PART II: NORTH-EASTERN NORTH ATLANTIC

THE SEA AROUND ICELANDERS: CATCH HISTORY AND DISCARDS IN ICELANDIC WATERS

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ABSTRACT

This paper aims to give and overview of the fisheries 'around Icelanders' and explains the methods involved in constructing a database on these fisheries. This refers to fisheries 'around Icelanders' because information is given both for fisheries of all countries in the waters around Iceland and for fisheries conducted by Icelandic boats in distant waters. The introductory section will include and overview of these fisheries, descriptions of the fishing grounds, a history of fisheries management in Icelandic waters and a description of the sources of data used to reconstruct the catch and effort database. The second section introduces the fishing fleets operating in Icelandic waters. Icelandic fleets are discussed by fishing gear and foreign fleets by country. Information on how the effort history was reconstructed and information on the engine power of the Icelandic fleet is also included in this section. Reconstruction of catch history and discard estimates is explained in the third section, which also includes a brief summary of all species harvested in Icelandic waters. Finally, some primary results and a discussion are presented.

INTRODUCTION

Few people in the world are as dependent on fisheries as Icelanders. Marine resources around the island, particularly cod, are the foundation of the country's export earnings. While fishing and fish processing represent 15% of GDP, fisheries account for 75% of the total export earnings, with cod representing 25% of the 75% (*www.hagstofa.is/talnaefn/Lh_1999/Lh_1999.htm*). Thus, a good knowledge of the history of the fisheries is vital for the country.

Here catch and effort information from the Icelandic fishing grounds since 1950 and some of the main factors concerning the Icelandic fisheries are discussed. Obviously, not all of these factors can be fully covered in the limited scope of this report, but references are given to other more detailed sources of information. A great amount of literature is available about Icelandic fisheries from a wide variety of data sources; however, large gaps are still found and many inconsistencies exist between sources. These gaps in the records can be partly filled in with careful historical analysis of old documents (which was not possible within the framework of this project). Although many of the gaps or inconsistencies may never be fully resolved, attempts were made to leave no gaps and therefore, when information was lacking, indirect clues were used to give the best estimate possible.

The contribution of this report on Icelandic Fisheries to the *Sea Around Us* project (SAUP) is a database which contains all the information on fisheries in Icelandic waters, as well as for fisheries conducted by Icelandic boats in distant waters. This database will function as the main Icelandic input in order to direct further studies within the SAUP project (Pauly and Pitcher, 2000). The aim of this specific paper is to primarily describe the methods used to analyze and reconstruct these fisheries and, secondly, to provide a short history of these fisheries. The resulting database is not given in this document since it is too large, and interested parties should contact the author.

The Fishing Grounds

The geographic boundaries of the Icelandic fishing grounds have changed with time. Originally, the grounds consisted of the waters above the continental shelf, which then changed to the International Council for the Exploitation of the Sea (ICES) fishing area 'Va'. Most recently, the grounds have been extended to the 200 nm economic exclusive zone (EEZ) (Figure 1). These boundaries do, however, overlap to a large degree. All of the continental shelf above 400 m depth is both within ICES Va and the 200 nm EEZ, as is most of the shelf above 600 m depth. The minor exception is the Iceland-Faroe Ridge, which does not go below a depth of 600 m. This means that until around the 1970s most fisheries carried out in Icelandic waters were within these zones. The only part of the ICES area Va that is outside the 200 nm EEZ is an area east of Greenland that does not sustain large fisheries. However, the 200 nm EEZ also includes deep water north, east, south and west of Iceland that is not included within the boundaries of ICES Va. Also, some of the Faroese grounds (ICES Vb) are located within the Icelandic 200 nm EEZ. Generally, the Icelandic 200 nm zone covers most of the ICES Va, but also includes parts of ICES XIVa, IIa, Vb, XIII and XIVb.

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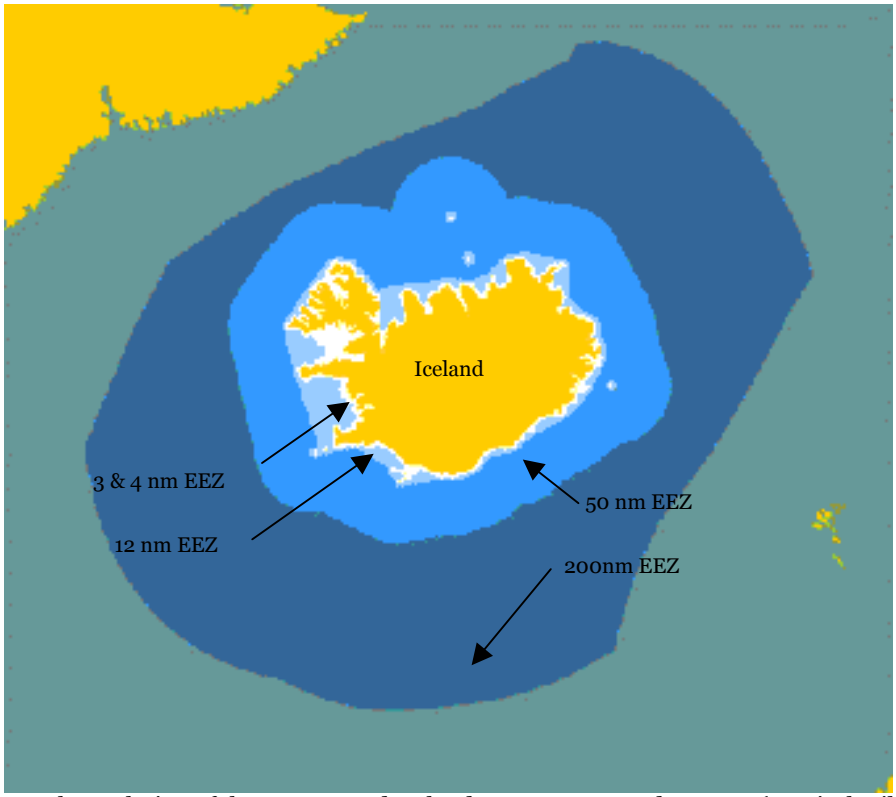

Figure 1. The evolution of the EEZ around Iceland; 3 & 4, 12, 50 and 200 nm (nautical mile) EEZ are shown. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

The period since 1950 has seen large changes in the size of the Icelandic EEZ (Figure 1.). In the beginning it consisted of a 3 nm extension from the coastline. The northern boundary of the EEZ was extended to 4 nm in 1950, including all bays, while the EEZ in all other regions remained at 3 nm. All trawl, Danish seine fisheries (including Icelandic) and foreign herring (*Clupea harengus*) fisheries were forbidden to operate within the EEZ. In 1952 the EEZ was extended to 4 nm all around Iceland. At this time the foreign fleets did not go beyond or protest the extension. In 1958, the Icelandic government extended the EEZ from 4 nm to 12 nm and severely limited trawl and Danish seine fisheries within this area. This time the foreign fleets refused to comply since large parts of their major fishing grounds became off limits. British naval destroyers entered the zone to protect their fishing vessels and their confrontation with Icelandic vessels, which became known as the first modern 'cod war' (*Gadus morhua*), lasted until 1961. This restricted both foreign and Icelandic trawler operations and was, in fact, a major contributor to the stagnation and decline of the Icelandic trawler fleet during that period. These actions also meant that Danish seine fisheries were almost non-existent until 1960 when they were once again allowed within limited areas.

The next extension of the EEZ was to 50 nm in 1972 and at that time Icelandic trawlers were excluded from the restrictions. This meant that cod was virtually off limits to foreign fleets and they could only sustain their catches within this zone when under the protection of their navies. The 50 nm limit was only a temporary measure by the Icelandic government until they could extend it to 200 nm. They did this in 1975 promoting the third and last modern cod war. Icelanders were eventually successful in laying claim to the extension of the EEZ boundary to 200 nm and the British fleet left Icelandic waters in 1976 followed by the West German fleet in 1977. However, Belgian, Faroese and Norwegian boats were allowed to continue fishing limited amounts.

Currently, Iceland has maritime boundaries with Greenland, Faroe Islands and Norway (Jan Mayen). The boundary with Jan Mayen is 200 nm north of Iceland; since the islands are uninhabited, the Norwegians did not lay claim to a boundary set equidistant between the two countries in this region. However, some parts of

the Icelandic EEZ overlap with parts of EEZs claimed by Greenland and the Faeroe Islands.

Most fisheries in Icelandic waters take place within all of the aforementioned areas (Icelandic continental shelf, ICES Va and 200 nm EEZ). These fisheries consist of haddock (*Melanogrammus aeglefinus*), catfish (*Anarhichas* spp.), plaice (*Pleuronectes platessus*[a)]), scallop (*Chlamys islandica*), lobster (*Nephrops norvegicus*) and many more species. Other species such as cod, Icelandic summer spawning herring, golden redfish (*Sebastes marinus*), saithe (*Pollachius virens*) and shrimp (*Pandalus borealis*) migrate to some extent to other waters or have small trans-boundary stocks however, these are minor or infrequent and therefore can be ignored. Problematic stocks, are stocks that either migrate regularly to Icelandic waters or have large trans-boundary components. These stocks include:

- Capelin (*Mallotus villosus*)-found in ICES Va and XIVa, Icelandic, Norwegian and Greenlandic EEZs;
- Oceanic redfish (*Sebastes mentella*)-found in ICES Va, Vb, XII and XIVb, Icelandic, Greenlandic EEZs and international waters;
- Greenland halibut (*Reinhardtius hippoglossoides*)-found in ICES Va, XIVb, IIa and Vb, Greenlandic, Icelandic and Faroese EEZs;
- Norwegian spring spawning herring-found in ICES Va, I, IIa and IIb, Russian, Norwegian, Faroese, Icelandic EEZs and international waters; and
- Blue whiting (*Micromesistius poutassou*)-found in ICES Va, VIII, VII, VI, Vb and IIa, EC, Faroese, Icelandic, Norwegian EEZs.

A few other species are occasionally found in Icelandic waters but usually in low quantities and include mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), turbot (*Psetta maxima*), bluefin tuna (*Thynnus thynnus*), pollack (*Pollachius pollachius*) and squid (*Loligo* spp.).

Management of the fisheries

Except for the limits on trawl and Danish seine fisheries mentioned above, little was done for a long time to restrict the Icelandic groundfish fisheries. After the expulsion of the foreign fleets, Icelandic groundfish fishing capacity grew considerably and quickly reached the same level as all the fleets combined in previous years. Icelanders had only temporarily managed to steer away from serious overfishing of groundfish species. Effort restrictions were enforced in 1977 so that each boat could only fish a limited number of days per year. However, there were no limits of entry into the fishery. This system was only used until 1982 as it proved to be economically wasteful (Arnason, 1996). The prototype of the Individual Transferable Quota (ITQ) was introduced into the groundfish fisheries in 1984. Initially, under this new management system some boats were allowed to go for effort quotas and boats less than 10 Gross Registered Tones (GRT) were not included. This management system was largely abolished in 1990 when a uniform quota system was established for all important species.

The first fishery to be managed by a quota system in Iceland was the herring fishery, which experienced a total stock collapse, resulting in a moratorium being put in place in 1972. The fishery was partly resumed in 1975 and boats were given individual non-transferrable quotas. Due to economic reasons this was changed to fully transferable quotas in 1979. The other large pelagic fishery, the capelin fishery, followed a similar trend later. Individual quotas were introduced in 1980 and made transferable in 1986.

Although it is not within the scope of this study to evaluate the Icelandic ITQ system, its effects on the fisheries are hard to ignore. Of direct interest to our analysis is the fact that the system promoted a reduction of discarding of certain species and an increase in discarding of other species. Species that did not have a Total Allowable Catch (TAC) were now retained or targeted specifically instead of being discarded (most likely dead) as they had been in the past. Hence, the landing statistics show an increase in landings for these species, which does not necessarily reflect the same increase in fishery-induced mortality due to the discarding activity in the past. On the other hand, the ITQ system encouraged discarding of small individuals from species that now had a TAC (high-grading).

It is, however, an over-simplification to describe the Icelandic fishery management as a pure ITQ system. The fisheries are also managed by various other methods, such as gear restrictions, minimum mesh sizes and mandatory use of sorting grids in some fisheries. Large nursery areas are permanently closed to fisheries, and spawning areas for cod are closed during the main spawning season. Temporary area closures

a) The correct scientific name for the European plaice, often called *Pleuronectes platessa*, is *P. platessus*. All scientific names in this report are based on FishBase (*www.fishbase.org*).

are also used extensively if the catch is found to have a high number of juveniles. Of these fisheries, those using trawlers are generally more restricted than other fisheries. For example, trawlers (with some exceptions) are not allowed to operate within 12 nautical miles from the coast.

Subsidies have played a part in the management of Icelandic fisheries. Money earned in good years was used to subsidize fisheries in bad years, or, probably more often, loans were used for subsidies in the hope that future revenues and taxes from fisheries could re-pay them. Taxation and subsidies also differed between fisheries. Exchange rate manipulation was also often used. This was particularly extensive after the Second World War through the 1970s (Runolfsson, 1997), but has diminished substantially since then. The remaining subsidies are in the form of personal income tax breaks whereby fishers can withhold a certain amount from taxes for each day registered at sea. This has been estimated to be about US $23 million per annum in lost revenues for the government. Indirect government expenditures related to the fishing industry has been estimated to be approximately US $38 million. This includes fishery related education, various monitoring and research institutions related to the fishing industry (including marketing), the Ministry of Fisheries and part of the operations for both the Ministry of Environment and Ministry of Foreign Affairs (Agnarsson, 2000). Of this amount, expenditures directly aimed at managing the marine stocks Marine Research Institute, Coast Guard, Ministry of Fisheries, Directorate of Fisheries) have been estimated at around US $16 million per annum. In turn the government receives about US $8.5 million per annum from the fisheries from various fees and licenses.

Information sources

All Icelandic fishing boats (except those fishing for lumpfish *Cyclopterus lumpus*), are required to get their catches weighed (by species) at ports of landings by government certified officials. These reports are collected by the Fisheries Association of Iceland (*Fiskifélag Íslands*) in order to get the total landings. The information from the Fisheries Association is in variable format. *Útvegur* (Fisheries Association of Iceland 1978-1998 and Statistics Iceland 1999-2000) provide excellent information on effort and catch by gear from 1977 to 1999 also some information on total landings since 1968. This report also provides information on various aspects of Icelandic fisheries such as the size and capacity of the fishing fleet, effort by fishing gear, landings and catch value of the fishing fleet by fishing gear or port of landing. The Fisheries Association also provided a file on the distribution of catches by fishing fleets since 1982. This is from the database behind the information provided by *Útvegur*. There are, however, slight differences between the two. In cases of discrepancy the information on the file was used since it is continuously updated as new information becomes available.

Using these two sources of data, the period from 1977 is well covered by the landing information provided by fishing gear, effort by each fleet and fishing capacity. Records prior to 1977 are much more problematic and patchy. These records include annual reports from 1957 to 1976 on the fisheries by Icelandic boats in *Ægir* (Elísson 1957 to 1969, Anon., 1970 to 1977), a journal published monthly by the Fisheries Association. There are also special reports in the same journal on the trawler fleet (Elísson 1956, Björnsson 1958, Árnason 1959, 1959a, 1960 to 1964, Steinsson 1969, 1969a, 1969b, 1970, 1970a, 1971), the herring fleet (Anon 1963, 1963a, 1965 to 1969) and the winter season groundfish fleet (Anon 1958 to 1962 (incl. a and b), 1963b, 1963c, 1964, 1966c, 1966d, 1967b, 1968b, 1966a to 1972a). These reports provided vital information, but suffered from various problems. These problems included changes in format between years, different information given for different periods, and inclusion of catch from distant waters in some years (i.e., the numbers were often not directly comparable between years and could not be used without prior standardization).

The *Bulletin Statistique des Pêches Maritimes* published by ICES (1905-1990), provides vital information on fisheries in Icelandic waters until 1987 and is the almost exclusive source of information on the distant water fleets in Icelandic waters. The *Bulletin Statistique* also provides valuable information on the Icelandic fisheries by gear from 1966, supplementing information provided by *Ægir*. This information is far from being perfect and it had to be used with caution. The *Bulletin Statistique* also provided vital information on Icelandic catches in distant waters since catch was generally not separated by grounds in Icelandic sources. Information on distant water fleets in Icelandic waters after 1987 was taken from a database provided by ICES (STATLANT).

Nytjastofnar sjávar (Anon. 2000) is an annual report published by the Marine Research Institute in Iceland. This provided numbers for total catch each year for many species. This information agreed reasonably well with *Bulletin Statistique*

and *Útvegur*, but there were always some differences. *Nytjastofnar* only provides total catch information on the most important commercial species, and it does not give information on effort. However, it does give information on various aspects of the biology of the stocks such as stock size, growth and maturity. The time periods for which catch data were reported varies between species; cod has information since 1905, haddock, saithe and other important species since 1950 and other species of lesser importance have records for shorter time periods.

Hagskinna is a single publication by Statistics Iceland (Jónsson and Magnússon, 1997). It is a collection of various historical statistics for Iceland, stretching back many centuries. However, most of the information on fisheries in *Hagskinna* is from the Fisheries Association or ICES *Bulletin Statistique*, although parts have been corrected from contemporary sources. *Hagskinna* does not provide catch information or effort by fishing gear, but does provide some information on categories such as the total catch by trawlers, total number of boats, and average weight of trawlers and decked boats. The effort is given in sea-days for the trawlers, but these numbers were not directly useable because they included number of sea-days in distant waters. The same applies to catch numbers. As well, the foreign catch was not separated to species except for capelin and herring. *Hagskinna* was thus only useful for our analysis for comparison to other sources and provided valuable information for periods prior to 1950.

