

Deep Water Fisheries at Iceland

by

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Introduction

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During the first half of this century, the modern fishing technique developed rather rapidly in the Icelandic fishery when it changed from hand- and longline fishery carried out from open and small-decked hand- and wind-powered boats to motorised cutters and steam trawlers. However, the fishery remained in relatively shallow waters, i.e. less than 400 m in spite of the modernisation of the fleet and gear. Also, the target species in particular cod (*Gadus morhua*) remained the same.

In the thirties, steam trawlers ventured into somewhat deeper waters and the fishery for redfish (*Sebastes marinus*) commenced. In the seventies, deep water fishing (<500 m) developed rather rapidly in Iceland. Within relatively few years, deep water fishing became of great importance to the Icelandic demersal fishery. The most important species are by far deep-sea redfish (*Sebastes mentella*) and Greenland halibut (*Reinhardtius hippoglossoides*). A targeted deep-water fishery has been executed on the following species with varying intensity:

- Deep-sea redfish (*Sebastes mentella*)
- Greenland halibut (*Reinhardtius hippoglossoides*)
- Blue ling (*Molva dypterygia dypterygia*)
- Orange roughy (*Hoplostethus atlanticus*)
- Greater silver smelt (*Argentina silus*)

Further, incidental catches have been reported on e.g. roundnose (*Coryphaenoides rupestris*), roughhead (*Macrourus berglax*), *Chimaeridae*, *Squalidae*.

The fleets involved are very much the same, changing from one fishery to another mostly using the same kind of gear. The two main fleets are trawlers and to a much smaller extent, also longliners. The gear used in the different deep-sea fisheries is basically the same as for fishing in shallower water with some minor modifications and some alterations made by the individual captains. The bottom topography of the ocean region around Iceland forms barriers influencing drastically the hydrographic conditions in the region causing a very variable environment in deep water off the different coasts

Material and Methods

The official catch statistics, log books and fleet register have been examined. Further, information have been gathered from the data base of the Marine Research Institute (MRI), Iceland.

Material was collected from gear producers, and their technical experts, and captains on fishing vessels were interviewed and consulted. Information was collected from several publications and from unpublished reports.

Results

Hydrography

Iceland is situated on a submarine ridge extending from Scotland to Greenland. This ridge forms a barrier which separates the bottom water of the Arctic region from that of the Atlantic.

Topographically there are four different deep-sea basins around Iceland:

1. In the north, the basin between Iceland and Jan Mayen (Iceland Sea and Iceland-Greenland channel)
2. The basin east of Iceland (Norwegian Sea)
3. In the south, the basin between the Reykjanes Ridge and the Iceland-Faroe Ridge (Iceland basin)
4. West of Iceland, between the Iceland-Greenland Ridge and the Reykjanes Ridge (Irminger Sea).

Arctic bottom water dominates in the deep layers north and east of Iceland characterised by salinity of about 34.9 ‰ and low temperatures ($< 0^{\circ}\text{C}$).

West of Iceland, temperatures of 3°C - 4°C and salinities of 34.85 - 34.90 ‰ dominate in depths of 500 to 2000 metres. In the Icelandic basin (south of Iceland), the temperature is from about 7°C to $3\text{--}4^{\circ}\text{C}$ in 500 to 2000 m depth, and higher salinity where the 35 ‰ isobar reaches below 1000 m depth.

Inventory of the fleet

As a result of the government's policy to reduce the fishing fleet because of less availability of fish stocks, on the traditional fishing grounds, there was a considerable reduction in most of the vessel categories i.e. in the number of vessels, in gross register tons as well as in engine power (kilowatt) during 1991-1995 (Fig. 1).

One vessel category, however, i.e. trawlers larger than 500 GRT increased in number as well as in GRT and power. The expansion in this size category consisted mainly of big freezer trawlers. The efficiency for trawling in deep and distant waters has, together with improved fishing technique increased considerably. Thus, this fleet category is a very effective part of the fishing fleet.

Table 1. The Icelandic fleet 1991-1995. Number, G.R.T and Power (kW) are shown for each vessel category (t)

Each vessel category (t)											
Year	Cutters								Trawlers		Total
	Vessel categories (t)										
	≤ 12	13-20	21-50	51-110	111-200	201-500	500-800	>800	≤ 500	> 500	
Number of vessels											Total
1991	438	49	83	114	99	82	10	5	80	33	
1992	427	47	81	103	91	82	10	5	69	38	
1993	421	47	80	100	94	77	10	5	68	41	
1994	363	50	76	88	89	78	10	4	64	45	
1995	341	48	73	84	82	69	10	4	64	50	
G.R.T.											Total
1991	3506	802	2598	8962	15346	23142	6879	4443	31005	24947	
1992	3333	766	2505	8091	14120	23503	6879	4443	26843	29913	
1993	3269	766	2480	7859	14715	21758	6750	4443	26660	32529	
1994	2780	813	2354	6913	13989	22139	6750	3622	25388	37039	
1995	2581	778	2292	6620	13038	20106	6764	3622	25635	41930	
Power (kW)											Total
1991	43519	6833	18123	42718	55125	66117	19497	10651	99926	63911	
1992	44980	6445	17867	38769	51454	66496	19497	10651	87369	80487	
1993	45491	6492	17603	37751	53697	61708	18865	10651	86594	86639	
1994	40895	7101	16637	33139	51345	63231	18865	8444	82455	98838	
1995	38548	7019	16014	31587	47285	56433	18865	8444	83743	107401	

Basically, the same trawler fleet is engaged in the various deep water fisheries, i.e. they shift over from one fishery to another. A few vessels of smaller categories engage in the trawl fishery for deep-sea redfish and greater silver smelt, and longliners(500-700 HP engine power), for Greenland halibut.

