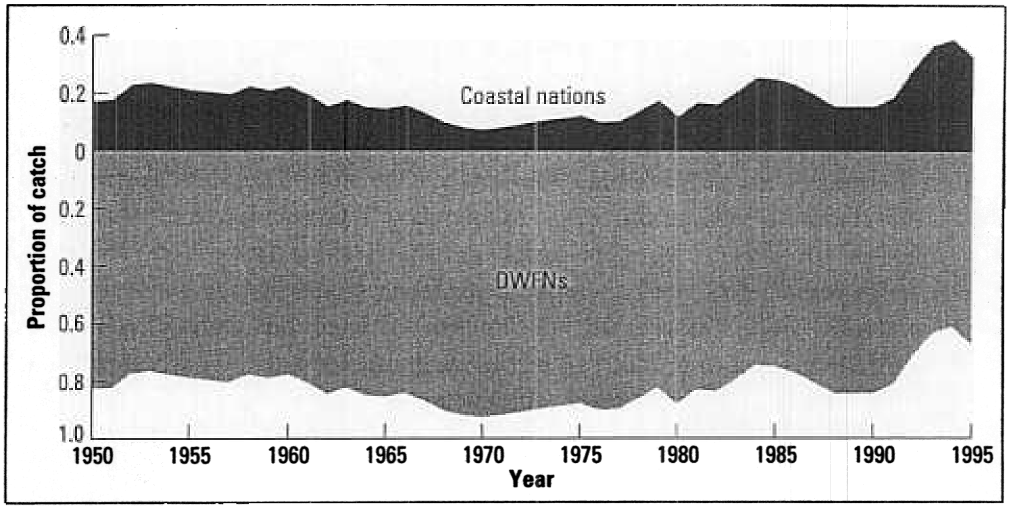
Figure 5. **DWFNs take the largest proportion of the catches in northwest Africa, fishing about 6.25 times more than the coastal nations**



FLEET CHARACTERISTICS AND NUMBERS

There is little easily accessible information on numbers of vessels fishing off Mauritania and Senegal, especially historical data. Most of the information available is scanty and dispersed. However, two things seem to come out from this information: foreign fleets have always been more important off Mauritania than off Senegal and, with time, the DWFs fishing off Mauritania seem to have either increased in number or at least remained more or less constant.

Brulhet (1976) provides some figures for the fleets fishing off Mauritania in the mid-1970s before declaration of the EEZ regime. According to his report, there were three Mauritanian purse-seiners of 62 t and about 40 purse-seiners from the Canary Islands (maximum of 20 t) in operation. Norway had two large oceanic seiners and a factory ship supplied by about 15 catching vessels. Another large factory ship from the Netherlands was supplied by some 20 South African catchers under Dutch flag. Japan had 23 trawlers of 100-293 t fishing mainly for cephalopods which were iced and delivered at Nouadhibou. In addition, 30 large freezer trawlers from Japan were fishing for cephalopods but did not land their product in Mauritania. The USSR had 25 trawlers using ice, all of 273 t, also fishing mainly for octopus, some squid, and cuttlefish. Kuwait had four old shrimp freezer trawlers of 160 t fishing for octopus. Algeria had four trawlers of 62 t and Spain two smaller trawlers. There were also five French vessels fishing for lobster which landed their catches in Nouadhibou to be air-shipped to Europe. An unknown number of Spanish oceanic tuna freezers were also fishing in the area. Brulhet adds that while some 60 industrial vessels were based at Nouadhibou during those years, more that 100 larger vessels fished with licences off Mauritania without ever landing fish in Nouadhibou. These reports amount to a total of some 175-200 vessels with an installed fishing capacity of more than 20,000 t (not considering the factory vessels of Norway and the Netherlands).

Beaudry et al. (1993) report 65 vessels fishing in Mauritanian waters under joint-venture schemes in 1991. Before its disintegration, the USSR operated with fleets of

30-40 large stern factory trawlers managed by a commander with headquarters in a large mother ship which received and processed catch from the trawlers, then passed it to refrigerated carriers that took fish to home ports. More recently, Russia and Romania had "Super-Atlantic" freezer vessels of circa 80-100 metres (m) length specializing in pelagic fish. Libyan and Algerian joint ventures with Mauritania use refrigerator vessels fishing for demersal (deep-sea) fish and cephalopods (chiefly squid). By 1993, the Mauritanian industrial fishing fleet totalled 263 vessels (Beaudry et al., 1993). Of these, 149 had fishing permits, 106 were freezers, and 43 had refrigerators. The remaining 114 vessels were chartered (70 with freezers, 44 with refrigerators). Ismail (1992; cited in Maus, 1997) reports chronic problems of old age and poor maintenance that led to high operating costs in the Mauritanian industrial fishing fleet. Of the 327 vessels operating in 1992, 165 were national, 74 joint-venture, and 88 EU and Japanese, but only 250 of them were fishing. Up to 38 of the national vessels were permanently out of operation (22 freezer and 16 ice box). Most of the national and joint-venture vessels in Mauritania are Chinese made and chartered to national companies.

The small-scale fishing sector has been consciously promoted by the Mauritanian government since the early 1990s and it is currently the fastest growing fisheries sector (Maus, 1997). The aims of the government are to promote employment, national food production, currency generation, and distribution of wealth. The small-scale fleets operate out of Nouadhibou (56 per cent) and Nouakchott (26 per cent) and by 1995 comprised some 1,800 boats, 96 per cent of which were motorized. This compares to only about 60 Senegalese pirogues operating out of Nouadhibou in the mid-1970s (Brulhet, 1976). The rapid growth of this sector in the 1990s is mainly attributable to an increase in participation of Senegalese pirogue fishermen and the establishment of an aluminium boat-building facility in Nouadhibou. By 1993, nearly 6,000 people were employed by the small-scale fishing sector while only about 1,500 took part in the industrial fishing sector (CNROP, 1995; cited in Maus, 1997).

There are very few statistics about the number of foreign vessels fishing in Senegal. It is known that shrimp trawlers as well as groundfish trawlers – both with freezing capabilities – were fishing in Senegal in the 1980s. Thiam and Gascuel (1994) report between 8 and 17 of these vessels in the period 1979-1982, and 6 to 12 in 1983-1990, with this number increasing after 1990. Since 1986, some large Korean trawlers with freezing capabilities have fished off Senegal, mainly for octopus (Thiam and Gascuel, 1994).

In Senegal, the predominant artisanal fishing sector is composed of pelagic and demersal pirogues, the former fishing with purse seines, encircling nets, and beach seines, and the latter with bottom longlines, traps, jigging hooks, and setnets (Kebe, 1994; Caveriviere, 1994; Samba, 1994a). There is also a smaller industrial sector mainly composed of bottom trawl vessels and some small sardine seiners. The number of artisanal fishing vessels in 1977 was 2,400 pirogues with motor and 600 with sail, employing a total of about 25,000 artisanal fishermen (Gerlotto et al., 1979). Data presented in Table 6 (Samba, 1994a) indicate that while some 3,900 pirogues were recorded in 1960, their numbers had increased to nearly 4,500 in 1970, 8,500 in 1980, and reached 10,900 in 1991. Reportedly, some 7,000 of these are motorized, but this information seems at odds with reports from Kebe (1994) stating that 100 per cent of the artisanal fleet is motorized. Meanwhile, the number of fishermen involved in the

Table 6. **Number of fishing vessels by type and subtype in Senegal**

Year	Pirogues		Trawlers		Sardine seiners	
	with oars	with motor	based	non-based	local	foreign
1960	3,900		11			
1961	3,900		20			
1962	3,100		26			
1963	5,500		23			
1964	5,500		33		1	
1965	5,400		36		1	
1966	4,600		39		2	
1967	4,400		34			
1968	5,100		38			
1969	4,400					
1970	2,451	1,995	68	4	4	1
1971	2,715	2,578	69	14		4
1972	2,408	3,209	67	25	3	2
1973	2,369	3,561	68	24	12	0
1974	2,255	4,187	64	23	13	0
1975	2,000	4,041	71	19	11	0
1976	2,257	3,743	76	4	12	0
1977	3,593	3,263	82	85	9	0
1978	3,796	3,957	88	91	8	0
1979	3,986	4,631	99	85	13	0
1980	3,869	4,616	103	89	17	0
1981	4,180	4,931	110	65	14	0
1982	4,327	4,774	128	58	19	0
1983	3,226	5,300	140	28	20	0
1984	3,904	5,138	133	30	12	0
1985	1,445	3,640	142	43	8	0
1986	2,813	4,808	136	43	5	0
1987	2,731	5,830	144	43	3	0
1988	2,413	6,210	137	80	5	0
1989	3,580	6,425	139	81	9	0
1990	3,889	6,522	121	78	9	0
1991	3,920	6,979	131	60	8	8

Source: Samba, 1994

artisanal sector grew from 25,000 in 1966 to 32,000 in the early 1990s (Kebe, 1994). In total, over 100,000 people are employed in the fisheries sector in Senegal (Goffinet, 1992), although it is not clear if this includes only direct employment in fishing or added-value activities such as processing and services.

The industrial fleet grew at a slower, but still rapid, rate during this period, from 20 trawlers and a single sardine fishing vessel in 1961, to 72 and 5 respectively in 1970, 192 and 17 in 1980, and slightly decreased to 191 and 16 in 1991 (Samba, 1994a; Thiam and Gascuel, 1994). Trawlers are of diverse types, some with freezers others with ice boxes. Since 1985, the number of vessels with freezer has surpassed ice-box vessels, and in 1991 about 100 freezers and 50 ice-box vessels were recorded (Thiam and Gascuel, 1994). Foreign high-seas tuna and sardine vessels fishing out of the Senegalese coast are not considered in this table.

FISHERIES MANAGEMENT BY COASTAL STATES

There is little information available about specific fishery regulations in Mauritania. A system of closed areas and seasons is in place but it is unknown if total allowable catches (TACs) are set for the different stocks. According to Maus (1997), catch limitation for the industrial fisheries is set through controls on effort (maximum length of trips for pelagic fisheries is 40 days and for demersal fisheries 60 days). Each type of industrial fishery has to follow particular specifications on allowed fishing areas, targeted species, legal sizes, bycatch levels, gear types, mesh sizes, engine power, etc. All demersal catches (except those from EU vessels) must be landed in Mauritania; pelagic catches are transhipped under the supervision of Mauritanian customs officers. Other requirements are that bycatch from demersal vessels should not exceed 10 per cent and only 3 per cent for pelagic fisheries, crews must be 80 per cent Mauritanian in joint-venture vessels and 35 per cent on foreign chartered vessels. For joint-venture fisheries, at least 35 per cent of the turnover in the case of cephalopod/demersal fisheries and 33 per cent in the case of small pelagic fisheries, must go to the Mauritanian partners. Observers should be allowed in all fishing vessels.

The DWF and industrial sectors of Mauritania are controlled through licensing. The artisanal fleet, although not controlled through a licence system, has to follow area and season restrictions. Artisanal fleets have no restriction on which species they can target, but cannot use trawl nets and cannot have freezing facilities on board (Maus, 1997). There are conflicting reports about some of the management policies. While Maus (1997) reports that until 1995 the costs of fishing licences in Mauritania were negligible (only administrative charges), Kaczynski (1989) reports on DWF (not joint-venture) vessels having to pay licence fees that are set according to the vessel's gross registered tonnes (GRT). What is clear, is that the main source of fisheries revenue in Mauritania is through export taxes. These are set according to the commercial value of the processed products and vary from 6.5 per cent to 17 per cent (Kaczynski, 1989). This strategy, combined with compulsory landing of most of the catch and inspection of transhipped catches is the basis of the Mauritanian fisheries policy.

Senegal has a system of zoning to allocate exclusive fishing rights to the different sectors involved in the industry. The "Grande Côte" north of Dakar and the region of Casamance have a 6 nautical mile-wide zone from the shoreline set exclusively for artisanal boats (pirogues) where industrial vessels are prohibited. This zone is 7 miles wide in the "Petite Côte" south of Dakar (Diallo, 1994). The Centre of Oceanographic Research of Dakar-Thiaroye has collected fishery data since the early 1970s (Ferraris et al., 1994). The few available reports on stock assessment indicate that trawl survey estimates of total exploitable biomass for demersal fish in 1974 were of 266,000 t between Cape Timiris and Cape Roxo (Samba, 1994b). Further research indicated reductions in the biomass from 173,000 t in 1983 to 81,000 t in 1991. Acoustic surveys for pelagic fish are very variable and indicate biomasses of 1,600,000 t in 1974 and 755,000 t in 1980 (Freon and Lopez, 1983; cited by Samba, 1994b). More recent acoustic survey estimates average about 588,000 t for the period 1983-1988 (Marchal, 1991; cited by Samba, 1994b).