Additional information was found in databases from the *Food and Agriculture Organization* of the United Nations (FAO) and the Northwest Atlantic Fisheries Organization (NAFO, *www.nafo.ca/science/stats/index.htm*). The information provided by NAFO was used to find the Icelandic fisheries in the N.W. Atlantic, since this was not provided in *Bulletin Statistique*. The FAO information was only used for comparison with other sources, since it only provides information on the whole of Northeast Atlantic and specific to grounds.

Below is a summary of the data sources used and how they are cited in the text:

- *Útvegur*, annual report since 1977, cited as *Útvegur*;
- *Ægir*, monthly journal published for the whole period here, many articles, cited with authors name or cited as *Ægir* when talking about in general;
- *Hagskinna*, one publication on historical statistics, cited as *Hagskinna* or Jónsson and Magnússon (1997);
- *Bulletin Statistique*, annual publication on fisheries from 1903 to 1987, cited as *Bulletin Statistique* or ICES;
- ICES database, a follow up on *Bulletin Statistique*, cited as ICES;
- *Nytjastofnar sjávar*, annual report by the MRI, cited as *Nytjastofnar* or Anon. (2000);
- FAO database on worldwide catches since 1950, cited as FAO; and
- NAFO database on the catches in the N.W. Atlantic since 1950, cited as NAFO.

More detailed texts in English about the fisheries in Icelandic waters are to be found in Jakobsson (1992), Jónsson (1994), Schopka (1994), Thor (1995), Arnason (1996), Baldursson *et al.* (1996), Halliday and Pinhorn (1996), Hannesson (1996), Runolfsson (1997), Vilhjálmsson (1997), Jakobsson and Stefánsson (1998), Valtysson (1998), and Guðmundsson and Scopka (1999). Good information is also found in Jónsson (1984), Þorsteinsson (1980), Jónsson (1988), Jónsson (1990) and Gunnarsson *et al.* (1998), but these are all in Icelandic. Other information is to be found on the web sites listed in Appendix I.

THE FISHING FLEET

Fisheries have a long history in Icelandic waters. There are references to fishing in the age of Settlement (874 to 930 AD). The importance of fisheries increased during the 14th century and has been a considerable part of the economy since. Until the 19th century fisheries by Icelanders were almost exclusively conducted by open rowing boats. These proved efficient since the fishing grounds were usually close to shore. Decked sailing vessels were first used in Greenland shark fisheries and, to a limited degree, in cod fisheries from the beginning of the early 19th century. It was only after 1880 that decked sailing vessels became an important part of the cod fishery. However, their heydays were short-lived and they declined in numbers after 1907 and were phased out altogether by 1928. By that time rowing boats were also becoming rare and very few of them seem to have survived past 1950. The reason for the decline of these boats was, of course, the motor. The first motor was put into an Icelandic fishing boat in 1902 and the first all-Icelandic owned steam trawler was bought in 1904.

The Icelandic fishing fleet has traditionally been split into 3 groups; trawlers, decked boats, and

undecked boats. However, the divisions among these are not always clear. The trawler group is split into side trawlers used from 1905 to 1978 and stern trawlers used since 1970. The decked boat category is by far the most diverse. It ranges from small boats (smaller than many undecked boats) to large purse-seiners and large multipurpose boats. The separation of decked boats and trawlers is not very clear since many decked boats use trawl gear. Many of the decked boats are also structurally identical to stern trawlers, and some of the old side trawlers were converted to purse-seiners, which put them into the decked boat class. This classification is in fact a kind of an anachronism from the times when boats were much smaller than trawlers. This started to change around 1960 when large purse-seiners began operating. Since Icelandic data sources always separate between these classes and the amount of information on each is very different, they cannot, except in a few cases, be combined. Examples where they could be combined include trawlers and decked boats using gillnets, and decked boats and undecked boats using scallop dredges. In these cases, the trawlers and undecked boats are added to the decked boat class because the fisheries by these gear type are insignificant compared to the decked boats. This was not possible in most other cases where the boat categories used a common fishing gear on a larger scale, such as trawlers and decked boats using trawl and undecked and decked boats using handline, longline and gillnets.

Nowadays, radar, fish finders and global positioning system (GPS) are standard equipment on most small and large Icelandic fishing vessels. Icelandic fishers were, in fact, the first in the world to put some of this equipment in their fishing boats (Óskarsson, 1991). The trawler *Ingólfur Arnarson* (named after the first settler in Iceland), which came newly built to its Icelandic owners in 1947, was the first fishing boat in the world with radar. By 1950, almost the entire trawler fleet was equipped with radar and automatic sounders and was considered, at that time, the most modern trawler fleet in the world. This equipment greatly increased the fishing capacity of the trawlers, helping them find the fishing grounds and almost unexpectedly, find the fish with the sounders. The herring fleet was also at the forefront of the use of new technology. The first Icelandic purse-seiners were experimenting with sonar in 1954, and the powerblock in 1959. By 1961, the whole purse-seine fleet was equipped, and this technology had almost completely replaced traditional drift netting (Jakobsson, 1980). Another primary example of this rate of dissemination was when the Icelandic trawler fleet changed from being outfitted with side trawlers to a fleet composed entirely of stern trawlers within a span of 9 years. More recently the handline fleet has changed almost completely from traditional handlines to automatic, computerized jigging reels.

The evolution of the Icelandic fisheries can therefore best be described as punctuated equilibrium. As has been demonstrated above, changes in the Icelandic fisheries are usually rapid. From the first use of new equipment, techniques or approaches, only a few years pass until the entire fleet is following suit. The main factors influencing the Icelandic fisheries are given in Appendix II. Furthermore, it should be noted that most boats use two or more types of fishing gear. They regularly switch between lobster trawl and longlines, between shrimp trawls and Danish seines, between purse-seines and shrimp trawls, between pelagic trawls and bottom trawls, etc.

Engine capacity

The standardized unit used for effort is Horsepower-sea-days. There is no source that gives this unit directly per fishing gear fleet, therefore HP and sea-days had to be acquired or estimated independently.

All information on the engine power is from *Útvegur*. It gives the number of boats and total HP per size classes of boats in 1970, 1975, 1980 and after 1982. Information on the HP by fishing gear is not available, but information on the weight (GRT) of boats using each fishing gear is available for all the fleet after 1975 and for trawlers from 1950 onwards (*Ægir* and *Hagskinna*). Hence, we estimated the average HP of each fleet after finding the relationship between boat weight and HP. The average HP of each fishing gear fleet was calculated with a power function

$$HP = aGRT^{b} \qquad \ldots 1)$$

The parameters a and b are estimated for each year by minimizing the sum of squares of the difference between observed and predicted numbers. There seems to be a rather consistent linear increase in parameter a from 1970 to 1985 and then a shift towards an even steeper linear increase after that (Figure 2). Parameter b, however, seems to be stable until 1985 but then begins to decrease. These changes in the parameters indicate that the boats are getting more powerful per weight with time, but the

increase is faster in smaller boats than in larger ones. Given these trends, it is quite simple to estimate the parameters for years when

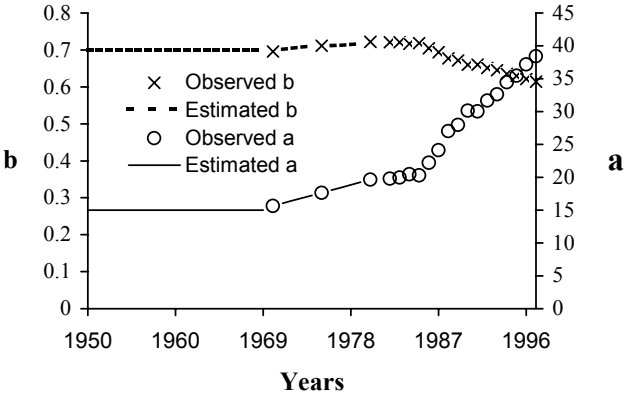

Figure 2. Observed and estimated parameters in the GRT-HP function.

information was not available, simply by fitting a line between known years. There was no information available on engine power before 1970. It was therefore decided to use the 1970 value for all the years from 1950 to 1970.

There is no information readily available on the average weight of undecked and decked boats by fishing gear use prior to 1976. However, there is information available on the total number of boats and their total weight (*Bulletin Statistique*). The average weight (W_{xy}) of boats by fishing gear category prior to 1976 was estimated by calculating how the known average weight in 1976 ($W_{1976,y}$) for each gear category changed based on proportional breakdown of fleet by geartype.

$$W_{xy} = \frac{W_{1976,y} \sum W_{x,y}}{\sum W_{1976,y}} \qquad ...2)$$

where W_{xy} is average weight, x is the year and y is fishing gear category. From this we get estimates on the average weight of fleet categories prior to 1976 assuming that changes are the same for all the fleets.

Handline

This is the traditional fishing gear in Icelandic waters, used since ancient times. It is the primary fishing gear of the undecked boats, but also used by decked boats. Although the handline is a traditional fishing gear, it has gone through many changes. The line itself has changed from wool, to hemp to nylon and the hook has also evolved and become more effective. By far the most revolutionary change in handline technology has been the invention of the computer-driven electronic jigging reel, whose development was much influenced by an Icelandic firm. Consequently the majority of the Icelandic handline fleet are now equipped with electronic jigging reels. The difference in efficiency from the old days (before the mid-1980s) where one fisher would be at each line doing everything manually to the current way is immense. By having a computer control the jigging activity, one man can now easily operate many handlines. In addition to electronic jigging reels, many modern undecked boats (and probably all decked boats and trawlers) are equipped with fishfinders, radar and GPS. This, of course, means that the catch per day per boat is much higher for modern boats given the same amount of fish in the sea. The handline is mostly used to catch cod but also, to a much lesser extent, other groundfish species. A version of the handline is also used to fish for squid.

Data on effort by the decked boat fleet are well covered by *Útvegur* after 1975, where sea-days for each gear category are well documented. *Ægir* is the main source of effort data from 1972 to 1975 and *Bulletin Statistique* from 1966 to 1971. There was no information on the total effort by decked boat fleets from 1950 to 1965, but information was available on catch by gear and total effort in the winter fishery from 1958 to 1972 (*Ægir*). This was used to estimate the effort from 1958 to 1965. However, the catch by gear is not separated by species, but it is mostly cod. From this we can estimate the annual effort spent by the handline, longline and gillnet fleets for the period from 1958 to 1965. This was not a simple task for many reasons. The first was because effort by decked boats was given in number of trips until 1965 and between 1969 and 1972, but in sea-days between 1966 and 1972 (both sea-days and number of trips were given between 1969 and 1972). Therefore, the pre-1966 numbers had to be converted to sea-days using information from years where both effort units were known. However, boats were much smaller in 1958 than in 1969, and therefore probably did not spend as much time at sea per trip. This problem was solved by assuming that the number of sea-days per trip increased from 1.67 in 1958 to 1.80 in 1965; for comparison, the average from 1969 to 1972 was 2.02. With this we can calculate the total number of sea-days in the winter fishery for the missing years. The next problem was to convert the number of sea-days for the winter fishery to total sea-days for the whole year. On the average 55% of the total annual effort was spent during the winter fishery between 1966 to 1969 and this number was used

to convert sea-days in the winter fishery for the missing years to sea-days spent during the whole year. The next problem, and probably the most complicated, was to assign this effort to fishing gear. Total effort (E) by gear (g) was estimated as

$$E_g = e_g \sum E_g \Big/ \sum e_g \qquad ...3)$$

where total annual effort in sea-days ($\sum E_g$) is known and e is relative effort calculated by

$$e_g = \frac{C_{g,winter} \sum E_{g,winter}}{q_g \sum C_{g,winter}} \qquad ...4)$$

where $C_{g, winter}$ is catch, and q_g is a proportionality parameter, calculated by

$$q_g = \frac{'C_{g,winter} \sum 'E_{g,winter}}{'E_g \sum 'C_{g,winter}} \qquad ...5)$$

These equations cannot be simplified because the parameters needed in Equation (3) are estimated from later years, while the parameters in Equation (1) and (2) available for each year. The proportionality constant q_g was estimated as 0.04 for handline, 0.18 for longline and 1.18 for gillnets. Gill netters have the highest value since they have the highest catch during the winter fishery.

The effort in each year (E_y) prior to 1958 was assumed to be proportional to total number of decked boats (*Hagskinna*), i.e.,

$$E_y = E_{y+1} N_y \Big/ N_{y+1} \qquad ...6)$$

where N_y is number of boats and y is year. No other more detailed effort unit was available for these years. Effort by undecked boats is not as well documented as the decked boat category. Total effort for undecked boats is known for 1969, 1970, and after 1975 from *Útvegur*, and by gear after 1982. The effort between 1970 and 1975 was assumed to be the average from 1969, 1970, 1975, 1976 and 1977, or 45,000 sea-days. The sea-days from 1963 to 1968 were assumed to be 43,000. The sea-days before 1963 were assumed to be proportionally the same as the number of reported open boats (the 1962 number was set to 43,000 sea-days for calibration), which is only available until 1962 (Statistics Iceland 1967) and after 1975 (*Útvegur*). The effort by gear until 1982 was assumed to be the same as the average proportions from 1982 to 1992.

Longline

Longlines are much more effective than handlines, but more difficult and expensive to operate. They are therefore used on larger boats, mainly decked vessels. The longline was the most popular groundfish fishing gear by the decked boats until the 1960s, when gillnets were increasingly used during the spawning season. Longlines are, however, still more popular during other parts of the year. The line is usually set close to the bottom, except for minor fisheries targeting porpeagle (*Lamna nasus*; from 1959 to 1962) and bluefin tuna (since 1997). The longline fishery has become increasingly mechanized in recent years, e.g., baiting is now commonly done at sea by machines. The longline fishery can be split into shallow and deep-water fisheries. Cod is the primary target in shallow water fisheries, but Atlantic catfish, haddock, tusk (*Brosme brosme*) and ling (*Molva molva*) are also caught, although tusk and ling are mostly found at intermediate depths. The main species fished in deep waters are Greenland halibut and redfish. The deep-water boats are much fewer, larger and more mechanized than those involved in shallow-water fisheries. Most foreign longline fisheries in Icelandic waters can be considered to occur at intermediate depths since they target species such as cod, halibut, tusk and ling, which are either found at, intermediate depths or over a wide depth range. Specialized longlines are used to target Greenland shark and halibut, as well as porpeagle and bluefin tuna. Mobile longlines (troll lines) are not used in Iceland.

The information available on effort and catch by this fishing gear is similar to that of the handline fleet and the same methods were used to fill in the missing years. However, undecked boats rarely use longlines, which makes the information on total effort more reliable.

Nets

The first recorded use of nets in Iceland was in 1753. However, this gear did not become popular until the 1950s when nylon became available. By 1961, when information on catch by gear during the spawning season became available, the gillnet catch was 100,000 t, compared to 58,000 t by longlines and 9,000 t by handline during the same season. The longline and handliners may have ended up with larger catches for the year since they are used throughout the year, whereas gillnets are more or less restricted to the spawning season.

Cod is the primary target as with so many other fishing gears, but large amounts of saithe are also fished, as well as smaller amounts of haddock and ling. Many specialized versions of bottom gillnets are used, mainly differing in mesh size. There are nets optimised for haddock (140-150 mm mesh size), lumpfish (180-270 mm), flatfish (Pleuronectiformes) (165-200 mm), Atlantic halibut (*Hippoglossus hippoglossus*) (460 mm), salmon (*Salmo salar*) (105-125 mm), trout (*Salmo trutta* and *Salvelinus alpinus*) (40-80 mm), and seals (harbor seal, *Phoca vitulina*; common seal, *Halichoerus grypus*) (280-290 mm). Common gillnets used in cod fisheries have a 139.7 to 254 mm mesh size, the former being the minimum allowed in most grounds. Common haddock, flatfish and halibut nets are included in the net category used here (the information available does not give numbers for each net type), other rules apply to the other nets. Generally they are all used in shallow waters, even freshwater, and although information is generally not available on the effort spent using these nets, they are at least not included in the gillnet category used here. Except for the lumpfish fisheries these are all very small fisheries. All of these nets mentioned are bottom gillnets. Driftnets have only been used in herring fisheries (63 mm mesh size).

Gillnets are mainly used by small to intermediate size decked boats, similar in size to longliners. The main change in gillnets was the introduction of nylon in 1954. It made the nets stronger and thinner, and recently new synthetic fibres are also being used. Another change was the introduction of lead sinkers in 1979, which replaced the use of stones. It has been estimated that this increased the catchability of cod by 20-30% (Þorsteinsson, 1980) since fewer fish escaped under the net. However, this innovation probably did not change the catchability of saithe substantially, since they are usually located higher off the ocean bottom than cod. Information available on catch and effort by bottom gillnets is very similar to that which is available for longlines and handlines, thus the same analytical methods were used.

Information on driftnets for herring is only available since 1972. However, catches were very low during the 1960´s since the purse-seines were much more efficient. Driftnets were commonly used before that, but information on effort and catch by gear is not available.

