn
<i>Penaeus indicus</i>	Indian banana prawn
<i>Penaeus longistylus</i>	Red spot king prawn
<i>Penaeus latisulcatus</i>	Blue-legged king prawn
<i>Penaeus plebejus</i>	Eastern king prawn
<i>Penaeus esculentus</i>	Brown tiger prawn
<i>Penaeus semisulcatus</i>	Grooved tiger prawn
<i>Penaeus monodon</i>	Leader prawn, giant tiger prawn
<i>Metapenaeus ensis</i>	Red endeavour prawn
<i>Metapenaeus endeavouri</i>	Blue endeavour prawn
<i>Metapenaeus macleayi</i>	School prawn
<i>Metapenaeus bennettiae</i>	Greasyback prawn
<i>Trachypenaeus</i> spp.	Hardback prawn

1960s. Initially, NPF was a banana prawn fishery, with vessels targeting the abundant schools or “boils” of prawns in the southeast corner of the Gulf. The numbers of vessels rose dramatically in the mid-1970s, partly as a result of huge catches in 1974, when more than 12 500 tonnes were landed. The open access nature of the fishery, shipbuilding subsidies and government development priorities for the Northern Territory resulted in a rapid buildup of vessels and an expansion of effort across the NPF area. The banana prawn season shrank from year-round in the 1960s to only a few months a year in the 1970s and to just a few weeks in the 1980s. In recent years, a poor banana prawn season, usually associated with reduced rainfall, may last little more than two weeks. This decline was exacerbated by a particularly dry decade in the 1980s that forced vessels to seek new fishing opportunities, leading to an increase in effort in the tiger prawn fishery. As the banana prawn fishery began to decline, attention turned more and more towards tiger prawns. The tiger prawn fishery rapidly expanded until it too began to suffer from an excess of capacity and declining catches in the late 1970s. In September 2005, the fishing fleet comprised 85 purpose-built steel trawlers from 13 m to 29.2 m in length, most of which are “company” boats. These trawlers are capable of sorting, grading, packing and freezing catches at sea and are serviced by mother ships that accept the frozen products and supply fuel, gear and other provisions. At present, the NPF has two components, as described below.

- A banana prawn fishery, which commences when the NPF season opens and usually lasts for a few weeks in April/May. The fishery generally operates during daylight hours and targets prawn aggregations, frequently using spotter aircraft. Fishing is extremely intense with vessels often working in close proximity and in strong competition. Very large catches can be taken in a short time.
- A tiger prawn fishery, which operates from September to December, generally at night, and is more widespread across the NPF area than the banana prawn fishery.

The Commonwealth Torres Strait Prawn Fishery is located between the tip of the Cape York Peninsula and the south coast of Papua New Guinea. About 70 vessels participate in the fishery and the operators target tiger and endeavour prawns. The value of the shrimp catch was about \$A19.2 million in the 2002/03 season. Since the 1998/99 season, harvests have decreased each year, contributing to the fall in value of the fishery. Fishing is carried out at night using otter trawls. Few vessels fish exclusively in the Torres Strait area; most move between the Queensland East Coast Trawl Fishery and the NPF. The fishing season in the Torres Strait Prawn Fishery is from March to December (Galeano *et al.*, 2004).

At the South Australia Spencer Gulf Prawn Fishery, western king prawns were first trawled in 1909, but it was not until the mid-1960s that fisher trials showed their

The Commonwealth Northern Prawn Fishery (NPF) is the most important shrimp fishery in the country and in the 2003/04 period produced about 6 000 tonnes of shrimp worth \$A74 million. Cartwright (2003) provides information on its history and structure. The fishery covers a large geographic area of some 700 000 km², extending across much of the northern coastline, from Queensland to Western Australia. Surveys in the mid-1960s, by the Commonwealth Scientific and Industrial Research Organization (CSIRO), resulted in the establishment of a commercial prawn fishery in the Gulf of Carpentaria in the late

commercial potential. By the late 1960s, a small industry had been established. At present, commercial fishing is undertaken using otter trawling. This trawling takes place at night for nine to 13 hours, depending on the hours of darkness (daylight trawling is prohibited). The Spencer Gulf Prawn Fishery (and the nearby west coast area) is the largest in the world for western king prawns, with an average annual catch of 1 800 to 2 000 tonnes, which in recent years has been worth from \$A35 million to \$A40 million. The fishery (including the west coast) has a limited entry consisting of 42 licence holders, with the average vessel fishing 60 days per year (Palmer and Miller, 2005).

The New South Wales (NSW) Estuary Prawn Trawl Fishery involves the harvesting of prawns and, in some estuaries, squid and fish, by licensed commercial operators, using prawn trawl nets. The practice of trawling for prawns in NSW began in 1926 in Port Jackson. A single net connected to a pair of otter boards to spread it out was towed behind a small boat. In the 1940s, prawn trawling spread to four other estuaries (Clarence, Hunter and Hawkesbury Rivers and Botany Bay), following improvements in transport, the development of markets and the advent of motorized vessels. The introduction of mechanical winches on prawn trawling boats allowed the boats to trawl in deeper waters. In 1984, a freeze on the issue of new boat licences was introduced and, in 1988, the number of vessels operating in the fishery was limited to 309. Prawn trawling is currently permitted in four estuaries in NSW: the Clarence, Hunter and Hawkesbury Rivers and Port Jackson. At present, the fishery uses a single otter trawl net to target school prawns and eastern king prawns and, in the case of the Hawkesbury River, squid. With the exception of the Hawkesbury River, the fishery operates in defined seasons (generally October to May) and, within each estuary, is confined to specific times and a specific area (around 50 percent of the tidal area of each estuary). Most prawn catches are landed during the dark of the moon. In 2002–03, 322 tonnes of prawns, squid and other fish were harvested from the four estuaries, with a total estimated value at the first point of sale of \$A2.9 million. Approximately 220 fishers are currently entitled to operate in the fishery (DPI, 2005).

The Queensland East Coast Trawl Fishery extends from Cape York to the NSW border and is divided into three components: (i) the northern portion (mainly the Great Barrier Reef lagoon), which harvests tiger, endeavour and red spot king prawns; (ii) the southern portion (south of 220°S), which takes eastern king prawns and saucer scallops; and (iii) Moreton Bay, which harvests eastern king prawns, squid and blue swimmer crabs. From 6 000 to 9 000 tonnes of prawns are harvested annually by the Queensland East Coast Trawl Fishery. In recent years, the number of boats participating in the fishery varied from 700 to 800. King prawns are the major component of the trawl harvest, historically contributing 27 percent, with tiger prawns accounting for 21 percent (Williams, 2002).

A small Northwest Slope Trawl Fishery extends from 114°E to about 125°E off the Western Australian coast between the 200 m-isobath and the outer limit of the Australian Fishing Zone (AFZ). Seven vessels catch pink prawn (*Haliporoides sibogae*), red prawn (*Aristaeomorpha foliacea*), striped prawn (*Aristeus virilis*), scarlet prawn (*Plesiopenaeus edwardsianus*), red carid (*Heterocarpus woodmasoni*) and white carid (*Heterocarpus sibogae*). In the 2003/04 season, 61.6 tonnes worth \$A1 149 100 were landed.

Recreational fishing for shrimp is important in Australia. A national recreational survey showed that the largest component of recreational fishing in terms of numbers caught was the prawn shrimp fishery. This type of fishing occurs mainly in the estuaries of northern NSW and Queensland (Morgan, 2004a).

TARGET SPECIES, CATCH AND EFFORT

The annual catches of shrimp by political entity in Australia are given in Table 22.

The various shrimp fisheries catch different species of shrimp. Three examples are given below.

TABLE 22
Australian shrimp catches

Area/fishery	Catch	2001/02	2002/03	2003/04
		Tonnes		
New South Wales	King prawns	1 113	1 180	849
	School prawns	522	563	635
	Other prawns	277	258	155
	Total prawns	1 912	2 001	1 639
Victoria	Total prawns	126	91	56
Queensland	Endeavour prawns	933	965	1 128
	King prawns	3 372	3 858	3 329
	Tiger prawns	1 527	1 861	2 242
	Other prawns	944	936	1 551
	Total prawns	6 775	7 620	8 250
Western Australia	Total prawns	3 555	3 934	3 689
South Australia	Total prawns	2 610	1 740	2 126
Northern Prawn Fishery	Tiger prawns	1 958	1 969	2 186
	Banana prawns	5 419	3 325	3 516
	Endeavour prawns	1 132	395	418
	King prawns	2	3	1
	Other prawns	7	6	71
	Total prawns	8 518	5 699	6 192
Torres Strait Fishery	Tiger prawns	706	665	630
	Endeavour prawns	889	750	681
	King prawns	167	122	81
	Other prawns	3	5	4
	Other	73	52	37
	Total	1 838	1 594	1 432

Source: ABARE, 2005.

- NPF is a multispecies fishery that catches at least nine species of prawns. Three species (the white banana prawn *Fenneropenaeus merguensis*, the brown tiger prawn *Penaeus esculentus* and the grooved tiger prawn *P. semisulcatus*) account for almost 80 percent of the total annual landed catch weight from the fishery. Endeavour prawns (*Metapenaeus endeavouri* and *M. ensis*) and red-legged banana prawns (*F. indicus*) constitute most of the remainder of the catch. Other components of the commercial catch include the giant tiger prawn (*P. monodon*), western king prawn (*Melicertus latisulcatus*) and the red spot king prawn (*M. longistylus*) (NORMAC, 2002).
- Robins, Campbell and McGilvray (1999) give the species in the Queensland East Coast Otter Trawl Fishery: eastern king prawn (*Penaeus plebejus*), banana prawn (*P. merguensis*), red spot king prawn (*P. longistylus*), brown tiger prawn (*P. latisulcatus*), brown tiger prawn (*P. esculentus*), grooved tiger prawn (*P. semisulcatus*), giant tiger or leader prawn (*P. monodon*), red endeavour prawn (*Metapenaeus ensis*), blue endeavour prawn (*M. endeavouri*), school prawn (*M. macleayi*), greasyback prawn (*M. bennettiae*) and hardback prawn (*Trachypenaeus* spp.).
- Broadhurst, MacBeth and Wooden (2005) indicate that, in NSW, three species of shrimp account for more than 98 percent of the total annual production: eastern king prawn (*Penaeus plebejus*), school prawn (*Metapenaeus macleayi*) and greasyback prawn (*M. bennettiae*).

TABLE 23
Catch and effort in the Northern Prawn Fishery, 1980–2004

Year	Banana prawns (tonnes)	Tiger prawns (tonnes)	Endeavour prawns (tonnes)	King prawns (tonnes)	Total prawns (tonnes)	Number of vessels	Banana fishery effort (days)	Tiger fishery effort (days)
1980	2 835	5 124	1 891	111	9 964	269	8 391	30 594
1981	5 672	5 559	2 073	95	13 400	286	11 524	31 895
1982	3 875	4 891	2 124	144	11 036	271	8 751	32 956
1983	2 382	5 751	1 488	207	9 831	254	6 856	34 551
1984	3 770	4 525	1 714	83	10 095	252	5 932	32 447
1985	4 469	3 592	1 671	77	9 811	231	6 946	26 516
1986	2 935	2 682	748	85	6 451	238	7 132	26 669
1987	4 257	3 617	772	65	8 713	234	7 954	22 478
1988	3 381	3 458	669	81	7 591	222	6 655	26 264
1989	5 466	3 173	909	85	9 636	223	7 439	27 036
1980–89 average	3 904	4 237	1 406	103	9 653	248	7 758	29 141
1990	2 221	3 550	735	128	6 636	200	5 044	25 525
1991	6 605	3 987	879	81	11 554	172	6 515	20 744
1992	2 254	3 084	880	47	6 267	170	5 132	21 789
1993	4 292	2 515	733	35	7 572	127	6 299	16 019
1994	2 157	3 162	872	72	6 263	128	4 955	18 592
1995	4 961	4 125	1 150	58	10 294	125	4 880	16 834
1996	4 078	2 311	1 235	41	7 665	127	5 525	16 635
1997	4 587	2 694	1 870	51	9 202	129	5 476	15 385
1998	3 569	3 218	1 322	20	8 123	130	5 301	18 003
1999	3 904	2 136	885	21	6 947	129	5 639	12 675
1990–99 average	3 863	3 078	1 056	55	8 052	144	5 477	18 220
2000	2 195	2 190	958	13	5 355	121	3 697	12 736
2001	7 245	1 983	1 157	4	10 389	118	6 247	10 440
2002	4 577	1 943	411	5	6 936	114	4 148	8 718
2003	3 238	2 222	435	4	5 898	97	4 114	8 503
2004	3 520	1 767	396	3	5 686	96	3 985	7 793
2000–04 average	4 155	2 021	671	6	6 849	109	4 438	9 638

Source: Perdrau and Garvey, 2005.

The issues of catch and effort are discussed in more detail below for Australia's most important shrimp fishery, the NPF. Catch and effort information for this fishery for 1980 to 2004 is given in Table 23.

Although effort is given in the Table in terms of vessel days for the two fisheries, in practice the measurement of effort is complex and is evolving over time. The issues of effort, effort creep and capacity for the NPF are discussed in the section *Management of the Northern Prawn Fishery* below.

ECONOMIC CONTRIBUTION OF SHRIMP FISHING

The values²³ of shrimp catches in Australia are given in Table 24.

Since 2002, the total annual catch of shrimp for Australia has been between 22 000 and 26 000 tonnes, valued between \$A300 and \$A365 million. In a national perspective, the value of total annual Australian fisheries production is about \$A2.2 billion. The shrimp fisheries are therefore roughly responsible for about 15 percent of the value of production from Australian fisheries. Gross domestic product (GDP) calculations by fishery or fishery commodity do not feature prominently in Australian shrimp literature; however, the contribution of all Australian fisheries to GDP is less than 0.3 percent.

²³ Values given are the assessed values at the point of landing and exclude transport and marketing costs.

TABLE 24
Australian shrimp catch value, by season (\$A'000)

Area/fishery	Catch	2001/02	2002/03	2003/04
New South Wales	King prawns	23 258	24 109	17 795
	School prawns	3 907	5 801	4 973
	Other prawns	1 336	1 231	538
	Total prawns	28 501	31 141	23 306
Victoria	Total prawns	1 644	1 159	730
Queensland	Endeavour prawns	11 192	11 583	13 542
	King prawns	39 061	44 884	39 469
	Tiger prawns	22 904	27 908	33 635
	Other prawns	6 830	6 961	11 962
	Total prawns	79 986	91 336	98 607
Western Australia	Total prawns	47 068	45 807	44 782
South Australia	Total prawns	47 405	32 459	43 423
Northern Prawn Fishery	Tiger prawns	48 321	34 640	32 072
	Banana prawns	71 910	42 797	36 043
	Endeavour prawns	13 130	4 543	4 388
	King prawns	31	47	12
	Other prawns	42	21	610
	Total prawns	133 434	82 048	73 126
Torres Strait Fishery	Tiger prawns	13 510	10 700	8 511
	Endeavour prawns	8 221	6 902	5 194
	King prawns	2 109	1 586	932
	Other prawns	22	17	9
	Other	710	582	378
	Total	24 572	19 787	15 023

Source: ABARE, 2005.

Employment data for the fishing industry are collected by the Australian Bureau of Statistics (ABS). The data are gathered from the population census survey every five years. The most recently available ABS employment data for the Australian fishing industry (2001) indicate that 1 040 people were employed in shrimp fishing, geographically distributed as follows: New South Wales, 223 people; Victoria, six; Queensland, 472; Western Australia, 150; South Australia, 109; and Northern Territory, 80. These 1 040 people in shrimp fishing represent about 5 percent of those employed in the fishing industry as a whole.

A national nutrition survey of 13 858 Australians in 2004 indicated that the national consumption of shrimp is about 75 g/day, or 20.8 kg/year, for people over two years of age (Anon., 2004a).²⁴ Simplistically, if shrimp production from commercial capture fisheries is assumed to be 25 000 tonnes per year, aquaculture production 3 500 tonnes, shrimp exports 9 000 tonnes, shrimp imports 25 000 tonnes, and the Australian population 25 million, then an approximate estimate of annual per capita consumption of commercial shrimp in the country is about 2.2 kg.

TRADE ASPECTS

Table 25 gives Australian shrimp exports for several years by product form.

²⁴ This seems unreasonably large in view of the results of Australian fish consumption studies that show that per capita consumption of all types of seafood in Australia was about 20 kg/ year in the mid-1990s (Gillett and Preston, 1997).

TABLE 25
Australian shrimp exports, by product form

Product	2001/02		2002/03		2003/04	
	Tonnes	\$A'000	Tonnes	\$A'000	Tonnes	A\$'000
Headless	785	18 607	580	12 002	307	5 353
Whole	10 870	239 367	8 739	192 567	8 852	151 488
Other	270	4 853	213	3 676	237	3 762
Total	11 925	262 827	9 532	208 245	9 396	160 603

Source: ABARE, 2005.

The most important export destinations in 2003/04 in terms of weight were Japan (34 percent), Spain (18 percent) and China (12 percent). Australia also imports shrimp from various countries – 24 448 tonnes in the 2003/2004 period. The main supplying countries were China, India, Indonesia, Thailand and Viet Nam. It should be noted that import/export data include shrimp from capture fisheries as well as from aquaculture.

The data above show that Australia is a net importer of shrimp. In 2003/04, shrimp imports were 2.6 times that of exports.

In May 1996, the Government of the United States of America placed an embargo on the import of prawns from countries not implementing sea turtle conservation measures required by United States law. Australian shrimp exports were included in the embargo. The trade ban did not appear to have much direct effect on Australia because, prior to the embargo, it exported only a small proportion of its shrimp to the United States. The embargo could have had some indirect effects because Japan, the main Australian export shrimp market, may have experienced some oversupply since embargoed shrimp from other countries was diverted there. In July 2000, the general United States embargo on Australian shrimp was lifted.

At present, the United States position is that because the Australian Government maintains good governance over specific fisheries and keeps separate shrimp harvested in specific fisheries apart from specific fisheries labelled separately, the United States certifies Australian shrimp on a fishery basis. In early 2006, Australia had five fisheries certified: Torres Strait, Exmouth Gulf, Spencer Gulf, Northern Prawn and Queensland East Coast. Only shrimp from these five fisheries is allowed to enter the United States.

BYCATCH ISSUES

Commonwealth policy defines bycatch as: (i) that part of a fisher's catch that is returned to the sea either because it has no commercial value or because regulations preclude it from being retained; and (ii) that part of the catch that does not reach the deck of the fishing vessel but is affected by interaction with the fishing gear (NORMAC, 2002).

Robins, Campbell and McGilvray (1999) give an overview of bycatch issues in Australian shrimp trawl fisheries. Bycatch issues in northern Australian prawn trawl fisheries focus predominantly on unwanted fish bycatch and the incidental capture and mortality of sea turtles in trawl nets. Bycatch issues in southern Australian prawn trawl fisheries focus predominantly on unwanted fish and crustacean bycatch. There are several reasons why bycatch issues in Australian prawn trawl fisheries have received considerable attention over the past decade:

- Australian fisheries management agencies have a legislative mandate to ensure that trawl fisheries comply with the principles of ecological sustainable development;
- many Australian prawn trawl fisheries also have legislation or policies that require a reduction in the take of non-target species and a minimization of the impact of trawling on the ecosystem;
- the drowning of sea turtles in trawl nets of Northern Australia has been given wide exposure;
- “World Heritage” status has meant increased scrutiny of commercial fishing practices, especially trawling operations, to ensure that the exploitation of fisheries

TABLE 26
Bycatch issues in some Australian shrimp trawl fisheries

Fishery	Bycatch issue	Key initiators
Queensland East Coast*	Sea turtle and fish, since the late 1980s	Conservation-driven but supported by industry
Torres Strait	Sea turtles, unwanted fish bycatch	Conservation-driven
Northern Prawn	Sea turtle, unwanted fish bycatch since the late 1980s	Conservation-driven but supported by industry
Western Australia: Kimberley coast	Jellyfish	Industry-driven
Western Australia: Exmouth Gulf	Fish, seaweed and crabs since 1996	Industry-driven
Western Australia: Shark Bay*	Sea turtles and crabs since 1996	Industry-driven
South Australia: Spencer Gulf and West Coast	Crabs and fish since the mid-1980s	Industry-driven
South Australia: Gulf of St Vincent	Small prawns and fish since 1995	Industry-driven
New South Wales: estuaries	Fish since the 1980s	Government-driven, supported by industry
New South Wales: oceanic	Fish since the late 1980s	Government-driven, supported by industry

Source: Robins, Campbell and McGilvray, 1999.

* Fisheries either entirely or partially within a "World Heritage Area".

resources does not occur at the expense of the quality of the ecosystem – two Australian prawn trawl fisheries occur within "World Heritage Areas"; and

- all export fisheries require accreditation through a strategy (environment) which, among other issues, gives consideration to levels of bycatch from a fishery.

The bycatch issues and associated initiators are different in the various Australian fisheries. Table 26 summarizes the situation in ten Australian shrimp trawl fisheries.

Reducing fishery bycatch in Australia had been addressed primarily through the use of technological gear solutions, such as TEDs and BRDs. Additional ways to reduce the overall bycatch of prawn trawl fisheries have been the reduction in the number of days fished, restrictions on fishing areas or specifications of allowable fishing gears.

Kelleher (2005) comments on discard rates from some Australian shrimp fisheries. Three northern shrimp fisheries (Northern Prawn, Torres Straits and Queensland East Coast Trawl Fisheries) jointly discard approximately 80 000 tonnes. The NSW Ocean Prawn Trawl Fishery has a high discard rate (88.7 percent), generating approximately 16 000 tonnes of discards. Progressive implementation of bycatch action plans for the various fisheries is likely to reduce the discards and discard rates presented above.

Many of the shrimp fisheries in Australia are covered by bycatch management plans. The NPF has a comprehensive bycatch management plan that covers bycatch issues; bycatch caught in trawls; cause of the bycatch problem; extent of the issues; stock status; strategies for managing the issues; and management of bycatch. With respect to the management of bycatch, the plan states: "There are two main elements to managing bycatch. First, industry needs to adopt measures to reduce the amount taken. Second, the management agency must monitor the success of the measures" (NORMAC, 2002). With respect to the success of efforts to reduce prawn trawl bycatch in Australia, the following observations are especially significant.

- In reviewing the history of prawn bycatch reduction efforts in Australia, Robins, Campbell and McGilvray (1999) comment that the greatest advances in the rates whereby fishers adopt TEDs and BRDs have occurred after respected individuals within the fishing industry have developed or modified gear that reduces bycatch. In hindsight, Australia has benefited greatly from overseas experiences in the development and implementation of technology to reduce fishery bycatch.
- Robins *et al.* (2002) give the results of a study of the effectiveness of TEDs in reducing sea turtle bycatch in the NPF. The study showed that prior to the use of TEDs, an estimated 5 000 sea turtles were caught annually by the trawl fleet. Since TEDs have been installed, the catch of sea turtles is estimated to have fallen possibly to fewer than 200 turtles per year. In addition, turtle mortality is estimated to have decreased from close to 40 percent in earlier years to around 22 percent in recent years. In summary, since the introduction of TEDs, few turtles are expected

to die as a result of capture in trawl nets in the NPF. Recent catch data (2004) from the Australian Fisheries Management Authority (AFMA) show the annual catch of turtles as 27, of which 24 were released alive (Perdrau and Garvey, 2005).

- An important lesson learned is that rather than governments researching and driving bycatch reduction technology, a better approach seems to be for regulators to set targets/requirements (and perhaps initial style), and allow industry to innovate them. In the NPF, TEDs were originally seen as a necessary evil but, since they also removed large animals such as bull rays and sharks, they also increased prawn quality and crew safety. Now, they would be a matter of choice rather than of obligation (I. Cartwright, personal communication, January 2006).

PROFITABILITY AND RESOURCE RENT

The Australian Bureau of Agricultural and Resource Economics (ABARE) has been undertaking economic surveys of selected Commonwealth fisheries since the early 1980s and, on a regular basis for particular fisheries, since 1992. ABARE surveyed four individual Commonwealth fisheries in 2003, including NPF and the Torres Strait Prawn Fishery. Galeano *et al.* (2004) describe the methodology and give the results of the 2003 work. Between February and June, an ABARE officer visited the owners of each shrimp boat selected in the sample to interview them in order to obtain physical and financial details of the fishing business for the survey years. Further information was subsequently obtained from accountants, selling agents and marketing organizations.

The results of the studies (Tables 27, 28 and 29) provide insight into the economic performance from the perspective of fishing vessel operators as well as that of the overall fishery. The latter is especially useful in gauging how well AFMA is performing against their legislated objectives of maximizing economic efficiency and providing efficient and cost-effective management. According to a former senior Australian fisheries manager (R. Kearney, personal communication, January 2006), rent in fisheries is not calculated for taxation purposes, which is against current government policy.

Galeano *et al.* (2004) summarize the performance of the two fisheries.

Northern Prawn Fishery

- The real (2002–03 \$A) gross value of NPF production reached a record \$A175 million in 2000–01 before falling to \$A140 million in 2001–02 and to under \$A83 million in 2002–03.
- Average prawn receipts per boat fell by 21 percent in 2001–02 to \$A1.17 million; this partly reflected lower catches.

TABLE 27

Financial performance of the Northern Prawn Fishery

	Revenue	Operating costs	Capital	Net returns (excl. management costs)	Management costs	Net returns (incl. management costs)	Number of vessels
\$A million*							
1990–1991	149.4	110.7	98.1	22.3	n.a.	22.3	169
1991–1992	115.8	94.5	80.3	10.0	n.a.	10.0	160
1992–1993	128.6	99.1	68.5	21.3	n.a.	21.3	129
1993–1994	140.8	108.0	59.7	21.9	n.a.	21.9	132
1994–1995	173.8	116.6	77.8	44.0	n.a.	44.0	133
1995–1996	147.7	111.1	92.3	21.1	1.6	19.5	134
1996–1997	139.1	101.3	80.6	24.1	1.9	22.2	128
1997–1998	167.4	109.5	77.1	43.8	1.7	42.1	130
1998–1999	153.0	105.0	73.2	35.6	1.4	34.2	133
1999–2000	121.9	89.2	58.3	22.1	1.1	21.0	130
2000–2001	185.7	114.3	52.7	62.4	1	61.4	118
2001–2002	139.3	97.1	45.4	34.0	1.1	33.0	118

* At 2002/03 value.

TABLE 28
Financial performance of the Torres Strait Prawn Fishery

	Revenue	Cash costs	Capital	Net returns (excl. management costs)	Management costs	Net returns (incl. management costs)	Number of vessels
\$A million*							
1992–93	17.6	14.9	11.4	1.4	n.a.	n.a.	61
1993–94	17.6	14.8	10.1	0.8	n.a.	n.a.	64
1994–95	19.1	16.0	11.2	1.1	n.a.	n.a.	60
1995–96	18.2	15.9	9.5	0.6	n.a.	n.a.	60
1996–97	19.9	16.9	8.6	1.5	n.a.	n.a.	80
1997–98	22.3	17.6	7.0	3.3	0.2	3.1	83
1998–99	26.9	21.5	12.0	3.3	0.2	3.1	82
1999–00	26.8	20.8	10.6	4.0	0.2	3.8	79
2000–01	28.6	21.4	11.9	5.1	0.3	4.8	78
2001–02	24.7	19.7	10.0	3.1	0.3	2.8	75

* At 2002/03 value.

- The fall in average prawn receipts per boat was slightly greater for small boats and, while there were some cost reductions across the fleet, profit at full equity for all boats fell on average by 35 percent to \$A305 000 per boat.
- On large boats, cost reductions were not as large and profit at full equity fell by 44 percent to an average of \$A337 000 per boat in 2001–02.

Estimated real net returns (including management costs) to the NPF resource fluctuated substantially since 1990–91, averaging around \$A29.4 million annually (in 2002–03 \$A). Net returns (assuming constant stocks) were estimated at \$A61.4 million in 2000–01 and \$A33.0 million in 2001–02.

Torres Strait Prawn Fishery

- Despite a relatively stable harvest of prawns between 2000–01 and 2001–02, average prawn receipts per boat for the fleet as a whole are estimated to have fallen by 15 percent in the second season to \$A671 000.
- Fuel and crew costs were the main contributors to an estimated 9 percent fall in costs across the fleet between 2000–01 and 2001–02. Boat cash income across the fleet fell by an estimated 45 percent between 2000–01 and 2001–02 while, according to specialists, it fell by an estimated 17 percent.
- Net returns to the fishery (including management costs and assuming constant stocks), are estimated to have fallen in real terms from \$A4.8 million in 2000–01 to \$A2.8 million in 2001–02.
- These net returns are much lower than the estimated average long-term net returns to the NPF (\$A38.3 million), yet higher than the average for the Southeast Trawl Fishery (\$A2 million) over the same period.

