

Distribution, size and sexual maturity of Arctic Cod (Boreogadus saida) in the
Northwest Atlantic during 1959-1978

by

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INTRODUCTION

The Arctic cod (Boreogadus saida) is circumpolar in distribution and is reported to occur along the Labrador coast south to the northwestern Gulf of St. Lawrence (Leim and Scott, 1966). The Arctic cod prefers low temperatures and its distribution is often associated with ice (Hognestad, 1968). The east-west distribution in the Barents Sea is related to temperature variations (Thielemann, 1922). The Arctic cod occurs in those areas which have lowest temperatures except for the spawning season when it migrates into water with higher temperatures during autumn (Ponomarenko, 1961, 1963) preparatory to the spawning during the first months of the year when they are found in great concentrations in the Barents Sea (Andriyashev, 1964). Outside the spawning season, the Arctic cod seems to be found mainly at temperatures around or below zero (Hognestad, 1961). Arctic cod fry may be distributed in temperatures of 4⁰ to 7⁰C but larger fish were always below 3⁰C (Olsen 1962).

The Arctic cod in the Soviet Arctic form several separate stocks (Ponomarenko, 1968). Within the Soviet Arctic the Arctic cod is found from the White and Barents Sea in the west to the Bering Sea in the east. The several major stocks here are: 1. Kara, Barents and White Sea stocks. 2. Chukotsk and Bering Sea stocks and 3. Lapter and East Siberian

stocks. These stocks differ in feeding areas, migration routes and spawning places. All these stocks, however, mix in the boundary areas. Very little is known of the populations of Arctic cod within the Canadian Arctic except as food of narwhales (Mansfield, Smith and Beck, 1975), Arctic char (Moore and Moore, 1974) harp seals (Sergeant, 1973), and murrees (Bradstreet 1977). Bain and Sekerak (1978) reported on the life history, distribution and movements of Arctic cod collected during summer 1977 in Allen and Resolute Bays, Cornwallis Islands and summarized available information on Arctic Cod in the Central Arctic.

The purpose of this paper is to present data on distributions by depth and temperature of Arctic cod in various areas of the Northwest Atlantic based on lined otter trawl catches by the research vessels "A.T. Cameron" and "Gadus Atlantica" and to present additional data on length distributions for various areas of the Canadian shelf and on sizes at maturity for Northern Labrador.

MATERIALS AND METHODS

The data were collected during all seasons on survey cruises of the 51 m side trawler "A.T. Cameron" during 1959-77 and the 80 m stern trawler "Gadus Atlantica" during 1977-78. The distribution data for the "A.T. Cameron" were based upon catches by the standard 41.5 Yankee otter trawl in which the codend was lined with a 6-29 mm nylon mesh and also the No. 36 shrimp trawl with 38 mm mesh throughout with 3.7 m of the codend lined with 13 mm nylon mesh. The distribution data for the "Gadus Atlantica" were based upon catches by the 164 Engels High Rise otter trawl in which the codend was lined with a 29 mm nylon mesh. Only catch records of sets in which no damage to gear occurred were used in presenting data on distribution.

The geographic distribution and relative abundance of Arctic cod are presented by $1/2^{\circ}$ latitude and 1° longitude rectangles for each of the two research vessels. For each research vessel the total numbers of hours fished, total numbers caught and the average number caught per 30-minute tow per rectangle are presented as indices of abundance. The distribution and relative abundance by depth and temperature are presented as the average number caught per 30-minute tow by ICNAF Division by 50 m depth interval. For each ICNAF Division and 50 m depth interval the average number caught per 30 minute tow in which Arctic cod occurred are presented with the averages standard deviations and ranges of bottom temperatures.

Fork length distributions were obtained from some of the more recent research cruises. Fork lengths are expressed to the nearest centimeter and are presented by ICNAF Division or by some other arbitrary area or time interval where there were some obvious differences in size distributions. The sizes at sexual maturity for males and females from Divisions 2GH during September, 1978 were based on visual observations of gonads onboard the research vessel. The sizes at which 50% of the fish were sexually mature (M_{50}) were calculated by probit analysis (Bliss 1952) as applied by Fleming (1960) for cod.

RESULTS AND DISCUSSION

Geographic Distribution and Relative Abundance

On survey cruises of the "A.T. Cameron", conducted from Southern Nova Scotia to Greenland (Fig. 1) during 1959-77, using the 41.5 standard lined otter trawl or the shrimp trawl, Arctic cod were found mainly from the northern Grand Bank along the northeast Newfoundland shelf, Labrador shelf, off Baffin Island and in the Davis Strait. Arctic

cod were found very rarely on the southern half of the Grand Bank or in the Gulf of St. Lawrence and never on the Flemish Cap or the Nova Scotian Banks (Fig. 2). The highest catches per 30-minute tow were off Baffin Island (203.3 individuals) (Fig. 3), Northern Labrador (105, 139 and 1119 individuals), Hamilton Inlet Bank (130.9 individuals), near the northern tip of Newfoundland (235.6 individuals), off Cape St. John (355.0 individuals) with a smaller catch off Baccalieu (30.2), decreasing sharply to the area off Cape St. Francis (2.4) and to 0 on the Southern edge of the Grand Bank. There was no uniformity of catches in any one area. This suggests that possibly within the area of the Newfoundland-Labrador shelf there were occasional migrations of large schools of Arctic cod from more northern areas. Outside the immediate area of these large concentrations the catches were very low or negligible.

On survey cruises of the "Gadus Atlantica" conducted from the southern Grand Banks to northern Labrador (Fig. 4) during 1977-78 using the 164 Engels High Rise lined otter trawl, the best catches of Arctic cod were obtained during September, 1978 in ICNAF Division 2G off Northern Labrador (Fig. 5). The three best catches during September, 1978 were 115,785, 43,269 and 19,320 fish. The set details for these catches were as follows:

| SET. NO: | NO. CAUGHT: | WT. CAUGHT(kg) | BOTTOM TEMP (°C) | DEPTH(M) | LAT: | LONG: |
|----------|-------------|----------------|------------------|----------|--------|--------|
| 90 | 19,320 | 1958 | -0.3 | 143 | 59-26N | 62-45W |
| 92 | 115,785 | 13176 | -0.2 | 116 | 59-15N | 62-26W |
| 103 | 43,269 | 4540 | 0.3 | 134 | 58-34N | 61-04W |

No Arctic cod were caught by the "Gadus Atlantica" during 1977-78 in the Gulf of St. Lawrence, Southern Grand Bank or Flemish Cap (Fig. 5). The best overall catch rates per 30-minute tow were in Northern Labrador (34244.8 and 12531.8 fish),

decreasing to 111.5 fish/tow on Hamilton Inlet Bank, to 3.5 off White Bay, although in many of the unit areas in the immediate vicinity of these larger catches, the catch rates were small or negligible especially off Southern Labrador and Northern Newfoundland (Fig. 6). This indicates that the Arctic cod at times are highly concentrated in schools especially during pre-spawning and spawning times and hence are highly vulnerable to over-exploitation at various times of the year, a situation which could be disastrous to the spawning stocks.

Vertical Distribution

During September 1978, the set which yielded the largest catch of Arctic cod (13176 kg; Set No. 92 of Text Table) was at a depth of 116 m. The Arctic cod were in a large very dense school (Fig. 7) and were vertically distributed from the bottom up to about 25 m above the bottom, thus most of them were well above the mouth of the net which had a vertical opening of 6.7m. In set No. 90, which yielded a catch of 1958 kg the Arctic cod were distributed in a large rather loose school from the bottom (142-144 m) to about 30 m above the bottom (Fig. 8) although there were fairly strong echoes as high as 45 m above the bottom. Arctic cod were observed in a very large, extremely dense school between 59-26N, 62-45W and 59-14N, 62-44W over bottom depths of 136-144 m (Fig. 9). The school was densely distributed from the bottom to about 35 m above the bottom with a few markings about 40-45 m above the bottom. These were also markings in the upper to mid-pelagic depths at 28-64 m which may be Arctic cod or possibly capelin or some other pelagic fish or invertebrate.

In the area between 60-04N, 62-10W and 60-06N, 62-40W, smaller, densely concentrated schools of presumably Arctic cod were observed over bottom

depths of 156-168 m (Fig. 10). The largest of these schools was from 10 to 56 m above the bottom in the densest portion, with some echoes about 62 m above the bottom. The temperatures within the vertical boundaries of these larger concentrations ranged from 1.6°C down to -0.3°C (temperatures obtained from bathythermograph readings).

Distribution by Depth and Temperature

The best catches of Arctic cod by the A.T. Cameron during 1959-77 in ICNAF Division 0 (Baffin Island) were in bottom depths from 201-400 m and bottom temperatures from -1.4 to 2.2°C (Table 1). The highest catch rate for catches in which Arctic cod occurred was in 201-250 m and in temperatures ranging from -1.4 to -0.6°C . Arctic cod were found in very low numbers at West Greenland possibly because the survey was conducted during the summer (July-August, 1965) and when temperatures were relatively warm (averages from 1.60 to 3.20°C) for Arctic cod.