Traps

Traps are rarely used in Icelandic fisheries. They are only used in freshwater to catch eels, of which both the European and American form (*Anguilla anguilla* and *A. rostrata*) occur in Iceland, and in the sea to catch whelk (*Buccinum undatum*). From 1985 to 1987 traps were also used to catch spider crab (*Hyas araneus)* and Norway lobster (*Nephrops norvegicus*), but were discontinued. Low scale experimental trap fisheries for cod have been conducted but proved unsuccessful. Except for the freshwater fisheries for eel, trap fisheries are well documented.

Mobile seines

The Danish seine is the principal fishing gear used to target flatfish species at shallow and intermediate depths. They are also used to target cod and haddock. The boats using Danish seines are similar in size to longliners and gill-netters. In fact many boats switch between gear types seasonally. There were considerable fisheries carried out by Danish seine from the early 1930s until 1951. However, no information is available on the catch and effort of these vessels during that time period. Therefore, they were not included when total catch was divided amongst gear types. This may have a significant effect with regard to plaice, which was the main target species of the Danish seiner, but the influence on other species should be minimal since catch by other gear was probably much higher. The Danish seine has always been a controversial fishing gear in Icelandic waters. In the past, Danish seiners had to obey the same rules as trawlers (which were also controversial), and were not allowed to operate within the EEZ when it was extended to 4 miles off the coast in 1952, and to 12 miles in 1958. This meant that there were virtually no Danish seine fisheries during those times since it was then strictly a shallow water gear. However, trawlers could still operate in deeper water areas.

By 1960 Danish seines were again allowed into some formerly restricted areas and have been operating in Icelandic waters ever since. One of the results of this controversy was that the Danish seiners were well monitored and catch and effort statistics are therefore much better than for other decked boat fleets, excluding the lobster boats. We, therefore, have information on effort and catch by species since 1961 (*Ægir* from 1961 to 1971, *Bulletin Statistique* from 1972 to 1975, and *Útvegur* after 1975). The 1960 effort was assumed to be half the 1961 effort. Current minimum mesh size of Danish seiners is 120 to 155 mm, depending on the fishing area.

Seines

The first recorded use of purse seines in Iceland was in 1904. Purse seines are used by intermediate to large decked boats, some of which are of similar size to large trawlers. Purse seines are primarily used to fish capelin and herring; bycatch of other species is low. Two main types of purse seines are the herring and capelin seine. The main difference is the mesh size, which is 31.4 mm in herring seines and 21 mm in capelin seines. Information on the effort of the herring fleet is fragmentary as with many other gear types used by decked boats. Since the capelin fishery is much more recent, more information is available (in *Ægir* and *Útvegur*). There is good information on the pelagic seine fishery from 1961 to 1965 (*Ægir* , from 1966 to 1971 in *Bulletin Statistique*). This information is given in number of trips but converted to sea-days by multiplying it by the average number of sea-days per trip (3.5) in later years when both are known (1972 to 1975 in *Ægir* and thereafter in *Útvegur*). The only other information available on effort is the total number of boats participating in the herring fishery since 1955. Each boat spent roughly 100 sea-days from 1962 to 1967 and the same was assumed for boats from 1955 to 1961. Total number of sea-days was assumed to be 13 200 from 1950 to 1954, or the same as calculated in 1955.

Cod fisheries were also conducted with seines from 1962 until 1976. These proved to be highly efficient, too efficient actually, the quality of the catch being low, it could not be processed in time and a large part of the catch was wasted. These fisheries were, therefore, restricted within a few years after they started and were banned after 1976. Information on the effort in the cod seine fishery is not available until 1972 (*Ægir*), however, it was at its peak a few years prior to records being available. The only information available from 1964 to 1971 is on the sea-days spent by boats capable of using purse seine during the winter cod. This does not necessarily mean that they used cod seine during the winter cod fishery, they could as well have used purse seines in the herring fishery but switched to gillnets or longline during the winter cod fishery. Nevertheless, this is the only clue we have on the effort spent by cod seine (or more accurately on effort spent by boats capable of using cod seine). The total annual effort was estimated by assuming that the effort in 1971 was twice the known effort in 1972 since the known catch was double in 1971. Effort by cod seine (E_{cs}) before 1971 was then assumed to be proportional to the number of purse-seine capable boats (N_{ps}) participating in the fishery

$$E_{cs} = \frac{N_{ps,y} * E_{cs,y+1}}{N_{ps,y+1}} \qquad ...7)$$

The effort in 1962 and 1963 was estimated with Equation (4) since there was information only pertaining to the catch by cod seine in the winter fishery, but none pertaining to effort.

Trawls

The first trawler to be reported in Icelandic waters was a British trawler, in 1890. There were more of them each year thereafter, and at the turn of the century it was estimated that there were around one hundred foreign trawlers operating in Icelandic waters, most of which were British. In 1904, one year before statistics on the distant water fisheries in Icelandic waters became available, there were 180 trawlers reported in Icelandic waters, 150 of them being British. For comparison, 100 Norwegian boats fishing for herring, 150 French schooners, 100 Faroese and 130 Icelandic decked sailing vessels, and 2000 Icelandic rowing boats were also reported in the same year (Jónsson, 1984). The trawlers were very unpopular among the Icelanders, since they frequently destroyed the Icelandic fishing gear and were suspected of “destroying” the fishing grounds. The Icelanders, however, realized that their operation could not be prevented and soon began their own trawl experiments. The first Icelandic experiment with trawl was in 1901 with a sail trawler, followed by the first Icelandic steam trawler in 1904. Since then, trawlers have been in continuous use by Icelanders. Trawls are used for diverse fisheries. The ‘common’ trawl is used to fish for cod, haddock, saithe and other groundfish at shallow and intermediate depths, and for redfish and Greenland halibut in deeper waters. Specialized trawls are used to fish for Norway pout (*Trisopterus esmarki*), shrimp, lobster and pelagic fish.

Many species are caught as bycatch in trawl fisheries, some of which (halibut and common skate - *Raja batis*) are always retained while other close relatives such as long rough dab (*Hippoglossoides platessoides*) and starry ray (*Raja radiata*) are mostly discarded. In the past, shrimp trawlers caught large amounts of other species such as cod, haddock, redfish and Greenland halibut. However, sorting grids have been obligatory since 1996 and bycatch of these fish species has been greatly reduced. Sorting grids are not used by lobster trawlers, which

therefore have large amounts of cod, redfish, haddock, monkfish (*Piscatorius lophius*) and witch flounder (*Glyptocephalus cynoglossus*) as bycatch. Boats using lobster trawl are mainly decked boats of intermediate size. The shrimpers are a much more variable fleet. Some very small undecked boats fish for inshore shrimp while large trawlers fish offshore. Trawls and purse seines were, until recently, almost the only fishing gears that Icelanders used in distant waters. A longline fishery in distant waters has also developed recently. About half of the current trawler fleet are wetfish trawlers while the other half are freezer trawlers. Beam trawls are not used in Icelandic waters.

The minimum allowed mesh size for groundfish and midwater trawls has been increased with time, from 110 mm in 1954, to 120 mm in 1963, 135 mm in 1976 and finally to 155 mm in 1977, the largest minimum mesh size in the N. Atlantic (Halliday and Pinhorn, 1996). Trawling with 135 mm is, however, still allowed in some areas in the south, mainly for redfish. The minimum mesh size in the cod and shrimp fisheries is 36 mm, and 80 mm in lobster trawls.

Extracting data from the information available for this fishing gear proved to be the most problematic. Trawlers almost exclusively use trawl, but decked boats commonly use this gear as well. Catch and effort information on the real trawler is much better then for the decked boat, but a proportionally large part of the real trawler catch is from distant waters, primarily Greenland. This is rarely separated from the catch from Icelandic waters in Icelandic data sources. The effort spent by real trawlers in Icelandic waters is available in *Útvegur* after 1976. *Ægir* has information on the effort from 1968 to 1976. Total effort is given in both sea-days and hours trawled, but effort by grounds is given in days fishing or hours trawled. These, therefore, had to be converted to sea-days. Fortunately, there were years when all effort units were used and so the conversion factors could be estimated (sea-days = 1.5 x days fishing and 8 x hours towing). Effort in sea-days by grounds is also known from *Ægir* from 1960 to 1963. However, there is no information on effort by grounds between 1964 and 1967 and before 1960, only on total effort and catch by ground. The effort by ground was estimated by assuming that the relationship between percentage of catch in Icelandic waters and percentage effort in Icelandic waters was the same for the years where effort by grounds was unknown and known. The relationship was found to be:

$$E = 1.05C^{0.91} \qquad \text{...8)}$$

where E is percentage of effort spent in Icelandic waters and C is the known percentage of catch in Icelandic waters. *Ægir* gives separate information on effort by stern and side trawlers after 1971, but only effort by side trawlers prior to 1971. This leaves two years of missing data on stern trawler effort since the first one started operating in 1970. However, the number of stern trawlers was known for those two years and if we assume that each one of them spent 275 sea-days per year, which is to the average between 1972 and 1975, the effort can be determined. The *Bulletin Statistique* does not separate decked boats and trawlers when effort information is available, but instead separates them by size and it also gives the catch by grounds. The smaller trawlers (below 500 GRT) in *Bulletin Statistique* were assumed to be decked boats, thereby providing information from 1966 to 1971. After 1971 data were available in *Ægir* from 1972 to 1975 and from *Útvegur* after that. The effort by the larger trawlers in *Bulletin Statistique* was given in hours fishing and thus not directly useful for data analysis. Trawling by undecked boats before 1966 is poorly documented. Presumably, trawls were also not commonly used by decked boats after 1951 when the EEZ was extended to 4 miles since decked boats were generally too small to be able to trawl outside this limit. The boats, however, became larger in the 1960s as a result of the herring fisheries, and therefore they could trawl in deeper waters outside of the herring season. Because of this, we assume there were no trawl fisheries by decked boats before 1962 (Jónsson 1984). Catches between 1962 and 1966 were estimated from catch information in *Ægir* on the winter fishery. This catch was assumed to be half the total annual catch from 1962 to 1966 (it was roughly half the total catch between 1966 and 1969). The estimated total annual catch was then divided by the average catch/effort between 1966 and 1969, assuming that catch/effort remained constant to arrive at an estimate on effort for the unknown time period (1962-1966).

The effort and catch by lobster trawlers is well documented since 1961, three years after the fishery began. Information used was from *Ægir* until 1971, from *Bulletin Statistique* from 1972 to 1975 and *Útvegur* thereafter. Effort prior to 1961 was assumed to decrease linearly from the 1961 value to zero in 1958.

Information on effort in shrimp fisheries is available from 1966 to 1975 in *Bulletin Statistique* and from *Útvegur* thereafter. Effort prior to 1961

was assumed to be directly proportional to landings.

Fisheries with Norway pout trawl are first documented in 1969. Effort and catch by this gear is known from *Ægir* between 1972 and 1975, but from *Útvegur* thereafter. Effort from 1969 to 1971 (where only catch is known from *Ægir*) was estimated based on the assumption that the CPUE was the same as the average from 1973 to 1976.

Pelagic trawls are the principal fishing gear used in oceanic redfish fisheries, but they are also used alongside purse seines for the pelagic species. The first use of midwater trawls in Iceland was in 1952 and was not for pelagic species, but rather for cod on the spawning grounds. When the EEZ was moved to 12 miles and Icelandic trawlers were excluded from this zone, this fishery stopped. However, we do not have information on the effort or catch for these fisheries, and so they are not included in the analysis. It is possible that the catch is accounted for by inclusion in the bottom trawl catch. Small amounts of pelagic species were fished with midwater trawls in 1966 and 1967 (*Bulletin Statistique*), between 1972 and 1983, and after 1990 (*Ægir* and *Útvegur*). Considerable amounts of oceanic redfish have also been fished with this gear since 1989 (*Útvegur*).

Dredges

Although there are basically four types of dredges used in Icelandic waters, ocean quahog, scallop, sea urchin and kelp dredge, there is wide variation in the design between each of them. Good information is available on the catch composition and effort of these dredge types (except for the kelp dredge) since these fisheries all began relatively recently. Scallop fisheries are the most important of these fisheries and were also the first dredge fishery to start up (1969). Information on effort and catch for these species is available since 1972 in *Ægir* and after 1975 in *Útvegur*. The effort from 1969 to 1971 was estimated based on the assumption that the catch/effort was the same as the average in 1972 and 1973. Breiðafjörður Bay in western Iceland was, and remains, the most important fishing area for scallop and kelp, while ocean quahog and sea urchin are harvested all around Iceland.

Other gears

Other fishing gear types used in Iceland are limited and used in very special cases. Fishing rods are, of course used both in freshwater and marine sport fisheries. Information on the use of fishing rods is understandably very scarce. Nowadays, salmon is mostly fished by fishing rods, as is a large portion of the trout fishery. Sport fishing on the ocean has never been popular in Iceland, although the activity has been increasing lately.

Harpoons are used to hunt whales and guns to hunt seals. However, information on the effort of these is not available. The simplest fishing gear used in Iceland is the human hand, used by a few divers to collect sea urchins, scallops and other benthic invertebrates.

Whaling has a long history in Icelandic waters. Deep-sea whaling was conducted by Basque, Dutch and French boats in the 17th and 18th century, but was largely abandoned by the late 18th century due to declining whale populations. During this time period the catches probably included right whales (*Eubalaena glacialis*), since they have a low swimming speed, and humpback whales (*Megaptera novaengliae*). Icelanders also caught whales opportunistically when they entered the fjords and could be harpooned or driven ashore. Large-scale whaling started again in Icelandic waters in 1883, when steam vessels became available and blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*) and sei (*Balaenoptera borealis*) whales were targeted by Norwegian whaling boats in the western and eastern fjords of Iceland. Whaling was quite important economically for a short while, but like whaling in previous centuries the species were quickly overexploited. Whaling was banned in Icelandic waters in 1915 because of concerns about the whale populations, and to prevent foreigners from exploiting them. Whaling was then briefly resumed from one whaling station in Hvalfjordur ('Whale Fjord') in southwest Iceland. However, whale watching is now growing in Iceland (Kaschner *et al.*, this volume).

FOREIGN FISHERIES IN ICELANDIC WATERS

The first references to distant water fisheries in Icelandic waters are those of English boats fishing for cod in 1412. They became quite numerous in the 15th century and participated quite openly in Icelandic domestic politics (Iceland was under the Danish crown at that time). Because of this, the 15th century was dubbed "the English century" in Iceland. By the late 15th and early 16th centuries the English fisheries had declined due to conflicts with the locals, who were in part, supported by German merchants representing the Hanseatic league. Given this history of conflict, Cod wars

between Icelanders and English fishers is not strictly a 20th century phenomenon (Þorsteinsson, 1976).

After the decline of the British Fleet, boats from the Netherlands became the most numerous distant water fleet in Icelandic waters surpassing English presence in the early 16th century. French boats from Brittany and Flanders replaced the Dutch as the most numerous distant water fleet from the early 19th century, until the arrival of the British trawlers. Fairly good information is available on the landings from these boats from the mid-18th century (Pálmadóttir, 1989). Until the beginning of World War II, French boats primarily used handlines on decked sailing vessels. The French fleet also conducted some limited trawl fisheries in Icelandic waters, as did most other countries. Faroese boats began fishing cod in Icelandic waters in the late 19th century, using similar boats and technology as Icelanders. Initially they were unpopular with Icelanders (as were all other distant water fleets). This animosity between Icelanders and the Faroese fleets did not last long due to the fact that the Faroese landed a large part of their catch in Iceland providing employment for Icelanders, and because information was shared by the Faroese fishers with Icelandic fishers. Faroese boats, since that time, have fished extensively in Icelandic waters and is the only distant water country with uninterrupted catch history in Icelandic waters for the entire 20th century. Norwegians have also been important players in Icelandic fisheries since the 19th century. It was primarily they who initiated large-scale whaling and herring fisheries in Icelandic waters during that century. They participated quite extensively in the herring fisheries and in the groundfish fishery to a lesser extent.

The English returned in the late 19th century with trawlers. English boats once again dominated the distant water fisheries in Icelandic waters in the 20th century, until the extension of the Icelandic EEZ to 200 miles. The main species targeted by the English fishers in the 19th century were flatfish and haddock; large amounts of cod were discarded until cod itself became the target species.

The second most important country participating in the groundfish fishery in Icelandic waters during the 20th century was Germany, mainly West Germany after the Second World War. Their total tonnage was lower than the British, and they always fished in deeper waters catching more saithe and redfish. Boats from Belgium, Denmark, East Germany, Poland, the Soviet Union, Finland, Sweden, Greenland, Japan, and United States also participated at one time or another in the Icelandic fisheries. The target species of these foreign fisheries was diverse. Belgian, Dutch and Scottish boats were fishing groundfish (Belgian boats were allowed to fish in Icelandic waters long after the EEZ had been extended to 200 miles). The Danes were fishing flatfish (although Iceland was under the Danish crown until 1944, Danish boats were never numerous in Icelandic waters). East Germans and Poles were fishing for groundfish, particularly in deep waters, targeting redfish and Greenland halibut. Vessels from the former USSR also fished in deep waters targeting redfish and Greenland halibut, but also participated in the herring fisheries. Finns and Swedes have also been involved in the fishery for herring. Recently, Greenlanders began fishing for capelin and Japanese for bluefin tuna. American boats have not been reported in Icelandic waters this century, but it is perhaps interesting to mention that schooners from Gloucester, Massachusetts, came to fish halibut in Icelandic waters in 1873. This fishery did not prove successful at that particular time, however, they came back 11 years later and fished extensively in Icelandic waters until 1897. Boats from Portugal, Spain and Italy have also allegedly fished only small amounts in Icelandic waters. The fact that the great fishing countries, Spain and Portugal, have not been very active on Icelandic grounds in the 20th century is surprising.