ENERGY INPUT ASPECTS

Fuel is a major cost component of shrimp fishing. In the 2001/02 season, fuel accounted for 23.5 percent of all costs in the Torres Strait Fishery and 20.6 percent in the NPF (Table 29). Fuel costs have increased considerably since that period and, in 2006, constituted a much larger portion of total costs. According to the summary of the December 2005 meeting of the Northern Prawn Fishery Management Advisory Committee (NORMAC), “Fuel is a huge expense and the cost base of producing a kilo of prawns is on an upward spiral against the prices flat-lining or declining” (AFMA, 2005a).

- Many opinions have been expressed on how to cope with rising fuel costs. For some time it was thought that one of the incentives for reducing bycatch is that fuel costs would be less (reduced net drag) (Robins, Campbell and McGilvray, 1999). A Fuel Sales Grants Scheme (FSGS) has provided relief to fuel users in regional and remote Australia in the recent past, cutting the price of fuel, including

TABLE 29
Estimated financial performance of an average vessel*

	Torres Strait Fishery		Northern Prawn Fishery	
	2000/01	2001/02	2000/01	2001/02
Prawn receipts	788 649	671 429	1 486 473	1 167 646
Other fishing receipts	134 419	68 343	23 644	25 363
Non-fishing receipts	28 225	20 276	26 689	28 638
Total cash receipts	951 293	760 048	1 536 807	1 221 647
Administration	13 005	11 148	18 435	15 621
Crew costs	285 095	225 279	377 240	303 194
Freight and marketing expenses	21 490	14 717	35 344	27 992
Fuel	158 212	140 891	201 300	184 868
Insurance	15 492	18 877	37 380	38 043
Interest paid	9 919	16 782	15 070	14 495
Leasing			23 129	17 548
Licence fees and levies	13 578	15 911	23 887	29 651
Packaging	10 644	11 456	13 903	15 920
Repair and maintenance	102 615	111 948	188 922	192 673
Other costs	21 407	28 556	56 059	50 009
Total costs	651 458	595 564	990 671	890 014
Boat cash income	299 835	164 484	546 136	331 633
less depreciation	29 549	27 830	42 614	42 403
Boat business profit	270 286	136 655	503 521	289 230
plus interest leasing and rent	10 703	23 465	38 906	32 468
Profit at full equity	280 989	160 120	542 428	321 698
Capital				
– excluding quota and licences	530 026	584 584	1 129 929	1 101 816
– including quota and licences	n.a.	2 242 396	n.a.	4 547 864
Rate of return to boat capital	53%	27.4%	48%	29.2%
Rate of return to full equity	n.a.	7.1%	n.a.	7.1%

Source: Galeano *et al.*, 2004.

*All vessels in the fisheries.

Note: units, unless otherwise specified, are in \$A.

diesel, used on fishing vessels by up to 2 cents/litre, thus reducing the fuel bill in the NPF alone by around \$A1 million a year. This scheme, however, was abolished in January 2006 (Australian Seafood Industry Council [ASIC] Web site information). ASIC has formulated a three-point proposal to address fuel costs and help mitigate the loss of the FSGS:

- extend relief from the 2 cents/litre ultralow sulphur diesel levy to the seafood industry;
- cut another 4 cents/litre by applying goods and service tax to the net cost of fuel after diesel fuel rebate, not to the gross cost; and
- ensure that oil companies pass on the full benefit of the 35 percent revaluation of the Australian dollar.

Currently, twin gear (two nets) is used in the NPF. This gear is considerably less fuel-efficient than the quad rig (two nets per warp), which was used until it was banned as part of new management arrangements. With spiralling fuel prices, it is becoming increasingly attractive to seek ways of reducing fuel use, including revisiting the quad-rig ban, and the development and use of more fuel-efficient trawl boards and netting material (I. Cartwright, personal communication, January 2006).

BIOLOGICAL ASPECTS

The status of most significant fisheries in Australia is assessed and reported on annually by the management agency to state and national governments through formal “state of

the fisheries” reports (Morgan, 2004a). As such, most of the important shrimp fisheries have been assessed in terms of their biology, and many have undergone economic and environmental evaluations. From a biological perspective, because most of the country’s shrimp fisheries are fully or overexploited, there is not much potential for the expansion of shrimp catches.

Although a full account of the biological aspects of all of Australia’s shrimp fisheries is beyond the scope of this brief review, summary biological information from one large shrimp fishery (NPF) and one small one (Exmouth Gulf) are given below.

The biological status of the target species in the NPF, as given by several authors, is summarized by Galeano *et al.* (2004).

- *Banana prawns.* Banana prawn catches in the NPF are made up of white banana prawns and red-legged banana prawns. The sustainable long-term average annual catch for both species of banana prawns is estimated at around 4 000 tonnes, approximately the average annual catch over the past ten years. The catch of banana prawns from the NPF is considered likely to be sustainable, but the reliability of the assessment is moderate. The annual productivity of banana prawns has been linked to rainfall levels. Expected catches based on these levels are compared with observed catches to give an assessment of the banana prawn fishery. Preliminary results from an age-structure model indicate that, at least in certain areas, there may be a relationship between stock size and subsequent recruitment for white banana prawns.
- *Tiger prawns.* In 2001, an independent expert was contracted to review the 1999 tiger prawn assessment. It was concluded that brown tiger prawn stocks were at 42 to 54 percent and grooved tiger prawn stocks at 66 to 86 percent of target levels in 2001; tiger prawn stocks were overfished; and levels of effort were too high to promote recovery. The model used to assess the status of tiger prawns has been updated in recent years but still shows brown tiger prawns as overfished. However, effort levels in 2002 are thought to have been below the level needed to achieve the stock associated with maximum sustainable yield (MSY) and projections suggest that rebuilding of the target spawning stock size will occur within a couple of years if 2002 effort levels are maintained. The stock is considered fully exploited and is projected to remain at this level, based on the assumption that the 2002 levels are maintained and not increased.

The Australian Department of Fisheries (2002) summarizes the biological information on the Exmouth Gulf Prawn Fishery in Western Australia.

- The breeding stock level for tiger prawn stock in the Exmouth Gulf is currently above the agreed reference point.
- The historical catch and effort trends over the past 40 years indicate that there has been no decline in the production levels for king prawn in the Exmouth Gulf, which is consistent with there being sufficient ongoing levels of spawning biomass for this species.
- Historical catch trends indicate that production levels for endeavour and banana prawns remain within natural environmental levels, which is consistent with the recruitment potential of these species that have not been affected by the fishery.
- The level of capture of other by-product species by this fishery is too small to have a significant impact on their dynamics.
- The two main target species for the Exmouth Gulf, the tiger and king prawns, are both classified as fully exploited.

IMPACTS ON THE PHYSICAL ENVIRONMENT

The subject of the impact of shrimp trawling on the physical environment is addressed in many of the reviews on particular Australian fisheries. Several of the reviews indicate that shrimp trawling is definitely having an impact, but that the effects are mitigated to some extent by the fact that the actual trawling only covers a portion of the fishery

area and the intensity of trawling is decreasing as management measures reduce fishing capacity. Some specific observations are given below.

- *Gulf St Vincent*. Like all trawling methods used in the fishing industry, the demersal otter trawl technique used in Gulf St Vincent may cause some damage to the benthos. This results from the very nature of the operation, which requires contact with the seabed in order to catch bottom-feeding crustaceans. There are, however, some mitigating factors that tend to minimize adverse effects on the ecology of the regions fished. Prawn trawling can only take place where the water is relatively deep (more than 10 m in depth) and seagrass beds are avoided. The sand and mud bottom is generally smooth and free of snags. Furthermore, as a result of long-term management strategies that have reduced fishing times, disturbance to the benthos has been reduced by progressive reductions in the actual number of annual fishing hours (Zacharin, 1997).
- *NPF*. The disturbance and mortality of benthic communities as a result of interaction between the otter boards and the groundchain of trawl nets are issues here. These impacts are mitigated by the fact that a relatively small proportion of the area is trawled (around 14 percent) and that areas containing sensitive seagrass communities have been closed to trawling since 1983 (Cartwright, 2003).
- *Spencer Gulf*. Trawling does not cover all the area available to the fishery. Research has demonstrated that less than 15 percent of this area is trawled, with over 60 percent of the catch taken in two areas that cover less than 8 percent of the Gulf (Palmer and Miller, 2005).
- *Exmouth Gulf*. The potential impact on the mud and sand habitat on Exmouth Gulf as a result of prawn trawling operations was considered unlikely to have even a minor consequence (which provides a low risk), because of the following:
 - only around 35 percent of the area permitted to be trawled is actually trawled (through targeting of known favourable grounds);
 - twenty-eight percent of the area is permanently closed to trawling;
 - studies of actual impacts from prawn trawling suggest only minimal impacts on infaunal communities; and
 - the mud substrate in Exmouth Gulf is generally comprised of coarser and heavier sediments and is therefore thought to be more resistant to disturbance by trawling activities. Moreover, such exposed seabeds are naturally dynamic as a result of environmental influences (Department of Fisheries, 2002).
- *New South Wales Estuary*. Although there is some uncertainty associated with the assessment of trawling on biodiversity and habitat of estuaries, the damage from trawl gear to benthic habitats has been well documented. An environmental impact statement concluded that the precautionary measures adopted ensure a relatively high confidence that most habitats, especially seagrass beds, will be sufficiently conserved. The fishery has been impacting its areas for 60 years and species found within the trawled areas have probably adapted to frequent disturbance from trawling activity (Department of the Environment and Heritage, 2004a).

CSIRO and the Queensland Department of Primary Industries and Fisheries (QDPI) carried out five years of research on the environmental effects of trawling on the far northern Great Barrier Reef Marine Park (GBRMP) (CSIRO, 1998). The study covered 10 000 km² in an area closed to trawling since 1985, known as the “Green Zone”. The project surveyed the physical and biological makeup of the study area; conducted experiments to simulate the physical impact of trawling on seabed animals and plants; compared the biology of areas open to trawling with those closed to trawling; and investigated prawn trawl bycatch. Because this work represents the world’s largest and most comprehensive study of the environmental effects of trawling, and the first study on the effects of prawn trawling in the tropics, the results deserve special mention.

- *Biology.* The lagoon and inter-reef areas of the GBRMP had been thought to be flat, muddy and relatively barren of life, but the study recorded more than 1 000 seabed species revealing a high biodiversity. It showed that while there are extensive bare, muddy or sandy areas, there are also seagrass and algal meadows, diverse sponge and coral garden patches, and deeper coral reefs.
- *Comparisons of areas closed to trawling (Green Zone) versus areas open to trawling.* Few differences were found between the areas that were clearly a result of trawling, for which there are several explanations. The effects of earlier trawling and/or current illegal trawling may have masked any differences between open and closed areas. In addition, the open areas next to the untrawled areas were not trawled heavily and some parts were not trawled at all, making these open areas similar to the closed areas. Furthermore, the two open areas studied were found to be either as different from each other as they were from the Green Zone, or more different from each other than from the Green Zone, making it difficult to detect differences resulting from trawling.
- *Physical impact.* Commercial trawling typically targets aggregations of prawns by repeatedly trawling patches of productive seabed before moving to another aggregation. In a series of experiments to simulate commercial trawling activities, the study showed that the pass of a single trawl has less impact than previously thought, i.e. that a trawl would remove nearly everything from the seabed, but research showed that each pass of a trawl along the seabed removes about 5 to 25 percent of seabed life. However, there is a cumulative effect: seven trawls over the same area of seabed removed about half of the seabed life, while a total of 13 trawls removed 70 to 90 percent.
- *Vulnerability.* Research shows that different seabed species exhibit different levels of impact. For example, large sponges and flowerpot corals are particularly susceptible to trawling, whereas seaweeds and gorgonians are more resistant.
- *Recovery.* Recovery rates of damaged seabed life are poorly known but are thought to range from one to 20 years, depending on the species. It is estimated that over the last 20 years, trawling in the GBRMP has depleted the most vulnerable fauna (those easily removed and slow to recover) in trawled areas by more than half, with the result that less vulnerable species (those difficult to remove and/or quick to recover) dominate the seabed community.

The study concluded that there is potential for environmentally sustainable management of prawn trawling in the GBRMP, although there are important information gaps that need to be filled.

IMPACTS ON SMALL-SCALE FISHERIES

In Australia, the interaction between large-scale and small-scale shrimp fisheries does not appear to be a major issue. Unlike many other tropical countries, subsistence fishing is not extremely important in Australia. Recreational fisheries are, however, significant. A survey undertaken in 2000/01 showed that in the states of New South Wales, Victoria, Queensland, Tasmania and South Australia, approximately 2.7 million people undertook marine recreational activities during the study period (Morgan, 2004a).

The precise degree to which large-scale shrimp fishing affects recreational fishing is not known; however, the study on the effects of trawling in the GBRMP (previous section) produced some results relevant to the issue. This study had a component on the effects of shrimp trawling on other fisheries (Poiner *et al.*, 1997), which concluded the following.

- A comparison of the catch from 122 paired fish and prawn trawls showed that, although there were recreational or commercially important fish in intershoal areas, extremely few were caught by the prawn trawl.

- With the single exception of the painted sweetlips (*Diagramma pictum*), the prawn trawl did not catch significant numbers of juveniles of any recreationally or commercially important fish species.

There have been environmental assessments on many of the Australian shrimp fisheries, which usually contain information on interactions with small-scale fisheries.

Examples are the following.

- For the NPF area, it has been concluded that the take of prawns by the indigenous and recreational sectors is insignificant; however, some species caught as by-product and/or bycatch in this fishery are targeted by these users and by other commercial fisheries (Department of the Environment and Heritage, 2003).
- The harvest of western king prawn by recreational fishers in South Australia is minimal and there is no known harvest by the indigenous sector (Department of the Environment and Heritage, 2003).
- In Western Australia's Shark Bay, there is no significant take of prawns by the indigenous and recreational sectors; however, some species caught as by-product and/or bycatch in this fishery are targeted by these users and by other commercial fisheries (Environment Australia, 2002).
- In the NSW Estuary Prawn Trawl Fishery, there is both commercial and non-commercial Aboriginal fishing activity, which is affected to some degree by non-Aboriginal fishing and by fishery management restrictions.

MANAGEMENT REGIMES AND LEGISLATION

In general, the management of fisheries in Australia, including that for shrimp, is highly developed and is characterized by a collaborative approach between the Australian Government and industry. All major fisheries are limited entry in nature, although entry entitlements are generally freely tradable. In recent years, two significant trends have emerged: first, the move to a "user pays" system, where participants in each fishery are increasingly responsible for funding management, research and compliance costs that support the fishery; and second, the broadening of management objectives away from a "single-species" approach to include more general ecosystem management issues. This second trend has been driven by Australia's more general commitment to the principals of ecological sustainable development (Morgan, 2004a). There has been a move towards comanagement approaches, as already practised in Spencer Gulf, incorporating management advisory committees and other industry/government/research collaborative mechanisms.

Fisheries resources within the AFZ are managed under either Commonwealth or state/territory legislation. The demarcation of jurisdiction and responsibilities among these various governments has been agreed to under the Offshore Constitutional Settlement, which was needed to clarify the complex fisheries management arrangements after the establishment of the AFZ in 1979. Under this settlement, the states and territories have jurisdiction over localized, inshore fisheries; the Commonwealth has jurisdiction over offshore fisheries or fisheries extending to waters adjacent to more than one state or territory. Each government has separate fisheries legislation and differing objectives (FAO, 2003a).

The most important fisheries legislations at the national level are the Fisheries Administration Act (1991) and the Fisheries Management Act (1991), while the fisheries objectives of Torres Strait are contained in the Torres Strait Fisheries Act (1984). At the national (Commonwealth) level, fisheries legislation is reviewed on an annual basis and necessary amendments made. At the state level, legislation is reviewed on a regular basis, according to need, and major legislative reviews are undertaken every five to ten years (Morgan, 2004a).

The management of shrimp fisheries is generally good in Australia, but there is some variability. One shrimp specialist (D. Leadbitter, personal communication, October

2005) commented on the quality of management of shrimp fisheries in the country:

Some of the prawn trawl fisheries are very sophisticated in terms of management. Spencer Gulf and Exmouth Gulf are two examples. Some are good (e.g. Northern Prawn), some are in transition (Queensland East Coast Trawl) and some limp along (NSW Offshore Prawn Trawl).

Although a full account of the management of all Australia's shrimp fisheries is far beyond the scope of this review, summary management information from one large shrimp fishery (NPF, managed by the Commonwealth) and one small one (Spencer Gulf, managed by the South Australia State Government) can provide some insight into the management processes.

MANAGEMENT OF THE NORTHERN PRAWN FISHERY

The fishery is managed under the Northern Prawn Fishery Management Plan (1995) (as amended), which obtains its authority from the Fisheries Management Act (1991) and the Fisheries Administration Act (1991). The Management Plan sets out the range of management measures, objectives and performance criteria for the fishery. Under the plan, AFMA is required to develop, and industry to implement, a Bycatch Action Plan for the fishery. The Northern Prawn Fishery Bycatch Action Plan (2003) contains clear objectives, strategies and actions to address ongoing bycatch issues. A new Bycatch Action Plan for the fishery is currently being developed. In addition, NORMAC produces Five Year Strategic Plans for consideration by the AFMA Board. The Northern Prawn Fishery Strategic Plan (2001–06) contains detailed objectives and strategies that AFMA and NORMAC intend to pursue over the period of the plan. Strategies and performance measures are reported in NORMAC's annual report to AFMA, fishers and other stakeholders. NORMAC also produces a Five Year Research Plan (Department of the Environment and Heritage, 2003; W. Whitelaw, personal communication, January 2006).

Cartwright (2003) reviews the evolution of management arrangements for the NPF. The fishery was established in the 1960s and developed rapidly throughout the 1970s. By 1977, when limited entry regulations were introduced, concerns with overcapitalization and stock declines had begun to be expressed. In 1985, measures were taken to address the capacity issue through "unitizing" the fleet, by issuing all NPF licence holders with two forms of tradable rights and implementing boat replacement policies aimed at limiting and reducing capacity. The two forms of unit were: Class-A units (vessel capacity) related to vessel characteristics, and Class-B units (a licence to fish), which gave each holder the right to fish in the NPF.

As operators rearranged inputs and utilized new technology, effective effort continued to increase. In order to combat this situation, a range of effort-reduction strategies was implemented in the 1980s and 1990s, including two major buy-back programmes. These schemes cost US\$28 million, of which industry paid more than 80 percent. They were eventually effective in removing capacity, reducing the number of NPF vessels by 55 percent and capacity in terms of A-Class units by 70 percent, by 1993. In 1995, the two classes of NPF fishing rights became statutory fishing rights (SFRs), providing operators with strong, long-term access rights to the fishery. These rights, combined with industry "investment" in the fishery through funding for the buy-backs, have tended to encourage operators' strong interest in the longevity and sustainability of the fishery. In 2000, vessel-based (Class-A) units in the NPF were replaced with gear SFRs based on net (headrope) length, combined with a 15 percent cut in capacity. Gear SFRs were considered to provide the basis for a more flexible gear-based management regime.

Despite almost continuous management interventions and effort adjustments during the life of the fishery, overcapacity has remained a problem. The annual NPF stock assessment in 2001 reaffirmed that tiger prawn stocks were overfished; consequently,

industry reacted strongly by agreeing to a major (40 percent) reduction in capacity, implemented during the 2002 season. The reduction was achieved through removing gear SFRs (25 percent) and reducing season length in an effort to restore tiger prawn biomass to target levels. A further cut of 25 percent of gear units in the fishery was agreed in November 2005 for the start of the 2006/07 season.

The programme of capacity reduction in the NPF has not been easy and has at times required difficult negotiations between differing sectoral interests. These interests have usually been divided between larger corporate fleet owners and generally smaller, more “lifestyle”-oriented operators.

In the future, there are likely to be major changes in management of the NPF. In the past, management using input controls resulted in decades of “effort creep” and excess capacity, and contributed to the present low profitability of the fishery. Recent studies have suggested that output controls would be more effective (Kompas and Gooday, 2006).

Galeano *et al.* (2004) indicate that, from 1995 to 2002, annual management costs attributed to the NPF ranged from \$A1 million to \$A1.9 million (Table 27).

MANAGEMENT OF THE SPENCER GULF FISHERY

Palmer and Miller (2005) review the management of the South Australia Spencer Gulf Prawn Fishery. In October 1967, commercial shrimp fishing began in the Gulf and, in March 1968, the Director of Fisheries introduced restricted entry in an attempt to prevent overexploitation of the resource and overcapitalization within the fishery. Today, the fishery has a limited entry of 39 licence holders, while the adjacent West Coast Fishery has three licence holders.

The fishery is managed jointly by the Australian Government and industry through the Prawn Fisheries Management Committee, headed by an independent chair. This comprises representatives from primary industries (fisheries), a senior prawn biologist from the South Australian Research and Development Institute, ten fishers elected to the committee by other fishers, a processor’s representative (who provides information related to prawn sizes and marketing), and the South Australian Recreational Fishing Advisory Council.

Current gear restrictions on licence holders include:

- vessel size limited to 22-m overall length;
- engines restricted to 365 HP;
- mesh size – codend (4.5 cm); wings and body (5 cm);
- gear configuration and net size limited to a double rig (two nets) with a maximum headline length of 14.63 m per net.

Other controls are also used in managing the Spencer Gulf Prawn Fishery:

- permanent closures to protect small prawns that occur in particular areas of the Gulf;
- temporary area closures to allow prawn growth and/or spawning;
- temporary full closure of the fishery to reduce overall effort and allow spawning (e.g. in January and February); and
- rotation of grounds.

The above controls result in an average of 55 to 60 nights per year, and trawling taking place on only 15 percent of the entire Gulf. Each fishing trip varies in length from ten to 16 days. Usually, only six trips occur each year, with one for each vessel in November, December, March, April, May and June.

An innovative management arrangement that has been used effectively is the Committee at Sea made up of fishers elected to the Prawn Fisheries Management Committee. During harvesting periods, the Committee at Sea monitors all areas open to fishing. With up-to-date communication systems, the committee can very quickly relay information in order to close areas that were initially open, so as to protect small

prawns that may have moved into them. These changes are then immediately broadcast to the fleet and accepted as a rule. By focusing on landing large prawns of very high quality, the fishery is able to differentiate its product in the market from aquaculture products, and is thus more insulated (but not isolated), from the price pressures being experienced in the NPF.

The fishers themselves take an active role in research by participating in stock assessments using their vessels and crew, capturing tagged prawns and recording information, providing high-resolution catch and effort data in logbooks, and measuring samples of prawns from the catch. Industry pays 100 percent of the attributable management and research costs by way of annual licence fees. An annual research levy per licence holder, based on the production value of the fishery, is also included in the levy.

ENFORCEMENT

Surveillance and enforcement arrangements differ between the shrimp fisheries managed by the Commonwealth and those managed by the states.

AFMA develops a compliance plan for each major Commonwealth fishery, including the Northern Prawn and Torres Strait Prawn Fisheries. Compliance plans contain strategies to manage the potential risks for non-compliance and details of compliance activity, performance measures and proposed budgets.

The Northern Prawn Fishery Compliance Plan identifies the risks to compliance and presents a programme detailing the compliance tasks, agency responsibilities and related performance indicators. Compliance and enforcement tools implemented in the fishery include the mandatory installation and use of a vessel monitoring system (VMS) and random at-sea and port inspections. AFMA also provides educational material and holds port meetings to ensure that operators are aware of the rules and regulations that apply in the fishery. The NPF Compliance Plan requires that a minimum of 65 percent of vessels in the fleet be subject to regular and random at-sea inspections, combined with a programme of aerial surveillance. At-sea inspections check net lengths, ensure compliance with TED and BRD regulations, check logbook and transshipment records, and inspect catch to ensure compliance with size and catch limits. In-port measuring of all nets is conducted, and involves the measuring and tagging of nets, making at-sea inspection easier (Department of the Environment and Heritage, 2003).

The VMS requirement was introduced into the NPF in 1998. The system has reduced compliance costs and allowed for more efficient means of opening the fishing season, enforcing closed areas and targeting compliance activity. It has also improved the flow of information to the fleet from AFMA, and provided details to researchers and managers concerning the fine-scale distribution of effort in the fishery. While initially resisted by some operators, VMS is now well accepted, with company vessel managers using it to monitor the activity of their fleet (Cartwright, 2003).

As an example of enforcement in a state-managed fishery, Western Australia's Exmouth Gulf Prawn Fishery has sea patrols and radar watches on a random basis during the season. Aerial compliance checks are also conducted. Compliance operations are mainly focused on maintaining the integrity of the nursery areas within the fishery. Enforcement staff also conduct licence and gear inspections both at sea and in port. Given the value of the licences, fishers themselves are also a source of information on illegal activities. VMS requirements were introduced in 2002, and random patrol activities are decreasing overtime, while targeted patrols investigating specific incidences will become the major focus of patrol activities (Department of Fisheries, 2002).

In general, expenditure on surveillance and enforcement of management rules is considered a management cost in Australia. Current government policies for Commonwealth-managed fisheries provide that the fishing industry pays for costs

directly attributed to fishing activity on a full cost-recovery basis, with the Australian Government paying for or contributing to activities that may benefit the broader community as well as industry. Recoverable management costs include the running costs of management committees, AFMA's day-to-day fisheries management activities, costs of developing and maintaining management plans, and logbooks and surveillance, but do not include enforcement costs (Cartwright, 2003).

RESEARCH

At the Commonwealth and state levels, fisheries research priorities are identified both as part of fisheries-specific management plans and as more strategic, long-term priorities. Research is carried out by a variety of Commonwealth and state research agencies. These include fisheries research laboratories that are part of each state's fisheries management agency, CSIRO and various universities in Australia. Generally, research is carried out by the agencies that also have legislative responsibility for a specific fishery so that, for example, research on state-controlled fisheries is carried out by that state. The Fisheries Research and Development Corporation (FRDC), created in 1991, is Australia's main funding agency for fisheries and aquaculture research. FRDC aims to improve the production, processing, storage, transport and marketing of fish and fish products, and to achieve sustainable use and management of fisheries resources. The Australian Government contributes 0.5 percent of the gross value of fisheries production to FRDC, with fishers also contributing, which attracts further government support in the form of matching funding. State governments also contribute directly to the funding of research undertaken by their own agencies, which in many cases, is the most significant part of total research funding (FAO, 2003a).

In Australia, much of the research related to shrimp fishing is focused on stock assessment of target species; impacts on non-target species; effects of trawling on the seabed; improvement of economic efficiency; optimum harvesting strategies; and gear technology, especially for reducing bycatch. Recently, there has been a considerable shift towards researching the bioeconomic aspects of shrimp fisheries, in response to cost/price pressures. The research requirements and resources available for research are obviously greater for the larger shrimp fisheries. The NPF receives substantial research effort, while most of the smaller state-managed fisheries enjoy less attention.

According to the Northern Prawn Fishery Five Year Research Plan (2001–06) (AFMA, 2001b), the high and medium research priorities are:

- assessment of the fishery status, including management strategies for the fishery (target and by-product species);
- effects of fishing – improved efficiency in fishing gear and techniques to reduce bycatch and discarding, increased survivorship of bycatch and environmental impacts on the benthos;
- improved knowledge of environmental factors of importance to the fishery;
- improved efficiencies in the economics of fishing; and
- utilization of bycatch species.

With respect to research in a state-managed shrimp fishery, the main objective of recent prawn research in the Spencer Gulf of South Australia has been to obtain information that can be used to determine optimum harvesting strategies. This requires an understanding of the mechanics of the fishery, including the grounds and the movement of prawns over the grounds; size composition of prawns over the grounds; growth; juvenile movement and behaviour; recruitment patterns over the regions; natural mortality; fishing mortality; catchability; and the effects of lower water temperature and the full moon phase. Fishers themselves take an active role in research by: (i) undertaking stock assessments using their vessels and crew; (ii) capturing tagged prawns and recording information; (iii) providing high-resolution catch and effort data in logbooks; and (iv) measuring samples of prawns from the catch (Palmer and Miller, 2005).

DATA REPORTING

In the NPF, catch and effort data reporting plays a vital role in underpinning research and management decisions. Although costly, face-to-face contact with fishers has been pivotal to good logbook data, especially through the work of logbook officers in the 1980s and early 1990s. Data are at present collected in two main areas: from vessels via logbooks, and landing returns from owners and processors. Logbooks have undergone an adaptive process, reflecting the development of this fishery towards tiger prawns in the 1970s; since 1977 their completion became compulsory. The evolution of logbook design has involved continuous industry involvement and input since the accuracy of the data is a function of industry satisfaction and commitment to the process (Cartwright, 2003). Twenty-one operators used electronic logbook reporting in 2004 (Perdrau and Garvey, 2005).