In ICNAF Division 2G the best catches were in depths of 151-300 m and average bottom temperatures ranging from 0.53 to 2.54°C . In Division 2H Arctic cod were caught mainly in 351-500 m and average temperatures of 3.33 to 3.50°C . The best catches in 2J were in 201-250 m and average temperature of 0.03°C (range from -1.2 to 1.5°C). The best catches in 3K were in 151-250 and 301-750 m and temperatures ranging from -1.7 to 2.5°C . In 3L the best catches were in 151-200 m and temperatures ranging from 1.6 to 0.1°C . In the more southerly areas (3N0, 3PS) there were very few Arctic cod caught and these incidental catches were caught merely in depths of 101-200 m and temperatures of -1.5 to 0.9°C . In the Gulf of St. Lawrence (4RS) only a few Arctic cod were caught; mainly in depths of 201-350 m and temperatures of 3.3 to 5.3°C . The overall catches by 30-minute tow by the "A.T. Cameron"

during 1959-77 (Table 2) indicated that Arctic cod in Division 0 occurred mainly in depths of 201-400 m although there were no large catches. Catch rates at West Greenland (IABC) were also low. The best overall catch rates were in 2G in 151-300 m, 2H in 351-500 m, 2J in 201-250 m, 3K in 151-250 m, 3L in 151-200 m. Catches in the eastern or southern areas 3M, 3NO, 3P, 4RS, 4T and 4VWXZ were negligible or zero. A possible reason for the low catch rates of the "A.T. Cameron" may be the smaller opening of the net (3.4 m as compared to 6.7 m for the net used by the "Gadus Atlantica").

The best catches were obtained by the "Gadus Atlantica" during September 1978 in ICNAF Division 2G in 101-150 m and temperatures of -0.4 to 0.6°C (average of -0.03°C) (Table 3). In general in 2G and 2H the Arctic cod were most abundant in depths of 101-200 m and temperatures averaging from -0.03 to 0.59°C (ranges from -0.7 to 3.6°C). In 2J the catches were smaller than in 2G but similar to those in 2H and were mainly in depths of 201-300 m and temperatures averaging 2.02 - 2.09°C (ranges of 0.4 to 3.6°C). Catches in 3K and 3L were very low as were those in some depth zones in more northern areas where the average temperatures exceeded 3.0°C (Table 3). The best overall catch rate per 30-minute tow by the "Gadus Atlantica" was in Division 2G in 101-150 m (25,772 Arctic cod/30-minute tow) decreasing to 658/tow in 151-200 m with no Arctic cod caught deeper than 300 m (Table 4). Smaller catch rates (29 to 59/tow) occurred in 2H, the highest occurring in 101-200 m, and in 2J even lower catch rates (highest of which ranged from 19 to 5/ tow) occurred in 201-300 m with none being caught deeper than 650 m in 2H or 500 m in 2J. Catch rates were very low in 3K (0.2 to 0.3 / tow) mainly in depths of 201-250 m and 301-350 m. In all other areas surveyed Arctic cod catches were zero or negligible.

Sex and Maturity

Sex ratios of Arctic cod collected during September, 1978 in ICNAF Divisions 2G and 2H (Table 5) showed that for the smaller and intermediate-sized fish (9-25 cm), there was an overall ratio of about 50:50 of males: females. Among the larger fish (26-33 cm) the females were in a significantly higher proportion ($\chi^2_{[1]} = 144.9$; $P < .01$) with an average male: female ratio of 1:3.13. This is similar to results found by Bain and Sekerak (1978) for the Central Canadian Arctic. For the Arctic cod off northern Labrador (Divisions 2G and 2H) 50% of the males matured at 12.8 cm while 50% of the females matured at 15.4 cm (Fig. 11). If the growth rates of Arctic cod are similar to those reported by Bain and Sekerak (1978) for the Central Canadian Arctic and if the growth rates of males and females are similar, then 50% of the males were maturing at about 2 years of age while 50% of the females showed indications of maturing at about 3 years of age. This does not differ greatly from the results of Andriyashev (1964) who found that most Arctic cod were mature by age 4. Hognestad, (1968) suggested that some Arctic cod matured by age 2, an observation that agrees with the present study especially in the case of the males. The gonads of the maturing male Arctic cod were relatively large and convoluted (Fig. 12). The gonad weights expressed as percentages of body weight from a sample of 28 maturing males (21 to 26 cm fork length) varied from 5.9 to 14.7% (average of 9.8%). The gonads of the maturing female Arctic cod were relatively smaller (Figs. 13 and 14). The gonad weights expressed as a percentage of body weights for a sample of 43 maturing females (22 to 28 cm fork length) varied from 2.3 to 5.2% (average of 3.8%). The egg diameters varied from 0.1 to 1.0 mm (average of 0.48 mm). This was considerably smaller than eggs of fully mature fish whose egg diameters range from 1.53 to 1.90 mm (Rass, 1968).

Thus it appeared that the gonad development of the females lagged behind that of the males. Rass (1968) stated that Arctic cod spawn from the end of December to the end of March, mostly in January-February, thus the gonads would be expected to be in an early stage of development during September. It is quite possible that lengths at 50% maturity observed immediately prior to the spawning season might be different from those observed during September.

Length Distributions

The length composition of Arctic cod sampled during September, 1978 in northern Labrador changed markedly from north to south (Fig. 15). The average fish lengths of Arctic cod from the three northern areas exhibited significant differences ($P < .001$). There was a decreasing trend from north to south in average fork length. Based upon the 50% maturity ogive (Fig. 11), which suggests that Arctic cod are 100% mature at a length of 20 cm, then in the northern area ($59^{\circ}30'N$ to $6^{\circ}30'N$), almost 100% would be mature; in the area $59^{\circ}00'N$ to $59^{\circ}30'N$, a small proportion would be expected to be immature, and an increasing proportion of immature fish would be expected in the samples from north to south with most of the fish in the southern section of ICNAF Division 2G ($57^{\circ}40'N$ to $58^{\circ}30'N$) and the entire Division of 2H in the immature category. There is also a sharp change from a unimodal distribution of larger fish (28 cm mode) in the north to a bimodal distribution of small and intermediate sized fish (12 cm and 18 cm modes) in the southern area (Division 2H and southern section of 2G).

The large concentrations of Arctic cod in the northern part of Division 2G (Saglek Bank) are clearly pre-spawning concentrations based

upon the size distributions and maturity ogives. The length distributions from Division 2J for various months were significantly different ($P < .001$) according to an analysis of variance performed on 5 of the areas shown in Fig. 16 in which the sample from Gadus 12 during August 5-6, 1978 was omitted because it was polymodal. If the assumption is made that for the years under consideration, there was no annual variation by month in the length distributions, then it can be concluded that there were seasonal variations in the length distributions of the Arctic cod from Division 2J. The length distribution of Arctic cod from Division 2J during August 1978 was polymodal with major modes at 11, 17 and 19 cm (Fig. 16). On the basis of the fork length frequency distributions, it was apparent that, with the possible exception of the samples from Gadus 6 during February, 1978 and Gadus 12 during August, 1978, most of the Arctic cod caught in Division 2J were in the immature category. Even in those samples from the Gadus cruises 6 and 12, only a small proportion would be expected to be maturing based upon the frequencies and the maturity ogives.

The fork length frequency distributions for 3K, 3L and 3Ps (Fig. 17) indicated a population of large Arctic cod in Division 3K in a length range which would suggest that they may be maturing. The Arctic cod from Division 3L were smaller fish composed of 2 major size groups with modes at 10 and 16 cm during May, 1974 most of which would be expected to be immature. There were only 13 Arctic cod caught in Division 3Ps. These were of the intermediate size group from 13 to 19 cm.

REFERENCES

- Andriyashev, A.P. 1964. Fishes of the northern seas of the USSR. Translated from Russian by Israel Program for Scientific Translations, Jerusalem, 617 p.
- Bain, H. and A.D. Sekerak. 1978. Aspects of the biology of Arctic cod, (*Boreogadus saida*), in the central Canadian Arctic. Unpubl. Rept. by LGL Ltd. for Polar Gas Project, 104 p.
- Bliss, E.I. 1952. The statistics of bioassay with special reference to the vitamins. Academic Press, Inc. New York, N.Y., 184 p.
- Bradstreet, M.S.W. 1977. Feeding ecology of seabirds along fast-ice edges in Wellington Channel and Resolute Passage, N.W.T. Unpubl. Rept. by LGL Ltd. for Polar Gas Project, 149 p.
- Fleming, A.M. 1960. Age, growth and sexual maturity of cod (*Gadus morhua* L.) in the Newfoundland area, 1947-1950. J. Fish. Res. Board Can. 17: 775-809.
- Hognestad, P.T. 1961. Contributions to the fish fauna of Spitsbergen. I. The fish fauna of Isfjorden. Acta boreal. A. Scientia, (18).
- Hognestad, P.T. 1968. Observations on Polar cod in the Barents Sea. Rapp. et P.-V. de Reun. Cons. Perm. Int. Explor. Mer., 158: 126-130.
- Leim, A.H. and W.B. Scott. 1966. Fishes of the Atlantic Coast of Canada. Fish. Res. Board. Can. Bull., 155, 485 p.
- Mansfield, A.W., T.G. Smith and B. Beck. 1975. The Narwhal, (*Monodon monoceros*), in Eastern Canadian Waters. J. Fish. Res. Board Can. 32: 1041-1046.
- Moore, J.W. and I.A. Moore. 1974. Food and growth of Arctic char, (*Salvelinus alpinus* (L)), in the Cumberland Sound area of Baffin Island. J. Fish. Biol. (1974) 6, 79-92.
- Olsen, S. 1962. Observations on Polar cod in the Barents Sea. ICES CM 1962 (35) 5 pp (mimeo).
- Ponomarenko, V.P. 1961. Distribution of Polar cod in the autumn/winter period in the Barents Sea. ICES CM 1961, (78) 7 pp (mimeo).
- Ponomarenko, V.P. 1963. The autumn winter distribution of pre-spawning and spawning concentrations of Polar cod (*Boreogadus saida* Lep.) in the Barents Sea. Trudy PINRO, 15: 177-198.
- Ponomarenko, V.P. 1968. Some data on the distribution and migrations of Polar cod in the seas of the Soviet Arctic. Rap. et P.-V. de Reun. Cons. Perm. Int. Explor. Mer., 158: 131-135.
- Rass, T.S. 1968. Spawning and development of Polar cod. Rapp. et P.-V. de Reun Cons. Perm. Int. Explor. Mer., 158: 135-137.