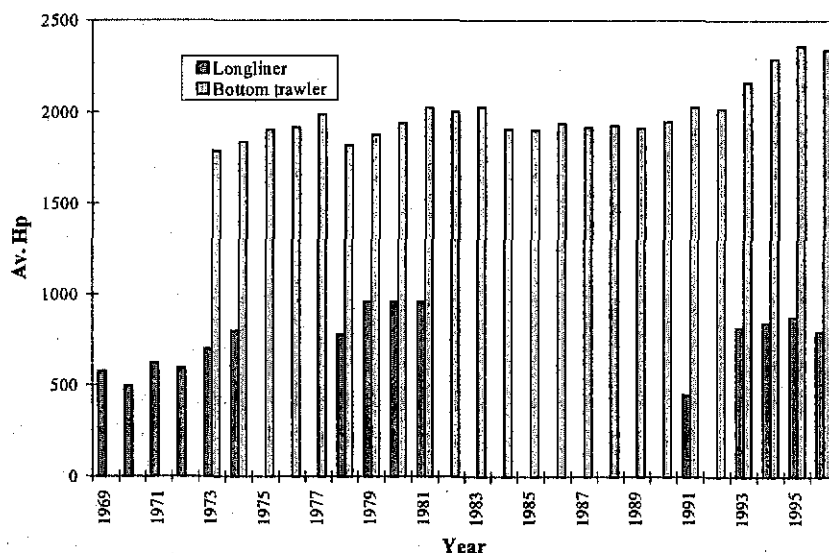


Fig. 1. Icelandic Greenland halibut fisheries. Av. Hp of the fleet 1969-1995.

Fishing gear

There are three types of gear which have been used for deep-water fishing by the Icelandic fleet:

1. Bottom trawl
2. Gloria midwater trawl
3. Deep-sea longline

1. Bottom trawl

The bottom trawl is used for the two well established deep-water fisheries for Greenland halibut and deep-sea redfish. The same kind of trawl is used for both fisheries in general. Basically, the trawl is of the same type for the whole trawler fleet. The general description of such a trawl is shown in Appendix I.

The trawl is characterised as a high opening two-panel trawl. It has a longer belly than the conventional trawls used before and it is popular to use 200 mm mesh size in the front of the trawl resulting in less drag in towing. The codend has the prescribed 135 mm mesh size. The lower part of the wing ends are omitted and only the top wing (flyer) part is used which is attached to the foot rope by a chain.

The length of sweeplines and bridles are usually 70 fm and 30 fm respectively but may vary somewhat by individual captains. The trawl doors used to this kind of trawl are oval, heavy duty doors with a slot. The weight and size may vary somewhat depending on the vessel size and /or power.

2. Gloria midwater trawl

In recent years, considerable catches of deep-sea redfish are taken with a midwater trawl. All trawlers use the same type of trawl, i.e. the Gloria midwater trawl which is a four-panel trawl with very big meshes in the front part. In Appendix II, a schematic picture of the 2560 m Gloria trawl, together with the bridle arrangements is shown.

The size of this trawl is somewhat variable depending on the towing power of the respective vessels. The size is indicated by the length in metres of the circumference at the greatest width of the belly by stretched meshes.

Special otter boards of Suberkrub type are used for this midwater trawl. The POLY-ICE type is used by all the vessels but of variable size. Compared to bottom trawl doors, the midwater otter boards are bigger but lighter.

Statistics

Redfish (*Sebastes mentella*)

In the 1960s and 1970s, deep-sea redfish was a substantial part of the German redfish fishery at Iceland. The German fleet ceased to fish at Iceland in 1977. After this time period, the Icelandic fleet activated the fishery on deep-sea redfish which became an important part of the redfish catches at Iceland. The total catch of deep-sea redfish increased considerably during 1988-1994 in Iceland and reached its maximum in 1994 with almost 57000 tons but the catch per unit effort (CPUE) decreased greatly during the same period. By the quota regulation which was introduced on the *Sebastes* species separately in 1994, the landings declined to 35000 tons, in 1996 (see Fig. 2).

