Shrimp fishing in Mexico

Based on the work of D. Aguilar and J. Grande-Vidal

AN OVERVIEW

Mexico has coastlines of 8 475 km along the Pacific and 3 294 km along the Atlantic Oceans. Shrimp fishing in Mexico takes place in the Pacific, Gulf of Mexico and Caribbean, both by artisanal and industrial fleets. A large number of small fishing vessels use many types of gear to catch shrimp. The larger offshore shrimp vessels, numbering about 2 212, trawl using either two nets (Pacific side) or four nets (Atlantic). In 2003, shrimp production in Mexico of 123 905 tonnes came from three sources: 21.26 percent from artisanal fisheries, 28.41 percent from industrial fisheries and 50.33 percent from aquaculture activities.

Shrimp is the most important fishery commodity produced in Mexico in terms of value, exports and employment. Catches of Mexican Pacific shrimp appear to have reached their maximum. There is general recognition that overcapacity is a problem in the various shrimp fleets.

DEVELOPMENT AND STRUCTURE

Although trawling for shrimp started in the late 1920s, shrimp has been captured in inshore areas since pre-Columbian times. Magallón-Barajas (1987) describes the lagoon shrimp fishery, developed in the pre-Hispanic era by natives of the southeastern Gulf of California, which used barriers built with mangrove sticks across the channels and mouths of estuaries and lagoons.

The National Fisheries Institute (INP, 2000) and Magallón-Barajas (1987) reviewed the history of shrimp fishing on the Pacific coast of Mexico. It began in 1921 at Guaymas with two United States boats. During the 1930s, 17 Californian sardine boats were modified to trawl and were incorporated into the fleet. Japanese trawlers explored the Mexican Pacific coast and located the main trawling areas in the same decade. In 1941, a fleet of 21 shrimp vessels landed 1 900 tonnes of shrimp from the area around Guaymas. During the 1940s and 1950s, the fishery expanded to the entire

TABLE 61
Major fishing areas, industrial fleet distribution and main shrimp species

Fishing areas	Number of vessels	Main shrimp target species
Pacific coast	1 674	
West coast of Baja California	71	*Farfantepenaeus californiensis* and *Litopenaeus stylirostris*
Gulf of California	1 456	*F. californiensis, L. stylirostris* and *L. vannamei*
Gulf of Tehuantepec	147	*L. vannamei, F. californiensis* and *L. stylirostris*
Gulf of Mexico	703	
Tamaulipas	293	*F. aztecus* and *L. setiferus*
Veracruz	72	*F. aztecus* and *L. setiferus*
Tabasco	20	*F. aztecus* and *L. setiferus*
Campeche	311	*F. aztecus, L. setiferus* and *F. duorarum*
Yucatán	7	*F. aztecus*
Caribbean Sea	35	
Quintana Roo	35	*F. brasiliensis* and *Sicyonia brevirostris*

Source: ICES/FAO, 2005.

Gulf of California and to the Gulf of Tehuantepec. During the late 1950s, double-rig trawls were introduced. By 1960, fishing operations extended to the southwest coast of Baja California. During the late 1960s and early 1970s, fishers gradually reduced mesh size.

On Mexico's east coast, the development of shrimp fishing in the southern Gulf of Mexico and western Caribbean was greatly influenced by the United States fleet (Iversen, Allen and Higman, 1993). In the 1940s, shrimp fishing in the United States grew remarkably and, by the early 1950s, most of the potential fishing grounds in waters adjacent to the southeastern states had been discovered. The United States shrimp fleet then extended operations to the east coast of Mexico and the western Caribbean Sea. From the early 1960s to the early 1970s, 632–860 United States vessels fished off Mexico. In 1976, a treaty between the United States and Mexico resulted in United States shrimping in Mexican waters being phased out by the end of 1979.

There are four main shrimp fleets in Mexico: the offshore trawl, inshore, seabob and the Magdalena fleet.

The offshore trawl fleet. This comprises about 1 674 vessels on the Pacific coast and 738 in the Gulf of Mexico and the Caribbean Sea. The boats are characteristically steel, 18–25 m in length and equipped with 240–624 HP engines. The fleets operate differently in the two oceans.

- On the Pacific coast, offshore shrimp trawlers operate in waters between 9 and 64 m deep, using two trawl nets. The nets have a headline of 23–36 m, 3.81–4.13 cm mesh in the codend, and are also equipped with TEDs.
- In the Gulf of Mexico and the Caribbean Sea, the fleet operates in waters between 9 and 64 m deep, using four trawl nets. The nets have a headline of 10.6–13.6 m, 3.81–4.45 cm mesh in the codend, and are also equipped with TEDs.

The inshore fleet. This consists of boats that catch shrimp in waters 5–15 m deep in lagoons, estuarine systems, rivers and the coastal zone. The vessels, numbering between 75 000 and 80 000 during the fishing season, are 6–9 m in length and use 55–100 HP outboard engines. About 60 percent of the fleet is based on the Pacific coast and 40 percent in the Gulf of Mexico and Caribbean Sea. The fleet uses many different types of gear, including cast nets, enmeshing nets and various forms of small trawl nets, locally called *suriperas, changos, conos* and *bolsos.*

The seabob fleet. In Del Carmen city, Campeche state, 200–300 small craft target Atlantic seabob (*Xiphopenaeus kroyeri*). These vessels range from 6 to 9 m in length overall, and are equipped 45–65 HP outboard engines and trawl nets with headropes of 7.6–10.6 m.

Magdalena fleet. This is made up of vessels similar to those of the seabob fleet, but they are all based in southern Baja California. The boats are required by law to use a trawl net that has a 13-m headline.

TABLE 62
Sources of shrimp production in Mexico, 2003

Origin (tonnes)	Pacific coast	Atlantic Ocean and the Caribbean	Total
Artisanal landings	15 682	10 660	26 342
Industrial landings	22 165	13 036	35 201
Aquaculture	59 260	3 101	62 361
Total	97 107	26 797	123 904

Source: SAGARPA, 2004a.

Offshore shrimp vessels are characteristically owned by the private sector. The vessels of the other three fleets usually belong to unions, cooperatives or individual fishers.

On the Pacific coast, the shrimp fishing season is from September to February, with some variations for lagoons and estuaries. In these areas, the season usually opens 15 days earlier for artisanal fishers. In the Gulf of Mexico, there is a temporary closed season from May to August for Tamaulipas and Veracruz, and from mid-May to October for the region from Tabasco to Campeche. On both coasts, the fishing season can be modified according to the results of biological research.

TARGET SPECIES, CATCH AND EFFORT

The main commercial shrimp species on the Pacific coast are the blue shrimp (*Litopenaeus stylirostris)*,[31] whiteleg shrimp (*L. vannamei*), yellowleg shrimp (*Farfantepenaeus californiensis*) and crystal shrimp (*F. brevirostris*).

In the Gulf of Mexico and Caribbean Sea, the main species are the northern brown shrimp (*Farfantepenaeus aztecus*), northern pink shrimp (*F. duorarum*), northern white shrimp (*Litopenaeus setiferus*), redspotted shrimp (*F. brasiliensis*), Atlantic seabob (*Xiphopenaeus kroyeri)* and the crystal shrimp (*Sicyonia brevirostris*).

Table 61 shows Mexico's major fishing areas, the industrial fleet distribution and the main target species in the various areas.

Commercial shrimp fishing in Mexico began in the 1930s. Industrial catches increased from 630 tonnes in 1930 to 5 102 in 1940, 20 373 in 1950 and 39 776 in 1960. In 1970 and 1980, total catches were 42 872 and 51 726 tonnes, respectively. A maximum industrial shrimp catch of 59 602 tonnes was attained in 1987 and, subsequently, there were considerable annual variations. The average industrial catch of 1994 to 2003 was 47 168 tonnes.

In addition to industrial shrimp catches, shrimp production in Mexico also comes from artisanal fishing and aquaculture. Table 62 gives the various sources of shrimp production in 2003, while Table 63 gives the Mexican industrial and artisanal shrimp catches from 1990 to 2004.

Shrimp fishing effort in Mexico is measured in a variety of ways, including the number of boats, fishing trips, days at sea or fishing days, depending on the available fleet information. For the

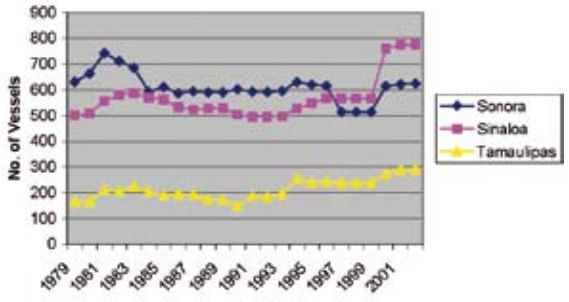
TABLE 63
Shrimp catches in Mexico, 1990–2004

Year	The Gulf and Caribbean	Pacific Ocean	Total
1990	23 847	34 081	57 928
1991	29 284	36 185	65 469
1992	22 715	35 174	57 889
1993	28 058	40 280	68 338
1994	22 709	41 134	63 843
1995	23 435	46 599	70 034
1996	21 450	44 114	65 564
1997	21 984	49 083	71 067
1998	23 170	43 416	66 586
1999	20 155	46 336	66 491
2000	21 288	40 309	61 597
2001	21 847	35 662	57 509
2002	18 533	36 100	54 633
2003	23 697	37 848	61 545
2004	22 320	35 744	58 064

Source: FAO, 2006a.

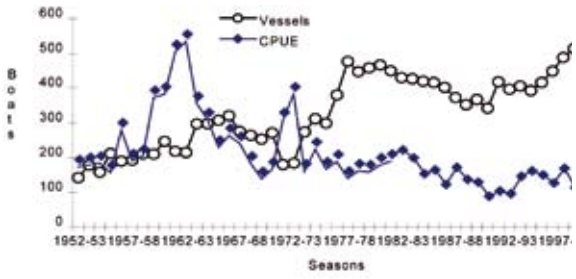
[31] For shrimp in the Americas, many taxonomic authorities (including in Mexico) divide the genus *Penaeus* into two genera: *Litopenaeus* and *Farfantepenaeus* and the nomenclature convention is followed in this report. The English names are those used by FAO.

FIGURE 34
Offshore shrimp vessel numbers in three Mexican states



Source: SAGARPA, 2004a.

FIGURE 35
Shrimp vessel numbers and CPUE at the port of Mazatlan



Source: SAGARPA, 2004a.

inshore fleet in general, the only measure of effort collected is the number of boats.

There were 104 vessels in the offshore fleet in 1930 but the fleet grew to a maximum size of 2 880 vessels in 1983. Since then, the national fleet has oscillated in size and, in 2006, the number on both coasts was 2 412. Figure 34 gives the changes from 1979 to 2002 of the number of vessels based in the states of Sonora, Sinaloa and Tampico, where the major shrimp ports of Guaymas, Mazatlan and Tampico are located, respectively.

Following several years without much change in vessel numbers, fleet growth occurred in all three states in 2000. Shrimp vessel numbers and CPUE (tonnes per season) for the main shrimp port in Sinaloa, Mazatlan, are given in Figure 35. It can be seen that in the 1960s and early 1970s there was a large oscillation in CPUE, followed by a gradual decline to the present.

From 1929 to 1969, for both coasts, the CPUE for the offshore fleet increased to 60.86 kg of shrimp/hr in 1961 with some annual variation. After 1961, there was a constant decline to 16.96 kg/hr in 1981. The catch rate appears to have stabilized in recent years.

There is general recognition that overcapacity is a problem in the various shrimp fleets of Mexico. This has been noted in the shrimp fishery literature of the country since the 1970s. A recent example of government intervention to mitigate this problem occurred in mid-2005. The National Aquaculture and Fisheries Commission (CONAPESCA) allocated 27 million pesos (US$2.54 million) to producers from Sinaloa, Tabasco and Tamaulipas as part of the framework for voluntary decommissioning of the Mexican fleet to reduce the fishing effort on shrimp.

ECONOMIC CONTRIBUTION

Between 1995 and 2000, the total fishing activity in Mexico was responsible for 0.8 percent of the country's GDP. Fisheries have considerably greater local importance in some parts of Mexico; in Sinaloa and Sonora, they comprise nearly 4 percent and 2.3 percent of GDP, respectively (FAO, 2003d). The specific contribution of shrimp fishing to GDP is not readily available.

Fishing in general accounts for 0.31 percent of all employment in the country (Gomez, 2001). In 2002, according to official statistics, there were 246 551 people involved in fishing in inland, inshore and offshore waters. It is estimated that the shrimp fishery provides employment for 190 884 fishers and indirect employment for 573 000 others.

In 2002, according to SAGARPA, the Mexican Agriculture, Livestock, Rural Development, Fisheries and Food Secretariat (2004a), the direct consumption of all fish (including shellfish) in the country was 874 549 tonnes, equivalent to 8.3 kg per capita. The consumption of shrimp was 69 078 kg, or 0.66 kg per capita.

TABLE 64
Mexico's shrimp trade, 1990–2004

	Export quantity (tonnes)	Export value (US$ '000)	Import quantity (mt)	Import value (US$ '000)
1990	17 682	202 396	35	274
1991	17 365	221 613	6	35
1992	16 968	170 872	359	1 378
1993	23 436	291 319	4 011	26 670
1994	24 434	312 753	4 240	18 083
1995	35 885	455 675	2 639	6 969
1996	35 763	368 407	2 783	7 141
1997	35 712	478 516	2 633	7 259
1998	46 584	491 364	12 175	7 998
1999	47 049	425 314	3 139	8 156
2000	37 359	455 495	5 357	10 625
2001	39 280	436 643	7 267	20 796
2002	25 335	285 228	6 218	25 586
2003	26 212	300 988	6 289	28 083
2004	30 640	346 322	4 837	24 234

Source: FAO, 2006b.

SAGARPA (2004b) comments on the importance of shrimp and shrimp fishing in Mexico.

- In terms of volume, shrimp is the most important fishery commodity.
- In terms of value, shrimp is the most important commodity after sardines and tuna.
- Shrimp is the most important fishery commodity export.
- In terms of numbers of fishing vessels, more are involved in shrimp fishing (both offshore and artisanal) than in any other type of fishing.
- Shrimp fishing is responsible for more employment than any other fishery.

At the micro level, shrimp fishing can be extremely important for coastal communities in particular areas. Ocean Garden (2005) reports that about 4 500 jobs are dependent on the shrimp business in the small towns of San Felipe, Puerto Peñasco and the Gulf of Santa Clara.

TRADE ASPECTS

Table 64 shows Mexico's shrimp trade from 1990 to 2004. During this period, the volume of shrimp exports[32] almost doubled.

In 1990, shrimp exports constituted 61.8 percent of the total export of fishery products from Mexico. However, their relative importance has decreased and, in 2003, the contribution was 45.5 percent.

Some issues that are especially important for the Mexican shrimp trade are the following.

- Mexico is among the 13 countries that currently meet the standard set by the United States National Marine Fisheries Service (NMFS) regarding the use of TEDs; Mexican shrimp exports are therefore not subject to the United States embargo.
- Some Mexican fishery products have obtained greater access to the Japanese market after the signing of a Japan/Mexico economic partnership agreement in 2004. This agreement has provisions for tax exemption for yellowfin tuna, oysters, lobsters, octopus and shrimp (INFOFISH, 2004).
- Mexico's shrimp industry and Ocean Garden Products of San Diego, the largest Mexican shrimp importer in the United States, launched a marketing campaign

[32] Shrimp exports also include farmed shrimp.

in March 2004 to promote the flavour and texture of shrimp from Mexico. The campaign, touted as "The naked truth about shrimp," is designed to give farmed and wild Mexican shrimp the brand recognition that products such as Colombian coffee and Mexican tequila already enjoy (Seafood Business, 2004).

- In July 2004, the United States Department of Commerce imposed duties varying up to 113 percent on shrimp from six countries. Some concern was expressed during the process of formulating this trade sanction that Mexican shrimp would be included, but fortunately this did not occur.

BYCATCH ISSUES

The National Fisheries Institute carried out studies on bycatch from 1956 to 1996. Results were reported by Chapa (1976), Rosales (1967), Chávez and Arvizu (1972), Corripio (1979), Grande-Vidal and Díaz (1981), Grande-Vidal (1987), Aguilar and Grande-Vidal (1996) and Grande-Vidal (1996). Some of the more important findings are given below.

- The results obtained by Grande-Vidal and Díaz (1981) showed that 60–63 percent of the bycatch from the shrimp fishing fleets on both coasts was composed of various species of fish, with the remainder being crustaceans, molluscs and echinoderms. The authors found that the proportion of bycatch to shrimp was 9:1 on the Pacific coast and 3:1 in the Gulf of Mexico. Between ten to 18 of the bycatch species were abundant enough to be commercialized.
- From 1992 to 1994, experiments were carried out in the Pacific Ocean using trawl nets with five types of TEDs. The results showed that bycatch was reduced from 35.3 to 30.0 kg/hr depending on the type of TED. The loss of shrimp was from 0 to 2.14 kg/hr (Aguilar and Grande-Vidal, 1996).
- The same set of experiments showed that the average ratio of bycatch to shrimp was maintained at 9:1 in the Pacific, but there were major differences by zone: Sonora 3.9:1, Sinaloa 3.76:1 and the Gulf of Tehuantepec 24:1 (Grande-Vidal, 1996).

Bojórquez (1998) states that, without BRDs, the average ratio of shrimp to bycatch is 1:10 in the Pacific and 1:3 in the Gulf of Mexico and the Caribbean. In the Pacific, the bycatch consists of 70 percent by weight of fish, made up of 105 species. In the Gulf and Caribbean, the bycatch consists of 65 percent by weight of fish, made up of 91 species. The report claims that the use of TEDs reduced the fish bycatch by 45 percent.

Kelleher (2005), citing Bojórquez (1998), indicates that Mexico's Gulf of Mexico shrimp fisheries generate 19 000 tonnes of discards (a discard rate of 46.2 percent) and the Pacific shrimp fisheries approximately 114 000 tonnes (a discard rate of 76.7 percent).

INP (2000) states that activities to protect sea turtles started over 30 years ago in Mexico. Since December 1993, shrimp trawlers in the Gulf of Mexico have been required to use TEDs. This has been a requirement on the Pacific coast since April 1996.

Seefoó Ramos, Sarmiento Náfate and Balmori Ramírez (2004) summarize recent developments in the use of TEDs in Mexico. The use of hard TEDs is mandatory for all vessels in the industrial shrimp trawl fleet. In 2004, a new regulation came into force, requiring a larger TED escape opening and allowing the possibility of using a single or a double cover for the opening. An assessment of this new regulation by paired fishing trials was conducted in the Gulf of Tehuantepec. Results showed that the new TED design with a single cover has similar shrimp catch efficiency to the former design, but decreases the bycatch by 3.3 percent. Double-cover TED trials showed increases of 2 percent in shrimp catch efficiency and an 11 percent decrease in bycatch.

As reported in the section above, Mexico is among the 13 countries that currently meet the standard set by the United States NMFS regarding the use of TEDs.

Mexico has actively participated in the FAO/GEF/UNDP project "Reduction of the Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Technologies and Change of Management". This participation has included gear technology work, training of observers and transfer of technology to other Latin American countries.

PROFITABILITY

There are few data in the public domain on the profitability of shrimp fishing in Mexico. Nevertheless, some observations can be made.

If the change in number of vessels in each shrimp fleet is a rough indicator of profitability, then Figure 34 would suggest that, in the 1990s, there has been no great change in profitability of the industrial shrimp fleets based in the states of Sonora, Sinaloa and Tampico.

INP (2000) considered all the commercial shrimp species on the Pacific coast and their main landing points. One finding was that some of the stocks are at biomass levels below that of maximum productivity, for which it is necessary to consider measures for reducing fishing effort in order to increase fishery profitability.

ENERGY INPUT ASPECTS

Fuel consumption is an important aspect of shrimp fishing in Mexico. The average offshore vessel consumes between 20 000 and 25 000 litres of diesel per fishing trip (average trip 22–26 days), and a small craft consumes 80–150 litres of petrol per day. The April 2006 price of diesel fuel was US$0.45/litre and regular petrol was US$0.63.

Some issues regarding fuel use in shrimp fishing in Mexico are the following.

- There is a fuel subsidy for shrimp fishing vessels. The subsidy in 2006 was equivalent to US$0.09/litre of the normal value for diesel and petrol for authorized fishing vessels registered with CONAPESCA.
- The price of fuel has increased steadily in recent years.
- The use of outboard engines for various forms of small-scale trawling is widespread in Mexico, but this activity is relatively fuel-intensive compared with diesel inboard engines.

BIOLOGICAL ASPECTS

There have been many assessments of the condition of Mexico's shrimp resources, including studies on both coasts. The main results are summarized by SAGARPA/INP (2001).

- The Pacific Ocean studies indicate that the commercial species of shrimp have a short life cycle (a maximum of two years). Juveniles are caught in estuaries and lagoons, and adults are caught offshore. In general, the shrimp populations have rapid growth and a high resilience to fishing pressure. An analysis was carried out using the dynamic pool Schaeffer model and the age-structured Deriso model. Results show that the stock of *Farfantepenaeus californiensis* is in good shape, but that stocks of *Litopenaeus stylirostris* and *L. vannamei* are depleted.
- The Gulf of Mexico and Caribbean Sea studies indicate sequential exploitation – capture as juveniles in lagoons by artisanal fisheries and then offshore by the industrial fishery. Recruitment is characterized by considerable interannual variation and is concentrated in particular times of the year, which are different for the various species. An analysis was carried out using age-structured models and yield per recruit models. Results show that the stock of *Farfantepenaeus aztecus* is good, but that stocks of *F. duorarum* and *Litopenaeus setiferus* are depleted.

As regards Mexico's Pacific coast shrimp resource, the National Fisheries Institute (INP, 2000) considered all the commercial species and main landing points, and concluded that catches of Mexican Pacific shrimp have reached their maximum and

that fishing effort should not be increased in any region or on any species. Some of the stocks are at a biomass level below that of maximum productivity, for which it is necessary to consider measures for reducing fishing effort in order to increase fishery profitability.

Grande-Vidal (2006) examined Mexican shrimp fishing from 1929 to 2003. The study estimated MSY for all commercial species of shrimp in both oceans at 48 769 tonnes.

IMPACTS ON THE PHYSICAL ENVIRONMENT

There have been few, if any, studies in Mexico on the impact of shrimp fishing on the sea bottom.

A management plan for Mexico's Pacific shrimp resources (SAGRAPA, 2004c) cites several problems associated with shrimp fisheries, including their impact on the sea bottom. It also states that one of the management objectives for shrimp fisheries is to minimize the environmental impact, particularly in areas that are ecologically significant.

IMPACTS ON SMALL-SCALE FISHERIES

INP (2000) indicates that the activity known as "shrimp fishing" is actually made up of various components of a sequential nature; shrimp are targeted at various stages in their life cycle in different environments by different fishing gear and scales of fishing. As a result, there is a strong interaction between the three different types of shrimp fisheries in Mexico – the high seas, the bays and the estuaries. There is also significant interaction between illegal fishing and these three fisheries. In addition, shrimp fisheries take considerable bycatch of high-value commercial fish, which negatively impacts fishers targeting these species.

A management plan for Mexico's Pacific shrimp resources (SAGRAPA, 2004c) states that one of the management objectives for shrimp fisheries is to mitigate the effects of the negative interactions that occur because of competition among the shrimp fishing subsectors.

MANAGEMENT

Díaz de León (2004) reviews the institutional arrangements and legal basis for general fisheries management in Mexico. From the end of 2000, at the beginning of a new federal administration, fisheries institutions were transferred to what is now the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). The agency responsible for fisheries management, monitoring and enforcement is CONAPESCA.

Marine fisheries are under federal jurisdiction. The Mexican Constitution establishes that the central federal government is empowered to manage all marine and inland fisheries resources found within federal national waters. Fisheries legislation and management are the responsibility of the federal government, leaving little room for local governments to manage fisheries resources.

The highest-ranking instrument of Mexican fisheries legislation is the Federal Fisheries Law (*Ley de Pesca*). It gives general guidelines to regulate fisheries and can be modified through the intervention of the Chamber of Deputies and the Senate. The Union Congress of Mexico has issued eight laws on fisheries: in 1925, 1932, 1938, 1948, 1950, 1972 and 1986, and the amended law of 1992. The Fisheries Regulations were drawn up by the Executive on the basis of the general guidelines given in the Federal Fisheries Law. They deal with particular aspects and can be modified directly by the Executive without the intervention of legislature, which results in some degree of flexibility. Particular instruments of legislation are the *Normas Oficiales Mexicanas* (NOMs, the Mexican Official Standards), which deal with specific aspects such as regulating mesh sizes, gear types used and spatial restrictions, *inter alia*, which need

to be changed from time to time and which, if included in a more general instrument, would make the regulating process cumbersome. The process that shapes or modifies NOMs involves the participation of stakeholders, NGOs and other interest groups in committees. These committees also consult on issues such as setting dates for closed seasons for selected fisheries (including shrimp). INP presents relevant research and monitoring results at these meetings to assist in the decision-making process. Decisions from the meeting are made official by being published in the Federation's Official Registry. Passing of NOMs and related decisions requires an assessment of the regulatory impacts expected from the implementation of NOMs.

INP (2000) gives some historical perspective on shrimp fishery management on the Pacific coast. From 1939, the shrimp fisheries were reserved for cooperative societies. In 1992, with the new fisheries law, the private sector was allowed to participate in the fishery. The use of a closed season for the management of shrimp resources began in 1938 in the Gulf of California. In 1960, closed seasons were established in the Gulf as a shrimp conservation measure to protect shrimp spawning. Seasonal closures were extended the following year to the west coast of Baja California and the Gulf of Tehuantepec. In 1977, regulation of mesh sizes began. After 1980, closed seasons were used to protect not only shrimp spawning, but also shrimp growth, taking into consideration economic factors.

The main regulatory measures are covered in a Mexican Official Standard (NOM-002-PESC-1993). This legal instrument has provisions for:

- control and reduction of fishing effort (number of boats);
- closed seasons;
- closed area;
- reduction of turtles and other bycatch through the use of TEDs; and
- regulation of the mesh size in the codend of the trawl nets to prevent the catch of juveniles of shrimp.

Another important aspect of fisheries management in Mexico is the National Fisheries Chart (CNP). Although the Fisheries Law initially referred to the CNP as a mere inventory, a modification made to the Fisheries Regulations (amended in September 1999) endowed it with the function of defining levels of fishing effort applicable to species and groups of species in specific areas, and providing guidelines, strategies and provisions for the conservation, protection, restoration and management of aquatic resources (Díaz de León, 2004).

The March 2004 CNP lays down strategies for the management of shrimp fisheries in four regions of the Pacific coast and four regions of the Atlantic coast. For example, in the upper Gulf of California area, the following strategies are proposed.

- With regard to the species *Litopenaeus stylirostris*, measures should be continued to maintain the reproductive biomass remaining at the end of each season and protect spawning.
- Regarding the species *Farfantepenaeus californiensis*, measures should be applied to halt the decrease in biomass and avoid lengthening the fishing season under the pretext of taking greater advantage of this species, since this will affect other species.
- The fisheries potential of new species, underexploited offshore or deep-water species should be evaluated and a scheme for their management eventually implemented.
- Alternative fishing gear should be evaluated for the shrimp fishery in the upper Gulf of California.

Díaz de León (2004) notes some major difficulties in fisheries management in Mexico that seem especially relevant to the shrimp fisheries.