BYCATCH

There is almost no information available on bycatch and discard for the fisheries of Mauritania and Senegal. However, some reports indicate that bycatch in squid and shrimp fisheries can be five times larger than the targeted species (Kaczynski, 1989).

Mauritanian fishing regulations stipulate that bycatch should not exceed 10 per cent and 3 per cent in demersal and pelagic fisheries respectively (Maus, 1997). The Senegalese shrimp trawlers had discard rates of 75 per cent in the early 1980s (Monoyer, 1980; cited in Thiam and Gascuel, 1994), mainly from small bottom fishes. Caveriviere and Rabarison (1988; cited in Thiam and Gascuel, 1994) report discard rates of 68 per cent and 71 per cent in cold and warm seasons respectively for Senegalese shrimp trawlers. According to Lamourex (1985; cited in Thiam and Gascuel, 1994) during 1983 foreign trawl vessels in Senegal had discard rates (mainly Balistes, gastropods, and rays) of 69-73 per cent (shrimp boats) and 52-56 per cent (groundfish boats). The discards were of adults of non-commercial species as well as of juveniles of species of importance to the Senegalese artisanal and industrial sectors.

FISHING AGREEMENTS

Nigeria had fishing agreements with Mauritania and Senegal in the mid-1980s (Fadayomi, 1987). Furthermore, Mauritania and Senegal have bilateral fishing agreements with each other and Senegalese pirogue fishermen are known historically to fish in Mauritanian waters. According to Beaudry et al. (1993), Mauritania signed agreements between 1987 and 1992 with the EU and Japan (only minor Japanese catches were taken during this period). An agreement with Ukraine was signed in 1993. A renewed agreement with the EU for August 1993-July 1996 allowed some 100 EU-flagged ships to fish in Mauritania. The terms of this latter agreement stipulated quotas for crustaceans (10,000 t/month annual average), black hake (15,000 t/month annual average), and pelagic trawlers and seiners (9,000 t/month annual average). The EU agreement included provisions stipulating legal mesh sizes, gear restrictions for lobster fishing, catch reporting, and employment of 25 per cent Mauritanian crews. Further fishing agreements were recently signed between the EU and Mauritania for the period 1996-2001, and between the EU and Senegal for 1997-2001.

BENEFITS

The benefits of granting fishing rights to DWFs can be of various kinds. The most obvious is direct cash revenue and foreign currency acquisition, but additional benefits can occur in the form of training, infrastructure (processing plants, ship yards, patrol vessels, etc.), and development of local fishing capacity. While it is difficult to assess the real economic benefits of DWFs in sub-Saharan Africa because of limited information, it seems that at least in the case of Mauritania, there have been clear benefits but these seem to have fallen short of their full potential (see principal-agent discussion in chapter 6 of this report).

Because of structural and cultural differences, Mauritania has a larger and more complex interaction with DWFs than Senegal. The latter is much less dependent on DWFs to realize benefits from its fishery resources which are largely exploited by its own very strong artisanal sector. Mauritania has only half-heartedly tried to develop its own fishery

Table 7. Estimated proportion of fishery catches taken by each fleet out of each country's EEZ

Year	Mauritania	DWFs	Senegal	DWFs
1972	0.051	0.949	0.312	0.688
1973	0.039	0.961	0.572	0.428
1974	0.016	0.984	0.671	0.329
1975	0.011	0.989	0.762	0.238
1976	0.009	0.991	0.970	0.030
1977	0.012	0.988	0.770	0.230
1978	0.028	0.972	0.623	0.377
1979	0.028	0.972	0.704	0.296
1980	0.014	0.986	0.622	0.378
1981	0.039	0.961	0.618	0.382
1982	0.017	0.983	0.612	0.388
1983	0.025	0.975	0.806	0.194
1984	0.041	0.959	0.972	0.028
1985	0.040	0.960	0.788	0.212
1986	0.031	0.969	0.759	0.241
1987	0.024	0.976	0.717	0.283
1988	0.016	0.984	0.709	0.291
1989	0.014	0.986	0.778	0.222
1990	0.014	0.986	0.661	0.339
1991	0.018	0.982	0.676	0.324
1992	0.031	0.969	0.688	0.312
1993	0.038	0.962	0.849	0.151
1994	0.047	0.953	0.941	0.059
1995	0.035	0.965	0.956	0.044

sector and relies heavily but inefficiently on DWFs to exploit its fisheries. Table 7 illustrates how Senegal has consistently kept control over its fishery stocks by developing its artisanal and industrial fleets, while Mauritania has virtually remained with the same share of its own fishery resources throughout the last 25 years. Thus, Mauritania has not benefited from DWFs in terms of developing its independent fishing capacity.

Economic benefits have certainly been obtained through Mauritania's government-led open policy for foreign investment (encouragement of joint ventures with at least 51 per cent local capital). This policy brought initial tangible benefits to the nation as fisheries grew at an annual rate of 28 per cent during the period 1980-1986 to become the most important sector in the economy. By 1988 the rent from fisheries attained US$308 million and constituted 68 per cent of the total foreign income (Maus, 1997). Despite some success, there continued to be problems of surveillance whilst illegal fishing still accounted for about 50 per cent of the total catches (see next section). During 1991 the fisheries sector shrank to US$236 million, but continued to account for about 20 per cent of foreign revenues. Currently, fish processing is one of the main industries in Mauritania. DWFs have usually agreed to land at least part of their catch in Mauritania, but at least in the early years, large quantities of fish never made it to the mainland. Brulhet (1976) reports Dutch and Norwegian vessels in the mid-1970s transhipping part of their catches of pelagic fishes and landing another part in the port of Nouadhibou. The Mauritanian system of taxation and licensing as a way to harness revenues from fishery resources seems to be favoured and praised by Cunningham et al. (1995) and Maus (1997), but is seen with scepticism by other authors such as Kaczynski (1989) and Goffinet (1992)(see next section).

Aid programme assistance has been given to Mauritania's fishing sector by France, Germany, Japan, and Spain, as well as from the African Development Fund, European Development Fund, Arab Fund for Social and Economic Development, and the World Bank. These resources have been used to develop local fisheries and coastal surveillance programmes, and to promote traditional fishing development (Beaudry et al., 1993). During 1994, Germany agreed to aid Mauritania with US$4.4 million to support surveillance, monitoring, and control of fisheries (Anon., 1996a).

There is little information about licensing, and about any benefits accrued from DWF operations in Senegal. Goffinet (1992) observes that United States and Canadian aid has been granted to the Senegalese navy in order to reinforce its surveillance and monitoring capabilities.

CONFLICTS

Having one of the most productive fishing regions in the world off an underdeveloped coast poses serious problems for management. These problems range from poor or non-existent knowledge of the biological potential of the stocks, to lack of capability to set adequate management policies, and inability to implement monitoring and surveillance effectively. In this region of the world, very frequently the limited regulations that exist to control fisheries are not adequately enforced (Goffinet, 1992).

Under-reporting and illegal fishing have been old problems for Mauritania and Senegal and many vessels are still suspected to be fishing illegally (Anon., 1996a). The most obvious consequence of this problem is loss of revenue through taxes and licence fees, but longer-term concerns are overfishing and the lack of accurate statistics to assess the levels of exploitation of the stocks.

In Mauritania, a joint-venture policy failed during the 1970s as there was widespread under-reporting of catches because of poor inspection systems, Mauritanian crews were paid to stay on shore, and most of the foreign companies failed to process their catches on shore preferring instead to tranship at sea and transport them to foreign ports (Maus, 1997). The very limited surveillance and enforcement capability of Mauritania has allowed widespread overfishing (Beaudry et al., 1993). Industrial fishing vessels continuously violate areas reserved for small-scale fisheries and when fines are imposed these are not always paid by violators (from 1988 to 1992 only US$3 million of fines were paid out of a total of US$5 million in violations).

As mentioned above, the benefits of DWF activities seem to have fallen short of expectations in this region. According to Kaczynski (1989) the share of the catches between DWFs and local nations in the sub-Saharan region remained practically unchanged between 1977 (90 per cent for DWFs) and 1985 (81 per cent for DWFs). In contrast, a 25 per cent reduction in total catches was observed for the whole of the

CECAF area between 1976 and 1985, mainly because of lower catches of the DWFs, increased costs of access, and overexploitation of some commercial stocks by long-range fleets (Kaczynski, 1989).

Another problem is that of lost revenue. In Mauritania, Kaczynski (1989) estimates that perhaps some 50 per cent of the fees payable by the total permitted fleet and only 33 per cent of the fees payable by DWF vessels are actually paid to the government. On top of this, taxation on fishery exports, the largest source of income, also falls short of its supposed targets. Kaczynski estimates that in 1983, only about 38 per cent of the expected revenues from fish exports were actually collected by the Mauritanian government. Under-reporting of up to 50 per cent of the total catches by DWF nations is one of the main reasons for the low level of revenue.

Poor investment and overcapacity are additional pressing problems. Due to the lack of shipyards in the country, Mauritania promoted the purchase of fishing vessels in the 1980s. However, this has turned into a financial problem as many owners have been unable to pay back loans to the local banking system, causing major losses to the banks. As a consequence, a large part of the fleet is ageing and paralysed. In 1993, more than 50 per cent of the cephalopod fishing fleet was over 15 years old. Large-sized freezer vessels are sub-optimal for the relatively low-volume cephalopod catches so that very frequently they return to port with only 25 per cent of their hold capacity filled after their 40-day allowed trips (Maus, 1997).

Although the zoning system of Senegal is supposed to avoid any possible direct interaction between the industrial and artisanal fleets, in practice the illegal fishing of industrial vessels inside the artisanal exclusive zone and the non-regulated fishing of artisanal vessels outside their 6-7 mile zone are known problems in the region (Diallo, 1994). Additionally, the exploitation of mutual stocks by the two fleets leads to indirect competition for the resource and for the corresponding markets.

In short, lack of adequate surveillance systems and lack of compliance by the developed nations' DWFs is one of the main factors responsible for the lack of fully realized benefits to the coastal countries in this region. However, due to the prohibitive costs of effective surveillance systems, it seems unlikely that the coastal countries will be able to take full control and obtain fair benefits from their rich fishery stocks without external technical and financial aid. What is needed here is a more involved participation of DWF countries that assumes full responsibility of their role as developed nations trying to do honest business with coastal nations, instead of taking advantage of the difficulties these countries have in managing and surveying their natural resources. On the other hand, the full control of these countries' fisheries will not come only from effective surveillance through (typically) military bodies, but will need improvements in the civilian monitoring, control, management, and policy-making functions (Kaczynski, 1989).

Ironically, the above problems are compounded by the relatively good management of fisheries in other parts of the world (i.e. developed countries). Comparatively speaking, more-developed countries are more successful at managing their fishery stocks than less-developed countries. This effectiveness, although beneficial to the more-developed nations, usually has the effect of shifting the effort towards overseas fisheries and therefore increasing the pressure on fishery stocks belonging to countries with less effective or absent management systems (Goffinet, 1992). The only solution to the problem of fisheries management in coastal nations allowing DWFs is for the DWFNs to assume a more responsible role. One option for this, proposed by Goffinet (1992) is the internationalization of fisheries management.

Map 3. **The Galapagos Islands lie more than 1,000 km from Ecuador in the Equatorial Pacific Ocean**

Boxed Case Study 1. Illegal Fishing in the Galapagos Islands

Background

The Galapagos are a group of volcanic islands situated about 1,050 km off Ecuador in the Equatorial Pacific Ocean. This 7,844 km^2 archipelago is a province of Ecuador consisting of 15 large and many small islands. Although situated right in the equator, the climate and oceanographic regime of the islands are influenced by cold waters from the Antarctic, thus providing a unique setting for a very diverse marine life. In addition, its isolation from the mainland has allowed terrestrial life to evolve into singular forms. These islands are home to 11 subspecies of giant tortoise, the only marine iguana and flightless cormorant in the world, the only tropical penguin, and 13 unique finches. Overall, the Galapagos are regarded as one of the most important places in the world for their unique biodiversity and high rate of endemism. For these reasons, in 1959 Ecuador set aside 97 per cent of the land area of the archipelago as a national park. The islands have also been recognized internationally as a Man and Biosphere Reserve and as a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Furthermore, in 1986 the Galapagos Marine Resources Reserve was established to protect the waters around the archipelago.