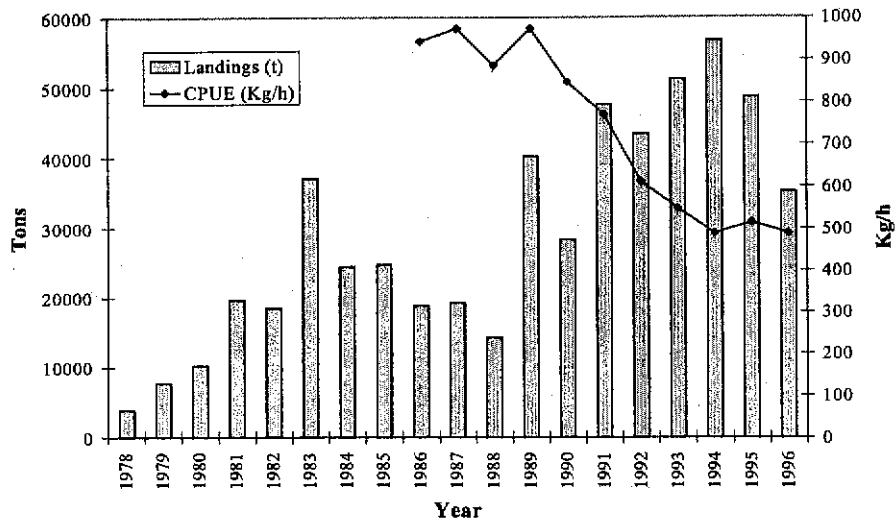


Fig. 2. Deep-sea redfish. Total landings 1978-1996 and CPUE since 1985

The deep-sea redfish has almost exclusively been taken by bottom trawl and in late years, also by midwater trawl.

Greenland halibut (*Reinhardtius hippoglossoides*)

Iceland commenced fishing on Greenland halibut with longline in 1969 and with bottom trawl in 1973. The landings remained, however, moderate until 1977, reaching 10000 tons. In the following years, the landings increased and reached their maximum in 1987 - 1989 with an increase from 45000 tons to almost 60000 tons.

Since then, the fishery on Greenland halibut has declined and the CPUE dropped drastically, after 1989 (Fig.3). Currently, the fishery is managed by a strict quota regulation.

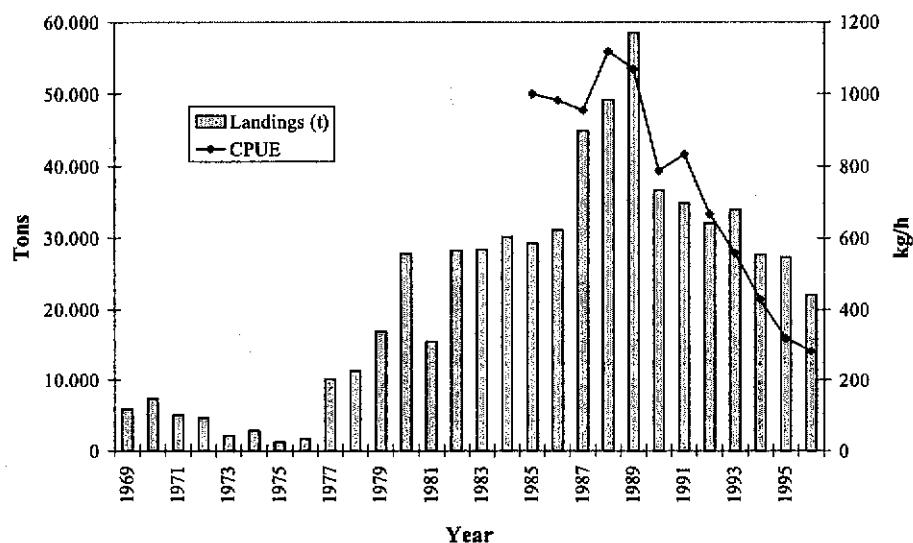


Fig. 3. Greenland halibut. Total landings 1969-1996 and CPUE since 1985

Blue ling (*Molva dypterygia*)

Fig. 4 shows the total Icelandic landings of blue ling from 1969 to 1996. In most years, the landings which were exclusively by-catches amounted to about 2000 to

3000 tons. The peaks in the landings (Fig. 4) represent a targeted fishery on spawning concentrations.

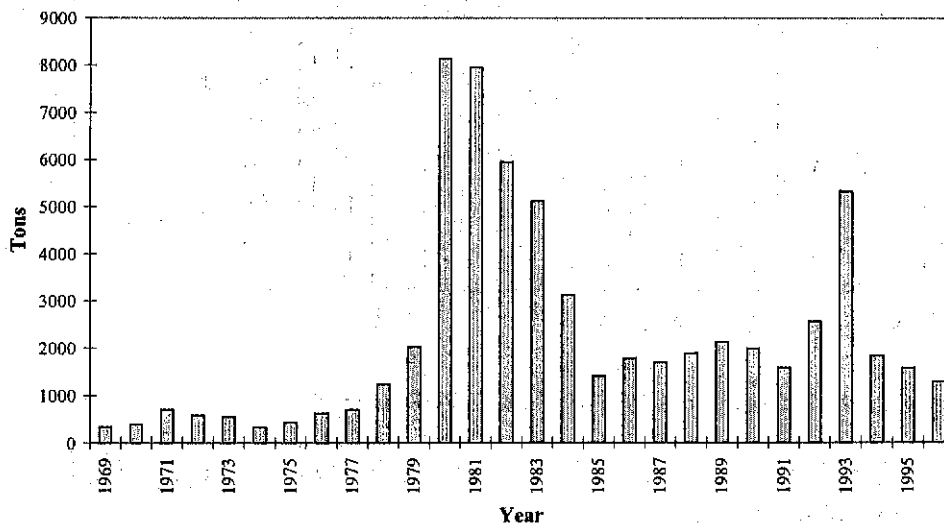


Figure 4. Blue ling. Total Icelandic landings of blue ling 1969-1996.