The current distant water fleets fishing in Icelandic waters are: Norwegian and Faroese longliners fishing for groundfish; Norwegian, Faroese and Greenlandic purse-seiners fishing for capelin and herring; Japanese longliners fishing for tuna; and Greenlandic and European Union (British and German) trawlers fishing for redfish. Furthermore, Russian and European herring boats and Faroese boats fishing for blue whiting are allowed to fish in a certain amount in Icelandic waters. Except for the Japanese longliners, all catches are very low in comparison to catches made by Icelandic boats. The reason for these boats being allowed to fish in Icelandic waters is due to reciprocal fishing rights (groundfish, redfish), shared stocks (capelin, herring, blue whiting and redfish) or in the case of tuna, because Icelanders do not possess the knowledge to catch this species. Except for the groundfish fisheries, these all occur at the fringes of the Icelandic EEZ; redfish in the southwest, tuna in the south, herring in the east and capelin in the north.

The information on the effort and catch of the distant water fleets is almost exclusively from *Bulletin Statistique* and more recently from other ICES sources. The effort units were standardized to hours fishing. Where the effort was given in other units they were converted to hours fishing calculated from years where both units were given. This applies mainly to German boats, and to a lesser extent Scottish boats. The other source of information is from Thór (1995), which gives further information on the English fleet. Information on the effort of the foreign fleets in Icelandic waters is not available after 1977, but by that time, effort was severely reduced since the main fishing countries, Germany and Great Britain, had been expelled from Icelandic waters.

The species composition of the catch by foreign fleets is somewhat curious. Some catch is only given by group name (e.g., shellfish, flatfish or salmonids) and there are also some reported catches of species that are very rare or non-existent in Icelandic waters. Some of these questionable catches might be correctly reported, as in the case of rare species such as turbot, mackerel and squid. For other species, such as conger eel and sole, these reports are less likely, given that these fishes have never been identified by scientists in Icelandic waters. It has been assumed that these are either misidentifications or they were not fished in Icelandic waters. For example, it is conceivable that some boats did catch a few tows in their home waters after having fished in Icelandic waters, but did not report the catch separately.

ICELANDIC BOATS IN DISTANT WATERS

Iceland is a coastal fishing country and the majority of landings from Icelandic boats have always been from Icelandic waters. The first distant water fishery was an experimental fishery in Newfoundland waters which was started just a few years after the first trawler arrived. Although this fishery did not prove successful, real fisheries in distant waters were established for cod in the Barents Sea in 1934. These fisheries were on a relatively low scale until after the Second World War when they increased to about 5,000 t in 1950. During this time, the Icelandic boats had found new and better grounds in Greenlandic waters. Thus, the groundfish fisheries in the Barents Sea declined and were virtually non-existent after 1952. Although cod was always an important species, catches of redfish surpassed cod in some years. Icelandic trawlers also sought fish in North American waters in which large catches of redfish were fished in 1958 and 1959, but were significantly smaller approaching 1972. The distant water fisheries declined in importance when the side trawlers were phased out, since the stern trawlers initially preferred coastal water.

Icelandic trawlers did not really leave Icelandic waters from 1977 to 1993. However, during this time, significant quota reductions were being introduced and fishers began looking for alternative fisheries to participate in. Much to the annoyance of the Norwegians, Icelanders located an area in the Barents Sea in 1993 where cod migrated through an area that was outside any nations' EEZ. Icelanders have fished in this area ever since although an agreement with the Norwegians concerning quotas was negotiated. Icelandic trawlers also found another ground which did not fall in an EEZ. This area is known as the Flemish Cap and is located off the Grand Banks of Newfoundland. The main species fished in this area has always been shrimp. Icelandic boats have also recently sought shrimp in the Barents Sea. Prior to these two fisheries, Icelandic boats were also fishing oceanic redfish, found in Icelandic, Greenlandic and International waters. Since this is a straddling stock, it is questionable if this can be classified as a distant-water fishery, although part of the catch by the Icelandic fleet is fished outside the Icelandic EEZ.

Herring fisheries were quite important for the Icelandic economy in the 1960s. In the mid-1960s, the Norwegian spring spawning stock started to change its migration pattern, moving further and further from Iceland. At the same time, the stock was being heavily overfished. As a result, Icelandic purse-seiners began to seek herring in distant waters after 1964. These fisheries were conducted until 1976 throughout the North Atlantic, from the North Sea to the waters off Canada. The purse- seiners withdrew into Icelandic waters at the same time as the trawlers in 1977, but did not resume a search for other opportunities until 1994. At this time, the Norwegian spring spawning herring stock had partially recovered and their migrations patterns brought them again near the Icelandic EEZ.

Other pelagic fish species have also been fished in distant waters, mainly driven by the collapse of the spring spawning herring mentioned above. Mackerel was fished in the North Sea from 1967 until 1976, horse mackerel (*Trachurus* spp.) and sardinella (*Sardinella* spp.) in West Africa in 1975, capelin in Canadian waters from 1975 to 1978, and blue whiting in Faroese waters from 1977 to 1983.

RECONSTRUCTING THE CATCH HISTORY

Estimating the annual catch of the Icelandic fleet proved to be more difficult than originally thought. It was not simply a matter of locating data and entering them into spreadsheets. The data were often found to differ between sources, in some cases very significantly, and none of the data combined or directly gave complete information on catch by species, by gear, from 1950. In general, the catch history of Iceland was reconstructed starting with the total catch. Catch numbers from different sources were compared, and catches in distant waters were subtracted where needed. The catch was then split by gear, based on available data, or estimated as explained below. *Nytjastofnar* was used as the main source information for total catch statistics prior to 1977. *Bulletin Statistique* and *Ægir* were considered less accurate because they have not been revised and updated to the same degree as *Nytjastofnar*. However, *Nytjastofnar* does not include as many species and has no information on catch by fishing gear. *Bulletin Statistique* and *Ægir* were therefore used extensively to supplement *Nytjastofnar*. After 1976, *Útvegur* is the main source of information. In some cases after 1976 the numbers from *Bulletin Statistique* and *Nytjastofnar* were preferred when they agreed on some number that was quite different from *Útvegur* (there were sometimes unexplainable differences between theses data sources). There was no information available on catch by fishing gear from 1950 to 1955, only on total catch. Catch (C) by gear (g) and year (y) was therefore estimated by:

$$C_{g,y} = \frac{E_{g,y} C_{g,y-1} \sum C_{g,y}}{(E_{g,y-1} \sum (E_{g,y-1} \sum (\frac{E_{g,y} C_{g,y-1}}{E_{g,y-1}}))} \quad ...9)$$

where $E_{g,y}$ is effort and $\Sigma C_{g,y}$ is total catch minus known catch by gear in later years where some catch by gear was known. This equation gives us catch estimated from the catch/effort of the previous year, corrected by changes in catchability (total catch/total effort). The main weakness of this approach is that catchability is assumed to change in the same manner for all gear.

Catch composition by trawlers is available in *Ægir* from 1956 to 1968, and can therefore be subtracted from the total catch that is used in equation (5). Catch by the Danish seine and lobster trawl fleets is available from the same source from 1960 to 1971. Some fragmented information is available in *Bulletin Statistique* on other gear from 1962 to 1965. However, the information in *Bulletin Statistique* was not used directly since there were large differences between these numbers and total catch. An example of this type of discrepancy is outlined for haddock in 1964. Total catch is about 57,000 t, catch by trawlers accounts for about 9,000 t, catch by Danish seine and lobster trawl about 8,000 t and the catch in distant waters is negligible. This leaves about 40,000 t unaccounted for. Catch by handline, gillnet and longline given in *Bulletin Statistique* is only about 20,000 t, leaving 20,000 t unaccounted for. The unaccounted 20,000 t could have been fished by cod seine, or decked motor boats (DMB) using trawl. However, if one compares catches from the surrounding years for the cod seine and decked motor boats when the total catch is known, it seems unlikely that these two gear types could account for the extra 20,000 t. In these types of cases the catch was divided among the fishing gear according to equation (5), and the information in *Bulletin Statistique* was essentially ignored. Good information is available from 1966 to 1976 in *Bulletin Statistique* on the most important species, i.e., cod, haddock, saithe, herring, plaice, and redfish. Most other species are problematic since information on catch by gear actually gets worse with time. There is no information on the catch of these species by trawlers after 1968, or catches of these species by lobster trawl and Danish seine after 1971. For years when the catch composition was not known we simply let the catch by gear follow a linear trend from the last year known before and the first year known after, but corrected proportionally to add up to the known total catch. Some species were, however, only assigned to one fishing gear since this gear fished the large majority in known years. Examples are blue ling (all unknown catch to trawl), herring (all to purse-seine between 1959 and 1970), tusk (all to longline), shrimp (all to DMB trawl and lobster (all to lobster trawl). After 1976 more clarity prevails in the data sources, since catch by different fleets is well documented, fisheries in distant waters are well known and they are clearly separated from catch in Icelandic waters.

It was also necessary to evaluate how to split the catch amongst boats using trawl (decked motor boats, side trawlers and stern trawlers) prior to 1977. The information in *Ægir* was considered accurate for the catch by the side trawlers (we only have to subtract the distant water catch), but the information in *Bulletin Statistique* is very flawed. It obviously does not include all trawling boats in some years since the catch by side

trawlers in *Ægir* is much higher than trawl catch given in *Bulletin Statistique*. In other years the catch is given to "motor" trawlers, but a large part of the Icelandic trawlers were steam trawlers, which is a separate category in *Bulletin Statistique*. All this makes the information on trawlers in the *Bulletin Statistique* difficult to evaluate except for the values after 1971. The uncertainties in regards to splitting trawl catches, was solved by allowing the catch by side trawlers decrease linearly from 1968 to 1977 since the number of trawlers did decrease almost linearly during that time (by 1978 they were no longer in use). The catch by the stern trawlers followed their increase in number from 1970 (when the first stern trawler was brought to Iceland) up to the known 1977 number. The remaining uncertainty involves catches by decked motorboats using trawls. Their catch from 1971 to 1976 was simply found by subtracting the estimated catch by the other trawl classes from the known catch in *Bulletin Statistique*. In the process, the decked motorboat trawler category became a catch-all for unaccounted catch from 1962 until 1971 (their catch was assumed to be zero prior to 1962).

The last part of the catch history that needed to be manipulated was the catch of cod, haddock and saithe by undecked motorboats until 1981 (catch of other species was assumed to be zero for this boat class). The total catch by undecked boats was known from 1977 to 1981 and was assigned to fishing gear according to the average proportion from 1982 to 1992 (there was no consistent trend in the proportions during this period). This proportion between the fishing gears was also used for the period from 1950 onward. From 1971 to 1976 the undecked boats acted as a catch-all for unaccounted catch (and the numbers seem quite realistic). Before 1971, the catch was estimated by equation (5). Overall, there were many dangerous assumptions made in order to reconstruct catches of undecked boats. However, it is anticipated that because the undecked boats were not important players in the Icelandic fisheries, any errors in estimates will not have significant impacts on the big picture.

THE SPECIES

Below is a short description of each of the fish species, species group and landings that are included in the spreadsheet. Information on the marine fish species is mostly from Jónsson (1992) but also from Gunnarsson *et al.* (1998) and Anon. (2000). Other sources are cited in the text for each species or group.

Sharks and skates

Black dogfish (*Centroscyllium fabricii*):
Common in deep waters WSW and S of Iceland. Small amount reported in deep-water fisheries since 1992 (*Útvegur*); might have been discarded in some amounts before.

Portuguese shark (*Centroscymnus coelolepis*)
Common in deep waters WSW and S of Iceland. Small amount reported in deep-water fisheries since 1992 (*Útvegur*); might have been discarded in some amounts before.

Spiny dogfish (*Squalus acanthias*)
Not very common in Icelandic waters but still the most common shark species present. Considered a pest by Icelandic fishers in the past and probably often discarded. Retained more often in recent years but still only when encountered as bycatch in other fisheries. The first reported landings are in 1963 (*Bulletin Statistique*), there is no catch in 1964, but landings are reported from 1965 to 1968 (*Ægir*); landings values are from *Útvegur* after 1968.

Dogfish (unidentified)
The dogfish catch of the foreign fleets is not identified to species (*Bulletin Statistique*) but was most probably spiny dogfish

Greenland shark (*Somniosus microcephalus*)
Greenland shark fisheries have most likely been conducted in Icelandic waters from the time of settlement (Júlíusson *et al.*, 1992). They reached a large scale in the 18th century, and a maximum in 1867 when 13100 barrels (each barrel contained about 62 liters) of shark oil were exported. At this time, this species was probably the most important marine resource in Icelandic waters. These were the only fisheries by Icelanders prior to the 20th century that can be described as deep-water fisheries. They were first conducted on open rowing boats, but later became the first Icelandic fisheries to use decked sailing boats. Only the liver was retained for its valuable oil, which was used for lighting up streetlights of European cities. When whale oil and fuel oil became more available the markets for the shark oil disappeared and direct fisheries for the Greenland shark were over by about 1910. Catches have been low during this century and it is now mostly caught as bycatch in other fisheries. However, a few are caught each year in direct longline fisheries and since this is the only fish species where the majority of the catch goes to local consumption (it is considered poisonous when fresh but Icelanders have a way to cure it

and get rid of the poison)[a], it is quite possible that actual catches are higher since there no incentive to report them. Landing statistics are not available for Icelandic boats until 1960, and then they apply for fisheries in the N.W. Atlantic. Statistics for Icelandic waters are available from 1962 to 1976 in *Bulletin Statistique* and in *Útvegur* thereafter. All catch prior to 1977 was assigned to trawlers. Catch for the early part of the century is only given in barrels of oil exported. Therefore, this has to be converted to live fish harvested. The conversion has to be done in several steps since no direct information is available on how to convert barrels of oil to live fish. Each barrel of oil (62 L) is estimated to consist of 1.67 barrels of liver (Guðmundsson 1977). The density of oil is assumed to be 0.95 for conversion to kg, and liver is assumed to be 25% of body weight (based on related species in Þrastarson et al 1994). This gives the conversion factor of 393.5 to convert barrels of oil to kg live shark.

Porbeagle (*Lamna nasus*)
Direct fisheries were conducted for porpeagle from 1959 to 1962 (Jónsson 1992), but no statistics are available; catch was assumed to be 10 t a year for this period. Information on catch is available in *Ægir* from 1965 to 1968 and in *Útvegur* thereafter.

Common Skate (*Raja batis*)
Used to be common in Icelandic waters, but is now overfished. This species probably provided the bulk of the reported skate and ray catches in the past, the other species either being to small to be of interest or living in deep waters out of reach to fishing gear at that time. A relatively big part of the catch goes to local consumption and is probably cured at sea by the fishers and not reported in landings. Actual catches might therefore be considerably higher than reported. This is illustrated by the large differences in landings between the different data sources that cannot be properly explained. Four possible reasons for this are: some sources might report only the weight of that portion which was retained from the skate (a relatively large part of it is cut off when gutted); a large part of the catch goes to local consumption and might not be reported, but is possibly estimated by some sources; some part of the catch might be fished in distant waters; and finally, a part of the catch might actually be another ray species. Landing statistics were used from *Bulletin Statistique* from 1950 to 1976, and from *Útvegur* thereafter.

Shagreen ray (*Raja fullonica*)
Found in rather deep waters SW and S of Iceland, probably used to be more common. Might have been part of the skate and ray catches of the past. Catches have been increasing in recent years as the trawlers go to deeper waters and it is caught as bycatch. All information on catches is from *Útvegur*.

Starry ray (*Raja radiata*)
The only cartilaginous fish that can be considered common in Icelandic water. Found all around Iceland, but usually dispersed. Has always been fished and caught as bycatch and until recently was always discarded, at least by Icelanders. The increase in landings in recent years could therefore partly be explained by increased retention. All catch information is from *Útvegur*.

Skates and rays (unidentified)
Skates and rays were not identified in the past. However most of these catches were probably common skate. The Icelandic catches in Icelandic waters were all assigned to common skate when these catches were not identified. Unidentified catches in distant grounds (*Bulletin Statistique* and NAFO) were, as the name indicates, not identified to species.

Knifenose chimaera (*Rhinochimaera atlantica*)
Found in deep waters WSW and S of Iceland. A small amount reported every couple of years since 1992 (*Útvegur*); might have been discarded in some amounts before.

Large eyed rabbitfish (*Hydrolagus mirabilis*)
Found in deep waters WSW and S of Iceland. Small amount reported in 1992 and 1995 (*Útvegur*); might have been discarded in some amounts before.

Rat-tail (*Chimaera monstrosa*)
The only Icelandic chimaera that is not confined to deep waters. Was probably discarded in the past but retained now, which would explain increasing landings. However, at times boats have targeted it (when out of quota for other more valuable species). Information on landings is from *Útvegur*.