Conservation Issues

Despite the protected status of the Galapagos Islands, they suffer some serious conservation problems. There are severe issues of infestation by exotic land species introduced by man which threaten the local flora and fauna. In addition, because agriculture and fishing are economically important they are often at odds with conservation objectives.

Since early this century, the fishery resources of the Galapagos have been under exploitation. First, local fishermen using oar and sail powered boats caught mainly *Mycteroperca olfax* and a suite of serranids, labrids, lutjanids, and carangids (Merlen, 1995), and pole and line tuna vessels from the United States fished for yellowfin tuna. After World War II, a fish processing plant and up to 30 diesel powered boats 5-10 m long formed the "traditional" fishery in the archipelago. During those years, fishing was almost exclusively a locally owned industry. In the 1960s and 1970s, four 20-30 m large-capacity ships carrying 12-16 divers arrived from the mainland to exploit rock lobsters. Foreign boats started buying the catches from the local fishermen, thus creating a lucrative market for all fishery products. The export of lobster was banned and foreign vessels were prohibited from entering the archipelago in 1974. But the local fishermen remained and the exploding human population of the islands motivated by the tourism industry created conditions for increased fishery exploitation. To make matters worse, scientific investigation in fisheries ceased in 1981 leaving a void of vital catch statistics (Merlen, 1995).

Recent Problems of Illegal Fishing

The last two decades have been characterized by the activities of high-mobility fibreglass boats. Fisheries diversification and lack of control led to all kinds of illegal fishing practices and conflicts between government and fishermen (Merlen, 1995). The trade of shark fins, based exclusively on finning practices, was initiated and stimulated by Asian fishing vessels in earlier decades and is now widespread among local fishermen. Fishing for sharks within 80 nautical miles from shore was banned in 1989, but the fishing close inshore continued. Lobsters (*Panulirus* spp.), sea cucumbers (*Isostichopus fuscus*), and shellfish are also heavily exploited. The government closed the lobster fishery in 1992, but illegal fishing carried on. In the late 1980s, the sea cucumber industry became one of the most important fisheries, causing not only depletion of sea cucumbers in some areas of the ocean floor, but also inducing mangrove cutting in the delicate island ecosystem for preservation of the cucumbers (boiling). This fishery was closed in 1992, but illegal fishing continued.

Although the Galapagos Marine Resources Reserve – declared in 1986 – protects an area more than 15 nautical miles from shore, the regulations of usage within the reserve have never been fully enforced. According to Merlen (1995), among the many reports of illegal fishing practices in recent years in the Galapagos Islands are: fishing by purse-seine tuna vessels within 500 m from shore; gillnets close to shore so full of hammerhead sharks (*Sphyrna lewini*) that they could not be lifted by fishermen; fishing for sea cucumbers and opening of illegal camps on shore plus transhipment of the product by tuna vessels; and large fishing vessels operating at night 5 km from the coast. Camhi (1995) reports that up to 80 major DWF fishing vessels from Japan, the Republic of Korea, and Taiwan licensed to fish for tuna have illegally longlined for sharks and traded for other marine stocks within the reserve.

During 1997 the fishing vessel *Magdalena* was captured by personnel from the Galapagos National Park within the confines of the biological reserve carrying 40,000 processed sea cucumbers on board. This vessel also acted as a mother ship to small boats fishing illegally for sea cucumbers. As a result of the seizure, a park guard was seriously injured when he was shot by illegal sea-cucumber fishermen. After a long and difficult judicial process marred with accusations of extortion, breach of confidence, bribery, and legal irregularities, the original penalty allowing the auction of the *Magdalena* was still not acted upon and the legal battle continues.

It is evident that there are great conflicts between the objectives of conservation and those of pursuit of economic growth and development in the Galapagos Islands. This has often led to ineffective conservation measures that are not enforced properly or that are overturned as a result of political pressure. The list of ineffective or not-respected measures is impressive: the declaration of the Marine Resources Reserve in 1986, prohibition of lobster exports from the archipelago in 1974 and closure of the fishery in 1992, banning of shark fishing near shore in 1989, closure of sea-cucumber fishing in 1992, the management plan for usage of the marine reserve in 1992. All have failed to attain control of the exploitation of natural resources in the region. Clearly, one of the most pressing problems in the archipelago is the lack of a capacity and perhaps a will to monitor illegal activities and enforce compliance with regulations. There is a strong need for effective patrolling of the national park and the marine resources reserve.

On 6 March 1998, the Galapagos special law was passed. The new law recognized the islands as a "priority area", banned commercial fishing, imposed limits for immigration to the islands, implemented an inspection and quarantine system, and required that a larger part of the hard currency earned through ecotourism be used towards conservation. It remains to be seen if this time finally, the laws will be respected.

Map 4. **The "donut hole" high seas enclave sustained an important DWF fishery for walleye pollock**

■ Case Study: Walleye Pollock and the North Pacific "Donut Hole"

ECOSYSTEM

Environmental Conditions

The Bering Sea is a sub-polar area bounded by the Aleutian Islands in the south and the Bering Strait in the north. It has a total surface of 2,274,020 km^2 and a mean depth of 1,636 m. The Bering Sea is generally regarded as an extension of the North Pacific Ocean, significantly influenced by the Arctic Ocean (Canfield, 1993). The eastern Bering Sea is considered as one of the most productive marine ecosystems in the world, a feature probably related to the size of its continental shelf which, at 500 km wide at its narrowest point, is the second widest in the world (Bakkala, 1993). The "donut hole" is a portion of the Bering Sea surrounded by the EEZs of Russia and the United States. It lies just off the eastern Bering Sea on the Aleutian Basin, and at 55,000 square nautical miles comprises 19 per cent of the Aleutian Basin and 8 per cent of the Bering Sea. The "donut hole" is essentially a high-seas enclave outside the jurisdiction of any country.

Food Chain

The Aleutian Basin, and in particular the pollock stocks of the "donut hole", depend greatly on resources from the eastern Bering Sea. A large part of the yearly primary production from the outer shelf of the eastern Bering Sea is channelled into the pelagic food web of the Aleutian Basin though the effect of tidal currents. This energy supply is what supports the large population of walleye pollock and other semi-demersal species of this area (Bakkala, 1993).

THE DWF NATIONS

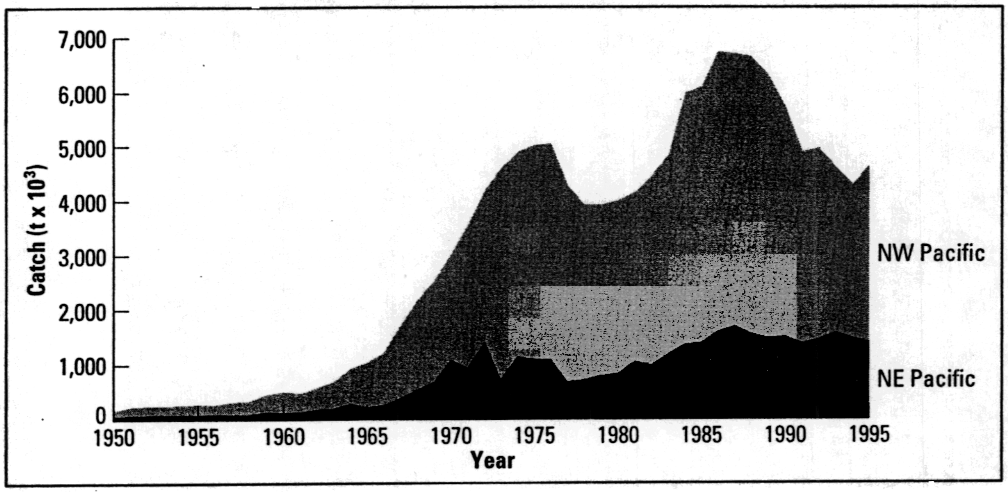
The modern exploitation of fisheries in the Bering Sea started in the early 1950s when Japanese vessels began fishing for flatfishes, mainly yellowfin sole (*Pleuronectes asper*). The Soviet fleet followed at the end of the decade. Although there were some catches of walleye pollock (*Theragra chalcogramma*) in the late 1950s, the real breakthrough in the exploitation of this fish came in the 1960s. According to Bakkala (1993), the major development in the fishery was the implementation by Japan of on-board production methods for surimi (minced meat) from pollock. The Japanese fishery thus shifted to walleye pollock and production grew from 175,000 t in 1964 to 1.9 million t in 1972.

Other nations followed suit, among them the Republic of Korea (1968), Poland (1973), Taiwan (1974), Germany (1980), and Portugal (1984). Although most of these countries fished for pollock, their catches were minor compared with those of Japan. By 1988, however, the United States was catching all of the pollock in the eastern Bering Sea and delivering it to foreign vessels through joint-venture fisheries that were set up soon after declaration of the 200-mile EEZ (Bakkala, 1993; Traynor et al., 1990).

THE FISHERY RESOURCES

Walleye pollock is the single most important fishery resource of the entire North Pacific and particularly the Bering Sea. This species single-handedly supported peak catches of 6.7 million t in 1987 (Figure 6), more than 7 per cent of all fishery catches in the world that year. The Sea of Okhotsk and the eastern Bering Sea are the main fishing grounds, although important catches are also taken in the Aleutian Basin's "donut hole". According to data from the early 1990s taken from Wespestad (1993),

Figure 6. **Most of the reported catches of walleye pollock are taken in the northwest Pacific**



FAO 1995

40 per cent and 56 per cent of the total pollock catches are taken in the Sea of Okhotsk and Bering Sea respectively; the "donut hole" (Aleutian Basin) and the eastern Bering Sea catches account for 19 per cent and 23 per cent of the total.

After pollock, groundfish constitute the most important commercial fisheries in the Bering Sea, specially yellowfin sole, Pacific halibut (*Hippoglossoides stenolepis*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), and Pacific Ocean perch (*Sebastes alutus*). Other important fishery resources for DWFs in the Bering Sea are Pacific salmon (*Oncorhynchus* spp.), king crabs (*Lithodes* spp. and *Paralithodes* spp.), and snow crabs (*Chionoecetes* spp.). The Japanese catches of Pacific salmon inside the "donut hole" were phased out in 1991.

Wespestad (1993) summarizes information on the biology of walleye pollock. The species is endemic to the North Pacific. In the eastern Bering Sea, pollock live on average to 9 years, but strong year classes remain abundant for up to 12-15 years; the oldest recorded age is 21 years. They mature at about age 3-4 (40-45 cm or 0.5 kilogram (kg)) and tend to become more demersal as they age. The natural mortality rate is estimated at 0.3 for fish less than 2 years old (Bakkala, 1993) and there are reports of cannibalism in this species. The maximum sustainable yield estimate for the eastern Bering Sea pollock stock is 1.5 million t. Genetic studies have shown the existence of two clearly distinct stocks of pollock, one in the Bering Sea-Gulf of Alaska region, and another in the Sea of Okhotsk (Iwata, 1975; cited in Bakkala, 1993). There is less clear information about stock structure in the Bering Sea. Some studies suggest the presence of western and eastern stocks but evidence is not conclusive. Furthermore, the eastern Bering Sea might host several stocks. Length-at-age data suggest a stock inhabiting the NE shelf and slope and the Aleutian Basin that would be distinct from pollock in the remaining eastern Bering Sea (Lynde et al., 1986; cited in Traynor et al., 1990). However, genetic studies do not support this hypothesis (Grante and Utter, 1980; cited in Traynor et al., 1990). A basin stock, a northeastern slope stock and a rest of the eastern Bering shelf and slope stock were suggested by studies showing differences in spawning site and fecundities (Hinckley, 1987; cited in Traynor et al., 1990).

According to reports from the International North Pacific Fisheries Commission (INPFC) (1992), poor recruitment since 1984 caused declines in pollock abundance in the eastern Bering Sea and Aleutian regions towards the early 1990s. The allowable biological catch for 1992 was estimated at 1.497 million t, based on a policy of an F0.1 exploitation rate. In general, pollock stocks appeared to be in decline in most regions of the Bering Sea.