Fishers in the NSW Estuary Prawn Trawl Fishery are required to submit records on a monthly basis, detailing their landings and fishing effort. The information includes landings for each species, the effort expended (for each method) to take the catch, and the area/s fished. This information is entered in a database by NSW fisheries and allows for analysis of fishing activity, reported landings and effort levels. The accuracy of the data provided on catch returns is variable, particularly with respect to fishing effort data. There are a number of management responses to improve the quality and reliability of the information provided on catch returns, including a review of the current monthly catch return and validation of landings and effort data under the scientific monitoring programme (NSW Fisheries, 2003).

In the Shark Bay Prawn Fishery of Western Australia, data are obtained through compulsory monthly logbooks, which all operators voluntarily complete on a daily basis. Commercial logbooks are validated against processor records and against VMS data. The logbooks contain information on daily and shot-by-shot target and byproduct catch, hours trawled and areas of operation. Data on protected species interactions have been collected through the observer surveys operating in the fishery since 1998 (Environment Australia, 2002).

In general, because of the involvement of fishers in the management process and the nature of the right to fish in a limited entry fishery, information supplied by shrimp fishers in Australia is considered to be of reasonably good quality, especially for the target species.

IMPACTS OF SHRIMP FARMING ON SHRIMP FISHING

Shrimp production from Australian commercial capture fisheries is roughly 25 000 tonnes per year; aquaculture production, roughly 3 500 tonnes; shrimp exports, roughly 9 000 tonnes; and shrimp imports, roughly 25 000 tonnes (ABARE, 2005). Aquaculture production constitutes therefore about 8 percent of the Australian shrimp market, much of which is exported. As a result of its small market share, it seems that domestic aquaculture production does not have a major effect on Australian domestic shrimp prices, nor much impact on domestic shrimp fishing.

A large portion of shrimp imports into Australia are from aquaculture. Because of its low price, this imported farmed shrimp is having a downward effect on prices for Australian captured shrimp. The prices for imported farmed shrimp, especially *P. vannamei* from China, are a fraction of those for shrimp from Australian fishing operations. Although species/sizes are very different in domestic fishing and overseas aquaculture, there is some flow-on effect to all segments of the Australian shrimp market. According to the Australian Prawn Farmers Association:

Over the past 18 months the industry has been devastated by a flood of cheap imported Penaeus vannamei prawns from China and Asia. Chinese P. vannamei prawns land in Australia for between \$A5.50 and \$A6.50, and retail for between \$A9.00 and \$A14.00 (www.apfa.com.au).

MAJOR ISSUES RELATED TO SHRIMP FISHING

The major issues related to shrimp farming in Australia are:

- the low current profitability of many of the shrimp fisheries;
- increased attention to bycatch reduction;
- overcapacity resulting from effort creep, even in shrimp fisheries with relatively good management; and
- increased scrutiny of the physical effects of trawling, especially within “World Heritage Areas”.

Shrimp fishing in Cambodia

AN OVERVIEW

Although marine fisheries in Cambodia are of minor importance compared with freshwater fisheries, shrimp fishing is significant along Cambodia's short coast. Annually, trawling and, to a lesser extent, other gears take from 3 000 to 4 000 tonnes of shrimp. Shrimp is important for domestic consumption and is the most valuable fishery export of the country.

The management of shrimp fisheries in Cambodia faces major challenges. The obstacles to deriving greater benefits from shrimp fisheries by management interventions are considerable, with regard to the paucity of biological information on shrimp resources; the few legal instruments available for managing shrimp fishing; the poor enforcement of those that do exist; and the open access nature of coastal fisheries in the country.



DEVELOPMENT AND STRUCTURE

The coast of Cambodia is 435 km in length, located along the Gulf of Thailand from the Thai border in the northwest to the Vietnamese border in the southeast. The coastal area includes several large bays and extends across the provinces of Koh Kong and Kampot, and the municipalities of Sihanoukville and Kep. The offshore marine area has numerous islands. The exclusive economic zone (EEZ) covers approximately 55 600 km² and is relatively shallow, with an average depth of about 50 m.

The most important marine shrimp fishing gears in Cambodia are trawls, gillnets, push nets and stow nets. Table 30 gives information on these four gear types.

Trawling in Cambodia was first attempted in the mid-1920s when the Oceanographic Institute of Indochina started a trawling survey of French Indochina in 1925. It was concluded that catches were too small to permit the use of a European trawler. Developments in Thailand (which shares the Gulf of Thailand with several countries,

TABLE 30
Fishing gear in Cambodia that catches shrimp

Gear	Target species or group	Bycatch
Shrimp trawls	Penaeid shrimp (<i>Penaeus semisulcatus</i> , <i>P. canaliculatus</i> , <i>P. latisulcatus</i> , <i>P. merguensis</i>)	Black tiger shrimp (<i>Penaeus monodon</i>); <i>P. silasi</i> , Swimming crabs (Portunidae), Trash fish
Shrimp gillnets	<i>Penaeus merguensis</i>	Trash fish; squid (Loliginidae); <i>Penaeus merguensis</i>
Push nets	Mixed fish species; peregrine shrimp (<i>Metapenaeus</i> sp.); sepiolid squid (Sepiolidae sp.); octopus (<i>Octopus</i> sp.); very small shrimps	Multispecies juvenile fish and shrimp
Stow nets	Mixed fish species; Sepiolid squid (Sepiolidae); squid (Loliginidae); Penaeidae and metapenaeid shrimp	

Source: Touch and Todd, 2002.

TABLE 31
Number of trawlers on the Cambodian coast

Province/ municipality	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Kep							5	7	52	52	52	52	10
Kampot	31	16	5	186	186	20	30	22	89	89	89	89	120
Sihanoukville	227	242	276	262	244	226	296	283	656	756	807	783	787
Koh Kong	164	184	268	186	130	214	214	342	719	413	651	322	322
Total	422	442	549	634	560	460	545	654	1 516	1 310	1 599	1 246	1 186

Source: Official statistics, Department of Fisheries.

including Cambodia) resulted in the introduction of trawling to Cambodia. In the late 1950s, a fisheries scientist from (the former Federal Republic of) Germany began to advise the Government of Thailand on increasing fishing landings. In 1961, a trawl was designed that did not get stuck in the soft mud that characterizes the Gulf of Thailand. Between 1960 and 1966, the number of trawlers in Thailand soared from 99 to 2 700, and the catch from 59 000 to 360 000 tonnes. Rising prices for shrimp and for trash fish enabled operators to persist and flourish. In 1964, fleets began to expand out of Thailand into Malaysia, Cambodia and Viet Nam (Butcher, 2004).

Later, during the Khmer Rouge period (1975–78), additional trawlers from Thailand began fishing in Cambodia. In the 1980s, small trawlers became popular because of their relatively low costs and ability to fish shallow productive inshore areas. The boom in the shrimp market also encouraged further trawling. Table 31 shows the distribution of trawlers along the Cambodian coast. About a quarter of all motorized marine fishing vessels in Cambodia are trawlers.

There are two main types of Cambodian trawlers, although not distinguished in official statistics. Small trawlers (defined as vessels with engines of less than 30 HP) fish mainly inshore areas and catch both shrimp and fish. They usually fish at night and return to port each morning. Another class of trawler is characteristically about 20 m in length. Fishing from the latter is in offshore areas and trips usually range from one to four weeks. The catch is predominantly fish and squid, which is often transhipped at sea rather than being landed in a Cambodian port.

Most small trawlers operate in shallow inshore areas, but the basic fisheries decree (Fiat-Law No. 33 on Fisheries Management and Administration, 1987) prohibits trawling between the shore and the 20-m isobath, which is often located 10 km offshore. Many trawlers are inappropriate for fishing so far offshore and, consequently, a great deal of trawling takes place in illegal areas. Another important feature of trawling in Cambodia is excess capacity: 1 500 trawlers represent 3.4 vessels per linear km of coastline. A major fisheries management issue is the need to reduce the number of small trawlers.

There is a significant amount of foreign trawling in the Cambodian zone. The Department of Fisheries indicates that about 150 trawlers (mainly from Thailand) are licensed to fish in the offshore “overlap zones” with Thailand.

With respect to non-trawl shrimp fishing, gillnets are the second most important gear type. They tend to catch larger shrimp than trawls and are used most commonly in the rainy season (June to September). The International Center for Living Aquatic Resources Management (now WorldFish) (ICLARM, 1999) reports fewer shrimp trawlers in the late 1990s, while the number of shrimp gillnetters increased. Table 32 gives shrimp gillnet numbers in the four coastal areas of Cambodia.

TABLE 32
Number of shrimp gillnets

Province/ municipality	2003	2004
Kep	0	1 500
Kampot	21 000	16 500
Sihanoukville	252 600	239 500
Koh Kong	594 776	515 250
Total	868 376	772 750

Source: Official statistics, Department of Fisheries.

TABLE 33
Shrimp fishing gear in Thmor Sor village, Kompong Som Bay

Gear type	Engine HP (daily fuel consumption)	Net size ¹ (m)	Mesh size (cm)	Fishing grounds	Catch	Catch (kg/day)	% of catch
Single trawl	8	8 x 7	5	In front of village, 2–3 km	Shrimp	6	26
					Squid	2	9
					Mixed fish	15	65
Single trawl	18	11 x 3	4	In front of village, 1–2 km at 4 m depth	Shrimp	10	31
					Squid	2	6
Single trawl	8 (30 litres)	4 x 2	4	4 km from village, at 6 m depth	Mixed fish	20	63
					Shrimp	8	35
					Crab	4	17
					Squid	1	4
Single trawl	30 (45 litres)	11 x 11	4	5 km from village, at 2–3 m depth	Mixed fish	10	43
					Shrimp	20	38
					Squid	2	4
					Mixed fish	30	58
Single trawl	18 (30 litres)	12 x 8	5	In front of village, 4–5 km	Shrimp	20	38
					Crab	5	10
					Squid	2	4
					Mixed fish	25	48
Single trawl	18 (30 litres)	12 x 8	4	km In front of village, 1–2	Shrimp	8	25
					Crab	2	6
					Squid	2	6
					Mixed fish	20	63
Single trawl	8	9 x 3	4	In front of village, 5–10 km	Shrimp	10	27
					Crab	3	8
					Squid	4	11
					Mixed fish	20	54
Push net	8 (30 litres)	8 x 7	4	In front of Thmor Sor, Chamkar Leur	Shrimp	20	38
					Crab	3	6
					Mixed fish	30	57
Shrimp gillnet	5	1200 x 2	4	In front of Chamkar Leur, 2–3 km	Shrimp	3	
Shrimp gillnet	11	720 x 2	4	In front of Thmor Sor, Chamkar Leur	Shrimp	2	
Shrimp gillnet	13	900 x 2	3.8	In front of Thmor Sor, Chamkar Leur 1–2 km	Shrimp	3	
Shrimp gillnet	17	1 800 x 2	3.8	Koh Rong, Chrouy Svay	Shrimp	4	
Shrimp gillnet	18	400 x 2	3.8	Chamkar Leur	Shrimp	2	
Shrimp gillnet	7	600 x 2	3.8	Chamkar Leur, Phum Thmey, Ta Meak	Shrimp	3	
Shrimp gillnet	7	700 x 2	3.8	2 km from village	Shrimp	3	

Source: Chu *et al.*, 1999.

¹ It is assumed that these dimensions are net opening x length of net, but the report does not clarify this.

Although stow netting used to be widespread, it is now confined to estuaries in Koh Kong Province (Touch and Todd, 2002). Total production from stow nets (shrimp and fish) is only about 50 to 100 tonnes per year.

A study on the fishing practices of eight villages around Kompong Som Bay, Koh Kong Province (Chu *et al.*, 1999), describes the various gears used to catch shrimp. Results obtained by interviewing fishers from one of the villages are given in Table 33.

- The motorized, therefore illegal, push net has a daily fuel consumption about the same as a trawler.
- All trawling takes place in waters less than 20 m deep and is therefore illegal.
- Shrimp gillnets appear to be the most selective of the three gear types, but the daily catch is relatively low.

TARGET SPECIES, CATCH AND EFFORT

The Department of Fisheries (I. Try and O. Vibol, personal communication, December 2005) says that there is considerable uncertainty as to the taxonomy of the shrimp catch in Cambodia. Table 30 shows that the major species of shrimp caught with the

TABLE 34
Shrimp catches, 2003 and 2004 (tonnes)

	Kep	Kampot	Coastal area		Total
			Sihanoukville	Koh Kong	
2003	54	325	2 209	1 265	3 853
2004	50	316	2 546	783	3 695

Source: Official statistics, Department of Fisheries.

two main Cambodian shrimp fishing gears are *Penaeus semisulcatus*, *P. canaliculatus*, *P. latisulcatus* and *P. merguensis*, with *P. monodon* as a bycatch. Try (2003) states that ten species of shrimp are known in Cambodia: *P. canaliculatus*, *P. semisulcatus*, *P. merguensis*, *P. latisulcatus*, *P. monodon*, *P. japonicus*, *Metapenaeus affinis*, *M. spinulatus*, *Parapenaeopsis sculptilis* and *Parapenaeopsis* sp. He adds that “*Metapenaeus affinis* and *M. spinulatus* comprise around 60 percent of the total catch”.

Shrimp of the genus *Acetes* is not mentioned above but is probably significant in Cambodia; it is extremely important in other Southeast Asian countries, where its main use is for shrimp paste, which is also popular in Cambodia.

Annual shrimp catches for 2003 and 2004 are given in Table 34.

In the 1996 to 2001 period, Try (2003) states that annual shrimp catches ranged from 2 721 to 4 061 tonnes. National fisheries statistics on shrimp catches have not been reported to FAO since 1993. The Organization estimates that, on the basis of increased marine total catches in recent years, 12 600 tonnes of shrimp were captured in Cambodia in 2004 (FAO *Cambodia fishery country profile*, FAO, 2005a) (L. Garibaldi, FAO, personal communication, March 2006).

With respect to the accuracy of the Cambodian shrimp catches given above, three difficulties should be noted: the inherent problems of the fisheries statistical system; catches by Cambodian vessels landed outside the country; and legal/illegal catches by foreign vessels.

- There is compelling evidence that the official catches for the Cambodian coastal zone are a major underestimate of actual catches (FAO, 2005a).
- Further offshore, Flewelling and Hosch (2004a) estimate that 25 percent of the volume of total marine catch by Cambodian vessels is landed outside Cambodia, and is therefore not accounted for in official statistics.
- Little accurate information is available on shrimp production by legal or illegal foreign vessels fishing offshore. Gillett (2004) states that, according to Department of Fisheries internal reports, total catches (shrimp and non-shrimp) from licensed Thai vessels in Cambodian waters are estimated to be from 26 500 to 37 500 tonnes. If this were the case, such an amount would approach the total marine catch recorded for all Cambodian vessels. Furthermore, it is thought that there is a substantial amount of illegal fishing by non-licensed vessels from both Thailand and Viet Nam. Butcher (1999) studied the situation of illegal Thai trawlers and indicated that between 40 and 60 percent of the total catch of these vessels came from outside Thai waters; it appeared that Thai trawlers had long fished in Cambodian waters under unofficial agreements. Butcher concluded that Thailand has a huge number of trawlers and not many fish, while there are far more fish in the waters of nearby countries.

Because of the above factors, Gillett (2004) concludes:

Many of the studies of marine fisheries in Cambodia rely to some extent on the statistics produced by the Department of Fisheries. The rudimentary nature of the statistical system for marine fisheries, the fact that fish are not landed at a central location, direct exports are made to foreign vessels, and other factors all contribute to inaccuracies. The landing data for marine fisheries given in this report should therefore be treated with caution and be considered indicative at best.

This statement is also applicable to the present report.

Gillett (2004) comments in a general sense on increasing fishing effort in Cambodia: *Excess fishing effort and associated declines in abundance of target species are thought to be serious problems for most of Cambodia's marine fisheries. The major causes appear to be population increases coupled with: (i) an economy that is not expanding rapidly enough to cater to rising needs; and (ii) the government policy of not denying to anyone the opportunity to fish for subsistence or income. Unregulated foreign fishing activity is another cause. Improved management in the forestry sector, however desirable, has produced an increase in migration of people to the coastal zone where many become involved in fishing where entry costs are low. Export demand also encourages additional fishing effort, especially the high-value species in overseas markets.*

Effort data are not collected from shrimp fisheries in Cambodia, according to the Department of Fisheries. Consequently, the following should be noted.

- There is a general theory among observers of the fisheries situation in Cambodia that the catch rate from inshore trawlers has decreased in the last two decades, but there are few data to back up this assumption.
- Although CPUE data have not yet been collected for the marine fisheries in Cambodia, surveys from its neighbouring country, i.e. Thailand, may give some leads (Try, 2003).
- Kongprom *et al.* (2003) state that CPUE from trawl surveys in the Thai portion of the Gulf of Thailand declined from 298 kg/hour in 1961 to around 20 kg/hour in the early 1990s, and that, in 1961, the trawlable biomass in the Gulf declined to only about 8.2 percent of the biomass level.
- Try (2003) mentions a 1999 socio-economic survey in Kep, which showed that from 1996 to 1998, the collection of shrimp by small boats fell from 20 kg of shrimp/night to 5 kg/night.
- In the survey of trawl fishing in eight villages around Kompong Som Bay, Koh Kong Province, mentioned earlier (Chu *et al.*, 1999), some anecdotal information on CPUE was obtained. Fishers using all kinds of equipment are reporting declines of up to 90 percent in CPUE over the last ten years. This decline is likely to result from both overfishing and habitat destruction. There are two elements to the overfishing problem: an increase in the total number of fishers and a shift in fishing gears towards more modern and efficient methods.

ECONOMIC CONTRIBUTION

Lamberts (2001) gives seven estimates of the contribution of both inland and marine fisheries to Cambodia's GDP. The Planning and Accounting Office of the Department of Fisheries states that the contribution of all fisheries to the Cambodian GDP is 11.4 percent. The contribution of marine fisheries to GDP has not been assessed accurately; it would require a good estimate of production, the value of this production at the producer level, and an estimate of the value added by the producer. The specific contribution of shrimp fishing to GDP is therefore unknown at present.

The March 1998 census indicated that the population of the two coastal provinces and two coastal municipalities was about 840 000, or about 7 percent of the country's total population. Although population density in the coastal provinces is low in relation to other parts of the country, the number of people in coastal areas increased by about 25 percent in the five-year period ending in 1998. Touch and Todd (2002) estimated that about 10 000 people are employed in the marine fishery sector, including fishing, gathering, processing, and marketing but this figure is not further broken down into employment associated with shrimp fishing. More recent data (2004 official statistics) from the Department of Fisheries give the number of people involved in marine "medium-scale fishing", which approximates to the number of people working on motorized fishing vessels in the country: 50 workers in Kep, 2 100 workers in Kampot, 5 764 workers in Sihanoukville and 25 300 workers in Koh Kong, i.e. a total

of 33 214 workers. Considering that trawlers make up about a quarter of the motorized vessels on the Cambodian coast, employment related to shrimp fishing is obviously important to Cambodia's coastal region.

There is also employment associated with the post-harvest aspects of shrimp fisheries. In late 2005, there were two export-oriented shrimp processing facilities in Sihanoukville. ICLARM (1999) states that one of these factories (Sun Wah Fisheries Co. Ltd) employed 780 people. Small-scale processing for domestic consumption is also important; the most popular products are dried shrimp and shrimp paste (Sok, 2005). Touch and Todd (2002) state that, in 2000, about 185 tonnes of dried small shrimp and 92 tonnes of shrimp paste were produced.

There is little documentation with respect to shrimp consumption in Cambodia. Of the shrimp consumed (3 892 tonnes annually in the early 1990s), 97.5 percent was consumed fresh and 2.5 percent dried (Touch and Todd, 2002).

TRADE ASPECTS

Official statistics of the Department of Fisheries give export information on four types of shrimp products (Table 35). In the statistics, shrimp produced by aquaculture operations (90 tonnes in 2004) is combined with that from shrimp fishing. Shrimp caught offshore and directly transhipped to foreign countries is not included.

These official statistics are available for volumes of exports and not for value. Nevertheless, shrimp is the most valuable fishery export commodity (Touch and Todd, 2002).

The Department of Fisheries indicates that the primary export destinations for shrimp products are Taiwan Province of China (fresh) and China (processed).

Currently, Cambodia cannot export shrimp to the United States, under Section 609 of United States Public Law 101–162, which stipulates that shrimp or products from shrimp harvested with commercial fishing technology that may adversely affect certain species of sea turtles protected under United States laws and regulations may not be imported into the United States. At the root of the United States prohibition is the requirement that commercial shrimp trawl vessels use TEDs – approved in accordance with standards established by the United States NMFS – in areas where there is a likelihood of intercepting sea turtles.

There is yet another aspect to shrimp trade with the United States. Quick Frozen Foods International (QFFI, 2005) reports that Cambodian exports of shrimp to the United States were zero in 2003 but soared to 5 330 tonnes in 2004. Exports of shrimp from China to Cambodia also soared from zero in 2003 to 2 664 tonnes in 2004. Because China's shrimp exports to the United States have been subject to anti-dumping duties since July 2004, a possibility is that Chinese producers have begun exporting shrimp to the United States via Cambodia to evade punitive duties.

TABLE 35
Shrimp product exports of Cambodia, 2003 and 2004 (tonnes)

	Item	Coastal Area				Total
		Kep	Kampot	Sihanoukville	Koh Kong	
2003	Fresh shrimp	0	120	23	1 022	1 165
	Dried shrimp	0	30	30	1	61
	Peeled/frozen shrimp	0	0	308	17	325
	Dried shells	0	0	0	0	0
2004	Fresh shrimp	0	35	557	600	1 192
	Dried shrimp	0	12	40	9	61
	Peeled/frozen shrimp	0	0	365	24	389
	Dried shells	0	5	48	0	53

Source: Official statistics, Department of Fisheries.

BYCATCH ISSUES

Kelleher (2005) states that discards in Cambodian marine fisheries are small:

An arbitrary discard rate of 1 percent was assigned to the fisheries of Thailand, Malaysia and Cambodia, which are considered to generate combined discards of less than 50 000 tonnes.

With discards from fisheries not a concern in Cambodia, the major bycatch issues in shrimp fishing are related to trash fish and endangered species.

The term “trash fish” has recently been defined as “fish that have a low commercial value by virtue of their low quality, small size or low consumer preference” (Funge-Smith, Lindebo and Staples, 2005). In Cambodia, according to Fisheries Department officials, trash fish normally means the part of the catch that is not for human consumption; trawling produces most of this commodity. Several reports on Cambodian marine fisheries mention trash fish.

- Try (2003) states that, after the opening of the fertilizer factory in 1993, trawlers changed their target species to trash fish for fertilizer. This trash fish is composed of small-size fish that have no market value, non-edible species, and unacceptable juveniles of economically important species. During the 1980s, fish caught by trawl fisheries contained 30–40 percent trash fish, but it now comprises 60–65 percent of the total catch.
- The study on the fishing practices of the villages around Kompong Som Bay, Koh Kong Province (Chu *et al.*, 1999), states that trawlers catch shrimp, squid and crabs as well as fish in the bay. Mixed fish, much of which is trash fish (*trey chi*, made into fertilizer), makes up to 50–60 percent of the catch.
- The Department of Fisheries and National Institute of Statistics (2003) state that 70 percent of the catch landed by trawlers in Cambodia’s marine area is considered to be trash fish, which amounted to 10 867 tonnes in 1999.

A senior officer in the Fisheries Department (O. Vibol, personal communication, December 2005) provides information on the current use of trash fish. Most of the fish comes from large trawlers, with much less from the huge number of small trawlers. Trash fish is used for reduction in factories; as bait in crab traps; (iii) animal farming operations (aquaculture, crocodiles and ducks); and export to Thailand. The price given to fishers fluctuates seasonally and recently varied from US\$0.12 to US\$0.30 per kg.

Cambodia is somewhat unusual in Southeast Asia with respect to trash fish and its use because there is significant targeting of the fish, particularly for fertilizer, unlike other neighbouring countries where it is mostly processed into animal feed.

Another facet of shrimp fishing bycatch in Cambodia is the catch of endangered species: trawlers are capable of taking large marine mammals and sea turtles in their nets. Bycatch is thought to be one of the main threats to Cambodia’s marine mammals and accidental catches of these species are usually discovered after the animal has died. Other countries have been testing devices to reduce capture of sea turtles with some success. However, Cambodia’s trawler vessels are not required to be equipped with devices such as TEDs which, in any case, are not suitable for Cambodian fishing vessels because the boats are too small.

Cambodia participated in a five-year bycatch reduction project sponsored by the Southeast Asian Fisheries Development Center (SEAFDEC). The aim was to reduce incidental catch of turtles and minimize the catch of small juvenile fish.

PROFITABILITY

The Department of Fisheries has undertaken very little economic analysis on aspects of marine fisheries. Available information on the profitability of shrimp fishing in Cambodia appears to be confined to anecdotes and a single externally funded project of the Department of the Environment.

TABLE 36
Profitability of shrimp fishing in Kompong Som Bay

	Type of gear (number of units analysed)	Average income (US\$)	Average costs (US\$)	Average profit (US\$)
Koh Sdach	Trawl (6)	127.03	21.12	105.91
	Shrimp gillnet (3)	1.69	2.53–7.47	.79–5.78
Chrouy Svay Commune	Trawl (9)	21.20	10.11	11.09
	Shrimp gillnet (7)	2.82	1.06	1.77
Thmor Sor Commune	Trawl (1)	20.60	8.91	13.30
	Push net (5)	31.31	–	–
	Shrimp gillnet (24)	3.13	1.15	1.98
Chikkar Kraom Commune	Push net (1)	23.76	7.92	15.84
	Shrimp gillnet (12)	2.32	1.08–1.58	0.71–1.24

Source: Chu *et al.*, 1999.

Note: US\$1 = B37.88 (Thai baht).

With regard to marine fisheries in Cambodia, Sour (2005) states that there is “very limited information about profitability/economic return of fishing. However, this economic return seems to be very low.”

The study of the villages around Kompong Som Bay, Koh Kong Province (Chu *et al.*, 1999) produced some information on the profits²⁵ of three types of shrimp fishing at four locations on the bay (Table 36).

Bearing in mind that all trawling in the bay is illegal because the water is shallower than 20 m and all motorized push nets are banned in Cambodia, the study concludes:

It is clear why trawlers and push netters are unwilling to give up their illegal activities and switch to gillnetting. Their profits would decrease by up to 90 percent.

Despite the few economic data, it appears that both the profitability of individual shrimp fishing operations and the rent from the various shrimp fisheries are low, as a consequence of the open access nature of Cambodian coastal fisheries; the rising coastal population; low barriers to participation; lack of non-fishing sources of livelihood; indications of low profitability, the rising proportion of trash fish; and falling CPUE. This is a stark example of the inability of fishery resources to support large and increasing numbers of fishers with few non-fishing alternatives – or what Pauly (1993) terms “Malthusian overfishing”.

ENERGY INPUT ASPECTS

Operators of fishing vessels indicated that, in late 2005, diesel fuel for their vessels cost US\$0.75 per litre whereas, in late 2004, it cost US\$0.55 per litre. Fuel smuggled from Thailand reportedly cost US\$0.55 per litre in late 2005.

No studies on fuel consumption in Cambodia’s marine fisheries have been undertaken. Some data on fuel consumption by trawlers and push netters are given in Table 33. To summarize, small trawlers at Thmor Sor village, Kompong Som Bay, use between 30 and 45 litres of fuel/day, and push netters 30 litres/day.

If a small trawler uses 38 litres of fuel/day and the cost of fuel rises by US\$0.20/litre, then the daily fuel cost would increase by US\$7.60/fishing day. This would have a significant effect on the daily profits of small trawlers, which range from US\$11.09 to US\$105.91, as shown in Table 36.

The effects of a rise in fuel cost would be minimal for non-motorized shrimp fishing with small push nets and short shrimp gillnets.

²⁵ It appears that the study considered operating expenses and gross income from sales of fish, so the difference between the two is actually the net operating income. In addition, it should be remembered that information was obtained from interviews rather than from verified documentation.

BIOLOGICAL ASPECTS

Few biological studies have been undertaken on the shrimp resources of Cambodia. This has been mentioned in several general reviews of the marine fisheries of the country, including the following.

- Very little is known about the status of fish stocks in Cambodia's marine waters (Try, 2003). There are concerns about stock depletion in the marine fishery, but substantial stock assessments are needed to substantiate these concerns.
- Stock states and exploitation rates are relatively unknown (Flewwelling and Hosch, 2004a). Data are mostly production-oriented and fail to include basic information for the computation of essential indicators for stock assessment (e.g. CPUE).
- Since there are no data related to CPUE, it is difficult to identify trends of specific fishery commodities, impact on any specific species, or impact of a particular gear (FAO, 2005a).