Greater silver smelt (*Argentina silus*)

The landings of greater silver smelt have been moderate and variable from year to year in a range of 42 tons in 1987, to 1255 tons in 1993. In 1997, the catch increased suddenly to about 3400 tons and the landings continued to increase greatly in 1998 (Fig. 5).

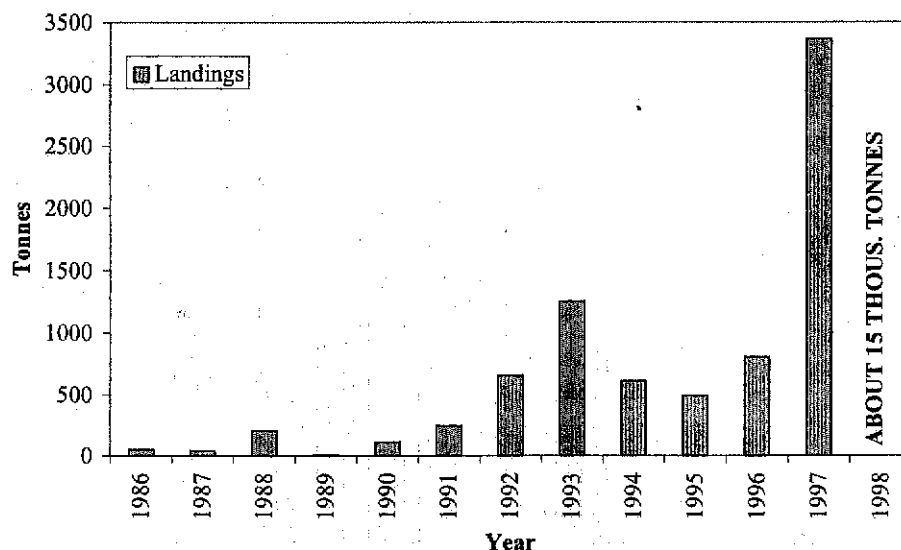


Figure 5. Greater silver smelt. Total landings 1986-1998.

Orange roughy (*Hoplostethus atlanticus*)

The catches of orange roughy were small. The highest landings on record are 715 tons, in 1993 (Table 2)

Other species

The catches of deep water species other than those mentioned above have been very small. They are presented in Table 2. It should be noted that in the figures for roundnose grenadier, some mixing with figures for roughhead grenadier could be possible.

Table 2. Icelandic deep water fisheries. Catches and by-catches (tons)*

English names	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Black dogfish	0	0	0	0	0	1	0	0	1	4	6
Portuguese shark	0	0	0	0	0	1	1	0	0	0	2
Rat-tail	0	0	0	0	498	106	3	60	106	21	794
Knifenose chimaera	0	0	0	0	0	1	2	0	2	1	6
Smooth-head	0	0	0	0	0	10	3	1	1	0	15
Greater silver smelt	42	206	8	112	246	657	1255	613	492	808	4439
Spine eel	0	0	0	0	0	0	0	0	0	1	1
Rough head grenadier	0	0	0	0	1	0	0	28	6	15	50
Roundnose grenadier	0	2	2	3	48	210	276	210	398	139	1288
Blue antimora	0	0	0	0	0	0	0	0	0	2	2
Orange roughy	0	0	0	0	65	382	715	158	64	40	1424
Black scabbard fish	0	0	0	0	0	0	0	1	0	0	1

* Deep-sea redfish, Greenland halibut and blue ling are omitted

Fisheries

Redfish

Redfish (*Sebastes marinus*) was commonly caught in minor quantities together with cod, in relatively shallow waters. A directed fishery for redfish at Iceland was initiated by German trawlers before World War I. This fishery was very moderate in the beginning but increased considerably during the time period 1920 to the 1930s until the beginning of World War II when Germany ceased to fish at Iceland during the war.

The redfish fishery is a well established fishery in Iceland since the mid thirties.

In the beginning of the fishery on redfish in Icelandic waters, neither the fishermen nor the scientific community was aware of the existence of the deep-sea redfish, *Sebastes mentella*. In 1951, the deep-sea redfish was described as a separate species by Travin (1951). Both species (*Sebastes marinus* and *S. mentella*) were, however, landed unsorted as redfish, until 1994. For scientific purposes, they were separated by indirect methods from 1978 onwards. Before 1978, only total landings of redfish (both species mixed) are reliable.

The deep-sea redfish is distributed along the slope area west, south and south-east of Iceland. The fishing mostly takes place at depths of 500 - 700 m. During the mating period in autumn (September to November), the deep-sea redfish aggregates off the bottom in the Reykjanes Ridge area and along the slope off the south coast and is then caught in pelagic trawl to some extent.

Fig. 6 shows the main fishing ground for deep-sea redfish at Iceland.