Sergeant, D.E. 1973. Feeding, growth and productivity of Northwest Atlantic harp seals (Pagophilus groenlandicus). J. Fish. Res. Board Can. 30: 17-29.

Thielemann, M. 1922. Wissenschaftliche Ergebnisse einer Untersuchungsfahrt des Reichsforschungsdampfers "Poseidon" in das Barentsmeer in Juni und July, 1913. "Die Fische". Wiss. Meeresunters, Abt, Helgoland, N.F. 13: Heft 2, 185-228.

Table 1

Catches of Arctic cod, numbers of 30-minute tows in which Arctic cod occurred and numbers caught per 30-minute tow by 50 metre depth zone, by ICNAF Division and the averages, standard deviations, and ranges of temperatures in which Arctic cod were caught by the "A.T. Cameron" during 1959-77.

| ICNAF Division | Depth (M) | Total Number Caught | Number of 30-Minute Tows | No. Caught/ /30-Minute Tow | Average Temp. (°C) | S.D. | Range |
|----------------|-----------|---------------------|--------------------------|-------------------------------|--------------------|------|--------------|
| 0 | 201-250 | 253 | 1.9 | 133.2 | -1.00 | 0.57 | -1.4 to -0.6 |
| | 251-300 | 40 | 2 | 20.0 | -0.70 | 0.57 | -1.1 to -0.3 |
| | 301-350 | 38 | 5 | 7.6 | 0.48 | 0.67 | -0.4 to 1.2 |
| | 351-400 | 33 | 7 | 4.7 | 0.77 | 0.88 | -0.5 to 2.2 |
| | 401-450 | 3 | 1 | 3.0 | 3.60 | - | - |
| | 451-500 | 1 | 1 | 1.0 | 1.80 | - | - |
| | 501-550 | 6 | 1 | 6.0 | 2.20 | - | - |
| | 551-600 | 4 | 1 | 4.0 | 4.10 | - | - |
| 1A,B,C, | 201-250 | 8 | 1 | 8.0 | 2.40 | - | - |
| | 351-400 | 3 | 1 | 3.0 | 3.20 | - | - |
| | 451-500 | 1 | 1 | 1.0 | 1.60 | - | - |
| | 551-600 | 2 | 2 | 1.0 | 1.65 | 0.92 | 1.0 to 2.3 |
| 2G | 101-150 | 3 | 1 | 3.0 | -0.30 | - | - |
| | 151-200 | 104 | 3 | 34.7 | 0.53 | 0.58 | 0.2 to 1.2 |
| | 201-250 | 185 | 3 | 61.7 | 0.93 | 0.76 | 0.1 to 1.6 |
| | 251-300 | 338 | 5 | 67.6 | 2.54 | 0.75 | 1.6 to 3.4 |
| 2H | 101-150 | 1 | 1 | 1.0 | 0.60 | - | - |
| | 151-200 | 5 | 3 | 1.7 | 0.33 | 0.81 | -0.6 to 0.9 |
| | 201-250 | 25 | 5 | 5.0 | 0.52 | 1.00 | -0.7 to 1.5 |
| | 251-300 | 7 | 2 | 3.5 | 1.50 | 0.42 | 1.2 to 1.8 |
| | 301-350 | 14 | 5 | 2.8 | 2.46 | 0.95 | 1.0 to 3.3 |
| | 351-400 | 108 | 7 | 15.4 | 3.34 | 0.33 | 2.9 to 3.9 |
| | 401-450 | 82 | 6 | 13.7 | 3.50 | 0.20 | 3.1 to 3.6 |
| | 451-500 | 69 | 4 | 17.3 | 3.33 | 0.56 | 2.6 to 3.9 |

Table 1 (cont'd)

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| ICNAF Division | Depth (M) | Total Number Caught | Number of 30-Minute Tows | No. Caught/ /30-Minute Tow | Average Tow Temp. (°C) | S.D. | Range |
|----------------|-----------|---------------------|--------------------------|-------------------------------|------------------------|------|--------------|
| 2J | 101-150 | 5 | 1 | 5.0 | -0.50 | - | - |
| | 151-200 | 64 | 2.5 | 25.6 | 0.00 | 1.25 | -1.0 to 1.4 |
| | 201-250 | 2581 | 8 | 322.6 | 0.03 | 1.04 | -1.2 to 1.5 |
| | 251-300 | 58 | 8 | 7.3 | 0.70 | 1.13 | -0.9 to 2.4 |
| | 301-350 | 13 | 2.6 | 5.0 | 1.20 | 1.30 | 0.4 to 2.7 |
| | 351-400 | 160 | 3 | 53.3 | 2.97 | 0.32 | 2.6 to 3.2 |
| | 401-450 | 76 | 2 | 38.0 | 2.80 | 0.14 | 2.7 to 2.9 |
| | 451-500 | 9 | 1 | 9.0 | 3.10 | - | - |
| | 501-550 | 5 | 1 | 5.0 | 3.10 | - | - |
| 3K | 151-200 | 961 | 5 | 192.2 | -0.60 | 1.04 | -1.7 to 0.5 |
| | 201-250 | 392 | 11 | 35.6 | -0.29 | 0.85 | -1.4 to 1.4 |
| | 251-300 | 83 | 9 | 9.2 | 0.53 | 1.27 | -1.4 to 2.5 |
| | 301-350 | 527 | 5 | 105.4 | 1.00 | 1.54 | -1.5 to 2.5 |
| | 351-400 | 12 | 1 | 12.0 | -1.10 | - | - |
| 3L | 101-150 | 28 | 11 | 2.6 | -1.01 | 0.24 | -1.3 to -0.6 |
| | 151-200 | 687 | 23 | 29.9 | -0.91 | 0.39 | -1.6 to 0.1 |
| | 201-250 | 168 | 25 | 6.7 | -0.42 | 0.72 | -1.5 to 1.3 |
| | 251-300 | 83 | 11 | 7.6 | 0.46 | 0.92 | -0.9 to 2.2 |
| | 301-350 | 14 | 9 | 1.6 | 0.84 | 1.00 | -0.5 to 2.4 |
| | 351-400 | 1 | 1 | 1.0 | 1.80 | - | - |
| | 451-500 | 1 | 1 | 1.0 | 3.80 | - | - |
| 3NO | 101-150 | 8 | 4 | 2.0 | -1.23 | 0.25 | -1.5 to -0.9 |
| | 151-200 | 2 | 2 | 1.0 | -1.15 | 0.07 | -1.2 to -1.1 |
| | 201-250 | 1 | 1 | 1.0 | 1.20 | - | - |

.../3

Table 1 (cont'd)

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| ICNAF Division | Depth (M) | Total Number Caught | Number of 30- Minute Tows | No. Caught/ /30-Minute Tow | Average Temp. (°C) | S.D. | Range |
|----------------|--------------|------------------------|------------------------------|-------------------------------|-----------------------|------|-------------|
| 3Ps | 101-150 | 1 | 1 | 1.0 | 1.60 | - | - |
| | 151-200 | 9 | 3 | 3.0 | -0.50 | 1.21 | -1.2 to 0.9 |
| | 251-300 | 1 | 1 | 1.0 | 6.30 | - | - |
| | 351-400 | 1 | 1 | 1.0 | 5.40 | - | - |
| 4RS | 151-200 | 1 | 1 | 1.0 | 2.30 | - | - |
| | 201-250 | 4 | 3 | 1.3 | 3.93 | 0.55 | 3.3 to 4.3 |
| | 251-300 | 2 | 2 | 1.0 | 4.60 | 0.42 | 4.3 to 4.9 |
| | 301-350 | 2 | 1 | 2.0 | 5.30 | - | - |

Table 2

Total numbers of 30-minute tows made, total numbers of Arctic cod caught and numbers of Arctic cod caught per 30-minute tow by ICNAF Division by 50 metre depth zone.
by the "A.T. Cameron" during 1959-77.