- It appears that effort restrictions face the strongest resistance from fishers, who see them as "a lack of flexibility in management" and name them, together with "a

lack of investment" as one of the biggest problems in Mexican fisheries (Comisión de Pesca de la Cámara de Diputados, 2001).

- The introduction of new regulations has contributed to improving some fisheries performance in the short term, but social constraints have tended to erode their effectiveness with time. For example, in 1993, the implementation of a closed season in the Tamaulipas Shrimp Fishery doubled catches in offshore fisheries, but rigidity in its implementation (given that it restricted only the lagoon fishery, minimally affecting the industrial offshore fishery) resulted in the closed season involuntarily becoming an instrument of allocation, greatly diminishing its effectiveness (Fernández *et al*., 2000).

Information on the costs of management of the shrimp fisheries in Mexico is not readily available.

ENFORCEMENT

The enforcement of fishing laws is the responsibility of the federal government through CONAPESCA. The latter undertakes surveillance and enforcement with respect to such topics as closed seasons and compliance with technical measures, such as mesh size, TED usage and fishing areas by species.

Many years of work have resulted in several other government agencies cooperating with CONAPESCA in fisheries law enforcement, including the following.

- Secretaría de Comunicaciones y Transportes controls the licensing of vessel navigation at sea and carries out at-sea safety checks.
- Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT, the Environment and Natural Resources and Fisheries Secretariat) is involved with the conservation and protection of natural resources in the country. Within this agency is a further institution, Procuraduría Federal de Protección Ambiental (Federal Environmental Protection Agency), which is of relevance to shrimp fishing and is responsible for supervising the economic activities of hunting, fishing and of all natural resources.
- Secretaría de Marina is involved with surveillance of the EEZ and coasts. This agency usually works with CONAPESCA through official agreements to supervise fishing activities.

It should be noted that surveillance activities are often carried out by members of cooperatives and unions, especially on the activities of non-members.

RESEARCH

INP bears responsibility for, *inter alia*, research on and assessment of the status of national fisheries as well as the evaluation of fishing gear. Regulations usually arise from the detection of an actual or potential problem. For example, INP research resulted in the implementation of closed seasons for the shrimp fishery in the Gulf and Pacific regions. INP carries out periodic monitoring and systematic assessments of most of the important fisheries, but it lacks the personnel and means to cover many artisanal fisheries. Although the Institute still includes 13 regional centres and some of the most experienced researchers in the country in its ranks, it has been severely downsized by at least 100 of its former 400 researchers and technicians (FAO, 2003d; Díaz de León, 2004).

Because shrimp is the basis of some of the most important fisheries in Mexico, it is the most studied fishery resource in the country and receives the largest proportion of INP human and financial resources (INP, 2000). Studies are carried out on shrimp growth, fecundity, reproduction and recruitment. Research cruises focused on shrimp are undertaken in both oceanic and lagoon areas. During the fishing seasons, landings are sampled at the principal ports for species composition, length and sex, and information is obtained on indices of abundance. Despite this large research

effort, there are still gaps in the knowledge of fishing activity, especially artisanal shrimp fishing.

INP has 100 to 125 scientists and technicians working on different aspects of the shrimp fisheries: biology, stock assessment, technology and shrimp culture. Shrimp-related activities account for 40–50 percent of the total INP budget.

DATA REPORTING

When applying for a fishing licence, the owner of each fishing vessel must provide specifications for the vessel. This information is subsequently included in a national fishing register. The fishing vessel owners are required to report the results of each fishing trip to the fishing authorities, with specific data on catch, effort, species and fishing conditions. This information is collected on the form known as *aviso de arribo*, and is then entered into a database on the fishery.

Although the quality of information on fishing activity is generally good, mistakes do happen. For this reason, the current thinking is that data could be improved by cross-checking by port/factory inspections and by research programmes.

IMPACTS OF SHRIMP FARMING

Shrimp farming in Mexico began in the 1980s. Official statistics on this activity show that production was 35 tonnes in 1985, 15 867 tonnes in 1995 and 33 480 tonnes in 2000. The production of farmed shrimp in 2002 of 61 283 tonnes was close to the fishing production of 61 024 tonnes.

The main farmed shrimp species in Mexico is *Litopenaeus vannamei*, but there is also production of *L. stylirostris* and *Farfantepenaeus californiensis*. *L. vannamei* is native to the Pacific coast of Central and South America, but is now being farmed in other regions and is the major farmed species in the world.

International shrimp prices have been stagnant or declining in recent years. At least some of the downward pressure on prices on many types of shrimp (farmed as well as captured) comes from the increasing amount of farmed shrimp on the world market, especially *L. vannamei* from China.

MAJOR ISSUES

The major issues related to shrimp fishing in Mexico are:

- declining CPUE and overcapacity in many of the shrimp fleets;
- the improvement of profitability of shrimp fishing; this may require effort reduction, but effort restrictions face strong resistance from fishers;
- shrimp exports are extremely important to the country; however, since the major market is the United States, the various forms of sanctions that could conceivably be applied to the shrimp trade could have extreme negative consequences;
- incomplete knowledge of the large amount of artisanal shrimp fishing activities; and
- management of the interactions between the three different types of shrimp fisheries in Mexico: those of the high seas, the bays and the estuaries.

Shrimp fishing in Nigeria

Based on the work of B.B. Solarin

AN OVERVIEW

Shrimp fishing in Nigeria is undertaken by about 225 industrial shrimp trawlers and a large number of fishers inshore, using small trawls, beach seines and stow nets. Shrimp, the most important agricultural export of the country, is responsible for a substantial amount of employment and is a significant source of food in coastal areas.

Major difficulties associated with shrimp fishing are the damage caused by industrial operations to small-scale fishers and overcapacity of the trawl fleet. Good data on shrimp catches, shrimp fishing effort and shrimp exports are not readily accessible, and those that are available, are often conflicting.

DEVELOPMENT AND STRUCTURE

Nigeria has a coastline of 853 km along the Gulf of Guinea in the Atlantic Ocean. The continental shelf is relatively narrow, ranging in width between 14.8 km to the west off Lagos and 27.8 km to the east off Calabar. The country has about 46 000 km^2 of shallow ocean area (with a depth of less than 200 m). Oceanographic conditions, including poor upwelling, limit the productivity of the waters off the Nigerian coast (FAO, 2000c).

Most Nigerian commercial shrimping grounds lie east of longitude 5°E at the Nigerian/Cameroon border, principally around the Niger Delta, river mouths and in estuaries and lagoons with soft mud deposits. Marine shrimp is caught by both artisanal and industrial trawlers. The artisanal vessels catch shrimp in the area between zero and five nautical miles offshore, while trawlers are required to fish outside this zone. Nigeria's major shrimping areas are offshore of the mouths of the Rivers Escravos, Forcados, Ramos, Pennington, Brass, San Bartholomew and Calabar.

Trawling for fish and shrimp commenced in the late 1950s after the 1950–53 Colonial Development Corporation exploratory survey (Longhurst, 1965).) Serious private sector trawl fishing in Nigeria started in 1982 with the introduction of 49 medium-size trawlers (Amire, 2003). A tremendous growth in trawl fishing took place in 1985 with the deployment of 149 fishing and shrimping vessels, harvesting a total of 23 766 tonnes of fish and 2 376 tonnes of shrimp. The original focus of trawlers brought in from Greece, Spain, Italy, Japan and the United States of America was finfish, with shrimp featuring as a bycatch (Chemonics, 2002). During this period, the Nigerian naira was strong (at about NGN1 to US$1), so the fish catch sold profitably on the local market. In 1986, the naira devalued as a result of a structural adjustment programme. Thereafter, fish sold locally could not even cover operational costs and the Nigerian Government's appetite for foreign exchange increased. Shrimp, which used to be a bycatch, became the focus because of its high export earnings. In 1987, the fish

catch by trawlers fell by 13.2 percent to 28 411 tonnes, while shrimp production rose by 82.5 percent to 5 234 tonnes (Amire, 2003).

The industrial shrimp fleet of Nigeria consists of about 225 vessels, ranging in length from 23 to 26 m, and is operated by 28 fishing/shrimping companies. The vessels are typically Mexican-type trawlers built in the United States. They mostly use quad-rigged, four-seam trawls with headlines of 15–20 m, and have an onboard blast or plate freezer and a cold store capable of maintaining products at -18°C to -20°C. They operate day and night using their booms to pull either two or four otter trawl nets with tickler chains. Towing speed is between 2.5 and 3.0 knots and trawling time is about three hours. The vessels are crewed with 3 000 foreign and Nigerian crew, the latter being mainly mate certificate holders and second-class engineers. The skippers and chief engineers are mostly Asian and Ghanaian nationals. The trawling industry is represented by the Nigerian Trawler Owners Association (NITOA), the members of which operated about 250 Nigerian-flagged vessels in 2004 (Chemonics, 2002; FAO, 2000c; ICES/FAO, 2005).

Non-industrial shrimp fishing in Nigeria has three components.

- First, there are 8–12 m wooden canoes propelled by a 15–40 HP outboard engine, which tow conical filter nets for targeting/catching the estuarine prawn (*Nematopalaemon hastatus)* in inshore waters less than 5 km from the shoreline. This type of fishing is undertaken in all eight Nigerian maritime states.
- Second, there is an artisanal beach seine net fishery, which uses nets of 500–1 500 m in length and operates in shallow coastal waters. The Beach Seine Fishery started in the 1950s. Larger nets were introduced by fishers who migrated eastwards from Ghana, Togo and Benin. The large seine nets are owned by one or two families, but operated by a group of fishers referred to as "the company", which is disbanded at the end of each annual fishing season. The beach seine fishery has been declining because of a lack of adequate labour to pull the net ashore manually. The fishery, which had been operated by previous generations, is not especially attractive to the youth of today, who prefer to work as deck hands on vessels.
- Third, conical stow nets are used passively for catching mainly submature shrimp in the sheltered brackish waters of the lagoons, creeks and estuaries.

TARGET SPECIES, CATCH AND EFFORT

Amire (2003) provides information on the important shrimp in Nigeria. The species[33] mostly exploited are: the southern pink shrimp, *Penaeus notialis*, which is most abundant and most valued economically; Guinea shrimp, *Parapenaeopsis atlantica*; caramote prawn, *Penaeus kerathurus*; and the deep-water rose shrimp, *Parapenaeus longirostris*. *P. notialis* prefers supra-thermocline muddy sand with fine particles and abundant organic matters at 25°C. Concentrations of this species are particularly high in the Niger Delta, at 20–30 m. *Parapenaeopsis atlantica* is prevalent at 10–40 m in depth, while *Parapenaeus longirostris* is found in deep waters from 60 to 400 m.

The estuarine prawn (*Nematopalaemon hastatus*) is the basis of a major fishery. Exclusively exploited by small-scale operators with passive cane or netting gear in estuaries and with small trawls in the surf zones, it constitutes about 50 percent of estuarine shrimp catches. Also harvested by artisanal fishers are the brackish water prawn (*Macrobrachium macrobrachion*), river prawn *(M. vollenhovenii*) and juvenile southern pink shrimp.

Ogbonna (2001) lists the species in the inshore shrimp fishery of Nigeria, in ascending order of importance:

- *Penaeus notialis;*
- *Parapenaeopsis atlantica;*

[33] The English names have been modified to conform to standard FAO nomenclature.

- *Parapenaeus longirostris;*
- *Penaeus kerathurus;* and
- *Nematopalaemon hastatus.*

An important and interesting feature of late has been the arrival of *Penaeus monodon* wild giant tiger prawns in trawler catches (Chemonics, 2002). *P. monodon* appeared in the late 1990s and apparently occurs mainly in the Calabar/eastern delta zone where it comprises as much as 10 percent of trawler catches. This is an Asiatic exotic that could have only arrived through human agency (African current patterns preclude natural introduction), and presumably escaped from a West African (Gambian, Senegalese or Cameroonian) shrimp farm. FAO (2000c) states: "As reported for Cameroon, the non-native giant prawn *Penaeus monodon* is increasing in abundance".

Information on the amount of shrimp caught in Nigeria is fragmented and sometimes conflicting.

- Data reported by the Government of Nigeria to FAO during the previous decade indicate that the annual shrimp catch varied from 15 000 to 30 000 tonnes, with an average of 22 452 tonnes.
- Chemonics (2002) reports that reliable production data are scarce, but historic data show reported landings of 10 000 to 15 000 tonnes annually, although anecdotal reports mention 30 000 tonnes (as do some landings statistics that cover the 1980s). Discrepancies are usually accounted for by illegal at-sea sales that go unreported. Trade data from the Organisation for Economic Co-operation and Development (OECD) give an alternative measure – some 6 800 tonnes were imported into Europe in 1998 (which takes the great bulk of Nigerian shrimp). Adjusted for weight loss on processing, this equates to 10 000 tonnes (live-weight equivalent), so there is some corroboration for a figure of this magnitude.
- The annual catch of shrimp between 1992 and 1997 was more than 9 000 tonnes (up to 12 000 tonnes) (Ogbonna, 2001). In 1998, total shrimp exports to Europe were 8 300 tonnes.

It appears that at least some of the differences between the various estimates of shrimp catches are caused by the lower estimates mainly for licensed shrimp vessels, while the upper estimates include all forms of shrimp fishing, including small-scale.

With such uncertainty over the amount of the annual shrimp catch, information on CPUE is even more doubtful. Nevertheless, some information is available. Ogbonna (2001) gives annual CPUE on licensed shrimp vessels between 1985 and 1997 (Table 65).

Operational information from the industrial shrimp fleet in recent years indicates that between 5 and 10 tonnes of shrimp and about 40 tonnes of retained bycatch are considered typical for a 45– to 55–day fishing trip. Vessels trawl continuously, completing six to eight hauls per 24 hours (240–400 hauls during each trip), and characteristically retain 20 kg of shrimp and 150 kg of bycatch per haul. However, catches vary considerably among vessels and across areas and seasons.

TABLE 65
CPUE data on licensed shrimp vessels, 1985–97

	Total shrimp catch (tonnes)	Number of shrimp vessels	Catch (tonnes/vessel/year)
1985	2 376	40	59.4
1986	2 623	54	48.57
1987	3 517	82	42.80
1988	2 868	132	21.72
1989	5 234	158	33.72
1990	3 666	195	18.80
1991	6 200	195	31.70
1992	9 373	203	46.10
1993	8 956	223	40.16
1994	8 884	230	40.16
1995	12 252	235	34.27
1996	9 551	196	48.73
1997	10 807	266	40.63

Source: Ogbonna, 2001.

ECONOMIC CONTRIBUTION

Nigeria's shrimp fisheries, both industrial and artisanal, are a major source of both direct and indirect employment. This includes shrimp capture/production, processing for local and export markets, and jobs associated with gear sales/repair and cold-storage facilities.

It is estimated that members of NITOA provide either full- or part-time employment for about 50 000 people,

including work on vessels, in processing plants and in distribution. Current estimates suggest that 1.2 million people have formal or informal employment associated with shrimp fishing and downstream activities (Federal Department of Fisheries statistics, NITOA, 1998).

Against these employment benefits, it should be noted that many of the inputs into the Nigerian shrimp industry (e.g. vessels, trawl nets and accessories) are imported.

Data on the domestic consumption of shrimp and shrimp products are not readily available. It is well known, however, that the estuarine prawn (*Nematopalaemon hastatus*) is both a major source of relatively cheap animal protein and an important condiment in food preparation. Trawler bycatch retained and sold ashore is also an important food.

According to information from the Central Bank of Nigeria, fishing is responsible for about 5 percent of agriculture's contribution[34] to Nigeria's GDP. The specific contribution of shrimp fishing is not readily available.

TRADE ASPECTS

Shrimp and shrimp products are the second most important commodity export of Nigeria after petroleum. FAO (2000c) reports that about half the country's total shrimp catch (both large- and small-scale fishing) is exported. The quantity and value of shrimp exports for recent years are shown in Table 66.

TABLE 66
Shrimp exports from Nigeria, 1992–2001

Year	Quantity (tonnes)	Value (US$)
1992	3 400	13 966 526
1993	2 322	8 539 423
1994	3 368	11 163 114
1995	4 265	13 393 769
1996	3 845	14 345 623
1997	2 946	8 386 458
1998	8 028	31 163.784
1999	7 418	46 485 491
2000	6 303	39 495 886
2001	6 694	48 820 467

Source: Dada, 2004.

Chemonics (2002) reports on shrimp processing, export and domestic sales of Nigerian shrimp.

- Most Nigerian shrimp is frozen whole at sea. It is often packed on board as a finished product for the "head-on" whole shrimp market (plate frozen in 2-kg boxes). The main role of the shore facilities in Lagos is to store and aggregate the frozen landed product prior to export by 40-foot (12.2 m), 18-tonne container. Alternatively, bulk (blast) frozen shrimp can be further processed in the Lagos plants. The shrimp is thawed and deheaded, and can either be packed as such or peeled. Since the trend in the market is towards requiring increased value added, further processing may become a more important activity in Nigeria.
- With regard to export markets for Nigerian shrimp, most is sold in Europe. In 2002, the total EU shrimp market was about 280 000 tonnes, with a value of about US$1.75 billion. Nigeria, in effect, holds about 2 percent of the European market. Important market components are Spain (25 percent of sales), France, Belgium and the United Kingdom.
- As regards domestic shrimp marketing, the highly perishable nature of shrimp dictates that it is mostly sold smoked, unless it is sold close to the point of capture where fresh/live products can be on sale. Distribution relies upon small traders who buy and deliver small quantities of dried/smoked seafood to rural markets, using local transport. This is a trade dominated by women – the "fish mammies", who tend to control artisanal post-harvest activities throughout West Africa, often within family businesses where the men fish while the women manage and sell.

FAO (2000c) reports that Nigeria achieved harmonization in the EU market for its fish products exports, mainly shrimp, and other products such as sole fillets, cuttlefish and crab claws. The harmonization of Nigeria with EU regulations resulted

[34] This includes crop production, livestock, forestry and fishing.

in the listing of approved vessels. Responsibility for monitoring and maintenance of standards and recommendations for listing/delisting has been vested in the Federal Department of Fisheries in accordance with EU legislation.

In February 2004, the United States Government announced that it would ban imports of shrimp from Nigeria, according to Section 609 of United States Public Law 101–162, which provides 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 unless certified. The foundation of the United States programme governing the incidental taking of sea turtles in the course of shrimp harvesting is, according to the United States NMFS, the requirement that commercial shrimp trawl vessels use TEDs, approved in accordance with standards established by NMFS (C. Stanger, personal communication, Office of Marine Conservation, United States Department of State, October 2005).

Although exports to the United States only constituted a minor part of total Nigerian shrimp exports before the closure, both the Nigerian Government and the shrimp industry have been very anxious to have United States exports reopened. This is both to increase exporting flexibility and because of the concern that the EU may follow the United States in adopting turtle excluder requirements (ICES/FAO, 2005).

BYCATCH ISSUES

In the small-scale shrimp fisheries, bycatch is minimal. Most small-scale shrimp fishing targets the estuarine prawn (*Nematopalaemon hastatus*), which has a shrimp to fish ratio ranging from 8:1 to 15:1.

Industrial shrimp trawlers catch a diverse assemblage of finfish, crustaceans and cephalopods, including juveniles of some commercially important species. The shrimp to bycatch ratio ranges from 1:5 to 1:15.

Most of the retained bycatch includes teleosts such as croakers (Sciaenidae – *Pseudotolithus* spp.), threadfins (Polynemidae – *Galeoides decadactylus*, *Polydactylus quadrifilis* and *Pentanemus quinquarius*), sole (Cynoglossidae – *Cynoglossus* spp.) and grunter (Pomadasyidae – *Pomadasys jubelini*). Some are sold sorted by species (in 20-kg bags) according to size (e.g. large, medium and small), while others are combined with various species and packaged in four categories, with a progressive decrease in fish size, as mix 1, mix 2, mix 3 and, more recently, mix 4. Fish smaller than mix 4, which can be up to 40 percent of the bycatch, are sometimes sold at sea by the trawler crews to small-scale fishers. These fish are resold ashore, resulting in the development of bycatch markets along the coast of the eight Nigerian maritime states.

Akande (2002) provides some information on the trade of shrimp bycatch. Officially, shrimp bycatch must be landed at a designated port, jetty or fishery terminal. The law stipulates that any shrimper operating in Nigerian inshore waters must land 75 percent of the shrimp bycatch. There is, however, much evidence that there is a thriving business of transfer to canoes on the high seas. Bycatch collection is now an occupation attracting an increasing number of artisanal fish traders in all the coastal states of Nigeria. Despite limitations on the size of their collector vessels (canoes), the occasionally rough sea and the technical problems of transferring bycatch at sea, the artisanal fishers find the collection of bycatch a viable alternative source of income. The first category of artisanal fishers involved in the transfer of bycatch at sea concerns those who, because of the high costs of fishing operations, opt to undertake the full-time business of accepting bycatch from shrimp trawlers. The second group normally concentrates on *bonga* and *sardinella* during the peak season, but instead chooses the bycatch transfer trade during the low season.

Irrespective of fish size, it is apparent that few of the organisms caught by Nigerian shrimp trawlers are discarded. Kelleher (2005) states that trawl fisheries in Ghana,

Nigeria and Cameroon have low discard rates since there is extensive collection at sea. Because of high demand for fish products and high coastal populations in many areas, discards in the artisanal fisheries are negligible.

Some years ago, Akande (2002) reported that BRDs are not used on any of the registered shrimp vessels and there are no plans to introduce them. A more recent ICES/FAO report (2005) states, however, that the investigation of the performance of BRDs as an attractive and environmentally friendly option to mitigate the problem of bycatch in shrimp trawling has commenced. The use of TEDs on shrimp trawl nets has been a requirement since September 1996, but was still not fully implemented until the beginning of 2006, as documented by the United States import ban.

Nigeria participates in the global FAO/GEF/UNEP project "Reduction of the Environmental Impact of Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management". The project's objective is to introduce bycatch reduction technologies in order to protect juvenile fish and marine turtles. Through the concerted action of this project, the fishing industry, the Nigerian Institute for Oceanography and Marine Research (NIOMR) and the Department of Fisheries, Nigeria was recertified for exporting wild shrimp to the United States market in January 2007 after United States inspectors had found the implementation of TEDs satisfactory during an inspection in August 2006.

In Nigeria, an important issue related to bycatch is that traditional small-scale fishing gear catches large quantities of juvenile shrimp. It is desirable that fishers using this gear change their practices to allow the shrimp to grow to maturity, contribute to recruitment and attract higher market value, thereby improving the overall value of the fishery. It has been suggested that the traditional small-scale shrimp filter/stow nets be modified so they can be more selective for larger-size shrimp.

PROFITABILITY

Few recent data are available on the profitability of shrimp fishing in Nigeria.

In 2002, shrimp trawler production costs in Nigeria were analysed (Chemonics, 2002). It was concluded that, in former years, shrimp trawling had prospered in the country since it was both profitable and generated foreign exchange. When production costs in previous years were nearly US$5/kg of whole shrimp, this equated to US$7.80–8.00/kg of tails (allowing for processing weight loss). While prawn tail prices averaged US$10/kg, the business was clearly profitable, generating margins of 30 percent. A number of events subsequently occurred in the shrimp industry, negatively affecting profitability: catch rates and shrimp prices fell, fuel costs rose and piracy increased. Consequently, in 2002, shrimp trawling in Nigeria was close to breakeven at best and the situation still remains. The exit of many players from the industry in 2002 supported the contention of low profitability. Chemonics (2002) came to several conclusions.

- Economic revival will depend on either prices rising or catch rates improving, as there is little scope to reduce costs.
- If prices do not rebound, then the principal option facing the industry must be to reduce overall capacity to allow unit catch rates to increase for the remaining vessels.
- To restore profitability, catch rates need to increase by 50 percent (i.e. from 60 to 90 tonnes/boat/yr). This would imply a fleet reduction of at least 35 percent (i.e. reducing the fleet to 100–110 trawlers).

ENERGY INPUT ASPECTS

Each industrial shrimp trawler stays out of port for 45–55 days and requires 30–50 tonnes of fuel.

Despite its rich oil resources, Nigeria does not have the refining capacity to meet domestic demand and has to reimport consumable refined oil. For the past decade,

under pressure from donors demanding market liberalization, governments across West Africa have been calling a halt to fuel subsidies, which cost the Nigerian Government alone US$2 billion a year. In September 2005, thousands of angry Nigerians took to the streets to protest against 30 percent rises in fuel prices (Mail and Guardian, 2005).

The current price of diesel fuel ranges from US$0.50 to US$0.70/litre. The price remained the same after the September 2005 increase, and the Federal Government gave assurances that the current price would be retained throughout 2006.

In addition to fuel costs, the main complaint related to fuel for trawlers has been the inadequate and irregular supply of fuel. A further problem concerns fuel bunkering. Most companies operate from private jetties within the state of Lagos, which makes bulk purchase or delivery of fuel difficult. To mitigate this problem, the Federal Government was contemplating building a fishing terminal complex in the Lagos area, funds permitting.

BIOLOGICAL ASPECTS

Amire (2003) summarizes the results of studies on the inshore and offshore trawl fisheries.

For the inshore fishery, *Ajayi (1982), analysing the 1971–1978 catch and effort data of Nigerian shrimpers, calculated a sustainable yield of 2 008 tonnes for 12 651 days at sea. Ajayi and Adebolu (personal communication, 2006), combining shrimp catch data from Cameroonian shrimpers with those of Nigerian fishing trawlers and shrimpers, estimated an MSY ranging from 3 250 to 4 000 tonnes. Pooling all the estimates, the potential of the Nigerian inshore shrimp resources is between 3 250 and 4 016 tonnes.*

For the offshore fishery, *Tobor (1990) estimated the potential yield of Nigeria's offshore demersal resources to be 6 370 tonnes. Earlier results from the Guinea Trawl Survey estimated approximately 31 000 tonnes as the standing stock within the 50–200 m depth area. The potential of the offshore royal shrimp,* Parapenaeus longirostris, *which occurs in this zone from 50 to 200 m depth, is yet to be determined.*

A Workshop on the Assessment and Management of Shrimp and Crabs in Southwest Africa was held in 1999. The report of the workshop (Caramelo, Lamboeuf and Tandstad, 1999) indicated that because only catch and effort data were made available to the workshop, only simple production models could be used in the analysis. Regarding the shrimp resources of Nigeria, MSY for the shallow-water shrimp fisheries was calculated at 8 800 tonnes and the equilibrium effort of MSY was calculated at 48 000 fishing days. This was taken as an indication that the fishery was exploited close to the MSY level at that time. It was also concluded that the relationship between effort and CPUE in the previous nine years was not significant, which probably resulted from the limitations of data collection.

It is clear that the output level of the shrimp fishery was considerably beyond the potential long-term yield estimates (FAO, 2000c).

IMPACTS ON THE PHYSICAL ENVIRONMENT

Although there have been no specific studies in Nigeria on the effects of shrimp trawling on the ocean bottom, there is a general perception that the groundropes, tickler chains and doors of shrimp trawl nets that are dragged over the sea bottom to catch shrimp also disturb the soft bottom. This disruption occurs by direct contact or through turbulent resuspension of sediments.

NITOA is working with the Nigerian Government to address the numerous problems of the industrial fishery sector, including environmental concerns (FAO, 2000c).

Another less obvious environmental concern relates to the harvest of fuelwood for smoking shrimp and bycatch. This is responsible for some destruction of mangrove areas, which serve as breeding and nursery grounds for fish and shrimp. It also

exacerbates coastal erosion and promotes the spread of exotic plant species, particularly the Nypa palm.

