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Status of the Greenland Halibut (*Reinhardtius hippoglossoides*) Fishery in Cumberland Sound, Baffin Island 1987-95

by

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Introduction

Since the mid 1980's, Baffin Island Inuit have sought access to marine commercial fishery opportunities for turbot, shrimp and scallops in the inshore marine areas and adjacent offshore areas of Hudson and Davis Strait. Marine fisheries are an important supplement to the traditional Inuit fisheries for Arctic charr and marine mammals. The 1993 Nunavut Land Claims Agreement stipulates that special consideration will be given by government to the principles of adjacency and economic dependence when allocating commercial fishing licences in the adjacent offshore marine areas. As a result, a fishery for Greenland halibut, (Reinhardtius hippoglossoides) has developed in Cumberland Sound, starting in 1986.

Greenland halibut are caught in Cumberland Sound only during the winter, typically from February until the end of May. The fishery generally takes place within about 60 km of the town of Pangnirtung (Fig. 1) and is accessed by snowmobile. Fishermen commonly use longlines with about 100 hooks (range 50-200), attached to the longline at 2 m intervals by snoods approximately 0.5 m in length. The most widely used hook is a 14/0 circle hook, baited with strips of turbot meat with skin attached, usually 2-5 cm wide and 15-20 cm long. The longline is attached to a groundline which consists of at least 2000 m of 2-4 mm braided polypropylene or nylon cord. Power winches are typically used to retrieve the longlines. Longlines are set using a 'kite' consisting of a weighted, rectangular piece of sheet metal attached to the end of the longline. The kite is oriented in the proper direction in the ice hole, then released and allowed to drag the longline and groundline. The kite provides enough lateral movement to allow the full length of the longline to lie on the bottom. When the kite reaches the bottom, a sliding weight is dropped, travelling down the groundline to the longline. More line is then released until the entire longline lays on the bottom. In the early years of the fishery, most fishermen set a single line by hand-cranked winch for a duration of about 2 hours, but today most fishermen operate with power winches and fish more than one longline simultaneously.

Immediately after capture, fish are gutted and their heads are removed. They are then placed in 0.5 m^3 insulated tanks filled with seawater slush. In this condition, they can be held for 2-4 days without freezing. They are transported to the fish plant in Pangnirtung by snowmobile and sled. Most fish are filleted and shipped fresh or frozen to southern markets.

Commercial Catch and Effort

The 1995 Total Allowable Catch (TAC) of Greenland halibut set by the Northwest Atlantic Fisheries Organization (NAFO) in Sub-areas 0 and 1 combined (See Fig. 1), was 11,000 tonnes. Of this, the Canadian allocation in Sub-area 0 was 5,500 tonnes (50%). From the Canadian allocation 1,000 tonnes has been sub-allocated to the Baffin inshore (Inuit) fishery. Currently, the winter fishery in Cumberland Sound operates within this sub-allocation under an experimental licence. Also within the sub-allocation, there is a joint venture between Broughton Island Inuit and a Newfoundland enterprise that operates a 65 ft vessel equipped for gillnetting and longlining in open water.

The inshore fishery for Greenland halibut in Cumberland Sound, Baffin Island has developed rapidly since an initial harvesting of 186 fish in 1986 when Greenlandic fishermen visited to demonstrate marine fishing methods. By 1992 the catch had risen to around 400 tonnes where it remained relatively stable until 1994 (Fig. 2). In 1995 the total harvest dropped to about 300 tonnes because late ice conditions prevented most fishermen from fishing until the middle of February, whereas they usually begin 45 days earlier. Most of the increase in catch can be attributed to an increase in the number of fishermen (Fig. 2), but catches in 1992, 1993 and 1994 were also affected by changes in technology (see below). The Cumberland Sound fishery is now an important part of the local economy, valued at about $750,000 in 1993, and employing about 130 people seasonally as fishermen and fish plant workers.

The catch and effort have been monitored each year of the fishery except 1988 by the fishermen who fill out forms on which they record details of their fishing activity. Each year the Canadian Department of Fisheries and Oceans samples the catch from entire longline sets of individual fishermen to measure the length, weight, sex and maturity of fish. Total catch is monitored at the fish processing plants in Pangnirtung.

Estimation of catch-per-unit-effort (CPUE) in the Greenland halibut fishery of Cumberland Sound is complicated by rapid technical change which took place between 1987 and 1995. The major change has been a shift from hand-operated winches to power winches, an increase in the average number of longlines set daily per fisherman, and an increase in the average duration of longline sets. From 1987 to 1991, most longline sets were fished from 1-3 hours (Fig. 3, Table 1). But from 1992 to 1993, fishermen began experimenting with longer set durations. By 1194 and 1995 the average set duration was between 7 and 9 hours (Table 1), and sets of 24 hours were not uncommon (Fig. 3).

Although there has been little change in the number of hooks fished per set (Table 1), the catch of Greenland halibut per set was significantly correlated with the number of hooks. Therefore the catch rate is adjusted to a standard unit of 100 hooks. When data from all sets and years were combined, there was an observable relationship between the catch per 100 hooks and the duration of sets (Fig. 4). On average, the catch after a set of one hour was about 12 fish/100 hooks, and for each hour after that, the catch increased at a rate of about 1.1 fish/100 hooks until a set duration of 10 hours was reached (Fig. 4). In order to adjust the catch rate for the set duration, catch rate was regressed against set duration within each year (Table 2). This relationship was not statistically significant ($P_{[m=0]} > 0.05$, Table 2) in 1987, 1988 and 1989 because set durations were tightly grouped around 2-3 hours during this time. Therefore to calculate the CPUE in these years, the catch per 100 hooks was simply averaged. From 1990 to 1995 however the relationship was statistically significant, and for these years catch per 100 hooks was adjusted by regression to a standard set duration of 2.0 hours, so that they would be comparable with the earlier years. The adjusted catch per unit effort ($CPUE_{adj.}$) was then expressed as number of fish caught per 100 hooks per 2.0 hours of set.

Although $CPUE_{adj.}$ varied significantly between years, there was no temporal trend (Fig. 5). The $CPUE_{adj}$ in the last three years of the fishery were not statistically different from that in the first two years. The adjusted CPUE would indicate that current levels of fishing effort have not reduced the fishermen's catch rate using a standard of 100 hooks. Factors which might cause $CPUE_{adj}$ to vary among years are the location and depth of fishing. Although fishing locations vary among years because of the location of the ice edge and ice conditions at the completion of freeze-up, the most common locations are generally found within a 25 km radius of each other. Within this area, water depth can vary between 750 m and 950 m.

In Greenland, catch per unit effort in longline fisheries is expressed as the average weight (kg) of fish caught by a standard of 100 hooks. The CPUE values for inshore Greenlandic longline fisheries between 1962 and 1994 ranged from 16.5-3.1 kg/100 hooks, with measurements for 1993 and 1994 ranging from 5.2-3.1 kg/100 hooks. In comparison, the weight of Greenland halibut caught per 100 hooks in Cumberland Sound was much higher, remaining stable at around 60 kg/100 hooks between 1987 to 1995 (Fig. 6A). This was the result of two opposing factors: since 1993, the mean weight of Greenland halibut has decreased (Fig. 6B), while the number of Greenland halibut caught per 100 hooks has increased (Fig 6C). The latter effect has been brought about by a shift to longer longline set duration (see above). This analysis indicates that there has been a demonstrable effect of the fishing upon the average size of the Greenland halibut in Cumberland Sound, but that this has been offset by increases in fishing effort.

There was no seasonal change in the catch rate within years. When the catch per 100 hooks per hour for each set was plotted against date within each year, no consistent seasonal trends were observed.