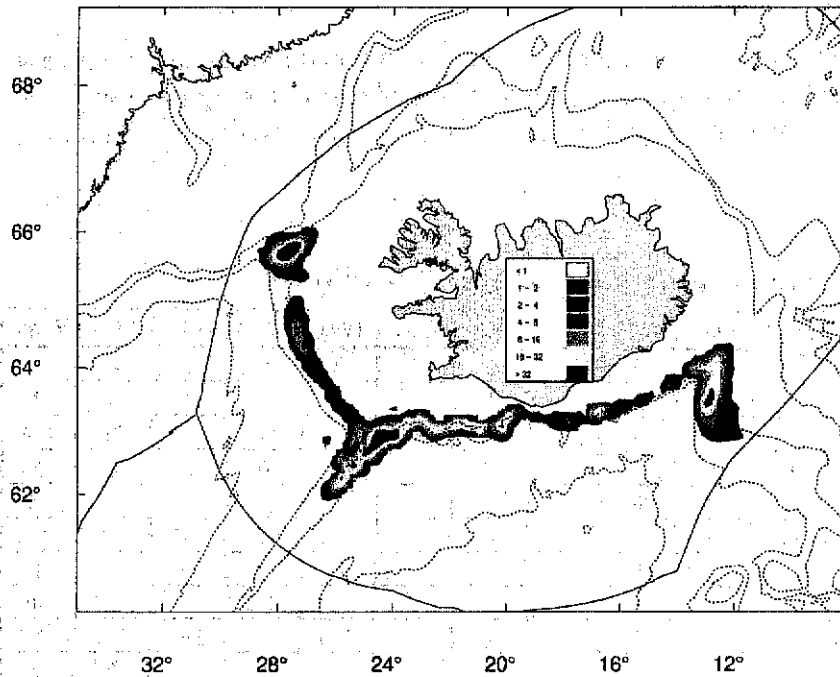


Fig. 6. Deep-sea redfish. Main fishing areas based on tons per nm² over four years (1992-1996)

Greenland halibut (*Reinhardtius hippoglossoides*)

In the early 1960ties, foreign fishing fleets started a fishery for Greenland halibut (*Reinhardtius hippoglossoides*) at Iceland. Iceland started a directed fishery on Greenland halibut in 1969 off the north coast of Iceland with longline. All other nations fished with bottom trawl mainly off the west coast. In Fig.7, the main fishing areas are shown for Greenland halibut at Iceland.

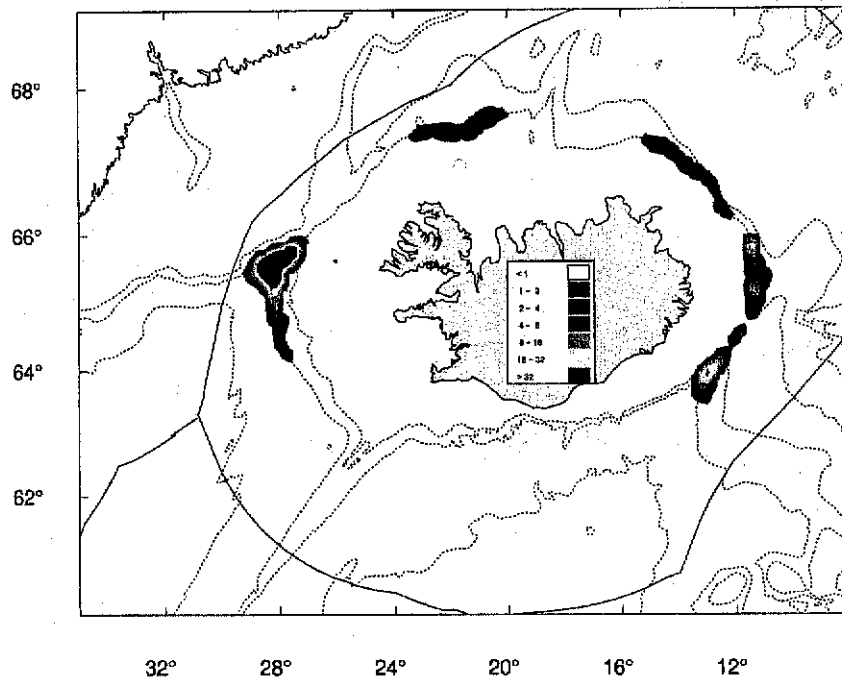


Figure 7. Greenland halibut. Main fishing areas based on tons per nm² over four years (1992-1996).

In spring time, Greenland halibut aggregates in a rather limited area between 65°N and 66°N and 27°W and 28°W. In this area, the major bottom trawl fishing takes place in April to June mainly in 700-1000 m depth. Thus, the Greenland halibut fishery used to be highly seasonal. In later years, the seasonal character is still maintained but much more catches are now taken outside this limited area at other times of the year.

Blue ling (*Molva dyperygia*)

The fishery for blue ling. in Iceland is basically a by-catch fishery mainly in connection with the deep-sea redfish fishery. However, a targeted fishery for blue ling was carried out in exceptional cases. This happened only when spawning concentrations were located as, for example, during 1980-1984 and in 1993. These spawning concentrations were located in very restricted areas..

In Fig. 8, the main fishing areas for blue ling at Iceland are shown.