HISTORICAL CATCHES

The fishery for walleye pollock in the "donut hole" developed in the mid-1980s as a result of the exclusion of DWFs from inside the EEZs of the USSR and the United States (Traynor et al., 1990; Dunlap, 1995). Catches increased rapidly from over 180,000 t in 1983 to 1.3 million t in 1987. The main DWFs involved in fishing operations inside the "donut hole" were Japan, the Republic of Korea, and Poland, although the USSR and China also participated in the fishery (Table 8). During this period, the catches of pollock in the "donut hole" slightly exceeded those made by United States vessels in the eastern Bering Sea (Traynor et al., 1990). During the peak year of 1989, the 1.4 million t of pollock caught in the "donut hole" represented 22 per cent of the world catches of this species. International management of the walleye pollock resource led to a moratorium of fishing in the "donut hole" area since 1993 which is still in place (see agreements section).

Table 8. **Reported catch (t x 10^3) of walleye pollock in the donut hole area 1983-1992**

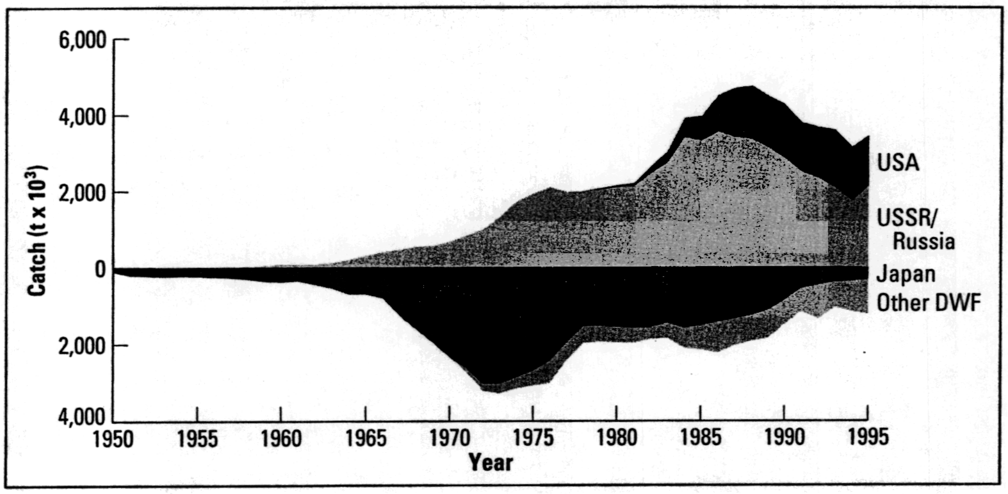
Year	China	Japan	Korea Rep.	Poland	USSR/FSU	Total
1983						175
1984			-	-		181
1985	2	164	82	116	-	363
1986	3	706	156	163	12	1,040
1987	17	804	242	230	34	1,326
1988	18	750	269	299	61	1,378
1989	31	655	342	269	151	1,416
1990	28	417	244	223	5	917
1991	17	140	78	55	3	293
1992	-			-		11

Sources: Traynor et al., 1990; McDorman, 1991; Canfield, 1995; and Wespestad, 1993

A comparison of pollock catches of DWFs and countries surrounding the "donut hole" (United States and USSR) outlines the major trends of the fishery in the North Pacific (Figure 7). Up until the mid-1970s the catches by DWFs – led by Japan – far exceeded those of the local nations. This trend was reversed with the implementation of 200-mile EEZs. While the DWFs' share decreased, the ex-USSR rapidly increased its share and has since taken the largest part of the total pollock catch, mainly in the Sea of Okhostk. The United States has also expanded its catches of pollock since the early 1980s. During the late 1980s DWFs' catches showed a slight increase due to catches taken inside the "donut hole" after the DWFs were excluded from their former main fishing grounds in the eastern Bering Sea. Overall, pollock catches of foreign fleets have declined steadily since the early 1970s.

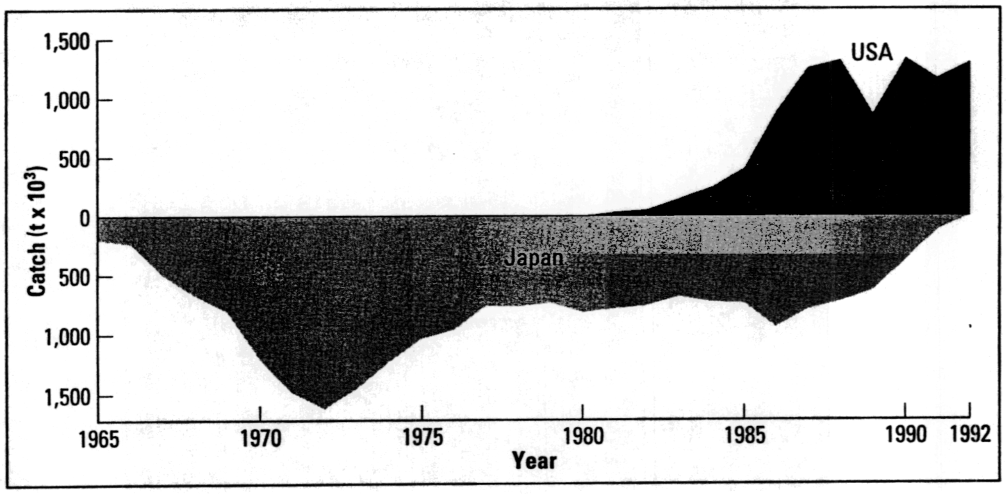
Catch statistics specific to the Bering Sea are available only for the United States and Japan through the INPFC reports. These partial data show the same trend as the whole

Figure 7. **DWFs took the largest part of the walleye pollock catch until the mid-1970s**



North Pacific data: a reassignment of catches from DWFs to the coastal nations (Figure 8). While Japan took most of the pollock until 1980, a slow but definite growth of United States pollock catches since the mid-1980s was matched by a concurrent decrease of Japanese catches. By 1992, Japan had ceased to fish for pollock in the Bering Sea.

Figure 8. **Japan's walleye pollock catches were gradually replaced by USA catches**



INPFC data

Two events were responsible for this trend. First the establishment of joint-venture fisheries in the eastern Bering Sea inside the United States EEZ to replace DWFs, and second the moratorium on pollock fishing inside the "donut hole" area – which was the last enclave of DWFs in the Bering Sea – since 1993.

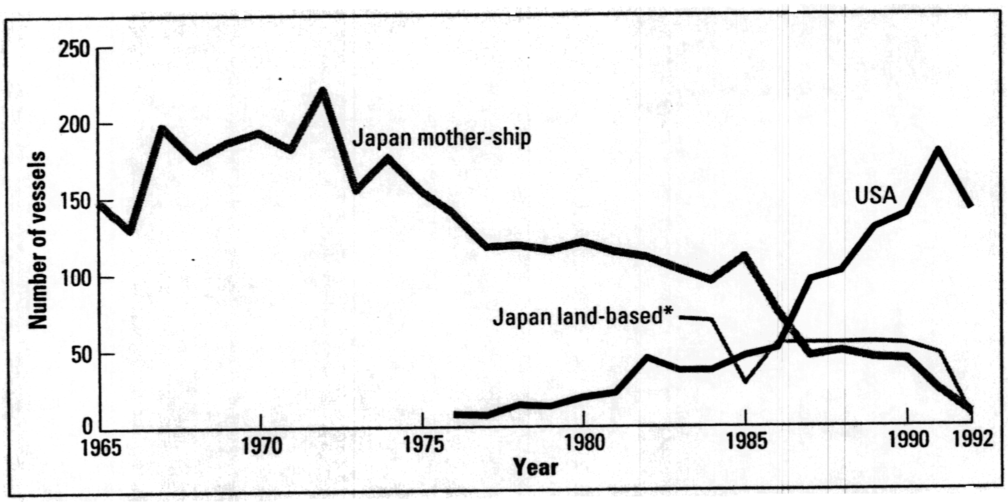
FLEET CHARACTERISTICS AND NUMBERS

Information on the size, number, and characteristics of the fishing fleets is fragmentary. Bakkala (1993) provides some data on the fleets catching pollock in the eastern Bering Sea. Japan had two different fleets targeting pollock in the 1970s. The mother-ship fishery used large processing vessels supplied by fleets of trawl catchers. These catcher vessels used Danish seines, pair trawls, and stern trawls to fish pollock and ranged from about 100 to 350 GRT. The second fleet was composed of land-based stern trawlers of 2,500 to 5,500 GRT. These vessels were prohibited from transhipping at sea and had to return to land their catches in Japan. Soviet factory stern trawlers fishing for pollock were of 2,600 to 3,900 GRT, and Republic of Korean stern trawlers ranged between 2,200 and 5,700 GRT. Fredin (1987) indicates that the number of Japanese mother-ship groundfish fleets in the Bering Sea increased from 2 in 1954 to 33 in 1961. By 1984, 6 mother-ship fleets supplied by 77 catcher vessels were operating in the Bering Sea while 43 land-based stern trawlers were also present (INPFC, 1987).

There is no readily available information on the number of vessels fishing in the "donut hole". Limited data on sightings of foreign vessels indicate that these peaked at 2,470 vessels during 1990-1991, were 1,221 in 1989, and fell to 871 during 1991-1992 (Canfield, 1993). It should be noted that sightings include an unknown number of multiple sightings of the same vessels.

The INPFC is an alternative source of partial information on number of vessels fishing for groundfish in the Bering Sea. However, it is difficult to distinguish how many of these vessels were fishing for pollock and how many were targeting other groundfish stocks. The data presented in Figure 9 mirror the trends observed in the share of the catch by these two countries (see above). Japan maintained between 100 and 180 trawling vessels until 1983, then decreased steadily to only 11 boats in 1992. Meanwhile the United States fleet grew rapidly between 1986 and 1992, virtually replacing the Japanese fleet.

Figure 9. **The number of trawlers in the Bering Sea reflects the changes in the share of the catches between Japan and the United States**



*information not available prior to 1975 but vessels known to have operated in the Bering Sea

INPFC data

FISHERIES MANAGEMENT

Before the declaration of EEZ regimes by the United States and USSR, the management of the Bering Sea fisheries was mostly a decision of each country. Initially, the United States had jurisdiction only in a 3-mile zone from the coast. Under this provision, the United States permitted groundfish trawling in its waters starting in 1942. The Japanese

DWF was managed directly by the Japanese government. In 1959, Japan declared some areas closed to its own trawl fisheries in the Bering Sea and around some of the Aleutian Islands, mainly to avoid gear conflicts with other fisheries (Fredin, 1987). Furthermore, Japan limited the number of licences and areas of operation of all components of its groundfish fleets in the Bering Sea during 1967. The United States extended its jurisdiction to a 9-mile contiguous fishery zone in 1966 which led to a number of bilateral fishing agreements. These provided some limited management measures for pollock. Area and seasonal closures were established during several years. In the early 1970s, pollock quotas agreed upon were: Japan 1.5 million t (1973), 1.3 million t (1974), and 1.1 million t (1975-1976); the USSR 210,000 t (1975-1976). These quotas were based on average catches over a number of preceding years and were intended to serve as a cap while stock assessments were carried out (Fredin, 1987).

The implementation of the EEZ regime by the United States in the eastern Bering Sea during 1977 changed the rules of the game. Optimum yield (OY) levels for the different groundfish species were identified by United States scientists and used to provide fishing quotas for DWFs. The OYs for pollock ranged between 950,000 t and 1.5 million t during 1977-1985. In addition to this, DWFs were required: (1) to stop fishing in the United States EEZ once the specified quotas were fulfilled; (2) to carry on-board United States observers at no cost to the United States (in contrast to this, see the Mauritania and Senegal case study above); and (3) to provide the United States government with catch and effort statistics for each vessel on a regular basis. Additional regulations were included to minimize the bycatches of juvenile Pacific halibut.

Initial efforts for international fisheries management in the North Pacific took shape in 1952 in the form of the INPFC. This body – formed by Canada, Japan, and the United States – was to undertake research and management of fishery resources for situations where no bilateral agreements existed between at least two of the member countries. Effectively, the work of INPFC was centred on salmon stocks. Although some research on groundfish took place under the auspices of the INPFC (sablefish and Pacific Ocean perch), no management recommendations were ever issued for walleye pollock (Fredin, 1987).