Catch-at-age and Size-at-age

The commercial catch was sampled over a period of several days in each year. The age of fish in the commercial catch ranged from 7-16 years (Table 3). Fish between 9 and 13 years of age comprised 85% of the catch while fish between 10 and 12 years comprised 65% of the catch. The age of fish which dominate the commercial catch did not exhibit a discernable trend between 1987 and 1995(Table 3) and there was no decrease in the average age of fish in the catch between 1987 and 1995.

There has been a decreasing trend in average length-at-age of Greenland halibut in samples from the commercial catch from 1987 to 1995 (Fig. 7). This trend is most pronounced for larger fish. The sample size on which these analyses are based is shown in Table 3, and the variability (coefficient of variation) is shown in Table 4. Correspondingly, there has been a decreasing trend in average weight-at-age of Greenland halibut in samples from the commercial catch from 1987 to 1995 (Fig. 8). This trend is most apparent in larger fish. The sample size on which these analyses are based is shown in Table 3, and the variability (coefficient of variation) is shown in Table 5. It is not clear why there the pronounced decrease in size-at-age was not accompanied by a decrease in the mean age of fish in the sampled commercial catch. There is no reason to assume errors in age reading since the age reader has been constant throughout this study.

Sex, Maturity ,Growth,and Distribution

Sex and maturity of Greenland halibut in the commercial fishery were assessed from 1990 onwards. Ninety-seven percent of Greenland halibut sampled were female, and both males and females were either immature or not in spawning condition. It is perhaps not surprising that males form only a small proportion of the catch since recruitment into the Cumberland Sound longline fishery begins at a length of about 500 mm, and males are much smaller than females (Fig.9). Females also dominate the catch in Greenland longline and gillnet fisheries (Riget and Boje, 1987).

Growth was essentially linear over the observed age range (Fig. 10). Females grew faster than males, and growth rates were similar to those found for Greenland halibut in Davis Strait by Atkinson *et al.* (1982). Length and age distributions for female Greenland halibut caught in Cumberland sound (Fig. 11) covered a much narrower range than those for fish caught in otter trawl fisheries in Davis Strait (Atkinson and Bowering, 1987) or the Gulf of St. Lawrence (Bowering, 1982), but were similar to those for fish caught by otter trawl in Cumberland Sound (see below). Length and age distributions from the Cumberland Sound longline fishery were similar to those seen in Newfoundland and Greenland longline fisheries (Lear, 1970; Boje, 1991). It is likely that these differences are at least partially a function of gear selectivity, since otter trawls are far more effective in catching Greenland halibut <500 mm in length than are longlines (Chumakov *et al.*, 1981). However, experimental use of hook and bait sizes smaller than those used in the commercial fishery did not produce significantly smaller fish in Cumberland Sound. Thus it may be that smaller fish simply do not occupy the deep areas of Cumberland Sound that are fished commercially.

Stratified, Non-random Trawl Survey in Summer, 1994

In the summer of 1994, an exploratory trawl was fished in Cumberland Sound in an area outside of the winter fishing ground (Anon, 1994). A 67 foot, 650 hp, wooden stern dragger trawled to a maximum depth of 960 m using an IC 350 otter trawl with a 38 m headrope and 46 m foot rope. The trawl had a mesh size of 140 mm (5 1/2 in). The cod end had a 38 mm (1 1/2 in) mesh liner inside it. A total of 23 trawls were made along the northeastern shore of Cumberland sound from Pangnirtung to the mouth of the sound, but excluding the winter fishing area where no mobile gear was permitted (Fig. 12). The trawled area was divided into equal zones 30' of latitude and 1 degree of longitude in size. Some trawls were made in each area. The total area was further stratified into 50 m depth strata and fishing effort was distributed equally to these. Within each depth stratum trawl locations were non random.

The trawlable biomass ranged from 0.0 kg/km2 at < 275 m depth, to 2,678 kg/km^2 at 900 m depth (Table 6). The length of Greenland halibut ranged from 184 - 980 mm with a mean of 494 mm (Fig. 13). Very few small fish were caught. Of 165 fish sampled, 48.1% were females, and 51.9% were males. Seventy-two percent of fish were immature (Table 7). Ten percent of fish, mostly females, were in maturity stage 2, and 11%, all females, were ripening for the current year. The distribution of maturity stages was confirmed by an additional sample of 53 fish sent for analysis at the Freshwater Science Laboratory in Winnipeg.

Also during the summer of 1994, longlines and gillnets were fished on the winter fishing ground. Ground-lines consisted of an 11 mm rope, 91 m in length, with 36 cm hook lines attached at 1.8 m intervals. Each hook line had a #12 "Millward" circle hook, that was baited with seal entrails, mackerel or herring until Greenland halibut became available. Ground-lines were joined to form a longline fleet with a length of 549 m and 300 hooks. The CPUE of these longlines was fifteen times lower than comparable longlines fished during the winter in the same area. The summer Longline CPUE was similarly low in areas where Greenland halibut were caught by summer trawling. Gillnets fished on the bottom during the summer in the same areas also yielded low catches. These nets were monofilament, with a panel size of 91 m long by 3.7 m deep. The nets were joined to make a fleet of 10 or 15 nets. The results of these fishing trials suggest that during the summer Greenland halibut move either away from the winter fishing area or off the bottom. In deep Greenland Fjords, Greenland halibut are reported to move towards the fjord mouth in the summertime (pers. comm., Gert Bech, pers. commun.). However, in Cumberland Sound, longlining trials carried out in summer,1995 in the centre of the sound from the sill towards the winter fishing area did not confirm this behaviour, although the low average catch rates of 0.55 fish per 100 hooks per 2 hours of set time were consistent with previously reported low summer catch rates. Winter catch rates are 15-20 fish per 100 hooks per 2 hours (Fig. 5).

Issues in the Cumberland Sound Fishery

One of the most important issues regarding the Cumberland Sound Greenland halibut fishery is whether the fish in Cumberland Sound contribute to the Davis Strait stock, either by emigration of juveniles spawned in Cumberland Sound, or by migration of adults into Davis Strait for spawning. Understanding the contribution of Greenland halibut from Cumberland Sound to Davis Strait is critical to the management of the fishery, especially in view of quota allocations between the inshore fishery and the Davis Strait fishery.

The channel connecting Cumberland Sound to Davis Strait is much more shallow (ca. 300 m) than the Sound proper, which extends to over 1,000 m. Also, bottom water temperatures down to a depth of 300 m during the summer are colder than -0.5 degrees celsius, while temperatures near the bottom of the Sound are slightly above 0 degrees (Fig. 14). It may be that colder water at 300 m depth acts as a barrier to adult migration out of the sound. On the other hand, several attempts to catch Greenland halibut in commercial quantities in deep water during the summer have been unsuccessful. This suggests that the Greenland halibut might migrate away from the fishing areas in summer, or alternatively, that they are less associated with the bottom during the summer. Low longline and gillnet catches in areas where fish were caught by trawling tend to support the latter supposition.

Attempts to tag fish during the winter fishery have not been successful, presumably because fish died after being lifted from -1.75 degree water through sub-zero air temperatures into holding tanks on the ice. It is probable that the low water temperatures in the top 100 m of

the water column (Fig. 15) were not a limiting factor, based on the experiences of researchers in Greenland and in Saguenay Estuary.

The genetic and morphological relationship among stocks of Greenland halibut in Cumberland Sound, Davis Strait, Gulf of St. Lawrence and other locations is being analyzed by the Canada Department of Fisheries and Oceans. Alloenzyme, meristic and morphometric analyses are being carried out through the Freshwater Institute Science Laboratory in Winnipeg, Manitoba, in collaboration with the Northwest Atlantic Fisheries Centre in St. John's, Newfoundland which is carrying out DNA analyses on the same samples of fish.