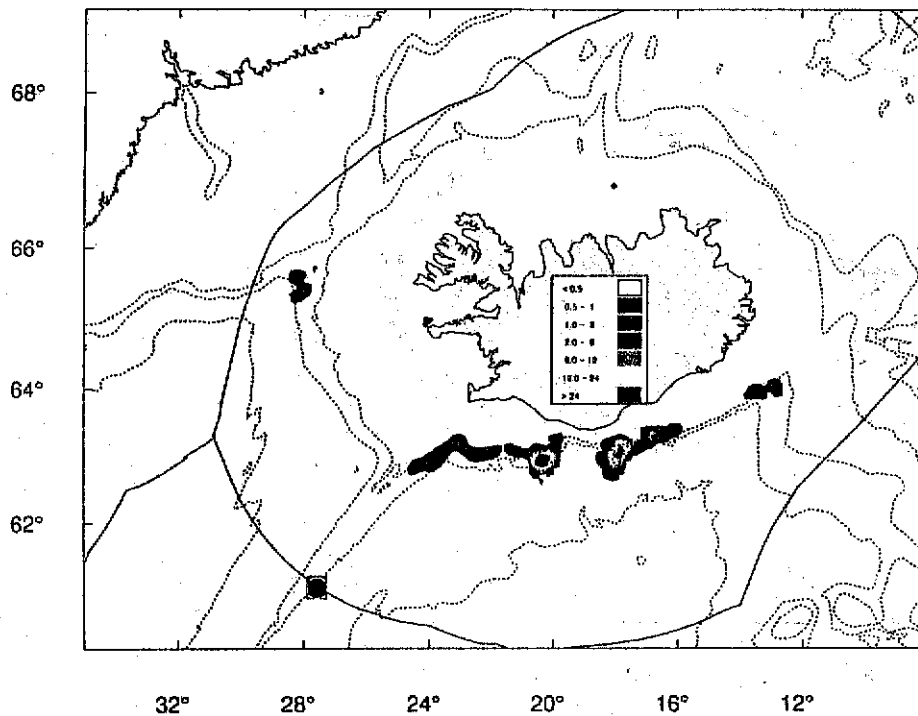


Figure 8. Blue ling. Main fishing areas based on tons per n.m.² over four year (1992-1996).

Greater silver smelt (*Argentina silus*)

Greater silver smelt is quite abundant in Icelandic waters. It has been caught as by-catch in the redfish fishery over a long period of time but was not landed. When bigger meshes were introduced in the codends of trawls in the 1970s, the by-catch of greater silver smelt was considerably reduced. In recent years, the interest in catching greater silver smelt has increased. The main fishing areas for greater silver smelt are off the west and south coasts. The areas of commercial fishing activities are shown in Fig.9. The species is mostly caught in 400-700 m depth variable according to area with high-opening bottom trawls, mostly four-panel trawls with 80 mm mesh in the codend.

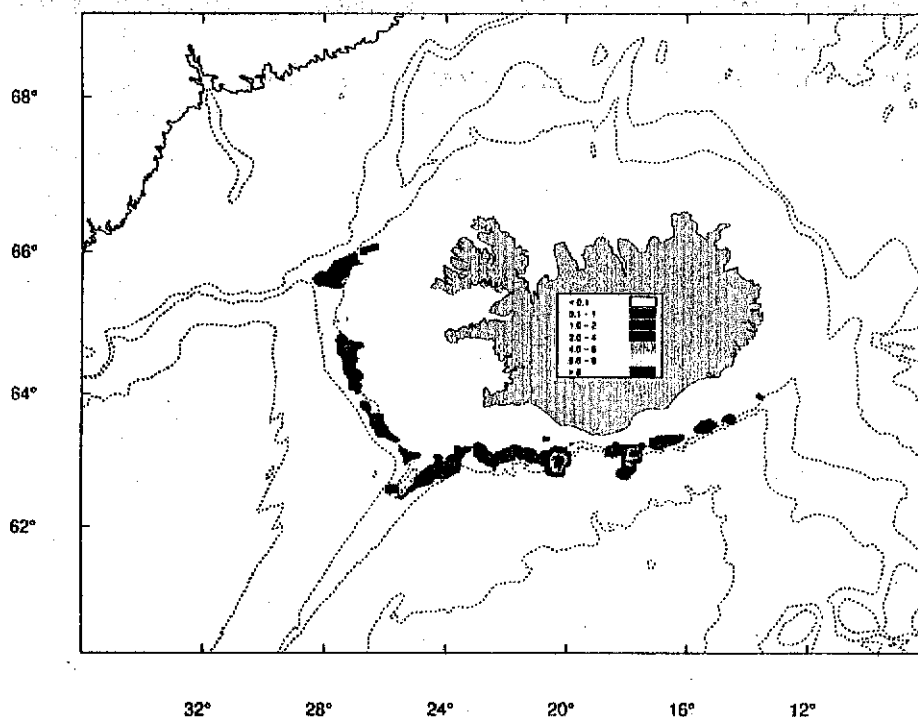


Figure 9. Greater silver smelt. Main fishing areas based on tonnes per n.m.² over four years (1995-1998).

Orange roughy (*Hoplostethus atlanticus*).

The fishery on orange roughy (*Hoplostethus atlanticus*) in Icelandic waters is only a small fishery of recent date. In 1991, a single trawler made some noteworthy catches of orange roughy off the south coast of Iceland. During the following years, the catches of orange roughy were, however, only moderate in spite of a great interest and considerable effort. It has proved difficult to locate concentrations of this species. The bottom conditions were extremely difficult for trawling where this species was detected.