Non-teleost fishes (unidentified)
Some countries report catches in this category. For the Icelandic fleet this was porbeagle and Greenland shark in the past, but most recently chimaeras. However, we can not find out what the foreign catch species composition is, except that it is probably not a skate species or spiny dogfish

[a] with the result tasting like overripe camenbert, but with the same texture as a shredded carpet [Note by editor #3].

since they are clearly separate in the information source (*Bulletin Statistique*).

Pelagics

Capelin (*Mallotus villosus*)
A major fishery in Iceland, the tonnage caught in some years is as high as for all other species combined. This fishery was quite small until after the collapse of the herring stocks in the early seventies. Most of the capelin goes to reduction so price per weight is low. Capelin spawn mainly along the shore of southern Iceland and die after first spawning. Larvae and adults live in the cold waters north of the country. In some years the adult stock migrates to Norwegian (Jan Mayen) or Greenlandic waters, therefore these countries have a share in the fisheries according to an agreement between the countries. All countries are currently allowed to catch a certain share in other EEZ's. The Icelandic fishery has mostly been within the Icelandic EEZ, but also covering ICES areas Va, IIa, and XIVa. Agreements were reached with Norway in 1980 and Greenland in 1989 on the respective divisions of the TAC and reciprocal fishing rights (Vilhjálmsson 1994). The Icelandic catch in the other EEZs are minor and cannot be separated from the catch in the Icelandic zone from our sources. The catch values used from 1962 to 1976 are from *Hagskinna*. Thereafter, the picture becomes less clear (although there are no major differences between data sources), mainly because some sources round the numbers to 100s of t (*Nytjastofnar* and *Hagskinna*) and others do not separate the catch by ICES areas (*Útvegur*). This leaves ICES as the main data source used from 1977 to 1989. After 1989 the landings data from *Útvegur* are used.

Herring (*Clupea harengus*)
A big fishery in Iceland today but was most important in the 1960s. Herring fisheries began in Icelandic waters in the mid-19th century and were initiated by Norwegian fishers. Somewhat surprisingly, there are no references to Icelanders harvesting herring before that time. However, Icelanders soon began to fish herring. Initially the herring was fished with beach seines, but this changed to purse seines and driftnets just before the turn of the 20th century. The catch by these fishing gears is known since 1971, and can be assumed to be mostly by purse-seiners from 1961 to 1970 (Jakobsson, 1980). Prior to that, the division between gear types is not possible with the data sources available. We therefore assigned the catch 50/50 to each gear type prior to 1956 and gradually reduced the driftnet portion until 1959 when we assigned it all to purse-seiners. Three herring stocks were found in Icelandic waters all of which collapsed in the late 1960s. These stocks were the Icelandic spring spawning stock; the Icelandic summer spawning stock; and the Norwegian spring spawning stock. The Icelandic spring spawning stock is the only stock out of the three that have not yet recovered. Since these collapses, almost all the herring fisheries in Icelandic waters have concentrated on the Icelandic summer spawning stock. In recent years, as the stock has been migrating to international waters, Icelanders have been fishing a certain part of the Norwegian spring spawning stock according to an agreement between the countries involved (Norway, Russia, Iceland, Faroe Islands and the European Union). This fishery is almost exclusively in international waters just northeast of the Icelandic EEZ (although a small part has been caught within the Icelandic EEZ). Information on the landings of herring is apparently good owing to the fact that the herring fishery is a single species fishery and is of considerable importance. Total catch information is from *Nytjastofnar* from 1950 to 1976, and *Útvegur* thereafter.

Sandeels Sandeels of the species *Ammodytes marinus*, *Ammodytes tobianus*, and *Hyperoplus lanceolatus* are common in Icelandic waters. Some amount was fished between 1979 and 1980 but catches have decreased since (*Útvegur*). There has been interest in resuming this fishery. Most catches were probably *A. marinus*. Lately, sandeels have been imported as bait for the haddock fisheries.

Blue whiting (*Micromesistius poutassou*)
Blue whiting is native to Iceland, however, the Icelandic stock is small and does not sustain large fisheries. Most of the fisheries are from the large stock that spawns northwest of the British Islands. This stock migrates to feeding grounds in the Norwegian Sea and can sometimes be found in large concentrations in the Icelandic EEZ. Except for the period from 1977 to 1983 and after 1996 (*Útvegur*), Icelanders have not been active in the direct blue whiting fishery. A large part of this fishery (including Icelandic boats) was in Faroese waters in the late seventies and early eighties. There was also some fisheries in Greenlandic and international waters. The fishery since 1995 has mostly been in Icelandic waters; 1999 was an exception when the fishery started on the spawning grounds west of the British Islands. Besides this direct fishery a considerable amount of juvenile blue whiting was caught as bycatch in Norway pout fisheries from 1972 to 1989 (Sveinbjornsson, 1981, *Útvegur*). This amount is not included in some data sources.

Catch values used for blue whiting are from Nytjastofnar from 1972 to 1989 and from *Útvegur* after 1989.

European smelt (*Osmerus eperlanus*)
This species is not found in Icelandic waters and the reported catch by Germany in 1976 (*Bulletin Statistique*) This is either a case of misidentification (with capelin (*Mallotus villosus*) or great silver smelt (*Argentina silus*)) or was not caught in Icelandic waters.

Horse mackerel (*Trachurus trachurus*)
Horse mackerel is not native in Icelandic waters but has in some years migrated there and some low amounts reported (*Útvegur*). The catches of the foreign fleets are suspiciously high, however, and might therefore actually not have been fished in Icelandic waters. Icelandic boats did fish considerable amounts in the North Sea in 1973 and 1974 (*Bulletin Statistique*) and in the East Central Atlantic in 1975 (FAO).

Mackerel (*Scomber scombrus*)
Mackerel is not native in Icelandic waters but migrates there in some years, and small amounts have been reported (since 1991 in *Útvegur*). The catches of the foreign fleets are suspiciously high, however, and might therefore actually not have been fished in Icelandic waters. However, Icelandic boats fish considerable amounts in distant waters, especially in and around the North Sea from 1967 to 1976 (*Bulletin Statistique*) and in some unspecified grounds from 1997 onwards (*Útvegur*).

Clupeoids (unidentified)
Catch of 72 t reported in 1972 by East Germany (*Bulletin Statistique*); probably herring.

Scombriformes (unidentified)
Catch of 16 t reported by East Germany in 1979 (*Bulletin Statistique*); probably mackerel.

Bluefin tuna (*Thunnus thynnus*)
Not considered native to Icelandic waters but sometimes migrates there and is 'accidentally' caught. Recently, Japanese boats were allowed to do some experimental fisheries in the southernmost part of the Icelandic EEZ. One Icelandic boat has also been equipped for tuna fisheries in Icelandic waters (although it operates in ICES area XII). Data on landings are from *Útvegur*.

Sunfish (*Lampris guttatus*)
Found in the southern part of the Icelandic EEZ and occasionally further north and is incidentally caught there. Low amount reported approximately biannually since 1993 (*Útvegur*)

Sardinellas (*Sardinella* spp.)
Not found in Icelandic waters, but some amount was fished off West Africa in 1975 by Icelandic boats (FAO).

Splendid alfonsino (*Beryx splendens*)
Found in Icelandic waters but no catches reported there. Low amounts reported by Icelandic boats in the Western Central Atlantic in 1996 (*Útvegur*).

Alfonsino (*Beryx decadactylus*):
Found in Icelandic waters but no catches reported there. Some amount reported by Icelandic boats in Western Central Atlantic in 1997 and 1998 (*Útvegur*).

Breams (unidentified)
Rare in Icelandic waters (but see *Beryx* spp. above). Foreign catches might be misidentification or fished in other waters.

John Dory (*Zeus faber*)
Rare guest in Icelandic waters. Icelandic boats fished small amounts in unspecified distant grounds in 1997 (*Útvegur*).

Groundfish

Aggassiz' smoothhead (*Alepocephalus agassizii*)
Found in deep waters WSW and S of Iceland. A small amount reported in 1992 (*Útvegur*). Bycatch in recent deep-water fisheries; might have been discarded in some amounts.

Black scabbard fish (*Aphanopus carbo*)
Common in deep waters WSW and S of Iceland. Caught in small amounts since 1992 as bycatch in deep-water fisheries in Icelandic waters, but also in the Western Central Atlantic in 1996 and 1999 (*Útvegur*). Might have been discarded in some amounts before.

Scabbard fish (*Lepidopus caudatus*)
Rare in Icelandic waters and has never been reported in catches, however, low amounts were reported by Icelandic boats in unspecified distant waters in 1997 (*Útvegur*).

Cardinal fish (*Epigonus telescopus*)
Common in deep waters WSW and S of Iceland. Small amount reported in Icelandic waters in 1999 and in unspecified waters in 1996

(*Útvegur*). Bycatch in deep-water fisheries; might have been discarded in some amounts before.

Blackfish (*Centrolophus niger*)
Rare in Icelandic waters and has never been reported there in landings. Low amounts were, however, reported by Icelandic boats in other grounds in 1997 (*Útvegur*).

Atlantic (or common) catfish (*Anarhichas lupus*)
The most common catfish species in Icelandic waters and it provides the bulk of the catfish catch. Found on the shelf all around Iceland. Both targeted specifically when migrating from spawning grounds and is bycatch in other fisheries. Reported landings in early years do probably include spotted catfish (see under that name). From 1950 to 1972 the catch numbers in *Bulletin Statistique* were used. After 1973 the numbers in *Hagskinna* and *Útvegur* were used (The first *Útvegur* edition is from 1977, but there is some catch information available for previous years in each issue).

Spotted catfish (*Anarhichas minor*)
The spotted catfish is not infrequent in the colder waters north and east of Iceland but is always as bycatch. Probably not separated from Atlantic catfish before 1958 in the Icelandic distant water fisheries (information after 1958 is from *Bulletin Statistique*, FAO supplemented by *Ægir*) and before 1968 in fisheries in Icelandic waters (*Útvegur*). Even after 1968 it is quite probable that some of the landings were included in reports as Atlantic catfish. Catch prior to 1977 is assigned to trawlers, since they are the gear with the majority of known catches. This species is considered good for mariculture and some experiments have been conducted recently.

Arctic (or jelly) catfish (*Anarhichas denticulatus*):
Found in deep cold waters, not considered edible since flesh is jelly-like. Some boats have nevertheless reported some minor catches since 1992 (*Útvegur*). Some bycatch in fisheries for Greenland halibut and shrimp but discarded because of low value.

Catfishes (unidentified)
Foreign fleets did not separate the catfish catch between species (*Bulletin Statistique*). The catch is therefore not split between species, however, considering the area fished the large majority is probably Atlantic catfish.

Vahl's Eelpout (*Lycodes vahli*)
Small fish that is frequently caught as bycatch in shrimp fisheries. Usually discarded but some boats reported small amount in 1992 and 1993 (*Útvegur*). Found in deep waters north of Iceland.

Esmark's eelpout (*Lycodes esmarki*)
The largest of many eelpout species found in Icelandic waters. Not infrequent catch in fisheries for shrimp and Greenland halibut; usually discarded. Some boats have retained it since 1993 (*Útvegur*). Found in deep waters north and west of Iceland.

Great silver smelt (*Argentina silus*)
Common in medium depths W, SW, S, and SE of Iceland. Common bycatch in Greenland halibut and redfish fisheries but until recently mostly discarded. Recently there has also been a direct fishery for this species. Catch statistics from 1961 to 1968 are from *Ægir*, after that from *Útvegur*.

Gurnard (*Eutrigla gurnardus*):
Not infrequent in medium shallow waters W, SW, and S of Iceland. Usually discarded by the Icelandic boats due to small size and low value, but some retained by foreign fleets. Small amounts have been reported by Icelandic boats annually since 1996 (*Útvegur*).

Lumpfish (*Cyclopterus lumpus*)
Common in all Icelandic waters. Caught in a directed fishery and as bycatch in others. The direct fishery is unique among Icelandic fisheries since they did not have to be reported to the same extent as other fisheries, although the fishers fishing for the roe have required a special permit since 1976. Some sources of information only give the bycatch from those fisheries not directly targeting this species since reporting is mandatory in these cases.

The *Marine Research Institute* does, however, estimate the total catch from reports from the lumpfish fishers. The male goes to local consumption but the roe is kept from the females and exported as (fake) caviar. The first catch statistics are available in 1966. Catches until 1970 are from *Bulletin Statistique*, from 1971 to 1989 from *Nytjastofnar*, and from *Nytjastofnar* (assumed to be the direct catch) plus *Útvegur* (the bycatch) after 1989.

Monkfish (*Lophius piscatorus*)
Common in the warmer waters around Iceland. Caught as bycatch (mostly in lobster fisheries) and recently became a direct fishery. Very valuable fish; might not have been reported

specifically in early years. Catch information is available in *Ægir* from 1961 to 1964, *Bulletin Statistique* from 1965 to 1976 and *Útvegur* thereafter.

Orange roughy (*Hoplostethus atlanticus*)
Found in concentrations in some deep waters W, SW, S, and SE of Iceland. Caught as bycatch and also has occasional target fisheries. Very valuable fish. Catch information is from *Útvegur*.

Redfishes (unidentified)
The redfish species (*Sebastes* spp.) in Icelandic waters are not well known despite heavy fisheries for a long time. The species found are at least four (*S. viviparous*, *S. mentella*, *S. marinus* and *S. fasciatus*, the last one being a rare guest), but possibly six (the fifth might be the so called giant redfish which has been considered the same species as *S. marinus*, and the sixth might be a species previously considered within the *S. mentella* complex). A number of multinational studies (incl. genetic studies and acoustic surveys) are attempting to clarify these matters. Although this distinction will be of great value in the future it is much more difficult to find out what was the species proportion in the past. It is likely that the early catches in Icelandic waters were predominantly *S. marinus* since it is very common and lives in more shallow waters than the other species (but see below for each species). The stocks are found over a large area covering many ICES zones and EEZ's, and they sustain large fisheries by many countries. Redfish catch by the Icelandic boats in Icelandic waters is from *Nytjastofnar* from 1950 to 1976, after that from *Útvegur*. The split up of the catch between *S. marrinus* and demersal *S. mentella* is from *Nytjastofnar*. Icelandic catch in distant waters is from *Bulletin Statistique*, NAFO, FAO and from *Útvegur* in more recent years recently.

Redfish (*Sebastes marinus*)
This is the most common redfish species on the continental shelf around Iceland. It is usually associated with the bottom and found all around Iceland, usually above 500 m depth. It probably provided the bulk of the catches by all fleets in Icelandic waters until about 1980. It is targeted directly and is also caught in smaller amounts as bycatch. All the catch was assigned to side trawlers in years when catch by gear was not available since the majority of catches were by trawlers in years when catch by gear was known. Most of the fishable stock of this species is probably within ICES area Va and the Icelandic EEZ.

Redfish (*Sebastes mentella*, demersal)
This species (stock) is similar to *S. marinus* and for a long time they were not separated in catches. It is usually found below 500 m depth, and since the trawl fishery until the 1980s was mostly on the shelf, it was probably a small part of the total catch. The proportions in landings by the Icelandic fleet have been estimated since 1978 (Anon., 2000). The previous Icelandic fishery in Greenlandic waters probably targeted both *S. marinus* and *S. mentella* and currently it is not possible to split the past fishery according to species, however, the proportions are probably similar to those in Icelandic waters.

Redfish (*Sebastes mentella*, oceanic)
This is considered the same species as above but a distinct stock with different horizontal distribution and a pelagic lifestyle; it also looks somewhat different. The fishery for this stock is a direct fishery using mid-water trawl. Eastern European fleets were the pioneers in this fishery but the majority of the catch is now by Icelandic boats. This stock is found over the Reykjanes ridge SW of Iceland; part of the catch is within the Icelandic EEZ (Icelandic boats), part outside (many countries, including Iceland). The affinities between the demersal and oceanic stocks of S. mentella are unclear. There seems to be some genetic difference, but there could still be some intermingling between the stocks. It has been proposed that there is a third stock of this species, a pelagic version of the demersal stock, found in the same area as the oceanic stock but living at greater depth. Catch information is from *Útvegur*.

Redfish (*Sebastes viviparus*)
Small shallow-water species. Probably discarded before because of its small size but a small target fishery has evolved recently. Catch information from *Nytjastofnar*.

Smooth head (*Alepocephalus bairdii*)
Common in deep waters WSW and S of Iceland. Caught in small amounts as bycatch in recent deep-water fisheries, might have been discarded in some amounts before. A low amount has been reported annually since 19922 (*Útvegur*).

Spine eel (*Notocanthus chemnitzii*)
Common in deep waters WSW and S of Iceland. Caught in small amounts as bycatch in recent deep-water fisheries; might have been discarded in some amounts before. Low amount reported each year since 1992 (*Útvegur*).

Cusk eel (Ophidiidae; unidentified)
Not found in Icelandic waters. Small amount reported by Icelandic boats in distant but unspecified waters in 1997 and 1998 (*Útvegur*).

Conger eel (Congridae; unidentified)
Not found in Icelandic waters, probably misidentification or fished in other waters.

Demersal percomorphs (unidentified)
There is no information available in *Bulletin Statistique* on what this category (perch-like) consists of for the foreign fleets, but when applied to the Icelandic fleet, it is always lumpfish.

Salmonids (unidentified)
Some amount reported every other year between 1964 and 1975 by East German, West German and Soviet fleets; probably great silver smelt.