Very few fish from Cumberland Sound have been observed in spawning or post-spawning condition. This situation is analogous to that in the fiords of western Greenland. Boje and Riget (1987) postulated that temperatures were not warm enough in the Greenland fiords to permit spawning in most years. It is possible that a similar situation exists in Cumberland Sound.

Fishery Prognosis

The decline in mean fork length and weight in samples from the commercial fishery over the past four years is cause for concern because it coincides with increases in catch and effort both inside and outside Cumberland Sound, and therefore may constitute evidence of overexploitation. However, there has been no decrease in the mean age of fish harvested up until 1995, the last year for which ages are available, and also there has been no discernible decrease in the adjusted catch per unit effort ($CPUE_{adj}$) for the fishery as a whole. There is little evidence to indicate that the stock in Cumberland Sound has declined since the fishery has begun. Nevertheless, the observed changes in the fishery are causes for concern. The decline in weight-at-age indicates that the largest fish in each age group (older than 9 years) are being removed by the fishery and are not being replaced by natural production at the same rate as they are being exploited. The consequence of this is that the value of the catch to the fishermen has declined. Up until now, the fishermen have been able to compensate for the smaller fish by increasing the number caught per longline set. This has been brought about by increasing the length of time that the sets remain in the water. The catch and effort data indicate that there is little gain to be made by leaving the sets down for more than about 10 hours, on average, so that the main benefit to the fishermen of a set time longer than 10 hours is that it allows them to fish more than one longline. The number of longlines per fisherman has increased from one line in the early days of the fishery, to two and sometimes three, in the last two years.

Feasibility of Tagging Fish in Summer

In response to recommendations of the 1995 NAFO Scientific Council Report, (NAFO 1995), the Canada Department of Fisheries and Oceans studied the feasibility of capturing Greenland halibut in Cumberland Sound during the summer, for the purpose of tagging them. The objectives of the study were:

- to see whether a substantial concentration of turbot could be located in Cumberland Sound so that a tagging study would be cost-effective.

- to estimate the cost of a tagging study, based on the catch rates observed.

The study fished with longlines for 5 days, moving from the mouth of the sound, down its centre, to the boundary of the winter fishing ground. Twelve sets of about 300 hooks each were made. Only 50 fish were caught. There was much fouling of lines by Greenland sharks. The study found that insufficient Grienland halibut could be caught by longline during the summer to make a summer tagging program effective. It has been recommended to the Pangnirtung Hunters and Trappers Association that winter tagging would be more feasible than trying to tag the fish during the summer months. A plan for carrying out winter tagging has been formulated and forwarded to the HTA. In this plan, the fish would be brought slowly to the surface and they would not be removed from the water. They would be measured (head measurements only), tagged and released. The entire operation would be conducted inside a tent.

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Table 1. Characteristics of longline sets in the Cumberland Sound Greenland halibut fishery, 1987-95.

YEAR	NO. SETS EXAMINED	MEAN SET DURATION (hrs)	MEAN NO. HOOKS SET	MEAN NO. HOOKS LOST	MEAN NO. HOOKS FISHED
1987	111	1.9	96	19	87
1989	827	2.0	106	5	100
1990	1447	2.0	102	5	98
1991	485	3.0	103	2	101
1992	482	3.4	107	2	105
1993	1127	5.2	105	3	102
1994	699	6.9	104	4	101
1995	1752	9.3	116	5	111

Table 2. Linear regressions between Greenland halibut catch per 100 hooks and set duration, Cumberland Sound commercial fishery, 1987-1995. Regression equation is: CPU = a + m(D), where CPU = catch per 100 hooks and D = set duration.

YEAR	N	a	P[a]	m	P[b]
1987	110	10.053	0.116	3.520	0.295
1989	808	15.853	0.000	0.127	0.401
1990	1395	13.121	0.000	0.273	0.241
1991	474	11.843	0.000	0.243	0.032
1992	476	14.086	0.000	1.598	0.000
1993	477	15.706	0.000	0.868	0.000
1994	690	17.293	0.000	0.670	0.000
1995	1726	13.598	0.000	0.499	0.000

[a] probability that a = 0.
[b] probability that m = 0

Table 3. Greenland halibut in the Cumberland Sound commercial fishery. Distribution of catch-at-age by year between 1987 and 1994. Data for 1995 not available.

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	TOTA
7	4	0	1	3	0	0	0	0	0	8
8	16	4	1	1	1	3	4	0	3	33
9	65	3	13	7	2	20	16	9	9	144
10	65	30	20	15	5	29	35	16	30	245
11	62	47	50	41	6	37	45	38	45	371
12	29	39	35	25	13	27	27	40	30	265
13	9	26	4	9	16	16	11	32	13	136
14	3	1	3	3	3	7	3	12	5	40
15	1	0	0	1	1	0	0	5	1	9
16	1	0	0	0	1	0	1	1	0	4

Table 4. Greenland halibut in the Cumberland Sound commercial fishery. Length-at-age for each year. Mean fork length (upper value, mm) and C.V. (lower value, proportion) are shown.

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995
7	**493**	-	**572**	**533**	-	-	-	-	-
	0.02	-	-	0.06	-	-	-	-	-
8	**528**	**523**	-	**595**	**580**	**583**	**563**	-	**496**
	0.04	0.05	-	-	-	0.05	0.06	-	0.13
9	**607**	**593**	**607**	**620**	**600**	**602**	**569**	**549**	**574**
	0.05	0.09	0.13	0.08	0.01	0.10	0.10	0.04	0.14
10	**671**	**642**	**685**	**668**	**626**	**646**	**607**	**559**	**604**
	0.04	0.06	0.09	0.06	0.15	0.10	0.08	0.06	0.09
11	**723**	**704**	**725**	**716**	**701**	**632**	**653**	**594**	**666**
	0.03	0.05	0.05	0.06	0.18	0.12	0.09	0.07	0.12
12	**781**	**760**	**767**	**773**	**754**	**688**	**718**	**656**	**690**
	0.03	0.03	0.10	0.03	0.12	0.12	0.06	0.07	0.08
13	**849**	**813**	**809**	**823**	**798**	**749**	**784**	**700**	**749**
	0.05	0.04	0.01	0.06	0.09	0.15	0.10	0.09	0.14
14	**823**	**880**	**853**	**859**	**891**	**779**	**868**	**790**	**810**
	0.07	-	0.07	0.07	0.06	0.12	0.04	0.11	0.12
15	**870**	-	-	**945**	**790**	-	-	**829**	**845**
	-	-	-	-	-	-	-	0.09	-
16	**1050**	-	-	-	**1010**	-	**935**	**905**	
	-	-	-	-	-	-	-	-	

Table 5. Greenland halibut in the Cumberland Sound commercial fishery. Annual weight-at-age for the most frequently caught ages. Mean weight (upper value, kg) and C.V. (lower value, proportion) kg, in bold letters) are shown.