IMPACTS ON SMALL-SCALE FISHERIES

Large-scale industrial shrimp fishing has a significant impact, both directly and indirectly, on small-scale fishing activity. The artisanal vessels catch shrimp in the area between zero and five nautical miles offshore, while trawlers are required to fish outside this zone. The problem is that large trawlers frequently encroach upon this zone, especially in the highly productive mouths of rivers, which often results in physical interaction with small-scale fishing gear. Many incidences of gear damaged by trawlers are not adequately redressed because of non-reporting or the apathy of industrial fishers. Coastal communities generally believe that industrial fishing has reduced the standard of living of fishing families living in coastal areas.

Large-scale industrial shrimp fishing also affects small-scale fishing activity indirectly through competition for the same resources. It has been shown that much of the industrial bycatch is finfish juveniles, which are important in small-scale fisheries. Similarly, some of the most significant shrimp species are targeted by both the large- and small-scale fisheries.

As mentioned previously, traditional shrimp stow nets in Nigeria catch large quantities of juvenile shrimp. There is the contention that fishers using this gear should change their practices to allow the shrimp to grow to maturity, contribute to recruitment and attract higher market value, thereby improving the overall value of the fishery. This seems to be a case of small-scale shrimp fishing negatively affecting large-scale fishing.

MANAGEMENT

Amire (2003) reviews the evolution of the legal basis for fisheries management in Nigeria. The first comprehensive law, Sea Fisheries Act No. 30, was promulgated in 1971. The subsidiary Fishing and Licensing Regulations of the Act were enacted in 1972. Following lapses observed in the effectiveness of this decree over time, it was repealed and replaced by Sea Fisheries Decree No. 71 of 1992. The main decree contained general provisions for the conditions relating to the issuance of fishing and shrimping licences, vessel operations, duties and powers of authorized persons and penalties for offences. The Sea Fisheries Fishing and Licensing Regulations enacted under the new decree contain provisions similar to those of the repealed Sea Fisheries Act No. 30 of 1971. However, they provide for, *inter alia*, wider and stiffer penalties for offenders.

ICES/FAO (2005) review the sea fisheries licensing and fishing regulations that impact on shrimp trawling and associated bycatch. These provisions and justifications are the following.

- An obligatory pre-purchase assurance in writing by the licensing authority that any procured vessel entering the Nigerian shrimping business would be licensed after the due process. This is a measure to control, before investment, fishing effort and prevent overcapitalization.
- A requirement for a vessel survey and tonnage measurement, by the Nigerian Government Inspector of Shrimping from the Federal Ministry of Transport, to ensure that only suitable and permissible vessels enter the Nigerian shrimping or fishing fleet.
- Restriction in size of a shrimp trawler to less than 23.2-m length overall and 130 GT, to prevent oversized vessels from entering the trawl shrimp fishery.
- Delimitation of a non-trawling zone of five nautical miles, which places restrictions on trawling in a sea water area covering about 7 900 km^2 of the Nigerian continental shelf. This is to safeguard nursery grounds from indiscriminate fishing and protect artisanal fishers who operate within the zone.

- A minimum codend mesh size of 44 mm (stretched) for any shrimp trawl net, in order to promote the sustainability of inshore trawl fisheries.
- Prohibition of the use of the same vessel licensed to trawl for fish from trawling for shrimp, in order to limit shrimp trawling effort.
- Prohibition of discarding edible and marketable sea products and transhipment at sea of bycatch. The immediate purpose of this is to encourage vessels to bring all catches back to the home port to increase the supply of fish to the domestic market. This should also indirectly discourage non-compliance with the mesh size regulation, which leads to catching small-sized or juvenile fish.
- A regulation concerning minimum fish sizes for sale, to discourage the catching of undersized fish and ensure the use of legal mesh size in the codend.
- Prohibition of single and pair trawling by motorized vessels of less than 20 GT and in waters shallower than 18 m, to protect juvenile fish and biodiversity in fishing grounds, which are also nursery grounds in some areas.
- The requirement for using a TED on shrimp trawls (from September 1996).

Amire (2003) discusses two additional issues important in the management of Nigeria's shrimp fisheries.

- *Removal of subsidies*. In an effort to stimulate the development of the fisheries subsector, the Nigerian Government adopted various subsidy arrangements of up to 50 percent on all canoes, fishing equipment and spare parts that it supplied to members of registered fishers' cooperative societies up to 1984. This subsidy was subsequently withdrawn when the government was satisfied with the level of capacity development in the subsector. Fishers now procure or are supplied with fishing items, whenever available, at current market rates.
- *Consultative arrangements*. There is an elaborate consultative mechanism between the government and representatives of owners of fishing vessels licensed to operate Nigerian-flagged vessels within or outside Nigerian waters. All trawler owners are required to be members of NITOA, which plays a vital communications part between members and the government on all issues that affect members. The Association is usually consulted on all relative matters and its suggestions are usually given serious consideration before decisions are taken.

ENFORCEMENT

In 1991, the Government of Nigeria established the national fisheries resources Monitoring, Control and Surveillance Unit (MCSU) in the Federal Department of Fisheries in order to achieve fisheries management objectives. Its mandate is to ensure that adequate data on effort and capacity used in harvesting the country's fisheries resources are collected and collated for sustainable management. Other mandated functions of the unit include search and rescue operations for distressed fishing vessels, in collaboration with the Nigerian navy, sea patrols and surveillance to ensure compliance with fishing regulations, and monitoring of resources to enable it to advise the government on the state of resources (Amire, 2003).

The activities of the MCSU include all industrial fishing and shrimping vessels that berth or fish in any part of the country. In order to discharge their duties effectively, some officers of the unit have been deployed to the fishing companies on a permanent basis. Observers on board are also used to the extent that funds permit.

Unauthorized fishing (without a licence) attracts a US$250 000 fine, a five-year imprisonment term or both. All other offences now attract a US$5 000–20 000 fine, instead of the derisory US$400 of previous years.

Perceived difficulties in enforcing shrimp fishery management measures include the lack of an operational fisheries patrol and weaknesses in prosecuting violations of fisheries legislation.

RESEARCH

Fisheries research and training are the responsibilities of fisheries research institutes and their affiliated colleges. Development departments, such as the Federal Department of Fisheries, also contribute to human resources development through short-term training programmes and the sponsorship of trainees in colleges. NIOMR is the Federal Government agency established to conduct research on the resources and physical characteristics of Nigerian territorial waters and the EEZ. Its activities include fisheries and other aquatic resources surveys, marine geology and geophysical surveys, physical and chemical oceanography, fishery technology research, brackish water aquaculture research, extension research and liaison services. NIOMR is based in Lagos, with a substation at Aluu, Port Harcourt.

NIOMR's contributions to shrimp fishery research and management include:

- an exhaustive mesh selectivity experiment as the basis for the mesh requirements in the 1971 Sea Fisheries Decree;
- reappraisal of the 1971–72 management provisions as the basis for 1992 regulations;
- exploratory shrimping surveys (when vessels were functional);
- determination of the optimum number of inshore shrimp vessels;
- the 1991–96 inventory of small-scale coastal fisheries potential;
- establishment of a catalogue of small-scale fishing gear in Nigeria.

Major external research projects related to shrimp fishing in Nigeria have included:

- the Guinea Trawling Survey, executed in the early 1960s, which covered the entire Gulf of Guinea region;
- a month-long regionwide (Ghana to Cameroon) trawl survey undertaken in February and March 1999, using a 25-m Nigerian shrimp trawler – 44 percent of the trawling was conducted in Nigerian waters;
- a survey by the research vessel Dr Fridtjof Nansen in the eastern Gulf of Guinea (Nigeria, Cameroon, Sao Tome and Principe) in June and July 2004;
- the GEF/UNEP/FAO shrimp fisheries project, "Reduction of the Impact of Tropical Shrimp Trawling Fisheries on Living Marine Resources, through the Adoption of Environmentally Friendly Techniques and Practices", has carried out research on Nigerian shrimp fisheries, including resource monitoring, socio-economic investigations relating to trawl bycatch, and development of appropriate bycatch reduction technology.

DATA REPORTING

Catch data on shrimp fisheries are collected at landing sites along the coast of Nigeria. They are then collated in the state field offices and sent to Abuja for final collation and publication.

The only on-board data available to date are those collected under the GEF/UNEP/FAO shrimp fisheries project.

Regarding data quality, Chemonics (2002) reported that reliable production data on shrimp fisheries in Nigeria are scarce. However, there have been some recent improvements.

- New data formats have been designed and subsequently reviewed by the National Steering Committee of the GEF/UNEP/FAO shrimp fisheries project. They are being used to collect data from 224 industrial trawlers.
- A five-day training workshop was organized for 49 data collectors and fisheries assistants. This involved species identification, sampling methods, sorting/measurement and recording of data.

IMPACTS OF SHRIMP FARMING

Shrimp farming has not started on any appreciable/commercial scale in Nigeria; its effects on shrimp fishing in the country are therefore negligible.

MAJOR ISSUES

The major issues related to shrimp fishing in Nigeria are:

- the interaction between large- and small-scale shrimp fishing, including the encroachment of industrial shrimp trawlers upon areas reserved for small-scale fishing, and competition for the same fishery resources;
- the major importance of shrimp as a basis for both employment and exports;
- overcapacity in the trawl fleets;
- lack of reliable catch and effort data;
- the current low profitability of commercial shrimp fishing caused by piracy, falling catch rates and shrimp prices, and increasing fuel costs; and
- limitations to enforce management measures while at sea.

Shrimp fishing in Norway

Based on the work of Øystein Hermansen

AN OVERVIEW

Norway is a major shrimp producer. Between 60 000 and 70 000 tonnes of shrimp are caught annually and the country is the 14th largest producer of shrimp in the world. Shrimp fishing in Norway is, however, not nearly as important as fishing for other species such as herring, blue whiting, cod and saithe. Shrimp represented about 4 percent of the value of all Norwegian fishery products exports in 2003.

The main shrimp stocks exploited by Norwegian fishers are those in the Barents Sea, Skagerrak and the North Sea. In addition, many Norwegian fjords have small local stocks. For regulatory purposes, the shrimp resources are treated as three separate stocks: north of 62°N, Skagerrak and the North Sea. In addition, Norwegian vessels are allocated quotas around Greenland and the Flemish Cap.

The poor profitability of many types of shrimp vessels in Norway is a major problem. This has probably arisen from a combination of factors, including excess capacity, increasing fuel costs and falling market prices for shrimp.

Much of the management of Norwegian shrimp fishing, both domestically and internationally, is driven by the need to avoid both overfishing and the bycatch of cod and other important species.

DEVELOPMENT AND STRUCTURE

Modern Norwegian shrimp trawling began in the 1890s, when the renowned fisheries researcher Johan Hjort collaborated with Danish researchers and introduced trawl technology for shrimp fishing. The fishery started as a coastal fishery in the southern part of Norway and, by the 1930s, had spread all along the Norwegian coast.

The catch was predominantly boiled on board and hand-peeled on shore. Much of the production in the northern part was exported, while the local market for fresh shrimp in the southern part was larger and more developed.

In 1970, the Norwegians started exploiting the shrimp stock in the Barents Sea and around Spitsbergen, using large ocean-going trawlers. The quantities caught from this

TABLE 67
Number of licences for shrimp trawlers

	1990	1995	2000	2004
Offshore trawlers	147	119	108	90
Coastal south 62° N			173	174
Coastal north 62° N*			104	78

* A licence is not required for vessels under 50 GRT; the number given is the number of vessels that have delivered fresh shrimp.
Source: Norwegian fishers sales organization.

stock quickly surpassed the coastal fisheries and grew to a maximum of 128 000 tonnes in 1984.

Norwegian vessels have also exploited stocks in the northwest Atlantic, off Canada and Greenland. The fishery off Canada started in 1993.

The Norwegian shrimp fishery is in general a single-species fishery for northern shrimp. Operations are carried out by two distinctly separate fleets: one fishing inshore, employing small trawlers (wood/steel) of 10–20 m in length, and the other fishing offshore with large steel trawlers of 20–70 m in length. Most of these vessels use high-opening bottom trawls, rigged as single or twin.

Even though the fishery is single-species, about half of the offshore trawlers also have licences for catching groundfish, but these are carried out as separate fisheries with different trawls and locations.

The coastal vessels fish in the fjords along the Norwegian coast and in Skagerrak, and deliver their catch fresh. The large trawlers fish at several locations: around Spitsbergen, in the Barents Sea, east of Greenland, the Flemish Cap and Jan Mayen. This catch is delivered frozen.

Access to the shrimp fisheries is regulated through a licensing regime. This applies both to offshore trawlers and coastal vessels fishing south of 62°N. North of this boundary, access is open for coastal vessels. While most of the fisheries operate within the EEZs of various countries, the fishery in the west of the Atlantic also operates in international waters. This fishery is managed through the Northwest Atlantic Fisheries Organization (NAFO). Within zone 3M (Flemish Cap), the fishery is managed through an effort allocation scheme, in which Norway had 1985 fishing days in 2006 and participated with 32 vessels.

Over the last decade, the numbers of both coastal and offshore trawlers have declined. The number of licences issued in the offshore fleet and in the fishery south of 62°N are shown in Table 67. In 1998, access to the latter fishery was closed (and licences became mandatory), hence there is no licence information for 1990 and 1995. The number of coastal vessels that delivered fresh shrimp north of 62°N is also shown, giving an indication of activity in the fishery. Statistics from 1990 and 1995 are unreliable for this group.

Through the Participants' Act, only persons with Norwegian citizenship are allowed to own fishing vessels; the shrimp fleet is therefore domestically owned. To a large extent it is owned by the vessel operators themselves, or by close family. There are a few companies, particularly in the western part of Norway, operating more than one large offshore trawler.

TARGET SPECIES, CATCH AND EFFORT

Norwegian shrimp trawling targets a single species, the northern shrimp (*Pandalus borealis)*, which is also known as the pink shrimp and the deep-water red shrimp. It is widely distributed in the boreal waters of the North Atlantic, North Pacific and Arctic Oceans. In the North Atlantic, the southern boundary of the stock to the west is the Gulf of Maine, while the North Sea forms the southern limit of the stock in the eastern Atlantic (Graham, 2005).

Cold-water shrimp landings come mainly from four North Atlantic countries: Canada, Greenland, Iceland and Norway itself. In 2004, global landings were estimated at 450 000 tonnes, of which about 175 000 tonnes were landed by Canada (IntraFish, 2005).

TABLE 68
Norwegian catches of shrimp by area, 1995–2004

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
North Sea	5 181	5 143	5 460	6 519	3 987	3 556	2 959	3 709	3 736	4 638
Skagerrak	2 879	2 772	3 112	3 092	2 761	2 562	3 952	3 612	3 979	4 360
Barents Sea	19 337	25 445	29 079	44 792	52 612	55 333	43 021	48 799	34 652	36 188
Other areas	11 853	8 118	4 305	2 643	4 177	5 053	15 279	13 019	23 662	14 041
Total	39 250	41 478	41 956	57 046	63 537	66 504	65 211	69 139	66 029	59 227

Source: ICES, 2005.

TABLE 69
LPUE and effort for Norwegian vessels in Skagerrak and the North Sea, 1996–2004

	1996	1997	1998	1999	2000	2001	2002	2003	2004
LPUE	37	42	44	32	31	32	39	47	57
Effort	214	212	219	219	195	217	186	166	159

Source: ICES, 2005.
Note: units: effort – 1 000 trawl hours; LPUE - kg/hr.

TABLE 70
Effort and CPUE for Norwegian vessels in the Barents Sea, 1996–2004

	1996	1997	1998	1999	2000	2001	2002	2003	2004
CPUE	179	180	238	229	204	226	216	200	191
Effort	84.9	124.9	153.8	197.2	237.4	182.5	223.6	151.4	165.4

Source: ICES, 2005.
Note: units: effort – 1 000 trawl hours; CPUE – kg/hr.

There are several individual stocks of northern shrimp. The main stocks exploited by fishers from Norway are those in the Barents Sea, and the one in Skagerrak and the North Sea. In addition, many Norwegian fjords have small local stocks. Catches of shrimp by area, from 1995 to 2004, is shown in Table 68.

Table 69 shows the history of landings per unit effort (LPUE) and estimated effort measured in 1 000 trawl hours for the shrimp fishery in Skagerrak and the North Sea, from 1996 to 2004.

The development in CPUE and estimated effort measured in 1 000 trawl hours for the fishery in the Barents Sea, from 1996 to 2004, are shown in Table 70. The first double trawls entered service in 1996, and their use has spread rapidly to most vessels.

ECONOMIC CONTRIBUTION

The Norwegian Directorate of Fisheries conducts a survey each year of profitability and employment in the various vessel groups. This survey only encompasses the vessels that are considered to be operating all year. Table 71 summarizes employment on these vessels, calculating the share from shrimp fishing on the basis of its proportion of catch value.

TABLE 71
Employment on various types of Norwegian vessels

Vessel group	Number of people employed	Shrimp catch (tonnes)	Shrimp share (value) (%)	Number of people employed by the shrimp industry
Factory trawlers	714	7 138	10.7	76
Large cod trawlers	835	14 912	20.6	172
Medium cod trawlers	473	13 236	28.8	136
Shrimp trawl 8–11 m	38	23	71.9	27
Shrimp trawl 11–28 m	288	5 914	78.1	225
Shrimp trawl >28 m	234	17 459	100	234
Total		58 682		870

Source: Directorate of Fisheries, 2004.

To the 870 jobs attributed to shrimp fishing, the following must be added.

- Only 8–28 m shrimp trawlers participate in the catch in Skagerrak/North Sea. A share of 5 937 out of 7 715 tonnes is covered in the Directorate's survey. It is assumed that the remaining 1 778 tonnes have the same employment effects, providing jobs in the fishery for a further 64 people.
- In the Barents Sea, a catch share of 31 953 out of 34 652 tonnes is covered in the survey. Assuming the remaining 2 699 tonnes all come from large cod trawlers, this provides jobs for a further 31 people.
- For catch in other areas, a share of 21 191 tonnes is covered in the survey. Assuming the remaining 2 471 tonnes are caught by shrimp trawlers of more than 28 m in length, employment is provided for an additional 33 people.
- Total employment on board Norwegian shrimp fisheries is therefore estimated at 998 people.

Regarding domestic nutrition, because a high proportion of Norway's shrimp catch is exported, the nutritional contribution from shrimp fisheries is not large. Hempel (2001) states that the per capita consumption of shrimp was 1.7 kg in 2000. This is a small proportion of the Norwegian annual per capita consumption of all fish and fish products, which is 54.7 kg according to FAO (2005d).

The contribution of fishing to Norway's GDP in 2003 can be determined by using the profitability survey conducted by the Directorate of Fisheries, in which value added to the various Norwegian shrimp fisheries is estimated. For large offshore trawlers, it is estimated that value added is NKr5 700/tonne.[35] For smaller coastal trawlers, value added is estimated at 8 480 NKr/tonne. These fleets obtain significantly different prices for their catch, with NKr27kg for the small trawlers compared with 21.4 for the large trawlers. The small trawler value added per tonne estimate is multiplied by the Skagerrak and North Sea shrimp catch. The large trawler estimate is multiplied by the shrimp catches in the Barents Sea and other areas. This yields a total value added and contribution to GDP of NKr397 million. Of a total Norwegian GDP of NKr1 561 billion, this is a mere 0.25 percent. There is an additional contribution to GDP from the shrimp processing industry.

TRADE ASPECTS

Shrimp is exported from Norway in varying degrees of processing. The value and quantity of Norwegian exports in 2004 are shown in Table 72.

TABLE 72
Export of shrimp from Norway by product, 2004

Product	Value (million NKr*)	Quantity (tonnes)
Peeled, frozen	588.5	15 547.3
Raw, frozen	106.9	8 131.7
Boiled, fresh, shell on	62.4	1 455.9
Peeled in brine	45.0	728.0
Boiled, frozen, shell on	42.7	1 509.0
Raw, fresh	18.1	1 337.5
Dried or salted	7.6	139.5
Other	5.4	186.9
Total	876.6	29 035.8

* Average exchange rate of US$1 = NKr6.793 (2004).
Source: Norwegian Seafood Export Council, 2005.

The Skagerrak/North Sea fishery produces two main categories of products: boiled or fresh large shrimp (35 percent total catch) and the smaller factory-processed shrimp (65 percent). About 60 percent of the large fresh shrimp is for the domestic Norwegian market, with the remainder exported to Sweden.

Shrimp represented about 4 percent of the value of all Norwegian fishery products exports in 2003 (Stella Polaris, 2005). The country's main markets, in decreasing order of importance, are Sweden, the United Kingdom, Denmark, Finland, Iceland and Japan. Hempel (2001) reports that Norway also imports shrimp, both cold-water shrimp and tropical species. In 2000, 28 021 tonnes were imported.

IntraFish (2005) reports a soft market for cold-water shrimp from Norway and the other main producers (Canada, Greenland and Iceland). There is increasing competition

[35] The average exchange rate was US$1 = NKr7.079 in 2003.

from tropical species, which are generally larger. A major shrimp processor in recent years closed nine cold-water shrimp processing plants, including three in Norway. Hempel (2001) stated that there were ten shrimp peeling plants in Norway in 2000, but only two remain in operation.

BYCATCH ISSUES

Norwegian shrimp fisheries target only shrimp, but in the shrimping process other species groups are taken. The catch composition in the North Sea and Skagerrak shrimp fisheries in 2003 is given in Table 73.

Norway has a discard ban for all commercially important species. The ban requires that when these species are captured as bycatch and as juveniles of the target species, the catch has to be taken ashore and deducted from the TAC of the species concerned. According to Kelleher (2005), this discard policy, exercised through international fishing agreements, is one of the factors responsible for relatively low discard rates in the major fisheries of the North Atlantic.

The discard ban does not mean that Norwegian fisheries, including shrimp fisheries, do not discard unwanted fish but rather stipulates that important species are not to be discarded. In recent years, the North Sea and Skagerrak shrimp fisheries landed about 6 000 tonnes of shrimp and discarded 6 300 tonnes of various species for a discard rate of 51.2 percent (Kelleher, 2005).

Norway uses various means to reduce bycatch in shrimp fisheries. Graham (2005) summarizes the situation.

In the Barents Sea and Svalbard area, Norwegian rules are that the fisheries be regulated by fishing licences and by smallest allowable shrimp size (maximum 10 percent of catch weight may be less than 15 mm carapace length). Fishing grounds are closed if bycatch limits given as number of individuals in 10 kg of shrimp are exceeded. In 2004 and 2005, the values of allowed bycatch are set at eight for the sum of cod and haddock, ten for redfish and three for Greenland halibut per catch of 10 kg shrimp. Sorting grids in shrimp trawls first became mandatory operating within the Norwegian 12-mile zone in February 1990. In October 1991, this directive was extended to apply to shrimp trawls used in all of the Norwegian EEZ. In 1993, the Joint Norwegian Russian Fisheries Commission agreed that the sorting grid was to be mandatory for all vessels conducting shrimp fishery in the Barents Sea and the Svalbard area. The maximum bar spacing permitted is 19 mm in all areas.

The various countries and international regimes involved with North Atlantic shrimp have different measures for reducing bycatch. Table 74 compares these requirements.

Cod bycatch is a major issue. Although it is only about 1 percent of total shrimp landings, the cod stock is at low levels in some areas. ICES, the organization that coordinates and promotes marine research in the North Atlantic, recommends a zero

TABLE 73
Bycatch in the North Sea and Skagerrak shrimp fisheries, 2003

Species	North Sea		Skagerrak	
	(Tonnes)	(% of total catch)	(Tonnes)	(% of total catch)
Norway lobster	15	0.3	28	0.7
Pandalus shrimp	3 927	85.6	3 700	86.3
Anglerfish	135	2.9	26	0.6
Whiting	11	0.2	14	0.3
Hake	13	0.3	6	0.1
Ling	34	0.7	28	0.7
Saithe	164	3.6	58	1.4
Witch flounder	5	0.1	34	0.8
Cod	125	2.7	184	4.3
Other	158	3.4	208	4.9

Source: ICES, 2005.

BOX 35
The Nordmøre grid

The Nordmøre grid is the most widespread gear-related technical measure used in the North Atlantic Shrimp Fishery to reduce bycatch. The concept came from a shrimp fisherman, Paul Brattøy, who lived in the Nordmøre area of Norway, hence the name. He developed the grid, which had comparatively large bar spacing initially used to exclude the bycatch jellyfish often found on shrimp grounds.

In 1989, after a few months of testing and modification, the Nordmøre grid was introduced to the shrimp fishery. Fishing grounds that were closed because of the high bycatch of juvenile cod and haddock were opened for shrimp trawling when a grid was installed in the trawl. Fishers were at first reluctant to use the device, but when a few skilled shrimpers proved that they both managed to handle the grid and access shrimp grounds giving very good catches, the grid was a success. Soon a large proportion of the coastal fleet used the grid voluntarily.

Following the success of this device, a series of formal experiments with a grid system having narrower bar spacing (19 mm) were undertaken in Norway. The research demonstrated considerable reductions in the bycatches of cod, haddock, redfish, Greenland halibut and polar cod with minimum loss of shrimp (around –5 percent). In 1991, Canadian researchers tested grid technology on the Gulf of St Lawrence Fishery. A number of vessels were fitted with 19 mm Nordmøre grids with retaining bags fitted to the escape outlet. The catch retained was used to estimate the quantity of bycatch escaping from the trawl as well as monitor potential shrimp loss. On average, the reduction of bycatch was 97 percent with only a 2 percent loss of shrimp. Other experiments in the eastern Scotian Shelf showed bycatch reductions of 97, 100, 95 and 100 percent for plaice, cod, redfish and haddock, respectively.

Source: Graham, 2005; Isaksen, 1997.

TABLE 74
Overview of technical measures to reduce bycatch

Country/region	Minimum mesh size (mm)	Nordmøre grid	Bar spacing (mm)	Bycatch limit
NAFO	40	Y	22	Y
EU	40	N	n.a.	Y
Greenland	44	Y*	26	Y
Faeroe Islands		n.a. – international fleet		
Canada	40	Y	28	Y
Norway	35–40	Y	19	Y
Iceland	36	Y	22	Y
United States of America	n.a.	Y	25	n.a.

* The inshore sector has dispensation for a grid.

catch of cod in Skagerrak and the North Sea. At present, the Norwegian quota in these areas is about 4 000 tonnes. Norway enforces an active closure scheme to protect juvenile cod in the Barents Sea (Kelleher, 2005). In this scheme, the closed areas change in relation to the distribution of the undesirable bycatch of juveniles. Closures are determined according to the percentage of juveniles in the catch, based on combined information from research cruises, observer reports and monitoring of chartered commercial trawlers.

Poseidon (2003) examines the legislation in Norway and lists 21 decrees, regulations and directives dealing with bycatch.