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/30-Minute Tow | ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/30-Minute Tow |
|------------|-----------|------------------|-----------------------|--------------------------|------------|-----------|------------------|-----------------------|--------------------------|
| 0 | 51-100 | 0 | 12 | 0.0 | 2G | 101-150 | 3 | 1 | 3.0 |
| | 101-150 | 0 | 15 | 0.0 | | 151-200 | 104 | 3 | 34.7 |
| | 151-200 | 0 | 19.5 | 0.0 | | 201-250 | 185 | 4 | 46.3 |
| | 201-250 | 253 | 17.4 | 14.5 | | 251-300 | 338 | 9 | 37.6 |
| | 251-300 | 40 | 19 | 2.1 | | 301-350 | 0 | 1 | 0.0 |
| | 301-350 | 38 | 10 | 3.8 | | 351-400 | 0 | 2 | 0.0 |
| | 351-400 | 33 | 18 | 1.8 | | 451-500 | 0 | 1 | 0.0 |
| | 401-450 | 3 | 3 | 1.0 | | 551-600 | 0 | 1.7 | 0.0 |
| | 451-500 | 1 | 2 | 0.5 | | 751-800 | 0 | 1 | 0.0 |
| | 501-550 | 6 | 1 | 6.0 | 2H | 101-150 | 1 | 3 | 0.3 |
| | 551-600 | 4 | 7.5 | 0.5 | | 151-200 | 5 | 7 | 0.7 |
| | 651-700 | 0 | 1 | 0.0 | | 201-250 | 25 | 9 | 2.8 |
| | 701-750 | 0 | 1 | 0.0 | | 251-300 | 7 | 6 | 1.2 |
| | 751-800 | 0 | 2 | 0.0 | | 301-350 | 14 | 11 | 1.3 |
| ABCD | 1-50 | 0 | 2 | 0.0 | | 351-400 | 108 | 13 | 8.3 |
| | 101-150 | 0 | 2.9 | 0.0 | | 401-450 | 82 | 8 | 10.3 |
| | 201-250 | 8 | 1 | 8.0 | | 451-500 | 69 | 8 | 8.6 |
| | 251-300 | 0 | 1.9 | 0.0 | | 551-600 | 0 | 2 | 0.0 |
| | 351-400 | 3 | 1.7 | 1.8 | | 701-750 | 0 | 1 | 0.0 |
| | 451-500 | 1 | 2.9 | 0.3 | | 751-800 | 0 | 1 | 0.0 |
| | 551-600 | 2 | 3 | 0.7 | 2J | 101-150 | 5 | 2 | 2.5 |
| | 671-700 | 0 | 1 | 0.0 | | 151-200 | 64 | 10.5 | 6.1 |
| | 751-800 | 0 | 2 | 0.0 | | 201-250 | 2581 | 47.9 | 53.9 |
| | | | | | | 251-300 | 58 | 83 | 0.7 |
| | | | | | | 301-350 | 13 | 63.4 | 0.2 |

Table2. (cont'd)

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow | ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow |
|------------|-----------|------------------|-----------------------|---------------------------|------------|-----------|------------------|-----------------------|---------------------------|
| 2J | 351-400 | 160 | 43 | 3.7 | 3L | 51-100 | 0 | 80 | 0.0 |
| | 401-450 | 76 | 17 | 4.5 | | 101-150 | 28 | 289 | 0.1 |
| | 451-500 | 9 | 25 | 0.4 | | 151-200 | 687 | 165.9 | 4.1 |
| | 501-550 | 5 | 12 | 0.4 | | 201-250 | 168 | 142.8 | 1.2 |
| | 551-600 | 0 | 18 | 0.0 | | 251-300 | 83 | 94.9 | 0.9 |
| | 601-650 | 0 | 4 | 0.0 | | 301-350 | 14 | 84 | 0.2 |
| | 651-700 | 0 | 8 | 0.0 | | 351-400 | 1 | 50 | <0.1 |
| | 701-750 | 0 | 5 | 0.0 | | 451-500 | 1 | 18.7 | 0.1 |
| | 751-800 | 0 | 4 | 0.0 | | 501-550 | 0 | 3 | 0.0 |
| | 801-850 | 0 | 1 | 0.0 | | 551-600 | 0 | 9 | 0.0 |
| 3K | 101-150 | 0 | 3 | 0.0 | 3M | 601-650 | 0 | 4 | 0.0 |
| | 151-200 | 961 | 9 | 106.8 | | 651-700 | 0 | 4 | 0.0 |
| | 201-250 | 392 | 29 | 13.5 | | 751-800 | 0 | 1 | 0.0 |
| | 251-300 | 83 | 60 | 1.4 | | 151-200 | 0 | 10 | 0.0 |
| | 301-350 | 527 | 73 | 7.2 | | 201-250 | 0 | 12 | 0.0 |
| | 351-400 | 12 | 43 | 0.3 | | 251-300 | 0 | 30 | 0.0 |
| | 401-500 | 0 | 5 | 0.0 | | 301-350 | 0 | 69 | 0.0 |
| | 451-500 | 0 | 23 | 0.0 | | 351-400 | 0 | 11 | 0.0 |
| | 501-550 | 0 | 4 | 0.0 | | 401-450 | 0 | 3 | 0.0 |
| | 551-600 | 0 | 10 | 0.0 | | 451-500 | 0 | 6 | 0.0 |
| | 601-650 | 0 | 4 | 0.0 | | 501-550 | 0 | 1 | 0.0 |
| | 651-700 | 0 | 7 | 0.0 | | 551-600 | 0 | 29 | 0.0 |
| | 701-750 | 0 | 1 | 0.0 | | 601-650 | 0 | 2 | 0.0 |
| | 750-800 | 0 | 5.2 | 0.0 | | 651-700 | 0 | 2 | 0.0 |
| | | | | | | 701-750 | 0 | 1 | 0.0 |
| | | | | | | 751-800 | 0 | 2 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Table 2(cont'd)

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow | ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow |
|------------|-----------|------------------|-----------------------|---------------------------|------------|-----------|------------------|-----------------------|---------------------------|
| 3N0 | 51-100 | 0 | 584.8 | 0.0 | 3P | 501-550 | 0 | 4 | 0.0 |
| | 101-150 | 8 | 363.6 | <0.1 | | 551-600 | 0 | 2 | 0.0 |
| | 151-200 | 2 | 161.7 | <0.1 | | 651-700 | 0 | 1 | 0.0 |
| | 201-250 | 1 | 182 | <0.1 | 4RS | 1-50 | 0 | 1 | 0.0 |
| | 251-300 | 0 | 151.5 | 0.0 | | 51-100 | 0 | 34 | 0.0 |
| | 301-350 | 0 | 76.5 | 0.0 | | 101-150 | 0 | 58 | 0.0 |
| | 351-400 | 0 | 29 | 0.0 | | 151-200 | 1 | 59.8 | <0.1 |
| | 401-450 | 0 | 5 | 0.0 | | 201-250 | 4 | 155.7 | <0.1 |
| | 451-500 | 0 | 16.8 | 0.0 | | 251-300 | 2 | 124.8 | <0.1 |
| | 501-550 | 0 | 3.8 | 0.0 | | 301-350 | 2 | 40.0 | 0.1 |
| | 551-600 | 0 | 13 | 0.0 | | 351-400 | 0 | 35.0 | 0.0 |
| | 601-650 | 0 | 2 | 0.0 | | 401-450 | 0 | 1 | 0.0 |
| | 651-700 | 0 | 7 | 0.0 | | 451-500 | 0 | 10 | 0.0 |
| | 701-750 | 0 | 4 | 0.0 | | 501-550 | 0 | 2 | 0.0 |
| | 751-800 | 0 | 4.9 | 0.0 | 4T | 201-250 | 0 | 29 | 0.0 |
| 3P | 801-850 | 0 | 1.4 | 0.0 | | 251-300 | 0 | 21 | 0.0 |
| | 51-100 | 0 | 113.2 | 0.0 | | 301-350 | 0 | 26 | 0.0 |
| | 101-150 | 1 | 133.1 | <0.1 | | 351-400 | 0 | 19 | 0.0 |
| | 151-200 | 9 | 144.4 | 0.1 | | 401-450 | 0 | 1 | 0.0 |
| | 201-250 | 0 | 194.7 | 0.0 | | 451-500 | 0 | 2 | 0.0 |
| | 251-300 | 1 | 230.6 | <0.1 | | 501-550 | 0 | 1 | 0.0 |
| | 301-350 | 0 | 151.5 | 0.0 | 4VWXZ | 51-100 | 0 | 5 | 0.0 |
| | 351-400 | 1 | 68 | <0.1 | | 101-150 | 0 | 24 | 0.0 |
| | 401-450 | 0 | 23 | 0.0 | | 151-200 | 0 | 44 | 0.0 |
| | 451-500 | 0 | 16 | 0.0 | | 201-250 | 0 | 37.2 | 0.0 |

Table 2(cont'd)

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30- Minute Tows | No. Caught/ 30-Minute Tow |
|---------------|--------------|---------------------|---------------------------|---------------------------------|
| 4VWXZ | 251-300 | 0 | 24 | 0.0 |
| | 301-350 | 0 | 8 | 0.0 |
| | 351-400 | 0 | 13 | 0.0 |
| | 401-450 | 0 | 5 | 0.0 |
| | 451-500 | 0 | 9 | 0.0 |
| | 501-550 | 0 | 3 | 0.0 |
| | 551-600 | 0 | 6 | 0.0 |
| | 601-650 | 0 | 3 | 0.0 |
| | 651-700 | 0 | 4 | 0.0 |
| | 701-750 | 0 | 2 | 0.0 |
| | 751-800 | 0 | 2.8 | 0.0 |