Extended jurisdiction in the late 1970s initiated a process of retreat of the DWFs from coastal nations' waters. The DWFs fishing pollock in the eastern Bering Sea were replaced by joint-venture fisheries in the early 1980s, forcing the rapid development of the Aleutian Basin's "donut hole" pollock fishery. The uncontrolled growth of this fishery spurred worries about overfishing and the effects of Aleutian Basin catches on the pollock populations of the eastern Bering Sea. Such worries were underscored by the precipitous fall of pollock catches in the "donut hole" during 1989-1991 and the accompanying decreases in catch per unit effort (Canfield, 1993).

Effective management of the "donut hole" fishery did not come about until the early 1990s. This took shape in the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea which is one of the rare examples of successful international cooperation. This agreement – detailed below – offered the possibility of a complete halt of fishing in the "donut hole" area. Under provisions of this agreement, all DWFs involved in the "donut hole" pollock fishery during the 1980s agreed to stop fishing from 1993 in order to allow recovery of a depleted stock in need of strong conservation measures. At time of writing of this paper, the moratorium on pollock fishing is still in force and is scheduled for review in 1998.

BYCATCH

Information on bycatch in the walleye pollock fisheries of the Bering Sea is not readily available. According to Canfield (1993), some reports indicate that Alaskan trawlers fishing for pollock and Pacific cod discarded about 9,000 t of halibut and some 250,000 t of groundfish in 1990. However, it is difficult to know how much of this pertains to pollock-targeted fishing. Judging from the nature of the "donut hole" fishery for pollock where all the fishing is by mid-water trawl it is expected that only minimal problems of bycatch occur.

FISHING AGREEMENTS

During the 1950s and 1960s, all of the bilateral agreements between nations fishing in the Bering Sea included provisions for avoiding gear conflicts and bycatch of valuable species but no provisions existed for the management of pollock stocks. For example, an agreement of May 1967 imposed some time/area restrictions for trawling by Japanese vessels in parts of the Aleutian Islands, but in the words of Fredin (1987), controlling the impact of foreign fisheries on pollock and other groundfish stocks was not an issue for the United States at that time. This changed drastically in 1972-1973 when Japan and the USSR agreed to a United States proposal of adopting catch quotas for pollock for the first time in addition to seasonal/area restrictions (see management above). Most of the bilateral agreements of the mid-1970s were political tools used to allocate shares of the fishery rather than means of "selling" fish to DWFs as is the case in many DWF situations in other parts of the world.

The most important international agreement for managing pollock fisheries in the Bering Sea is the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. This agreement, signed by China, Japan, Poland, Russia, the Republic of Korea, and the United States in 1994, came into force in 1995. Dunlap (1995) provides a compelling account of the development of this agreement. In his opinion, it has a unique combination of enforcement mechanisms, and offers potential to become one of the most effective multinational agreements ever reached. It is one of the few fishing agreements in the world signed by all the parties fishing in the area of interest. The agreement was developed during 1991-1994 in a very swift process which was undoubtedly fertilized by the rapid and evident collapse of the stocks in question. Unequivocal evidence of the decline in pollock abundance in the Aleutian Basin was becoming available as the ten conference meetings proceeded, causing a swift change in the positions initially adopted by the DWF nations. This fortunate incident was perhaps the most important breakthrough in the signing of the convention. Under the terms of reference of this agreement, the contracting parties agreed to a suite of commitments aimed at the conservation, management, and optimal utilization of the pollock resources of the central Bering Sea ("donut hole" area). Among the most important aspects of the agreement are: (1) provisions for the determination of annual harvest levels and individual nation quotas for each year; (2) effective mechanisms for dealing with non-complying parties; (3) broad provisions for dealing with nations who are not a party to the agreement and intend to undermine the objectives of the Conference; (4) cooperation in research and exchange of fisheries data; (5) satellite tracking for all fishing vessels; and (6) establishment of a scientific observer programme for full coverage of fishing activities.

BENEFITS

One obvious benefit from the occurrence of DWFs in the Bering Sea is probably the discovery and development of the important pollock fisheries. It was the Japanese who found a use for pollock in the form of surimi. The coastal nations, in particular the United States, have capitalized through joint-venture fisheries and thanks to extended jurisdiction, on the market and fisheries developed by the DWFs, particularly Japan. At the end of the day, there is benefit for all nations as the management brought about in recent years will be the only chance to avoid repetition of the far too common overexploitation of marine stocks that occurs in most open access situations.

However, the most important benefit derived (even though a little late) from the fishing activities of DWFs in the "donut hole", was the realization of the recent agreement for conservation and management of pollock describe in the preceding section. This agreement constitutes a breakthrough in modern international fisheries agreements for the "high seas" and will probably serve as the benchmark for several years to come.

CONFLICTS

Overall, the DWF fisheries in the Bering Sea area have been devoid of major conflicts. Ignoring the overexploitation of the pollock resource in the "donut hole", currently under a recovery regime, there have been no major negative effects of DWF activities.

For a number of years, there were several instances of alleged illegal incursions of DWF vessels from the "donut hole" into the eastern Bering Sea to catch pollock. Between 1989 and 1992, at least 11 seizures of vessels supposedly fishing pollock in the "donut hole" were made by the United States Coast Guard in the eastern Bering Sea (Canfield, 1993). These relatively minor problems have apparently been successfully resolved through the "donut hole" agreement described above. Recent news, however, indicates that illegal fishing in the Bering Sea is still attempted occasionally by some nations. A Chinese vessel was recently caught fishing illegally for salmon in the Russian EEZ (*The Vancouver Sun*, 1998; Omori, 1998). On 31 May 1998, the Russian fisheries enforcement vessel *Brest* intercepted and seized 13 trawlers from the Democratic People's Republic of Korea allegedly fishing illegally in Russian waters in the Bering Sea (Dow Jones News, 1998).

■ Case Study: Iceland and DWFs*

ECOSYSTEM

Environmental Conditions

The three major current systems that influence Icelandic waters are (1) the warm and saline Irminger current – an offshoot from the Gulf Stream – flowing from the south; (2) the colder and less saline East Greenland current of Arctic origin flowing from the

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* Prepared by Hreidar Valtysson

northwest; and (3) the East Iceland current from the northeast, made up from mixing of cold arctic waters and the warmer Gulf Stream northeast of Iceland (Map 5) (Stefánsson, 1962). There is also a freshwater-induced coastal current flowing clockwise around the country. The Irminger current and the mixing of all these currents is the main reason for the high productivity found in Icelandic waters. The Irminger current keeps the waters south and west of Iceland relatively warm and stable both inter- and intra-annually.

Map 5. Iceland has moved from being a nation hosting DWFs to becoming a DWFN itself

Phytoplankton blooms around Iceland occur in early spring and autumn. The spring bloom is driven by longer-lasting days and by warmer, stratified waters. This allows phytoplankton to stay in the surface waters. By summer, the rapid growth of the phytoplankton renders the surface waters nutrient deficient and photosynthesis declines to a low level. The autumn bloom is aided by vertical mixing caused by temperature differentials in the air-sea interface. Stronger bloom years are generally linked to warmer ocean temperatures caused by a stronger Irminger current. The total primary production in Icelandic waters has been estimated to be around 55 million t carbon annually, or 218 g carbon m^{-2} y^{-1} in the continental shelf and 151 g carbon m^{-2} y^{-1} offshore (Thórthardóttir, 1995). The biomass of zooplankton (dominated by the copepod *Calanus finmarchius*) in northern surface waters increases in May, then declines during the summer. Productivity is generally greater in the waters south and west of the country, where blooms also occur earlier and autumn blooms are also more prominent (Ástthórsson and Gíslason, 1995; Gíslason and Ástthórsson, 1997).

Food Chain

Among the large benthic invertebrate fauna in Icelandic waters, the most important crustaceans are northern shrimp (*Pandalus borealis*), Norway lobster or scampi (*Nephrops norvegicus*), and a few crab species that are currently not utilized. The main molluscs are the Icelandic scallop (*Chlamys islandica*), ocean quaghog (*Arctica islandica*), horse mussel (*Modiolus modiolus*), common mussel (*Mytilus edulis*), and whelk (*Buccinum undatum*). The only echinoderm fished is the green sea urchin (*Strongylocentrotus droebachensis*). These are all low in the food web, either filter feeders or bottom scavengers, or feeding on algae.

The main pelagic species off Iceland are capelin (*Mallotus villosus*) in the colder waters and herring (*Clupea harengus*) in the warmer waters. They feed on zooplankton, mostly copepods. Other common pelagic or benthopelagic species such as redfishes (*Sebastes* spp.), blue whiting (*Micromesistius poutassou*), Norway pout (*Trisopterus esmarki*), Arctic cod (*Boreogadus saida*), greater silver smelt (*Argentina silus*), and sandeels (*Ammodytidae*) share similar trophic levels. They feed predominantly on euphasids but also other zooplankton and benthic invertebrates. Many of these fishes are important food for other species. Basking sharks (*Cetorhinus maximus*), fin whales (*Balaenoptera physalus*), and sei whales (*B. borealis*) are common in Icelandic waters and feed also predominantly on zooplankton, as does the much rarer blue whale (*B. musculus*). Minke (*B. acutorostrata*) and humpback whales (*Megaptera novaeangliae*) are also abundant but feed on fish as well as zooplankton.

The main benthic feeding fish are haddock (*Melanogrammus aeglefinus*), wolf-fishes (*Anarhichas lupus* and *A. minor*), grenadiers (*Macrouridae*), rattails (*Chimeridae*), sculpins (*Cottidae*), eelpouts (*Lycodidae*), common skate (*Raja batis*), starry ray (*Raja radiata*), and flatfishes. However, they feed also on capelin in large quantities when available. Higher in the trophic level are the piscivorous fishes, dominated by Atlantic cod in the warmer waters and by Greenland halibut (*Reinhardtius hippoglossoides*) in colder regions. Other species in this level are mostly gadoids such as saithe (*Pollachius virens*), whiting (*Merlangius merlangus*), tusk (*Brosme brosme*), and lings (*Molva molva* and *M. dypterygia*). Other less numerous groups are salmonids, Atlantic halibut (*Hippoglossus hippoglossus*), spiny dogfish (*Squalus acanthias*), and angler fish (*Lophius piscatorius*). In general, species in this group eat mostly small invertebrates when small, shrimp and capelin at medium sizes, and other fish when fully grown. The top predators are the Greenland shark (*Somniosus microcephalus*), porbeagle (*Lamna nasus*), seals, and toothed whales, which eat squid and various fish species (Pálsson, 1983; Jónsson, 1992; Anon., 1997a).

THE COASTAL NATION

Iceland is the second largest island in Europe, and lies close to the Arctic Circle in the North Atlantic. The maritime boundaries are Greenland in the west and northwest, Jan Mayen (Norwegian) in the north, and the Faeroe Islands in the southeast. The total size of the 200-mile EEZ is 758,000 km^2, of which 111,000 km^2 is continental shelf less than 200 m deep, where most of the fishing is done. The south shore is characterized by sandy beaches without good harbours; the west, north, and east coasts however have many fjords and bays with good harbours. The total length of the coastline is about 5,000 km.

Considering how far north it is, the climate in Iceland is temperate but is nevertheless not well suited for agriculture. Only 1 per cent of the land is cultivated, a further 20 per cent is used in summer for pasture, the rest is glaciers, lava fields, deserts, and other wasteland. Besides fish, relatively cheap electricity from hydro and geothermal power plants is almost the only other natural resource. Virtually no minerals are available in commercial quantities.

About 270,000 people of homogeneous Norwegian/Celtic ancestry live in Iceland. More than half of them live in or close to the capital Reykjavik and the rest mostly in small fishing villages scattered along the coast. Agriculture, mainly sheep farming, has historically been the mainstay of the economy, fisheries coming close second, usually being conducted seasonally by the farmers or farm workers. This century, fisheries have however become far more important, and are the main reason the nation was able to develop from a poor agricultural country to a prosperous modern society. Since fisheries are so dominant, the economy is vulnerable to fluctuations in fish prices and stock sizes.

THE FISHERY RESOURCES

The most important fishery resources in Icelandic waters are medium- to long-lived demersal species typified by the Atlantic cod; the most obvious exception is the capelin which is a short-lived pelagic fish.