TABLE 75
Average profitability of individual shrimp vessels, 2003[a]

	Factory trawler	Large trawler	Medium trawler	Shrimp trawler 8–11 m	Shrimp trawler 12–28 m	Shrimp trawler > 28 m
Revenues	36 772	20 232	18 362	663	1 828	32 508
Running costs	37 992	20 741	17 969	669	1 782	34 590
Operating profit	-1 220	-509	393	-6	45	-2 082
Financial income[b]	864	201	118	5	25	822
Financial costs[c]	4 254	3 023	2 750	36	112	4 894
Net income	-3 390	-3 331	-2 632	-37	-41	-6 154
Operating profit/ revenues	-3.3 %	-2.5 %	2.1 %	-0.9 %	2.5 %	-6.4 %
Revenues/assets	0.51	0.36	0.42	0.94	0.69	0.34
Return on assets	-1.7 %	-0.9 %	0.9 %	-0.9 %	1.7 %	-2.2 %
Length (m)	61.2	49.3	40.3	10.5	16.7	60.6
G(R)T	1963	925	716	13	172	2 216

Source: Directorate of Fisheries, 2004.
Note: units: NKr1 000.
[a] The average exchange rate was US$1 = NKr7.079 in 2003.
[b] Financial income is interest earned on bank deposits.
[c] Financial costs are primarily interest on loans.

PROFITABILITY

There is good-quality information on shrimp vessel profitability in the annual surveys conducted by the Directorate of Fisheries. Vessel owners are required to supply data for the studies, which are scrutinized and adjusted manually by Directorate officers.

Regarding these surveys, the following should be noted.

- Because many vessels do not fish exclusively for shrimp, there is some difficulty in separating the shrimp fishing profit from that of other species.
- Some inaccuracies can occur by allocating costs without detailed knowledge of the production process.

Table 75 gives the average 2003 profitability of individual vessels in the various Norwegian fleets that catch shrimp. Large trawlers are on average 50 m in length, while medium trawlers average 40 m. The catches by factory trawlers, large trawlers and medium trawlers are 10–20 percent shrimp. Catches by the three classes of shrimp trawler shown in Table 75 are almost exclusively shrimp. It can be seen that none of the fleets show a positive net income. Some observers feel that this suggests that resource rent is dissipated by excess capacity or overfishing of stocks. It should be noted that fuel prices in 2004 and 2005 were almost double those of 2003 and that prices for cold-water shrimp have been slack.

ENERGY INPUT ASPECTS

Shrimp trawling consumes a relatively large amount of fuel per kg of catch compared with most other Norwegian fisheries. Fuel use per kg of shrimp is shown in Table 76, assuming a price per litre of fuel in 2003 of NKr1.7/litre. The average length of the shrimp trawl is 16.7 m and serves as a proxy for coastal trawlers, while other trawls are 60.6 m long and illustrate ocean-going vessels.

Applying these figures to the shrimp catches in Skagerrak/North Sea and the Barents Sea gives a rough estimate of total fuel consumption for the shrimp catches of 125 million litres.

Increased fuel taxes are possible in the future because of CO_2 and SO_2 emissions.

BIOLOGICAL ASPECTS

Shrimp stocks in Skagerrak/North Sea were assessed by ICES through a cohort analysis from 1987 to 2000, but the approach was abandoned as a result of methodological

TABLE 76
Fuel data by fleet, 2003

	Shrimp trawl 12–28 m	Shrimp trawl >28 m
Fuel costs (NKr)	211 850	8 051 533
Fuel price (NKr/litre)	1.7	1.7
Fuel consumption per kg/shrimp	1.9	1.9

TABLE 77
Shrimp biomass indices in the Barents Sea

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Russian index	441	765	576	966	800	468	980		
Norwegian index	276	300	341	316	247	184	196	212	151

Source: ICES, 2005.

problems. A new assessment approach was introduced, applying a stock production model, including predator relationships. This model was used for making assessments from 2001 to 2003. A break in time-series data and criticism of the stock production model resulted in a lack of updated assessments for 2004. However, changes in LPUE and results from Norwegian trawl surveys indicate a stable stock. Models predict the stock size to be above the MSY level and ICES has concluded that a TAC of 15 000 tonnes is unlikely to have an impact on stock status.

The stock in the Barents Sea is assessed though the Russian CPUE index and the Norwegian survey index (Table 77). Stocks peaked in 1998 and then declined until 2002 when they stabilized and showed signs of moderate increase. From 2003 to 2004, the Norwegian index decreased sharply to the lowest level observed since 1987. Russian data are not available for 2003 and 2004. There is fairly good correlation between the Russian and Norwegian indices but a large difference was recorded in 2002.

Norway and many other countries aim to bring the management of their fisheries resources to a level where the stocks are not viewed in isolation but as part of the ecosystem. From an ecosystem approach, the step towards bioeconomics is likely, where costs and earnings of fisheries are also taken into account.

Biological studies have shown that, in the Barents Sea, northern shrimp change sex from male to female at the age of four to seven years. Northern shrimp is an opportunistic omnivore and, in turn, is prey for demersal fish. Cod is the most significant predator of shrimp; when capelin is abundant, it is the primary food for cod but, when less available, cod turns to amphipods, krill and shrimp. From 1992 to 1998, total consumption of shrimp by cod was estimated to be between 317 and 532 000 tonnes, which is ten times the annual shrimp catch by fishing vessels (Reithe and Aschan, 2004). With a weak capelin stock, this predator-prey relationship gives an inverse relationship between the cod and shrimp stocks. Single-species management is thus unlikely to result in economic profit maximization.

IMPACTS ON THE PHYSICAL ENVIRONMENT

Only a few studies of the interaction effects between shrimp trawls and bottom fauna in Norwegian waters have been published. The review of study methodology and physical and biological impacts by Løkkeborg (2005) is a good source of information on this topic.

The physical impacts of otter trawling on the sandy/gravel bottom of the Barents Sea are generally furrows (20 cm wide and 10 cm deep) and berms (10 cm high) created by the doors. In addition, rockhopper gear creates smaller depressions (Humborstad *et al.*, 2004). These marks are relatively quickly cancelled out by natural forces.

Short-term biological effects have been studied in the Barents Sea by Kutti *et al.* (2005). Experimental trawling did not seem to have a great effect on the benthic

assemblage. This is probably related to the general environment with its strong currents and large temperature fluctuations. A study of relevance to trawling was conducted in the cold Norwegian waters of the Bering Sea (McConnaughey, 2000). This study concluded that biomass, niche breadth and diversity were reduced among sponges and anemones when heavily trawled. For the more motile groups and infaunal bivalves, results were mixed.

A longer-term study was carried out in a small fjord system in Sweden (Hansson *et al.*, 2000; Lindegarth *et al.*, 2000). Results from this study could not attribute any decrease in biomass to trawling, but did note that the number of echinoderms was reduced. This is different from other studies that had shown them to be resilient to trawling disturbance. The authors conclude that the disturbance caused by trawling is relatively subtle compared with the impact from natural factors.

There is an ongoing study of the effects of trawling disturbances in the North Sea on benthic communities, the EU-funded "Managing Fisheries to Conserve Groundfish and Benthic Invertebrate Species Diversity (MAFCONS)". As part of this study, Robinson (2003) observes that there is unequivocal evidence that the type of benthic substrate will affect the level of mortality of invertebrates in the towpath of the gear. This is partly because the level of penetration of ground gear will be affected by the type of substrate and also because there is a direct relationship between substrate type and the community composition of benthic invertebrates present in the area.

Communities in stable sediments subject to low-frequency natural physical disturbance have been shown to be less resilient to bottom trawling than communities subject to the same fishing regime in mobile sediment types.

IMPACTS ON SMALL-SCALE FISHERIES

The Norwegian Coastal Trawl Shrimp Fishery can be considered a small-scale fishery. The impact from the offshore shrimp fisheries on coastal trawlers is considered to be slight since they fish in different areas.

Any interaction between the large- and smaller-scale shrimp fisheries is likely to occur in the marketplace. The volume of shrimp landed from the offshore fleet probably has some negative impact on the price obtained for industry-grade shrimp from the coastal fleet. The dominant effect on these prices, however, is more likely to be a result of world market supply and demand.

The Coastal Trawl Shrimp Fishery could conceivably generate conflicts with local non-shrimp fisheries. However, the lack of information suggests that problems between the coastal shrimp fleet and other fleets are few or non-existent.

MANAGEMENT

With regard to the general management of fisheries in Norway, the Norwegian Government produced a White Paper in March 2002 stating the need for the principle of sustainable development to be integrated into management plans. More specific targets set by the White Paper include further development of the fishing industry and the implementation of an ecosystem-based management and precautionary approach. The paper also acknowledges the need to strike a balance between commercial interests, e.g. fisheries, aquaculture and the petroleum industry, and the need to protect the marine environment and biological diversity. Other future governmental plans are to reduce the fleet capacity to a level that will allow efficient harvesting of the marine resources in a sustainable way (FAO, 2005d).

As regards shrimp fisheries management, an important aspect is that Norwegian shrimp fisheries operate both in international waters in the northwest Atlantic and within the Norwegian EEZ. Accordingly, there are, two legislative management

regimes to consider: the national system and the NAFO regime.[36] For Norwegian shrimp fishing, the most important areas are 3M (regulated though an effort allocation scheme) and 3L (regulated by TAC), while there are a further two regimes regulating output within the NAFO area.

A licensing regime regulates access for shrimp fisheries in both the Barents Sea and Skagerrak/North Sea.

In Skagerrak/North Sea, management regulations are:

- a minimum mesh size of 35 mm;
- prohibition of fishing in water shallower than 60 m;
- a maximum of 50 percent bycatch of other species is allowed;
- the number of undersized cod and haddock cannot exceed a total of eight per 10 kg of shrimp;
- a maximum of 10 percent of undersized shrimp (<15 mm carapace length) is allowed;
- TAC is established;
- quota regulations in which fishing is divided into three periods with: (i) quotas per vessel in each period; (ii) trip quotas per vessel; and (iii) mandatory rest days between trips.

In the Barents Sea, management regulations consist of:

- a maximum of 10 percent undersized shrimp (less than 15 mm carapace length) is allowed;
- the mandatory use of sorting grids, with a maximum bar spacing of 19 mm;
- closure of an area if the bycatch in that area (in number of fish) exceeds a set limit per 10 kg of shrimp. In 2004, this number was eight for the sum of cod and haddock juveniles, ten for redfish and three for Greenland halibut.

In the Svalbard area, a 1920 treaty stipulates that Norway has full sovereignty over the islands. As a result of the somewhat special legal status, Norway has not created a full EEZ around the islands, but a fish protection zone. Norwegian fisheries regulations are in force within this zone but other countries are allowed to fish there, based on historical catch. In addition to the technical regulations in force for the shrimp fishery in the Barents Sea, each country is allocated a maximum number of vessels that can participate and a maximum number of fishing days.

The following is a chronology of regulations relevant to shrimp fishing in the Barents Sea, showing the evolution of management legislation in Norwegian shrimp fisheries.

- January 1973: minimum mesh size of 35 mm introduced.
- April 1973: vessels greater than 50 GRT require a licence.
- June 1978: no additional licences for vessels with freezers installed; not more than one licence per person; change of vessels not allowed (at the discretion of the authorities); prohibition on installation or expansion of freezing on board (at the discretion of the authorities); and licences not used for a period of two consecutive years can be withdrawn.
- March 1979: all vessels over 65 feet (19.8 m) or over 50 GRT require licences.
- June 1979: quotas are established for fresh and frozen shrimp; fishing can be stopped when the quota is reached.
- January 1980: no permission for replacement vessels will be given if fishing capacity expands.
- May 1980: the authorities can suspend fishing if undersized shrimp, cod or haddock are caught – fishing was suspended for 14 days during the summer.

[36] NAFO is an intergovernmental fisheries science and management body. It was founded in 1979 as a successor to the International Commission of the Northwest Atlantic Fisheries. NAFO's overall objective is to contribute, through consultation and cooperation, to the optimum utilization, rational management and conservation of the fishery resources of the convention area.

- March 1981: suspension for 14 days of fishing during the summer; vessels without freezing licences can apply to freeze if they deliver for processing on shore.
- 1982: vessels without freezing licences can apply to freeze if they deliver for production on shore.
- 1983: vessels that had applied for freezing in 1981 and 1982 can also freeze in 1983.
- 1984: vessels with permission for freezing in 1981–83 can also freeze in 1984.
- June 1984: Licences are granted to particular vessels/owners; hold capacity is determined for each vessel and larger catches are not allowed; the purchase of vessels and "transfer" of hold capacity are allowed with a maximum 20 percent increase, but the "giving" vessel has to be withdrawn from the fishery. In the case of vessel licence renewal, hold capacity can be increased by a maximum of 20 percent. A licence can be withdrawn if not active for more than two months during a two-year period.
- March 1992: mandatory use of sorting grids.
- November 2000: maximum hold capacity that can be utilized is 400 m^3. If the hold capacity is transferred from another vessel, the maximum allowed is 600 m^3 and the giving vessel must be withdrawn from the fishery. A maximum of 70 percent of the hold capacity can be transferred.

ENFORCEMENT

Management measures are enforced mainly through two organizations. First, all fish and shellfish must be sold through Norwegian fishers' sales organizations, which enables the recording of landed quantities for each vessel and notification when a quota is reached. This organization is also involved in coordinating requirements for limiting the number of vessels that can fish and for mandatory resting days between fishing trips. Second, the Norwegian Coast Guard performs controls at sea, ensuring that vessels respect closed areas and maximum bycatch levels.

The effectiveness of the above measures is thought to be good, although there is probably some high grading done in the Skagerrak/North Sea fishery.

The cost of the Norwegian management and enforcement regimes is hard to quantify, as the organizations involved have a number of tasks that are not only related to resource management/enforcement. It is even harder to allocate management costs to the level of species and fisheries. Because of these difficulties, the 2004 annual estimate of total management costs by the Ministry of Fisheries is available only to the level given in Table 78.

The amounts given for the budget items in Table 78 do not reflect the full costs, but rather those related to the catching sector. With regard to dividing expenses to the catching sector, the following should be noted.

TABLE 78
Costs of Norwegian fisheries management, 2000–03 in US$

	2000	2001	2002	2003
Ministry of Fisheries	28 188	26 052	29 818	30 140
Membership in international organizations	5 420	6 100	6 060	6 750
Institute of Marine Research	116 355	132 527	145 873	166 500
Operations of research vessels	88 577	94 212	174 802	94 900
New research vessel	0	0	284 545	0
Directorate of Fisheries	115 514	115 963	129 436	126 978
Coast Guard	344 455	364 667	386 548	389 448
Total	698 509	739 521	1 157 082	814 716

Source: 2004 annual estimate of the Ministry of Fisheries.
Note: The average exchange rate was US$1 = NKr7.079 in 2003.

- Ministry of Fisheries: an estimated 40 percent of the total costs of the Ministry are related to the catching sector.
- Membership in international organizations: this includes organizations relevant to the sector.
- Institute of Marine Research: an estimated 75 percent of total costs are related to the sector.
- Operations of research vessels: 100 percent of total net costs were expected to relate to the sector.
- New research vessel: the catching sector benefits in general from all activities of the research vessels; hence 100 percent of the transfer is reported.
- Directorate of Fisheries: the figures represent 50 percent of total costs minus user payments. Of the total user payments of NKr69 million in 2002 and NKr52 million in 2003, about NKr30 million are related to the catching sector in both 2002 and 2003.
- The Coast Guard: most activities of the Coast Guard are for the benefit of the capture fisheries; hence 60 percent of total costs are reported here.

RESEARCH

Norwegian research on shrimp is almost exclusively related to stock assessment, which is carried out by the Institute of Marine Research. Until 2005, a dedicated shrimp-swept area survey was carried out in the North Sea, Skagerrak and the Barents Sea. From 2005, the Barents Sea study has been replaced by a joint ecosystem study, thereby breaking the time-series and making stock assessment more difficult. Data for an age-structured model has also been collected and processed. The continuation of this work is dependent on budget and costs are not easily quantified; however, a leading shrimp researcher estimated the cost for 2004 at about NKr8 million.

ICES (2005) has made a number of recommendations for future research on shrimp stocks.

- It strongly recommends that the Russian and Norwegian shrimp surveys be reinstituted.
- If these shrimp surveys cannot be reinstituted, then the existing ecosystem survey should be calibrated by conducting a directed survey for shrimp in spring in a limited area in two consecutive years.
- Scientists should further investigate procedures for estimating the shrimp consumed by cod and give reliable estimates of biomass consumed.
- Licensing of vessels participating in the shrimp fishery must include an obligation for all countries active in the fishery to report length of and sex distributions from commercial catches.
- The authorities should enforce the submission of accurately completed logbooks; it is especially important that the use of single, double or triple trawls be recorded.
- Work on developing and evaluating assessment methods should be continued.
- Catch and effort statistics should be submitted to ICES by all countries active in the shrimp fishery in the Barents Sea and the Svalbard area by 1 September.

DATA REPORTING

As mentioned above, all shrimp is sold through fishers' sales organizations. Catch information is obtained from the sales documents written between buyer and vessel. In the Barents Sea fishery, where there is no quota, there are probably only small problems with high grading and reporting less catch. In the Skagerrak/North Sea fishery, these issues may be more common.

The fishers' organizations report the sales documents to the Directorate of Fisheries, which compiles Norwegian catch statistics. Effort estimates are obtained from the vessel's logbooks.

Overall, statistics from the shrimp fisheries are of good quality.

IMPACTS OF SHRIMP FARMING

No shrimp farming takes place in Norway. Overseas shrimp farming may affect Norwegian shrimp fishing to the extent that the current falling prices for tropical shrimp could negatively impact world market prices for some cold-water shrimp products.

MAJOR ISSUES

The major issues related to Norwegian shrimp fishing are:

- the current low profitability of most shrimp fishing operations;
- competition with other countries, especially Canada, in the northern shrimp market;
- competition with warm-water farmed shrimp;
- the need to avoid cod and other important species as bycatch in the shrimp fisheries; and
- the mitigation of environmental impact.

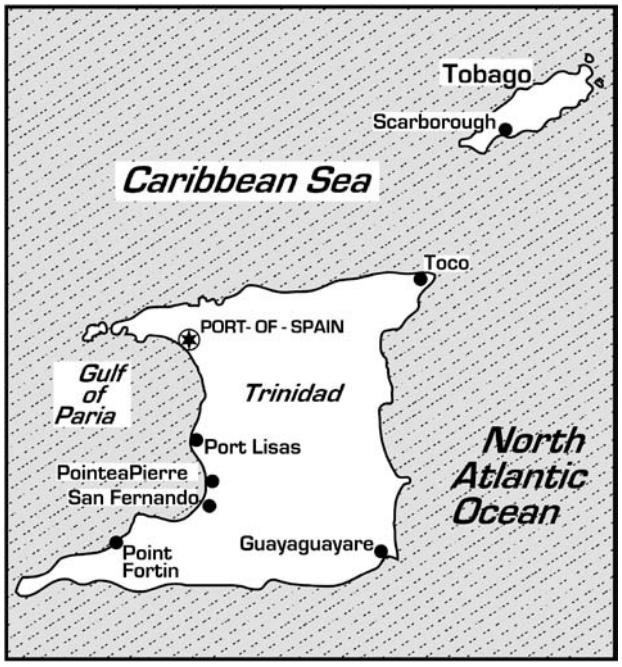
Shrimp fishing in Trinidad and Tobago

Based on the work of Suzuette Soomai

AN OVERVIEW

Shrimp fishing is carried out in Trinidad and Tobago by 102 artisanal trawlers, ten semi-industrial trawlers and 20–25 industrial trawlers. Annual shrimp catches from 1999 to 2004 averaged about 825 tonnes. In 2004, an estimated 785 tonnes of shrimp were landed, valued at US$2.72 million, and 703 tonnes of groundfish bycatch, valued at US$0.65 million. Currently, 96 percent of exports go to the states of the Caribbean Community (CARICOM).

There is a high incidental fish catch associated with shrimp trawling. This is one of the most important sources of conflict between the trawl fishery and other fisheries in the country. Other areas of concern are the full or overexploited condition of shrimp stocks as well as that of bycatch, the high levels of bycatch/discards and the degree of overcapitalization in the trawl fishery.



DEVELOPMENT AND STRUCTURE

According to Kuruvilla *et al.* (2000), the trawl fishery developed in the early 1960s as an artisanal fishery targeting mainly the southern white shrimp, *Litopenaeus schmitti*.[37] The number of artisanal vessels increased from 66 in 1966 to 166 in 1969. The boats were generally 7–9 m in length, powered by two outboard engines, and set and retrieved one trawl net manually. These vessels operated out of sites on the west coast of Trinidad and fished mainly off the southwest coast of Trinidad and in the inshore waters of the Orinoco Delta on the coast of the Bolivarian Republic of Venezuela.[38] They returned to their bases daily to sell the catch.

In 1972, fishing permits were issued for a period of one year to 72 nationals of Trinidad and Tobago to trawl for shrimp in the Orinoco Delta region. In 1977, the first official bilateral fishing agreement was signed between Trinidad and Tobago and Venezuela permitting 60 artisanal trawlers access to inshore fishing areas of the Delta.

[37] The FAO name for this species is southern white shrimp *Penaeus schmitti*. In the Americas, many taxonomic authorities divide the shrimp genus *Penaeus* into two genera: *Litopenaeus* and *Farfantepenaeus*.

[38] The Bolivarian Republic of Venezuela, the official name of the country, is henceforth generally referred to as Venezuela.

The fishing agreement was renegotiated in 1985, permitting 70 artisanal vessels to operate under specified conditions in the Orinoco Delta for a seven-month season.

In 1991, artisanal vessels were categorized into Type I and Type II vessels. There were 113 Type I and 66 Type II vessels. Type I vessels had two outboard engines, each of about 56 HP and generally ranged in length from 6.7 to 9.8 m. They predominantly operated in the Orinoco Delta. Type II vessels ranged between 7.9 and 10.4 m in length and utilized one inboard engine of 48–110 HP. In 1995, access to the Orinoco Delta Shrimp Fishery was terminated and most of the Type I trawl fleet was subsequently refitted for other forms of inshore fishing. In 1998, 13 Type I trawlers were still operational. Both Type I and II vessels manually set and retrieve a single trawl net. They have neither storage facilities nor electronic equipment on board.

Towards the end of the 1960s and into the 1970s, development of the offshore sector was promoted. Gross (1973) states that, in the 1960s, for political and economic reasons, the capital of Trinidad and Tobago (Port of Spain) offered a desirable base from which as many as 115 industrial shrimp fishing vessels fished grounds off the Guianas and northeast Brazil. In 1969, in addition to the artisanal fleet, there were nine Gulf of Mexico-type (outrigger) industrial trawlers fishing locally. These trawlers were between 10.9 and 23.6 m in length, with 365–425 HP inboard diesel engines and a GRT of between 30 and 96 tonnes. They operated with two nets (one on each side) and were fitted out with electronic fishing aids, communication equipment and a fish/ice hold.

The local industrial vessels landed their catch in Trinidad at the state-owned National Fisheries Company (NFC) for processing and export. Between 1972 and 1979, NFC processed and exported shrimp from its fleet of 24 trawlers, in addition to purchasing some shrimp and fish from vessels owned by nationals and from foreign-based trawlers fishing on the continental shelf of northeast South America.

Between 1977 and 1985, NFC availability of shrimp and fish fluctuated and was dependent on the ability of the Trinidad and Tobago Government to obtain access for the industrial fleet to the shrimp grounds off Brazil. After 1985, NFC disposed of its trawlers, most of which were bought by nationals of Trinidad and Tobago and entered the local fishery.

The trawl fleet is now categorized into four types (I to IV) based on vessel length, engine HP and degree of mechanization. Types I and II are described above. Semi-industrial trawlers (Type III) are inboard diesel-powered and set/retrieve one trawl net at the stern; they are fitted out with electronic fishing aids, communication equipment and a fish/ice hold similar to the industrial trawlers (Type IV).

It is estimated that there were 102 artisanal trawlers (47 Type I and 55 Type II), ten semi-industrial trawlers (Type III) and 20–25 industrial trawlers (Type IV). Vessel numbers have remained more or less constant since 1991, except for the artisanal Type I fleet, which has declined significantly because of the termination of access to fish in the Orinoco Delta of Venezuela in 1995. Current numbers in the Type I fleet represent 42 percent of the 1991 fleet.

Regarding the age of the vessels, 78 percent of artisanal vessels are between five and 15 years old, while 22 percent are over 20 years old. Eighty-three percent of semi-industrial vessels are between 15 and 20 years old, while 17 percent are over 20 years old; some vessels as old as 30 years are still operating. Eighty-four percent of industrial vessels are over 20 years old. A large proportion of this fleet consists of vessels that once operated as trawlers out of the state-owned NFC during the 1970s. Other industrial vessels in the industrial fleet were purchased as used vessels from the United States of America or from locations within the Caribbean.

Artisanal vessels are constructed locally whereas semi-industrial and industrial vessels are built outside Trinidad and Tobago and imported into the country as used vessels. Therefore, in the semi-industrial and industrial fleet, the number of years that the vessel has operated in the local fishery is less than the age of the vessel.

TABLE 79
Landings, effort and revenue for trawl fleets, 1999–2004

Year	Landings (tonnes)		Effort (hours at sea)	Value of catch (US$ million)	
	Shrimp	Bycatch		Shrimp	Bycatch
1999	731.66	807.17	305 761	3.26	0.69
2000	848.76	854.65	306 591	3.47	0.63
2001	934.91	832.71	349 298	3.95	0.62
2002	940.00	1 004.87	346 420	3.80	0.77
2003	799.26	815.00	284 364	2.97	0.59
2004	685.09	702.82	238 726	2.72	0.65

The average artisanal trawler is owned by one individual and generally operated by a family relation of the owner. The average semi-industrial or industrial trawler is also owned by one individual, with the captain being a trained seaman. Some individuals own more than one vessel. Within each fleet, the average vessel changes ownership several times from when it first enters the local fishery.

Artisanal and semi-industrial vessels operate all year in the Gulf of Paria. The main fishing season for semi-industrial vessels runs from May to August in the Gulf of Paria and from October to March on the south coast.

Artisanal vessels operate at depths of between 1.8 and 18 m within an estimated area of 607 km^2. Semi-industrial vessels operate at depths of between 9 and 41.4 m within an estimated area of 1 793 km^2. Industrial vessels operate in the Columbus Channel at depths of 18–41.4 m and cover 1 740 km^2; in the Gulf of Paria at depths of 9–48.6 m over an area of 1 269 km^2; and on the north coast at depths of 37.8–57.6 m within a limited area of 184 km^2. Most vessels operating in the coastal waters of Trinidad and Tobago trawl both day and night.

All trawl fleets operate out of sites located along the Gulf of Paria where there are five major landing sites and eight landing sites of lesser importance.

Trawling is basically a single boat operation. Vessels within a particular fleet may, however, operate simultaneously on a fishing ground when shrimp or fish aggregations occur.

TARGET SPECIES, CATCH AND EFFORT

According to Kuruvilla *et al.* (2000), trawlers catch several shrimp species, the most important of which is the southern white shrimp (*Litopenaeus schmitti*).[39] Other important species are *Farfantepenaeus subtilis*, *F. notialis*, *F. brasiliensis* and *Xiphopenaeus kroyeri*.

Catches of groundfish are considered bycatch since the higher-valued shrimp is the target species. Certain species of finfish may, however, be targeted according to market demand or during the wet season when shrimp abundance decreases. Groundfish of commercial importance commonly caught by trawl are the sciaenids (*Cynoscion* spp., *Macrodon ancylodon*, *Micropogonias furnieri*); gerreids (*Diapterus* spp.); lutjanids (*Lutjanus* spp., *Rhomboplites aurorubens*); haemulids (*Haemulon* spp., *Genyatremus luteus*, *Orthopristis* spp.); and ariids (*Bagre* spp., *Arius* spp.).