With little biological information available on specific Cambodian marine fishery resources, one option is to look at assessments of shrimp resources in the Gulf of Thailand. Janetkitkosol *et al.* (2003) review the fishery resources of the Gulf and, with regard to shrimp, conclude that penaeid resources have been overexploited since 1982 (MSY of 22 000 tonnes and an optimal fishing effort of 25 million hours). Small-sized shrimp (*Trachypenaeus* spp. and *Metapenaeopsis* spp.) have also been overexploited, with an estimated MSY of 110 000 tonnes and an optimal fishing effort of 44 million hours. Kongprom *et al.* (2003) used trawl surveys (1961–95) and annual production statistics (1971–95) to examine the status of demersal fishery resources in the Gulf. Results showed that, by 1995, the trawlable biomass had declined to only about 8.2 percent of the biomass level in 1961.

IMPACTS ON THE PHYSICAL ENVIRONMENT

Although there have been no specific studies in Cambodia on the effects of shrimp fishing on the physical environment, there is considerable mention of damage by trawling in the country's fisheries literature, much of which relates to the destruction of seagrass beds. This may either reflect the general feeling of coastal communities or the priorities given to seagrass by external agencies, which have funded much of the work on marine resources in the country.

The report on the situation in Kompong Som Bay, Koh Kong Province (Chu *et al.* 1999) states that the bay probably used to support extensive seagrass beds, which acted as nursery areas and habitat for shrimp, crabs, juvenile fish and other marine fauna, including globally endangered dugongs and turtles. Trawlers and push nets destroy seagrass beds by dragging the seagrass out by its roots and damaging the muddy sea bottom; it is not known how much seagrass is left. The decrease in seagrass may be a contributing factor to the decline in fisheries catch, particularly shrimp and crabs.

A national report on seagrass (Department of Fisheries, 2005) found that the total area of seagrass in Cambodia's waters was 32 492 ha. These seagrass beds typically occur in water depths of 3–4 m and are mostly damaged by trawling, leaving seagrass shoots and leaves floating on the sea surface.

O'Brien (2003) proposes a National Marine Fisheries Management and Development Policy and Action Plan, noting that seagrass beds are being damaged by trawlers, push net boats and other bottom-weighted fishing methods. Seagrass habitats are important nursery areas for a range of marine species; up to nine species of seagrass beds have been identified in Cambodian waters, with most beds located in waters near Kampot and Kep. Destruction of seagrass beds may be contributing to the decline of some marine animal species, including dugongs. Trawling is one of the most destructive fishing methods used in Cambodia but it is also the source of significant income and employment. A major objective of marine fisheries management in Cambodia should

be “to reduce the impact of trawlers on the environment”, and two activities should be supported to obtain this objective: research on ways to reduce the impact of trawling; and education of fishers on the effects of destructive fishing methods.

IMPACTS ON SMALL-SCALE FISHERIES

Shrimp fishing in Cambodia, especially trawling and motorized push netting, causes considerable conflict with small-scale fishers. Trawlers destroy the fishing gear of small-scale fishers and often do not pay compensation (Sour, 2005). The fishers cannot claim compensation because the trawler crews are often banned and are usually under the protection of high-ranking military, police or political officials. Between 1989 and 2002, trawler crews killed 22 fishers along the coast (Weinberger and Chou, 2003).

To reduce conflict between trawlers and small-scale fishers, a fishery law bans trawling in the area between the shore and the 20-m isobath but, because most of the trawlers are relatively small, they are unsuitable for use in offshore areas. This means that much of the trawling takes place illegally in areas with considerable small-scale fishing activity. Despite the fact that inshore trawling is clearly illegal, the Department of Fisheries is reluctant to enforce the ban for various reasons, including the perceived financial difficulties that it would cause trawler operators. On the other hand, those that suffer from the trawling are frustrated by the lack of government action to halt the illegal activity.

Chu *et al.* (1999) describe the situation in Kompong Som Bay, Koh Kong Province.

Trawlers and family fishers are fishing in the same areas. This has led to conflict between the two groups. Trawlers catch their nets on the fishing gear of gillnetters and squid trappers, and the nets of both break. The gillnetters and squid trappers cannot afford to buy new nets. The trawlers sometimes pay compensation but often do not, and may even threaten small-scale fishers with guns if approached. Family fishers have boats that are only equipped to travel a maximum of approximately 2–3 km from shore. Trawlers can travel further, but only the largest trawlers consider it safe to go out past the 20-m line. Trawlers in Chrouy Svay consider themselves too small to leave Kompong Som Bay and usually trawl within the 10-m line. This leads to inevitable overlaps in fishing grounds and the damage or loss of nets of both trawlers and fishing families. Although it is illegal for any trawlers to trawl in shallow water, it is not possible to force small boats out past the 20-m line. There is potential for this conflict to be solved by direct talks between family fishers and trawlers to try to agree on boundaries within which each can fish safely.

MANAGEMENT

In July 2005, the Government of Cambodia made a statement on the National Fisheries Sector Policy, in which the main overall objectives of management and development of fisheries were enhancement of food security and contribution to poverty alleviation.

The legal basis for the management of shrimp fisheries in Cambodia is Fiat-Law No. 33 on Fisheries Management and Administration, 1987. The text consists of 44 articles divided into six chapters: Interpretation; Exploitation in inland fishery domain, aquaculture and processing freshwater fishery product; Exploitation in marine fishery domain; Aquaculture and processing sea product; Competent authorities for solving the fishery law violation; Penalty; and Final order. There are several other legal instruments for fisheries management in Cambodia, but most are applicable only to inland fisheries. The Department of Fisheries has been revising the existing Fisheries Law to apply better to the present social and economic situation. The revised law will reflect the need for community participation in fisheries management and emphasize the need for environmental protection and preservation (FAO, 2005a). The new law will have no provisions specifically targeted at shrimp fishing.

Shrimp fisheries are not managed separately in Cambodia, but rather as a component of all coastal fisheries, for which there are no formal management plans; the objectives of fisheries management must be inferred from the various legal instruments and past government interventions. Fiat Law No. 33 does not specifically cite the objectives of marine fisheries management, but they may be construed from its provisions, which are:

- generation of government revenue;
- production of information on the quantity of fish catch;
- avoidance of obstructing the passage of vessels;
- protection of mackerel;
- protection of the gear of inshore fishers and/or bottom habitats; and
- elimination of the use of destructive fishing gear.

To understand the management of shrimp fishing in Cambodia, it should be clear that other objectives of the present management regime are also important but not specifically articulated in the Fiat Law or in fisheries management planning documents. A major objective is to retain the possibility for all Cambodians, especially those too poor to enter other economic sectors, to participate in marine fisheries. This cannot be underestimated in a country that has been torn by decades of civil war and with limited economic opportunities for an expanding population. Although this objective has negative implications for marine resource sustainability, the political reality is that at this stage in Cambodia's history, it is difficult to deny poor people access to what is perceived as a low entry cost occupation. The legitimacy of this poverty alleviation is not disputed here, but an important point should be made: if the fisheries management system is charged with the responsibility for ensuring economic opportunities for a very large number of poor people, major restrictions are placed on the achievement of other management objectives (Gillett, 2004).

The following are current fisheries management measures relevant to shrimp fishing.

- All fishing, except family-scale operations, must be licensed. In addition, if fishing takes place from a vessel, the vessel must be licensed by both the fisheries agency and the police.
- Fishers must record on a daily basis the quantity of fish caught and report this monthly to the provincial/municipal fishery agency.
- Trawling between the shore and the 20-m depth line is prohibited.
- Certain fishing gear is specifically prohibited (explosives, electrical fishing gear and modern fishing gear have not yet been mentioned in a ministerial proclamation). This prohibition presumably covers motorized push nets and pair trawling, which fisheries officers often cite as illegal.
- Fishing is banned in designated marine protected areas.

Nevertheless, the present law does *not* specify any provision for limiting fish catches or fishing effort. The Department of Fisheries recognizes that the large number of small trawlers is a major threat to the sustainability of fisheries resources but, because of the open access situation in all Cambodian marine fisheries, there are few legal measures that can be taken to limit the numbers. The Department's strategy to limit efforts has been to explore the potential of limiting/reducing vessel numbers by comanagement with fishing communities and by promoting alternative livelihoods. Fisheries officials also report that they discourage – albeit with no legal basis – the construction of new small trawlers and the repair of older ones (e.g. by non-endorsement of requests for bank loans, discussions with trawler owners).

Considering the lack of biological information on shrimp resources, the few legal instruments available for shrimp fishing management, the poor enforcement of those that do exist, and the open access nature of all coastal fisheries, there are considerable obstacles to deriving greater benefits from the shrimp fisheries by management interventions.

ENFORCEMENT

The Marine Inspection Unit, based at Sihanoukville, employs some 80 people and is responsible for monitoring the compliance of fishing activities along the coastline. The unit operates two fairly old 45-ft (13.7-m) vessels and is charged with actively enforcing gear, season and zone restrictions, with appropriate penalties applied when necessary. A VMS is in place, and random and routine dockside/landing site inspections are carried out. Resources are lacking to monitor the national and foreign fleets in the 55 600 km² EEZ. Capacity within the Department of Fisheries is insufficient, however, to be able to enforce the law effectively (Flewwelling and Hosch, 2004).

The major issue in the enforcement of legislation relating to shrimp fishing concerns the ban on trawling in waters less than 20 m deep. The ban was intended to safeguard the interests of small-scale fishers but enforcement is selective at best. The result is that most of the shrimp landings in Cambodia are from trawling in prohibited areas. As stated previously, there is a reluctance to enforce the ban for various reasons, including the financial difficulties that it would cause trawler operators, who are perceived to be poor.

Some of the “concern for the poor” arguments for non-enforcement do not seem to hold up under close scrutiny (Gillett, 2004). Observations along the coast suggest that those who suffer the effects of non-enforcement are the small-scale inshore fishers who appear even poorer than the trawl fishers.

Chu *et al.* (1999) make an observation concerning problems in enforcement in Koh Kong Province:

Trawlers are supported by senior police and military and are owned by wealthy Thai and Cambodian businessmen. All trawlers pay bribes to police and military, as well as to fisheries officials, district and commune leaders. Because of the protection of high-level officials, lower-level officials cannot enforce the law prohibiting trawling.

Try (2003) concludes:

The lack of consistent enforcement within the Department of Fisheries is resulting in inequitable access to fisheries resources, community conflicts, a reduction in fish stocks through overfishing and habitat degradation by allowing fishing activities to continue in protected areas.

The costs of enforcing legislation relating to shrimp fisheries, or even to coastal fisheries in general, are not readily available. Calculations are complicated by the various agencies involved and the fact that most of the agencies have enforcement responsibilities outside the fisheries sector.

RESEARCH

An Inland Fisheries Research and Development Institute exists within the Department of Fisheries, but there is no equivalent for marine fisheries. Similarly, the Royal University of Agriculture has a faculty for fisheries research but focuses almost exclusively on inland fisheries. There is no formal research structure for marine fisheries in Cambodia and consequently the authorities rely almost entirely on donor-funded activities for research programmes or projects (Flewwelling and Hosch, 2004).

In recent years, externally funded research projects relevant to shrimp fisheries have included studies on trawling, seagrass, turtles, socio-economic status of coastal fishing communities, marine mammals, mangroves and marine biodiversity. Sponsors of these studies have included DANIDA, FAO, conservation NGOs, UNEP, SEAFDEC and GEF. The studies were mostly undertaken in cooperation with the Department of Fisheries or the Ministry of the Environment. The costs of these projects are not available.

Marine fisheries research conducted in neighbouring countries, such as Thailand, could have some applicability to Cambodia, as was mentioned in the section *Biological aspects* with regard to shrimp resources in the Gulf of Thailand.

DATA REPORTING

Much of the descriptive information on shrimp in this report relies to a certain extent on the statistics produced by the Department of Fisheries. Gillett (2004) states that numerous reviews of the fisheries sector in Cambodia highlight the deficiencies in the fisheries statistical system, mainly emphasizing the following points.

- Important elements of marine fisheries are not included: catches by subsistence fishers, and catches by Cambodian and foreign vessels (both licensed and illegal) that are landed outside Cambodia.
- As a result of the methodology, estimates for even those components covered by the statistical system could be inaccurate.
- The statistical system is oriented towards collection of production information, while even the most basic indicators useful for stock assessment (e.g. CPUE) are not included.

It should be acknowledged that collection of fisheries statistics is inherently difficult and expensive in a location such as the Cambodian coast. In this respect, the situation in Cambodia may be similar to that of many neighbouring countries. A study on inland fisheries statistics across Southeast Asia (Coates, 2002) came to a conclusion that could apply to the marine fisheries statistics of Cambodia:

The countries of Southeast Asia in general struggle with limited resources to compile information that, in many cases, they do not themselves trust, need, or use. At the same time, most of those countries are aware of what information it would be more logical to collect, but lack the methods and support to obtain it.

Senior staff of the Department of Fisheries (I. Try and O. Vibol, personal communication, December 2005), indicate that there have been recent improvements in Cambodia's marine fisheries statistics. They state that SEAFDEC has provided assistance to improve both the training of statistical staff as well as the procedures for collecting statistics.

IMPACTS OF SHRIMP FARMING

The Agriculture Productivity Improvement Project (APIP, 2001) reviews the history of shrimp farming in Cambodia. Coastal aquaculture began with shrimp culture, using technology from neighbouring countries, particularly Thailand. The culture was started extensively in Koh Kong Province, and was then expanded to Sihanoukville and Kampot Province. The main marine species cultured in the coastal area were *Penaeus monodon* and *P. merguensis*. Shrimp culture production rose remarkably, from 500 tonnes in 1993 to peak at 731 tonnes in 1995, but then dropping to just 63 tonnes in 1999. This decrease in production was caused by disease, which killed thousands of tonnes of shrimp and caused many farmers to become bankrupt.

Shrimp farm production from 1993 to 2004 is given in Table 37; location of production from 2001 to 2004 in Table 38.

There is a lack of economic data on shrimp fisheries (see section *Profitability*), including information on decreases in prices for shrimp on the domestic or international markets. However, price declines are unlikely to be related to the effects of shrimp farming in Cambodia because of the small quantities of shrimp produced. Worldwide, the large increase in farmed shrimp production has led to a fall in prices for all shrimp, including captured shrimp, and this could affect shrimp prices in Cambodia.

TABLE 37
Shrimp production in Cambodia,
1993–2004

Year	Production (tonnes)
1993	500
1994	560
1995	731
1996	600
1997	266
1998	197
1999	63
2000	21
2001	143
2002	53
2003	90
2004	75

Source: Official statistics, Department of Fisheries.

TABLE 38
Shrimp production by location

	2001	2002	2003	2004
Kep	3	1	2	0
Kampot	50	0	8	20
Sihanoukville	60	25	53	37
Koh Kong	30	27	27	18
Total	143	53	90	75

Source: Official statistics, Department of Fisheries.

There are other impacts of shrimp farming on shrimp fishing.

- Fisheries officers have heard complaints from trawl fishers that the destruction of mangrove forests, including those for shrimp farms, is negatively affecting their catches.
- Work in Koh Kong Province (Chu *et al.*, 1999) warns of pollution associated with shrimp farming. Development of shrimp aquaculture without adequate thought to the environment could be a disaster for the ecosystem of Kompong Som Bay and could have long-term detrimental effects on the environment and economy of the area.

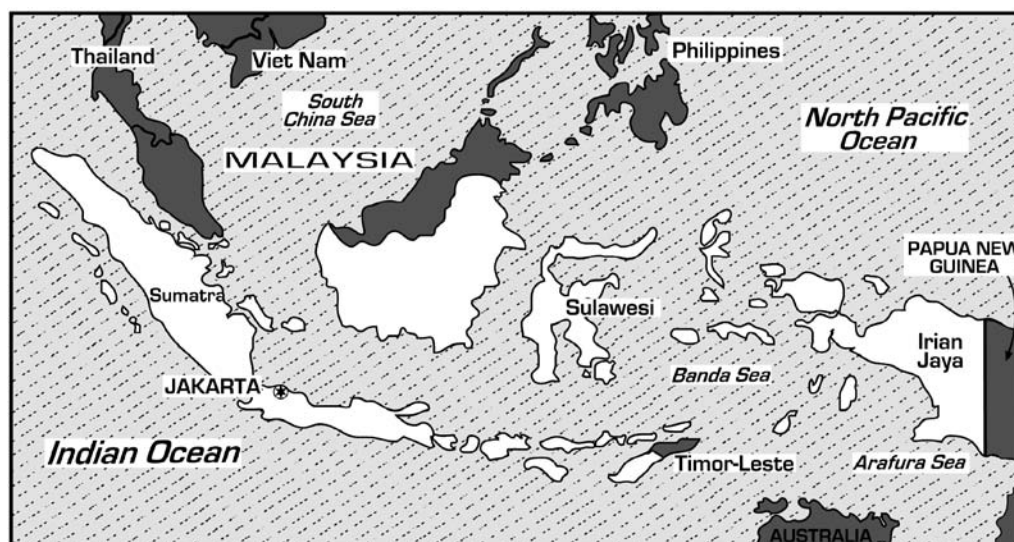
The relationship of trash fish to shrimp aquaculture is not as close in Cambodia as in other Southeast Asian countries, where a major use of trash fish is for feed for shrimp farming. This also occurs in Cambodia, although trash fish is more often used for fertilizer and for bait.

MAJOR ISSUES

The major issues related to shrimp fishing in Cambodia are that:

- trawling for shrimp and demersal fish produces most of the fisheries-related conflict along the coast;
- small trawlers are numerous and fish illegally in shallow waters, but they are unsuitable for offshore fishing;
- the relatively simple ban on trawling in shallow water cannot be enforced;
- there is an urgent need to reduce coastal fishing effort, especially by small trawlers, but this is extremely difficult because of the lack of enabling legislation and political will;
- there is a lack of biological knowledge of the shrimp captured and even considerable uncertainty as to what species are being fished; and
- considering the paucity of biological information on shrimp resources, the few legal instruments available for managing shrimp fishing, poor enforcement of those that do exist, and the open access nature of coastal fisheries in the country, the obstacles to deriving greater benefits from shrimp fisheries by management interventions are considerable.

Shrimp fishing in Indonesia



AN OVERVIEW

Shrimp fishing is of major importance to Indonesia. After China and India, Indonesia's shrimp catch is the largest in the world. Shrimp farming is also of great significance, with over 65 000 participating households. Shrimp production, from both fishing and aquaculture, has reached over 400 000 tonnes per year, and shrimp is by far the country's most valuable fishery export.

Shrimp fishing in Indonesia is not without its problems. A multitude of conflicts are generated, most of which involve small-scale fisheries. The 1980s trawl ban is cited as the most significant fisheries management measure ever to have taken place in the country, but its effectiveness has eroded over the years. As in many parts of the world, industrial-scale shrimp trawling operations are having major problems coping with the recent rise in fuel prices.

The structure of the shrimp industry is complex and problematic. There are a large number of boats that catch shrimp, many types of fishing gear and illegal fishing and trade activities. Moreover, poor statistical information and inadequate enforcement of regulations do not help to resolve the difficulties.

DEVELOPMENT AND STRUCTURE

Shrimp fishing has been important in Indonesia for centuries. Lift nets, push nets, beach seines, set nets, gillnets and a multitude of other gear have been used to catch shrimp for generations by small-scale fishers across the country. The development of larger-scale methods to catch shrimp was a slow process. From 1907 to 1911, in the hope of decreasing Java's dependence on imported fish, the Netherlands Indies Government undertook development work with trawling in the Java Sea, using a converted hopper barge from the Netherlands. The operation experienced problems with the soft mud and the large amount of sponges. Although the work dispelled the idea of being able to make significant catches on the bottom, some good trawling areas were found in the Madura Straits and off the south coast of Borneo. Japanese trawlers began basing in Singapore in 1935 and ranged as far as the Arafura Sea. These operations started scaling

down in 1937 as a result of pre-war animosity created by Japan's invasion of China. The next significant attempt to introduce trawling in Indonesia occurred in the 1950s when the Directorate-General of Fisheries carried out trawling trials. Although they were regarded as successful, "local fishermen did not respond, due to the difficulty of obtaining engines and spare parts" (Butcher, 2004).

Priyono and Sumiono (1997) recount the developments that led to the establishment of shrimp trawl fishing in Indonesia. Trawl fisheries started commercially in 1966 in the Malacca Straits, particularly in the area surrounding the estuary of the Rokan River, with Bagansiapiapi as its base. The fishery was characterized by wooden sampan-like motorized vessels of 5–20 GT, employing a single gulf-type shrimp trawl of 12–15 m headrope length. The fishery developed rapidly, engaging over 800 vessels by the end of 1971. The development of trawl fisheries in Indonesia may have been influenced by western Peninsular Malaysia. The ancestors of many Chinese fishers in Riau Province, Indonesia, have migrated from there and still maintain contact with their relatives in Malaysia. The number of Chungking trawlers (of type 15 GT) operating from Bagansiapiapi increased to 227 in 1976. In the following years, the trawl fishery spread throughout western Indonesia via southeastern Sumatra to the north and south coasts of Java, and to southern Sulawesi. The sizes of the trawlers gradually increased from 15 to 35 GT, and their engines from 66 to 120 HP. Polyethylene nets were used, with headrope length ranging from 13.5 to 22.5 m, and a codend mesh size of 2 cm. Data from the provincial fisheries offices of the Malacca Straits provinces of Aceh, North Sumatra and Riau showed that, in the early to mid-1970s, about 20 percent of trawler catch was shrimp. Trawling for shrimp in the Arafura Sea began in 1969 with nine trawlers, ranging in size from 90 to 600 GT and from 260 to 1 200 HP. By the end of 1982, the number of shrimp trawlers in the Moluccas and Irian Jaya in eastern Indonesia had peaked at 188 units. In the 1990s, there were only 87 trawlers.

Butcher (2004) provides information on the business aspect. Investment in trawling was fuelled by Chinese entrepreneurs who wished to diversify investment and take advantage of the foreign and domestic capital investment laws of 1967 and 1968, with their tax holidays and duty-free import of equipment. In 1969, the Indonesian Government tightened up considerably and foreign companies had to have a joint venture partner. Typically, foreign partners put up capital and local partners facilitated the connections. In 1970–71, 50 trawlers moved from Sumatra to the north coast of Java. Between 1967 and 1971, one wholly Japanese and ten joint ventures began operating in the Malacca straits, off Kalimantan and in the Arafura Sea. Catches of shrimp rose as new shrimping grounds were opened faster than older ones were overfished. Cold-storage plants were constructed; by 1976, there were 51 shrimp cold-storage plants in Indonesia.

Substantial conflict was generated between small-scale fishers and trawler operators. Trawling was subsequently banned in most of Indonesia by Presidential Decree No. 39/1980, which was implemented incrementally (see section *Impacts on small-scale fisheries*).

Shrimp fishing in Indonesia is a complex mixture of industrial and smaller-scale operations. The situation is complicated by the large number of units and gear types; the fact that many small-scale fishers catch shrimp with multispecies gear, and also that various types of trawl gear have been renamed to circumvent the trawl ban.

Large-scale shrimp trawling is, in principle, confined to the Arafura Sea and adjacent areas of eastern Indonesia. Purwanto (2005) gives the evolution of the fleet structure in the Arafura Sea in recent years (Table 39).

Industry sources (Sukirdjo, Association of Indonesian Shrimp Catching Companies, personal communication, December 2005) state that, in late 2005, there were about 140 Association shrimp trawlers fishing in eastern Indonesia (Arafura, Aru, Maluku) and about an equal number of non-Association vessels operating in the same area. A much

TABLE 39
Number of shrimp trawl vessels in the Arafura Sea

	Vessel size (GT)				Total
	<50	51–100	101–200	>200	
1992	n.a.	n.a.	n.a.	n.a.	250
1996	39	59	280	53	431
2000	70	207	198	51	526
2004	2	126	174	34	336

Source: Purwanto, 2005.

TABLE 40
Main small-scale fishing gear used to catch shrimp

Gear type	Number of fishing units	Distribution of gear
Shrimp nets and fishnets*	10 002	65% of units located in East Kalimantan
Demersal Danish/lampara seines	17 893	56% in North Java
Beach seines	18 925	
Shrimp gillnets	30 690	26% in North Java; 16% in the Malacca Straits; 18% in Bali-Nusatenggara; 14% in South Java
Trammel nets	42 131	47% in North Java
Stow nets	7 887	83% in East Kalimantan
Guiding barrier nets	9 482	
Total	137 010	

Source: 2003 statistics, Ministry of Marine Affairs and Fisheries.

*This category presumably includes the industrial trawlers operating in eastern Indonesia.

larger number of these vessels (perhaps a total of 500) had been operating, but most returned to China in 2003.

The size of the Association's vessels ranges from 150 to 200 GT, fishing trips average 60 days in length, and vessels are based in the ports of Ambon, Sorong, Kendari and Kupang. The 140 Association vessels are owned by 14 different companies, eight of which are joint ventures with foreign entities (seven Japanese, one Australian). All trawlers are "Florida type" with twin trawl nets and carry a crew of 15 to 20.

According to ICES/FAO (2005), three types of trawl gear are used in the Arafura Sea:

- double-rig shrimp trawl: the headrope length is between 15 and 26 m; the mesh size of the codend is generally 30 mm and made of polyethylene;
- single-rig stern trawl: the headrope length is between 26 and 35 m; and
- quad trawl where two trawls on each side are towed: headrope length of each trawl is between 20 and 25 m.

To complicate the Indonesian industrial shrimp fishing situation further, there is reportedly a substantial amount of illegal trawling by foreign vessels, as well as by Indonesian vessels, in areas of the country where trawling is, in principle, banned.

The structure of non-industrial shrimp fisheries in Indonesia is considerably more complex than the industrial operations. According to an Indonesian fishery scientist (M. Badrudin, personal communication, December 2005), many types of gear are used by small-scale fishers to catch shrimp; the major ones for which official statistics have been collected are given in Table 40. As can be seen from the Table, there are a considerable number of fishing units. An important point is that most of the gear types listed make substantial amounts of non-shrimp catches and therefore they cannot be considered strictly shrimp fishing gear. The most important non-trawl gears for catching shrimp are trammel nets and shrimp gillnets.

Almost 28 000 fishing units make up the categories "shrimp nets and fishnets"²⁶ and "demersal Danish/lampara seines". This represents an interesting collection of gear types, many of which function as trawls and are sometimes referred to as "mini-

²⁶ The name that appears in the official statistics and documents is always "BED-equipped shrimp nets/fishnets".

trawlers”. At least some of the Indonesian trawl gear terminology arose to circumvent the ban on using trawl gear in most areas of the country. Endroyono (2000) lists 25 named types of trawls used in the seven fishing areas of Indonesia:

- Arafura, Aru and Banda: two types of trawl gear, both used by industrial-scale vessels (more than 5 GT);
- Indian Ocean: four types of trawl gear, two of which are used by industrial-scale vessels;
- Malacca Straits: seven types of trawl gear, three of which are used by industrial-scale vessels;
- Java Sea: 15 types of trawl gear, one of which is used by industrial-scale vessels;
- Karimata Strait and South China Sea: five types of trawl gear, all of which are used by industrial-scale vessels;
- Makassar Strait and Flores Sea: six types of trawl gear, none of which is used by industrial-scale vessels; and
- Seram Sea, Tomini Bay, Sulawesi Sea, Pacific Ocean and Bituni Bay: four types of trawl gear, two of which are used by industrial-scale vessels.

In general terms, industrial-scale shrimp fishing takes place mainly in southeast Indonesia, while small-scale shrimp fishing occurs mainly in western Indonesia. Small trawlers operate in many parts of the country, but predominate in the west. Illegal foreign shrimp fishing activity is reportedly common in the good shrimping grounds in the southeast and in the South China Sea area, close to Indonesia’s Southeast Asian neighbours. Foreign shrimp fishing is allowed under licence in certain areas, but the Indonesian Government has indicated that it would be phased out in late 2006. In addition to marine catches, about 15 000 tonnes of freshwater shrimp²⁷ are taken per year.

TARGET SPECIES, CATCH AND EFFORT

Of the 81 species of penaeid shrimp found in Indonesia, at least 46 species are caught, of which just 14 are economically important. The banana shrimp group (*Penaeus merguensis*, *P. indicus*, *P. chinensis*), the tiger shrimp group (*P. monodon*, *P. semisulcatus*, *P. latisulcatus*) and the endeavour shrimp group (*Metapenaeus endeavouri*, *M. monoceros*, *M. affinis*) account for almost 95 percent of Indonesian shrimp export (Venema, 1996).