The fishery on orange roughy is a targeted but small bottom trawl fishery at Iceland carried out in a limited area, in great depths, i.e. around 1000 m

Other species

Several other species than those mentioned above are on record in the catch statistics.

These species are:

Black dogfish	<i>Centroscyllium fabricii</i>
Portuguese shark	<i>Centroscymnus coelolepis</i>
Rat-tail	<i>Chimaera monstrosa</i>
Knifenose chimaera	<i>Rhinochimaera atlantica</i>
Smooth-head	<i>Alepocephalus bairdii</i>
Spine eel	<i>Notacanthus chemnitzii</i>
Roughhead grenadier	<i>Macrourus berglax</i>
Roundnose grenadier	<i>Coryphaenoides rupestris</i>
Blue antimora	<i>Antimora rostrata</i>
Black scabbard fish	<i>Aphanopus carbo</i>

The landings of these species are given in Table 2, also including landings of greater silver smelt and orange roughy.

3. Deep-sea longline

The longline fishery in Iceland used to be a bank- and shallow water fishery for cod, haddock and several other species of fish inhabiting the continental shelf. In the late sixties, some fishing with longline was carried out on Greenland halibut. The longline used in deep water does basically not differ from that used in shallower waters.

The main features of this deep-sea longline at present is the use of a strong synthetic and relatively thin line to which the snoods are clipped by a swivel. This line has higher breaking strength than previous ones but is of the same thickness. It sinks faster and drifts less than the regular ropes. In Appendix 12, the attachment of the snood to the line by swivel which also can rotate around the line is shown.

Most recently, there has been a rapidly increasing interest in fishing in very deep water with longline targeting mainly Greenland halibut and giant redfish (a *Sebastes marinus* type). Only a few vessels have been engaged in deep water longlining but their number is increasing. It is, however, premature to define it as a well established fishery.

Discussion

It is believed that deep water species are mostly slow-growing and long-living and the recruitment to the adult stock takes a long time. Such stocks are very vulnerable to heavy fishing. A good example is the fishery on Greenland halibut. After a rather stable fishery in the 1980s based on quota regulations, a sudden increase in the fishery took place in the years 1987 to 1989. This sudden rise and the high CPUE was partly due to the extension of the fishing area but also to an increase in prices. To make the quota fishing more flexible, vessels were allowed to convert a certain amount of a quota for one fish species to another. There is a definite conversion factor for each fish species. During the time period mentioned, it became very profitable to convert the quota for other species over to that for Greenland halibut. Finally, the very effective fishing fleet belonging to the vessel size category of > 500 tons was expanding and becoming involved in the Greenland halibut fishery. It is most likely that this very intensive fishing over a relatively short period (3 years) caused the drastic drop in CPUE for Greenland halibut after 1989. This emphasises the point that fisheries on deep water species should be conducted with great caution.

The increase in the most efficient part of the fleet, i.e. the >500 tons size category in late years is remarkable. The number of trawlers, the size and engine power has increased. Also, the fast developing improvements of electronic devices and gear have made this part of the fishing fleet extremely efficient and able to fish in areas where trawling was considered impossible only a few years ago.

From interviews with trawler captains it is obvious that the by-catches of several deep water species are considerable. The landings do not give any realistic idea of the availability of those species. In Iceland, no stable market has been developed for these species, the prices are very low and the fishermen consider it not worthwhile to process and/or land these catches. They are, therefore, discarded. Unfortunately, no records are available on the discards. A regulation on discard newly imposed upon the fishing industry might change the situation somewhat.

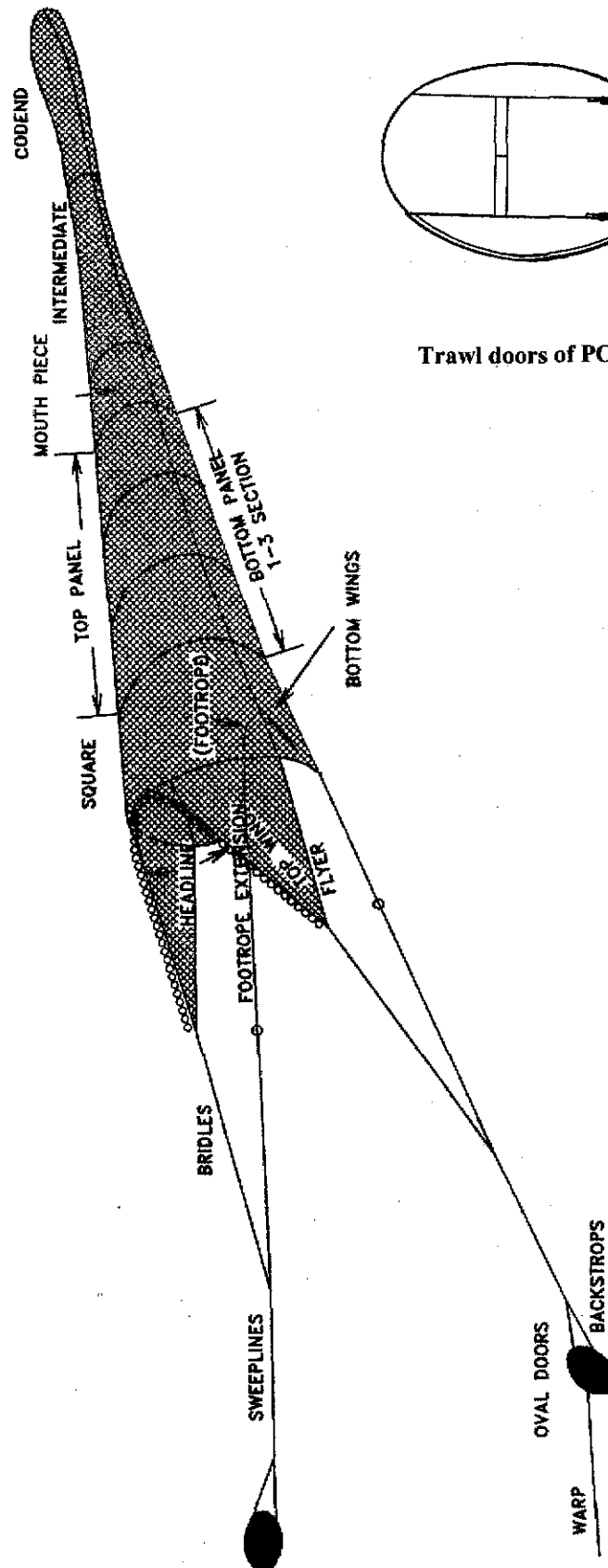
This emphasises the urgent need to put much more effort in research of deep water stocks in order to be able to give advice to the industry **before** the fishery has depleted the stocks.