The shrimp and fish resources in the Gulf of Paria and Columbus Channel are considered to be shared stocks exploited by the fleets of both Trinidad and Tobago, and Venezuela.

Landings, effort and value of catch for trawl fleets in recent years are shown in Table 79.

As regards the geographic distribution of trawling effort, the fishing grounds around Trinidad are located in fishing area 31 of the FAO major fishing area coding system.

[39] The FAO name for this species is southern white shrimp *Penaeus schmitti.*

Trawling was restricted by law in 1998 to the westernmost part of the coast and is also limited in this area by season and is restricted to daytime operations. Major areas of the seafloor of the east coast shelf are not suitable for trawling but are, however, prohibited to trawlers under existing legislation in order to protect other fisheries and to prevent damage to oil installations. All trawl fleets operate in the Gulf of Paria on Trinidad's west coast. In addition, the industrial fleet operates in the Columbus Channel on the south coast of the island. Some industrial vessels trawl off the north coast of Trinidad between November and January.

Under a 1997 fishing cooperation agreement with Venezuela, fishing vessels including trawlers from both Venezuela and Trinidad and Tobago are permitted to fish all year in the Columbus Channel located to the north of Venezuela and south of Trinidad. Access is prohibited only within a band of two nautical miles from the coastline of each country. There have been problems associated with the implementation of this agreement, however, and Trinidad and Tobago trawlers do not fully access Venezuelan territorial waters.

Fishing trips vary according to fleets.

- The average fishing trip for artisanal vessels lasts for eight hours but is recorded as one day. These vessels carry a crew of two for the day operations and three for the night.
- The average semi-industrial vessel carries a crew of three and has a fishing trip of 21 hours, which is also recorded as a one-day trip.
- The average industrial vessel carries a crew of four and has a fishing trip of 15 days, of which two days are used for travelling to and from the fishing grounds.

Shrimp landings and catch rates are generally higher in the first half of the year, which corresponds to the dry season. The highest catch rates have been observed for the artisanal fleet operating in Venezuela (3–9 kg/hr at sea),[40] followed by the industrial fleet (2–7 kg/hr at sea). The shrimp catch rate for the artisanal fleet operating in the southern Gulf of Paria is normally 2–4 kg/hr at sea, while that for the artisanal fleet operating in the northern Gulf of Paria and the semi-industrial fleet is 1–3 kg/hr at sea.

ECONOMIC CONTRIBUTION

Agriculture's contribution (which includes fishing) to the GDP of Trinidad and Tobago from 1985 to 2002 ranged from 5 percent in 1985 to 1.6 percent in 1999, with a steady decline in the last three years to 1.2 percent in 2002. The contribution of fishing to agricultural GDP averages 10 percent and has therefore contributed about 0.2 percent to national GDP in recent years (Kuruvilla *et al.*, 2002; Kuruvilla and Chan-A-Shing, 2002).

It is estimated, as mentioned earlier, that trawl fisheries are responsible for 20 percent of all fishery landings in Trinidad and Tobago. In 2004, the entire trawl fleet landed an estimated 785 tonnes of shrimp, valued at US$2.72 million and 703 tonnes of groundfish bycatch, valued at US$ 0.65 million.

In 1998, a survey of the local hospitality industry estimated an annual consumption of shrimp of 13 000 kg, valued at US$0.4 million.

There were an estimated 324 fishers directly involved in trawling. Fish landings at sites around the country are generally purchased by wholesale buyers who transport the catch to a processing plant, wholesale fish market, supermarket or to a chain of retail vendors. Some buyers supply hotels and restaurants. There were an estimated 70 buyers in Trinidad and Tobago and their operations generate employment for approximately 210 people.

[40] This high catch rate is for the Trinidad and Tobago vessels operating in the Orinoco Delta. These vessels operate illegally in this area because there is no longer access under the Trinidad and Tobago /Venezuela Fishing Agreement.

In-depth demographic and socio-economic analyses of two communities where trawling is the primary fishing activity (Boodoosingh, 1995; Camps-Campins, 1995; Ramjohn, 1995) revealed that the standard of living was considerably lower for the fishing component of the community than for the non-fishing component. The number of people per household was higher than the national average and education levels were low. Consequently, the ability to seek alternative forms of employment was limited.

A study is currently in progress to establish the social and economic importance of bycatch for the trawl fishing industry and the communities supported by the industry.

TRADE ASPECTS

Shrimp processing is handled by a variety of privately owned companies and cannot be clearly divided into industrial and artisanal shrimp processing since catches from all classes of trawlers are processed at the plants. Shrimp catches change with the season and processing follows this trend. Only about 16 processors/exporters operate on a full-time basis, handling both shrimp and finfish. There is also ad hoc processing at markets where shrimp is graded according to an existing size and species regime, prior to retailing.

Trawl catches destined for local markets are landed and sold fresh-chilled or frozen. The latter is undertaken by some industrial vessel operators who sell to wholesalers, who may then retail at the landing site and keep the catch on ice for van sales or to be sold to other fish markets, restaurants, supermarkets and private parties. Products sold locally include fresh-chilled, peeled and breaded shrimp.

Exports are mainly in the form of fresh-chilled or frozen shrimp. A small proportion of the exports are a heads-off, peeled and deveined product. The traditional export markets for shrimp used to be the United States, the United Kingdom, Canada and the CARICOM states; however, the relative importance of the latter has become more marked in recent years.

Shrimp exports increased from 288 tonnes, valued at US$1.0 million in 1992 to 500 tonnes, valued at US$2.8 million in 1995. This increase was accounted for mainly by demand from the United States, which received 67 percent of exports in 1995.

In 1994, the Fisheries Regulations (Conservation of Marine Turtles) requiring the use of TEDs by the local trawl fleet came into effect, in response to the legislative requirements of the United States. Access to the United States market for shrimp is now dependent on annual recertification by the United States authorities of both the semi-industrial and industrial shrimp trawl fleets. Trinidad and Tobago is currently not certified.

Shrimp exports declined after 1995 to 163 tonnes in 1998, valued at US$1.6 million, with 96 percent of exports going to CARICOM states. This resulted from several factors, including non-competitive prices in the United States market, exclusion from the EU market and the French departments of Guadeloupe and Martinique, and an increase in local shrimp sales with growth in the national economy.

In 2003, shrimp exports were estimated at 119 tonnes, valued at US$800 000.

BYCATCH ISSUES

The incidental fish catch associated with shrimp trawling may be as high as 90 percent for the artisanal trawl fishery; most of these fish are juveniles of other important coastal fisheries. This aspect of trawl fisheries is one of the most important sources of conflict between the trawl fishery and other coastal fisheries in national waters (Kuruvilla *et al.*, 2000).

The high level of bycatch and subsequent discarding are the result of two main factors. First, the shrimp trawl fishery is a tropical, multispecies coastal fishery targeted by relatively unselective gear. Second, the physical structure of the vessels, i.e. limited

hold capacity and the economics of operation, only supports the holding and landing of the shrimp target species and a portion of the bycatch for which there is commercial value. Implementation of management actions to improve selectivity and limit discards has been hampered by the lack of capacity to monitor activities at sea, limited data on catches and on the economics of the fishery, and limited alternative technological options in the harvest sector.

In addition to trawlers, groundfish resources are exploited by an artisanal multigear fleet. This fleet is composed of pirogues similar to the artisanal trawlers, using monofilament and multifilament gillnets and several types of demersal line gear.

Information on shrimp trawl bycatch is given in a number of studies.

- A study of the artisanal trawl fishery conducted from 1986 to 1987 (Maharaj, 1989) identified 70 species of finfish from 40 families in the bycatch, as well as several species of portunid crabs.
- A study of the semi-industrial trawl fishery in 1989 (Amos, 1990) identified 25 species of finfish in the bycatch from 14 families.
- A 1999 study on bycatch of artisanal trawl vessels identified 30 species of finfish from 20 families, as well as several species of portunid crabs.
- A 1991 study of the catch of semi-industrial vessels identified 26 species of finfish from 18 families in the bycatch.

An estimated 90 percent of the bycatch of artisanal vessels is discarded. The total bycatch to shrimp ratio is 12.2:1 and the bycatch landed to shrimp ratio is 1.2:1. Approximately 71 percent of the bycatch of the semi-industrial fleet is discarded. The total bycatch to shrimp ratio for this fleet is estimated at 9.1:1 and the bycatch landed to shrimp ratio is 2.6:1. The most common species in the bycatch landed by the artisanal and semi-industrial fleets belong to the families Carangidae, Gerreidae, Lutjanidae, Portunidae, Sciaenidae and Triglidae.

There is limited information on the non-fish bycatch of the trawl fishery. Populations of portunid crabs, which form a significant component of this category, are thought to have increased as a result of the discards from the trawl fishery, which is likely to be beneficial to scavenger species. This observation is based on both normal fishing practices where much of the crab bycatch is returned to the sea alive and on anecdotal information obtained from interviews with participants in the fishing industry who have described this change in the fauna of the Gulf of Paria.

There may also be incidents of turtle capture by the fishery but, according to Kuruvilla and Chan-A-Shing (2002), records do not indicate a high incidence of turtle capture in the areas where trawling is permitted.

The imposition of TED requirements on the semi-industrial and industrial trawl fleets was not well accepted by the industry. The requirement to use these devices is particularly unpopular with the semi-industrial fleet for which the United States export market is of less importance compared with other CARICOM markets. The fleets also claim that the device traps large debris in the net, causing damage to the net or significant loss of catch since shrimp is diverted away from the codend (Kuruvilla and Chan-A-Shing, 2002).

PROFITABILITY

From surveys conducted in 1997 and 2000, the net profit (gross cash flow less depreciation and imputed interest costs) for an average semi-industrial trawler was estimated at US$8 899, with the average artisanal and industrial vessels experiencing net losses of US$389 and US$996, respectively. The return on investments (net profit before tax as a percentage of the invested capital), indicating the profitability of trawling in relation to alternative investments, was estimated at -4 percent, 15 percent and -1 percent for an artisanal, semi-industrial and industrial trawler, respectively (Kuruvilla *et al.*, 2002).

Most vessel owners do not keep good financial records and hence do not account for depreciation in their operations. It is also possible that some costs may have been overestimated or revenues underestimated.

In examining the profitability of the shrimp trawl fleets, the following should be noted:

- Boat owners perform most of the labour themselves and further reduce costs by purchasing used engines and parts in order to make a profit or break even.
- The taxes paid by an average trawler owner in each vessel category are fairly negligible.

Kuruvilla *et al.* (2002) adjust the profit and loss account for an average vessel in each trawl fleet to examine the impact of subsidies on economic performance.

- *Scenario A*: without the subsidy on fuel and oil, and without the value-added tax (VAT) waiver on marine supplies. This cost, estimated at US$708 for an artisanal trawler, would increase vessel running costs. Most of the semi-industrial and industrial trawlers would not be affected by the removal of these two subsidies since most of them are VAT-registered and hence claim VAT back on all inputs to the business.
- *Scenario B*: without two of the main services offered to the industry by the Fisheries Division (landing site facilities and fisheries management). The cost for the use of landing site facilities is estimated at US$484/boat/year; the fisheries management cost is estimated at US$1 081/year for an artisanal vessel and US$13 887/year for semi-industrial and industrial vessels. The estimated fisheries management cost of US$2.5 million was allocated to the artisanal, semi-industrial and industrial fleets based on the ratio of the annual revenue of the particular fleet to the total annual revenue of all fleets. These costs would increase the fixed costs of the vessels.
- *Scenario C*: the impact of including a licence fee for access to the fisheries resources. It was determined that the licence fees collected from each of the artisanal, semi-industrial and industrial fleets should earn 3 percent of the annual ex-vessel value of the catch from the respective fleet. The licence fee was estimated to be US$277/year for an artisanal vessel and US$3 435/year for the semi-industrial and industrial vessels. The implementation of a licence fee would increase the fixed costs.

Considering the above scenarios, in the case of an artisanal trawler, the return on investment declines from -4 percent in the current scenario with subsidies to -8 percent in Scenario A, -23 percent in Scenario B and -25 percent in Scenario C. For a semi-industrial trawler, the return on investments decreases from 15 percent in the current scenario to -9 percent in Scenario B and -15 percent in Scenario C. In the case of an industrial trawler, the return on investments declines from -1 percent in the current scenario to -13 percent under Scenario B and -16 percent under Scenario C.

The increase in fuel cost over the years has caused an increase in operation costs for all trawler types and has consequently reduced profits (see following section).

ENERGY INPUT ASPECTS

Under the Agricultural Incentive Programme, a subsidy on fuel for use in fishing vessels is available to boat owners whose fishing vessel and engine are registered with the Fisheries Division. The subsidy is provided on petrol, diesel and oil under a quota system based on the size of the engine. These subsidies are small in relation to the cost of fuel. In 2000, government subsidies were: US$0.02/litre for petrol at a price of US$0.40 (TT$2.52)/litre; US$0.02/litre for diesel at a price of US$0.21 (TT$1.32)/litre; and US$0.12/litre for oil at a price of US$2.26/litre. Prices in 2006 for petrol and diesel were US$0.44 and US$0.24/litre, respectively.[41]

[41] The average exchange rate used was US$1 = TT$6.30 (April 2006).

The average trawler owner attempts to compensate for the loss in profits caused by increased fuel costs by increasing the sales price for the catch. This usually works when catches are low, demand is high and consumers pay the increased prices. Trawler owners are also attempting to reduce fuel usage by modifying some fishing practices, such as not trawling against the tidal current.

BIOLOGICAL ASPECTS

Brown shrimp (*Farfantepenaeus subtilis*) is one of the dominant species exploited by the trawl fleets of Trinidad and Tobago and Venezuela in the Orinoco-Gulf of Paria region. Joint biological analyses were conducted from 1973 to 1996 and from 1973 to 2001.

- Results of the study using data for *F. subtilis* for 1973–96 indicate an MSY of approximately 1 300 tonnes with a fishing effort of 13 000 days at sea for both fleets combined. The study also showed that the fishing effort should be maintained sufficiently below these days at sea for several years to allow stocks to rebuild (Alió *et al*., 1999a).
- The second study, using data for 1973–2001, indicates that the *F. subtilis* resource is severely overfished and that overfishing has been taking place since the 1970s. Current fishing mortality was estimated to be more than three times greater than the fishing mortality at MSY and the current biomass is less than one-quarter (23 percent) of the biomass at MSY, with MSY being 1 000–1 200 tonnes. The study recommended that measures be introduced to reduce fishing mortality and that Trinidad and Tobago and Venezuela develop a common strategy for effort control (Die *et al*., 2004).

An assessment using data for 1990–91 for white shrimp (*Litopenaeus schmitti*) and brown shrimp (*F. subtilis*) exploited by the Trinidad artisanal fleet in the Orinoco Delta, showed these resources to be fully fished to overfished. No increase in fishing effort was recommended (Lum Young, Ferreira and Maharaj, 1992).

Bioeconomic analyses of the shared Trinidad and Tobago/Venezuelan shrimp fishery from 1995 to 1998 indicate that at levels of effort during that period (8 175 days at sea for the Trinidad and Tobago fleet and 9 348 for that of Venezuela), there was a 39 percent probability of the biomass of *F. subtilis* falling below sustainable levels. The studies suggested that the shrimp resources were overexploited and a reduction to 80 percent of current levels of effort would reduce this probability to 15 percent and improve profits for the fishery by 12 percent (Seijo *et al.*, 2000; Ferreira and Soomai, 2001).

Assessments were conducted for southern pink shrimp (*Farfantepenaeus notialis*) and Atlantic seabob (*Xiphopenaeus kroyeri*) in the Trinidad and Tobago trawl fishery from 1992 to 2002 (Ferreira and Medley, 2005). Overall, results suggest full exploitation to overexploitation of the two shrimp stocks. Other findings included the following.

- Biomass per recruit models developed for *F. notialis* females suggest that the stock is fully exploited and that the catch is predominantly very young, small shrimp. At the current level of effort, the biomass of *F. notialis* remaining in the sea is estimated to be 39 percent of the unexploited biomass of the species, which is just about at the limit reference point of 40 percent.
- Biomass per recruit models developed for *X. kroyeri* females suggest that the stock is overexploited. At the current level of effort, the biomass of *X. kroyeri* is 22 percent of the unexploited biomass of the species, i.e. below the limit reference point. The effort exerted on this species would have to be reduced to less than 60 percent of the current level, in order to bring the biomass up to an acceptable level (i.e. 40 percent of the unexploited biomass).
- Based on a yield per recruit model for the two species combined (*F. notialis* and *X. kroyeri*), the 2002 fishing effort of the trawl fleets targeted at these species is

estimated at about 71 percent of the effort required to obtain the maximum yield from the fishery.

- Following on from the above, the management recommendation is to control fishing effort on these stocks by limiting the numbers of trawlers, with a view to a reduction in fleet size. This will require the implementation of a licensing system for trawlers and updating of fisheries legislation to facilitate a limited entry fishery (see section *Management* below.)

The biological status of some important elements of the shrimp trawl bycatch is described as follows.

- Biological assessments of *Micropogonias furnieri* (croaker) and *Cynoscion jamaicensis* (Jamaica weakfish) in the groundfish fishery in the Gulf of Paria and the Columbus Channel of Trinidad and Tobago were conducted from 1989 to 1997 (Soomai *et al.*, 1999). These assessments used data from trawl fleets and the artisanal gillnet and line methods catching groundfish in a depletion model. The results showed that fishing mortality values were well above the optimum biological condition of the species and that the resources are not generating optimum yield and are most likely experiencing potential spawning decreases. Results clearly indicate an extremely intensive exploitation of these resources.
- In 1999, a joint analysis by Trinidad and Tobago and Venezuela on *M. furnieri* in the Gulf of Paria and the Columbus Channel was conducted, using data from 1987 to 1998 (Alió *et al.*, 1999b) from all trawl fleets, as well as the artisanal gillnet and line fleets of Trinidad and Tobago, in a surplus production model. Results show that the current level of effort exceeds the levels at which yields of both species are maximized. MSY for croaker is 1 500 tonnes and was generally exceeded from 1987 to 1994 and in 1998, with landings ranging from 1 800 to 2 800 tonnes per year. These analyses used limited information from Trinidad and Tobago's industrial trawl fleet, as well as information on the size structure of the species caught by its gillnet and line fleets.
- A bioeconomic assessment of *M. furnieri* was conducted for the artisanal groundfish fishery of Trinidad and Tobago, using data for 1989–97 in a biodynamic economic model (Soomai and Seijo, 2000). Results show that a major decline in yield, net revenues and biomass of both species was expected if open access is continued. The net present value and the biomass of *M. furnieri* were examined under alternative management strategies, including combinations of limiting or banning certain artisanal gears. The recommended management option was to limit effort of all fleets to maintain the resource and the profits for the fishery at sustainable levels.

These results on shrimp trawl bycatch were considered preliminary because of limitations of the data and models, which are expected to be addressed in future research and assessments of the fishery. However, a precautionary approach should be applied to the management of the trawl fishery, based on the best scientific evidence available.

IMPACTS ON THE PHYSICAL ENVIRONMENT

To date, there have been no specific studies to determine the impact of trawling on the benthos in national waters. Some information suggests that the trawl grounds are swept twice a year by the fleets, although this is probably an underestimate for the inshore areas to which the artisanal vessels are restricted.

IMPACTS ON SMALL-SCALE FISHERIES

No specific studies of the impacts of shrimp fishing on small-scale fisheries have been conducted to date. It is well known, however, that the bycatch of the trawl fishery is also caught in the artisanal gillnet and line fleets. Assessments of a few commercially

important fish species (see *Biological aspects* section above) have been conducted and can give some feedback on impacts on small-scale fisheries.

Results of a 1994 local knowledge survey (Ramjohn, 1995) showed that non-trawl fishers perceived that trawling is the greatest threat to fishing in the Gulf of Paria. All respondents (trawl and non-trawl) noted a decline in individual catches and most thought that damage to the seafloor and destruction of juvenile fish by trawling were responsible. Trawl respondents replied that the major cause was pollution; however, 39 percent of all respondents felt that trawling was responsible, while artisanal trawlers held industrial trawlers responsible and industrial trawlers claimed that the inshore activities of artisanal trawlers were responsible.

In 1999, in the preparatory phase of a project to reduce the environmental impact of shrimp trawling (Project EP/GLO/201/GEF), a survey of trawl fishers was conducted to examine perceptions on issues related to shrimp exploitation and the impacts of trawling on resources and the environment (Kuruvilla, 2001). In 2000, a national workshop was held with the fishing industry (FAO and Fisheries Division, 2001) to discuss the results of shrimp and groundfish assessments. The general perception was that pollution of the inshore area through industrial and agricultural runoff contributed to the significant decrease in fish populations. Participants were also of the view that trawling for shrimp in inshore areas, which is prohibited under national legislation, is responsible for a further decrease in resources through the removal of large numbers of juvenile fish as bycatch, and for physical damage to fishing grounds. Fishers stated that there is an urgent need for the government to enforce the regulations governing area/zone restrictions, particularly with regard to artisanal vessels.

MANAGEMENT

The legislative basis for the management of domestic fishing in Trinidad and Tobago is Fisheries Act 1916 and its subsequent amendments, the Fisheries (Amendment) Act 1966 and the Fisheries (Amendment) Act 1975. The Act applies to all rivers and tidal waters in Trinidad and Tobago and to the 12-nautical-mile territorial sea; it does not apply to the EEZ.

The Act is limited in scope and merely empowers the Minister in charge of fisheries to make regulations controlling mesh size, form and dimensions of nets and appliances for fishing, and the manner of their use. It sets minimum sizes for species that may be fished or sold, declaring prohibited areas for fishing and prohibited fishing for specified species, either absolutely or by season or area. Furthermore, the Act prohibits the sale of fish or any species of fish, again either absolutely, or by season or area. Sanctions of US$323 or six months' imprisonment are imposed for most infractions.

Policy directions for the trawl fishery are influenced by the recognition that it cannot be managed only for the benefit of the shrimp resources harvested, but also for reducing its impact on other inshore species taken as bycatch. The high proportion of finfish bycatch and its negative impact on the coastal ecosystem, as well as on the resources harvested by other fisheries, also influence policy decisions on the fishery.

Management of the shrimp and groundfish fisheries needs to take into consideration many factors, including:

- the fully exploited or overexploited condition of targeted stocks as well as that of bycatch;
- high levels of bycatch/discards comprising juveniles of commercially important species targeted by other gears;
- the degree of overcapitalization in the trawl fishery;
- the socio-economic importance of artisanal fisheries to the stability of rural coastal communities;
- interaction between fleets exploiting the same resources, often leading to conflict;

- the need for cooperation in the management of the shrimp and groundfish resources exploited by the fishing fleets of both Trinidad and Tobago, and Venezuela; and
- the implications of semi-industrial and industrial trawlers using or not using TEDs.

Current management measures focus on fishing areas and fishing gear. Under Section 4 of the Fisheries Act, Fisheries (Control of Demersal [Bottom] Trawling Activities) Regulations 1996, and Fisheries (Control of Demersal [Bottom] Trawling Activities) (Amendment) Regulations 2001 specify restrictions on the areas of operation of the different trawler fleets and give gear specifications.

- Trawling is prohibited on the east coast of Trinidad and within 12 nautical miles of the coast of Tobago. This is a result of the topography, although there are some trawlable areas in the shallow waters in the southeast. Trawling is permitted on the north coast of Trinidad outside two nautical miles in the area west of Sauté Dead from 15 November to 15 January, but not at night, so as to reduce the impact on other established fisheries. It is permitted on the south coast of Trinidad outside two nautical miles. Trawling is subject to a zoning regime in the Gulf of Paria: (i) artisanal trawlers are permitted to operate outside one nautical mile from the coast; (ii) semi-industrial trawlers are permitted in depths of six fathoms (1 fathom = 6 ft/1.83 m) or more; and (iii) industrial trawlers are permitted in depths of ten fathoms or more.
- The stretched mesh size of the codend of the trawl net must be no smaller than approximately 7.5 cm (3 in) when trawling for fish and approximately 3.5 cm (1.38 in) for shrimp.

The Fisheries Act of 1916 does not provide a legal basis for controlling access by nationals of Trinidad and Tobago to fisheries resources under the national jurisdiction. Efforts to limit fishing effort in the trawl fishery have subsequently been carried out through a 1988 Cabinet decision to restrict entry of new vessels, both artisanal and industrial. This measure is effective to a greater extent for the semi-industrial and industrial fleet where permission for the importation of any new fishing vessel must be obtained from the Minister in charge of fisheries.

Under Fisheries (Conservation of Marine Turtles) Regulations 1994, the semi-industrial and industrial fleets are required to use TEDs on their nets. These regulations fall under Section 4 of the Fisheries Act and were drafted in accordance with trade requirements for the export of shrimp to the United States and the stipulations under Section 609 of United States Public Law. Regulations have also been drafted that address the type, specifications and proper installation of TEDs.

The Fishing Industry (Assistance) Act of 1955 makes provisions for the granting of financial assistance to the fishing industry by such means as fuel rebates, tax waivers and subsidies on fishing equipment.

Existing legislation is inadequate as a legal basis for a modern national fisheries management system. A Fisheries Management Bill prepared in 1995, which will be known on finalization as the Marine Fisheries Management Act, will repeal the Fisheries Act of 1916. The Marine Fisheries Management Act will provide for the preparation of fishery management plans and, accordingly, will control and limit access to fish resources through the establishment of a licensing system for both local and foreign fishing vessels.

A draft management plan for the trawl fishery proposes that trawler owners be required to hold entitlements to the fishery, which should be transferable, provided that the replacement vessel does not have a greater HP or fishing power, and provided that replacement of the vessel is in keeping with the level of fishing effort approved in the plan.

The current thinking of the Fisheries Division is that there is limited opportunity for reducing fishing effort in overexploited areas by expansion of fishing into new

areas. The artisanal Type II fleet is limited in its operations to the shallow inshore waters of the Gulf of Paria. There are no real opportunities for this fleet to expand its area of operation or to establish alternative trawling areas in waters under national jurisdiction. The situation for the semi-industrial fleet is similar in that, although mechanized, vessels are limited through operating depth and storage capacity to operations in the Gulf of Paria. The industrial fleet, although capable of a greater range in area of operation, is limited by topography and the current legislative regime, which does not favour expansion in trawling activity in national waters. There have not been any government initiatives to seek access for demersal trawlers to alternative domestic fishing grounds and it is unlikely that any request to do so would be treated favourably.

Alternative opportunities for the trawl fleets are available only through the refitting of vessels for other forms of fishing, although it is only the industrial fleet that has the capability of exploiting offshore resources. The results of preliminary assessments of inshore fisheries resources suggest that most of these resources are either fully exploited or overexploited. This supports the contention that the Fisheries Division be provided with the means to control fishing effort.

ENFORCEMENT

Under the Ministry of National Security, the Trinidad and Tobago Coast Guard is responsible for maritime surveillance, monitoring and enforcement of fisheries regulations as well as rules under fisheries agreements. It is a major participant in marine delimitation negotiations and carries out inspections of fishing vessels for compliance with fisheries regulations.

In 1999, the Fisheries Division, in collaboration with the Coast Guard, implemented an enhanced programme of dockside and at-sea inspections of semi-industrial and industrial trawlers to ensure compliance with Fisheries (Conservation of Marine Turtles) Regulations 1994, regarding the use of TEDs in their nets. The Fisheries Division is also currently involved in establishing a Fisheries Monitoring Surveillance and Enforcement Unit (FMSEU), which was commissioned in June 2004 after obtaining Cabinet approval. FMSEU will undertake, *inter alia*, visits to fish landing sites and at-sea surveys to ensure compliance with fisheries regulations and to enforce them where necessary. It will conduct inspections of processing plants and spot checking of shipments bound for export at the various ports in Trinidad and Tobago, to prevent mislabelling of goods.