Further clarification is given by Priyono and Sumiono (1997). The most important shrimp caught by trawl is:

- banana, or *jerbung* (*Penaeus merguensis*, *P. indicus*, *P. chinensis*);
- tiger, or *windu* (*P. monodon*, *P. semisulcatus*, *P. latisulcatus*);
- endeavour (*Metapenaeus monoceros*, *M. ensis*, *M. elegans*);
- rainbow, or *krosok* (*Parapenaeopsis sculptilis*, *P. stylifera*);
- pink (*Solenocera subnuda*, *Solenocera* spp.).

The first three groups are well defined in official fisheries statistics, while rainbow and pink shrimp belong to the “other shrimp” category.

The various shrimp fisheries in Indonesia catch different species.

- Industrial shrimp trawling in the Arafura Sea trawl catches 19–35 percent tiger shrimp, 29–43 percent banana shrimp and 21–31 percent endeavour shrimp (ICES/FAO, 2005).
- Small-scale shrimp fishing in Cilacap on the south coast of Java catches (i) banana/white shrimp; (ii) endeavour shrimp; (iii) *krosok* or a mixture of small species of shrimp; and (iv) *rebon* or small shrimp of Sergistidae and Mysidaceae. The first two categories are exported to Japan and the United States, the third group is used for canning and local consumption, and the fourth group is used for making shrimp paste (Naamin and Martosubroto, 1980).

²⁷ Since the present study is concerned with marine shrimp, freshwater shrimp is not considered further.

TABLE 41
Indonesia's shrimp catches, 1993–2003 (tonnes)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003*
Giant tiger prawns	16 116	16 960	24 501	19 393	25 929	30 047	34 223	40 987	43 759	38 088	34 190
Banana prawns	43 925	47 237	50 477	53 913	53 924	62 192	64 179	66 644	65 269	69 508	66 501
<i>Metapenaeus</i> shrimp	15 814	20 364	22 863	22 285	32 588	40 717	33 847	38 925	36 358	33 570	34 178
Other shrimp	79 714	91 152	81 261	89 215	95 790	87 200	103 372	98 880	113 161	95 561	100 221
Total	155 569	175 713	179 102	184 806	208 231	220 156	235 621	245 436	258 547	236 727	235 090

Source: 2003 statistics, Ministry of Marine Affairs and Fisheries.

* The 2003 shrimp catches, as reported to FAO, are 265 980 tonnes. For other years, the Ministry and FAO statistics are identical.

TABLE 42
Indonesia's shrimp catches by area, 2003 (tonnes)

Area	Giant tiger prawns	Banana prawns	<i>Metapenaeus</i> shrimp	Other shrimp	Total
West Sumatra	1 483	2 040	1 440	1 992	6 955
South Java	1 194	450	213	1 823	3 680
Malacca Straits	6 643	23 622	10 835	27 670	68 770
East Sumatra	940	6 038	6 598	20 943	34 519
North Java	1 833	7 159	1 547	15 890	26 429
Bali-Nusatenggara	166	178	144	346	834
South/West Kalimantan	1 690	6 702	2 596	10 154	21 142
East Kalimantan	9 114	13 114	7 191	10 777	40 196
South Sulawesi	3 427	4 241	1 025	2 432	11 125
North Sulawesi	17	156	0	151	324
Maluku-Papua	7 683	2 801	2 589	8 043	21 116
Total	34 190	66 501	34 178	100 221	235 090

Source: Ministry of Marine Affairs and Fisheries unpublished data, 2003.

- Tidal trap nets in Riau Province catch over 40 groups of fish/invertebrates, as well as the shrimp *Penaeus merguensis* (2 percent of total catch by weight), *Metapenaeus lysianasa* (1 percent), *Parapenaeopsis styliifera* (7 percent), *P. sculptilis* (3 percent) and *Acetes* spp. (1 percent) (Badrudin, Sumiono and Murtoyo, 2001).

The Indonesian Ministry of Marine Affairs and Fisheries (DKP) publishes statistics each year²⁸. Information on shrimp catches in Indonesia from 1993 to 2003 are given in Table 41 and the 2003 shrimp catch is divided by area in Table 42.

It can be seen from the tables that:

- production of shrimp in Indonesia generally increased during the 1993–2001 period, but fell during the following two years;
- the Malacca Straits, followed by East Kalimantan and East Sumatra, are the major shrimp-producing areas;
- the industrial-scale shrimp fishing in Maluku-Papua catches considerably less shrimp than the total of the smaller operations to the west; and
- the production of non-export shrimp (*Metapenaeus* and other shrimp) is greater than that of the export species (banana and tiger).

Some catch and effort data are available for industrial-scale shrimp trawling in the Arafura area, but similar data for the enormous number of smaller-scale shrimp fisheries are less available, accurate and comparable.

Purwanto (2005) summarizes recent CPUE data on industrial-scale shrimp trawling in the Arafura Sea:

- Biological studies indicate a decreasing trend in shrimp CPUE in recent years. In 1993, catch averaged 90 tonnes of shrimp/vessel/year, but this generally decreased to just over 60 tonnes in 2000.

²⁸ Cautions on data quality are given in Chapter 15, Data reporting.

- Industry data show much more variability between years, but a decrease from 63 tonnes of shrimp/vessel/year in 1993, to 32 tonnes in 2000, followed by an increase to 48 tonnes in 2001. The shrimp catch/vessel/day decreased from about 270 kg in 1993 to 160 kg in 2002.

Other sources give additional information on CPUE in industrial-scale shrimp trawling in the Arafura Sea.

- An industry source (Sukirdjo, Association of Indonesian Shrimp Catching Companies, personal communication, December 2005) stated that the catch/vessel/day has decreased from 300–350 kg per day two decades ago to the present 250–300 kg.
- The National Committee for Reducing the Impact of Tropical Shrimp Trawling Fisheries in the Arafura Sea (National Committee, 2001) gives the change in fishing effort from 1990 to 1998 and states that: (i) in 1990, the fishing effort in the Arafura Sea was estimated at 86 640 operational days or 632 472 hauls; and (ii) in recent years, even though the amount of effort increased, the CPUE (kg/haul) remained stable at between 25 and 37 kg. In 1990, the catch per haul was 33 kg but, in 1974, during the early days of the fishery, it averaged 95 kg.
- An Indonesian fishery scientist (M. Badrudin, personal communication, December 2005) has said that the current thinking among researchers is that the Arafura shrimp CPUE has been slack in the last few years, but that the species composition has changed, with the high-value species decreasing. Badrudin and Nurhakim (2004) use two different measures of CPUE (based on 1991–2002 data). The first is in the form of catch/vessel/year, while the second index is the catch/vessel/day. The trend of both indices from 1991 to 2002 is almost horizontal.

ECONOMIC CONTRIBUTION

Each year the Ministry of Marine Affairs and Fisheries publishes fisheries statistics, including the value of species groups. Tables 43 and 44 give the values²⁹ by type of shrimp, area and year.

DKP statistics also give the value of all marine fishery capture production in 2003 as Rp26 641 072 151 000, or about US\$3.1 billion. Therefore, the official statistics indicate that the landed value of marine shrimp capture fisheries is about 18 percent of that of all marine capture fisheries in the country.

The fisheries sector is responsible for about 2.9 percent of Indonesia's GDP. If the value added for shrimp fishing is about average for all fishery subsectors, then shrimp fishing represents about 0.52 percent of the country's GDP (DKP, 2005a).

According to the Director of the Center for Marine and Fisheries Socio-Economic Research in Jakarta, information on employment in shrimp fishing and other fisheries is not readily available in Indonesia (A. Purnomo, personal communication, December 2005). An appreciation of the importance of employment in shrimp fishing can be seen from Table 40. There are approximately 137 000 fishing units using the seven most important types of gear. The employment associated with these units completely overshadows employment on vessels of the industrial-scale shrimp fishery in the Arafura Sea – about 2 900 people on 280 boats.

Data on the consumption of shrimp in Indonesia are not readily available. Naamin and Martosubroto (1980) report that the two statistical categories “*Metapenaeus* shrimp” and “other shrimp” are consumed domestically, while the other categories are exported. In 2003, DKP statistics show that 134 000 tonnes of “*Metapenaeus* shrimp” and “other shrimp” were landed. An Indonesian fishery scientist (M. Badrudin, personal communication, December 2005) expressed the opinion that about half of Indonesia's shrimp catch, or about 118 000 tonnes, is consumed domestically. If it is assumed that

²⁹ Values given are those at the landing site.

TABLE 43
Value of shrimp capture production, 2003

	Giant tiger prawns	Banana prawns	<i>Metapenaeus</i> shrimps	Other shrimp	Total (Rp '000)	Total (US\$)
Sumatra	384 604 184	701 161 521	323 253 500	386 944 501	1 795 963 706	209 027 433
Java	190 978 025	292 954 834	37 684 824	184 967 768	706 585 451	82 237 599
Bali-Nusatenggara	4 503 500	3 361 800	2 699 100	6 712 350	17 276 750	2 010 795
Kalimantan	530 860 176	556 099 553	145 870 233	185 208 440	1 418 038 402	165 041 713
Sulawesi	79 308 000	53 627 760	13 133 830	43 438 867	189 508 457	22 056 385
Maluku-Papua	309 279 500	96 163 140	89 277 500	172 175 900	666 896 040	77 618 254
Total ('000 Rp)	1 499 533 385	1 703 368 608	611 918 987	979 447 826	4 794 268 806	
Total (US\$)	174 526 698	198 250 536	71 219 621	113 995 324		557 992 180

Source: Ministry of Marine Affairs and Fisheries, unpublished data, 2003.

Note: 2003 rupiah/dollar conversion at 8 592 (www.oanda.com).

TABLE 44
Value of shrimp capture production, 2000–03

	2000	2001	2002	2003
Giant tiger prawns	2 047 310 085	2 502 407 356	2 055 284 615	1 499 533 385
Banana prawns	1 701 405 234	1 688 705 550	1 812 160 747	1 703 368 608
<i>Metapenaeus</i> shrimp	618 150 159	619 325 594	631 191 513	611 918 987
Other shrimp	612 662 797	764 473 882	846 072 386	979 447 826
Total ('000 Rp)	4 979 528 275	5 574 912 382	5 344 709 261	4 794 268 806
Total (US\$)	591 744 299	541 621 722	571 626 659	557 992 180

Source: 2003 statistics, Ministry of Marine Affairs and Fisheries.

Note: 2003 rupiah/dollar conversion at 8 592; 2002 at 9 350; 2001 at 10 293; and 2000 at 9 350 (www.oanda.com).

125 000 tonnes are consumed domestically and the population of Indonesia in 2003 was 240 million, then the per capita consumption in 2003 was about 0.5 kg. Shrimp is consumed fresh as well as in processed forms such as cakes, balls, rolls and paste.

TRADE ASPECTS

As already mentioned, shrimp is Indonesia's largest fishery export. DKP (2005) gives the volumes and values of the 2003 and 2004 exports (Table 45). It can be seen that, in 2004, shrimp represented 15 percent of all Indonesian fishery exports by volume and 50 percent by value. By contrast, tuna (the second most important fishery export) represented 14 percent by volume and 13 percent by value.

The shrimp export situation is complicated by the fact that aquaculture shrimp is not distinguished from captured shrimp in the published DKP statistics. The total production of aquaculture shrimp in Indonesia was about 179 000 tonnes in 2003, much of which was exported. An additional difficulty is that, in 2005, both the United States and the EU made allegations that a substantial amount of shrimp from China was being repackaged in Indonesia for re-export in order to circumvent trade sanctions.

Suboko (2001) reports that 89 percent of all shrimp exports are frozen, 9 percent fresh chilled, and the remainder canned. With respect to shrimp exports that originate only from capture fisheries, a representative of the Association of Indonesia Shrimp

TABLE 45
Volumes and values of fishery exports, 2003 and 2004

	2003		2004*	
	Volume (tonnes)	Value (US\$)	Volume (tonnes)	Value (US\$)
Shrimp	137 636	850 222	139 450	887 127
Tuna	117 092	213 179	94 221	243 937
Other fishery products	603 055	580 141	668 687	649 769
Total fishery exports	857 783	1 643 542	902 358	1 780 833

* This is a provisional estimate.

Source: DKP, 2005.

Catching Companies (Sukirdjo, personal communication, December 2005) says that most of their shrimp production is exported frozen, with the product being specific to national markets: tiger shrimp (head-on) and banana shrimp (headless) are sold to markets in Japan; banana shrimp (head-on) are sold to China; small peeled shrimp are sold to the EU; and all shrimp sold to the United States is headless.

For 2000, the main shrimp export destinations (both capture and aquaculture products), were Japan (42 percent by value) and the United States (14 percent) (Suboko, 2001). A representative of the Association of Indonesian Shrimp Catching Companies (Sukirdjo, personal communication, December 2005) says that, in late 2005, the situation was quite different; virtually all captured shrimp exports were sold to markets in Japan and China, with little going to the EU and none to the United States.

Various forms of sanctions have been applied to Indonesian shrimp imports and exports.

- From December 2001 to July 2003, the EU banned imports of cultivated shrimp from Indonesia because they were found to contain the antibiotic chloramphenicol. The EU had previously warned Indonesia that it should comply with an EU directive prohibiting the use of this antibiotic. Indonesia itself had issued a ban on the distribution of chloramphenicol as early as 1982 (Down to Earth, 2002).
- In December 2004, in an effort to combat shrimp transshipments from China through Indonesia to the United States and the EU, the Government of Indonesia banned the import of *Penaeus vannamei*, *P. monodon* and *P. stylirostris* shrimp (United States Embassy press release, December 2005).
- In May 2002, the United States Government banned imports of shrimp from Indonesia and Haiti on the basis of the fact that that these countries are not certified by the United States Department of State as having met the requirement that shrimp entering the United States market are harvested so as to cause no harm to threatened turtle species (Caribbean Update, 2002).

There is considerable confusion in Indonesia with regard to the United States embargo on sea turtles. In late 2005, independent discussions with several Indonesian shrimp industry participants gave the impression that no embargo of Indonesian shrimp was in place, but rather that the United States had issued a warning a few years before, requiring greater compliance should Indonesia wish to continue exporting shrimp to the United States. On the other hand, a United States official (C. Stanger, personal communication, Office of Marine Conservation, United States Department of State, October 2005) said that Indonesian captured shrimp is not certified and cannot be imported into the United States.

The Center for Marine and Fisheries Socio-Economic Research in Jakarta is carrying out a study of non-tariff barriers in the main countries that import Indonesian shrimp. Although the study report has not been released, the authors state that the main result is that non-tariff barriers are more important than tariff barriers for the United States market while, for the EU, the converse is true (A. Purnomo, personal communication, December 2005).

BYCATCH ISSUES

The major bycatch issues in Indonesian shrimp fisheries are the high discard levels of industrial shrimp trawlers in the Arafura Sea; the adverse biological impacts of bycatch in the small-scale shrimp fisheries; appropriate measures to mitigate these bycatch problems; and enforcement difficulties associated with bycatch legislation.

Kelleher (2005) comments on discarding in Indonesia. With the notable exception of the Arafura Sea Shrimp Trawl Fishery, most Southeast Asian fisheries have been given a discard rate of 1 percent. While some discarding undoubtedly takes place, the volumes are so low as to be considered insignificant by most experts from the region. The Arafura Sea Shrimp Trawl Fishery discards over 80 percent of the total catch, around

230 000 tonnes per year. Despite the introduction of BEDs, the total discards remain high as a result of weak enforcement of regulations and lack of local markets for the bycatch, since the fishery is located at a considerable distance from major population centres. Kelleher concludes that:

Discards in Indonesia are considered insignificant as everything is used for home consumption or for commercial purposes, except for the Arafura Sea Shrimp Trawl Fishery.

The National Committee (2001) provides additional information on the Arafura fishery. The landings of bycatch (compared with discarding bycatch) are rather low as a result of operational factors and local socio-economic conditions. The operational factors include the small size of vessels (which do not have enough room for storage of bycatch); the time required to handle the bycatch; and short sailing times between fishing grounds and landing sites (Ambon, Sorong). Socio-economic factors include the decrease in the price of bycatch fish on the local market and costs for its storage and transportation.

Funge-Smith, Lindebo and Staples (2005) quote the legislation relevant to bycatch in the Arafura Sea. Presidential Decree No. 85/1982 requires that BRDs be used on shrimp trawlers. The same decree also stipulates that all bycatch be handed over to the state-owned company. Decree No. 561 of the Minister of Agriculture stipulates that all entities fishing shrimp are required to use the fish from their fishing activities as foodstuff for the population. Fisheries Decree No. IK.010/S3.80.75/1982 requires that trawlers in the Arafura area deploy TEDs, and Fisheries Decree No. 868/Kpts/IK.340/II/2000 requires that a BRD be installed on the body of the trawl (Zainudin and Pet-Soede, 2005).

According to industry sources, a common practice is for Arafura shrimp trawlers to stop using any BRDs about ten days before the end of fishing trips (60-day trips are average), so that the crew can have fish for consumption and sale. The National Committee carried out a survey to evaluate stakeholders' perception of shrimp exploitation. Around 38 percent of respondents from shrimp fishing companies stated that they always use BRDs as required by Presidential Decree No. 85/1982; 25 percent stated that they use them only occasionally or did not know whether they should use them or not. Only 25 percent believed that the use of a BRD is an obligation, while almost 38 percent believed that it is not. Twelve percent stated that they do not use BRDs for technical reasons (National Committee, 2001). It can be concluded from this survey that awareness and enforcement of bycatch legislation are major difficulties.

The catch of turtles in the shrimp trawls of the Arafura Sea has attracted the attention of United States authorities (see section *Trade aspects*), as well as that of Indonesian environmental NGOs. The latter have recently placed observers on shrimp trawlers in the Arafura Sea (Zainudin, 2005).

Measures that have been suggested to decrease the discard rate in the Arafura Sea include: larger minimum mesh requirements; development of a more appropriate BED; stricter enforcement of bans on trawling in inshore areas; increased use of mother ships for bycatch collection at sea; and reduced fishing effort. In addition, Indonesia participates in the GEF/UNEP/FAO shrimp bycatch reduction project.

Discards in the small-scale shrimp fisheries are low or negligible (Kelleher, 2005). Much of the bycatch fisheries is considered "trash fish", which has recently been defined as:

... fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fishmeal/oil (Funge-Smith, Lindebo and Staples, 2005).

Some of the issues arising from catch of trash fish by various fisheries, including shrimp fisheries, are:

- the increasing use of trash fish for aquaculture and other animal feeds;
- competition between the use of trash fish for fishmeal versus use for human food;
- sustainability of the current system;
- amount of fish that becomes trash through poor handling and post-harvest strategies;
- growth overfishing – harvesting of juveniles of commercial species.

WorldFish (2005) comments on trash fish and its associated management in Southeast Asia. The management of trash fish in capture fisheries is a significant challenge, even in comparison with that of managing other types of fisheries in the region. Trash fish generally comes from non-target fisheries using relatively unselective gear. Landings are particularly difficult to monitor since they are often far from major landing sites. There is a strong demand for trash fish that is also changing rapidly as markets evolve. These market drivers are occurring on a very local scale, making it difficult to monitor or influence them. Developing management strategies that will be effective, given the combination of these factors, should be a focus of future discussion.

Indonesia is participating in two international projects focused on reducing bycatch in shrimp fisheries.

- FAO is executing a GEF-funded project “Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management”. In Indonesia, the main emphasis is on selection and testing of suitable technologies to reduce bycatch (BRDs, mesh sizes, square meshes, towing time and towing speed) and collection, processing and marketing more of the unavoidable bycatch (FAO, 2000a).
- The Training Department of SEAFDEC is promoting the use in Indonesia and other Southeast Asian countries of devices that exclude large animals from trawls and those that exclude small fish.

PROFITABILITY

A limited amount of information is available on the profitability of shrimp fishing in Indonesia. Where available, it is often not possible to establish the reliability of the sources, rigorousness of the methodology used to calculate profit and, consequently, the credibility of the results.

Purwanto (2005) gives summary details of the profitability of shrimp trawling in the Arafura Sea, which are presumed to be for 2004.

The Association of Indonesian Shrimp Catching Companies (Sukirdjo, personal communication, December 2005) has a model to calculate break-even costs for shrimp trawling in the Arafura Sea. At specified fuel costs – set at Rp5 480 (US\$.56) per litre in December 2005 – the model can calculate break-even points for Association shrimp trawlers, using as variables:

- catch per day (range: 270 to 390 kg/day);
- percentage of days fished (range: 75 to 85 percent); and
- revenue per kg of shrimp (range: US\$6 to US\$7).

The model indicates that, for example, at a shrimp price of US\$6.50/kg operating 80 percent of days, the average Association trawler must catch 329 kg of shrimp/day to break even. If the price of shrimp increases to US\$7, then 306 kg of shrimp must be caught.

Officials representing several companies that trawl for shrimp in the Arafura Sea have indicated that because of the fuel price increase in Indonesia (see next section), few vessels were profitable in late 2005. Similarly, an Indonesian fisheries management specialist commented:

In short, fuel subsidy removal combined with an open access management system in the management has resulted in the collapse of some fisheries in the country. This policy

TABLE 46
Arafura Sea shrimp trawler profitability

	Vessel size (GT)			
	100–150	151–200	201–300	>300
Income	268 986	329 846	363 535	277 364
Expenditure	93 735	292 966	192 575	272 527
Profit before taxes	175 252	36 020	125 897	-28 414
Profits after taxes	124 633	25 748	42 629	-28 414
Price received per kg of shrimp	5.61	4.76	5.94	5.87
Cost of production per kg of shrimp	2.12	4.48	3.53	7.03
Profit per kg of shrimp	3.49	0.29	2.41	-1.15

Source: Purwanto, 2005.

Units: US\$; 2004 rupiah/dollar conversion at 8 945 (www.oanda.com).

TABLE 47
Cost and returns of Java Sea gear that catches shrimp

	Arad seine	Small Danish seine	Large Danish seine (<i>dogol</i>)
Tonnage of boat (GT)	23	5	23
Income (Rp million/yr)	82.62	30.21	80.43
Cost (Rp million/yr)	65.46	26.33	60.02
Margin (Rp million/yr)	17.16	3.88	20.42

Source: Purwanto, 2003; recalculated from a 1999 study.

Note: 1999 rupiah/dollar conversion used: US\$1 = Rp10 000.

has resulted in bringing many fishing companies to the brink of failure, especially those operating vessels larger than 30 GT in the Arafura Sea (P. Martosubroto, personal communication, May 2007).

With regard to small-scale shrimp fisheries, there is little information available on profitability. Bailey and Marahudin (1987) state that, despite the overwhelming importance of the small-scale fisheries sector in Indonesia, few cost and earnings studies have been attempted. The data available are either from a small number of case studies or from a series of extensive surveys conducted by the government, both of which have inherent limitations.

Cost and returns information on several types of fishing gear used in the Java Sea are given by Purwanto (2003). The results of the analysis of these gears that occasionally catch shrimp are shown in Table 47.

Purwanto concludes that the large Danish seine, a modification of traditional fishing gear called *dogol*, is the most economically viable fishing gear of those studied.

In 1999, a similar study of fisheries in central and northern Java (Priyono, 2003) concluded the following:

... assuming that fisheries activities have a medium risk factor of 10 percent and the existing interest rate is 27 percent, then beach seine, stationary lift net, monofilament gillnet, Danish seine (dogol) and set gillnet are profitable and feasible for investment.

A somewhat different conclusion was reached by a fisheries stock assessment meeting. In early 1995, the Indonesia/FAO/DANIDA Workshop on the Assessment of the Potential of the Marine Fishery Resources in Indonesia reviewed all available information on the shrimp fisheries and other important fisheries of the country. The report of the workshop stated:

In the light of the overall uncertainty, no further investment or effort increase in any shrimp fishery should be considered.

Chong *et al.* (1987) give the results of a 1984/85 study on costs and returns analysis for shrimp trammel net fishers in four central Java north coast sites. The net profits or returns for one unit of trammel net was estimated at Rp2 072 464 (US\$2 100) per year. This profit calculation was based on a nine-month operation/year, i.e. from June to November, and from January to March. Based on the prevailing share system, this

net profit was distributed according to the following breakdown: Rp563 848 (US\$575) for the owner and Rp1 508 616 (US\$1 539) for the crew of three men (excluding the captain) or Rp502 872 (US\$513) per person.

Analysis of resource rent in various fisheries is not a prominent feature of the fisheries literature of Indonesia. According to the Director of the Center for Marine and Fisheries Socio-Economic Research, there are few, if any, studies giving rent in Indonesian fisheries (A. Purnomo, personal communication, December 2005).

ENERGY INPUT ASPECTS

The major issue in Indonesian shrimp fisheries with regard to fuel use is the cost increase that occurred in mid-2005. Although Indonesia is a major oil producer (the only member of the Organization of the Petroleum Exporting Countries [OPEC] in Southeast Asia), increased domestic fuel consumption in concert with rising international prices (about US\$65 per barrel) created a situation where the cash-strapped Government could not continue with its long-standing generous fuel subsidies.

According to a representative of the Association of Indonesian Shrimp Catching Companies (Sukirdjo, personal communication, December 2005), fuel costs for Association vessels were Rp1 800/litre in early 2005 (US\$19.6 at a rate of 9 168), but increased to Rp6 300 in August 2005 and then settled at Rp5 340 in December 2005. Because of this increase, the average annual fuel cost for an Association vessel tripled, from about US\$210 000 to US\$625 000.

A number of measures are being contemplated by operators of Indonesian industrial shrimp vessels to mitigate the effects of a fuel cost rise, including the following.

- *Basing shrimp vessels closer to the fishing grounds.* Vessels currently have to travel considerable distances from their present bases in Sorong, Ambon, Kendari and Kupang. In future, it is expected that vessels will be based much nearer to the fishing grounds in Merauke and Aru.
- *Greater use of mother ships.* By keeping the boats working on the fishing grounds, less fuel will be spent transiting and the number of fishing days will increase.
- *Fleet reduction proposal to the government.* By reducing the numbers of fishing vessels, the profitability of the remaining vessels is expected to increase.
- *Government assistance.* Although a fuel subsidy is not likely, a reduction in licence fees and taxes would help profitability.

Most, but not all, of Indonesia's small-scale shrimp fisheries are motorized and therefore also subject to the negative effects of the recent fuel cost rise.

BIOLOGICAL ASPECTS

Many shrimp stock assessments have been carried out in Indonesia. Activities, such as the following, which bring together the results of various studies, are of particular importance.

- In 1995, the Indonesia/FAO/DANIDA Workshop on the Assessment of the Potential of the Marine Fishery Resources of Indonesia reviewed all available information on shrimp and other major marine fishery resources across the country.
- The National Commission of Marine Fish Stock Resources Assessment is comprised of members from DKP, research institutes and Bogor Agricultural University. The Commission meets periodically and reviews the status of the major marine fisheries in nine areas.
- The National Committee for Reducing the Impact of Tropical Shrimp Trawling Fisheries in the Arafura Sea met in March 2000 and was able to summarize the results of many relevant studies.

Table 48 gives the results of the shrimp assessments of the Indonesia/FAO/DANIDA Workshop. Although somewhat dated, the workshop's conclusions are still

TABLE 48
Shrimp assessment results of the Indonesia/FAO/DANIDA Workshop, 1995

Area	Landings 1992 or 1993	Estimated production (tonnes/km coast)	Estimate of potential, 1995	Status
West of Sumatra	2 400	0.5	3 700	Overexploited
West. of Java	5 300	0.5	5 400	Fully exploited?
Bali to Timor	900	0.1	1 100	Uncertain
Malacca Strait	19 800	11.9	19 800	Over- or fully exploited
South Sumatra and Kalimantan	13 800	2.0	9 500 12 200	Fully exploited Overexploited
Java Sea and East Kalimantan	21 900	6.6	17 200 6 200	Fully exploited? Fully exploited?
Makassar Strait	6 000	0.9	6 500*	Fully exploited
Banda Sea	6 300	0.0	-	No resource
Ceram, Maluku and Tomini	100	0.0	-	No resource
Arafura Sea	6 300	2.9	14 700	Fully exploited
Sulawesi Sea	2 200	0.8	0	Unknown
Pacific Ocean	500	0.2	0	Unknown
Total, and status	85 500	1.5	96 300	No expansion, but management

* This is probably from some other area, such as the Arafura Sea.

relevant because of the participation of a combination of Indonesian and international shrimp stock assessment specialists. The results (over a decade ago) are currently still of interest because they do not show much potential for the expansion of catches, whereas fishing effort has increased considerably over the past decade.

Two important conclusions of the workshop are given below.

- With regard to the industrial fishery in the Arafura Sea, the catch mostly consists of banana shrimp (*Penaeus merguensis*). The number of trawlers increased rapidly until 1973 when the catch was slightly higher than the MSY. The number of trawlers increased slightly thereafter until 1976 when effort started to stabilize at around 30 000 boat days; the optimum number of effort is about 23 000 boat days. This indicates that the shrimp resources in the Arafura Sea are overexploited. It is suggested that effort should be reduced to about 50 percent of that in 1993 to keep the catch around MSY.
- With regard to future shrimp stock assessments in Indonesia, these need to be redone with carefully scrutinized statistical data, starting at the *kabupaten* (regency) level. A detailed description of the shrimp fisheries is also necessary, with independent data to be collected on catch rates by different types of gear.