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995
7	**1.330**	-	**2.650**	**1.583**	-	-	-	-	-
	0.09	-	-	0.25	-	-	-	-	-
8	**1.623**	**1.425**	-	**2.100**	**1.950**	**1.900**	**1.763**	-	**1.297**
	0.14	0.08	-	-	-	0.16	0.20	-	0.35
9	**2.436**	**B**	**2.327**	**2.436**	**1.950**	**2.192**	**1.822**	**1.639**	**2.083**
	0.16	0.42	0.37	0.22	-	0.44	0.35	0.17	0.27
10	**3.336**	**2.895**	**3.475**	**3.063**	**2.540**	**2.846**	**2.360**	**1.753**	**2.293**
	0.16	0.20	0.31	0.23	0.52	0.34	0.33	0.20	0.27
11	**4.140**	**3.737**	**4.044**	**3.887**	**4.075**	**2.647**	**2.917**	**2.158**	**3.237**
	0.16	0.17	0.16	0.19	0.65	0.46	0.31	0.23	0.39
12	**5.476**	**4.713**	**5.134**	**5.066**	**5.304**	**3.628**	**3.922**	**2.943**	**3.574**
	0.12	0.11	0.24	0.14	0.43	0.40	0.22	0.22	0.27
13	**7.469**	**5.979**	**5.625**	**6.572**	**5.959**	**5.009**	**5.236**	**3.770**	**4.292**
	0.19	0.12	0.13	0.24	0.31	0.55	0.32	0.30	0.53
14	**6.433**	**7.150**	**6.650**	**7.567**	**8.500**	**5.521**	**7.067**	**5.867**	**6.197**
	0.22	-	0.3	0.27	0.22	0.45	0.27	0.37	0.42
15	**7.800**	-	-	**8.500**	**6.400**	-	-	**6.370**	**7.550**
	-	-	-	-	-	-	-	0.30	-
16	**13.600**	-	-	-	**13.050**	-	**10.050**	**8.500**	-
	-	-	-	-	-	-	-	-	-

Table 6. Summary of trawlable biomass of Greenland halibut by depth strata, in Cumberland Sound, Baffin Island. Area and Total Trawlable Biomass refer to strata within the survey area only.

DEPTH STRATUM (m)	NUMBER OF TOWS	TRAWLABLE BIOMASS (kg/m^2)	AREA (km^2)	TOTAL TRAWLABLE BIOMASS (kg)
91-183	1	0	6,277	0
184-274	5	0	6,625	0
275-366	7	10.99	3,961	43,531
367-457	1	9.71	1,477	14,342
458-640	2	523.98	1,105	578,998
641-732	1	18.94	997	18,883
732-823	2	2,171.29	885	1,921,592
824-914	2	2,677.80	859	2,369,853
915-1006	2	605.46	496	300,308
	TOTAL		22,684	5,247,507

Table 7. Percent of Greenland halibut caught by otter trawl in August, 1994 in Cumberland Sound at different maturity stage, by sex. N = 165. Immatures made up 5.5% of the sample.

	SEX		
MATURITY STAGE[a]	FEMALE	MALE	COMBINED
1	24.8	47.9	72.7
2	9.7	0.6	10.3
3	10.9	0.0	10.9
4	0.0	0.0	0.0
5	0.0	0.6	0.6

[a] Stage 1 = immature, Stage 2 = resting, first time mature, or ripening for next year, Stage 3 = maturing or ripening for the present year, Stage 4 = running or recently spent, Stage 5 = spent and recovering.

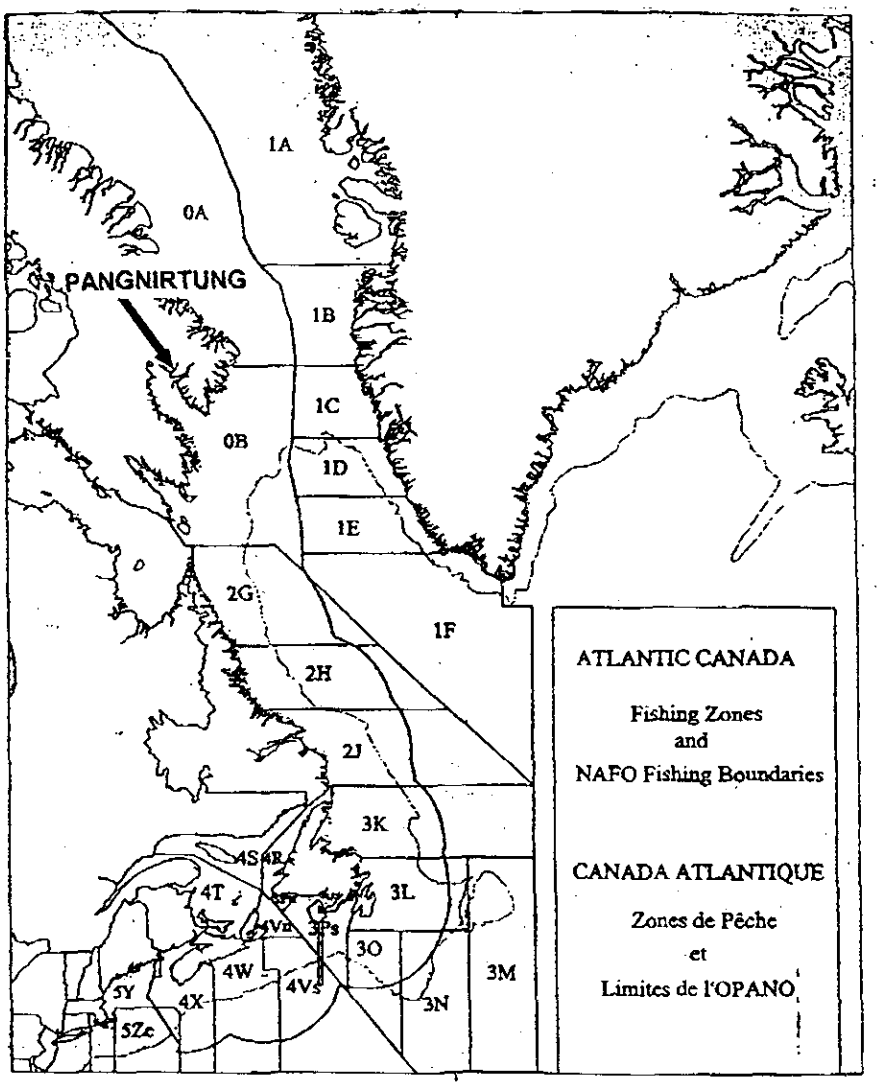

Figure 1. The major Sub-areas, indicated by numerals, and Divisions, indicated by letters, used by the Northwest Atlantic Fisheries Organization.

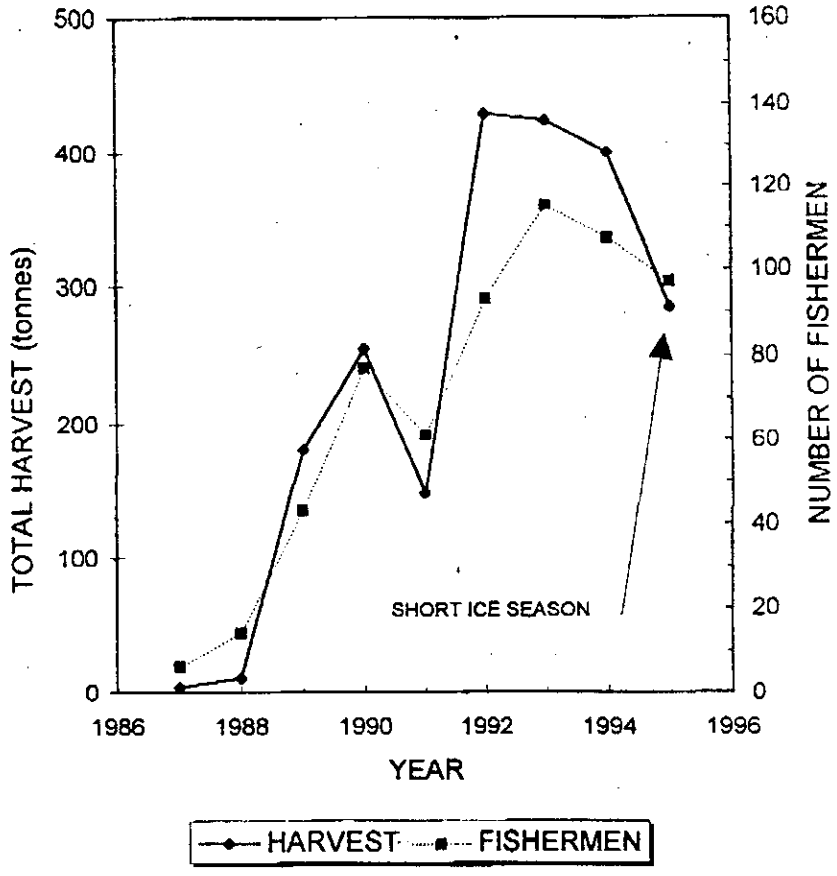

Fig. 2. Commercial harvest of Greenland halibut in Cumberland Sound from 1987 to 1994, (left axis), and number of licenced fishermen plus assistants (right axis), from 1987-1993. Number of licenced fishermen does not include assistants in 1994 and 1995.