Acknowledgments

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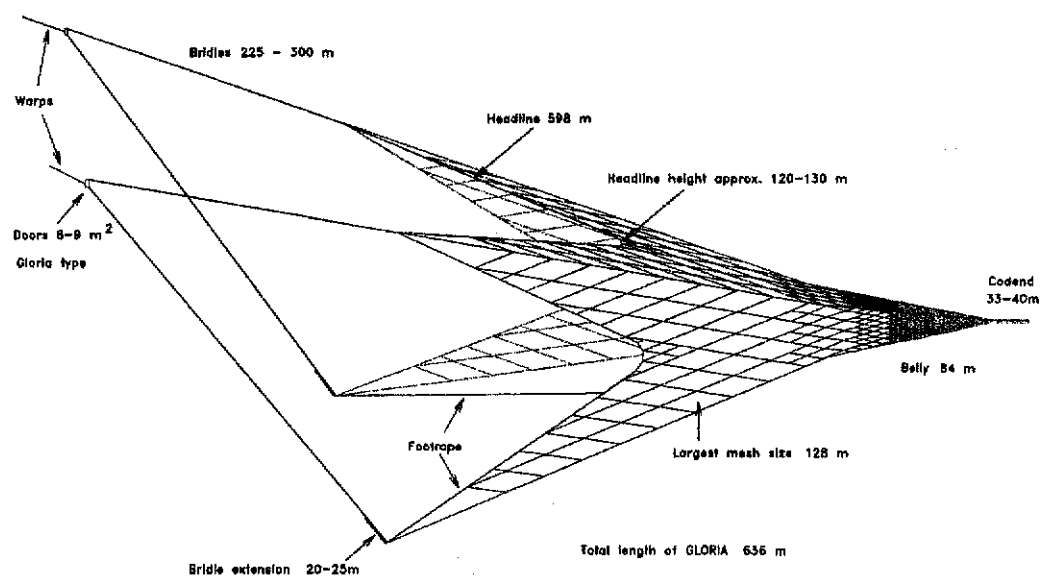
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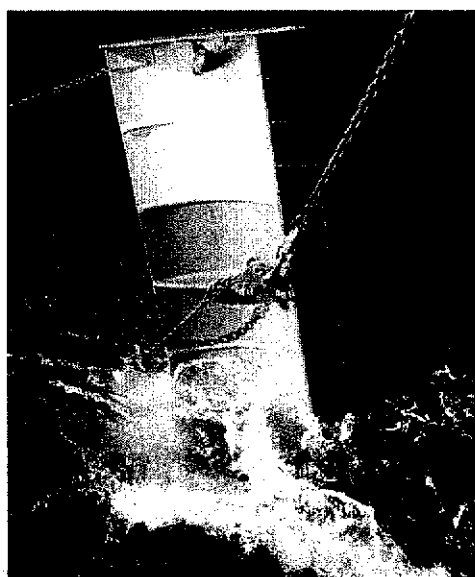


Trawl doors of POLY-ICE type

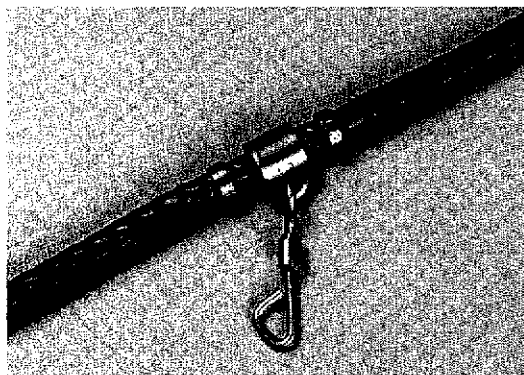
Two panel bottom trawl of Bacalao type



Gloria midwater trawl.



Midwater otter board of Suberkrub type with "Super Foil".



Longline of DYNEX type. Attachment of the snood to the line by swivel.



100

100

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