Table 3

Catches of Arctic cod, numbers of 30-minute tows in which Arctic cod occurred and numbers caught per 30-minute tow by 50 metre depth zone, by ICNAF Division and the averages, standard deviations, and ranges of temperatures in which Arctic cod were caught by "Gadus Atlantica" during 1977-78.

| ICNAF Division | Depth (M) | Total Number Caught | Number of 30-Minute Tows | No. Caught/30-Minute Tow | Average Temp. (°C) | S.D. | Range |
|----------------|-----------|---------------------|--------------------------|--------------------------|--------------------|------|-------------|
| 2G | 101-150 | 180,401 | 7 | 25,771.6 | -0.03 | 0.37 | -0.4 to 0.6 |
| | 151-200 | 12,494 | 17 | 734.9 | 0.59 | 0.42 | -0.5 to 1.3 |
| | 201-250 | 29 | 4 | 7.3 | 1.40 | 0.45 | 1.0 to 2.0 |
| | 251-300 | 208 | 4 | 52.0 | 1.98 | 1.42 | 1.0 to 4.0 |
| 2H | 51-100 | 1 | 1 | 1.0 | 1.00 | - | - |
| | 101-150 | 262 | 9 | 29.1 | 0.38 | 1.31 | -0.7 to 3.6 |
| | 151-200 | 411 | 5 | 82.2 | 0.52 | 0.72 | -0.1 to 1.7 |
| | 201-250 | 70 | 6 | 11.7 | 0.25 | 0.92 | -0.6 to 1.7 |
| | 251-300 | 19 | 1 | 19.0 | 3.40 | - | - |
| | 351-400 | 1 | 1 | 1.0 | 3.50 | - | - |
| | 551-600 | 1 | 1 | 1.0 | 4.20 | - | - |
| | 601-650 | 2 | 1 | 2.0 | 3.40 | - | - |
| 2J | 151-200 | 63 | 7 | 9.0 | 2.07 | 0.68 | 1.1 to 3.2 |
| | 201-250 | 929 | 14 | 66.4 | 2.09 | 0.94 | 0.4 to 3.2 |
| | 251-300 | 209 | 9 | 23.2 | 2.02 | 0.87 | 0.8 to 3.6 |
| | 301-350 | 45 | 3 | 15.0 | 2.73 | 0.35 | 2.4 to 3.1 |
| | 351-400 | 59 | 4 | 14.8 | 3.05 | 0.73 | 2.3 to 4.0 |
| | 451-500 | 16 | 2 | 8.0 | 3.05 | 0.35 | 2.8 to 3.3 |
| 3K | 201-250 | 3 | 2 | 1.5 | 2.35 | 0.64 | 1.9 to 2.8 |
| | 301-350 | 8 | 2 | 4.0 | 3.00 | - | - |
| | 401-450 | 1 | 1 | 1.0 | 3.10 | - | - |
| 3L | 151-200 | 1 | 1 | 1.0 | -0.70 | - | - |
| | 201-250 | 1 | 1 | 1.0 | 2.30 | - | - |

Table 4

Total numbers of 30-minute tows made, total numbers of Arctic cod caught and numbers of Arctic cod caught per 30-minute tow by ICNAF Division by 50-metre depth zone, by the "Gadus Atlantica" during 1977-78

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow | ICNAF Div. | Depth (M) | Total No. Caught | No. of 30-Minute Tows | No. Caught/ 30-Minute Tow |
|------------|-----------|------------------|-----------------------|---------------------------|------------|-----------|------------------|-----------------------|---------------------------|
| 2G | 101-150 | 180,401 | 7 | 25,771.6 | 2J | 351-400 | 9 | 16 | 0.6 |
| | 151-200 | 12,494 | 19 | 657.6 | | 401-450 | 0 | 18.8 | 0 |
| | 201-250 | 29 | 11 | 2.6 | | 451-500 | 16 | 17 | 0.9 |
| | 251-300 | 208 | 5 | 41.6 | | 501-550 | 0 | 9 | 0 |
| | 351-400 | 0 | 4 | 0 | | 551-600 | 0 | 14 | 0 |
| | 401-450 | 0 | 1 | 0 | | 601-650 | 0 | 4 | 0 |
| | 451-500 | 0 | 2 | 0 | | 651-700 | 0 | 1 | 0 |
| | 551-600 | 0 | 1 | 0 | | 701-750 | 0 | 1 | 0 |
| | 1101-1150 | 0 | 1 | 0 | | 751-800 | 0 | 4 | 0 |
| | 1351-1400 | 0 | 1 | 0 | | 801-850 | 0 | 2 | 0 |
| 2H | 51-100 | 1 | 1 | 1.0 | 3K | 851-900 | 0 | 2 | 0 |
| | 101-150 | 262 | 9 | 29.1 | | 1001-1050 | 0 | 3 | 0 |
| | 151-200 | 411 | 7 | 58.7 | | 1051-1100 | 0 | 2 | 0 |
| | 201-250 | 70 | 9 | 7.8 | | 1151-1200 | 0 | 2 | 0 |
| | 251-300 | 19 | 2 | 9.5 | | 1201-1250 | 0 | 2 | 0 |
| | 301-350 | 0 | 5 | 0 | | 1250-1300 | 0 | 1 | 0 |
| | 351-400 | 1 | 4 | 0.3 | | 1351-1400 | 0 | 2 | 0 |
| | 401-450 | 0 | 2 | 0 | | 1401-1450 | 0 | 1 | 0 |
| | 451-500 | 0 | 2 | 0 | | 201-250 | 3 | 18 | 0.2 |
| | 501-550 | 0 | 1 | 0 | | 251-300 | 0 | 20 | 0 |
| 2J | 551-600 | 1 | 3 | 0.3 | | 301-350 | 8 | 26 | 0.3 |
| | 601-650 | 2 | 2 | 1.0 | | 351-400 | 0 | 3 | 0 |
| | 751-800 | 0 | 1 | 0 | | 401-450 | 1 | 9 | 0.1 |
| | 801-850 | 0 | 1 | 0 | | 451-500 | 0 | 6 | 0 |
| | 1001-1050 | 0 | 1 | 0 | | 551-600 | 0 | 2 | 0 |
| | 1151-1200 | 0 | 1 | 0 | | 601-650 | 0 | 2 | 0 |
| | 1301-1350 | 0 | 1 | 0 | | 751-800 | 0 | 2 | 0 |
| | 151-200 | 63 | 15 | 4.2 | | 801-850 | 0 | 1 | 0 |
| | 201-250 | 929 | 50 | 18.6 | | 951-1000 | 0 | 1 | 0 |
| | 251-300 | 209 | 43 | 4.9 | | 1051-1100 | 0 | 1 | 0 |
| | 301-350 | 45 | 27 | 1.7 | | | | | |

| ICNAF Div. | Depth (M) | Total No. Caught | No. of 30- Minute Tows | No. Caught/ 30-Minute Tow | ICNAF Div. | Depth (M) | Total No. Caught | No. of 30- Minute Tows | No. Caught/ 30-Minute Tow |
|---------------|--------------|---------------------|------------------------------|---------------------------------|---------------|--------------|---------------------|------------------------------|---------------------------------|
| 3K | 1101-1150 | 0 | 2 | 0 | 3P | 301-350 | 0 | 3 | 0 |
| | 1151-1200 | 0 | 1 | 0 | | 401-450 | 0 | 1 | 0 |
| | 1301-1350 | 0 | 2 | 0 | | 451-500 | 0 | 1.8 | 0 |
| | 1351-1400 | 0 | 2 | 0 | 4RS | 51-100 | 0 | 1 | 0 |
| 3L | 151-200 | 1 | 6 | 0.2 | | 101-150 | 0 | 19 | 0 |
| | 201-250 | 1 | 12 | 0.1 | | 151-200 | 0 | 15 | 0 |
| | 251-300 | 0 | 45 | 0 | | 201-250 | 0 | 9.8 | 0 |
| | 301-350 | 0 | 35 | 0 | | 251-300 | 0 | 17 | 0 |
| | 351-400 | 0 | 42 | 0 | | 301-350 | 0 | 13.8 | 0 |
| | 401-450 | 0 | 19.9 | 0 | | 351-400 | 0 | 4 | 0 |
| | 451-500 | 0 | 7 | 0 | | 401-450 | 0 | 10 | 0 |
| | 551-600 | 0 | 6 | 0 | | 451-500 | 0 | 1 | 0 |
| | 601-650 | 0 | 3 | 0 | | 501-550 | 0 | 1 | 0 |
| 3M | 151-200 | 0 | 13.8 | 0 | 4T | 201-250 | 0 | 2 | 0 |
| | 201-250 | 0 | 19 | 0 | | 301-350 | 0 | 2 | 0 |
| | 251-300 | 0 | 33 | 0 | | 401-450 | 0 | 2 | 0 |
| | 301-350 | 0 | 57.6 | 0 | | | | | |
| | 351-400 | 0 | 22 | 0 | | | | | |
| | 401-450 | 0 | 16 | 0 | | | | | |
| | 451-500 | 0 | 6 | 0 | | | | | |
| | 501-550 | 0 | 3 | 0 | | | | | |
| | 551-600 | 0 | 6.6 | 0 | | | | | |
| | 601-650 | 0 | 3 | 0 | | | | | |
| | 651-700 | 0 | 5 | 0 | | | | | |
| 3NO | 51-100 | 0 | 28 | 0 | | | | | |
| | 101-150 | 0 | 27 | 0 | | | | | |
| | 151-200 | 0 | 9 | 0 | | | | | |
| | 201-250 | 0 | 2 | 0 | | | | | |
| | 251-300 | 0 | 1 | 0 | | | | | |
| | 301-350 | 0 | 1 | 0 | | | | | |
| 3P | 151-200 | 0 | 4 | 0 | | | | | |
| | 201-250 | 0 | 2 | 0 | | | | | |
| | 251-300 | 0 | 1 | 0 | | | | | |