Most of the important species do not generally leave the Icelandic EEZ, the exceptions are: (1) capelin that undertake large-scale feeding migrations up to Jan Mayen in the north and Greenland in the northwest; (2) Greenland halibut which undertake feeding/spawning migrations to Greenlandic and Faeroese waters; (3) blue whiting which spawn in British waters but undertake feeding migrations to Icelandic waters; (4) the large whales which use Icelandic waters for feeding but have nursery areas in tropical waters; (5) the Norwegian spring-spawning herring stock, which when not depressed spends the summers and winters feeding in Icelandic waters (see Boxed Case Study 2). In addition to these migratory species, there are straddling stocks such as shrimp and some of the redfishes living on the edge of the Icelandic EEZ. Occasionally, some quantities of mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), squid, and bluefin tuna (*Thunnus thynnus*) wander through the Icelandic EEZ, but generally not in fishable quantities.

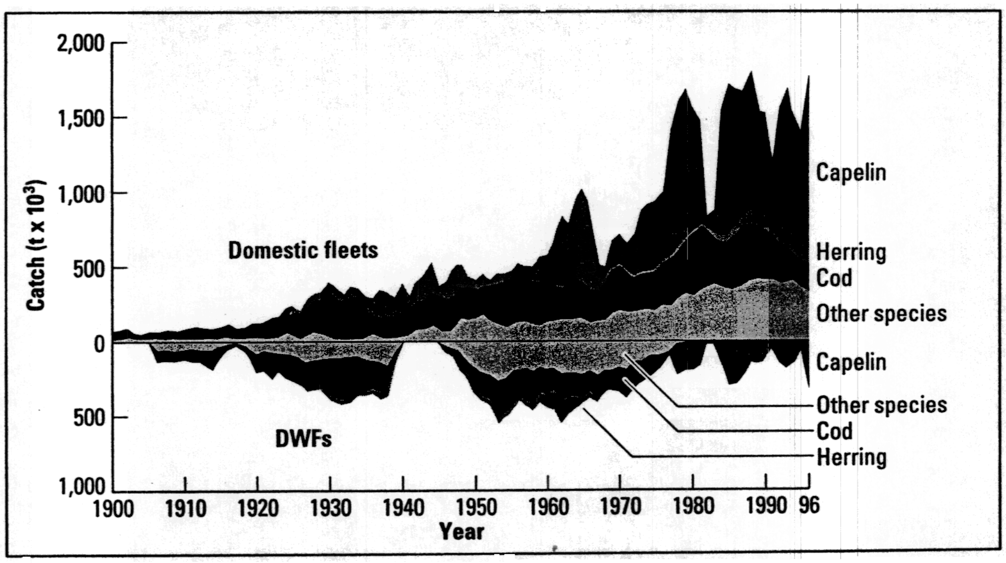
Few boats use only one gear or target one species. Purse-seiners catch capelin during part of the year, herring in other seasons, and sometimes trawl for shrimp during other parts of the year. Many of the smaller shrimp boats switch seasonally between Danish seine, gillnet, shrimp trawl, and longline. Large trawlers fish for Atlantic cod in one season, Greenland halibut in another, redfish the third, and then go for Atlantic cod or shrimp in distant waters.

The most important fishery resources of Iceland can roughly be split into ten major groups as follows.

Offshore Groundfish

This fishery is conducted on the continental shelf with bottom trawls. Atlantic cod is the main target species but others such as haddock, saithe, tusk, common ling, wolf-fishes, and flatfishes are also important. The distinction between bycatch and target species in this fishery is however blurred, depending on the quota status of the boats and area fished. Economically, this fishery – which was started late last century by British trawlers – is the most important. Before World War I, total groundfish catches were around 200,000 t/y, mostly Atlantic cod (Figure 10). Between the wars, catches were 400,000-700,000 t/y, and after World War II they ranged from 600,000 to 800,000 t; roughly half of this is Atlantic cod. About two-thirds of the groundfish catches were taken by trawlers, the rest by smaller inshore boats. The importance of Atlantic cod in trawl

Figure 10. **Capelin, herring, and cod have dominated the catches in Icelandic waters by foreign and domestic fleets**



fisheries has been diminishing lately because of restricted quotas. Other species in deeper waters, such as Greenland halibut, redfishes, and shrimp are being targeted more in turn.

Inshore Groundfish

Similar in species composition to the offshore fishery, this is however more seasonal and is conducted by many small, primarily Icelandic boats with handlines, longlines, or gillnets. Catches from these boats were below 100,000 t/y until after World War I, when they increased to about 150,000 t before the Great Depression. After World War II catches increased to 300,000 t and have remained at that level since.

Pelagic Fish

Capelin and herring are the main target in these fisheries, but Norway pout and blue whiting have also been targeted. These fisheries are usually conducted with purse seines, but also recently with pelagic trawls. Until the mid-1920s, herring catches in Icelandic waters were around 10,000 t/y, mainly by Norwegian boats. Catches increased steadily after Iceland joined the fishery. Production reached a peak of 770,000 t in 1966, but collapsed almost entirely two years later. The Icelandic summer-spawning stock has recovered and now supports a fishery of 100,000 t/y. This stock is currently the only herring stock in Icelandic waters and is only fished by Icelanders. Capelin fisheries started around 1963 and increased rapidly, specially after the collapse of herring stocks. Since 1978, with few exceptions, the capelin has sustained a catch of around 1 million t/y, by boats from Iceland, Norway, the Faeroe Islands, and Greenland. Landings from these fisheries are now usually more than half of the total annual catch in Icelandic waters, but since most of it is reduced to meal the total value is not as high as for many of the demersal species.

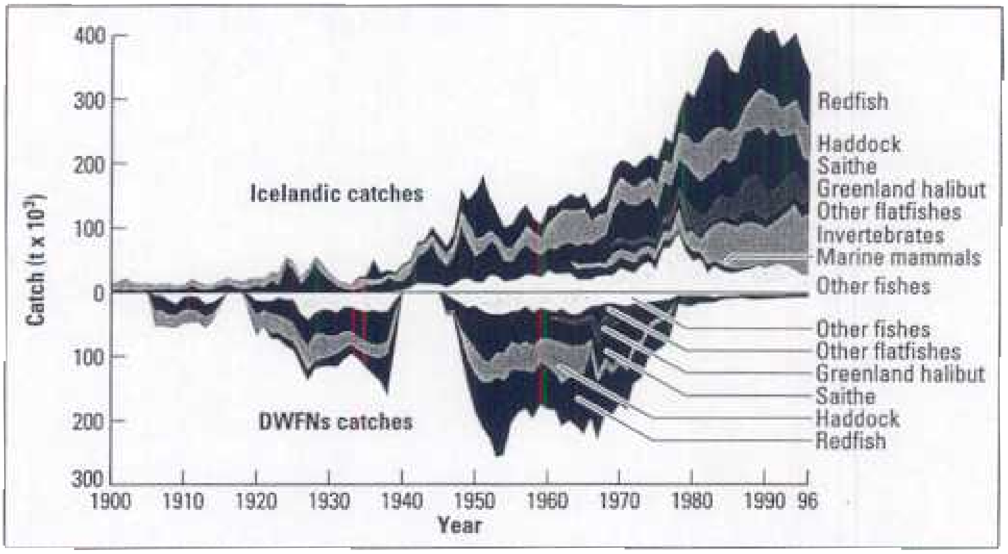
Greenland Halibut

This is a recent bottom trawl fishery conducted in deep waters west, north, and east of Iceland. The Greenland halibut fishery was probably started in the 1950s by the German countries. However, early on, landings of Greenland and Atlantic halibut were not separated so the statistics by species are not readily available. Catches increased rapidly and reached a peak of 30,000 t in 1974 when fleets from the USSR and later Poland joined the fishery. Catch declined rapidly afterwards due to the extended fisheries jurisdiction regime. Icelandic catches for this species started to increase rapidly after 1976, Faeroese catches after 1979, and Greenlandic catches after 1991. The total catch from these countries reached a peak of 60,000 t in 1989, mainly by Icelanders, but has declined since. The stock now shows signs of overfishing.

Redfish

These fisheries target the three major redfish stocks in rather deep waters south and west of Iceland. *Sebastes marinus* and demersal *S. mentella* are primarily caught with bottom trawls, but mid-water trawls are used for oceanic *S. mentella*. The fishery was developed mainly by German trawlers after World War II with catches of 50,000 – 100,000 t/y although Icelandic catches were also substantial (Figure 11). After the 200-mile EEZ declaration, catches of redfish by Icelanders increased. Initially most of the bottom trawl catches were *S. marinus*, but recently the annual catches of the two species have been similar at around 40,000 – 50,000 t each. These catches are almost entirely by Iceland. Catches of oceanic redfish started in 1982 by the USSR. Iceland joined the oceanic

Figure 11. **Catches of other species than cod, capelin, and herring in Icelandic waters**



redfish fishery in 1989. Recently catches have been around 150,000 t/y. The majority of these catches are however conducted outside the Icelandic EEZ and the foreign fleets have never fished for this stock in Icelandic waters. The demersal redfish stocks show signs of overexploitation, but very little is known of the status of the mid-water stock.

Offshore Shrimp

The shrimp fishery is exclusively conducted by Icelandic vessels using fine mesh trawl nets mainly off northern Iceland. The offshore shrimp fishery began on an experimental basis in 1975, catches increased sharply after 1983 to the current level of around 60,000 t/y. One of the shrimp stocks however lives on the Dhorn Bank at the boundary of the Greenlandic and Icelandic EEZs. This is a small stock and has therefore not sustained large-scale fisheries by Icelanders; other nations are however targeting it in Greenlandic waters. The shrimp catches are now the second most valuable in Icelandic waters after Atlantic cod. Bycatch is very low compared to many shrimp fisheries in warmer waters since species diversity is lower in these waters and the use of sorting grids is compulsory.

Inshore Shrimp

The fishery takes place in western and northern Iceland fjords with similar gear but smaller boats than the offshore fishery. Experimental shrimp fisheries started in 1924, but it was not until the late 1950s that real fisheries started. Since 1970, the inshore shrimp fisheries have fluctuated between 5,000 and 10,000 t/y. Only Icelanders have been involved in this fishery. Furthermore, large offshore shrimp trawlers are not allowed to catch inshore shrimp; only small boats from local towns are allowed to fish in each fjord. The smaller inshore shrimp boats can however buy quotas for offshore shrimp.

Flatfish

With the exception of plaice (*Pleuronectes platessa*) and halibut, Icelanders did not target the flatfish species in large quantities until recently. British trawlers however targeted them intensively until declaration of the Icelandic EEZ. This was followed by a 15-year period of low flatfish catches. The large-scale fishery started in the early 1980s by Icelandic boats using Danish seines. At first plaice was the main target, but from 1984 to 1988 catches of dab (*Limanda limanda*), lemon sole (*Microstomus kitt*), witch flounder (*Glyptocephalus cynoglossus*), megrim (*Lepidorhombus whiffiagonis*), and long rough dab (*Hippoglossoides platessoides*) started to increase sequentially. Currently the total catches of flatfishes in Icelandic waters have been around 30,000 t (10,000 t of plaice, 5,000 t of dab and long rough dab, 2,000 t of witch flounder, 1,000 t of lemon sole, and less than 500 t of megrim). In general, flatfish catches are now larger than before DWFs were driven out of the fishery (Hjörleifsson et al., 1998). Roughly half of the catches of plaice, megrim, and lemon sole are taken with Danish seines, the rest is caught by demersal trawlers. Atlantic cod, haddock, and other demersal species are a frequent bycatch in these fisheries.

Norway Lobster

The Norway lobster or scampi fishery takes place along the south shore with fine mesh trawls. The bycatch rate is high, especially for various flatfish species. Norway lobster is the most valuable species per weight in Icelandic waters. The fisheries started after World War II by foreign boats. These caught up to 500 t/y, but ceased after the extension of the Icelandic EEZ. In 1958 Icelanders started fishing for Norway lobster, the catches increased rapidly to more than 5,000 t/y but then declined and have been around 2,000 t/y for the last two decades. Currently only Icelandic vessels fish for Norway lobster in Icelandic waters.

Other Benthic Invertebrates

This fishery targets large benthic invertebrates, mainly with ploughs. Scallop has been the main target, but plough catches of sea urchin and ocean quaghog, and catches of whelk with traps have increased recently. The scallop fisheries started in 1969 and increased until 1982 when they levelled off at around 10,000 t/y. The ocean quaghog fishery started in 1987 and has been fluctuating up to 6,000 t/y. The sea urchin fishery started in 1992 with around 1,000 t/y, and the whelk fishery started in 1996, and is still very much on an experimental basis. Only Icelanders have been involved in these fisheries. The bycatch rate of other benthic invertebrates can sometimes be high.