Since the Indonesia/FAO/DANIDA Workshop in 1995, there have been several meetings of the National Commission of Marine Fish Stock Resources Assessment. According to an Indonesian shrimp researcher (M. Badrudin, personal communication, December 2005), the Commission's 1999 assessment of shrimp resources is still being used largely unchanged.³⁰

The Commission's assessments by management area are often transformed into estimates of present production, potential (a portion of a calculated MSY), and the ratio of the production over the potential, which is often assumed to demonstrate opportunity for expansion of catches. Table 49 gives the most recent summary of this for the penaeid shrimp resources of Indonesia.

In March 2000, the National Committee met for a workshop and sets out the results, which included a summary of Arafura Sea shrimp stock assessments (National Committee, 2001). Table 50 provides information on the standing stock of shrimp resources in the Arafura Sea.

³⁰ A meeting of the Commission was held in December 2005, but the shrimp stock assessment results, if any, are not available at the time of writing.

TABLE 49
Exploitation level of penaeid shrimp by management area

	Fisheries management areas									Total
	1	2	3	4	5	6	7	8	9	
Potential ('000 tonnes)	11.4	10.0	11.4	4.8	0.0	0.9	2.5	43.1	10.7	94.8
Production ('000 tonnes)	49.5	70.5	52.9	36.9	-	1.1	2.2	36.7	10.2	259.9
Level of present exploitation (%)	433.9	705.1	463.7	769.0	-	123.3	87.2	85.1	95.7	274.2

Source: Research Centre for Fisheries, 2001; DKP, 2005.

Note: Fisheries management areas: 1 = Malacca Strait; 2 = South China Sea; 3 = Java Sea; 4 = Makassar Strait and Flores Sea; 5 = Banda Sea; 6 = Seram Sea and Tomini Bay; 7 = Sulawesi Sea and Pacific Ocean; 8 = Arafura Sea; 9 = Indian Ocean.

TABLE 50
Standing stock of shrimp resources in the Arafura Sea

Fishing areas	Shrimp species				Total
	Tiger	Banana	Endeavour	Other shrimp	
Bintuni and Kaimana					
kg/haul	5	13	6	5.5	29.5
kg /km ²	98	256	118	108	580
Tonnes	1 470	3 840	1 770	1 620	8 700
Dolak					
kg/haul	2	18	11	6	37
kg /km ²	39	354	216	118	727
Tonnes	1 755	15 930	9 720	5 130	32 715
Aru					
kg/haul	9	1	6	10	26
kg /km ²	177	20	9 118	197	511
Tonnes	2 301	260	1 534	2 561	6 643
Total Arafura Sea	5 526	20 030	13 024	9 491	48 058

Source: National Committee, 2001.

With regard to the Arafura Sea shrimp stock status, the National Committee (2001) concluded:

Several assessments of shrimp resources in exploitation in the Arafura Sea have been carried out, based on the analysis of commercial fisheries. All results agree that the level of shrimp fishing has already reached a heavily exploited stage ... Shrimp and fish resources seem to have been under high pressure for the last 30 years. Indications of resource deterioration are perceived with the size of the fish and shrimp which are smaller and smaller and the reduction in average catching yield and catch per unit of effort, in general. Apart from this, the status of environment and ecosystems cannot be properly evaluated due to insufficient data.

The comments on stock assessment in this section refer generally to penaeid shrimp. It is recognized, however, that non-penaeid shrimp (e.g. sergestoid shrimps of the genus *Acetes*) are important in Indonesia. Little, if any, stock assessment has been carried out on these species in the country.

In reviewing the above and other work on the biological status of penaeid shrimp resources in Indonesia, the following observations can be made.

- There does not appear to be much potential for expansion of shrimp catches in the country. In many areas, shrimp resources appear to be considerably overexploited.
- Although a substantial amount of biological assessment has been undertaken on the Arafura Sea Industrial Shrimp Fishery, much less has been done on the many small-scale fisheries across Indonesia that, as a whole, catch large quantities of shrimp. This is understandable, considering the difficulties of data collection and analysis in dealing with dozens of gear types and over a hundred thousand fishing units.

- In the Indonesian fisheries literature, there is little mention of the role of environmental factors in features such as shrimp stock size and optimum shrimp catch. In the Australian Northern Prawn Fishery (which is adjacent to the Arafura Sea), annual productivity of banana prawns (the main species of the Arafura Sea fishery) has been closely linked to rainfall levels.

IMPACTS ON THE PHYSICAL ENVIRONMENT

There have been few studies in Indonesia to examine the effects of shrimp fishing on the physical environment.

The National Committee commented on the status of knowledge on the effects of trawling on the seabed:

The bottom habitats in the Arafura Sea have hardly been studied, after and before the utilization of the shrimp trawl. Research activities concerning bottom sediments, biological oceanography or coastal ecosystems such as mangrove were carried out at Banten Bay, Sele Strait and the Aru Islands. However, due to the inconsistency of time and space the information now available is very limited, making it difficult to analyse the impact of shrimp trawl on the seabed and habitat conditions (National Committee, 2001).

The National Committee also carried out a survey to evaluate stakeholders' perceptions of shrimp exploitation and environmental protection (National Committee, 2001). The report of the survey stated that most of the respondents (83 percent) feel that trawling is very dangerous for the biodiversity of living marine resources, while the remaining respondents consider the damage to biodiversity to be acceptable.

Bogor Agricultural University recently carried out a study of the environmental effects of shrimp trawling in the Arafura Sea. Although the results of the study are not available at the time of writing, the researchers involved state that it was oriented towards examining the area from inside the 10-m isobath (where there is no legal trawling) to that outside the 10-m isobath (A. Purbayanto, personal communication, October 2005).

The general feeling among Indonesian fishery researchers is that trawling causes some damage to the seabed, but this has not been adequately studied because of other research priorities (M. Badrudin, personal communication, December 2005).

IMPACTS ON SMALL-SCALE FISHERIES

Small-scale fisheries are extremely important in Indonesia. Some 94.6 percent of the total marine fish landings are taken by small coastal fishers using lines, traps, beach seines or lift nets, with pole and lines, trolling gear and mini-seines for tunas and small pelagics (Flewwelling and Hosch, 2004a). One major objective of the management of marine fisheries is to reduce conflict among various groups of fishers.

One of the greatest conflicts in Indonesian fisheries occurred in the late 1960s and 1970s, when the shrimp trawlers based in the Malacca Straits began to expand their area of operations. The origin and outcome of the trawl ban are described in Box 34. By banning trawling, the government in effect transferred inshore demersal resources from trawl owners to small-scale fishers (Butcher, 2004).

The trawl ban did not stop all conflict with small-scale fishers. Some of the effectiveness of the ban was undermined by weak enforcement and by renaming trawl gear. Endroyono (2000) lists 25 types of gear functioning as trawls that are used in Indonesian areas covered by the ban. Under the ban, trawling is allowed in certain parts of eastern Indonesia provided that it takes place in waters deeper than 10 m; nevertheless, trawling in shallow waters frequently occurs in eastern Indonesia, generating conflict with local communities.

The major critical areas with regard to conflict generated by shrimp fishing are West Kalimantan, North Sumatra and the Malacca Straits (M. Badrudin, personal

BOX 34

Origin and outcome of the Indonesian trawl ban

Butcher (2004) states that the conflict and even violence generated by shrimp trawlers was greatest along the north coast of Java because shrimps was concentrated relatively near to shore and so many fishers depended on these waters for their livelihood. During the 1960s and 1970s, the Indonesian Government introduced a multitude of regulations to restrict the number of trawlers and to prevent them from operating within various distances from shore, but these proved ineffective for various reasons. In 1977, fishers in seven sailing boats attacked a trawler operating off the east coast of Sumatra and killed its captain; there were similar clashes on the south coast of Java.

In July 1980, following many unsuccessful attempts to restrict trawling, President Suharto issued a decree banning trawling from the waters surrounding Java and Bali as of October of that year, and from the waters surrounding Sumatra as of January 1981. As the Director General of Fisheries explained, the banning was a “political decision” taken to reach social peace and stability, by way of providing better protection to poor traditional fishers. The All-Indonesia Fishermen’s Association, a functional group within the Golkar, the Government’s main electoral vehicle, had put considerable pressure on the government to ban trawling. At the same time, many in the government believed that various programmes to help improve the welfare of fishing communities would come to nothing unless the resources on which they depended were protected from trawlers. Unlike earlier attempts to restrict trawling issued as ministerial decrees, the ban carried the full weight of the President and the military. Moreover, it was much easier to enforce a total ban on trawling than to restrict it. Anyone operating a trawl could no longer claim to have been fishing outside areas where trawling was restricted.

Chong *et al.* (1987) summarize the outcome of the trawl ban. The immediate impact was seen in the reduction of violence, loss of human lives, property destruction and tension in the coastal areas and at sea. This in itself was extremely positive for a country such as Indonesia, which places a high value on peace and coexistence. However, close to 25 000 trawl fishers (owner, captain and crew) were immediately thrown out of work because of the ban. The minimum aggregate income foregone was Rp462.5 million or US\$1.11 million per month, or US\$13.4 million per year. The Government realized the economic hardships confronting the displaced fishers and took the necessary steps of action to soften the impact of the ban in the form of a large credit programme to trawl crew to purchase new boats and nets; much was used in already overexploited inshore areas. There was also an immediate interruption in shrimp and fish landings for Indonesia: a 5 percent drop in shrimp landings and a 22 percent drop in shrimp exports.

communication, December 2005). The usual conflict is caused by gear used as a trawl that interferes with smaller-scale fishing activity. In general terms, in attempting to resolve conflict among various scales of fishing activity, the Indonesian Government often relies on the principle of keeping larger vessels further offshore.

It is probable that certain small-scale shrimp fishing gears, such as push nets, have a negative effect on other small-scale gear through catching juveniles or habitat disturbance. These effects, if any, do not appear to be well documented or studied in Indonesia.

MANAGEMENT

Fisheries management in Indonesia is under the joint responsibility of the Ministry of Marine Affairs and Fisheries (DKP) and the provincial and district governments. Law No. 22/1999 devolves authority for government management, including fisheries, to the

provincial (0–12 nautical miles) and district levels (0–4 nautical miles). This devolution of authority occurred fairly recently, and policies and legislation are still evolving. Law No. 31/2004 concerning fisheries has replaced Law No. 9/1985 on fisheries.

Priyono and Sumiono (1997) summarize a major fisheries management dilemma in Indonesia. Although the importance of effective fisheries resource management is clearly understood in the country, nonetheless most government efforts have been directed towards resource development through the expanded use of more productive fishing gear and boats, rather than through effort controls. The most serious management problem facing policy-makers is related to the coastal resources exploited by the vast majority of fishers. Current management regulations attempt to protect both vulnerable resources and small-scale fishers' rights of access to fishing grounds. In the long term, these objectives will turn out to be incompatible, and critical choices will have to be made.

Fisheries management plans and their specified objectives are not a general feature of fisheries management in Indonesia. Objectives often have to be inferred by fisheries legislation. The legislation given below regarding shrimp fisheries gives some idea of the de facto objectives.

The various legal instruments related to shrimp trawling are listed by Endroyono (2005).

- Presidential Decree No. 39/1980, which bans trawling in some areas of Indonesia.
- Other decrees/instructions from 1980 to 1982 that implement the ban.
- Minister of Agriculture Decree 769/1988, which concerns the use of bottom seine nets.
- Director General of Fisheries Decree 340/1990, which stipulates that the mesh size on foreign trawlers may not be less than 5 cm.
- Director General of Fisheries Decree 340/1997, which provides specifications on the permitted gear that is similar to trawling gear.
- Minister of Agriculture Decree No. 1039/1999, which requires vessels using fish trawl nets in the Indian Ocean EEZ of Indonesia to be based in specific ports.
- Director General of Fisheries Decree 868/2000, which concerns specifications for TEDs.
- Ministry of Marine Affairs and Fisheries Decree No. 10/2003 allowing foreign fishnet vessels and shrimp trawl vessels to fish in Indonesia.

Legislation related to shrimp trawl bycatch is repeated from the *Bycatch issues* section and given below.

- Presidential Decree No. 85/1982, which includes provisions that (i) BRDs are to be used on shrimp trawlers; (ii) all bycatch be handed over to the state-owned company; and (iii) in areas of Indonesia where shrimp trawling is permitted, it must be undertaken beyond the 10-m isobath.
- Decree No. 561 of the Minister of Agriculture, which stipulates that all entities fishing shrimp are required to use the fish from their fishing activities as foodstuff for the population.
- Fisheries Decree No. IK.010/S3.80.75/1982, which requires that trawlers in the Arafura area deploy TEDs.
- Fisheries Decree No. 868/Kpts/IK.340/II/2000, which requires that a BRD be installed on the body of the trawl.

Other relevant legislation is the following.

- Minister of Agriculture Decree No. 02/Kpts/Um/1/1975, which prohibits all shrimp fishing activities in Irian Jaya waters with pair trawl gear.
- Minister of Agriculture Decree No. 392/1999 on Fishing Zones, which establishes three fishing zones, with the intention of keeping larger vessels further offshore; it also establishes a minimum mesh size of 1 inch (2.54 cm) (Article 7).

It can be inferred from this legislation that prevention of negative impacts on small-scale fishers is a major objective of shrimp fishery management in Indonesia. The trawl ban to safeguard the interests of small-scale fisheries has been referred to as the boldest fisheries management intervention ever to be implemented in Southeast Asia.

Protection of shrimp fisheries from overexploitation is a less prominent objective. With regard to large-scale shrimp fishing, attempts to restrict access to the trawl fishery of the Arafura Sea by using an established total allowable catch (TAC) to determine the number of vessels to be licensed (Minister of Agriculture and Fisheries Decree No. 995/1999) have not met with much success (ICES/FAO, 2005). With regard to small-scale shrimp fishing, the open access nature of coastal fisheries in Indonesia makes it very difficult to restrict fishing effort.

Industry sources indicate that at the lower levels of government (districts have management authority in the zone from zero to four nautical miles offshore), the main management objective appears to be the generation of government revenue and, to a lesser extent, mitigation of conflict. Resource protection does not appear to be prominent.

In terms of desirable changes in the future management of shrimp fisheries in Indonesia, shrimp trawl industry representatives suggest that the Arafura shrimp trawl fleet be reduced in size to increase the profitability of each vessel. They would also like to see greater resource management measures and stronger enforcement. With regard to small-scale shrimp fisheries management, several DKP staff have expressed the view that, because the management of fisheries – including shrimp fisheries – has been devolved to lower levels of government, these levels should acquire greater skill in fisheries management. Several shrimp researchers would like to see larger minimum mesh sizes for shrimp trawls. There is some discussion about relaxing the trawl ban, or at least modifying it so that it is consistent with present shrimp fishing practices (i.e. acknowledging the use of trawl-like gear).

ENFORCEMENT

Enforcement of fisheries legislation is characteristically weak in Indonesia, which has been noted in several reviews of the country's fisheries sector.

- Many of the problems in the management of fisheries in the country relate to enforcement difficulties. Furthermore, improvements in other aspects of fisheries management will have little positive effect unless this weak link in the system is improved (Gillett, 2001).
- Effective management of fisheries is difficult to achieve, particularly because of the lack of enforcement capabilities in Indonesia. An additional problem is that, at the provincial level, fisheries management matters tend to be dealt with by staff in production divisions as an additional rather than a prime responsibility (FAO, 2000b).
- Licensing and registration mechanisms are weak and lack enforcement. Enforcement of current laws by law enforcement agencies with appropriate penalties being handed down to violators is almost negligible for the national fleets. Lack of attention to these three key inputs to sustainable and responsible fisheries management significantly increases the challenge for DKP to meet its mandate, while reducing its probability for success (Flewwelling and Hosch, 2004a).

With regard to legislation related to shrimp fishing, enforcement is ineffective. While the major enforcement problems appear to be primarily associated with the trawl ban and the prohibition on fishing in shallow waters, these seem to be simply the areas where lack of enforcement is most noticeable. Enforcement is also a major difficulty in other areas, such as those concerned with bycatch and mesh size requirements.

As mentioned previously, Bogor Agricultural University recently carried out a study of the environmental effects of shrimp trawling in the Arafura Sea, oriented towards

examining the area from inside the 10 m-isobath (where there is no legal trawling) to that outside the 10-m isobath. A summary of the study (Monintja *et al.*, 2005) found a substantial amount of trawling in shallow waters, storage of TEDs on deck during fishing, and the use of pair trawl gear.

DKP (2005b) indicates that of the 559 fishnet and shrimp net vessels of Indonesian registry, 182 are equipped with VMS transponders. Full fleet VMS coverage was targeted for 2006.

The cost of enforcing shrimp fishing regulations is not available. Such a calculation would be complicated by the various agencies involved, and by the fact that all of the involved agencies have enforcement responsibilities outside the fisheries sector.

While identifying weaknesses of enforcement related to fisheries management in Indonesia is relatively easy, the challenge is to identify mechanisms to improve the situation. Tan *et al.* (1996) suggest that the political will to improve the dismal management/enforcement situation could be generated by demonstrating in clear terms to high-level policy-makers the financial costs of poor enforcement of legislation in the fisheries sector.

RESEARCH

With regard to Indonesian fisheries research in general, Flewwelling and Hosch (2004b) give a summary of the institutional aspects. The Indonesian Institute of Science and Technology, the Central Fisheries Research Institute and three other research institutes (Research Institute for Marine Fisheries, Research Institute for Freshwater Fisheries and Research Institute for Coastal Aquaculture) are the official agencies that provide research assistance to the Ministry of Marine Affairs and Fisheries. Universities, such as Bogor Agricultural University, often become involved in fisheries research to assist the Ministry in the development of policies and strategies in capture fisheries management.

The National Committee (2001) reviewed the research on the Arafura Sea Shrimp Fishery.

- *Living resources.* Research activities have consisted of obtaining information on: (i) shrimp species caught; (ii) size composition of shrimp in the various fishing grounds; (iii) distribution of effort and catch per species according to water depth and seabed conditions; (iv) population parameters; (v) reproduction parameters (e.g. spawning season, recruitment pattern); and (vi) stock assessment, sustainable yield and level of exploitation. In 1982, after the introduction of regulations concerning BRDs, research related to bycatch was undertaken, which included differences in compositions of trawl catch with and without BRDs, ratio of shrimp and fish catch with BRDs, bycatch species composition with and without BRDs, and ratio of utilized and discarded bycatch.
- *Fishing gear.* Research began in 1982 with the introduction of TEDs on shrimp trawls in the Arafura Sea. In 1997, more gear research was carried out to improve the earlier TED model (i.e. the introduction of super-shooter TED).
- *Oceanographic conditions.* Research was carried out on the mangrove community in Tanimbar Island, fertility levels and the hydrology condition of mangrove waters in Bintuni Bay, and the fish community in waters surrounding mangrove in the bay. In January 1996, a preliminary study was carried out on plankton and chlorophyll distribution patterns in the waters of Kai, and sediment composition in Sorong waters, Sele Strait, Irian Jaya.
- *Socio-economics of shrimp fisheries and bycatch utilization.* Research on the socio-economic aspects of shrimp fisheries in the Arafura Sea has been limited. Some analysis of technical economic parameters regarding shrimp trawl fishing units show more profitability, with increased number of days of fishing operation. Other studies have been carried out on fish handling, marketing and bycatch

utilization, including: (i) identification of the intermediates within the marketing process from producers to consumers, and benefits from bycatch; (ii) catch handling methods according to catch composition and characteristics; and (iii) processing/technology for bycatch value adding.

- *Future research.* Several topics should be considered: improving the accuracy of fisheries data; continuous monitoring of environmental conditions; product development based on unavoidable bycatch; bycatch reduction technology; and improvements in fisheries monitoring and control.

In addition to work in the Arafura Sea, a significant amount of research has been carried out on other shrimp fisheries in Indonesia. Most has been geared to estimating MSY using surplus production models (M. Badrudin, personal communication, December 2005). In addition, specific research has been undertaken on determining the effects of the trawl ban (Chong *et al.*, 1987), monitoring biomass levels (summarized in Priyono and Sumiono, 1997), and the impacts of development projects on shrimp resources and shrimp fishing.

With the support of SEAFDEC, Indonesia is a very active participant in the GEF/UNEP/FAO shrimp bycatch reduction project. The research goals are to find appropriate BRDs for industrial vessels to reduce the bycatch of juvenile fish.

The cost of shrimp-related research in Indonesia is not readily available. Again, estimating the cost is complicated by the large number of government, academic and donor agencies involved and by the difficulties associated with dividing budgets by species groups. Nevertheless, some understanding of the magnitude of financing available can be gained from the Research Institute for Marine Fisheries. Much of the government biological research on shrimp is undertaken at the Institute, which has an annual budget of about Rp3.5 billion (US\$350 000). Approximately 20 percent of the Institute's work is focused on shrimp (M. Badrudin, personal communication, December 2005).

DATA REPORTING

Official DKP fisheries statistics cover production, production units and socio-economic data for marine, inland open water and aquaculture operations. The statistical system in use was established by FAO in 1974/75 and has been described as one of the world's largest national fisheries statistical systems.

A major and chronic problem in the general management of fisheries in Indonesia is the quality of the official fisheries statistics. In the past decade, virtually all missions visiting Indonesia to review marine fisheries resources, stock assessment or fisheries management have concluded that there is an urgent need for better data from existing fisheries. Especially relevant comments have been made by the following.

- Project Concern International (PCI) (2001) mentions the questionable quality of the data and statistics on fisheries currently being compiled, which rely upon an obsolete data collection system based on a sampling framework and methodology developed about 30 years ago.
- Willoughby, Monintja and Badrudin (1999) suggest that the size of Indonesia's non-recorded fish deficit is more than a million tonnes per year – one-third of the total recorded catch.

Specifically with regard to shrimp fisheries, Venema (1996) records that shrimp stock assessments have been undertaken with data from various sources, including: (i) survey data from research vessels; (ii) data collected by scientists on commercial fishing boats; (iii) logbook data; (iv) data collected at landing sites; (v) data collected by interviewing captains and crews of commercial fishing vessels at fishing harbours; and (vi) government fishery statistics at the provincial and regency levels. After a thorough scrutiny of the data, it has been concluded that all assessments need to be redone with independent data, including those on catch rates by different types

TABLE 51
Shrimp pond area and shrimp production

	1998	1999	2000	2001	2002	2003
Area (ha)	357 331	393 186	419 282	438 010	458 107	478 570
Production (tonnes)	353 750	412 035	430 017	454 710	473 128	500 000
Shrimp	121 042	148 673	152 541	154 555	169 915	179 500
Milkfish	158 666	209 758	222 228	209 525	210 000	265 781
Others	35 203	12 543	14 554	37 417	33 836	35 758
No. of households	144 411	183 173	186 485	190 872	193 877	196 500

Source: Ministry of Marine Affairs and Fisheries, unpublished data, 2003.

of gear. Even rudimentary shrimp assessments were only possible in three areas, which were based on focused research results rather than the official statistics.

IMPACTS OF SHRIMP FARMING

Indonesia is a major shrimp farming country. Table 51 gives the shrimp pond area and production of shrimp and other species produced in association with shrimp. Indonesia's production of farmed shrimp is about 15 percent of the world total.

Shrimp farming is concentrated in certain areas of Indonesia. From Table 52 it can be deduced that 60 percent of present production is concentrated in Sumatra and Java. Kalimantan and Maluku-Papua have considerable potential for future production. DKP plans to increase the production of farmed shrimp to 300 000 tonnes per year, or an increase of almost 70 percent over the 2003 level.

The future of shrimp aquaculture in Indonesia is dependent to some extent on relative production costs, profitability and competition with Indonesia's Asian neighbours. Agbayani, Belleza and Agbayani (1997) give the results of a comparative study of these factors, which shows that China is a major competitor and that Indonesia enjoys some advantages in semi-intensive shrimp culture. Indonesia faces strong competition from other Asian countries in intensive and extensive shrimp culture.

Shrimp farming has several effects on shrimp fishing, including:

- the effects of mangrove destruction;
- the effects of shrimp fry collection;
- trash fish utilization;
- contribution to the profit squeeze of shrimp fishing.

Many of the shrimp farms in Indonesia are situated in former mangrove forests. A survey conducted in 12 Asian countries (ADB/NACA, 1997) shows that, across the region, 41.6 percent of shrimp ponds are sited in ex-mangrove areas. In Sumatra, large sections of mangrove forests have been transformed into shrimp ponds, from Aceh to Lampung, where the world's largest shrimp farm (18 000 ponds) was constructed in the 1990s (Butcher, 2004). The precise impact of mangrove clearing on shrimp fishing in Indonesia is not known, but there is likely to be some effect because of the importance of inshore areas in the life cycle of shrimp.

Although there is considerable hatchery production of fry for shrimp farming, there is still some collection of fry in the wild. DKP data indicate that 27.5 million tiger prawn fry (worth US\$275 000) were collected in 2003, mostly from Sulawesi. The effect of this collection on shrimp fishing in Sulawesi has not been studied.

TABLE 52
Current and potential production of shrimp and associated species, by area

	Current production (2003)	Potential production
Sumatra	99 926	204 200
Java	150 874	110 100
Bali-Nusatenggara	8 128	26 300
Kalimantan	60 178	318 100
Sulawesi	129 370	44 900
Maluku and Papua	9 631	209 400
Total	458 107	913 000

Source: Research Institute for Marine Fisheries, unpublished data.

The growth in aquaculture production in Indonesia has been associated with increases in the demand for feed, much of which comes from trash fish. Trash fish is most often used for shrimp farming in the form of pellets. Of Indonesia's total aquaculture production of 900 000 tonnes (all species), it is estimated that about 20 000 tonnes are dependent on trash fish feed, requiring about 96 000 tonnes of trash fish. The demand for trash fish in Indonesia has grown about 22 times since 1993. The largest source of trash fish is from trawl bycatch. Although the large amount of bycatch from the industrial fishery in the Arafura Sea is mostly discarded, much of the bycatch from various small trawls in other areas of the country is considered trash fish and used for aquaculture, including shrimp aquaculture. Shrimp farming in Indonesia is therefore dependent to some degree on trawling and its bycatch (Funge-Smith, Lindebo and Staples, 2005; WorldFish, 2005).

The large increase in farmed shrimp production globally has led to a decline in prices for all shrimp, including captured shrimp. The shrimp price decline plus the rise in fuel prices are the main components of the price squeeze noted in the *Profitability* section. This is having a major effect on commercial shrimp fishing in Indonesia and is likely to result in fewer Indonesian shrimp fishing operations and a lower shrimp catch. Another capture/culture market interaction relates to the species being cultured. Indonesia is substantially expanding the farming of *Penaeus vannamei* and decreasing the farming of *P. monodon*. This should result in a price increase for catches of *P. monodon*, especially the larger sizes.

MAJOR ISSUES

The major issues related to shrimp fishing in Indonesia are summarized below.

- Many of the problems in fisheries management relate to enforcement difficulties. Improvements in other aspects of fisheries management will have little positive effect unless this weak link in the system is improved. With regard to shrimp fishing, there are few regulations and poor enforcement of those that do exist.
- The trawl ban to safeguard the interests of small-scale fisheries has been referred to as the boldest fisheries management intervention ever to be implemented in Southeast Asia, but its effectiveness has been eroded by poor enforcement.
- Unlike Australia and the United States, there is little mention of the concept that changes in environmental conditions produce much of the variability in shrimp stock sizes, and that stocks can quickly recover with favourable conditions.
- The recent rise in fuel costs is having a devastating effect on the profitability of fishing operations, especially trawling.
- Although there are indications that the quality of data has improved in the last decade, there are still problems with fisheries statistics, which has major implications for understanding shrimp fishing in Indonesia.
- It can be seen from workshop results, discussions and reports that there are many local names for small-scale shrimp trawlers; however, some are not very small in scale.
- The results of socio-economic studies show that shrimp fishing is important to Indonesia but causes substantial conflict, and that bycatch issues are equally important and involve many aspects (trade, food security, aquaculture).
- There appears to be a negative feeling that BEDs reduce the shrimp catch and result in less fish for the crew. Simply demonstrating the use of BEDs without creating incentives may not result in much bycatch reduction.
- Fisheries enforcement in Indonesia is weak. A favourable environment for change could be created if the groups negatively affected by slack enforcement had a reasonable influence on government fisheries institutions.
- Despite the large importance of small-scale fisheries in Indonesia, there is relatively little biological or economic research on these fisheries.