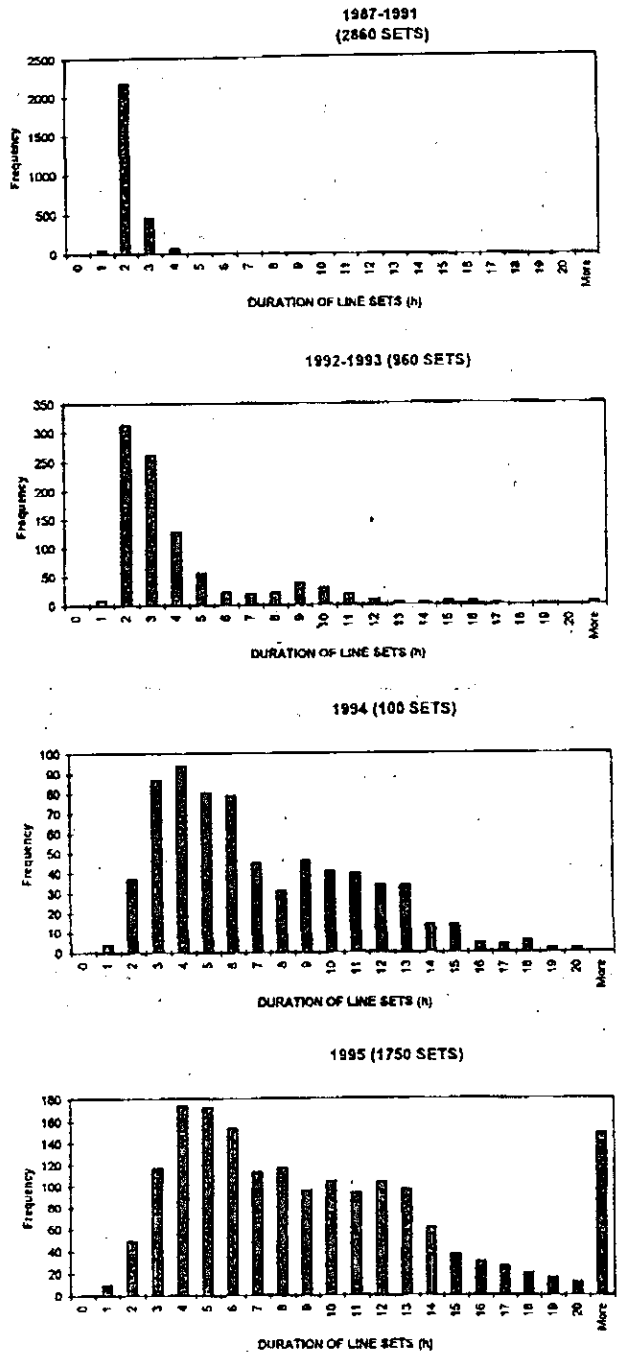

Fig. 3. Frequency distribution of longline set durations in the Greenland halibut fishery, Cumberland Sound, 1987-1995.

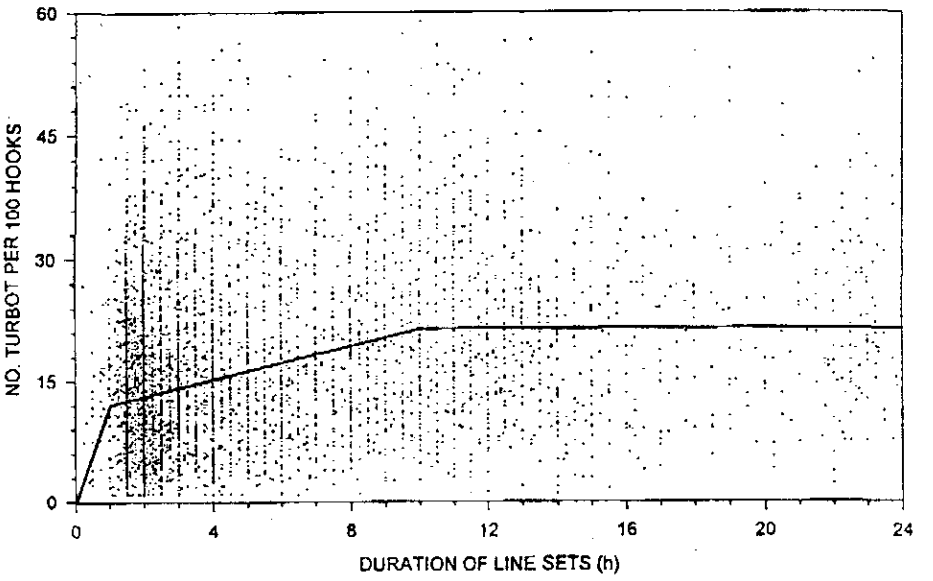

Figure 4. Relationship between the catch and the duration of the longline set for all sets from 1987 to 1995. The heavy line is a straightline approximation of the mean trend line using non-parametric LOWESS smoothing (Wilkinson, 1990).

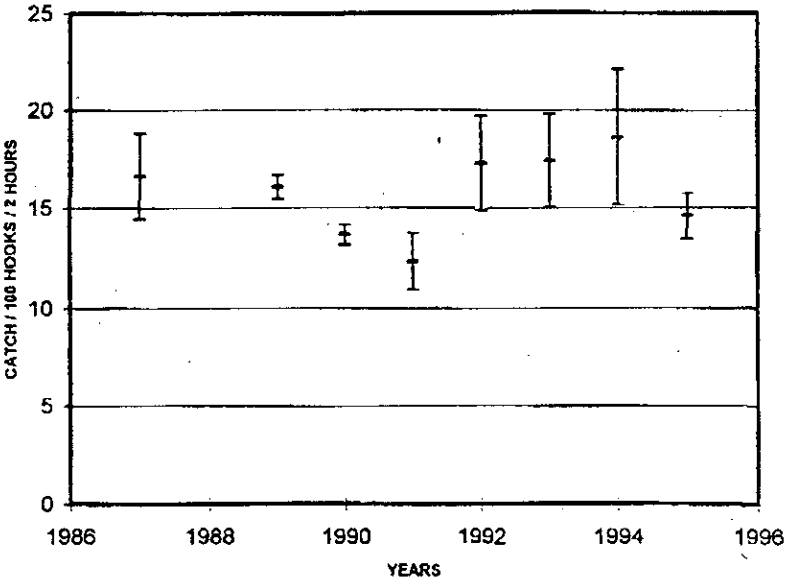

Fig. 5. Average catch per unit effort (adjusted CPUE) of longline sets for Greenland halibut in Cumberland Sound, showing 95% confidence limits. See text for method of calculation.