Other Fisheries

Many other minor fisheries exist or have existed in Iceland. Examples are the lumpsucker (*Cyclopterus lumpus*) fishery with specialized gillnets, the Atlantic halibut fishery with longlines, the porbeagle fishery with special hooks, the Greenland shark fisheries (prior to this century) with handline, and sport fisheries for brown trout (*Salmo trutta*), Arctic char (*Salvelinus alpinus*), and salmon (*Salmo salar*). The latter fishery is mainly conducted in freshwater, since it is illegal to catch salmon in the sea. Whaling and sealing can also be put into this group. Most of these fisheries were only conducted by Iceland; the exceptions are whaling by Norwegians early this century and longline fisheries for halibut up to this day by the Faeroese.

HISTORICAL CATCHES

Total fishery catches in Icelandic waters increased from roughly 200,000 t prior to World War I to about 700,000 t between the wars (Figure 10). After World War II the catches increased to 1.5 million t, then declined again because of the collapse of the herring stocks. Production increased again in the late 1970s and has fluctuated between 1 and 2 million t/y since. These fluctuations are explained by the volatile changes in the size of the capelin stock, which makes up roughly half of the total recent catch.

Icelandic Catches

In Iceland, Atlantic cod has always been the most important fish, accounting for more than half of total demersal catch until the early 1980s. The Icelandic fishery had changed little from the times of the first settlers until the beginning of the 20th century, when small oar or more rarely sail powered boats fished in shallow waters with handlines or longlines. The catches were probably 10,000 – 30,000 t/y during this period (Jónsson, 1994). The first Icelandic owned trawler started operating in 1905 (see also Kurlansky, 1997). At that time the total demersal catch by Icelandic vessels was 55,000 t. By 1924, 40 Icelandic trawlers were operating (Jónsson and Magnússon, 1997), and the total catch had a fourfold increase to 230,000 t. Demersal catches and number of Icelandic boats decreased during the Great Depression, but increased rapidly during and shortly after World War II, to a peak of 490,000 t in 1958. The deterioration of the trawler fleet caused the catches of this sector to fall to 57,000 t in 1972, but this was compensated by increased catches from other sectors; the total catch was 330,000 t that year. After extension of the EEZ to 200 miles, the number of Icelandic trawlers – now mostly state-of-the-art stern trawlers – increased rapidly to more than 100 vessels. Catches also increased rapidly, first catches of Atlantic cod, then followed by other species. New species are also added almost every year to the list of exploited species. Examples of the new fisheries are ratfishes (*Chimaera monstrosa*) and orange roughy (*Hoplostethus atlanticus*) in 1991, green sea urchin in 1993, *Sebastes viviparus* (small redfish species) in 1996, and probably bluefin tuna in 1998. This, together with the decreasing TAC for Atlantic cod has also meant that the importance of Atlantic cod has been declining and was about one-third of total demersal catch of 522,000 t and a quarter of the value of total landings in 1996. Other important demersal species are redfish (14 per cent of total demersal catch and 13 per cent of total landed value in 1996), shrimp (13 and 20 per cent), haddock (11 and 7 per cent), saithe (8 and 3 per cent), Greenland halibut (4 and 7 per cent), wolf-fish (3 and 2 per cent), and plaice (2 and 2 per cent). The trawl fleet now accounts for more than half of the total demersal catches of 520,000 t.

The herring fishery has also been very important for Iceland both economically and historically. It was especially prominent in the 1960s, when 400,000-600,000 t/y were caught (Table 9, Figure 10). The herring stocks collapsed in 1967, and catches remained low for a long time. The herring stocks have however recovered fully now. Iceland takes more than 100,000 t/y from the Icelandic summer-spawning herring stock, and catches of more than 150,000 t in international waters from the Norwegian spring-spawning herring stock (see Boxed Case Study 2).

After the herring stocks collapsed, the Icelandic purse-seiners turned their attention to the capelin, which was largely ignored before. This fishery increased rapidly to around 1 million t/y. The capelin stock size can however fluctuate wildly, since it is short lived and dies after first spawning. In 1982 the stock collapsed and there was a moratorium on capelin fisheries for almost 2 years. The stock however recovered quickly and the capelin now sustains a fishery of up to 1.5 million t/y. Landings from pelagic fisheries are now usually more than

Table 9. **Marine catches in Icelandic waters since 1950 (t x 10^3)**

SPECIES	ICELAND				FOREIGN FLEETS			
	Mean catch 1950-1996	Maximum catch 1950-1996	Year of maximum	Catch 1996	Mean catch 1950-1996	Maximum catch 1950-1996	Year of maximum	Catch 1996
Capelin	337.6	1,182.2	1996	1,182.2	49.1	315.2	1996	315.3
Cod	273.0	460.6	1981	180.8	97.9	262.5	1953	0.7
Herring	111.7	590.4	1965	95.9	21.4	172.4	1962	0.0
Redfish	50.4	122.7	1983	67.9	39.4	124.6	1953	0.5
Saithe	44.1	99.8	1991	39.5	26.9	76.4	1971	0.8
Haddock	39.5	67.0	1982	56.3	18.6	65.3	1962	0.6
Marine mammals	13.5	24.2	1957	A few seals	0.0	0.0	-	0.0
Greenland halibut	12.3	58.5	1989	22.1	3.3	30.1	1967	0.0
Shrimp	11.6	75.7	1995	68.7	0.0	0.0	-	0.0
Wolf-fish	10.3	17.8	1991	14.7	4.6	13.4	1952	0.0
Plaice	6.0	14.4	1985	11.1	2.5	8.0	1957	0.0
Iceland scallop	5.0	17.1	1985	8.9	0.0	0.0	-	0.0
Ling	4.3	8.9	1971	3.7	3.1	6.5	1971	0.6
Lumpsucker	3.6	13.1	1984	5.1	0.0	0.0	-	0.0
Tusk	3.4	7.0	1960	5.2	2.9	5.2	1973	1.0
Norway pout	3.2	34.6	1978	0.0	?	0.0	-	0.0
Blue whiting	2.7	34.8	1978	0.3	?	0.0	-	0.0
Norway lobster	2.1	5.6	1963	1.6	0.1	0.6	1959	0.0
Blue ling	1.3	8.1	1980	1.3	1.4	3.4	1966	0.1
Atlantic halibut	1.2	2.4	1951	0.8	1.6	4.6	1950	0.1
Others*	3.3	36.7	1955-1996	28.3	1.8	6.3	1951-1963	0.0

*includes dab, witch flounder, lemon sole, long rough dab, whiting, ocean quahog, megrim, green sea urchin. Year of maximum catch is a range over which the maximum for each species occurs.

half of the total annual catch in Icelandic waters, but since most of it is reduced to meal, the value is only 15 per cent of the total value, lower than for many of the demersal species.

Most of the important stocks in Icelandic waters such as shrimp, Norway lobster, haddock, herring, and capelin are in good condition and sustain considerable fisheries. However the reason the capelin and shrimp are in such a good shape has probably also a lot to do with the low stock size of their main predator, the Atlantic cod. Other stocks such as Greenland halibut, Atlantic halibut, saithe, redfishes, plaice, and witch flounder are however declining. Fishery biologists generally realize this, but managers have been too optimistic or under pressures from the fishing industry and thus often set the TAC higher than recommended. Often the fishers then in turn catch more than the TAC. These stocks were basically sacrificed so Atlantic cod quotas could be reduced. Very little is known about many other stocks that have been exploited at an increasing rate recently.

CATCHES OF THE DWFs

DWFs probably first came to Icelandic waters in the 15th century (Table 10), when English boats were first reported (Jónsson, 1994). Later, boats from the Netherlands and France joined and dominated this fishery. There were also some small contingents of boats from other nations. From 1880 to 1890 there were even American schooners catching halibut in Icelandic waters (Sæmundsson, 1926). The other fleets were however primarily targeting Atlantic cod. The catches from these DWFs were roughly 5,000 – 15,000 t/y from the late 18th century to the beginning of this century. Although considerable at that time, these fisheries probably did not have a great impact on the fish stocks, since the weather limited fishing to the summer months.

Table 10. **Historical and present-day DWFs operating in Icelandic waters**

Nation	Gear	Target species	Period	Annual catch range (t x 10^3)
Belgium	Trawl	Demersal fish	1905* to 1994	1 to 25
Denmark	Danish seine	Flatfish	1890 to 1955	Less than
Faeroe Islands	Longline + handline	Cod + haddock	1905* to present day	5 to 50
Faeroe Islands	Purse seine	Herring	1926 to 1966	1 to 10
Faeroe Islands	Purse seine	Capelin	1977 to present day	2 to 65
Finland	Purse seine	Herring	1931 to 1967	1 to 7
France	Handline	Cod	Mid-18th c. to 1915	1 to 5
France	Trawl	Demersal fish	1905* to 1973	1 to 15
Germany	Trawl	Demersal fish	1905* to 1977	10 to 200
Germany	Purse seine	Herring	1931 to 1968	1 to 27
Greenland	Purse seine	Capelin	1993 to present day	
Italy	Trawl	Demersal fish	Between wars	Unknown but small
Japan	Longline	Bluefin tuna	1996 and 1997	Less than 1
Netherlands	Handline	Cod	Mid-18th to mid-19th c.	1 to 3
Netherlands	Trawl	Demersal fish	1905* to 1965	1 to 3
Norway	Longline	Cod + haddock	1905* to 1989	1 to 15
Norway	Purse seine	Herring	1905* to 1968	10 to 150
Norway	Purse seine	Capelin	1978 to present day	50 to 200
Poland	Trawl	Greenland halibut	1970 to 1974	Less than 1
USSR	Trawl	Greenland halibut	1965 to 1974	1 to 20
USSR	Purse seine	Herring	1960 to 1968	10 to 200
Sweden	?	Demersal fish	1928 to 1950	Less than 1
Sweden	Purse seine	Herring	1905* to 1961	1 to 8
United Kingdom	Handline	Cod	15th to 17th century	Unknown
United Kingdom	Trawl	Demersal fish	1891 to1976	100 to 200
United States	Handline	Atlantic halibut	1880 to 1890	Unknown

***Official statistics not available before 1905.**

Large-scale fishing by DWFs started when the first British steam-powered trawler came to Icelandic waters in 1891 (Guthmundsson, 1981; Thór, 1982). The number of trawlers increased rapidly to around 200 in 1904, initially most of them British (both English and Scottish) but later on also a large German fleet. Boats from Belgium, the Netherlands, Denmark, Sweden, France, the Faeroe Islands, Italy, Poland, Norway, and the USSR also fished for groundfish in Icelandic waters, but the quantities caught were far lower than the British and German catches. There are no reports of boats from other nations fishing for groundfish in Icelandic waters.

The first British trawlers came to Icelandic waters for flatfishes; initially they even discarded large quantities of Atlantic cod (Guthmundsson, 1981; Thór, 1982). Later on, Atlantic cod became the main target although other demersal fishes were also important. After World War II, large parts of the German (then West German) catches were saithe and redfish while Eastern European boats were targeting Greenland halibut.

Foreign catches of demersal fishes increased steadily from 132,000 t in 1906 (official statistics are not available earlier) to 343,000 t in 1938 (Figure 10) (Thór, 1995). During World War II, foreign catches in Icelandic waters virtually ceased, but increased rapidly after the war to a peak of 505,000 t in 1953. Catches declined slowly afterwards due to overexploitation and the gradual extension of the Icelandic EEZ. Little less than half of the catches or 100,000-200,000 t/y were Atlantic cod. Catches of other species were around 50,000 t/y for haddock, saithe, and redfish and 1,000-5,000 t for most of the other species. Foreign catches of Atlantic cod were roughly similar to Icelandic catches, but foreign fleets caught much higher quantities of most other species (Anon, 1997b; Jónsson and Magnússon, 1997; Hjörleifsson et al., 1998).