Table 5. Sex ratios of Arctic cod by 1 cm length group caught during a cruise of "Gadus Atlantica", September 1978 in ICNAF Divisions 2G and 2H.

| FI(cm.) | MALE | FEMALE | TOTAL | % FEMALE |
|---------|------|--------|-------|----------|
| 9 | 1 | 4 | 5 | 80.0 |
| 10 | 18 | 18 | 36 | 50.0 |
| 11 | 43 | 42 | 85 | 49.4 |
| 12 | 63 | 46 | 109 | 42.2 |
| 13 | 38 | 15 | 53 | 28.3 |
| 14 | 22 | 24 | 46 | 52.2 |
| 15 | 27 | 33 | 60 | 55.0 |
| 16 | 37 | 36 | 73 | 49.3 |
| 17 | 40 | 44 | 84 | 52.4 |
| 18 | 41 | 37 | 78 | 47.4 |
| 19 | 22 | 24 | 46 | 52.2 |
| 20 | 24 | 19 | 43 | 44.2 |
| 21 | 11 | 21 | 32 | 65.6 |
| 22 | 15 | 22 | 37 | 59.5 |
| 23 | 30 | 31 | 61 | 50.8 |
| 24 | 48 | 55 | 103 | 53.3 |
| 25 | 57 | 53 | 110 | 48.2 |
| 26 | 55 | 87 | 142 | 61.3 |
| 27 | 51 | 123 | 174 | 69.1 |
| 28 | 15 | 100 | 115 | 87.0 |
| 29 | 7 | 60 | 67 | 89.6 |
| 30 | 3 | 31 | 34 | 91.2 |
| 31 | 0 | 7 | 7 | 100.0 |
| 32 | 0 | 5 | 5 | 100.0 |
| 33 | 1 | 0 | 1 | 0.0 |
| Total: | 669 | 937 | 1606 | 58.3 |
| 9-25 | 537 | 524 | 1061 | 49.4 |
| 26-33 | 132 | 413 | 545 | 75.8 |

Fig. 1. Total number of hours successfully fished by the research vessel A.T. Cameron during 1959-77 by $1/2^{\circ}$ lat. 1° long rectangles using the standard lined 41.5 otter trawl and the shrimp trawl.

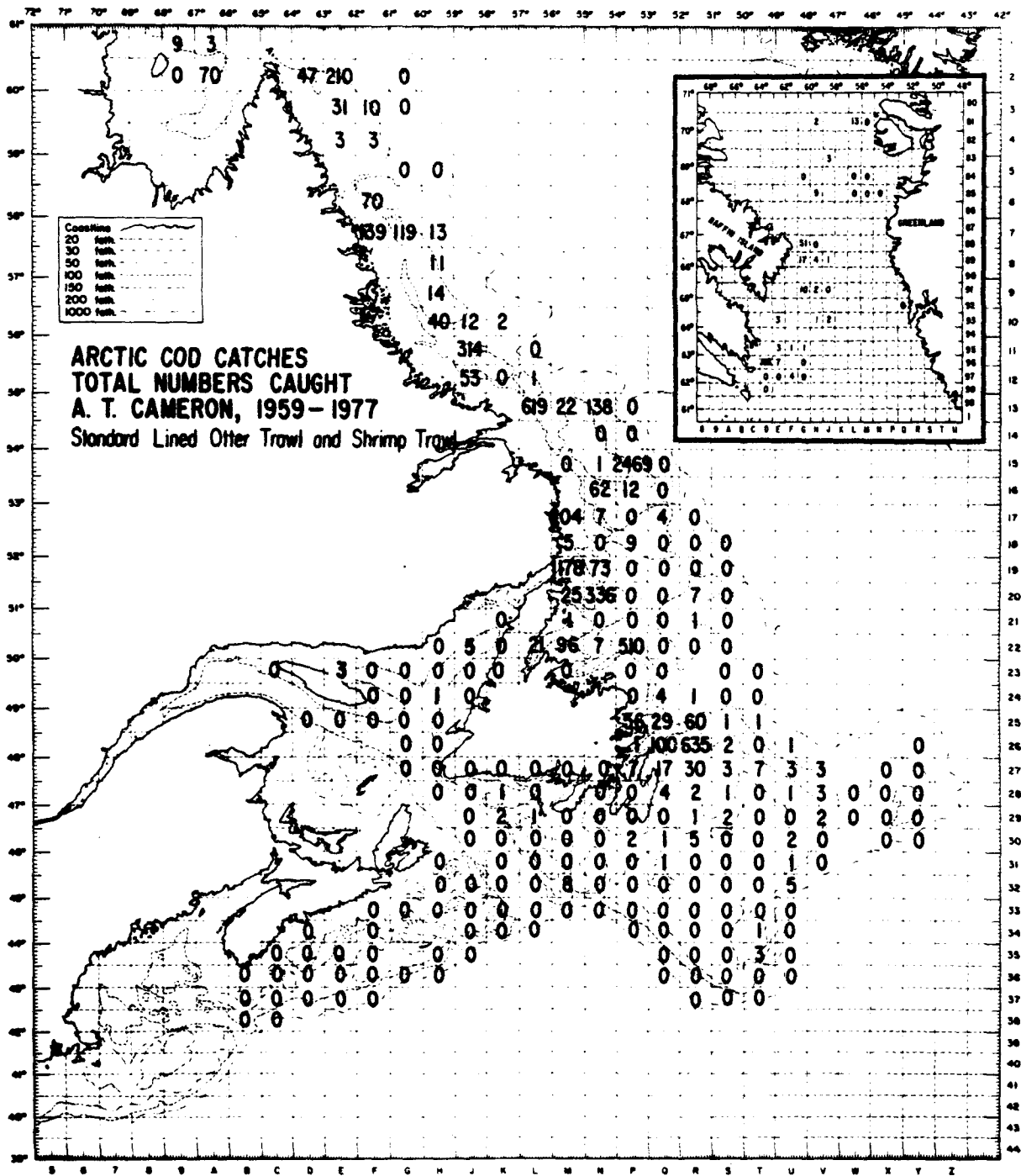


Fig. 2. Total numbers of Arctic cod caught by $1/2^{\circ}$ lat. 1° long. rectangles by the A.T. Cameron during 1959-77 using the standard lined 41.5 otter trawl and the shrimp trawl.