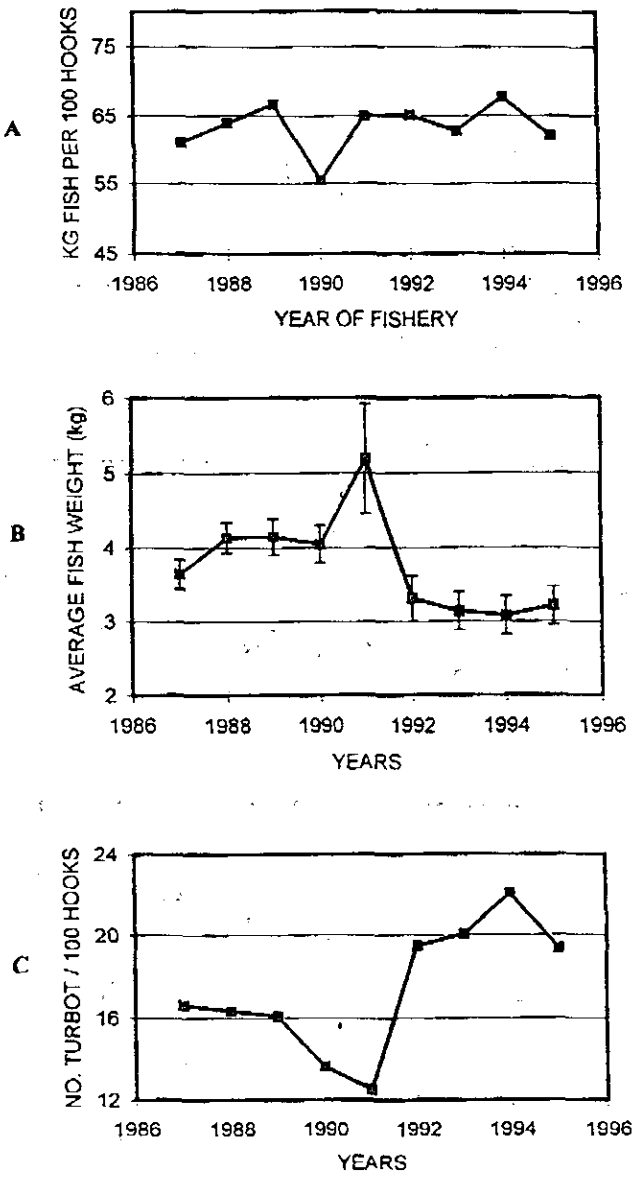

Fig. 6. Greenland halibut fishery in Cumberland Sound.
A) Average total weight of fish caught per 100 hooks of longline set.
B) Average fish weight in samples of the commercial catch.
C) Average number of fish caught per 100 hooks of longline set.

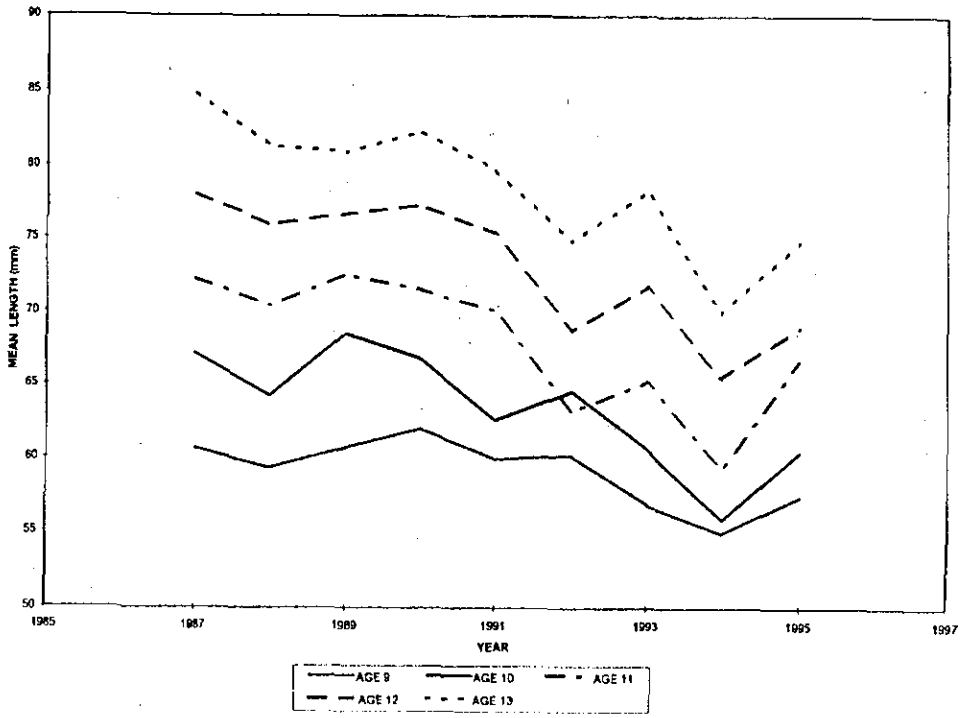

Fig. 7. Average length-at age for greenland halibut sampled from the commercial longline fishery in Cumberland Sound, Baffin Island, 1987-1995.

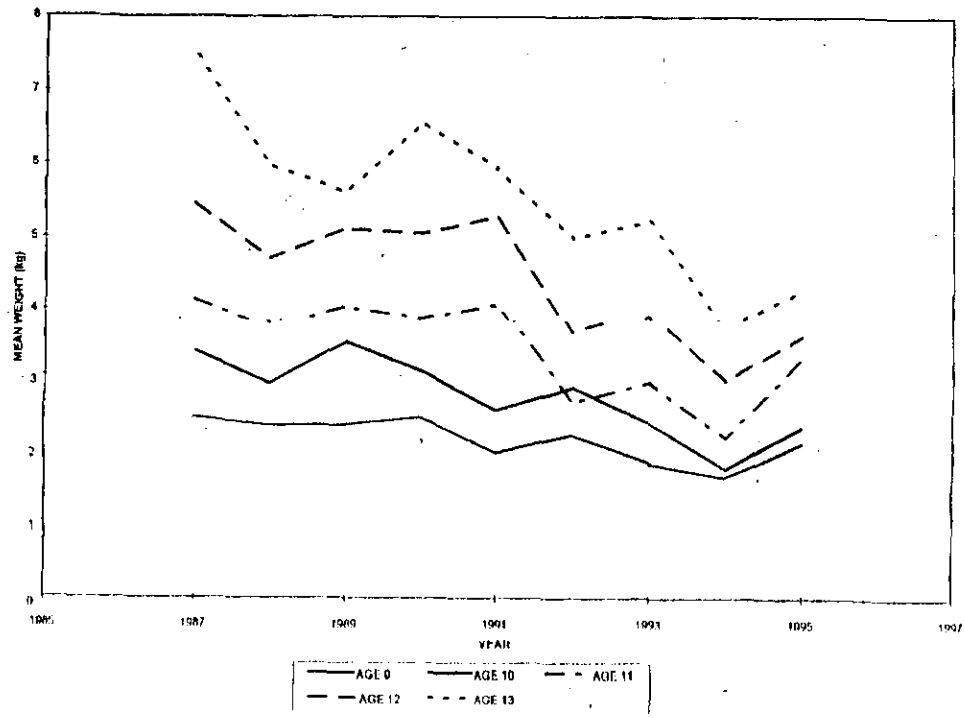

Fig. 8. Average weight-at-age for greenland halibut sampled from the commercial longline fishery in Cumberland Sound, Baffin Island, 1987-1995.