Other catch (unidentified)
Catch that cannot been assigned to other groups. From 1950 to 1952 this is from *Hagskinna*, from 1953 to 1968 from *Bulletin Statistique* and from 1969 to 1999 this is the unidentified catch in *Útvegur*. Not possible to say what this is in recent years, could be species already accounted for but also other species. In earlier years it probably includes species accounted for in later years.

Groundfish, gadoids

Blue antimora (*Antimora rostrata*)
Common in deep waters WSW and S of Iceland. Catch of 2 t reported in 1996 (*Útvegur*); might have been discarded in some amount.

Blue ling (*Molva dypterygia*)
Common in deep waters south and west of Iceland. Caught as bycatch in deep water fisheries, but also support targeted fishery. There are no reported Icelandic landings of blue ling before 1961. It is possible that blue ling was not separated from common ling in those early years. There is information available on landings in *Ægir* from 1961 to 1965, *Nytjastofnar* is used from 1966 to 1976, and *Útvegur* after 1976. All catch before 1977 was assigned to side and stern trawlers since catch by other gear is low compared to trawlers. Data on blue ling catches by distant water fleets are only available since 1973, however there is no doubt that a large part of the unidentified gadoid catch prior to that is blue ling.

Cod (*Gadus morhua*)
This is by far the most important marine resource in Icelandic waters. Its economic importance has been surpassed by herring and possibly Greenland shark at times, but these periods were relatively short-lived. The Icelandic cod stock is mostly found on the Icelandic shelf, although a few tag returns have been from other waters (Jónsson, 1996). There is one major exception to this rather localized distribution pattern. The Greenlandic cod stock is largely made up of larvae drift from Icelandic spawning grounds. When this fish matures, it returns to Icelandic waters to spawn. This return has at times had major influences on cod fisheries in Icelandic waters, contributing to large increase in the landings but also to large problems in assessing the stocks. This Greenland migration has not occurred since 1990, and is not expected to occur in the near future since the Greenlandic cod stock is at extremely low levels. The cod is the major target species in handline, longline, gillnet, Danish seine and bottom trawl fisheries. There has always been some discarding of small sized cod in Icelandic fisheries. This is specially so in fisheries where large amounts are fished during a short time (e.g., during spawning time) and there is little incentive to retain the small, lower valued cod. It is intensively debated if this has increased with the introduction of the ITQ system. Good scientific studies are not available to verify this, but the many reports by fishers about discarding cannot be easily ignored (although there are also fishers who claim discards to be lower). It is assumed that discarding has increased since the ITQ system was established and has been especially high in recent years, due to unusually high prices of quotas. Catch numbers were used from *Nytjastofnar* and *Bulletin Statistique* from 1950 to 1976 (these two sources had the same numbers), but from *Útvegur* thereafter.

Greater fork-beard (*Phycis blennoides*)
Common in deep waters WSW and S of Iceland. Small amount reported in 1994 (*Útvegur*); might have been discarded in some amounts before and after.

Grenadier (roughhead) (*Macrourus berglax*)
Common in deep waters WSW and S of Iceland. Caught in small amounts as bycatch in recent deep-water fisheries (*Útvegur*); might have been discarded in some amounts before.

Grenadier (roundnose) (*Cyrophaenoides rupestris*)
Common in deep waters WSW and S of Iceland. Caught in small amounts as bycatch in recent deep-water fisheries; might have been discarded in some amounts before. Catch Statistics are available in *Bulletin Statistique* from 1973 to 1976, but in *Útvegur* thereafter. All catch was

attributed to trawlers for period before catch by gear was known.

Haddock (*Melanogrammus aeglefinus*)
Haddock is very important in fisheries around Iceland. It is fished with many types of fishing gear, but the largest amounts by trawl and longline. This is the fish that Icelanders prefer to eat. Therefore, a proportionally large part goes to local consumption (*Útvegur*), or is eaten at sea. Actual catches might therefore be higher than reported landings. There could also be some highgrading, but probably less than that for cod, since the quota value of haddock is much lower and quotas therefore easier to obtain. Catch numbers used are from *Nytjastofnar* from 1950 to 1976, but from *Útvegur* thereafter.

Ling (*Molva molva*)
Common at intermediate depths S and W of Iceland. Bycatch in many fisheries and also a target fishery. Early landing statistics might include blue ling. Catch statistics from 1950 to 1976 are from *Nytjastofnar* and thereafter from *Útvegur*

Norway pout (*Trisopterus esmarki*)
Common south and west of Iceland; has at times sustained target fisheries for reduction. A problem with this fishery was that juveniles of more economically important species such as cod and haddock were frequent bycatch. Catch information from *Bulletin Statistique* was used from 1969 to 1976 and *Útvegur* thereafter.

Saithe (*Pollachius virens*)
Found all around Iceland, more common in the south and west. Caught as bycatch and is also a target species; mainly fished with trawl and gillnets. Discarding of small saithe has probably always occurred. However, recent rumours claim that some of the reported saithe landings are actually cod, meaning that landing statistics overestimate the saithe catches and underreport cod catches. This is because the quota value of cod is much higher than that for saithe. Assessing the stock has always been problematic, recruitment into the stock has always been difficult to determine (as opposed to cod) and saithe is highly migratory. It has been proved to migrate in large quantities to and from Icelandic waters. The fisheries in Icelandic waters are, however, on the continental shelf, within ICES area Va. Catch numbers used are from *Nytjastofnar* from 1950 to 1976, but from *Útvegur* thereafter.

Tusk (*Brosme brosme*)
Tusk is common in medium depths S and W of Iceland. It is mostly fished by longline. Little information is available on catch by fishing gear before 1977, except about the minor amounts fished by side trawlers, lobster trawlers and Danish seine boats for some periods. Catch that remained when these fishing gears had been subtracted from total catch was assigned to longliners since the majority was fished with longline in years where catch by gear is known. Total catch is from *Bulletin Statistique* from 1950 to 1976, but from *Útvegur* thereafter.

Whiting (*Merlangius merlangus*)
This is a shallow water species but not very common in Icelandic waters compared to the North Sea, for example. It is possible that some of the whiting catches were misidentified as hake by the foreign fleets. Whiting is not usually fished directly in Iceland, but occurs as bycatch in shallow water fisheries. It might have been discarded in large amounts since it is usually small in size, or reported with and not separated from haddock (mostly prior to 1965). Landings are only known since 1960 and come from a variety of sources. *Bulletin Statistique* covers the years 1960, 1964 and the time period 1965 to 1976; *Ægir* covers the years 1961 to 1963; and thereafter catches come from *Útvegur*.

Bib (*Trisopterus luscus*)
Never reported in Icelandic waters by scientists. The 1 t reported by Belgium in 1977 was probably a misidentification (Norway pout) or was not caught in Icelandic waters.

Hake (*Merluccius merluccius*)
Very rare in Icelandic waters. It is therefore unlikely that the foreign fleets caught as much as they reported there. The catch was probably either misidentified or was not fished in Icelandic waters. Perhaps the trawlers took a few hauls in home waters after returning from Icelandic waters before landing and reported all the catch in Icelandic waters. Some catch reported in unspecified grounds (not Icelandic) by Icelandic boats in 1997 and 1998 (*Útvegur*).

Pollack (*Pollachius pollachius*)
Pollack is not native to Icelandic waters, but is frequently found there (usually single individuals at a time). Some distant water countries, however, reported some catches. It is unclear if this is true; it could be misidentified saithe, or not fished in Icelandic waters.

Gadoids (unidentified)
Distant water fleets operating in Icelandic waters reported some catch as unidentified gadoids. A large part of this is probably blue ling and to a lesser extent grenadiers. Icelandic boats also reported small amount of unidentified gadoids in the North Sea in 1970 (*Bulletin Statistique*).

Groundfish, flatfish

Dab (*Limanda limanda*)
Dab is a common shallow water species in Iceland. Landings were low before 1988, but thereafter the Icelandic Danish seine fleet began targeting it directly. It is possible that it was discarded before or not separated from other flatfish species. The trawler fleet was, however, not allowed to fish in the shallow waters where dab is found, and it is not caught in great quantities by shallow water fishing gears such as longlines, handlines and gillnets. Dab now sustains a target fishery (usually boats that have finished their quota for more valuable species) and is caught as bycatch in the Danish seine fisheries for plaice. Catch by gear is more or less unknown before 1977, except for side trawlers. The catch that was not by trawlers was assigned to Danish seiners. Landings were, however, very low before 1985. Catch information from *Bulletin Statistique* was used from 1950 to 1976 (except in 1957 and 1963 when *Ægir* was used because *Bulletin Statistique* gave no values), but *Útvegur* thereafter.

Greenland halibut (*Reinhardtius hippoglossoides*)
The Greenland halibut fishery is currently the most important flatfish fishery in Iceland. As opposed to most of the other flatfish species the Greenland halibut is a deep-water species found in the cold waters E, N and W of the island. Little is known about the stock but the Greenland halibut in East Greenlandic, Icelandic and Faroese waters are considered the same stock. The Greenland halibut fishery was initiated by the German fleets in the 1950s but was then taken over by the Icelandic fleet. The Icelandic catches have declined (because of declining stock size) since 1988 and Faroese and Greenlandic catches have increased (fished in their home waters). Most of the Icelandic fishery is within the Icelandic 200 nm EEZ, but also includes ICES areas XIVb (where the major spawning grounds are), Va and IIa. There are also reported Icelandic catches in the Barents Sea and in an unspecified area, probably on the Rockall grounds. The Greenland halibut was probably reported with Atlantic halibut early on and actual landings therefore underestimated. Catch statistics for the Icelandic fleet is fragmentary for the two first decades. There are reported catches in the N.W. Atlantic in 1959 (FAO) and in Icelandic waters in 1961, 1962, and 1965 to 1968 (*Ægir*), from 1969 to 1976 catch statistics are available from *Nytjastofnar* (which agree very well with numbers from other sources), after that information from *Útvegur* is used. All catch prior to 1977 was assigned to trawlers. Landing statistics on Greenland halibut in *Bulletin Statistique* are incomplete: it is either not reported, reported as unidentified flatfish or 'halibut' (hence also making the halibut statistics questionable) depending on countries and years. Information on catch statistics have, however, been reassessed from 1961 to 1996 by Hjörleifsson (1997) and from 1950 to 1960 by Hjörleifsson *et al.* (1998).

Halibut (Atlantic) (*Hippoglossus hippoglossus*):
Halibut is one of the most valuable fish in Icelandic waters and is found all around the island. The catches have been declining for a long time as the stock has been heavily overfished. There used to be target fisheries for halibut by fleets from many countries. However, due to its low stock size, the current halibut catch is mostly a bycatch of other fisheries. Because of its dispersed distribution and since it is caught in most fishing gear it is difficult to manage the stock. A proportionally large part of the catch goes to local consumption or is eaten at sea and landing statistics might therefore be underestimates of catches. Catch information from 1950 to 1976 is from *Nytjastofnar* and after 1976 from *Útvegur*. Experimental halibut farming has been conducted in Iceland for some years, giving promising results lately. Production numbers are from Jóhannson (2000).

Lemon sole (*Microstomus kitt*)
Lemon sole is common in medium shallow waters in the warmer waters S and W of Iceland but is also found in the north. It was primarily caught as a bycatch species in trawl and Danish seine fisheries, but recently has also been targeted specifically. It is of high value and does not have a TAC, so discards are probably low. Landings have been increasing recently, but there are concerns that these might be misreports. Rumours exist that some fishers report catches of other species such as plaice or witch flounder (that have a TAC) as lemon sole (by having lemon sole at the top of the fish box but the other species below). If this is true, then this is one of the few cases where reported landings might actually be overestimates, as is the case when cod are

reported as saithe. Early catches of lemon sole might not have been separated from other flatfish. Catch statistics from 1950 to 1976 are from *Nytjastofnar* and thereafter from *Útvegur*.

Long rough dab or American plaice (*Hippoglossoides platessoides*)
This is probably the most numerous flatfish in Icelandic waters, and is found all around the country in a wide range of depths. It has always been caught as bycatch by most fishing gear and promptly discarded because of its small size and low value. Recently it has been the target of fisheries by the Danish seine fleet (by boats short of quotas for other, more valuable species). This species probably has the questionable honour of being the most discarded fish in Icelandic waters at all times and the mortality due to fisheries was, at least in the past, much higher than the landings indicated. The stock is, however, very robust and has never shown any signs of depletion. Landing statistics are from *Útvegur*, except for some minor distant water fisheries in 1964 and 1965 from NAFO.

Megrim (*Lepidorhombus whiffiagonis*)
The megrim is found at medium depths along the south shores of Iceland. It is bycatch in other fisheries such as Danish seines and lobster trawl. It is of relatively low value so it might have been discarded in some quantities in the past. Catch statistics are from *Bulletin Statistique* from 1950 to 1976 (*Nytjastofnar* gives the same numbers except in 1961, where other sources agree better with *Bulletin Statistique*).

Plaice (*Pleuronectes platessus*)
This species is very common in Icelandic waters and is found all around the island. It is also a valuable fish and has sustained considerable catches since 1950. The Icelandic catches were relatively low until 1983 when boats using Danish seines started targeting it substantially. The plaice is primarily targeted by Danish seine boats but is also a common bycatch in trawls and recently in gillnets. Early catches might include some other flatfish. Catch statistics might be underestimates in the most recent years since the TAC has been drastically reduced and some fishers claim that they are "forced" to discard it due to low quota status when fishing for other species (such as dab and lemon sole). Catch numbers used are from *Nytjastofnar* from 1950 to 1976, but from *Útvegur* thereafter.

Witch flounder (*Glyptocephalus cynoglossus*)
This species has probably been fished in Icelandic waters throughout the 20th century, but not much by Icelanders until recently. Some of the catch might be included under the lemon sole category (see above), but early catches were most likely included in 'other flatfish'. Witch is both targeted and caught as bycatch. Witch has mostly been fished by Danish seine boats since 1986, but before that by bottom and lobster trawlers. Total catch information is from *Nytjastofnar* (*Bulletin Statistique* gives the same numbers) before 1977 and *Útvegur* after 1976.

Brill (*Scophthalmus rhombus*):
This species has only once been reported in Icelandic waters and it is therefore unlikely that the foreign fleets did catch any there. The catches are either misidentification or not fished in Icelandic waters. Again, the trawlers probably took a few hauls in home waters after returning from Icelandic waters before landing and reported all the catch as coming from Icelandic waters.

Flounder (*Platichthys flesus*)
Was first reported in Icelandic waters by scientists in 2000 and was therefore either a misidentification or not caught in Icelandic waters (same as above for brill).

Sole (*Solea vulgaris*)
Has never been reported in Icelandic waters by scientists and was therefore either a misidentification or not caught in Icelandic waters (same as above for brill).

Turbot (*Psetta maxima*)
The turbot is not native to Icelandic waters but is a rather frequent visitor there; usually only one or few specimens are caught at a time. It is therefore not likely that the reported catches by the foreign fleets were actually fished in Icelandic waters. They could be misidentifications or have been fished in other waters (same as above for brill). The minor reported Icelandic catches are from *Útvegur*.

Flatfishes (unidentified)
This can be many species. Landings of flatfish prior to WW II were often not separated by species and can therefore contain many common species; however, usually halibut and plaice were reported separately. Foreign catches were also unidentified in some cases but could usually either be assigned to long rough dab (as for the English fleet) or Greenland halibut (as for the English and German fleets). For the period under consideration, most of the unidentified flatfish catches could be assigned to some species, but from 1955 to 1966 some small amounts were still left behind in the unidentified flatfish group.

Unidentified flatfish were also given in *Útvegur* after 1986.

Freshwater and anadromous fish (including aquaculture)

Abalone *(Haliotis rufuscens)*
Recent experiments have been conducted on abalone in mariculture. About 8 t were harvested in 1999 and an estimated amount of 23 t in 2000 (Jóhannsson, 2000).

Salmon (*Salmo salar*)
Native to Iceland; both in aquaculture and the wild. Some gillnet fisheries were conducted for salmon until 1998. Now all of the fisheries are either sport or gillnet fisheries in rivers. The sport catch is about 28000 individuals while about 6,660 are fished with gillnets. The gillnet catch has been declining from about 20,000 individuals in 1975, while the long term average is stable in sport fisheries (Guðbergsson, 2000). Historical catch statistics are quite unreliable since catches of freshwater fishes were not mandatory. Salmon farming began in 1984 and has leveled off at around 3,000 t/year. Total catch before 1960 was estimated from known years, catch from 1960 to 1996 is from *Bulletin Statistique*, and thereafter from Guðbergsson (2000).

Arctic char (*Salvelinus alpinus*)
Native and common in Iceland; both pure freshwater and anadromous stocks. Popular in aquaculture recently. The wild catch is included in 'unidentified trout'. Tonnage harvested is from FAO until 1996, but from Guðbergsson (2000) afterward.

Brown trout (*Salmo trutta*)
Native and common in Iceland; both pure freshwater and anadromous stocks. The wild catch is included in 'unidentified trout', but the amount harvested in aquaculture is reported separately and is low compared to the other trout species involved in aquaculture.

Rainbow trout
(*Oncorhynchys mykiss*) Not native to Iceland but used in aquaculture. Some have escaped and are to be found wild in a few streams.