Another historical DWF fishery conducted in Icelandic waters this century was for herring, mainly for the Norwegian spring-spawning stock. Most of these foreign catches were by Norwegian boats, but there were also contingents from the Faeroe Islands, Finland, USSR, Sweden, and Germany (Jónsson and Magnússon, 1997). With two exceptions, the foreign catches of herring were 10,000-20,000 t/y for this entire period. In the 1930s the catches increased slowly to 57,000 t in 1937 and then declined and finally stopped as a result of World War II. The other episode happened after 1958 when catches increased again, to a maximum of 172,000 t in 1962, then declined again and finally stopped entirely when the stock collapsed in 1968. Since then there have not been any herring fisheries in Icelandic waters except by Icelanders.

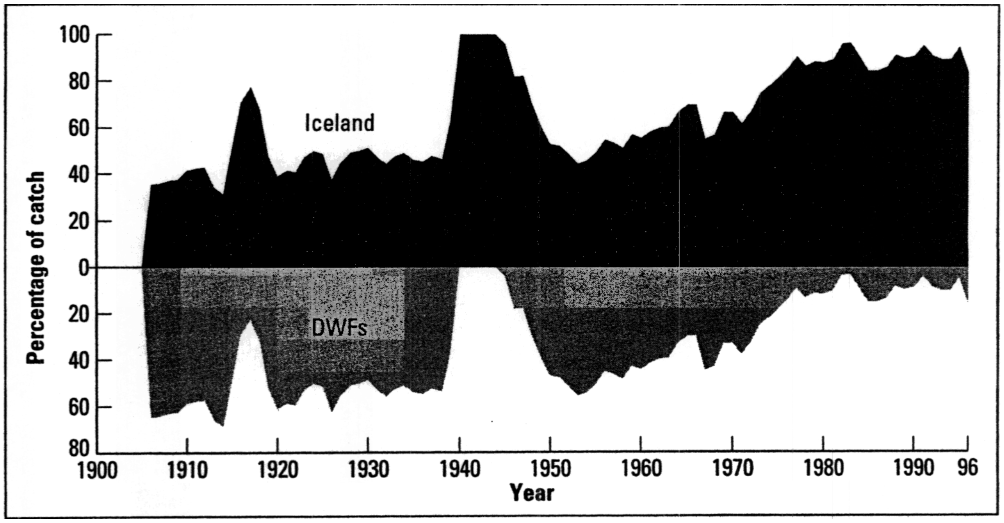
The foreign purse-seine fisheries did not worry Icelanders in any way. The foreign boats generally landed their catches in Iceland and there was a belief that there was enough herring for everyone. The near complete collapse of the herring stocks came as a surprise for all parties involved. In contrast, the foreign-trawler DWF posed many problems for Iceland. The trawlers did not land their catches in Iceland, they frequently destroyed the more primitive Icelandic fishing gear, and, of course, Icelandic fishermen were concerned that the trawlers were destroying the bottom and overexploiting their fish stocks. But since the oceans were considered free for everyone, any real measures to protect the stocks were quite hopeless. The two world wars offered a relief that might have saved the stocks from early collapse. This did not last long however as after the wars the DWFs always came back with larger boats and more advanced equipment, equipment often developed for military use during the wars.

Iceland emerged as an independent nation after World War II and was determined to reduce foreign fisheries in her waters. This resulted in the extension of the Icelandic EEZ to 4 miles in 1952, 12 miles in 1958, 50 miles in 1972, and finally 200 miles in 1975. These extensions resulted in conflicts with DWF nations, primarily Britain and

Germany. These were dubbed "the Cod Wars". A few shots were fired, and at least one life was lost during the conflicts. In the end, Iceland managed to expel the foreign fleets from the 200-mile zone. Foreign catches have been negligible in Icelandic waters ever since. The only exceptions were a few Belgian trawlers and Norwegian longliners that were allowed to catch small quantities of demersal species until recently, Faeroese longliners that are still allowed to catch various demersal fish species (about 4,500 t in 1996), Greenlandic, Faeroese, and Norwegian boats that have the right to catch 19 per cent of the total capelin TAC, Greenlandic boats that are allowed to catch half of their oceanic redfish TAC, and Faeroese, Norwegian, and Russian boats that are allowed to catch the Norwegian spring-spawning herring stock if it migrates into Icelandic waters. Other foreign boats can, under certain circumstances, get permits to fish experimentally in Icelandic waters. This is however rare, the most recent example happening in 1996 and 1997 when Japanese vessels were allowed to catch bluefin tuna in the southern edge of the Icelandic EEZ. This was allowed because Icelanders did not know how to catch tuna but saw a chance to learn the trade (Anon., 1997c).

Until the middle of this century (with the exceptions of the wars), DWFs took half or more of the total catch in Icelandic waters (Figure 10); after 1955 Icelanders however started catching the larger part. This trend has continued and foreign catches are now only a small part of the total in Icelandic waters (Figure 12).

Figure 12. **Iceland regained control over its fishery resources in the 1970s**



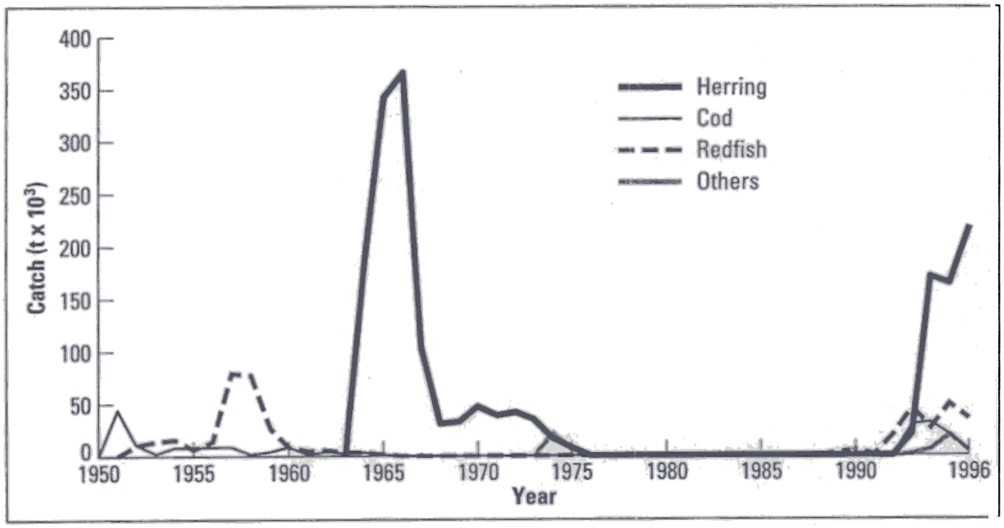
There are several fisheries on straddling stocks just outside Icelandic waters including fisheries for Greenland halibut in Greenlandic and Faeroese waters, for shrimp on the Dhorn Bank, and for oceanic redfish on the Reykjanes ridge southwest of Iceland. In 1996, Iceland and the Faeroe Islands were virtually the only nations catching Greenland halibut in their own waters, 22,000 and 6,000 t/y each respectively. However, 7,500 t were caught in Greenland waters by the United Kingdom, Norway, and Germany (Hjörleifsson, 1997). A similar situation occurs with shrimp on the Dhorn Bank. In 1997, estimated catches in the Greenlandic EEZ were Denmark 301 t, Faeroe Islands 588 t, Greenland 1,355 t, and Norway 1,219 t. Iceland caught 2,856 t in its own EEZ. The catches of oceanic redfish are conducted in international waters by many nations (Magnússon and Magnússon, 1995).

The total catch has been increasing from 60,000 t in 1982 (caught by Russian trawlers) to the current catch of 170,000 t, of which Iceland takes around 30 per cent.

ICELAND AS A DWF NATION

Until recently Iceland has mostly been a coastal fishing nation. There are however some exceptions. Early this century, Icelandic trawlers went fishing experimentally to Newfoundland, Norway, and Greenland (Thorleifsson, 1974). With the exception of Greenlandic waters, these fisheries were not maintained. Other exceptions were herring fisheries in the Norwegian Sea (mainly after the herring stocks collapsed in Icelandic waters), a small scale capelin fishery in Newfoundland waters in the mid-1970s, and considerable Atlantic cod and redfish fisheries in Greenlandic and Newfoundland waters during the 1950s and 1960s (Figure 13) (Óskarsson, 1991).

Figure 13. **Distant water fisheries by the Icelandic fleet have been increasing recently**



The current outward expansion of the Icelandic fleet has two main roots: the shortage of quotas in Icelandic waters, coupled with an oversized fleet, and the recent emergence of some very healthy fishing enterprises that began looking for expansion opportunities. Presently most stocks in Iceland have a TAC, but there is overcapacity in the fishing sector. Accordingly, fleets started to look at fishing opportunities elsewhere. These fisheries are now considerable and are mainly conducted on four species in four areas; Arcto-Norwegian cod outside the Norwegian EEZ in the Barents Sea, oceanic redfish on the Reykjanes ridge close to the Icelandic EEZ, Norwegian spring-spawning herring in the Norwegian Sea, and shrimp on the Flemish Cap off Newfoundland. Other brief experimental fisheries have also been conducted within the 200-mile zone of Rockall (British) and Svalbard (Norwegian). These ventures were actually implemented to find out if the nations claiming these islands were willing to defend the EEZ around them, which they did (Anon., 1994a). The current individual transferable quota (ITQ) system has allowed many Icelandic companies to make very healthy profits. This has allowed them recently to buy fishing companies, boats, and fishing rights, or to act as advisors to foreign companies all over the world. This includes the Falkland Islands, Chile, Mexico, the United States, Canada, Russia, Namibia, Malawi, France, Germany, Lithuania, Poland, and the United Kingdom.

Currently Icelandic companies own the majority of the German DWF. These are not allowed to fish in Icelandic waters but are catching Greenland halibut in Greenlandic waters and redfish on Reykjanes ridge, the same stocks as in Icelandic waters. Large parts of the EU quotas are thus actually used by the Icelanders to fish their own stocks in other waters.

Some Icelandic fishing ventures abroad, such as the pollock fishery of Alaska and squid fishery of the Falkland Islands failed. Others such as the shrimp fisheries in Mexico seem to be successful. Due to reduced or restricted quotas on most species in Icelandic waters, distant water fisheries are without doubt important for the Icelandic economy (see also Bates, 1996). However, with the exception of the Norwegian spring-spawning herring, all the Icelandic distant water catches declined between 1996 and 1997. Some of this can be explained by restricted quotas on the distant water stocks, or by unfavourable environmental conditions. Another factor is that quotas for Atlantic cod in Icelandic waters are increasing and boats can thus fish more at home. If this continues to increase as predicted (Anon., 1997d), then a large part of the incentive for distant water fishery is gone. In a similar way, if the Norwegian spring-spawning herring stock migrates back to Icelandic waters as predicted, this fishery will overnight switch from being a distant water fishery to a coastal fishery, although the catches and fleet composition will be the same. The sustainability of this outward expansion of the Icelandic fleet and fishing companies is thus difficult to evaluate at present time.

FLEET CHARACTERISTICS AND NUMBERS

The capacity of the Icelandic registered fleet declined in 1990 compared to the previous year for the first time since 1970, and continues in a slight decline. The total tonnage decreased until 1992 but has increased since as the boats are getting fewer but larger. In 1996 there were slightly fewer than 2,000 boats licensed to fish in Icelandic waters. The fleet is split into three major categories: about 1,000 small undecked boats, 679 decked boats of various size categories, and 121 trawlers (Anon., 1997b). Fifty-four trawlers are more than 500 GRT and roughly half of the total trawler fleet processes and freezes at sea. The decked boats are the most diverse category and often switched between different fishing gears: 17 of these boats are more than 500 t. These boats and some 30 other slightly smaller vessels are specialized for purse-seining, but can also use other fishing gear. The Icelandic DWF is made up of the large trawlers and the purse-seiners. Distant water fisheries are however only seasonal for most of them. Only seven to ten Icelandic boats fish purely in distant waters, with no fishing rights in Icelandic waters.

The land-based processing industry is made up of 140 freezing plants, 210 salting plants, 30 herring processing factories, 13 scallop plants, and 13 canning factories (Pálsson, 1996). The fishing industry provides full-time jobs for about 6,000 fishers and 7,000 people working on fish processing ashore (Anon., 1997b). This is a total of 11 per cent of the national workforce.

Foreign boats fishing in Icelandic waters are few compared to the Icelandic fleet and their number varies between years. Norwegian purse-seiners and Faeroese purse-seiners and longliners are mostly boats that conduct distant water fisheries seasonally, similar to the Icelandic DWF.