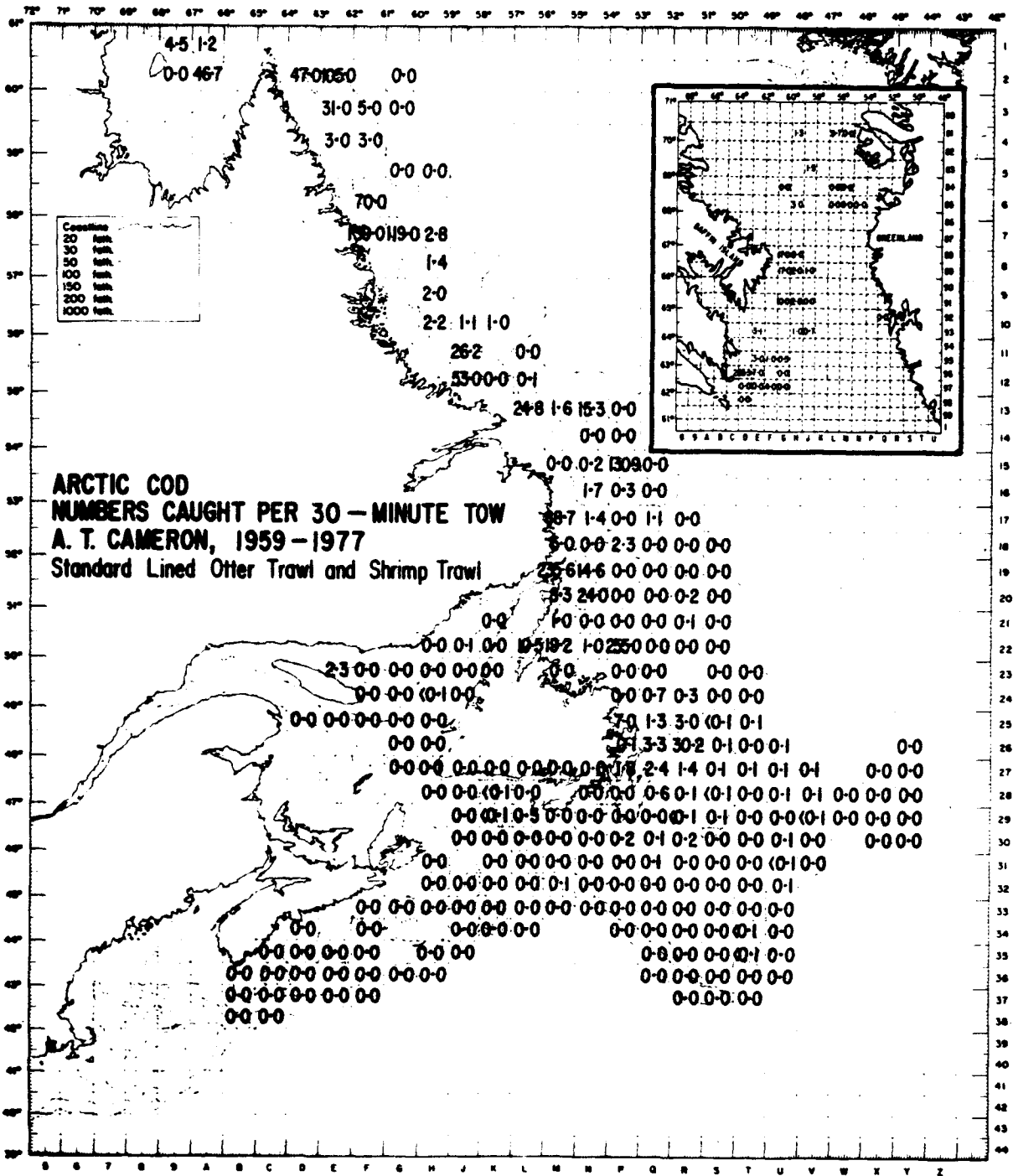


Fig. 3. Average number of Arctic cod caught by $1/2^\circ$ lat. 1° long. rectangles per 30-minute otter trawling tows of the A.T. Cameron during 1959-77.

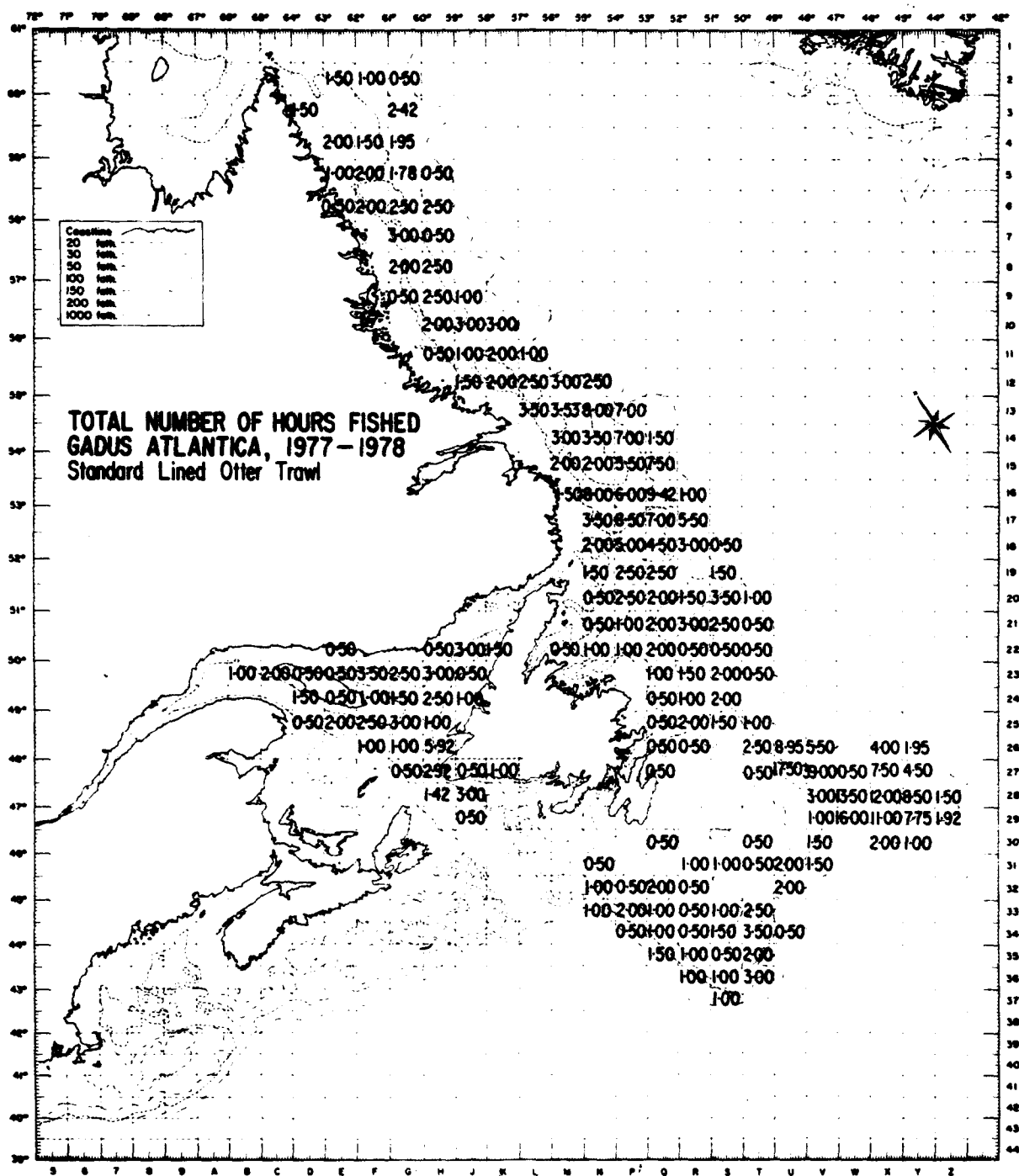


Fig. 4. Total number of hours successfully fished by the research vessel *Gadus atlantica* (cruises 3-6, 8, 9, 12, 13) during 1977-78 by $1/2^\circ$ lat. 1° long. rectangles using the standard lined Engels High rise otter trawl.

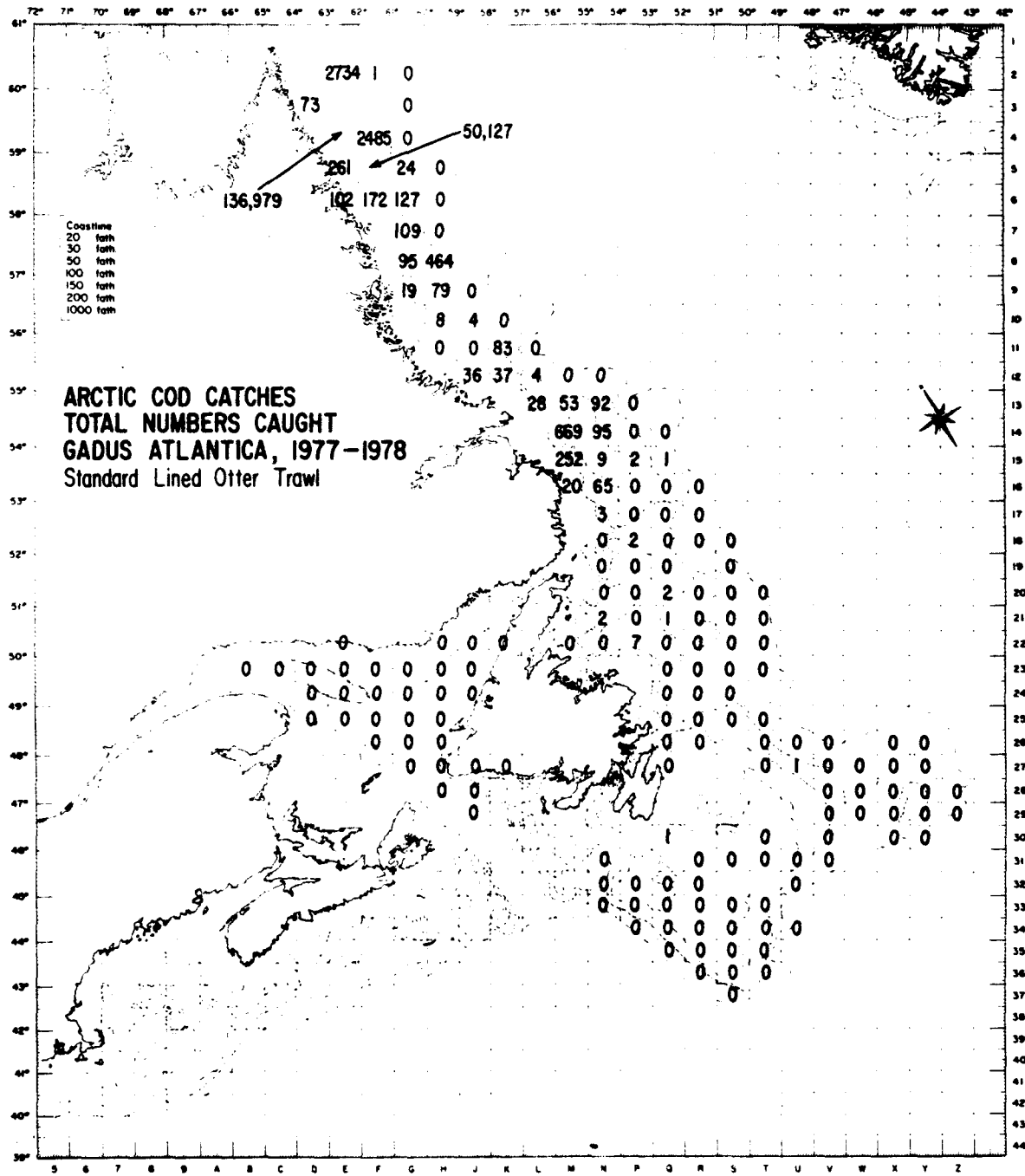


Fig. 5. Total number of Arctic cod caught by $1/2^\circ$ lat. 1° long. rectangles by the Gadus Atlantica (cruises 3-6,8,9,12,13) during 1977-78 using the standard lined Engels High rise otter trawl.