Trouts (unidentified)
Arctic char and brown trout. This catch is obviously only an estimate since it has been exactly the same for long periods. This is, however, the only estimate we have on the wild catch of trouts in Iceland. This is probably the total catch estimate from all Icelandic fisheries on these, either fished for sport in rivers and lakes, or fished commercially by gillnets in lakes or in shallow waters. The anadromous species are not fished with the saltwater species and it is not mandatory to report landings, as required for saltwater species. There are therefore large uncertainties about the fishery for this species. Catch information is from *Bulletin Statistique* (preferred) and FAO. The 1997 to 1999 catch is estimated from previous years.

European seabass (*Dicentrarchus labrax*)
A warm water species not native to Iceland, but recent aquaculture experiments using geothermally heated waters. Production numbers are from Jóhannsson (2000).

River eels (*Anguilla anguilla* and *A. rostrata*)
Native to Iceland; both American and European eels considered to be found. Fished in traps in streams. There have always been some catches, but probably low except in 1961 and 1962 when experiments were conducted with live eel exports (Gunnarsson *et al.*, 1998).

Freshwater fishes (unidentified)
The only freshwater species found in Icelandic waters are the species mentioned above, plus sticklebacks (*Gasterosteus aculeatus*). Germany reported 2 t of unspecified freshwater fish in 1976.

Invertebrates and algae

Spider Crab (*Hyas araneus*)
Common in shallow waters all around Iceland. This species is a frequent bycatch in other fisheries (mostly for scallop and gillnet) but is rarely retained. An experimental direct fishery was conducted between 1985 and 1987. Information on catches is from *Útvegur*.

Spiny Crab (*Lithodes maia)*
A common species in the warmer Icelandic waters. Sometimes bycatch in other fisheries and usually discarded; a small amount reported in 1994 (*Útvegur*).

Crabs (unidentified)
Small amounts of unidentified crab were reported by Germany and Belgium. Probably spider crab.

Norway lobster (*Nephrops norvegicus*)
Common in the warmer Icelandic waters. Sustains considerable fisheries and is the most valuable species in Icelandic waters by weight. The only Icelandic fishery that is partly managed by obligatory discarding since females cannot be

retained (presumably they survive the handling). Most of the fishery is direct but there is also small amounts caught as bycatch in other fisheries. Experimental lobster fisheries were first conducted in 1939, but were not continued. Some low scale fisheries began in 1951, and large-scale fisheries did not begin until 1958. No information was found on the catch before 1958; presumably it was low. Total catch information is available in *Nytjastofnar* from 1958 to 1976 and from *Útvegur* thereafter.

Shrimp (*Pandalus borealis*)
This is the only commercially exploited shrimp species in Iceland. Sometimes a very small part of the catch is *Pandalus montagui*, however, they are never separated in reports. The shrimp fishery in Icelandic waters is by three distinct fisheries on separate stocks (Skúladóttir and Pétursson, 1999), consisting of stocks inshore, offshore and on the Dhorn Banks between Iceland and Greenland. Inshore shrimp is fished by small local boats in bays and fjords in northern and western Iceland. It is assumed that separate stocks are found in each bay (and separated from the offshore shrimp). Experimental fisheries for inshore shrimp began in 1924 but failed. The second attempt began in 1939 and some amount has been fished annually since. Records are, however, only available since 1955, but fisheries were low before. The offshore shrimp is fished by larger boats in deep waters north of Iceland (within Icelandic 200 mile EEZ and ICES area Va). The same boats target the Dhorn bank shrimp stock close to the Greenlandic EEZ (within Icelandic 200 mile EEZ but in ICES area XIVb). Experimental fishery for offshore shrimp began about 1976 but was low until 1983. Recently Icelandic shrimp boats have been shrimp fishing in international waters on the Dhorn banks and within Norwegian EEZ in the Barents Sea. Landings prior to 1977 are from *Nytjastofnar*, but thereafter from *Útvegur*.

Pagurus crabs (*Pagurus* spp.)
Two species are common in Icelandic waters, *P. bernhardus* and *P. pubescens*. Except for a total of 2 t reported by Belgian boats in 1966 and 1968 they have never been reported in landings in Icelandic waters. They are, however, common bycatch in scallop fisheries, but never retained.

Crawfish (*Palinurus* sp.)
Has never been reported in Icelandic waters by scientists therefore the 6 t reported by France in 1953 is either a misidentification (possibly Norway lobster) or was not caught in Icelandic waters (same as above for brill).

Horse mussel (*Modiolus modiolus*)
Common in Icelandic waters, but has only been reported in a very small amount in 1991 (*Útvegur*).

Ocean quahog (*Arctica islandica*)
Common in Icelandic waters and has been harvested substantially for export in recent years. Previously, small boasts did harvest this species for bait, but there are no data on the amount. Some is also caught and discarded by scallop boats. Catch information is from *Útvegur*.

Scallop (*Chlamys islandica*)
Common in Icelandic waters and has been harvested there since 1969, mostly in Breidafjordur Bay in W. Iceland since. The only scallop species commercially exploited in Iceland. Information on landings before 1977 is from *Nytjastofnar*, and afterwards from *Útvegur*.

Squid (unidentified)
Many cephalopod species have been reported in Icelandic waters, however they are not fished regularly. Very little is known about them and studies are scarce (Bruun 1945, Jónsson 1980, Jónsson 1998). Occasionally large amount of European flying squid (*Todaroides sagittatus*) are noticed and some is fished, mostly for bait by specialized handlines. These are not considered resident stocks, but from deeper waters outside the Icelandic EEZ. Some catches have been identified as *Loligo* spp. However, these have not been identified in Icelandic waters by scientists, so this identification is somewhat dubious. The landings history of squid is from *Ægir* between 1955 and 1967, then there is no catch for some years, but landing statistics after 1978 are from *Útvegur*.

Whelk (*Buccinum undatum*)
Common all around Iceland and has recently been harvested with traps. Discarded in scallop fisheries. Catch information is from *Útvegur*.

Mollusks (unidentified)
Belgian boats reported 1 t of unidentified molluscs in 1972, which might be scallop.

Sea cucumber (unknown)
Most probably *Cucumaria frondosa*. Common all around Iceland and often discarded bycatch in dredge fisheries; small amounts reported in 1995 (*Nytjastofnar*).

Sea urchin (*Strongylocentrotus droebachiensis*)
Common all around Iceland and harvested for their roe in recent years. Most of the harvesting is

by dredges but some smaller amounts also by divers, the latter is not reported. The fishery collapsed after 1996 due to marketing problems. *Echinus esculentus* is also found in Icelandic waters, but is not as common as *S. droebachiensis* and is not targeted. Discarded in scallop fisheries. Information on catches is from *Útvegur*.

Invertebrates (unidentified)
Catch of 83 t of unidentified invertebrates reported by German boats in 1965, could be Norway lobster.

Shellfish (unidentified)
Some small amounts reported by foreign fleets from 1953 to 1961, could be scallop, but also possibly other species.

Brown Seaweeds (*Ascophyllum nodosum*)
Harvested by farmers for various uses, but mainly food for livestock. Commercially exploited on and off since 1939, reduced and used as food for livestock and recently for algin production. Information on brown seaweed harvest is only available from FAO and *Bulletin Statistique*, the latter was preferred when data were available in both sources.

Kelp (*Laminaria digitata*)
Basically the same as brown seaweed but also often used as fertilizer. Information only available in *Bulletin Statistique*.

Marine mammals

Blue whale (*Balaenoptera musculus*)
Blue whales were a large part of the catch prior to WW II (Sigurjónsson and Hauksson 1994). Between 1948 and 1960 between 5 to 33 individuals have been caught annually, and hunting of blue whales was banned in 1960. Information on numbers caught is from *Nytjastofnar*, and the average weight used to convert this to weight is from Trites and Pauly (1998). This source was used also to estimate weight of all other marine mammals.

Fin whale (*Balaenoptera physalus*)
The fin whale was an important target species in the period after WW II. Harvested until 1989 when whaling was banned in Iceland. Information on numbers harvested is from *Nytjastofnar*.

Harbour porpoise (*Phocoena phocoena*)
These are often caught as bycatch in gillnet fisheries. A total of 3 animals were reported in 1982 and 1990 (FAO). However, the actual numbers caught is much higher.

Humpback whale (*Megaptera novaeangliae*)
A few were caught after WW II (*Nytjastofnar*), but the catches were higher prior to the war.

Killer whale (*Orcinus orca*)
The killer whale has not been hunted systematically like the large whales. A few have been caught live for aquariums however,. This is probably what happened to the 9 animals reported in 1981 and 1982 (FAO).

Minke whale (*Balaenoptera acutorostrata*)
Minke whales have been hunted during most of the 20th century, although official records are only available after 1973 (*Nytjastofnar*). Prior to this, Icelandic catch was estimated by Sigurjónsson (1982) and the Norwegian catch was estimated by Víkingsson and Sigurjónsson (1998). Minke whales were caught by small boats all around Iceland, in comparison to the hunting of other baleen whales that was done on large boats from only a few stations. Minke whaling has not been permitted since 1985.

Sei whale (*Balaenoptera borealis*)
The sei whale was targeted after WW II, catches prior to that were probably lower because of the relative small size of the whale compared to the blue and fin whale. Information on numbers harvested is from *Nytjastofnar*.

Sperm whale (*Physeter macrocephalus*):
The sperm whale has been caught in large numbers in Icelandic water during the 20th century. Only immature males are found in Icelandic waters. Numbers harvested is from *Nytjastofnar*.

Toothed whales (unidentified):
These are probably medium sized species such as the pilot whale (*Globicephala melas*) and the bottlenose whale (*Hyperoodon ampulatus*), or possibly even dolphins (*Lagenorhynchus albirostris* and *Lagenorhynchus acutus*). They are not harvested systematically but for some reason a total of 10 animals were reported in 1989 and 1990 (FAO).

Seals (several species)
Only 2 species of seals are native to Iceland, grey seal (*Halichoerus grypus*) and common seal (*Phoca vitulina*). Greenland seal (*Phagophilus groenlandicus*), ringed seal (*Phoca hispida*), and hooded seal (*Cystophora cristata*) are frequent guests in the winter, while bearded seal (*Erignathus barbatus*) and walrus (*Odobenus rosmarus*) are rarer. The number of seals are split into different species and also pups and adults. However, they are all combined when the

biomass in catches is calculated. It is not unlikely that more seals were killed than accounted for here, since reporting them was not mandatory until recently. All the information on seal kills is from *Nytjastofnar*.

DISCARDS AND UNREPORTED CATCH

Discards are a very controversial issue in Iceland and no conclusive scientific quantifications are available on their magnitude. However, much can be derived from the history of Icelandic fisheries. For example, species living in deep waters have been subjected to very few fisheries until recently, therefore, we can assume that discards and misreporting are relatively non-existent in early years. When effort began to move to deeper waters and there was still no reported landings on these species, they must have been discarded. This has changed in recent years given that some catches have been reported so discarding has probably been reduced.

Many shallow water species, especially long rough dab and starry ray, have always been discarded in large amounts due to their low value. However, with the implementation of the ITQ system they were retained more since they did not have a TAC. The ITQ system has therefore reduced discarding or even created target fisheries on species without a TAC. The effect is opposite on those species with a TAC, especially if they are also of high value. Since the value of quota is high for many species and some boats have much more fishing capacity than allowed by quotas, they tend to highgrade the catch: small fish are discarded (which is illegal) or some species are falsely reported as others. There are rumors going around ranging from virtually no discarding by some fleets to thousands of tonnes annually by others. There are also a few cases where boats have been caught discarding, or are strongly suspected of doing so from indirect clues (such as comparing the catch with and without on-board observer).

Fish species in which a proportionally large part is used for local consumption are a special case. These are mainly haddock, halibut, skate and Greenland shark (*Útvegur*). These are all eaten by the fishers at sea and therefore not reported, which probably causes minor underestimates of actual catches. The fishers can also take some amount home for the family, usually one bag of fillets However, some of them take more, and some have even been caught in the act. These amounts are not reported in any landing statistics (both before and after the ITQ system was established). It is therefore quite possible that the part that goes to local consumption is underestimated and actual landings are higher than reported. Estimates of this form of local consumption can be made by assuming that the 5,000 fishers land 50 times per year, each taking 20 kg of ungutted haddock home. This makes a total of 5,000 t/y or about 12.5% of the total reported haddock catch. The part that goes to export, which is more than 99% for most species, is much better monitored, from the place of landing, through processing to the final exporting of the product.

From this knowledge, each species was given an estimate of discarding by decade. These estimates were categorized as low, low/med, med, med/high and high (Pitcher and Watson, 2000). The problem was then to assign some numbers (percentages) to these categories in order for this to be useful in stock assessment. The percentages used (Table 1) were based on several studies on discarding in Icelandic waters (Agnarsson 2000, see Appendix III). These are percentages of the average catch and were assumed constant from 1950 onwards.

It is mandatory to report all landings in Icelandic waters and Icelandic registered boats are mandated to report all of their catches in distant waters. Government officials and official weights at all ports of landing ensure this, and this also ensures that illegal fishing is minimal. The only exceptions from this mandated reporting are the lumpfish fisheries and fisheries for anadromous species in very shallow marine waters or in freshwater. Except for lumpfish, these numbers are low, but should still be evaluated with caution. All species have to be identified when landed; nevertheless there is always catches reported as unidentified, or as a group, such as flatfish or shellfish. There is no information on what these groups contain, but they might include species fished in low quantities during each trip. If they contain the commercially important species the amounts can be ignored since the values are low. However, if they contain species whose reported catches are low, they can skew the picture since they would be a large portion of the actual catch.

Table 1. Assigned percentage discards (range and mean) by estimated discard category, based on Agnarsson (2000).

Category	Discard range (%)	Average discard rate (%)
Low	0-5	2.5
Low/Med	5-10	7.5
Med	10-15	12.5
Med/High	15-25	20
High	25	50

RESULTS

Although it is beyond the scope of this paper to analyze in detail the data that have been gathered, preliminary results are presented and discussed in order to illustrate some general trends in the fisheries in Icelandic waters.

There has been a general increase in effort from 1965 to 1990 (Figure 3), reflecting a doubling in total number of days spent at sea by Icelandic boats, and a quadrupling of engine power spent per day at sea (see also Tyedmers, this volume). Around 1950 about half of the effort was spent by trawlers. This decreased during the 1960s when purse-seiners accounted for most of the effort. After the collapse of the herring stocks the trawlers took over again as the predominant boat type, especially after the stern trawlers began operating after 1970. Horsepower-sea-days also increased for other gear categories as the boats became larger and more powerful (Figure 4). There is also a sharp increase in horse power-sea-days by the smallest boats (handliners), after 1986.

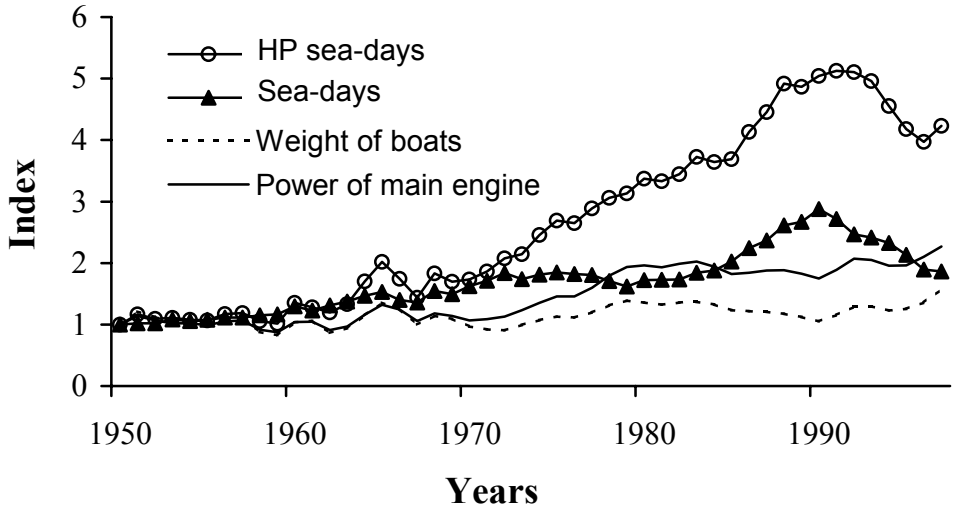

Figure 3. Relative indices of Horse-Power (HP) sea-days, total sea-days, average weight, and power of main engine of all boats since 1950; for Icelandic boats in Icelandic waters.