With regard to the costs of fisheries management and associated enforcement, there are no precise calculations; nevertheless, the following estimations from 2000 are available.

- It was estimated that 50 percent of the Fisheries Division's recurrent budget (personnel, goods and services) was allotted to administrative activities related to fisheries management services, which includes data collection, research and monitoring and control activities. This cost was approximately US$387 000.
- It was estimated that 10 percent of the recurrent general administration budget of US$6.5 million for the Ministry of Agriculture, Land and Marine Resources was allocated to the administration of fisheries affairs, based on the contribution of fisheries to agricultural GDP.
- It was estimated that fisheries-related services provided by the Coast Guard were valued at 10 percent of total costs, which included operating costs, recurrent expenditures (personnel), depreciation costs on fleets of vessels and aircraft, and depreciation costs on land-based infrastructure. This cost was approximately US$371 000.

RESEARCH

The Fisheries Division of the Ministry of Agriculture, Land and Marine Resources is responsible for the assessment, management and conservation of the marine fisheries resources of Trinidad and Tobago, and for the provision of extension and specialized information services on marine fisheries. These responsibilities include the implementation of ongoing fisheries monitoring programmes such as catch and effort, economic and biological data collection on the major commercial fish species for use in stock assessments, and the development of fisheries management plans.

Regarding research on shrimp fisheries, a biological sampling programme for shrimp has been in place since the early 1990s. Length frequencies have been collected from the artisanal, semi-industrial and industrial trawl fleets, and computerized in Excel. From the 1990s to the 2006, within the framework of the Western Central Atlantic Fishery Commission (WECAFC) ad hoc Working Group on the Shrimp and Groundfish Resources of the Brazil-Guianas Continental Shelf, a series of subregional workshops was conducted, involving Brazil, French Guiana, Guyana, Suriname, the Bolivarian Republic of Venezuela and Trinidad and Tobago to assess shared stocks of shrimp and groundfish.

Between 1994 and 1998, Trinidad and Tobago participated in the Shrimp and Groundfish Subproject under the CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP). CFRAMP collaborated with the FAO/WECAFC ad hoc working group in conducting shrimp and groundfish assessments. The Programme has now been replaced by the Caribbean Regional Fisheries Mechanism (CRFM), which has formed similar working groups to ensure continuity in the assessment work initiated under CFRAMP and FAO/WECAFC. CRFM coordinated its first scientific workshop in June 2004.

Trinidad and Tobago is participating in a GEF-funded global project coordinated by FAO, Project EP/GLO/201/GEF, "Reduction of the Environmental Impact from Tropical Shrimp Trawling through the Introduction of By-catch Technologies and Change of Management". The project seeks to reduce the negative environmental aspects of bottom trawling by removing barriers to the introduction of environmentally friendly gear and fishing practices. One of the specific objectives of the project is the reduction of discards of fish captured by shrimp trawlers. This involves gear research and subsequent modifications to reduce bycatch.

The current Trinidad and Tobago/Venezuelan Fishing Agreement outlines a Protocol on Fisheries Research, which is a collaborative approach to research on shared fisheries resources. To date, this Protocol has not been fully activated.

The average annual budget for research in the Fisheries Division is estimated at US$170 000. The budget supports the ongoing catch and effort, biological sampling programmes, participation in regional scientific working groups and counterpart funding for the GEF trawl project. It is estimated that 35 percent of the annual research budget is focused on the demersal trawl fishery (shrimp and groundfish resources), and another 35 percent on pelagic fisheries. The remaining 30 percent covers information services shared equally between demersal and pelagic fisheries.

DATA REPORTING

Fisheries catch and effort statistics have been collected in Trinidad and Tobago since 1954, mainly through two wholesale fish markets. In 1959, a formal onshore collection programme was launched at specific beaches and focused on artisanal fisheries. By the end of 1999, there were full-time enumerators at 17 landing sites, five of which are the main trawl landing sites. This data collection system has remained basically intact over the years in terms of the nature of the data recorded and the process by which it is recorded (Ferreira, 2000).

In 1991, a logbook system was introduced for the semi-industrial and industrial shrimp trawlers. Captains were expected to record catch data for each of the shrimp and fish components of the catch, including discards. By May 1992, however, owners stopped submitting logbook returns because of a number of commercial developments in the industry. There are plans to reimplement the logbook system for these fleets. Estimates of landings for the trawl fleets are being determined in the interim from data collected by the biological sampling team.

Catch and effort data collectors employed by the Fisheries Division live close to the beaches and record data on the beach, either from fishers directly or from the vendors who meet them on the beach to purchase catches from fishing vessels landing daily. The main document used for collection purposes is the Return of Fish Landed form. Data are collected for each vessel on vessel registration number, times of departure and return, number of crew, gear type used, weights of "species" landed (grouped by local names), ex-vessel price per "species" and area fished.

The catch and effort data collection system provides reasonably good coverage of vessels, since data collectors have been traditionally employed at the major landing sites throughout the years and each enumerated site is assumed to be representative of artisanal fishing activity within a zone. Data are recorded for at least 20 days selected at random in a month. When the collection system was first established in 1959, there was only an artisanal inshore fishery; the system began to cover the industrial fleet in 1995.

There are plans to implement an observer/at-sea sampling programme to obtain information on discards and verify logbook returns. In the interim, an at-sea sampling programme covering all fleets was initiated in 1999.

In the late 1990s, the Fisheries Division established a monitoring system for fish imports and exports, primarily to be able to provide actual and reliable export data. The system requires the return of export licences of the previous shipment, certified by customs, from all exporters. This involves detailed information on all shipped fish and fishery products prior to approval being granted for additional licences. The system is used to verify data from the Central Statistical Office.

The current catch and effort system has been developed in the Windows version of the Oracle Relational Database Management System (RDBMS). The Fisheries Division maintains a server on which the Oracle RDBMS resides, and the catch and effort application is a multi-user operating system. The system provides for secure, efficient and effective storage of landings data that can be readily retrieved. The combined strengths of both the operating system and RDBMS allow for extensive data collection.

A frame survey to determine numbers of fishing vessels, fishers and changes in operations is conducted at least every five years. However, with regard to trawling, current numbers of operating vessels are usually known, since the catch and effort data collection system has almost total coverage of trawl landing sites. A formal system to yield accurate data on the number and type of operations of the marketing and distribution subsector has yet to be instituted.

The nominal landings and effort statistics collected on major (enumerated) beaches are used to generate data for secondary (non-enumerated) beaches, where it is assumed that similar fishing takes place, at the same intensity. The nominal catch landings and fishing effort data are raised by two factors. A "first raising factor" adjusts the nominal statistics to account for the non-enumerated fishing days at each enumerated beach, i.e., fishing days on which the field data collector did not collect information. A "second raising factor" adjusts the first raised statistics to account for non-enumerated vessels, i.e., vessels that fished but for which no data were recorded.

Landings from trawling have been computerized since 1991. Trawling raised landings reports are produced for each enumerated beach by gear (trawler type) and fishing area. Total trawl landings and effort are estimated by fleet type and fishing area.

IMPACTS OF SHRIMP FARMING

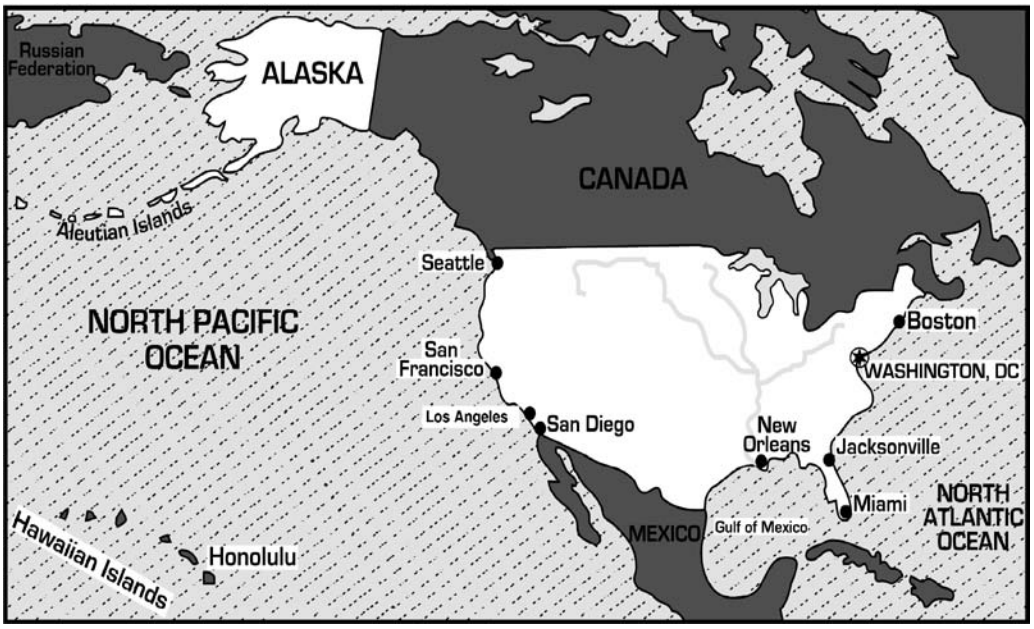
Domestic shrimp farming has no effect on shrimp fishing because for the moment there is no shrimp aquaculture in Trinidad and Tobago.

MAJOR ISSUES

The important issues related to shrimp fishing in Trinidad and Tobago are:

- the need to reduce shrimp fishing effort, but a lack of political will and legal tools to do so;
- the present low or negative profitability of shrimp fishing;
- the fact that while fishing effort is growing, the geographic area open for trawling is extremely limited;
- the ban on exporting to the United States; and
- the negative impacts of industrial trawling on small-scale fishing.

Shrimp fishing in the United States of America



AN OVERVIEW

Two main types of shrimp fisheries operate in the United States of America: those that target warm-water shrimp off the southeast Atlantic coast and the Gulf of Mexico, and those that target fisheries for cold-water shrimp in the northeast and northwest of the country. In terms of value, shrimp is the second most important fishery after crab.

In recent years, combined landings for domestic shrimp fisheries have been about 144 000 tonnes annually, with the warm-water fisheries responsible for over 90 percent in 2004 (Table 80). The United States domestic production is dwarfed by shrimp imports of 500 000 tonnes per year, over 80 percent of which is from aquaculture.

The domestic shrimp market has greatly expanded over the past few years. Shrimp is the most important seafood item for United States consumers – currently at 1.9 kg[42] edible weight per year. The United States market is now the largest in the world for shrimp, followed by the EU.

Despite record demand for shrimp in the United States, real and nominal prices have declined, primarily as a result of cheaper imported shrimp. This downward pressure on dockside prices, together with the increasing operational costs of domestic shrimp vessels, has resulted in severe financial difficulties in many United States shrimp fisheries.

TABLE 80
Recent commercial shrimp landings (tonnes)

	2003	2004	Average (1999–2003)
New England	1 121	1 304	1 388
South Atlantic	10 780	11 457	12 146
Gulf of Mexico	115 566	116 519	111 438
Pacific coast	15 538	10 552	18 886
Other	1	0	3
Total	143 007	139 833	144 185

Source: NMFS database.

[42] Seafood weights in the United States are often expressed in pounds (1 pound = 0.453 kg).

DEVELOPMENT AND STRUCTURE

Warm-water commercial shrimp fishing

Commercial shrimping began in about 1817 on the Atlantic coast of the southern United States, using cast nets and haul seines. In the early part of the twentieth century, the Mississippi haul seine fishery used 12-m sailing schooners to transport fishers 32–128 km to the fishing grounds to catch shrimp for canneries. In Florida, between 1912 and 1915, the large mesh otter trawl used to capture finfish was modified for shrimp fishing. By 1930, these new trawls produced about 90 percent of the shrimp catch, which was mostly canned or air-dried. Over the following decades, trawling and the use of larger vessels allowed fishing in deeper waters further from the shore where bigger catches could be made. By about 1950, most of the potential fishing grounds in waters adjacent to the southeastern states had been discovered. The United States shrimp fleet then expanded its operations to the east coast of Mexico and the western Caribbean Sea. From the early 1960s to the early 1970s, 632–860 United States vessels fished off Mexico. In 1976, a treaty between the United States and Mexico resulted in United States shrimping in Mexican waters being phased out by the end of 1979. From 1959 to 1979, up to 207 United States shrimp vessels fished off the northeastern coast of South America (Iversen, Allen and Higman, 1993).

Poseidon (2003) discusses recent changes in shrimp fishing gear in the Gulf of Mexico. From the mid-1970s through the early 1990s, the trawls used by the offshore shrimp industry changed significantly. Initially, the fleet used high-opening single balloon trawls that fished high in the water column. By the early 1980s, they were replaced by twin trawls with a low vertical opening, which fished lower in the water column, making it possible for the vessel to increase the swept area with the same or less energy. By the early 1990s, these were largely replaced by quad trawls, i.e. two trawls are towed on each side, with the trawls connected by a sledge, and otter boards are only placed at the outside wings. Again, this increased the fished area of the bottom with equal or less energy by reducing the height that the nets fished in the water column.

Cascorbi (2004b), citing several primary sources, states that otter trawls take 91 percent of the shrimp catch in the Gulf of Mexico and South Atlantic (GSA) region, skimmer trawls take 7 percent and various kinds of cast nets or stationary butterfly nets take the remaining 2 percent.

The shrimp harvesting industry in the GSA region represents one of the most economically important components of all the domestic commercial seafood harvesting sectors in the United States. In 2004, commercial shrimp landings from the GSA region were estimated at 127 000 tonnes, with a dockside value of US$409 million. This represents about 91 percent of the volume of all United States domestic commercial landings of shrimp for the year. Currently, there are more than 16 000 licensed vessels in the Gulf of Mexico and over 2 200 in the South Atlantic. There are numerous differences in shrimp fishing between the various parts of the region. For example, Louisiana's catch is dominated by smaller shrimp, which are targeted by the many smaller, inshore shrimp vessels that characterize the state's shrimp fleet. In contrast, the Texas shrimp fleet is characterized by larger vessels that fish further offshore for bigger, more valuable shrimp (Ward *et al.*, 2004; NMFS, 2005).

In 2005, hurricanes had a major effect on shrimp fishing in the Gulf of Mexico (Box 36).

Cold-water commercial shrimp fishing

Commercial fishing for cold-water shrimp began in about 1869 on the Pacific coast of the United States and in 1938 on the Atlantic coast. The original Pacific coast fishing grounds were in San Francisco Bay, later in the Puget Sound area of Washington and, by 1916, shrimp fishing was permanently established in southeastern Alaska. In about 1952, shrimping began in the offshore waters of Washington southwards to California.

BOX 36

Effects of the 2005 hurricanes on shrimp fishing

The impacts of the hurricanes on fishing activity were estimated by comparing fishery landings in September 2005 (after Katrina) with September catches from the same states in 2003 and 2004. In 2003–04 the average September catches of shrimp were valued at US$44 million. Based on figures obtained for September 2005, there was a 97 percent reduction in shrimp landings. Hurricanes Katrina and Rita devastated the shoreside infrastructure and fishing fleet in a wide swathe from Mississippi Sound through the Louisiana Delta, including parts of Florida Keys, western Louisiana and eastern Texas. There is no conclusive estimate of the number of fishing vessels sunk or driven ashore, but the United States Coast Guard initially estimated the number at between 3 500 and 5 000. This estimate includes nearly 2 400 commercial vessels and 1 200 recreational boats. Shoreside infrastructure was devastated in many areas of Mississippi, eastern Louisiana and Alabama. In contrast, it appears that this did not have a significant impact on populations of shrimp and finfishes in offshore areas of the northern Gulf of Mexico. Preliminary results of the survey show that shrimp and bottom fish abundance was the same or slightly higher than in the autumn of 2004, with shrimp and other valuable species relatively abundant and widely distributed (Hogarth, 2005).

In the late 1950s and early 1960s, Gulf of Mexico-style trawls began appearing on west coast shrimp boats. By 1975, in the Gulf of Alaska alone, 54 000 tonnes of shrimp were produced. The number of trawl vessels in the Pacific coast shrimp fishery reached a record high in 1980 but has since declined. Japan and the former Soviet Union fished shrimp off the Alaska coast in the 1960s and 1970s. Most of the fishing in Washington, Oregon and California now uses otter trawls. In 2003, over 90 percent of all Alaskan shrimp landings were from beam trawls and traps (Iversen, Allen and Higman, 1993; Roberts, 2005).

On the Atlantic coast, commercial shrimp fishing began in about 1938 in the coastal waters of Maine. The presence of large shrimp in lobster traps and cod stomachs is believed to have sparked off the Maine shrimp fishery. Today, some traps are used, but most of the shrimp catch is from otter trawling and many of the vessels are rerigged lobster boats, groundfish draggers and scallop boats. Three-quarters of the shrimp landings in New England have been by Maine vessels, with the remainder by Massachusetts vessels. The number of vessels fishing in New England waters has fluctuated considerably, with 300–400 vessels in some years. Many of the participants are opportunistic, switching to shrimp trawling if price, season and accessibility warrant the effort (Iversen, Allen and Higman, 1993; Roberts, 2005).

In 2004, the Pacific coast cold-water shrimp fisheries were responsible for 7.5 percent of United States domestic commercial shrimp landings, while those of the Atlantic were responsible for just less than 1 percent (NMFS, 2005).

Other shrimp fishing

In addition to the warm- and cold-water commercial shrimp fisheries described above, other shrimp fishing activity takes place in the United States (Iversen, Allen and Higman, 1993; Cascorbi, 2004b).

- Substantial amounts of shrimp are caught by recreational fishers. The main gear types are dip nets, cast nets, beach seines, push nets and traps. One estimate indicates that about 8 000 small boats participate in recreational shrimp fishing in the Gulf of Mexico.
- Commercial fishing for shrimp for bait for recreational fishing is important in the southeastern United States. In general, juvenile stages of shrimp are caught in

inshore areas. It has been estimated that about 2 200 tonnes of shrimp are caught in the Gulf for bait.

- There has been a considerable amount of experimental fishing in Hawaii for deep-water shrimp, using traps. Although significant catches have been made, commercial feasibility has not been demonstrated.

TARGET SPECIES, CATCH AND EFFORT

The major species of shrimp taken in the United States shrimp fisheries are the following.

- *Warm water*. In the GSA region, 97 percent of the commercial production is historically made up of pink shrimp (*Farfantepenaeus duorarum*), white shrimp (*Litopenaeus setiferus*) and brown shrimp (*F. aztecus*). Smaller quantities of other species are landed, including rock shrimp (*Sicyonia brevirostris*), royal red (*Pleoticus robustus*) and seabob *(Xiphopenaeus kroyeri*) (Ward *et al*., 2004; Iversen *et al*., 1993).
- *Cold water*. On the United States Pacific coast in the four-year period from 2000 to 2003, pink shrimp (*Pandalus jordani*, also known as ocean shrimp) made up 93 percent of the catch; northern shrimp (*P. eous*, also known as pink shrimp), 4 percent; and other species, 3 percent. Of the pink shrimp catches, 67 percent were made in Oregon, 19 percent in Washington and 7 percent in California. All the northern shrimp catches were from Alaska. The most important "other species" were spot prawns (*P. platyceros*), coonstripe shrimp (*P. hypsinotus*), ridgeback prawns (*Sicyonia ingentis*) and some bait shrimp. On the Atlantic coast, northern shrimp (*P. borealis*) is by far the most important, but small quantities of striped shrimp (*P. montagui*) are incidentally taken (Roberts, 2005).

The above shows that there is some duplication in the common names of shrimp in the United States. Three different species are known as pink shrimp and two species as northern shrimp.

Shrimp catches in the two major shrimp fishing regions of the United States are given in Table 81.

TABLE 81
Catches in the major United States shrimp fishing regions (tonnes)

	Southeast Atlantic and the Gulf of Mexico				Pacific Coast
	Brown shrimp	White shrimp	Pink shrimp	Total brown, white, pink	Pink shrimp (ocean shrimp)
1985	71 118.5	44 698.2	12 181.9	127 998.6	12 415.3
1986	76 052.6	54 506.1	9 455.7	140 014.4	26 354.5
1987	68 635.7	43 166.4	8 980.4	120 782.5	31 099.0
1988	63 168.6	36 586.2	7 903.7	107 658.5	32 345.1
1989	73 401.8	31 802.1	7 805.4	113 009.3	35 557.1
1990	80 324.8	36 078.8	6 213.4	122 617.0	24 563.8
1991	69 418.7	40 441.3	6 140.9	116 000.9	19 134.0
1992	52 894.8	40 494.6	5 586.7	98 976.1	35 870.0
1993	53 993.1	33 835.0	7 618.3	95 446.4	22 608.7
1994	50 633.6	37 760.6	7 382.6	95 776.8	15 273.3
1995	58 222.2	44 554.6	10 373.7	113 150.5	11 930.0
1996	56 279.3	29 852.4	14 185.7	100 317.4	14 357.7
1997	49 864.9	33 393.6	9 368.1	92 626.6	17 814.6
1998	59 118.8	44 719.1	12 542.8	116 380.7	4 835.0
1999	62 153.4	46 886.9	6 122.8	115 163.1	12 899.2
2000	74 924.1	55 767.7	5 784.0	136 475.8	14 953.6
2001	68 973.9	40 998.7	7 246.6	117 219.2	17 832.6
2002	58 865.4	43 701.1	8 329.4	110 895.9	25 541.0
2003	65 510.2	47 742.5	6 921.0	120 173.7	14 067.3
2004	56 615.2	57 092.0	7 209.4	120 916.6	9 254.2

Source: NMFS landings database.

In a comprehensive review, Ward *et al.* (2004) conclude that shrimp supplies from United States domestic fishing are relatively fixed in the long term, with annual fluctuations reflecting changes in environmental conditions from one year to the next.

In the GSA region, shrimp fishing effort is a complex subject, mainly as a result of both the large number of management units (federal and individual states) and vessels involved. There are more than 16 000 licensed vessels in the Gulf of Mexico and over 2 200 in the South Atlantic. Funds have been provided by United States Congress to conduct a study to determine the amount of fishing effort in the shrimp fishery (Ward *et al.*, 2004). Cascorbi (2004b), using several primary sources, comments on the shrimp fishing effort situation.

Estimating total fishing effort in United States shrimp fisheries is difficult. The exact number of vessels taking part in Gulf and Atlantic shrimp fisheries is not known to management authorities: there is currently no federal licensing requirement for the South Atlantic region; state licensing regulations vary; and, because shrimpers follow the shrimp across state water boundaries, many shrimp vessels are licensed in several states. The Gulf of Mexico Fishery Management Council (GMFMC) estimates the Gulf shrimp fleet at between 3 500 and 4 500 vessels and the South Atlantic Fishery Management Council estimates the South Atlantic fleet at 1 400 large vessels and 1 000 small boats.[43] *Although federal permits have been required for Gulf shrimpers since December 2003, and about 2 500 Gulf permits have been issued since that time, many vessels move in and out of the shrimp fishery opportunistically, fishing for other species when shrimp prices are down or fuel prices are too high. Because exact vessel numbers are not known, NMFS cannot calculate fishing effort as directly as in other fisheries. Currently, NMFS calculates shrimping effort by interviewing a representative sample of vessel captains to determine the number of hours spent fishing. The GMFMC notes that these NMFS effort estimates "have been controversial and not well understood, because the effort reported does not necessarily reflect the number of active vessels in the fleet".*

Effort data are more precise at the state level. A review of the shrimp fishing effort in all these areas is beyond the scope of this brief study, but an example from a warm-water shrimp fishery and one from a cold-water shrimp fishery can illustrate some important features.

- In Texas, shrimp fishing effort data are collected using nominal days fished, which are defined as actual hours of trawling per vessel, summed for all vessels that fished and converted to total days fished. These values do not consider changes in fishing power or efficiency over time. Annual fishing effort in the bays[44] has generally increased since 1966. Shrimp trawling for brown and pink shrimp in the bays was the most dramatic, with a tenfold increase from 1966 to the peak effort in 1994. Bay effort since then has declined substantially for all shrimp species, probably partly as a result of the licence buy-back programme and economic conditions in the industry. Annual fishing effort in the Gulf has also generally increased since 1966. Brown and pink shrimp were the dominant species sought, with a 72 percent increase in effort from 1966 to the peak effort in 1987. Gulf effort on brown and pink shrimp has generally declined since then. White shrimp effort has fluctuated widely with a 64 percent increase from 1966 to 2000 (TPWD, 2002).
- In Oregon, shrimp fishing effort data are expressed as "single-rig equivalent hours". From 1968 to 2003, effort ranged from about 18 000 to 160 000 hours, with a peak in 1980 and again in the late 1980s, followed by a declining trend since then. Fishing effort during 2003 was extremely low, both in terms of hours fished and in the number of vessels making Oregon landings. Only 59 vessels

[43] The numbers of vessels are presumably those that operate in the federal (offshore) fisheries and do not include those operating in exclusively state-managed areas.

[44] Two components of shrimp fishing in Texas are recognized: bay fishing and Gulf fishing.

landed shrimp into Oregon ports during 2003, the lowest number since 1984. The 59 vessels fished 31 883 hours, the lowest number since 1972. A low price structure probably kept many vessels from fishing shrimp and some vessels were unable to secure a market (Hannah and Jones, 2004).

ECONOMIC CONTRIBUTION

The value of shrimp landings from the major shrimp fishing areas is given in Table 82. It can be deduced that the GSA region is responsible for 96 percent of the value of shrimp landings in the country (2004). Ward *et al.* (2004) comment on the economic impacts of shrimp fishing on this region.

TABLE 82
Value of shrimp landings, 2003 and 2004

	2003	2004
New England	2 238 000	1 341 000
South Atlantic	40 663 000	42 106 000
Gulf of Mexico	362 471 000	367 181 000
Pacific coast	15 324 000	14 976 000
Other	9 000	1 000
Total	420 705 000	425 605 000

Source: NMFS database.

TABLE 83
Consumption of fish/shellfish in the United States

	Per capita shrimp consumption (kg)	Per capita total fish/shellfish consumption (kg)
1998	1.3	6.8
2002	1.7	7.1
2003	1.8	7.4
2004	1.9	7.5

Source: NMFS Web site: www.nmfs.noaa.gov

The shrimp industry contributes to local coastal economies on several levels. Shrimp is offloaded by shore-side handling facilities, which then set in motion a myriad of economic activities associated with processing, packing, wholesale distribution and consumer expenditures. Vessel maintenance, repair, refuelling and other activities also contribute to the overall economic activities associated with the industry. Previous studies have suggested that the commercial shrimp industry plays an important role in the economy of the GSA region. A 1984 study found that the shrimp industry within the GSA region created 73 000 jobs, generated approximately US$1 billion in income, and created $1.4 billion in added value for the United States economy. A more recent study in 2003 estimated that the commercial shrimp industry in Florida alone creates US$130 million in economic impact to the state's economy.

The consumption of shrimp in the United States has increased remarkably in recent years, as shown in Table 83. Shrimp (1.9 kg per capita in 2004) has overtaken tuna (1.5 kg) as the most important seafood in the country. Over three-quarters of the shrimp consumed in the United States is imported, most of which is from aquaculture.