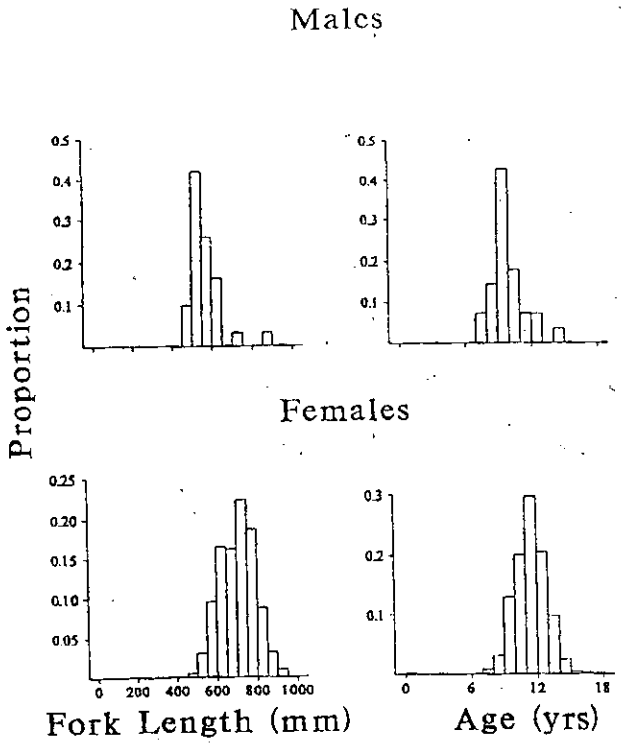

Fig. 9. Length and age frequencies of male and female Greenland halibut sampled from the Cumberland Sound winter longline fishery, 1987-1992.

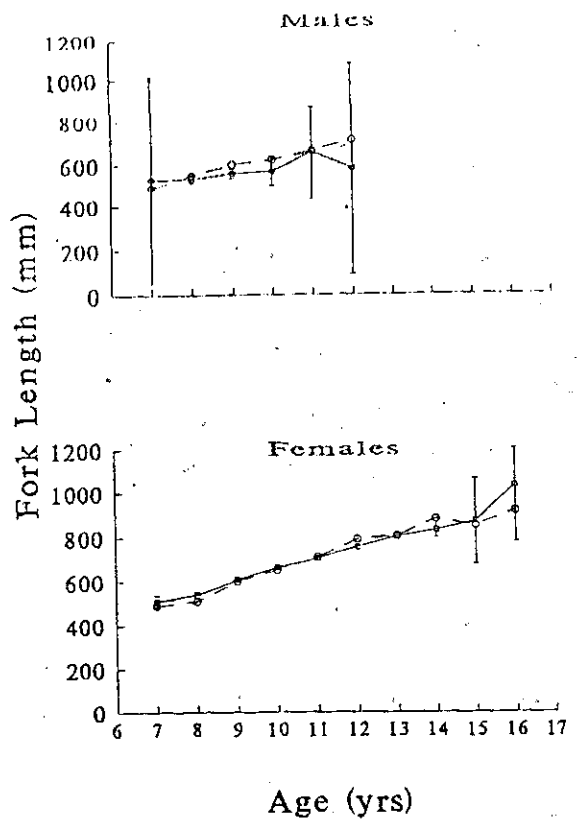

Fig. 10. Average length at average age of male and female Greenland Halibut caught in the Cumberland Sound winter longline fishery (solid line with 95% confidence limits), and from Davis Strait (dashed line, from Atkinson et al. 1982).

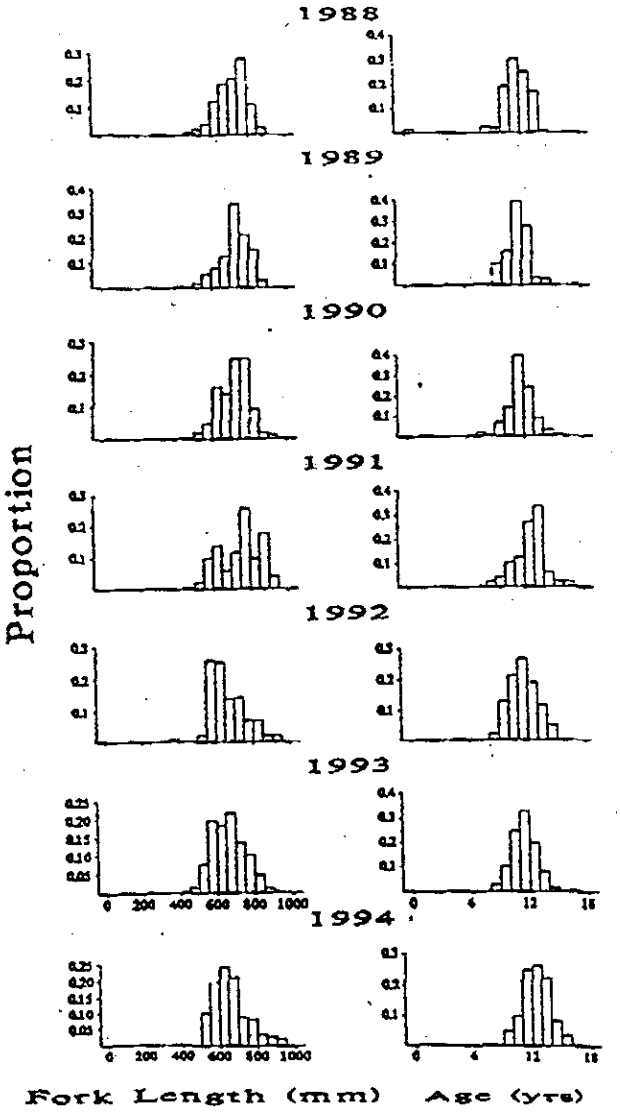

Fig. 11. Length and age distributions of female Greenland halibut caught in the winter longline fishery of Cumberland Sound, 1988-1992.