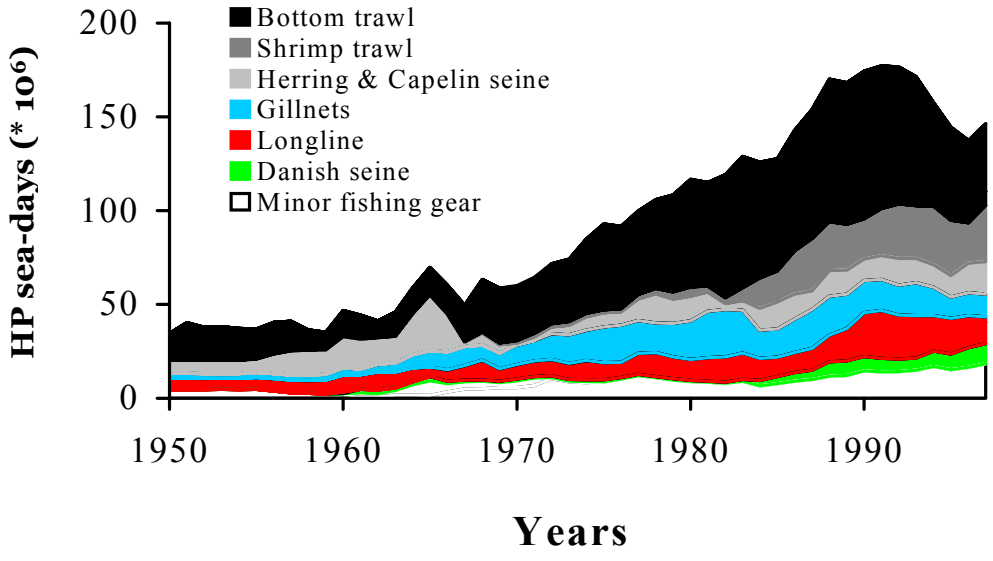

Figure 4. Horse-Power (HP) sea-days by gear category since 1950; for Icelandic boats in Icelandic waters. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

At first glance, the trend in total catch in Icelandic waters seems to fluctuate quite strongly (Figure 5). This is largely due to two pelagic species; herring and capelin. Trends in catch for other species are relatively smooth. Catches of small pelagics increased after 1960, during the herring years. After the herring stock collapsed it took some years for the capelin fishery to establish itself. The capelin stock does fluctuate widely, mostly due to variability in recruitment and its short lifespan (catch is usually only based on two year classes).

Catch of other species has been remarkably constant since 1950. Before 1975 Icelandic boats took more than half of the cod catch in Icelandic waters, but foreign boats took more than half of the catch of other species. After the extension of the EEZ the foreign catch declined to low numbers, but Icelanders increased their catches to amounts similar to all foreign catches combined.

Icelandic catch in distant waters fluctuates greatly (Figure 6). Cod and redfish fisheries in distant waters were extensive in the first decade because trawl fisheries were limited by regulation in Icelandic waters. Herring fisheries were considerable in distant waters from 1965 to 1975, due to the collapse of the stocks in Icelandic waters. This was followed by a period when Icelandic boats did not venture beyond Icelandic waters. Their outward expansion, however, began again around 1995, when severe measures to reduce the effort in Icelandic waters were implemented.

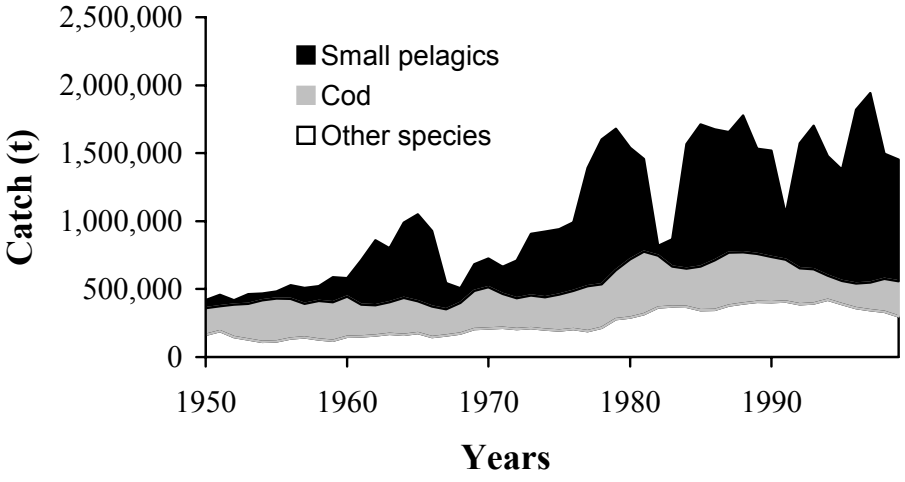

Figure 5. Total catch in Icelandic waters by species groups.

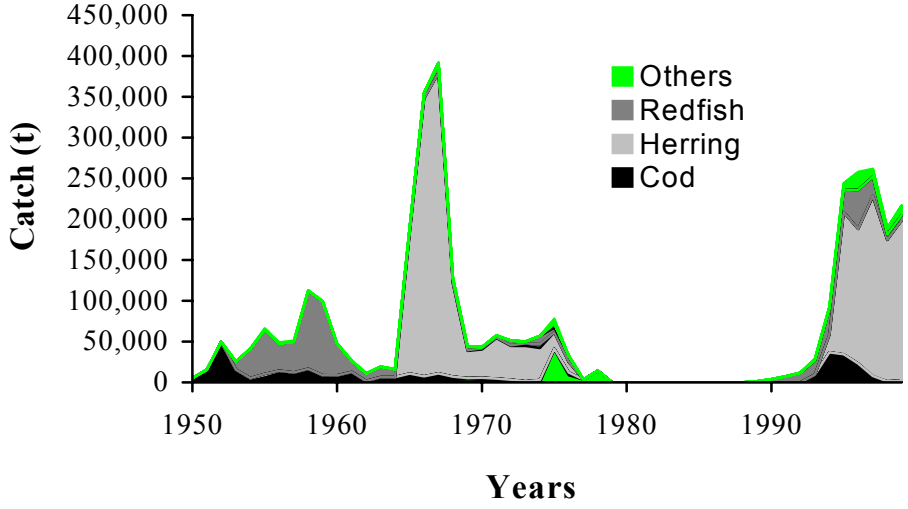

Figure 6. Catch by Icelandic boats in distant waters. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

The total catch per total effort is actually about the same in 1950 and 1997 (Figure 7). However, this is misleading due to the influence of increasing herring and capelin CPUE. When these species are excluded, a downward trend becomes obvious. If we examine the catch/effort by species and fishing gear, the changes with time are more variable. A declining trend is obvious for gear fishing cod. However, most effort in the early years was directed towards cod, whereas in later years when the ITQ system was put in place, many boats fished for other species and actively avoided cod, which makes their effort for cod impossible to separate from the total effort for that gear type in the data available. There is also a decline in haddock and saithe catch/effort. However, this is less clear since many fishing gears do not show any obvious trend. Redfish show a very different trend in that catch/effort increases for many fishing gear types in more recent years. Halibut shows an obvious decline in catch/effort by most fishing gears. There is also a decline in catch/effort of the plaice before 1970, which then fluctuates after that year. The high catch/effort before 1970 might reflect more the uncertainty in assigning the catch by gear and estimating the effort for those early years.

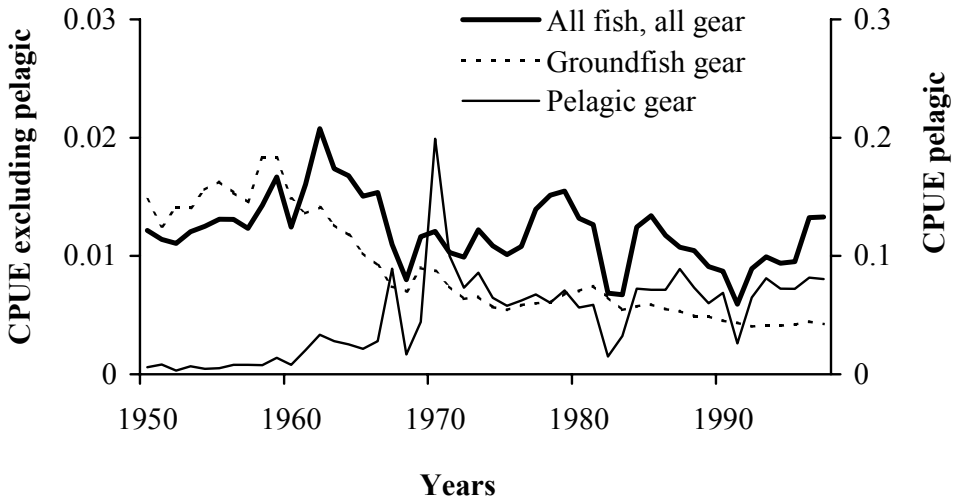

Figure 7. Catch Per Unit of Effort (CPUE) by Icelandic boats in Icelandic waters. Pelagic gear is capelin seine, herring seine, and driftnets. Groundfish gear is all other fishing gear.

DISCUSSION

The species mentioned above show differing trends, and direct us to different aspects of the data that should be questioned. Does the catch/effort trend of cod really reflect stock size? Why is the catch/effort trend by fishing gear so different for haddock and saithe? Why such a big difference in catch/effort for plaice before and after 1970? These questions are not addressed in the present report as this paper is only meant to explain the making of the database and to give a short overview on the subject.

In the beginning of the period under consideration (1950 to present), the fisheries around Iceland were already well developed. Trawlers had been operating there for more than 50 years, Icelandic boats had already ventured to distant waters, and foreign fleets had been fishing in Icelandic waters causing conflicts for more than 500 years. To extend this analysis to the early years of the 20th century, and even further to earlier centuries, would be extremely interesting, although resource intensive. It can also be argued that it would be more important to get more accurate information for the period after 1950 before earlier years are visited. Several gaps in knowledge have been identified. For instance, we do not know effort and catch by gear for major species before 1966 (with exceptions), we do not know catch by gear for species of lesser importance before 1977, and we do not know the total catch of many minor species for long periods. Furthermore, we have very little reliable information on discarding. Information on discards and other unaccounted mortalities due to the fisheries would be like locating an undiscovered stock of herring. This type of information is probably not available in printed format, and would therefore be difficult to estimate. The most promising way is probably to interview old fishers on what actually happened in the past. However, this too would be time consuming and costly.

Time consuming and costly or not, it is vital for a country as dependent on fisheries as Iceland to have access to information and a good understanding about its past fisheries. Information on fluctuations of catch, effort and catch/effort from days gone by are directly useful for today's stock assessment and can only help to improve our fisheries management. I would argue that this is especially important today given that new generations of fishery scientists are taking over who otherwise might lack the understanding and knowledge of past stock structure, biomass, fisheries and ecosystems.

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APPENDIX I: SOURCES OF FURTHER INFORMATION ON THE WEB

www.fauna.is Pictures of Icelandic fish species, as well as other animals.
www.fiskifrettir.is (Fishing news): A newspaper on Icelandic fisheries; available in Icelandic only.
www.fiskistofa.is (Directorate of fisheries): Information on various aspects of the Icelandic fishery system, available in Icelandic and English. However, the Icelandic is more detailed, which, among other things, provides up to date information on all landings in Iceland.
www.hafro.is/hafro (The Marine Research Institute): Information on various aspects of the marine environment and fisheries in Iceland. In Icelandic and English, however the Icelandic r is more detailed. Information on the latest stock assessments can also be found here (www.hafro.is/hafro/Radgjof/2000/summary.html) as well as a searchable database on articles by scientists at the institute (www.hafro.is/hafro/ Bokasafn/heimildir.e.cgi).
www.hi.is (University of Iceland): The largest university in Iceland's website address. Many of the departments in this university deal with various aspects of fisheries. It also has a graduate program in fisheries science (Fisheries Research Institute). Most information is only in Icelandic.
www.kvotathing.is Information on quota prices Icelandic only.
www.mar.is Information source, Icelandic only.
www.rfisk.is (The Icelandic Fisheries Laboratories): Information on research in the Icelandic fishing and processing industry
www.rsf.is (Fish markets): Up to date information on sales (amount and value) and availability in Icelandic fish markets since 1992. Both in Icelandic and English
www.sigling.is (The Icelandic Maritime Administration): Information on ships, lighthouses, harbours, etc. Mostly in Icelandic.
www.statice.is (Statistics Iceland): Very good site with statistical information from Iceland, includes among other things detailed information on fisheries in 1998 and 1999. Both Icelandic and English, although the Icelandic site is more detailed.
www.stjr.is/sjr (The Ministry of Fisheries): Information on various aspects of the Icelandic fishery system, in Icelandic (more details) and English. Fishery regulations can be found in the Icelandic version. The Ministry has sites with basic information on fisheries (www.fisheries.is/index.htm and www.stjr.is/ interpro/sjavarutv /english.nsf/pages/front-c)
*www.ths.is*_(National Economic Institute): Information on various aspects of the Icelandic economy. Both Icelandic and English, the Icelandic is more detailed.
www.unak.is (University of Akureyri): A university situated in Northern Iceland. It is unique in Iceland since it offers an undergraduate program in fisheries science (Faculty of Fisheries). Mostly in Icelandic.
www.veidimalastjori.is (Directorate of Freshwater Fisheries): Information on freshwater fisheries and aquaculture, mostly in Icelandic.
www.verdlagsstofa.is Information on fish prices, Icelandic only.

APPENDIX II: MAJOR CHANGES IN CATCHABILITY OF FISH IN ICELANDIC WATERS (TIMELINE)

Below is a summary of circumstances that have influenced the catchability of fish in Icelandic waters. Some of them decreased the catchability, such as the extension of the EEZ, while others increased it, such as

improvements in fishing gear design. In many cases the exact year they were first used is unclear, but they are given a year thought to be close to when they were first used. In addition there have been many and constant changes in the design of fishing gears. Many of these are probably gradual and therefore difficult to pinpoint in time, others are probably not. Further studies would be needed to pursue this problem further.

1950 Radar and sounders become common in use by trawlers; positive influence on catchability of groundfish since grounds became easier to find. EEZ extended to 4 miles along the north coast. This acted as a negative influence on foreign fleets and Icelandic trawl and Danish seine fleets since many grounds became off limits.

1952 EEZ extended to 4 miles all around Iceland; a negative influence on catchability of foreign fleets and Icelandic trawl and Danish seine fleets since many grounds became off limits.

1954 Nylon commonly used in trawl and gillnet fisheries; positive influence on the catchability of groundfish since the gear was lighter and much more reliable. 110 mm minimum mesh size enforced in trawl and Danish seine fisheries, negative influence for on the catchability of groundfish.

1957 Nylon commonly used in purse seines, positive influence on catchability of herring, since the gear was lighter and much more reliable.

1958 EEZ extended to 12 miles, a negative influence on foreign fleets and the Icelandic trawl and Danish seine fleets, since many grounds became off limit.

1961 Sonars and Powerblocks became widely used by purse seiners, positive influence on catchability of herring.

1963 120 mm mesh size enforced. Negative influence on catchability by trawl and Danish seine, since smaller fish escaped.

1972 EEZ extended to 50 miles, negative influence on catchability by foreign fleets since many major grounds became of limit.

1975 EEZ extended to 200 miles, most foreign fleets were expelled from Icelandic grounds.

1976 135 mm mesh size enforced. Negative influence on catchability by trawl and Danish seine, since smaller fish escaped.

1977 155 mm mesh size enforced in most grounds. Negative influence on catchability by trawl and Danish seine, since smaller fish escaped.

1978 Loran navigation system positive influence on catchability of most species since grounds were easier to find.

1979 Lead used instead of stones to sink gillnets, leading to 20 – 30% increase in catchability of cod, no increase for saithe.

1983 Computerized jigging reels, positive influence on handline fisheries.

1984 ITQ in groundfish fisheries, negative influence on catchability of species that do have a TAC (due to highgrading), but positive on species that do not have a TAC (species retained more).

1988 Rockhoppers, positive on bottom trawl fisheries since they could operate on rougher grounds and less time had to be spent fixing damages gear.

1991 Computers (MACSEA), positive on most species since it became easier to find grounds and store data on where good fishing took place.

1993 GPS, positive on most species, especially groundfish since it became easier to find grounds.

1993 D-graphic of the sea bottom on a computer screen.

APPENDIX III: STUDIES ON DISCARDING IN ICELANDIC WATERS

Summary of Results (roughly translated from Agnarsson, 2000)

1982 Study by the Marine Research Institute on decked boats comparing vessels fishing in the same area: 2/3 of undersize cod was discarded, this equals 6% of catch tonnage.

1987 Study by the Marine Research Institute on trawlers (same method as above): Similar as above or 5%.

1992 Study by the *Marine Research Institute* on Ocean redfish trawlers. 16-17% of catch discarded.

1994 Study by the *Marine Research Institute* on Ocean redfish trawlers. Similar as above.

1995 Study by a commercial fishing company (Venus) on Ocean redfish trawlers. Similar as above. (This species is mainly discarded since it frequently has a parasite that makes it low value, the parasite is much rarer in other species-

1990 Questionnaire to fishers by SKÁÍS : Questions to 900 fishers (300 on trawlers, 300 on decked boats, 300 on undecked boats), 591 answers back. From this it was estimated that about 40 thousand tonnes of groundfish (consisting of all species grouped into this category) were discarded in 1989. This represents about 6% of total groundfish catch. Discarding of cod and haddock was 2 times higher in trawlers than.

1992 Catch composition compared in gillnet boats with and without observers: 1 to 2% discards by weight (0.92% average). (This has been considered unrealistically low).

1992 Fishermen asked (confidentially) about discarding (occurrences/practices) on trawlers: Discarding of groundfish was 4.1% by weight, highest for redfish (12.9%), lowest for cod and saithe (0.4 and 0.2%, respectively). Other species: haddock 2.2%; Greenland halibut 2.2%; plaice 2.4%; other flatfish 17 tonnes and various catch 72 t (no percentage is given for the last two). Redfish was not identified to species in this study (however this is not Oceanic redfish as above). Only small redfish were discarded, they might have been small sized commercially exploited species (*Sebastes marinus* and demersal *S. mentella*), but were more likely *S. viviparous* which is a small species not utilized until more recent years.

2000 Catch composition compared in 4 gill netters and 4 Danish seiners with and without observers: Fewer small sized fish of the same species were encountered on those boats without observers, no quantitative results.