TRADE ASPECTS

The United States is a major player in the trade of shrimp products. The country represents the world's largest shrimp market and United States Government shrimp import policies have a significant effect on major shrimp exporting countries throughout the world.

Traditionally, Japan was the largest import market for shrimp. However, because of the country's economic problems in the late 1990s, shrimp imports stagnated together with most other imports, and the United States emerged in 1998 as the largest importer in volume and value. Since then, it has increased its shrimp imports even further. Imports topped 500 000 tonnes in 2003 for the first time and rose even higher in 2004 to 518 000 tonnes. The value of total imports in 2004 fell, however, by 2.1 percent (Lem, 2006).

Table 84 shows United States shrimp imports in recent years.

Shrimp is imported into the United States in various forms. Shrimp imports by product type are shown in Table 85.

With regard to the United States shrimp market and trade in recent years, the country has:

- produced commercially about 145 000 tonnes of shrimp per year, with only about 4 000 tonnes from aquaculture;

TABLE 84
United States shrimp imports, 2003 and 2004

		2003		2004	
		Tonnes	US$'000	Tonnes	US$'000
North America	Mexico	25 494	294 088	28 989	327 338
	Honduras	9 706	57 009	11 002	59 120
	Canada	6 478	40 727	8 176	53 683
	Panama	6 153	50 489	5 813	46 145
	Belize	6 218	40 121	6 436	37 921
	Nicaragua	4 507	24 187	4 546	24 051
	Guatemala	3 081	18 949	3 168	19 472
	Costa Rica	468	4 259	335	3 195
	El Salvador	602	5 229	311	1 962
	Jamaica	36	138	288	1 401
	Other	35	159	28	224
	Total	62 778	535 355	69 092	574 512
South America	Ecuador	34 029	211 258	37 509	212 872
	Venezuela (Bolivarian Rep. of)	9 958	60 864	16 268	85 711
	Brazil	21 783	96 764	9 228	40 724
	Guyana	11 423	37 870	8 453	27 966
	Colombia	2 278	17 004	3 539	21 994
	Peru	1 503	8 766	2 868	16 134
	Suriname	1 849	6 889	3 139	11 715
	Argentina	1 721	13 347	161	1 229
	Chile	173	1 414	132	1 035
	Uruguay	3	11	-	-
	Total	84 720	454 187	81 297	419 380
EU	Denmark	81	561	172	1 005
	Spain	29	230	32	186
	Belgium	7	35	17	85
	Netherlands	11	212	1	17
	Portugal	2	7	3	15
	Other	40	165	3	17
	Total	170	1 210	228	1325
Other Europe	Iceland	35	209	145	774
	Norway	-	3	5	21
	Ukraine	2	12	2	13
	Russian Federation	-	-	-	3
	Total	37	224	152	811
Asia	Thailand	133 220	997 694	132 141	871 948
	Viet Nam	57 378	595 014	37 099	386 044
	India	45 469	408 907	41 004	359 562
	Indonesia	21 663	168 047	46 966	339 994
	China	81 011	441 905	65 976	337 566
	Bangladesh	8 143	82 836	17 379	172 567
	Malaysia	1 294	9 381	12 693	122 467
	Cambodia	-	4	5 330	37 383
	Philippines	1 227	10 929	1 897	15 666
	Sri Lanka	1 110	10 715	1 121	11 573
	Other	6 097	41 076	5 014	25 948
	Total	356 612	2 766 508	366 620	2 680 718
Other	Oceania	100	1 408	125	1 965
	Africa	77	1 558	103	1 965
Total	All regions	504 494	3 760 450	517 617	3 680 676

Source: www.nmfs.noaa.gov
Note: Weights are based on individual products as received, i.e. raw headless or peeled.

- imported about 500 000 tonnes, with countries in Asia supplying 70 percent in 2004 –over 80 percent of shrimp imports are from aquaculture; and
- exported about 15 000 tonnes, with Canada and Mexico receiving about 75 percent of the total.

Clay (1996) makes some interesting observations about the domestic shrimp market:

TABLE 85
United States shrimp imports by product type

Type of product	2003		2004	
	Tonnes	US$'000	Tonnes	US$'000
Shell on (heads off)	248 951	1 854 812	244 635	1 760 153
Peeled:				
Canned	1 772	7 331	1 398	5 904
Not breaded:				
Raw	150 641	1 140 393	151 950	1 099 933
Other	94 373	705 985	103 068	728 322
Breaded	8 757	51 929	16 566	86 364
Total	504 494	3 760 450	517 617	3 680 676

Source: www.nmfs.noaa.gov

- brand names are not particularly important in the United States market, at least not at the consumer level;
- most shrimp purchasers in the United States are restaurants and institutions;
- local restaurant chains tend to be served by distributors, while national chains have central warehouses from which they supply their units;
- shrimp from various sources (domestic/imported, captured/cultured) tends to be handled in the same way by the same actors (brokers, distributors and processors); and
- New York, Chicago and Los Angeles are the principal centres for trading and holding activity.

Some of the important changes in the United States shrimp trade in recent years include the following.

- The total United States supply of shrimp on the domestic market has increased dramatically over the past 20 years. Domestic production and imports were about 200 000 tonnes in the early 1908s, but increased to over 650 000 tonnes in 2004.
- There has been a large increase in shrimp imports. The United States market share supplied by imports increased from 48 percent in 1978 to 80 percent in 2004. The rise in low-cost imports has led to a fall in shrimp prices on United States markets. Ward *et al*. (2004) indicate that ex-vessel prices declined by 27 percent in the Gulf of Mexico and 24 percent in the South Atlantic Shrimp Fishery between 1997 and 2002, as imports increased by 300 percent.
- Value-added products, particularly peeled products, have represented an increasing share of total shrimp imports. In 1980, for example, peeled shrimp represented 35 percent of imports; by 2004 its share had increased to 49 percent.
- Two decades ago, the major exporters of shrimp to the United States were Latin American countries. In 2004, seven of the ten most important exporting countries were in Asia.

The growth in shrimp imports into the United States is attributed to three factors. First, although economic conditions have declined in the three primary shrimp-importing regions (the United States, Japan and the EU), the relative strength of the United States economy has led to a greater rate of import growth. Second, a changing EU tariff structure has redirected shrimp from Thailand (a major producer) to the United States markets. Third, higher detection levels for the banned substances chloramphenicol and nitrofuran under sanitary and phytosanitary measures have resulted in a redirection of shrimp products from the EU to the United States. However, it is important to recognize that the increased trade flow reflects not only increased production in total, but also the source of the increased output (i.e. farmed versus wild production). The farm-raised product has greater consistent quality than the wild product; it is less seasonal in nature and therefore more reliable than its wild counterpart; species and sizes can be controlled better in the farm-based system than in the wild-based one; and the current trend towards vertical integration in the farming

system lends itself to better adaptation to consumer needs. These factors have led to a surge of shrimp imports into the United States over the last few years (Ward *et al.*, 2004).

The United States Government has made two major unilateral interventions affecting shrimp imports that have had significant consequences for both the United States and other countries. These interventions relate to turtle conservation and allegations of shrimp dumping.

According to the United States Department of State, Section 609 of United States Public Law 101–162 provides 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 unless the President certifies to Congress by 1 May 1991, and annually thereafter. The foundation of the United States programme governing the incidental taking of sea turtles in the course of shrimp harvesting is the requirement that commercial shrimp trawl vessels use sea TEDs, approved in accordance with standards established by the United States National Marine Fisheries Service (NMFS), in areas where, and at times when, there is a likelihood of intercepting sea turtles. The aim and chief component of this conservation programme is to protect sea turtle populations from further decline by reducing their incidental mortality by drowning in commercial shrimp trawl operations. The 13 nations currently meeting this standard are Belize, Colombia, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Pakistan, Panama, Suriname and the Bolivarian Republic of Venezuela. Twenty-four nations and one economy were certified as having fishing environments that do not pose a danger to sea turtles.[45] Of these, eight nations and one economy – the Bahamas, China, the Dominican Republic, Fiji, Hong Kong Special Administrative Region, Jamaica, Oman, Peru and Sri Lanka – harvest shrimp, using manual rather than mechanical means to retrieve nets, or other fishing methods not harmful to sea turtles. Sixteen nations have shrimp fisheries in cold waters only, where the risk of taking sea turtles is negligible: Argentina, Belgium, Canada, Chile, Denmark, Finland, Germany, Iceland, Ireland, the Netherlands, New Zealand, Norway, Russian Federation, Sweden, the United Kingdom and Uruguay (C. Stanger, personal communication, Office of Marine Conservation, United States Department of State, October 2005).

The United States policy on TEDs is not without its critics. Many shrimp fishers outside the United States are confused about the actual requirements, while others complain that they simply cannot afford gear similar to that used by relatively rich United States fishers. At a higher level, the United States Government is sometimes faulted for adopting unilateral measures that aim to compel other governments to alter their national policies to be more in line with United States objectives (Joyner and Tyler, 2000).

The second United States intervention affecting shrimp imports concerns anti-dumping action. While it directly affects only aquaculture shrimp exported to the United States by certain countries, it does have some impact on the global shrimp trade because of the size of the United States shrimp market.

Over time, the rise in imports, and in particular of farmed warm-water shrimp from low-cost producers, has led to a fall in shrimp prices on the United States market, with United States fishers consequently becoming less competitive. As a result, United States shrimpers accuse foreign producers of dumping. On 31 December 2003, the Southern Shrimp Alliance (SSA), a lobbying organization formed by shrimp fishers and processors in eight southern states, filed an anti-dumping petition with the United States Department

[45] With regard to Australia, the present United States position is that because the Australian Government maintains good governance over specific fisheries and keeps shrimp harvested apart from those specific fisheries labelled separately, the United States certifies Australian shrimp on a fishery basis and, in early 2006, five fisheries were certified.

BOX 37
An alternative view of shrimp dumping in the United States

Shrimp farming has proliferated for one simple reason: efficiency. Trawling for shrimp is costly and the harvest often varies considerably from year to year with changes in weather and ecological conditions. Shrimp farms not only produce shrimp at much less cost, but they also provide a steady and reliable volume. Seafood processors value the reliable volume: they buy harvested shrimp and produce finished products for consumers whose desire for shrimp does not fluctuate with weather and ecological conditions. As shrimp farming has expanded, world shrimp production has increased and shrimp prices have fallen. Shrimp prices are now so low that they threaten the market survival of United States shrimp trawlers. The trawlers have therefore turned to the United States Government and its anti-dumping law to protect themselves, not from dumping, but from market competition with their more efficient foreign competitors (Mathews, 2004).

of Commerce against shrimp farms in Brazil, China, Ecuador, India, Thailand and Viet Nam. On 6 July 2004, the Department imposed duties varying up to 113 percent on these countries. Some commentators see it from a different perspective (Box 37).

In the short term, some market specialists feel that this action is resulting in higher shrimp prices for consumers. Internationally, supplies directed away from the United States market are leading to falling prices elsewhere. In the long term, however, the duties will not have much of an effect on the United States market except for that of changing the sourcing mix for imported shrimp, and slowing down the overall growth of the market because of the higher costs imposed (Ianelli, 2004; Lem, 2006).

BYCATCH ISSUES

According to NMFS, the bycatch of fishery resources, marine mammals, sea turtles, seabirds and other living marine resources has become a central concern of the commercial and recreational fishing industries, resource managers, conservation organizations, scientists and the public, both nationally and globally. During the past 26 years, the regional fishery management councils and NMFS have responded to this concern by taking a variety of actions to address the issue of bycatch. Actions have included research to develop better methods for monitoring and reducing bycatch, outreach programmes to explain the bycatch problem and search for solutions, and regulatory actions to monitor and decrease bycatch (www.nmfs.noaa.gov).

In 1996, Congress amended the Magnuson-Stevens Fishery Conservation and Management Act. The revision specifically defines the term "bycatch" and stipulates that it must be minimized to the extent practicable. "Bycatch", as defined by the Act, "means fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. The term does not include fish released alive under a recreational catch and release fishery management program."

The major bycatch issues in United States shrimp fishing are: estimating bycatch in the various fisheries; impacts on protected species, non-protected species and the environment; and various initiatives to reduce this impact, both domestically and internationally.

In his global review of discards, Kelleher (2005) estimates the quantity of discards for the three most important United States shrimp fisheries.

- The Gulf of Mexico Shrimp Trawl Fishery[46] discards an estimated 480 000 tonnes, with a discard rate of 57 percent.

[46] Kelleher notes that numerous recent changes have occurred that may have reduced bycatch in these fisheries.

- The South Atlantic Shrimp Trawl Fishery discards over 70 000 tonnes, with a discard rate of 83 percent.
- The nearshore shrimp fishery of the three Pacific coast states discards approximately 20 000 tonnes, with a discard rate of 44 percent.

Drawing on a variety of sources, Cascorbi (2004b) summarizes the various estimates of bycatch ratios (finfish/shrimp) in the United States warm-water shrimp fisheries. The report states that the exact ratio of non-shrimp bycatch in GSA shrimp trawl fisheries is difficult to quantify. NMFS data suggest that there was a ratio of 10:1 in the 1970s before measures were put in place to reduce growth overfishing of shrimp. Estimates of the bycatch ratio for Florida shrimp trawls range from 6:1 to 1:1. Studies in the late 1990s, by the Texas Parks and Wildlife Department (TPWD) found ratios in Texas state waters of approximately 4:1. In 2003, an industry representative asserted that the GSA fisheries had reduced the bycatch ratio from 10:1 to 3:1 since the mid-1980s. The best recent, non-industry estimates (NMFS, in the late 1990s) suggest that for every pound of shrimp caught, about 4.5 pounds of bycatch are discarded in the United States South Atlantic and about 5.25 pounds of bycatch are discarded in the Gulf. BRDs are believed to reduce finfish bycatch by as much as 30 percent, meaning that, since 1997 (when BRD requirements were put in place), ratios could have reached 2.8:1 in the United States South Atlantic and 3.5:1 in the Gulf. The effectiveness of BRDs in reducing bycatch is currently under study.

According to the Gulf of Mexico Fisheries Management Council (GFMC) (2006), the incidental take of juvenile red snapper has been a significant bycatch problem in the Gulf of Mexico Shrimp Fishery, the resolution of which has challenged fishery managers for many years. Despite the use of BRDs in shrimp trawl gear, the fishery appears to be taking juvenile red snapper at a rate that jeopardizes the resource. Recent information suggests that BRDs used by the fleet to minimize bycatch have not been as effective as previously thought, and that a comprehensive effort reduction programme may be needed to achieve the large-scale bycatch reduction required to end overfishing of red snapper by the shrimp fishery.

Roberts (2005) reviews the bycatch situation in North American cold-water shrimp fisheries. The report states that bycatch is a far less serious concern in United States and Canadian cold-water shrimp fisheries than in warm-water ones. A mixture of seasonal regulation and technological fixes has brought bycatch rates down to less than 5 percent of the catch in the Canadian, New England and Oregon pink shrimp fisheries. Since similar regulations are also in place for the other United States and Canadian cold-water shrimp trawl fisheries, bycatch is likely to be equally low in these fisheries. Concerns remain, however, over the bycatch of juvenile groundfish in some fisheries. These concerns are recognized and research is ongoing to try to reduce bycatch even further. No marine mammals, seabirds or sea turtles have been observed caught in cold-water shrimp fisheries in Canada and the United States. Canadian Atlantic, British Columbian and Oregon shrimp trawl fisheries have comprehensive observer programmes in place to monitor bycatch. The New England Fishery, however, has not had an observer programme in place since 1997.

Kelleher (2005) notes that, with regard to bycatch issues in the United States, three features are especially noteworthy:

- the growing impact of the incidental catch of charismatic species in fisheries management and in trade;
- the emerging influence of civil society with regard to bycatch and incidental catch issues; and
- the importance of fisheries management plans in bycatch management.

There have been numerous management interventions to reduce bycatch in the major United States shrimp trawl fisheries. As regards warm-water fisheries, Cascorbi (2004b) states that a 1990 amendment to the Magnuson-Stevens Fishery Conservation

and Management Act authorized a three-year study of bycatch from GSA shrimp trawlers and prohibited federal regulations to reduce shrimp trawl bycatch before January 1994. In October 1992, North Carolina became the first state to require shrimp trawlers to use a finfish excluder device. Since 1997, federal regulations have required the use of BRDs on all shrimp trawls in the central and western Gulf, and an amendment approved by NMFS in 2003 extends the same BRD requirement to the eastern Gulf. Roberts (2005) states that all the major cold-water shrimp trawl fisheries in the United States and Canada have plans in place to reduce bycatch. The northern shrimp fisheries of both countries have mandatory BRD requirements. The Oregon and Washington Pink Shrimp Fisheries have mandatory grate or soft BRD requirements. These, and other measures such as seasonal closures and trawl modifications, have reduced bycatch to less than 5 percent of the total catch, and are therefore deemed effective.

The bycatch of sea turtles in United States shrimp trawl fisheries deserves special mention. Sea turtle conservation became a major issue in the United States in the late 1970s and early 1980s. All five sea turtle species inhabiting state and federal waters are protected under the Endangered Species Act of 1973. Concerns about the continuing declines of sea turtle populations and the potential impact of new gear regulations on commercial shrimp trawlers prompted the United States Congress to add a provision to the Endangered Species Act Amendments of 1988, mandating an independent review of scientific and technical information pertaining to the conservation of sea turtles by the National Academy of Sciences. Congress further mandated a review of the causes and significance of turtle mortality, including that caused by commercial trawling. In 1990, following the reviews, the Committee on Sea Turtle Conservation of the National Research Council (NRC) published a report on the subject. An important finding of the study was that shrimp trawling in the United States results in the deaths of 5 000–50 000 loggerhead turtles and 500–5 000 Kemp's ridley turtles each year. Collectively, all other fishing activity is responsible for an additional 500–5 000 loggerhead deaths and 50–500 Kemp's ridley deaths annually. The incidental capture of sea turtles in shrimp trawls was identified by the committee as the major cause of mortality associated with human activities – killing more sea turtles than all other human activities combined. The study concluded that the best method currently available (short of preventing trawling) is the use of TEDs (NRC, 1990).

Studies by NMFS showed that 97 percent of turtles caught in TED nets can escape. On the other hand, some fishers claim that TEDs reduce the shrimp catch by as much as 30 percent, although federal government tests indicated an average of 10 percent. Some United States fishers were behind the idea of TEDs from the beginning – the earliest TEDs were designed by fishers to keep unwanted catch out of their nets. Many were concerned with "jelly balls" – aggregations of jellyfish – and the fact that the grates released sea turtles was an additional benefit. Nevertheless, other fishers resisted the idea of putting an escape hatch on their nets, and took legal action under the Endangered Species Act to compel NMFS to require TEDs on all United States shrimpers operating in the GSA region. Since 1990, all United States warm-water shrimpers have been required to use TEDs. This federal mandate included all United States shrimp trawlers more than 25 feet (7.6 m) in length working in offshore or onshore waters of the GSA region (Cascorbi, 2004b). Griffin *et al.* (1988) estimated that the requirement for TEDs has cost United States shrimp fishers US$35 million. In 1992, as a result of lobbying by United States shrimp fishers and environmentalists, the TED provision was extended to foreign fleets. The saga of extending the TED requirement overseas is given in the *Trade aspects* section.

Samonte-Tan (2000) expressed an alternative opinion on the relationship between TEDs and the observed recovery of the Kemp's ridley sea turtle. The report contends that, although TEDs have been certified by NMFS to release 97 percent of turtles entering the trawls, the 97 percent effectiveness of TEDs is based on field certification

tests under controlled conditions and does not accurately reflect actual shrimp trawling operations. In actual applications, the reduction of turtle mortality is less than 97 percent because of: (i) improper installation of TEDs; (ii) inexperience of the crew; and (iii) variation in trawling conditions. For these reasons, the study states that TEDs have a maximum effectiveness of 45 percent. It reviews the recovery of the Kemp's ridley turtle in the Gulf of Mexico and concludes that nest protection, rather than the use of TEDs by shrimp fishing operations, has been and remains the major factor contributing to the recovery of the turtle.

In a recent review of bycatch and its reduction in the United States, Harrington, Myers and Rosenberg (2005) conclude that bycatch management programmes "need to be adaptive and make continuous improvements rather than consist of fixed regulations that are not performance-based. Regulations are needed to provide incentives to reduce bycatch and disincentives to continue fishing practices with high bycatch rates."

PROFITABILITY

Increased production costs and declining ex-vessel prices have recently resulted in low or negative profitability in most United States shrimp fisheries. Because this phenomenon is best documented in the GSA shrimp fisheries, much of the following discussion centres on that region and is taken largely from Ward *et al.* (2004).

The current economic crisis faced by the domestic shrimp industry is unprecedented in scope, magnitude and duration. Declining real and nominal prices, together with increasing operational costs, have created major difficulties in maintaining financial solvency for commercial shrimp vessels in the GSA region. The two components of this "cost/price squeeze" are given below.

- The costs of operating a commercial shrimp vessel in the GSA region have increased over the last few years. Key causes include higher fuel prices, more costly insurance and costs associated with utilizing TEDs and BRDs. One study found that that, between 1986 and 1997, total expenses for operating a commercial trawler in the Gulf of Mexico ranged from US$0.83 to US$1.19 per dollar of gross revenue. Over the period of the study, a cost of US$0.98 was incurred by the median trawler sampled to generate US$1.00 of gross revenue. Major costs included crew shares, fuel and repairs to vessels and gear; there is little possibility of passing on these costs in the form of higher dockside prices to the first handler of the shrimp.
- As regards prices for shrimp, the United States supply of shrimp has evolved so much that an increasing share is being derived from foreign sources. These foreign sources are themselves becoming more dependent on cultured shrimp than on trawled shrimp. The technology of culturing shrimp in coastal and inland impoundments has become standardized in many regions of the world. Costs associated with the culture process enable shrimp to be produced and shipped to United States markets at price levels and volumes that have exerted strong downward pressure on domestic dockside prices. Prices declined by 27 percent in the Gulf of Mexico and 24 percent in the South Atlantic shrimp fisheries between 1997 and 2002, as imports increased by 300 percent. It appears that domestic prices at the ex-vessel level decline by about 55 cents for every dollar decline in import price. As a result, gross revenue declined between 2000 and 2002 from US$654 million to US$381 million in the Gulf of Mexico and from US$80 million to US$54 million in the southern Atlantic states.

Without some form of financial relief, the shrimp fishery could suffer a catastrophic collapse that would severely impact on the economies of the GSA region. Two main mechanisms have been explored for supporting the dockside price of shrimp: import controls and market enhancement. Shrimp import controls and the issues related to their implementation have been described in the *Trade aspects* section. A marketing

programme would encourage consumers to pay a premium price for domestically produced shrimp as opposed to imported shrimp, based on quality, freshness, flavour and texture (Ward *et al*., 2004).

The shrimp fishing financial crisis in the GSA area is also being experienced in other areas of the country. In Oregon, the average ex-vessel price for pink shrimp in 2004 was US$0.54/kg, which has not been seen in nominal terms since 1977. The number of vessels to make shrimp landings in Oregon in 2003 (59 boats) was the lowest since 1984 (Hannah and Jones, 2004).

Studies on rent in the United States shrimp fisheries do not feature prominently in the country's literature; however, some studies have been conducted for the Gulf of Mexico Shrimp Fishery. Amendment 9 to the Gulf of Mexico Shrimp Fishery Management Plan estimated the present value of the shrimp fishery at US$1.9 billion (constant 1977 dollars). If optimal management was adopted for this fishery, its asset value could be increased to slightly over US$4 billion. The lost rent of US$2.1 billion is primarily the result of command and control management (TEDs and BRDs) in a relatively unrestricted open access management regime (J. Ward, personal communication, March 2006).

ENERGY INPUT ASPECTS

Rising fuel costs are a major concern for United States fishers. Because trawling is so fuel-intensive, fuel prices have hit the shrimp industry harder than most other United States fisheries. Increased expenditure on fuel is a major element of the current "price squeeze" described in the section on *Profitability* above. Although fuel prices in the United States are low, compared with those in many developed countries, they generally rose from the mid-1990s to the early 2000s. Especially large fuel price increases occurred in 2004 and 2005. Because shrimp capture fisheries are more fuel-intensive than shrimp aquaculture (Clay, 1996), rising fuel prices will create additional problems for domestic captured shrimp in its competition with imported shrimp, which is mostly from aquaculture.

Some fishers have attempted to mitigate the effects of fuel price increases through the use of stronger/lighter net material and altering fishing practices. This could include fishing closer to a vessel's home port and, in the Gulf, not targeting shrimp that requires greater use of fuel. In some fisheries, fuel consumption has been reduced by otter trawls being double- or even quadruple rigged (dragging multiple small nets rather than a single large one).

On a different level, Ward *et al*. (2004) point out that one of the conclusions of the Houston Shrimp Summit in 2003 was that cost increases related to fuel use may be difficult to control since most businesses that are not bulk purchasers of fuel have no influence on the per unit cost of fuel utilized. Therefore, by reducing fuel costs and most other operating costs, per unit of effort may not be a viable strategy for improving profitability for the industry in the short term; efforts should be made instead to increase prices received for shrimp.

According to a United States shrimp specialist (J. Ward, personal communication, October 2005), the most common strategy currently used by United States shrimp fishers to mitigate a peak in fuel prices is simply to refrain from fishing.

BIOLOGICAL ASPECTS

There are considerable differences between the biological aspects of warm- and cold-water shrimp.

The characteristics of warm-water shrimp in the United States are summarized by Cascorbi (2004b). Brown, white and pink shrimp is a short-lived and fecund species, completing its life cycle in 18–24 months, and reaching sexual maturity in perhaps 6–12 months. These species are so short-lived that they "provide an annual crop". In

TABLE 86
Productivity and status of warm-water shrimp resources in the GSA region

Species and area	Recent average yield	Current potential yield	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Brown shrimp, Gulf of Mexico	53 080	Unknown	57 653	Full	Near
Brown shrimp, Atlantic	2 645	Unknown	34 472	Full	Near
White shrimp, Gulf of Mexico	28 942	Unknown	29 980	Full	Near
White shrimp, Atlantic	6 045	Unknown	6 305	Full	Near
Pink shrimp, Gulf of Mexico	11 009	Unknown	7 469	Full	Near
Pink shrimp, Atlantic	730	Unknown	955	Full	Near
Royal red shrimp	250	Unknown	Unknown	Unknown	Unknown
Seabob shrimp	3 947	Unknown	Unknown	Unknown	Unknown
Rock shrimp	6 240	Unknown	Unknown	Unknown	Unknown

Source: Nance and Harper, 1999.

the GSA, fishery managers note that the annual abundance of shrimp seems to be most influenced not by fishing effort, but by environmental conditions in the late winter and early spring. Years with warm winters enable greater larval survival and abundant landings the next season; years with winter freezes or severe storms result in lower populations and landings. While most of the shrimp stocks in the GSA region show no clear signs of overfishing, it is believed that most of the populations in the region are currently exploited or near their MSY. Environmental conditions are believed to have a greater effect on shrimp stocks than fishing effort. The high fecundity and migratory behaviour of the penaeid shrimp are conducive to quick recovery from adverse conditions.

The productivity and status of the major warm-water shrimp resources in the GSA region have been summarized by Nance and Harper (1999) and are shown in Table 86.