- The lower levels of government have little capacity to take on their new management responsibilities, including those for shrimp.
- There is much wishful thinking in the literature published by DKP. Both a booklet and workshop were entitled *Discover the ecofriendly trawl in Indonesia waters* (Endroyono, 2000). In the official statistics, a gear type “BED-equipped shrimp nets” crops up.

Shrimp fishing in Kuwait

Based on the work of Mohsen Al-Husaini

AN OVERVIEW

The shrimp fleet of Kuwait has two components: 35 steel-hulled double-rigged Gulf of Mexico-type trawlers and 34 dhow trawlers. Only three species of shrimp are economically important: green tiger prawn *Penaeus semisulcatus* (60 percent of catches), jinga shrimp *Metapenaeus affinis* (30 percent of catches) and kiddi shrimp *Parapenaeopsis stylifera* (10 percent of catches). The landed value of shrimp is currently about 39 percent of that of all marine capture fisheries in the country. Total shrimp catches for the 2003/04 and 2004/05 seasons were low, at 1 577 and 1 420 tonnes, respectively. In the previous decade, 1996–2006, the average annual catch was about 1 900 tonnes. Shrimp catches fluctuated between 1 012 and 5 125 tonnes from the 1960s through the 1980s. The present low catches, high level of effort and low CPUE seem to indicate that the stock has been overexploited since 1993.



DEVELOPMENT AND STRUCTURE

Kuwait is situated in the northwestern corner of the Persian Gulf, which separates the Islamic Republic of Iran from the Arabian Peninsula, and has a small coastline on the Gulf. The sea area and coastline of Kuwait are characterized by extreme meteorological and hydrological conditions, with water temperatures reaching over 33°C during summer months (air temperatures of over 50°C), high evaporation rates and high salinities (Morgan, 2004b).

Abdul-Ghaffar and Al-Ghunaim (1994) review the development of shrimp fisheries in Kuwait. Commercial exploitation of Kuwait's shrimp resources started in the late 1950s (Boerema, 1969). Dhow boats, wooden-hulled sailing craft employed for fishing and trading, served as the first commercial shrimp vessels using scope nets. Their efforts were soon joined by purpose-built shrimp vessels when the Gulf Fishing Company, established in August 1961, imported Gulf of Mexico-type shrimping vessels to exploit stocks off Iran. By the mid- to late 1960s, dhow boats were fitted with diesel engines to make them more competitive with the introduction of industrial vessels, whose numbers increased in the mid-1960s with the formation of additional fishing companies: the Kuwait National Fishing Company and the International Fishing Company. The increase in the number of shrimp vessels, from 36 in 1964/65 to 124 in 1968/69, suggests that shrimp fishing was extremely good in those early years.

The industrial shrimp fleet is comprised of 35 steel-hulled double-rigged Gulf of Mexico-type trawlers, from 20 to 32 m in length, a beam of 3.7–7.3 m, GT of 79–159

tonnes and a draft of 2.4–3.5 m. The industrial fleet is owned by two fishing companies: the United Fishing Company (20 boats) and the National Fishing Company (15 boats).

The artisanal fishing fleet is comprised of 34 dhows with an average length of 19 m (ranging from 14 to 23 m), a beam of 5.7 m (3.7–6.6 m), a draft of 2.4 (1.8–3 m) and a GT of 45 tonnes (13–95 tonnes).

The landing sites for the industrial fleet are Doha (Kuwait Bay) and Shuaiba (south) ports, while the landing sites for the artisanal fleet are Sharque (Kuwait Bay) and Fahaheel (south) harbours. The catches of the industrial fleet are both processed and exported, and sold on the local market. The shrimp catch by the industrial fleet has declined in recent years, from 80 percent to less than 50 percent of total shrimp landings.

The standard industrial shrimp trawl nets are a four-seam design and operated in a dual-rig configuration (one net towed from each side of the boat). The nets are constructed from polyamide (nylon) material and have a 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, and 50 kg of 5/16 chain with five plastic oval-shaped floats of 20 x 17 cm.

The dhow standard trawl nets are similar in design to the industrial nets but with different specifications: 30.5 m headrope, 33-m footrope, 50-kg chain, 16 plastic oval-shaped floats of 15 x 11 cm, 32 x 45 mm stretched mesh size belly and 2 545 mm stretched mesh codend.

The fishing season usually starts on 1 September and ends in January or February (five to six months later), depending on the catch rates towards the end of the season. However, fishing in the 2004/2005 season started on 15 August and on 1 August in the 2005/06 season.

TARGET SPECIES, CATCH AND EFFORT

Nine species of penaeid shrimp are found in Kuwait's waters. At least four species are caught, of which just three are economically important. These are the green tiger prawn *Penaeus semisulcatus* (60 percent of catches), jinga shrimp *Metapenaeus affinis* (30 percent of catches) and kiddi shrimp *Parapenaeopsis stylifera* (10 percent).

Shrimp catches in Kuwait fluctuated between 1 012 and 5 125 tonnes from the 1960s through the 1980s. The highest catches occurred in the 1988/89 season, followed by the second highest of 4 057 tonnes in the 1989/90 season, through the highly favourable environmental conditions (Siddeek *et al.*, 1994) and regulated low fishing effort. The catches dropped to a level between 1 420 and 2 727 tonnes in the years after the Gulf war (after 1991) and have continued at this level. Fishing effort increased from around 3 000 boat days in the 1960s and early 1970s to more than 10 000 boat days after the war. Fishing effort for the 1993/94 season peaked at 14 600 fishing days and for the 2000/01 season, at 11 510. This high fishing effort with low catches resulted in the low CPUE (134 to 153 kg/day). Total catches for the 2003/04 and 2004/05 seasons were low, at 1 576 and 1 420 tonnes, respectively, and the fishing effort was 8 353 and 8 202 fishing days, respectively.

TABLE 53
Catch, effort and CPUE for Kuwait's shrimp fishery, 1965–2004

Year	Catch (tonnes)	Fishing effort (fishing days)	CPUE (kg/fishing day)
1965	2 747	3 100	886.1
1966	3 158	3 300	957.0
1967	2 697	3 600	749.2
1968	2 357	3 000	785.7
1969	1 772	4 000	443.0
1970	1 104	2 800	394.3
1971	1 804	3 400	530.6
1972	1 985	4 700	422.3
1973	1 437	2 500	574.8
1974	1 595	3 700	431.1
1975	1 012	2 400	421.7
1976	1 968	3 900	504.6
1977	1 084	3 300	328.5
1978	1 402	6 600	212.4
1979	1 215	6 500	186.9
1980	1 515	3 200	473.4
1981	1 699	9 400	180.7
1982	2 156	9 300	231.8
1983	3 140	13 300	236.1
1984	1 684	10 700	157.4
1985	1 778	11 500	154.6
1986	2 065	10 400	198.6
1987	2 455	7 200	341.0
1988	5 126	5 200	985.8
1989	4 057	4 000	1 014.3
1990			
1991	582	1 500	388.0
1992	2 530	5 700	443.9
1993	2 727	14 600	186.8
1994	1 461	10 200	143.2
1995	1 657	12 400	133.6
1996	2 031	9 200	220.8
1997	2 252	5 360	420.1
1998	2 289	7 620	300.4
1999	1 575	10 236	153.9
2000	2 394	11 510	208.0
2001	2 309	9 338	247.3
2002	2 002	13 115	152.6
2003	1 576	8 353	188.7
2004	1 420	8 202	173.1

TABLE 54
Species composition of shrimp catches of the artisanal fleet, 1995/96–2004/05

Season	<i>Penaeus semisulcatus</i> Green tiger shrimp		<i>Metapenaeus affinis</i> Jinga shrimp		<i>Parapenaeopsis stylifera</i> Kiddi shrimp	
	Catch (tonnes)	Percentage	Catch (tonnes)	Percentage	Catch (tonnes)	Percentage
1995/96	440.716	50.27	199.150	22.72	234.227	26.72
1996/97	476.019	61.83	219.005	28.45	72.981	9.48
1997/98	603.839	82.99	119.316	16.40	4.386	0.60
1998/99	534.204	73.26	154.522	21.19	40.131	5.50
1999/00	409.849	58.34	268.728	38.26	23.802	3.39
2000/01	628.796	65.69	234.937	24.55	65.319	6.82
2001/02	695.818	72.44	239.420	24.92	21.022	2.19
2002/03	797.445	77.46	221.376	21.50	10.666	1.04
2003/04	577.644	72.77	200.400	25.25	15.759	1.99
2004/05	592.215	81.14	134.251	18.39	3.308	0.45

TABLE 55
Value of shrimp landings, 2000–04

	2000	2001	2002	2003	2004
Total (US\$)	11 709 811	8 512 979	8 657 722	6 140 551	7 192 476

Source: Central Statistical Office, Kuwait.

Kuwait's shrimp fishing grounds are small. Because the artisanal and the industrial fleets have been fishing in the same area, species composition of the shrimp catch is believed to be similar. Precise monitoring of species composition of the catches for the industrial sector has not been undertaken in the last ten years. For the artisanal sector, such monitoring was carried out until the 1997/98 season. Since then, the species composition for the artisanal fleet has been estimated from fisher interviews (Table 54).

ECONOMIC CONTRIBUTION

Although shrimp trawling is a very important component of fishing in Kuwait, the contribution of the industry to Kuwait's economy is small in comparison with the oil industry. Morgan (2004b) states that fisheries in general are insignificant from an economic point of view in the country and therefore of a low political significance.

Kuwaiti nationals own all vessels and supporting infrastructure of the fishing industry, but almost all employees are expatriates. The main nationalities engaged in the fishing industry are Bangladeshi, Indian, Egyptian and Iranian (FAO, 2003c). With regard to shrimp fishing, there are 612 fishers employed on board the industrial fleet and 274 on board the dhow boats.

Each year the Central Statistical Office (CSO) of the Ministry of Planning publishes fisheries statistics, including the value of species groups. Table 55 shows shrimp values by year.

CSO indicates that the landed value of all marine fishery capture production in 2004 was KD5 342 864, or about US\$18 297 480; Therefore, the landed value of shrimp was about 39 percent of that of all marine capture fisheries in the country.

The contribution of shrimp fishing to GDP in 2003 was US\$4 728 224. This represents about 0.01 percent of Kuwait's total GDP of US\$47.15 billion.

Subsidies are an important economic aspect of shrimp fishing in Kuwait. The industry receives direct subsidies from the government through the Public Authority for Agriculture and Fish Resources. The present value of subsidy is KD2 000 for a steel trawler (US\$6 850.00) and KD750 (US\$2 570.00) for a dhow trawler.

TRADE ASPECTS

Information on Kuwait's shrimp import and export is given in Table 56, which shows that Kuwait both imports and exports shrimp, with the inward trade being about

TABLE 56
Import and export of shrimp, 1995–2004

	Export quantity (tonnes)	Export value (US\$1 000)	Import quantity (tonnes)	Import value (US\$1 000)
1995	263	3 266	193	1 384
1996	468	5 665	226	1 369
1997	839	9 802	191	1 062
1998	611	6 894	254	1 253
1999	570	4 366	169	818
2000	510	5 014	284	1 522
2001	403	3 096	282	1 305
2002	151	1 783	77	219
2003	215	1 381	100	422
2004	154	1 171	379	2 332

Source: FAO, 2006b.

twice that of outward trade. In the late 1980s, about 90 percent of the shrimp landings were exported (FAO, 2003c).

The largest market for Kuwaiti shrimp is the Middle East. The export shrimp data for 2004 showed that 186.9 tonnes were exported to Middle East countries such as Lebanon, the Syrian Arab Republic and Jordan. Shrimp exports to these countries in 2005 were 117.5 tonnes. Shrimp imports come mostly from Thailand.

The artisanal shrimp catches are landed at the main wholesale fish market and sold at local fish markets and retail shops. On some occasions, industrial catches are landed at the wholesale market on the request of PAAF in order to stabilize local prices.

The Iranian shrimp fleet often lands its shrimp catches at Kuwait's fish markets during the shrimp fishing season. The incentive for this is the difference in shrimp prices between the two countries. This offloading is believed to lower market prices in Kuwait by 20 to 30 percent during the fishing season.

BYCATCH ISSUES

The estimated total bycatch of the shrimp fishery in Kuwait has ranged in recent years from 34 737 to 55 495 tonnes. The amount of bycatch actually landed is small, from 1.32 to 1.61 percent of the total bycatch caught; more than 98 percent of the bycatch is discarded. In a recent standardized shrimp survey in the waters of the western Arabian Gulf (Bishop *et al.*, 2001), the fish bycatch in the waters of Kuwait was found to be higher than those of neighbouring countries to the south. On average, the capture of 1 kg of shrimp in Kuwait required the capture of 56.8 kg of fish, most of which was discarded (Bishop *et al.*, 2001).

In a study by Al-Ayoub *et al.* (2005) for only three periods during 2003, the bycatch-to-shrimp ratio was 7.2:1 in October 2003, 3.8:1 in December 2003 and 50.5:1 in February 2004. (The fishing season starts in September and ends in January/February.)

The bycatch in shrimp trawling in Kuwait includes juveniles and adult finfish, sharks, rays, crustaceans, sea snakes, turtles, soft corals, molluscs and echinoderms. Three species were responsible for half of all the finfish bycatch: *Otolithes rubber* (37.11 percent), *Saurida tumbil* (13.55 percent) and *Arius bilineatus* (6.71 percent). Thirteen other species of finfish were common.

Al-Ayoub *et al.* (2005) separately tested performance in comparison with standard nets of two types of BRDs, the fisheye and the square-mesh codend, and one type of TED. The results showed that nets equipped with TEDs caught more shrimp and less bycatch than the standard nets. Nets with the square-mesh codend retained shrimp catch and primary valuable fish bycatch species, while they significantly reduced discard species. The net with the fisheye reduced both the shrimp catch and bycatch.

There is no legislation in Kuwait requiring shrimp trawls to be equipped with BRDs or TEDs. However, the Fisheries Management Department of the Public Authority for Agriculture and Fisheries Resources (PAAF) has plans for the gradual implementation of this gear on a number of trawlers and subsequently adopting regulations and enforcement measures for the whole fleet within two years. Research to implement bycatch reduction technologies including TEDs has started in Kuwait. Because TEDs are not required in Kuwait's shrimp fishery, the country is not able to export shrimp to the United States; however, as a result of the current destination of shrimp from Kuwait, this issue is at present of little relevance to the shrimp trade.

PROFITABILITY

Few data are available on the profitability of shrimp fishing in Kuwait. However, some observations can be made.

- Despite low shrimp catch rates, the profitability of fishing units appears to be adequate, as shown by their continuing operation.
- The profitability of shrimp fishing is significantly distorted by direct (and increasing) government subsidies, which are a government response to the recent low catch rates. The annual subsidies are KD2 000 (US\$6 850.00) for a steel trawler and KD750 (US\$2 570.00) for a dhow trawler.
- Demand for shrimp is continuously increasing while production is decreasing; domestic prices of shrimp are consequently rising significantly.

Unlike other shrimp fishing countries, profitability of shrimp fishing in Kuwait is protected to some extent by marketing arrangements (most is sold on the domestic market where prices are rising) and by the fuel cost situation (stable prices for the last five years). Although catch rates have fallen over the last decades, subsidies partially compensate. However, these subsidies also contribute to overcapitalization, lower catch rates and decrease profitability without additional subsidies.

ENERGY INPUT ASPECTS

The fuel consumption by the 15 trawlers of the National Fishing Company for the 2005/06 season was about 900 000 litres (US\$215 750). That of the 20 trawlers of the United Fishing Company for the 2005/06 season was about 2 592 000 litres (US\$517 752). The estimated fuel consumption by the artisanal shrimp fishery for the 2005/06 season was 1 468 800 litres (US\$308 448).

Since fuel prices have not changed over the last years, fuel costs have not contributed to any instability in profits. In this respect, the profitability of Kuwait's shrimp fishery is among the few fisheries in the world unaffected by recent increases in fuel costs.

BIOLOGICAL ASPECTS

Most research on fisheries biology of shrimp has been concentrated on the major species, *Penaeus semisulcatus*. Peak spawning of *P. semisulcatus* in Kuwait waters occurs in March. A high percentage of gravid females are observed from December to May.

The distribution of *P. semisulcatus* extends from Kuwait Bay to Kubber Island and southwards towards the border with Saudi Arabia, while distribution of *Monoporeia affinis* extends from Kuwait Bay to Failakah Island and northeastwards around Bubiyan Island and the mouth of the Shatt Al-Arab. Juveniles of *P. semisulcatus* are most abundant in shallow waters in the spring on sandy or reefal bottoms with attached vegetation, whereas *M. affinis* is found on shallow muddy bottoms during summer. Biological oceanography and juvenile surveys in the early 1980s showed that Kuwait Bay and the coastal areas are important nursery areas for *P. semisulcatus*, and hence trawling was banned in these areas. Tagging studies indicated migration movement between Kuwait Bay and outside deeper waters.

Research carried out has allowed the estimation of growth and mortality for *P. semisulcatus* and *M. affinis*.

The estimated MSY for *P. semisulcatus* and optimal effort for the seasons 1969/70 and 1986/87 was from 1 794 to 1 872 tonnes at 6 061 to 7 032 boat days (Siddeek, Abdul-Ghaffar and El-Musa, 1988). Because the fishery is characterized by low catches, high fishing effort and low CPUE, it appears that the stock has been overexploited since 1993 (Al-Foudari, 2005a; 2005b).

The estimated recruitment index shows that annual recruitment is variable. By incorporating temperature and salinity parameters, a good 1988/89 season had been predicted. The yield per recruit and biomass per recruit analyses showed that a

1 September opening and an end of February closing of fishing maximizes catches (Siddeek, El-Musa and Abdul-Ghaffar, 1989).

The results of cooperative shrimp stock assessment in 1998–2001 (Bishop *et al.*, 2001) indicated that the percentage of gravid females of *P. semisulcatus* was relatively higher in Kuwait and Saudi Arabia than in the more southern countries, such as Bahrain and Qatar. A very marked north-to-south gradient was found for growth parameters of *P. semisulcatus*; this species seems to grow larger in Kuwait than in Bahrain. Yield per recruit analysis showed that maximum biomass and yield per recruit were obtained in Kuwait in August, while the maximum biomass and yield per recruit were lower in Bahrain and occurred in June. Accordingly, the opening of the fishing season in subsequent years was stipulated to be in August in Kuwait and in June in Bahrain.

IMPACTS ON THE PHYSICAL ENVIRONMENT

Bycatch, discarding and the impact of trawling on the seabed and on associated animals were issues considered in the environmental impact assessment of shrimp fisheries by Al-Yamani *et al.* (1999). The study showed that information on changes in benthic communities before and after trawling is lacking and therefore, precise assessment of the physical impact is difficult. The study did, however, recommend using BRDs and TEDs to reduce the impact of shrimp trawling on fish and benthic organisms. It also urged the reduction of fishing effort to decrease the amount of discards. In addition, the study found only minimum impact of waste and fuel discharging by trawlers.

IMPACTS ON SMALL-SCALE FISHERIES

There are some conflicts between shrimp trawlers and those who fish using traps and gillnets on fishing grounds during the shrimp fishing season. This is because of Kuwait's very limited sea area. Conflict has been minimized recently by the transfer of trap fishing operation areas beyond the territorial waters and where shrimp trawling occurs.

MANAGEMENT

Responsibility for fisheries management in Kuwait lies with PAAF, although national and regional environmental authorities have influence in the management of marine areas. Morgan (2004b) reviews the general framework for fisheries management in Kuwait. PAAF administers the national fisheries legislation, which is held in law No. 46 of 1980 on protection of fisheries resources. This is the basic fisheries law and includes regulations that address, *inter alia*: (i) the right of fishing and exploitation of marine resources that are determined by a decree; (ii) regulation of foreign vessels that can only fish with a licence issued by the competent minister; (iii) the requirement that all fishing vessels be owned by a citizen of Kuwait; (iv) the requirement that licences be issued to fishers operating licensed fishing boats; and (v) regulating gears used in fishing, in cooperation with other departments, to enforce regulations and law.

Morgan (2004b) reviews the evolution of shrimp fisheries management in Kuwait. Because of a rapidly expanding trawl fleet in the 1960s, catches in the 1970s dropped, resulting in the introduction of management measures in 1980. These included closed seasons, protected areas (Kuwait Bay and the three nautical mile coastal zone), mesh size regulations and effort limitation in order to optimize shrimp productivity. As a result of these management measures, and particularly with the reduction in the number of industrial vessels in the mid-1980s, shrimp landings rose to between 4 000 and 5 000 tonnes in 1988 and 1989. However, after the 1991 liberation of Kuwait from Iraqi occupation, industrial fishing capacity was permitted to increase to 35 vessels (with illegal fishing by dhow vessels in the nursery areas of Kuwait Bay also being common), resulting in a reduction of catches and catch rates.

The present shrimp fishery management measures consist of the following:

- *A closed season.* This usually begins in February or March, depending on the catch rates during January, and extends to September when the fishing season begins.
- *Closed areas to protect spawning as well as recruitment.* These areas are Kuwait Bay and the zone three nautical miles from the coast.
- *Effort limitation.* Entry to the fishery is limited to 35 industrial boats and 28 artisanal dhow boats; however, the number of artisanal boats has recently increased to 33.
- *A minimum mesh size* for shrimp trawl nets of 45 mm (stretched).

ENFORCEMENT

The enforcement of fisheries regulations in Kuwait's territorial waters is the responsibility of PAAF. Twenty-six surveillance and fisheries patrol boats are owned by PAAF and 130 people are involved in the operation of these vessels.

The total annual cost in 2005 for enforcement by PAAF for Kuwait's fisheries was KD1 091 532 (US\$3 714 600). It is estimated that the shrimp fishery is responsible for about 40 percent of all enforcement costs.

RESEARCH

Research on the assessment of shrimp resources has been conducted by the Mariculture and Fisheries Department of the Kuwait Institute for Scientific Research since 1977. Routine catch, effort and biological data collection systems were established and annual workshops held to discuss the findings and management decisions. Systematic sea surveys, shrimp tagging experiments, selectivity studies and a juvenile distribution study were also conducted. These research projects were supported by the Kuwait Institute for Scientific Research (KISR), the Kuwait Fund for the Advancement of Science, the Public Authority for Agriculture and Fisheries, and FAO (1977–79).

A cooperative project on shrimp stock assessment in the waters of Kuwait, Saudi Arabia, Bahrain and Qatar was conducted from 1998 to 2001. It was supported by the Kuwait Fund for the Advancement of Science, the Islamic Development Bank and Arab Funds for Economic and Social Development.

A research project started in 2007 to study the relationship between the shrimp stocks in Kuwait and the international waters near Kuwait in order to evaluate the fishing power of the fleets and to assess Kuwait's stock after recent changes in the environment of the northern Arabian Gulf.

In recent years it has been estimated that the annual costs of KISR research projects on the shrimp fishery average KD100 000 (US\$340 000, early 2006).

DATA REPORTING

There are three sources of fisheries data for Kuwait.

- The Central Statistical Office of the Ministry of Planning collects fisheries data on a daily basis. It covers the wholesale volumes of fish and shrimp by species on the local market.
- A second source of fisheries data is project-oriented. It is implemented by the Kuwait Institute for Scientific Research for fish stock assessment and other biological aspects. These data include catch, effort, species composition per sector, fishing area and month.
- In recent years, PAAF has collected catch and effort data on shrimp fishing by general census at the main wholesale fish market.

The data collection of the Institute is based on six sampling days per month. Biological samples are collected from each major fishing ground for each sampling day. The computerized database was lost by the Iraqi invasion troops in the 1990/91 war, but the data files were salvaged and secured.

IMPACTS OF SHRIMP FARMING

At present, there is no shrimp aquaculture activity in Kuwait. The only country in the Gulf region that has shrimp aquaculture is the Islamic Republic of Iran, but Kuwait does not import farmed shrimp from this country.

MAJOR ISSUES

The major issues related to shrimp fishing in Kuwait are the following:

- although shrimp trawling is an important component of fishing in Kuwait, in comparison with the oil industry, the contribution to the economy is small;
- present low catches, high level of effort and low CPUE seem to indicate that shrimp stocks have been overexploited since 1993;
- although shrimp fishing overcapacity has been generally recognized for some time and there has been an attempt to halt its increase, the number of industrial fishing vessels was allowed to increase in the mid-1990s;
- there is a high level of bycatch in shrimp trawling, more than 98 percent of which is discarded; and
- subsidies are an important economic aspect of shrimp fishing in Kuwait but contribute to overcapacity, which lowers catch rates and (without additional subsidies) reduces profitability.

Shrimp fishing in Madagascar

Based on the work of Zbigniew Kasprzyk

AN OVERVIEW

Industrial, artisanal and traditional fishers in Madagascar have captured between 10 000 and 13 000 tonnes of shrimp in recent years. Employment related to shrimp fishing is extremely important in the country and shrimp, both captured and farmed, is the most valuable fishery export. About 5 000 tonnes of shrimp have also been produced by farming operations. Shrimp from Madagascar is particularly appreciated in Europe and commands a higher price than shrimp products from Asia or Latin America.

About two-thirds of shrimp landings come from the export-oriented industrial trawl fleet, comprised of 70 trawlers. Eight thousand to 10 000 people are involved in traditional shrimp fishing, which is instead aimed primarily at the domestic market. The relationship between these two sectors is significant for shrimp fishing management in Madagascar.

A substantial amount of biological, economic and social research on shrimp fishing is carried out in the country. The major decline in shrimp catches in 2005 is likely to be the subject of much future research.

DEVELOPMENT AND STRUCTURE

There are two main categories of shrimp fisheries in Madagascar: the deep-water shrimp fishery and the coastal fisheries.

The deep-water shrimp fishery has been only slightly developed, and just along the coast. Annual shrimp production has fluctuated between 100 and 150 tonnes (130 tonnes in 2003). Fishing ceased in 2005 for several reasons: the seabed caused difficulties in trawling; there were limited shrimp resources; and trawlers were in a poor condition. The fishery started operations in 1992 with just one trawler. From 1998 to 2001, there were four trawlers, but in 2004 only one remained, which operated for a mere three months. The vessels were stern trawlers of 50–55 m in length, 400–600 GRT, 1 500 HP, and they were all more than 20 years



old. The fishing zone was located between the 400-m and 750-m isobaths. The major species captured were *Plesiopenaeus edwardsianus* and *Aristeomorpha foliacea*, known as scarlet shrimp and giant red shrimp, respectively.

The fisheries for coastal shrimp are much more developed. These fisheries are the most important marine fishery activity and also provide the most valuable fishery exports for the country. They are divided into three categories: industrial (68.6 percent of landings during the period 2000–04), traditional (27.3 percent) and artisanal (4.1 percent).

The industrial shrimp fishery consists of 70 freezer trawlers, of which 64 are active on the west coast and six on the east coast. They vary in length from 23 to 30 m and in HP from 250 to 500. The fleet exploits local shrimp stocks close to the coast at a depth of 7–25 m. The fishery began in 1967 with a Japanese-financed company. Currently, all industrial shrimp fishing companies in Madagascar are local companies relying on substantial foreign capital.

The artisanal shrimp fishery has 36 “mini-trawlers”, with engines of less than 50 HP and a length of 10 m. These vessels operate on the west coast, only during the day, and usually very close to the coast in estuary and mangrove areas. They characteristically trawl in waters up to a depth of 10 m. The mini-trawler design was introduced to Madagascar in the 1970s, under an FAO programme. At that time, it was thought that motorizing traditional fishing craft was a logical and necessary step towards modernizing traditional fishing. As it turned out, the most important factor driving the acceptance of this vessel design was the financial success of the industrial fishery. Although there was the idea that mini-trawlers could offer local fishers an entry into modern shrimp fishing, the reality is that all these vessels today belong to the owners of industrial shrimp vessels.

Traditional fishing is defined as fishing undertaken individually or as a group, using non-motorized vessels (powered by paddle or sail), or on foot with a very limited fishing area. Various forms of nets, weirs and traps are used. More than 600 traditional shrimp fishing sites have been identified along the Malagasy coast and, although the precise number of fishers involved in traditional shrimp fishing is not known, it is likely to range from 8 000 to 10 000 people. This fishery, which has operated for many years, is aimed primarily at the domestic market – dried shrimp (often boiled/dried) for inland markets and fresh shrimp for markets close to the coast. Over the last 25 years, the production of the traditional shrimp fishery has increased by 400 percent – from 800 tonnes in the late 1970s to about 3 500 tonnes in 2004. Significant factors in this increase were the development of a collection network, and the substantial migration of people to coastal areas, attracted by shrimp fishing opportunities. Because access to fishery resources in Madagascar is open, anyone can be a fisher. This has led to a situation in which many villages have more immigrants than locals. Since the locals often own fishing vessels and gear, they frequently rent them to immigrants.