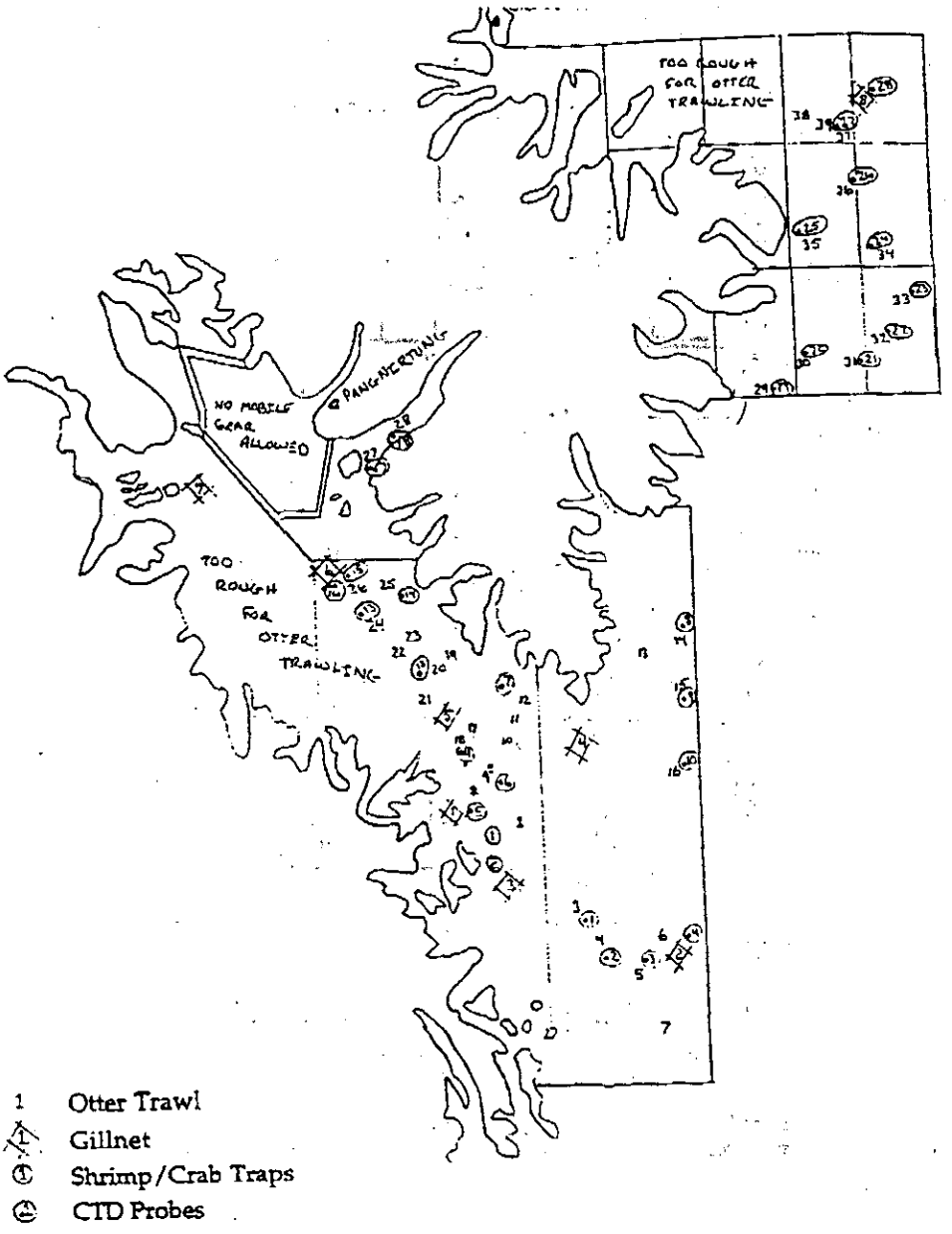

Fig. 12. Map of sampling sites for the Cumberland Sound otter trawl and gillnet survey, August, 1994..

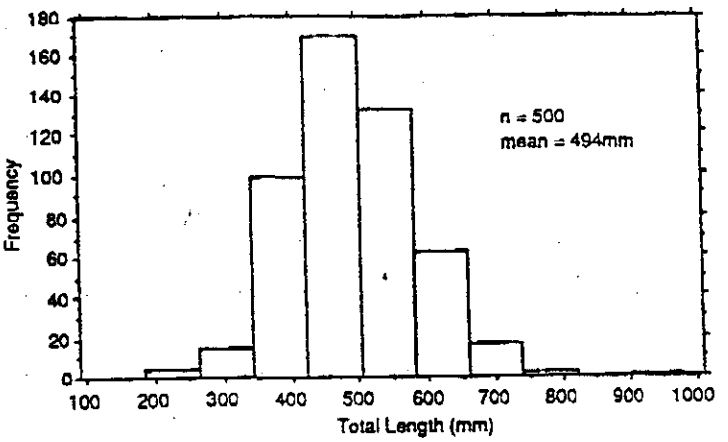

Fig. 13. Length distribution of Greenland halibut sampled by otter trawl in Cumberland Sound, August, 1994.

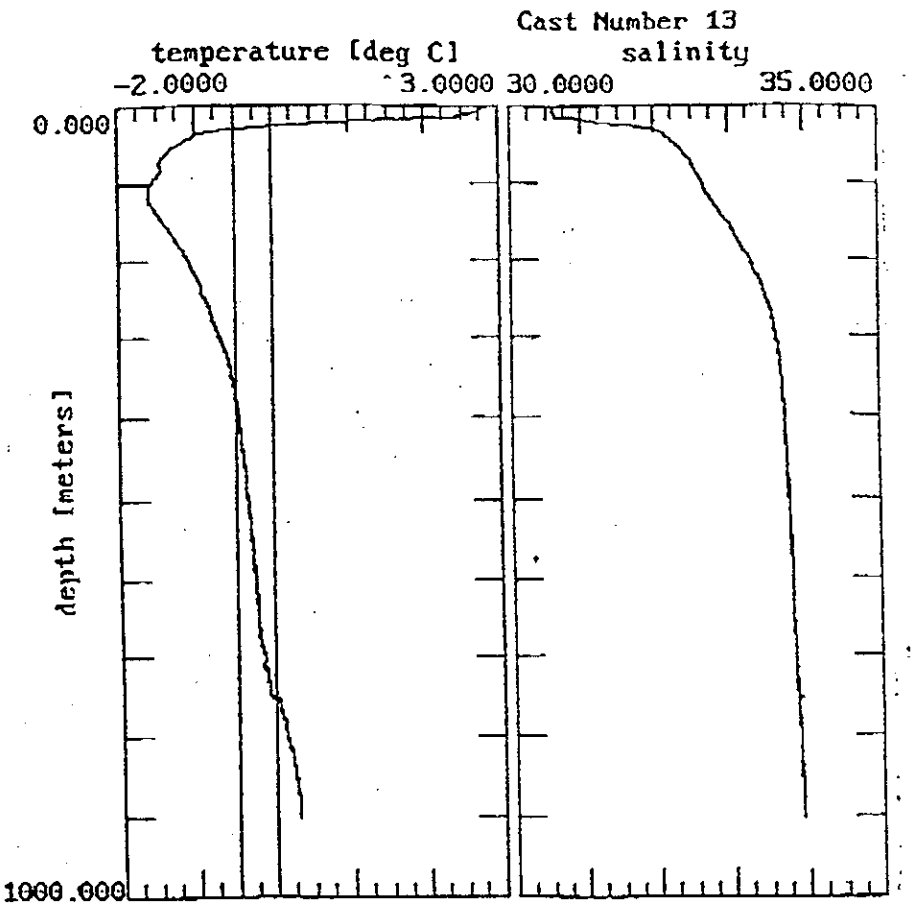

Fig. 14. A typical profile of temperature and salinity in the water column of Cumberland Sound, July, 1994.

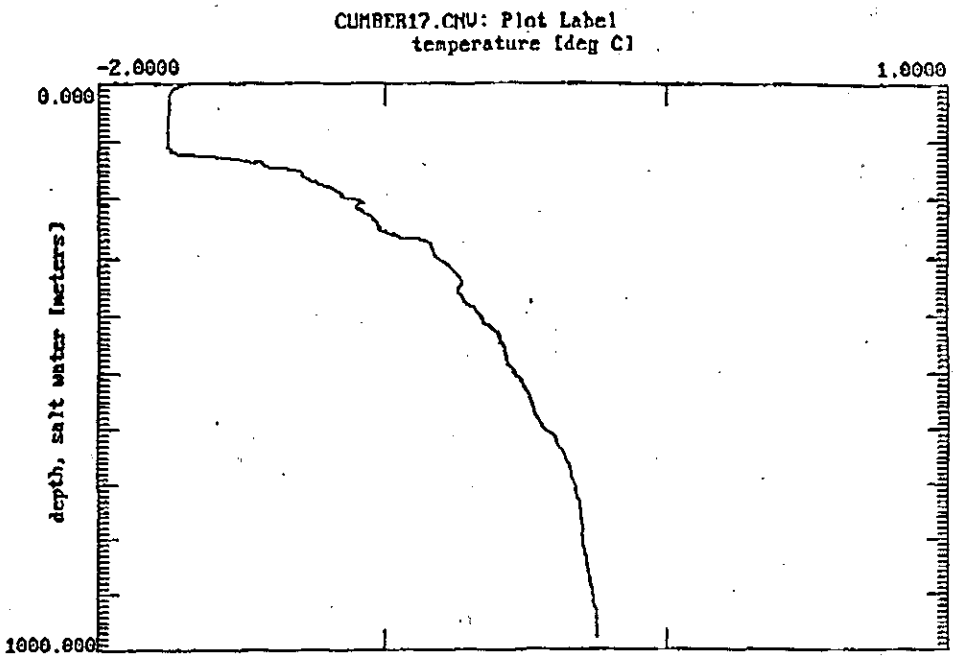

Fig. 15. Temperature profle of Cumberland Sound, March, 1994.