The characteristics of cold-water shrimp in North America are summarized by Roberts (2005), using several primary references. Pandalid shrimp is fast growing and early maturing, and produces several thousand young. These and other life history characteristics, such as environmental sex determination, make them inherently resistant to fishing pressure. Abundance and biomass in the *Pandalus borealis* Atlantic Canada Northern Shrimp Fishery have been increasing since 1997, and CPUE trends have remained stable or above the long-term average during the same time period. In contrast, New England northern shrimp was overfished for most of the 1990s and overfishing may still be occurring, although recent trends in fishing mortality and biomass indicate an improvement in the health of the stock. Overfishing also appears to be occurring in the Alaskan Spot Prawn (*Pandalus platyceros*) Pot Fishery. The Oregon Pink Shrimp (*Pandalus jordani*) and British Columbian Spot Prawn Fisheries appear to be fully fished; the status of all other cold-water shrimp fisheries is unknown.

IMPACTS ON THE PHYSICAL ENVIRONMENT

A great deal of documentation exists on the impacts of United States shrimp fishing on the physical environment. Two particularly relevant overall reviews are by Barnette (2001), which focused on the GSA region, and NRC (2002), which had a larger geographic scope.

Barnette (2001) carried out a major review of the fishing gear utilized within the GSA region and its potential impacts on essential fish habitat. As regards otter trawling, the report concluded that this fishing method has the potential to reduce or degrade structural components and habitat complexity by removing or damaging epifauna, smoothing bedforms (which reduces bottom heterogeneity), and removing structure-producing organisms. Trawling may change the distribution and size of sedimentary particles, increase water column turbidity, suppress growth of primary producers and

alter nutrient cycling. The magnitude of trawling disturbance is highly variable. Its ecological effect depends on the site-specific characteristics of the local ecosystem, such as bottom type, water depth, community type and gear type, as well as the intensity and duration of trawling and natural disturbances.

Several studies indicate that trawls have the potential to impact sensitive habitat areas, such as submerged aquatic vegetation, hard bottoms and coral reefs in a serious manner. With regard to hard bottoms and coral reefs, it should be recognized that trawlers do not typically operate in these areas because of the potential damage that their gear may incur. While trawl nets have been documented to impact coral reefs, typically resulting in lost gear, these incidents are usually accidental. Low profile, patchy hard bottom or sponge habitat areas are more likely to be impacted by trawls because of the gear's ability to work over these habitat types without being damaged. While it may be concluded that trawls have a minor overall physical impact when employed on sandy and muddy substrates, the available information does not provide sufficient detail to determine the overall or long-term effect of trawling on regional ecosystems. In general, few studies document recovery rates of habitat; those that do usually only do so after a single treatment, which does not reflect the reality of fishing impacts that are ongoing and cumulative.

NRC was asked by NMFS to study the effects of bottom trawling and dredging on seafloor habitats. In the report (NRC, 2002), it was concluded that: (i) trawling and dredging reduce habitat complexity; (ii) repeated trawling and dredging result in discernible changes in benthic communities; (iii) bottom trawling reduces the productivity of benthic habitats; (iv) the effects of mobile fishing gear are cumulative and are a function of the frequency with which an area is fished; (v) fauna living in low natural disturbance regimes are generally more vulnerable to fishing gear disturbance; (vi) fishing gears can be ranked according to their impacts on benthic organisms; and (vii) benthic fauna can be ranked according to their vulnerability.

Regarding management interventions, the NRC report concluded that the effects of trawling and dredging should be managed according to the specific requirements of the habitat and the fishery through a balanced combination of the following management tools.

- *Fishing effort reductions*. Effort reduction is the cornerstone of managing the effects of fishing including, but not limited to, effects on habitat. Both of the following management tools may also require effort reduction to achieve maximum benefit. The success of fishing effort reduction measures will depend on the resilience and recovery potential of the habitat.
- *Modifications of gear design or gear type*. Gear restrictions or modifications that minimize bottom contact can reduce habitat disturbance. Shifts to different gear types or operational modes can be considered, but the social, economic and ecological consequences of gear reallocation should be recognized and addressed.
- *Establishment of areas closed to fishing*. Closed areas are necessary to protect a range of vulnerable, representative habitats. Closures are particularly useful for protecting biogenic habitats (corals, bryozoans, hydroids, sponges, seagrass beds) that are disturbed by even minimal fishing effort. Because area closures could displace effort to open fishing grounds, effort reductions could be necessary in some cases to reduce habitat effects.

IMPACTS ON SMALL-SCALE FISHERIES

Commercial shrimp fishing interacts with small-scale fisheries on a variety of levels. These include resource conflicts with recreational fishers and, to a lesser extent, with small-scale commercial fishers. On the positive side, a significant amount of bait used for recreational fishing comes from commercial shrimp fishing.

Recreational fisheries are of great importance in the United States. It has been estimated that the 13 million recreational fishers catch 122 545 tonnes of fish – and have a great amount of political influence (FAO, 2005b). Participation in recreational fishing is much greater in the southeast than in other regions of the United States – over 50 percent of landings along the east coast of Florida are from recreational catches (NMFS, 2003). Some important recreational fish species are also taken by commercial shrimp fishers.

The main negative interactions between commercial shrimp fishing and small-scale fisheries concern the trawl bycatch. TPWD (2002) states that in the offshore waters of the Gulf of Mexico, shrimp trawling has affected important recreational and commercial species such as red snapper (*Lutjanus campechanus*). Combined catches of the recreational and commercial fishery for red snapper began a steady decline in 1983, reaching a low in 1990. Implementation of quotas and size limits in 1991 halted the decline, but stock assessments suggested that recovery was being slowed because age-0 and age-1 red snapper was being caught in shrimp trawls and discarded at a rate greater than the catch rate of the directed fisheries. To reduce red snapper bycatch, NMFS began to require the use of BRDs by the Gulf shrimp fleet in 1998. Cascorbi (2004b) states that the bycatch of juvenile king and Spanish mackerel in the Gulf of Mexico Shrimp Fishery exceeds the number taken in the directed commercial and recreational fisheries combined.

Gear conflicts have arisen between shrimp trawlers and trappers fishing for stone crab and blue crab: trawl nets bring up traps and entangle trap buoy lines. This has led to several management remedies, including seasonal "time-sharing" of fishing grounds off Florida (Cascorbi, 2004b).

Apart from these conflicts, a symbiotic relationship between commercial shrimp fishers and recreational fishers also occurs. Commercial shrimp fishing for recreational fishing bait is important in the southeast of the United States. It has been estimated that about 2 200 tonnes of shrimp are caught in the Gulf for bait. Commercial fishing for bait shrimp is also carried out on the Atlantic and Pacific coasts.

MANAGEMENT

The country's premier fisheries law, the Magnuson-Stevens Fishery Conservation and Management Act, created eight Regional Fishery Management Councils that work in partnership with NMFS to manage marine fish stocks. The council membership is a balance of commercial and recreational fishers, marine scientists, and state and federal fisheries managers who pool their knowledge to prepare fishery management plans (FMPs) for marine fish stocks in their respective geographic areas. These plans can limit fishing effort, seasons, fishing gear, the number of fishers allowed to fish for a certain species, and the total amount of fish that can be caught. NMFS receives its ocean stewardship responsibilities under many federal laws in addition to the Magnuson-Stevens Fishery Conservation and Management Act. The most important of these are: the Endangered Species Act, which protects species determined to be threatened or endangered; the Marine Mammal Protection Act, which regulates interactions with marine mammals; the Lacey Act, which prohibits fish or wildlife transactions and activities that violate state, federal and Native American tribal or foreign laws; and the Fish and Wildlife Coordination Act. Many other statutes, international conventions and treaties also guide the fisheries activities of the National Oceanic and Atmospheric Administration (NOAA) (www.nmfs.noaa.gov).

State governments generally manage fishing activity within three nautical miles of the coast, while regional fishery management councils undertake management in waters of the EEZ, from three to 200 nautical miles offshore.

In 1996, in response to findings that had accumulated over two decades, the Magnuson-Stevens Fishery and Management Conservation Act was substantially

revised by the Sustainable Fisheries Act. The amended law required the regional fishery management councils and NMFS to improve the sustainability of fisheries by stopping overfishing, "rebuilding" stocks, reducing bycatch, and identifying and protecting essential fish habitat. As regards bycatch, the revised Act required fisheries to have standardized reporting methodologies and minimize bycatch to the extent practicable.

Ward *et al.* (2004) describe the management of the shrimp fisheries in the GSA region. Each state in the region has jurisdiction over state waters. Management in the federal waters zone is conducted under the auspices of the federal fishery management council structure. Specifically, the shrimp fishery in the Gulf of Mexico region is managed by the Gulf of Mexico Fishery Management Council (GMFMC). The shrimp fishery in the South Atlantic region is managed by the South Atlantic Fishery Management Council. Management is conducted via FMPs for shrimp in each region. Changes in FMP are made via an FMP amendment process. The important events in shrimp fishery management by the two federal fishery management councils are presented below.

The FMP for the Gulf of Mexico Shrimp Fishery was implemented as a federal regulation on 15 May 1981. The major objective was to enhance yield in volume and value. Major amendments to the original FMP were the following.

- *Amendment 1* – Provided authority for adjusting the size of the Tortugas sanctuary or the extent of the Texas closure.
- *Amendment 2* – Updated catch/economic data in the FMP.
- *Amendment 3* – Resolved an ongoing shrimp/stone crab gear conflict on the west-central coast of Florida.
- *Amendment 4* – Simplified the annual review process for the Tortugas Sanctuary and extended the Texas Closure review date. A provision was also approved that allowed for landing of white shrimp in the EEZ in accordance with a state's size/possession regulations.
- *Amendment 5* – Defined overfishing for Gulf brown, pink and royal red shrimp, and provided for measures to restore overfished stocks if overfishing should occur.
- *Amendment 6* – Eliminated the annual reports and reviews of the Tortugas Shrimp Sanctuary in favour of monitoring and an annual stock assessment.
- *Amendment 7* – Defined overfishing for white shrimp and provided for future updating of overfishing indices for brown, white and pink shrimp as new data become available.
- *Amendment 8* – Addressed various aspects of the management of royal red shrimp.
- *Amendment 9* – Required the use of an NMFS BRD in shrimp trawls in the EEZ.
- *Amendment 10* – Proposed the requirement for installation of an NMFS-certified BRD to reduce the bycatch of finfish. The amendment also proposed utilizing existing trawl surveys to determine annual bycatch estimates.
- *Amendment 11* – Required all commercial shrimp vessels and boats that harvest shrimp in the Gulf of Mexico EEZ to obtain a renewable federal permit. It was also proposed that the use of traps in the royal red fishery be prohibited.
- *Amendment 13* – Required data and information on participation, effort and bycatch in the shrimp fishery.
- *Amendment 14* – Prevent excessive bycatch of juvenile red snapper. (Amendment was under consideration and not yet adopted.)
- A 15th amendment is being proposed to reduce effort and bycatch in shrimp fishing, with the aim of improving socio-economic conditions for fishery participants and fishing communities, further reducing incidental fishing mortality on the red snapper stock, and furthering the ability of the shrimp and red snapper fisheries to achieve optimum yield.

The FMP for the South Atlantic Shrimp Fishery was implemented as a federal regulation in December 1993. The major initial objective was to allow closure of EEZ waters adjacent to each state to protect white shrimp stocks from excessive mortality during periods of severe cold weather. The major amendments to the original FMP were the following.

- *Amendment 1* – Added rock shrimp to the management unit, prohibited rock shrimp trawling in areas of critical *Oculina* coral habitat and requested permits for all captains, vessels and dealers in the fishery.
- *Amendment 2* – Addressed issues related to brown and pink shrimp requirements on the use of BRDs in all trawls used within the EEZ and established a BRD certification process.
- *Amendment 3* – Addressed habitat requirements of the Magnuson-Stevens Fishery and Management Conservation Act with regard to rock shrimp.
- *Amendment 4* – Addressed Sustainable Fisheries Act requirements concerning the rock shrimp fishery, including amending data reporting requirements to comply with the Atlantic Coastal Cooperative Statistics Program, and adding information on fishing communities.
- *Amendment 5* – Proposed several actions pertaining to rock shrimp, including establishing a limited access programme, requiring captains of permitted vessels to have a vessel operator's permit, restricting the minimum mesh size, and requiring permitted vessels to install and use a VMS.
- *Amendment 6* – Proposed to address Sustainable Fisheries Act criteria (MSY, optimum yield, overfishing levels, etc.) and potential modification to the BRD protocol with regard to rock shrimp.

Cascorbi (2004b) summarizes information on shrimp management at the state level (within three nautical miles) in the GSA region. Regulations vary from state to state and area to area, but states are generally protective of the estuarine habitat so important to juvenile shrimp. As one example of a state-mandated programme, the Texas authorities recognized "growth overfishing" among shrimp caught in nearshore waters and undertook extensive modelling to determine the timing of optimal harvest. Noting that shrimp grows so quickly that a delay of even two weeks can mean the difference between growth overfishing and optimal harvest, the state designed a licence buy-back programme to reduce fishing effort, and closed shrimp nursery habitats during critical growth. Louisiana has tackled the same problem with a minimum size limit on white shrimp. In the southeast region, all commercial shrimpers require state licences.

As an example of the management of a cold-water shrimp fishery, the *Pandalus jordani* Pacific Ocean Shrimp Fishery has been under tri-state management since the 1950s. A management plan for shrimp was developed in 1980. Plan objectives include the prevention of biological growth and recruitment overfishing, and the promotion of the economic value of the shrimp resource. Historical management of the fishery has included policy measures to allow age-1 shrimp to escape the catch and to allow berried females to release juvenile shrimp. The trawl fishery is managed using: (i) a minimum mesh size restriction of 39 mm in the trawl nets; (ii) a minimum count per pound restriction of 160 shrimp per pound on landed catch; and (iii) a closed season from November to March.

Largely as a result of the current economic crisis in many United States shrimp fisheries (see section on *Profitability* above), increased attention has been focused on the need for management intervention to address overcapacity in the various shrimp fisheries. FAO (2005b) states that about half the current shrimping effort in the Gulf of Mexico could produce about the same yield. With regard to required management action, it appears that interventions are needed to reduce fishing capacity and prevent its subsequent buildup. Ward *et al.* (2004) summarize the situation in the shrimp fisheries of the GSA region.

Based on the simulation analysis for the Gulf of Mexico and the South Atlantic shrimp fisheries, it is clear that some type of effort reduction is needed to restore these fisheries to sustainable profitability. Biologically, the shrimp resource is just as productive as ever. Economically, however, shrimp fisheries cannot support as many vessels as they once did because the real price of shrimp has been declining. Simulation analysis demonstrates that to make long-term improvements in the financial condition of the shrimp fishery and develop an economically sustainable fishery, the number of vessels in the fishery must be reduced and barriers to entry must be established.

A 15th amendment is being proposed to the FMP for the Gulf of Mexico Shrimp Fishery, which features capacity reduction and improvement of socio-economic conditions for fishery participants. Among the options being explored are various schemes to limit the number of participants (GFMC, 2006). Ward *et al*. (2004) conclude that a permit or licence moratorium alone is insufficient to improve the financial viability of the fishery, if the price of shrimp is expected to remain low in the long term. They indicate that regulations are required to produce positive economic profits in the long term. This would entail some type of permit or licence moratorium that also limits capital stuffing and reduces the number of vessels in the fishery.

At the state level, there has been some success in attempts at reducing shrimp fishing capacity. In 1995, the Legislature of Texas enacted an inshore (bay and bait fisheries) shrimp vessel licence limited entry programme designed to reduce the documented fleet overcapitalization. The buy-back programme has purchased and withdrawn commercial inshore shrimp boat licences (422 bay and 393 bait) at a cost of approximately US$4.3 million. This represents 25 percent of the original 3 231 licences ushered into the fishery in 1995. TPWD (2002) concluded that the licence buy-back programme is showing progress towards reversing the high levels of inshore shrimping effort, but a similar limited entry and licence buy-back programme is needed for the Gulf (offshore) shrimp fleet.

A shrimp specialist at NMFS summarizes the shrimp management situation in the United States.

Biologically, shrimp needs little management attention since fishing effort has little impact on future recruitment levels in the fishery. However, management regulations have been imposed for a variety of reasons and under a number of different laws, including the Magnuson-Stevens Fishery Conservation and Management Act, the Endangered Species Act and the Coastal Zone Management Act. Most problems addressed by shrimp fishery managers derive from the use of an open access management regime that ignores economic efficiency criteria and implicitly stresses economic impacts in the form of state revenues from licence sales, taxes and low paying jobs (J. Ward, personal communication, March 2006).

ENFORCEMENT

Regarding general fisheries enforcement at the federal level, the United States Department of Commerce, through NMFS agents and the United States Coast Guard (USCG), is responsible for enforcing federal laws and regulations dealing with fisheries. Enforcement is carried out at sea, using USCG vessels and USCG and NMFS personnel, and on shore using NMFS enforcement agents. Agreements with 21 coastal states in the United States and three United States territories make over 2 000 state resource officers available (Everett, 2005).

For the enforcement of federal legislation dealing specifically with shrimp fisheries, a great deal of recent activity deals with ensuring compliance with requirements to use TEDs and BRDs.

Poseidon (2003) examines enforcement of TED regulations in the Gulf of Mexico. The Eighth District of the USCG monitors compliance with TED construction

requirements in all of their boardings. From 1999 to 2001, TED boardings averaged 1 600 to 1 800 annually, and compliance rates averaged 96 percent.

The NMFS budget for fisheries enforcement in fiscal year 2005 was about US$70 million. This did not include grants to states and funds of the USCG (Everett, 2005). It is difficult to determine the cost of USCG services related to fisheries enforcement, since the agency is involved in a large range of activities, including sea safety and the prevention of smuggling.

The states have a variety of systems for the enforcement of fisheries regulations, most of which include cooperation with NMFS. For example, in Texas, TPWD has a Law Enforcement Division with a current staff of 68 game wardens assigned to 14 coastal areas. In July 2001, the Law Enforcement Division entered into a Joint Enforcement Agreement (JEA) with NMFS. The JEA was created to enhance enforcement of shrimp, reef fish and highly migratory species regulations in the Gulf of Mexico. The programme increased law enforcement presence in the Gulf and provided Texas game wardens with additional equipment, allowing them to maintain a higher level of patrol in offshore waters. From the inception of the agreement, from July 2001 through March 2002, JEA wardens logged 3 572 patrol hours and 719 boardings and inspections. There were 77 citations issued and 6 206 kg of shrimp confiscated (TPWD, 2002).

RESEARCH

Most of the work on United States marine fisheries is conducted by or for NMFS. Since 1871, federal fisheries scientists have collected, researched, analysed and published peer-reviewed data on the nation's living marine resources, marine ecosystems and the benefits that they provide. Additional biological, economic and other forms of research are also conducted by universities, and federal and state agencies (FAO, 2005b).

Iversen, Allen and Higman (1993) indicate that, in the United States, biological research on warm-water shrimp began in the 1930s. During the intervening years, extensive basic research has been carried out on the life histories of the white, brown and pink shrimp, and on its relationship to the environment. The United States was considered the epicentre of shrimp fisheries research in the world until the 1960s, when priorities shifted towards research for shrimp farming (S. Garcia, personal communication, October 2005).

Cascorbi (2004b) summarizes warm-water shrimp fisheries research in the United States. An extensive programme to document and quantify bycatch in both Gulf and Atlantic shrimp fisheries (the Southeastern United States Shrimp Trawl Bycatch Program) began in 1992, and produced a comprehensive landmark report in 1998. Since 1991, red snapper bycatch in shrimp trawls has been the focus of a major cooperative research programme organized by fishery stakeholder groups, universities, and state and national management. Bycatch was characterized and various kinds of BRDs developed and tested, often with the cooperation of commercial shrimp fishers. Research generated by this group led to the 1997 decision by GFMC to require BRDs on most shrimp trawls. NMFS has also conducted research into the habitat effects of shrimp trawling in the Gulf and southeast regions. Perhaps the most significant publication to result from research is that of Barnette (2001) – a comprehensive review of the habitat effects of all gear types used in both regions. NMFS conducts stock assessments and evaluates recovery of all five sea turtle species impacted by United States shrimp trawling. A sea turtle management team is based at the Southeast Fisheries Science Center, whose main mandate is to analyse sea turtle bycatch and TED effectiveness in both the Gulf and South Atlantic fisheries. This group and others have developed and tested various kinds of TEDs, often in cooperation with commercial shrimp trawlers.

Roberts (2005) summarizes cold-water shrimp fisheries research in the United States. Assessments of cold-water shrimp stocks generally consist of monitoring population changes, using catch rate series and, in some cases, research surveys. These efforts provide general information on population structure and recruitment, which are used to identify when a change in quota or effort is needed. Biological reference points and formal yield projections are rare. Each state has different levels of research and monitoring. In Oregon (where the largest United States cold-water shrimp fishery is based), fishery-dependent data, particularly logbook data, are the primary sources of information on the distribution and abundance of pink shrimp. Such data have been used to demonstrate that the geographic stock area of pink shrimp expands and contracts roughly proportionally to shrimp recruitment. Research cruises and market sampling provide additional data on distribution, abundance and the likely age structure of the stock. Research cruises are also carried out for other purposes, such as testing the efficacy of different BRDs. The primary objective of the 2004 research cruise was to test the viability of logbook data in providing an accurate picture of the spatial structure of shrimp abundance.

Research on United States shrimp fisheries in the future is likely to focus increasingly on bycatch (reduction and fishery impacts on bycatch species), physical impacts of trawl gear on the environment, and the ecosystem impacts of shrimp fishing.

Science and technology programmes in NMFS totalled US$249.9 million in 2005 (AAAS, 2005). A breakdown of this research budget by specific fisheries is not available.

DATA REPORTING

Southeast collection of landings data and other fisheries-dependent data in the United States is conducted through the Fisheries Information Network, the Atlantic Coastal Cooperative Statistics Program and the Marine Recreational Fisheries Statistics Survey. The Marine Fisheries Commission of the Gulf states currently manages and coordinates the Southeast Fishery Information Network. The purpose of these state-federal cooperative programmes is to collect, manage and disseminate statistical data and information on the commercial and recreational fisheries of the southeast region (NMFS, 2003).

As regards data reporting on shrimp fisheries in the southeast United States, Cascorbi (2004b) reports that there is regular collection and assessment of both fishery-dependent and fishery-independent data. These include logbook reports, some observer coverage and dockside monitoring. NMFS observers on board are employed in the southeast otter trawl shrimp fisheries; the programme is voluntary and NMFS estimates that less than 1 percent of South Atlantic fishing hours is covered by observers.[47] In the Gulf, more than 1 percent of trips are covered by observers. Current stock assessment and other fishery-independent data are robust and reliable and long-term fishery-dependent data are also available.

At the state level, there are a variety of systems for reporting data on shrimp. For example, commercial shrimp resources in Texas are monitored with both fishery-independent and fishery-dependent data. Fishery-independent data include bag seine, bay trawl and Gulf trawl sample data, as well as NMFS trawl data. Fishery-dependent data include NMFS bay and Gulf shrimp landings and catch data, commercial bay and bait landings data, and recreational fishery bait-use data. Furthermore, TPWD has monitored shrimp size and abundance since 1959. Landings of marine species from Texas bays and the Gulf off Texas have been collected from seafood dealers since 1887 (TPWD, 2002).

[47] Subsequent to the Cascorbi report, Amendment 6 to the Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region requires an owner or operator of a trawler that harvests or possesses penaeid shrimp in or from the EEZ off the southern Atlantic states to, *inter alia*, carry an observer on selected trips and to submit catch and effort reports.

Roberts (2005) summarizes data sources and reporting for some of the United States cold-water shrimp fisheries. Data on Alaskan and Oregon trawl fisheries for pink/northern shrimp are collected from several sources, including logbooks, observers and dockside monitoring. In Washington, pink shrimp trawl vessels are not required to carry logbooks nor is there dockside monitoring (except for some enforcement activities). However, there is a logbook programme and dockside monitoring of the Coastal Spot Prawn Fishery. In California, landing statistics and fishers' local knowledge are the primary sources of information on the status of spot prawns, although logbooks are mandatory. Prior to 1994 on the east coast in the Gulf of Maine, effort (numbers of trips by state and month) was estimated from landings data collected from dealers and landings per trip information from dockside interviews of vessel captains. In the spring of 1994, a logbook reporting system replaced the collection of effort information from interviews. At the federal level, Amendment 1 to the west coast's northern shrimp FMP allows for an at-sea observer and logbook programme, as well as dockside monitoring.

There are currently requirements for the use of VMS in some United States shrimp fisheries, such as that for rock shrimp in the South Atlantic. GFMC (2006) discusses the issue of using VMS in the Gulf of Mexico Shrimp Fishery, since it has been shown to be an effective management tool for enforcement in policing closed fishing areas in the EEZ of other regions of the United States. Currently, numerous areas are closed to shrimping in state waters and the EEZ of the Gulf of Mexico. The requirement of VMS for shrimp vessels would provide an important addition to enforcement capabilities for these closed areas. On the other hand, if the shrimp industry is required to pay for and maintain these VMS, this would create an additional financial burden for an industry that is experiencing severely reduced profits, as a result of price reductions from competition with foreign imports and high fuel costs, as well as impacts from recent hurricanes. Finally, VMS or 100 percent coverage using electronic logbooks would be needed to enforce the proposed management system based on quota.

It is interesting to contrast the data reporting situation in the United States shrimp fisheries with that of Canada. In Canada, both the inshore and offshore shrimping industries have observer programmes to document independently what is caught and discarded; all landings are dockside monitored; and all fishers must keep and submit logbooks. The offshore fleet has 100 percent observer coverage; the inshore fleet, a target of 10 percent (Roberts, 2005).

IMPACTS OF SHRIMP FARMING

Ward *et al.* (2004) state that shrimp is cultured in the United States, although in relatively small quantities. There are shrimp culture facilities primarily in Texas, South Carolina and Florida but also in Alabama and Georgia. These operations produce small amounts of shrimp, mostly as a head-on product for local markets. In 2003, 4 627 tonnes of shrimp were produced by aquaculture in the United States (NMFS, 2005). Considering that capture fisheries were responsible for 143 007 tonnes in that year, aquaculture represented about 3 percent of United States domestic production of shrimp.

Clay (1996) indicates that although United States production of shrimp from aquaculture is not large, the country does have an impact on world shrimp aquaculture and has provided capital, feed, expertise, drugs/medication, training, information and research to shrimp farmers in 50 countries

It is unlikely that the small amount of domestically farmed shrimp has a major influence on the United States market. Yet, shrimp imports into the United States, most of which are from aquaculture, are thought to have a major effect on prices. According to Ward *et al*. (2004), domestic prices declined by about 55 cents for every one dollar

decline in import prices. United States ex-vessel prices declined by 27 percent in the Gulf of Mexico Shrimp Fishery and by 24 percent in the South Atlantic Shrimp Fishery between 1997 and 2002, as imports increased by 300 percent. Imports currently represent over 80 percent of the United States supply of shrimp, with aquaculture making up over 80 percent of shrimp imports.

It appears, therefore, that foreign aquaculture of shrimp has had a large impact on prices in the United States shrimp market and consequently on United States producers. Some view this as efficient overseas production to benefit United States consumers, while others feel that it represents dumping on the United States market to the detriment of domestic shrimp producers. A discussion of this debate and United States Government action is given in the *Trade aspects* section above.

MAJOR ISSUES

The important issues related to shrimp fishing in the United States are:

- the decrease in recent profitability in the industry because of a profit squeeze;
- environmental concerns: bycatch and physical impacts;
- the use of international trade sanctions on shrimp to achieve United States objectives; and
- interactions between shrimp fisheries and other fisheries.