Two additional major characteristics of shrimp fishing in Madagascar are the following.

- The number of operational industrial trawlers has begun to decrease. This process was initiated by the vessel operators themselves in order to improve profitability by increasing the productivity of each remaining vessel. On the other hand, the number of traditional shrimp fishers and fishing units has increased.
- Capital is heavily concentrated in three groups of operators. They largely dominate the industrial and artisanal fisheries, as well as the semi-industrial farming of shrimp.

TARGET SPECIES, CATCH AND EFFORT

Table 57 gives the shrimp species in the three fishery subsectors.

The combined Madagascar shrimp catch is dominated by *Penaeus indicus* (78 percent by weight). This species, known as the Indian white prawn, accounts for almost

TABLE 57
Shrimp species by fishery subsector

Shrimp fishing subsector	<i>Penaeus indicus</i> (%)	<i>Metapenaeus monoceros</i> (%)	<i>Penaeus monodon</i> (%)	Other (%)
Industrial	67	24	–	9
Artisanal	97	1	1.7	0.3
Traditional	99	–	1	–

Source: Dintheer, Andriambalotiana and Razafindrakoto, 1998.

TABLE 58
Shrimp catches by fishery subsector, 1996–2004

	Industrial	Artisanal	Traditional	Total
	(tonnes)			
1996	8 136	334	2 000	10 470
1997	8 146	609	2 000	10 755
1998	8 782	446	2 242	11 470
1999	7 888	480	2 139	10 507
2000	8 303	412	3 412	12 127
2001	7 889	437	3 450	11 776
2002	9 207	467	3 450	13 124
2003	9 370	494	3 450	13 314
2004	7 155	710	3 450	11 315
Average 2000–04	8 385	504	3 342	12 231

Source: Direction de la pêche et des ressources halieutiques (DPRH).

all of the traditional and artisanal shrimp fisheries in the country, and 67 percent of the industrial fishery. The second most important shrimp species in the catch is *Metapenaeus monoceros*, or speckled shrimp, which is taken almost exclusively by the industrial fleet. Other species taken are *Penaeus monodon* (giant tiger prawn), *P. semisulcatus* (green tiger prawn) and *P. japonicus* (kuruma prawn).

The species composition of the shrimp catch depends to some extent on the fishing area, the season and the fishing strategy (day or night fishing). For example, the east coast fishery is mainly based on *M. monoceros*, with some *P. indicus* caught at night.

The Madagascar shrimp catches by fishery subsector for recent years is shown in Table 58. It can be seen that:

- industrial production of shrimp remains dominant, with a substantial contribution by the traditional subsector;
- after good catches in 2002 and 2003, they fell 15 percent in 2004 as a result of a sharp decline in industrial production.

The 2005 statistics were not available at the time of writing, but the total shrimp catch for the year can be estimated at 9 500 tonnes or under. Industrial production fell to about 5 600 tonnes. Traditional catches also declined, mainly in the northwest of the country. There are numerous reasons for the falling catches but biological factors are likely to be the most important. Over the course of the last 30 years, it has been observed that after two, three or even four years of good catches, a fall in catch occurs. However, this decrease has never been as significant as in 2005, so other factors are likely to have contributed, which could include two cyclones at the beginning of the year, a rare occurrence on the west coast of Madagascar. Another factor could be the rapid and uncontrolled expansion of traditional shrimp fishing. The traditional fishery captures small- and medium-sized shrimp close to the coast (estuaries, mangrove areas and river mouths), which prevents growth of the shrimp offshore.

With regard to the seasonality of shrimp fishing, the industrial shrimp fleet catches more than 50 percent of its shrimp during the first three months of the season. The fishing season generally begins on 1 March and ends on 30 November. For traditional shrimp fishing, the best shrimp fishing is in March, April and May (like the industrial fleet) and then in October and November.

For the industrial and artisanal subsectors, shrimp fishing effort is limited by the number of licences allocated annually. In the 1990s, the number of licences for industrial trawlers increased from 51 to 75 and from 14 to 36 for mini-trawlers. At the beginning of the 2000 fishing season, the number of licences was frozen (Decree No. 2000-415). In 2004, the number of operational trawlers decreased to 70 due to a decision by operators themselves to improve production and profitability of the remaining vessels, as mentioned previously. “Effort creep” continues to occur in the fleet, mainly through increasing experience of the captain and crew. For the traditional shrimp fishery, there is currently no legal framework for limiting fishing effort.

The annual production of a shrimp trawler in Madagascar is relatively high compared with other countries. On the west coast, catches average about 150 tonnes of shrimp for a vessel of 500 HP, and 115 tonnes for a vessel of 270 HP. The average on the east coast is about 80 tonnes for a vessel of 500 HP. In recent years, however, the average catch has fallen dramatically in certain zones to about 100 tonnes per freezer trawler.

The catch of shrimp per hour of trawling has declined from more than 40 kg in the 1960s, to 30–35 kg in the 1980s and to 20–30 kg from 2000 to 2004.

ECONOMIC CONTRIBUTION

In 2004, the value of the shrimp catches from the industrial, artisanal and traditional fisheries was estimated at US\$70.2 million.

Shrimp fishing is Madagascar’s second most important source of foreign currency. Shrimp accounted for 11.9 percent of all exports in 2003. Shrimp fishing by the industrial and artisanal subsectors contributed about 1 percent to Madagascar’s GDP. Contributions to GDP by fishery subsector are given in Table 59.

In 2004, industrial and artisanal shrimp fishing employed 3 970 people: 3 210 in industrial fishing and 760 in artisanal fishing.

The number of traditional fishers that do at least some shrimp fishing during a year probably varies between 8 000 and 10 000 people.

All of the landed bycatch from the shrimp fisheries (about 4 000 tonnes annually), and a portion of the shrimp catch (1 500–2 000 tonnes, mainly from traditional fishing) are sold in local markets. Consumption of the bycatch of shrimp fisheries constitutes about 6 percent of the national intake of fishery products.

Licence fees paid by the industrial and artisanal shrimp fleets amounted to US\$4.6 million in 2005.

TRADE ASPECTS

In 2004, Madagascar exported 8 220 tonnes of products originating from shrimp fishing, valued at US\$68.2 million. About 80 percent of this came from industrial shrimp fishing, with the rest from artisanal and traditional fishing. For comparison purposes, in the same year Madagascar had exports of farmed shrimp of 5 430 tonnes, worth US\$55.7 million.

Industrial shrimp exports are dominated by whole shrimp (66 percent) and, to a lesser extent, headless shrimp (29 percent). Shrimp exports by the artisanal and traditional subsectors are largely peeled and headless. Most exported shrimp is sold whole to Europe, while the headless product (12 percent) is sold to Japan. A small portion is sold in neighbouring countries (Mauritius and Réunion). Madagascar was certified for export of wild-caught shrimp to the United States market in January 2007. This certification is conditioned by the proper use and implementation of TEDs.

TABLE 59
Contributions of shrimp fishing to GDP,
by subsector, 2001–03

Year	Industrial fishery (%)	Artisanal fishery (%)
2001	0.84	0.09
2002	0.91	0.07
2003	0.70	0.09

Source: Observatoire économique, 2004 and 2005.

BYCATCH ISSUES

The bycatch in Madagascar shrimp fisheries is largely made up small fish, which are mostly discarded at sea. Previously, 15–20 percent of the bycatch was retained for sale in local markets. Since 1998, the government fishery agency has required that each kg of landed shrimp be accompanied by at least 0.5 kg of fish. Over the last few years, the amount of bycatch landed annually by the industrial fleet has been about 4 000 tonnes.

At the beginning of a shrimp fishing season (February–April), when catches are good and it is difficult to handle all the shrimp, almost all of the bycatch is generally discarded. From May onwards, more of the bycatch is retained, and most is taken in September, October and November. Over the course of a fishing season, the shrimp catch decreases while that of bycatch increases.

The ratio of shrimp to bycatch on industrial trawlers varies between 1:1 and 1:5 in Madagascar. This proportion depends on the fishing area, the season and the time of day when fishing takes place. On the west coast, the ratio of shrimp to bycatch is 1:2 in the northern part and 1:4 in the south. From a study undertaken in the late 1980s, a ratio slightly greater than 1:3 was calculated for all industrial trawlers. Applying this same ratio to all trawlers (industrial and artisanal) gives a total bycatch of about 20 000 tonnes in 2004.

Using estimates of total bycatch and data on the amounts of bycatch and shrimp landed, discard rates of the industrial shrimp fleet can be calculated. These were about 65 percent in 2003 and 55 percent in 2004. Kelleher (2005), using data from a few years earlier, states that Madagascar's industrial shrimp trawl fisheries discard over 30 000 tonnes (72 percent discard rate).

The reduction of bycatch results in some economic losses for the industrial shrimp fishery. On the other hand, benefits accrue to the industry from not harvesting fish at the juvenile stage. The possibility of obtaining ecocertification also provides an incentive for reducing bycatch.

PROFITABILITY

Analysis by the Observatoire Économique of the economic performance of the Madagascar shrimp fisheries (industrial and artisanal) between 2000 and 2004 indicates that:

- the value of the average annual production was US\$51.9 million;
- the average annual intermediate expenses of the above production were US\$31.6 million;
- value added by the industrial and artisanal shrimp fishing activities is therefore US\$20.3 million.

Despite the positive average results from 2000 to 2004, it should be noted that, compared with 2001, 2004 was a year of crisis: the value of landings fell by 23 percent, value added decreased by 29 percent and employment fell from 5 000 in 2002 to 3 970 in 2004. Projections by the Observatoire Économique indicate that value added for the industrial and artisanal shrimp fisheries for 2005 was between US\$4.5 and US\$10.5 million, compared with US\$25.1 million in 2004. This is a decline of between US\$13 and US\$19 million.

ENERGY INPUT ASPECTS

Trawling is a fishing technique characterized by high fuel consumption. In 2001, the cost of fuel, as a proportion of all intermediate production expenses, was about 27 percent for the industrial shrimp fishery and 21 percent for the artisanal fishery. For both subsectors, fuel is the most significant intermediate expense.

Some steps have been taken to mitigate the effects of high fuel costs. Since 2001, the industrial shrimp fleet has taken advantage of offshore fuelling. In 2004 and 2005, a

project was undertaken on fuel reduction in shrimp fishing by studying various fishing gear modifications. Moreover, subsequent to changes in the management regime (increased closed season and a ban on night fishing), which started in 2004, fuel and oil consumption has been reduced by 20 percent.

BIOLOGICAL ASPECTS

Several assessments of MSY have been undertaken in the industrial shrimp fishery of the west coast (zones A, B and C, from the north to the south), using global production models (Schaefer and Fox). These estimates are shown in Table 60. For the east coast (Zone D), the figure represents the estimation method used by the government fisheries agency, and corresponds to the level of maximum catches over the long term.

According to the yield estimates in Table 60, the potential annual yield of Madagascar's shrimp fisheries is about 8 700 tonnes of shrimp, of which the west coast contributes 8 200 tonnes. This corresponds to the past average production of just the industrial shrimp fishery. Considering that, from 2000 to 2004, the entire annual production of shrimp from all three shrimp fishery subsectors averaged 12 231 tonnes, this suggests that Madagascar's shrimp resources are overexploited. However, it should be noted that the global models, which do not consider the biological parameters of stocks, are only able to give crude estimates of exploitation levels.

Since 2004, assessment of the principal stocks exploited by Madagascar's three shrimp fisheries has been undertaken using Pope's cohort analysis, which brings together the population and age structure, using catch data. The study consisted of an analysis of the four principal stocks at the end of the 2003 season: *Penaeus indicus* in zones A, B and C, and *Metapenaeus monoceros* in zone D. This is the first shrimp stock assessment in Madagascar to use the same geographic areas as for shrimp fisheries management. The main conclusions of the study are the following.

- The four stocks studied are largely in a condition of full biological exploitation.
- On the west coast, *Penaeus indicus* is most intensely exploited in zone A (the northernmost part of the west coast). At the end of the 2003 season, the stock was slightly overexploited.
- In zone B (on the west coast, south of zone A), the female stock is almost fully exploited, but the male stock appears to be greatly underexploited, although some caution should be attached to this finding.
- In zone C (central/south west coast), male and female stocks appear to be biologically lightly underexploited.
- The *Metapenaeus monoceros* stock of the east coast (zone D) appears to be biologically slightly underexploited.

There is some disagreement between shrimp vessel operators and fishery scientists on the status of shrimp stocks. The operators claim both economic and biological overexploitation, while the scientists feel that it is a situation of full exploitation or slight biological underexploitation of the resources. A large decrease in landings in 2004 and 2005 indicates the need for a new and detailed analysis of shrimp stocks.

TABLE 60
Estimates of shrimp yield

Zone	MSY (tonnes)	Estimation method
A	1 490	Global production models (Schaefer and Fox)
B	1 560	Global production models (Schaefer and Fox)
C	5 147	Global production models (Schaefer and Fox)
D	500	Maximum annual production
Total	8 697	

Source: Oceanic Development, 2005.

IMPACTS ON THE PHYSICAL ENVIRONMENT

The fishing technique of bottom trawling is characterized by a certain amount of destruction of benthic flora and limited selectivity. In the case of traditional shrimp fishing, where passive fishing gear dominates, the selectivity varies according to gear type.

Substantial efforts have been made by shrimp vessel operators to lighten fishing gear in order to reduce fuel consumption. At the same time, this gear modification is likely to have reduced the negative effect of trawling on the seabed.

Before 2003, the principal concern was to determine the closed season in order to allow for stock recovery. The official closed period became increasingly longer; it is now three months and also applies to traditional shrimp fishing. Shrimp vessel operators have themselves extended the closed season to 4.5–5 months per year.

Studies on the environmental impact of shrimp trawling have increased since the beginning of 2003, corresponding to the start of the process of ecocertification for the Madagascar shrimp fishery. The ecocertification, promoted by the Marine Stewardship Council (MSC), is a scheme to protect the environment and natural resources, which is based on consumer preference; it guarantees the buyers of fishery products that these products have been produced from well-managed fisheries.

IMPACTS ON SMALL-SCALE FISHERIES

In the Madagascar shrimp fisheries, there is a certain amount of competition between the industrial/artisanal fisheries and the traditional fisheries. This is a result of exploiting the same resource, often in the same area. At least some of the conflict in the past has arisen from trawlers destroying the fishing gear belonging to traditional fishers, but this situation now seems to be relatively rare. Damage should generally be compensated for by the trawler operators. The industrial fishers are trying to avoid conflict at sea and are aware that in other countries there is a coastal zone reserved for traditional fishing; however, this is not the case in Madagascar.

There is no legal restriction on trawling in the zone that extends two nautical miles out from the coast. The government fisheries agency is aware that placing a ban on trawling inside the two-mile zone, an area that encompasses 85 percent of the shrimp fishing grounds, would put an end to industrial shrimp fishing in the country, and with it an important source of national income and a principal source of foreign exchange.

Action was taken in March 2005 that may resolve the issue of the two-mile trawling ban. Cooperative management zones were created with the objectives of accommodating the various conflicting claims over marine resources; establishing long-term conflict resolution mechanisms; improving the conditions of fishing and fish processing; and adopting a participatory approach towards management action.

The creation of the cooperative management zones was an initiative of the industrial vessel operators with support from the government. The two partners wished to avoid open conflict among the different shrimp fishery subsectors, using all means possible. For political and social reasons, conflict would mostly be resolved in favour of the traditional fisheries.

There is a further negative impact of the industrial shrimp fisheries on the traditional finfish fishery. Since small-scale fishers are finding less fish in the zone around the coast where the industrial vessels trawl, they have to travel further offshore in their non-motorized canoes; this reduces their fishing time and consequently their catch. It also creates sea safety problems since the sea is fairly rough along the east and southeast coast and in all areas at certain times of the year.

MANAGEMENT

The Ministry of Agriculture and Fisheries is responsible for the management of fishing through the intermediary of the Direction of Fishing and Fish Resources. Ordinance

93022 of 4 May 1993 concerning the regulation of fishing and aquaculture establishes the basics of the fishing management process (Soumy, 2004).

Because of their socio-economic importance, Madagascar's shrimp fisheries have for some time received considerable management attention. The process of improving shrimp fishery management is carried out by the government fisheries agency in close cooperation with:

- the Groupement des aquaculteurs et pêcheurs de crevettes de Madagascar (GAPCM – the Madagascar Shrimp Fishers and Farmers Cooperative);
- the Centre national de recherches océanographiques et des pêches (CNRO –the National Oceanographic and Fisheries Research Centre) with respect to science;
- the Programme national de recherche crevette (PNRC – the National Shrimp Research Programme);
- the Observatoire Économique, which analyses the economic performance of the three shrimp subsectors.

Workshops on Madagascar's shrimp fishery management were held in 1996, 1998, 2000, 2003 and 2005. Participants included those from the government, national and international scientists and the various types of fishers, including traditional fishers. These workshops have allowed for the regular modification of management measures.

The licensing system has evolved in recent years. Since 1971, all shrimp trawlers must have a licence (Law D71.228 of 18 May 1971). In 1986, the two largest fishing companies obtained fishing rights in certain areas. In the case of the Pêcherie de Nosy-Be, exclusive fishing rights were obtained in what is now zone A; for the Société Malgache de Pêcherie, exclusive rights were obtained for what is now zone B. Zone C remained an open access area. The exclusivity arrangements were terminated in 2000.

As a result of a shrimp stock assessment undertaken in 1998, the number of licences was frozen in 1999 for a period of two years – at 75 for industrial trawlers and 36 for artisanal mini-trawlers (Decree No. 4942/99 of 14 May 1999).

In 2000, the Madagascar Government made major changes to the system of granting licences for industrial and artisanal shrimp fishing (Decree No. 000-415 of 16 June 2000). The resulting system is still in force. The main management measures are given below.

- There is a freeze on the number of licences.
- The introduction of a new scheme of fishing areas– four zones instead of 14.
- Exclusive fishing rights in zones A and B are eliminated.
- A licence is granted for a specific engine HP.
- Each licence is valid for 20 years, starting from 2000.
- All expired licences revert to the government.
- Licences are transferable between private operators, but with the provision that the new vessel has similar characteristics to the vessel originally associated with the licence.
- Fishing companies or groups of fishing companies are prohibited from having more than 40 percent of the total number of industrial fishing licences.
- Licences may be withdrawn for certain infractions such as non-payment of licence fees; failure to report data on catches; violations of fishing gear standards; fishing in unauthorized zones; underperformance as judged by the Observatoire Économique; and in the case of a need to reduce effort, as justified by scientific studies.
- At least 8 percent of the value of the catch is withheld as a licence fee.

The current management system includes technical measures regarding the power of the trawlers and specifications of the trawl net, as described below.

- The maximum authorized HP has increased from 25 to 50 HP for artisanal vessels and to 500 HP for industrial vessels (Decree of 26 August 1993).
- Trawl specifications are given in Decree No. 2003-1101 of 25 November 2003: the total length of the headrope cannot be more than 69 m; the mesh size at the codend cannot be smaller than 25 mm, and not less than 30 mm on the wings.

Furthermore, the trawl must be equipped with a TED; for vessels operating on the west coast, the trawl gear must be equipped with a BRD.

To regulate fishing effort, two measures are used: the distribution of the industrial fishing fleet and the length of the fishing season. The total fishing effort of the industrial fleet (measured by engine power) is distributed among the fishing zones, taking into consideration the potential of each vessel. Licences are distributed by zone according to the engine power of the vessels. The measure concerning the length of the fishing season was originally established to protect the species *Penaeus indicus* during the period of recruitment on the west coast. The closing day of the season was established as 1 December and, since 2004, 1 March as the opening day.

The principal management measures for the traditional shrimp fishery are described below.

- The fishery on the west coast is closed for three months (regulation of fishing effort).
- Shrimp collection is the subject of a recent regulation. Under Decree No. 060/2005 of 17 January 2005, fishers must hold a licence that authorizes shrimp fishing in a specific area, but does not allow any processing or freezing on board. This measure came into force on 1 July 2005.
- To ensure the sustainability of fishing activities and to limit conflict between the industrial/artisanal and traditional fisheries, cooperative management zones were established on 1 March 2005. These at present consist of activities in three regions (Ambaro Bay, Antongil Bay and Morondava) where the risks of conflict are greatest.
- Measures dealing with fishing are: (i) a ban on using the *pôto* trap gear which, because of its small mesh and the method in which it is used, captures mainly small shrimp, mostly juveniles; (ii) an increase in the allowable mesh size from 12 to 15 mm for the *kaokobe*, a multifilament net used from a canoe by four fishers; and (iii) a ban on the use of beach seines.

As mentioned earlier, the ecocertification promoted by the MSC is a scheme to protect the environment and natural resources, which is based on consumer preference; it guarantees the buyers of fishery products that these products have been produced from well-managed fisheries. The first steps in the process of certification (Decree No. 2003-1101) started in 2005 for the industrial shrimp fishery, with the following requirements:

- limitation of the combined length of the headropes to 69 m (10 percent shorter);
- an increase in mesh size to 25 mm in the body (belly) of the trawls and 30 mm in the wings;
- the use of BRDs; and
- the use of TEDs.

In addition to these government interventions at the request of the fishing industry (made during the workshop on shrimp fishery management in July 2003), other voluntary measures have been adopted by some shrimp vessel operators. These included: a night fishing ban during the first 45 days of the fishing seasons in 2005 and 2006; not using tickler chains in front of the body of the net (a practice that was widespread in the past); the use of a single trawl net instead of twin; and alternation between day and night fishing during the season.

ENFORCEMENT

Most of the fisheries management measures developed by the government with the collaboration of stakeholders have been implemented. The measures not yet in force at the time of writing are the following.

- The scheme whereby licences are withdrawn because of underperformance. The conclusions of the study on how to calculate performance were not accepted by

the vessel operators, who were opposed to the scheme even before the preparation of the decree on the subject.

- The legal framework and mechanisms for transferring licences.
- The regulation on compensating vessel operators for withdrawing licences when a need to reduce fishing effort has been demonstrated.

The use of TEDs does not appear to cause problems such as those caused by BRDs, which result in a significant loss of shrimp and probably also of fish of commercial size. The desire to avoid bycatch by the installation of BRDs on the trawl is starting to conflict with the desire to increase bycatch to supply local markets.

The original attempts to introduce BRDs suffered from the initial use of a fisheye model, which resulted in a significant loss of commercial fish. Subsequently, BRDs with square mesh windows were used and appear more effective at reducing unwanted bycatch while retaining commercial species.

Fisheries surveillance is carried out by the Centre de surveillance des pêches, which was created by the Minister in charge of fisheries by Decree No. 4113/99 of 23 April 1999. The objective of the Centre is to oversee compliance with the regulations in force at sea as well as on land. Twenty provincial agents are deployed along the coast to inspect boats and to verify fishing gear, which for shrimp fishing involves the length of the backrope, the mesh size of the trawl, and the installation of TEDs and BRDs. Thirty-five observers dedicated to the shrimp fisheries enable observation of fishing operations at sea. To regulate the fishing areas of the industrial shrimp trawlers, a VMS has been used since the beginning of the 2001 fishing season. All vessels are equipped with Argos or Inmarsat transponders. The Centre de surveillance des pêches has several funding sources, both national and international. Its annual budget is about US\$1.4 million.

RESEARCH

The National Shrimp Research Programme (PNRC) began in September 1997. Its legal basis is Decree No. 1697/97 of 13 February 1997. The programme has taken over the objectives of some previous shrimp research projects, including that of FAO, to become the focal point of Madagascar shrimp research. PNRC was initially oriented towards shrimp research in three areas.

- *Socio-economic research*: the importance of traditional shrimp fishing, the economics of the industrial/artisanal shrimp fisheries and an analysis of the types of management.
- *Biological research*: sound justification for the period of closure of shrimp fishing; considerations related to the proposed trawl ban within two nautical miles of the coast; the relationship between fishing and the environment; sites and importance of nursery grounds; determination of migration/growth/mortality from shrimp tagging; comparisons of biological cycles for the different fishing areas; stock identification; and evaluation of resource potential in the various fishing areas.
- Research encompassing both socio-economics and biology: the study of the biological and economic interactions between the three shrimp fishing subsectors – industrial, artisanal and traditional; and bioeconomic modelling to simulate the various management schemes.

In order to carry out this research, a PNRC financing plan was formulated for an initial three-year period (February 1997 to March 2000) and a second phase of two years (March 2002 to October 2004), with a transition period from April 2000 to February 2002. PNRC is a multidonor initiative with the participation of Agence française de développement, the Madagascar Government (the Fisheries and Aquaculture Development Fund and the Fisheries Agreement with the European Union), the Institut de recherche pour le développement and GAPCM. The original budget was about €2.0 million and €1.8 million for the second phase.

At the time of writing, PNRC is in a transitional phase. Following on from its workshop on the results of scientific studies in October 2004, several proposals for future shrimp research were made:

- extension of the work carried out at Ambaro Bay and other important areas on the traditional shrimp fishery;
- pursuing shrimp stock assessment in the various fishing areas using cohort analysis and yield per recruit analysis, integrating the catch data of the three shrimp fishing subsectors; and
- bioeconomic modelling of the fisheries by fishing area and undertaking simulations to determine optimal exploitation strategies.

DATA REPORTING

The system for collecting statistical data encompasses two different areas.

- One area is the formal sector, where data are obtained after an exhaustive census based on items such as logsheets and quarantine certificates. This is applicable to industrial/artisanal fishing, exporting, product collection and the domestic distribution of fishery and aquaculture products.
- The second area is the informal sector, where statistical data are collected using sampling methods based on surveys. This is done for traditional fisheries, inland aquaculture and fishery product distribution at the local market level.

There are various sources of data on shrimp fishing in Madagascar. Reports from various decentralized government agencies give information on fishery production, exporting, domestic distribution and local consumption. PNRC carries out surveys on production from traditional fishing. A statistical project (Système statistique national standardisé informatisé) collects statistics on inland and coastal traditional fishing, and is now working in Toamasina, Toliara, Morondava, Mahajanga, Antsiranana and Maintirano. A national database project on Madagascar shrimp fishing (BANACREM) processes fish receipts and logbook information supplied by industrial and artisanal fishing vessel operators. Reports from fishery observers on board allow for the comparison and verification of data. Quarantine and sanitation certificates produced by the national competent authority give information on exports. Finally, documentation associated with the repatriation of funds from exported products is compared with export data.

As regards quality, data for the industrial/artisanal subsectors are generally good, despite some data collection problems that affect the quality of the national shrimp database. During the process of data transmission to the vessel operators by the captains of the shrimp vessels, errors can be introduced when copying information from logbooks. Some companies send handwritten logbook information directly to the fisheries agency, which means that deciphering some of the data can require interpretation. Logsheets can be scanned at the Ministry of Agriculture and Fisheries and data entered into a database for verification before being transferred into the national database.

Statistical data for traditional fisheries is collected intermittently, according to requirements. The system of data collection tested by PNRC at the time of the study of shrimp fishing in Ambaro Bay (implemented in March 2003) proved to be effective and therefore appropriate for other sites. This system also has the advantage of providing biological information and the effects of overexploitation.

IMPACTS OF SHRIMP FARMING

In 2004, a total of 5 430 tonnes of shrimp was produced by farming operations. In the same year, shrimp fishing catches were 11 315 tonnes (63 percent by the industrial fleet).

The impact of shrimp farming on shrimp fishing in Madagascar is favourable. Madagascar shrimp farms specialize in the production of *Penaeus monodon* and are

almost all owned by the industrial and artisanal shrimp vessel owners. This situation enables resources to be pooled for effective monitoring of the international markets and associated exporting. By combining marketing for both wild and farmed shrimp, clients can be offered a wide range of shrimp: different species, different sizes and wild and/or farmed.

As mentioned at the beginning of this review, shrimp from Madagascar, both wild and farmed, is particularly appreciated in Europe, especially in France, and commands a higher price than shrimp products from Asia or Latin America. Madagascar shrimp is even sold in large supermarkets, but targets consumers who desire high-quality products. Because the shrimp competes on the international market with the large amount of inexpensive shrimp from Asia and Latin America, its marketing requires substantial publicity, stressing both the quality of the product and the positive environmental aspects of its production (ecocertification).

MAJOR ISSUES

The major issues related to shrimp fishing in Madagascar are:

- protecting the interests of traditional shrimp fishers from the negative interaction of industrial/artisanal shrimp fishing, with appropriate consideration given to the benefits to the national economy from larger-scale operations;
- difficulties associated with controlling effort increases in the traditional shrimp fishery;
- the need for a new and detailed assessment of shrimp stocks;
- reconciling the position of vessel operators with that of fishery scientists as to the appropriate level of fishing effort;
- the major fall in shrimp catches in 2005;
- maintaining the favourable position of Madagascar shrimp in the European market; and
- reconciling the need to reduce bycatch with the economic benefits of selling it.