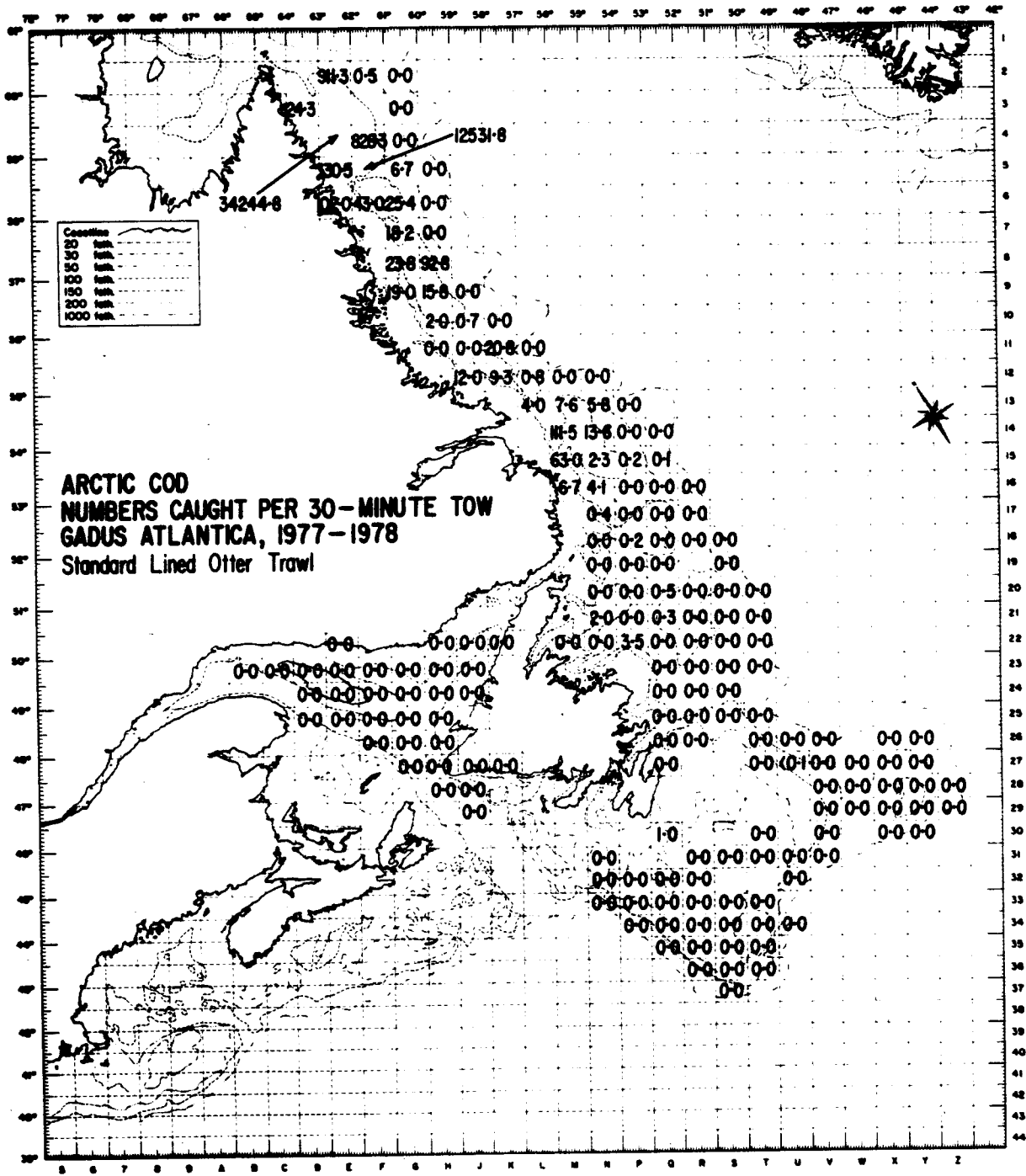


Fig. 6. Average number of Arctic cod caught by $1/2^{\circ}$ lat. 1° long. rectangles per 30-minute otter trawling tows of the Gadus Atlantica (cruises 3-6, 8,9,12,13) during 1977-78.

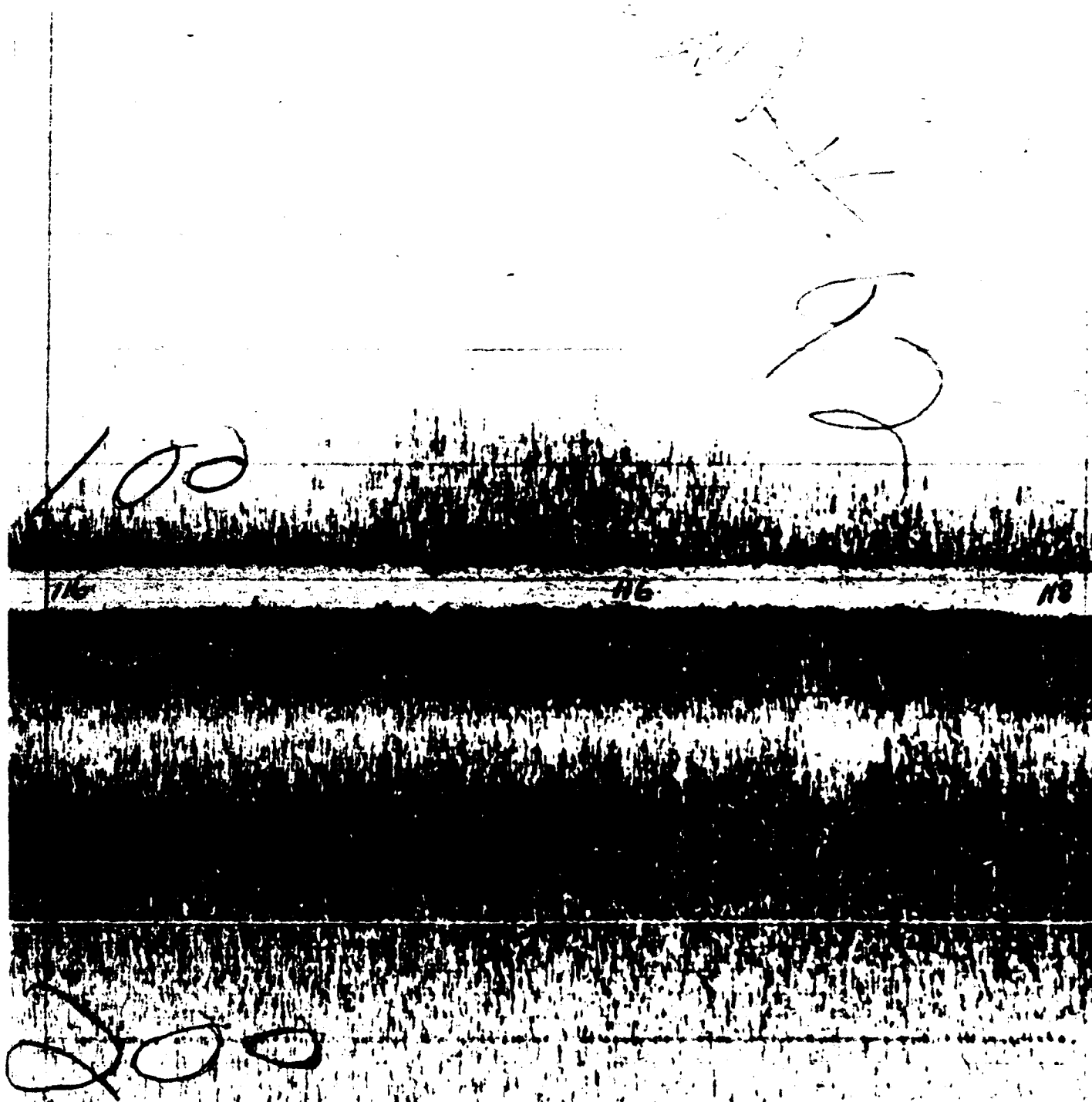


Fig. 7. Echo sounder record of Arctic cod concentration fished by *Gadus Atlantica* during September 27, 1978 at $59^{\circ}15'N$, $62^{\circ}26'W$ at a depth of 116-118 m. Arctic cod catch for this 30-minute tow was 115,785 (13,176 kg.).

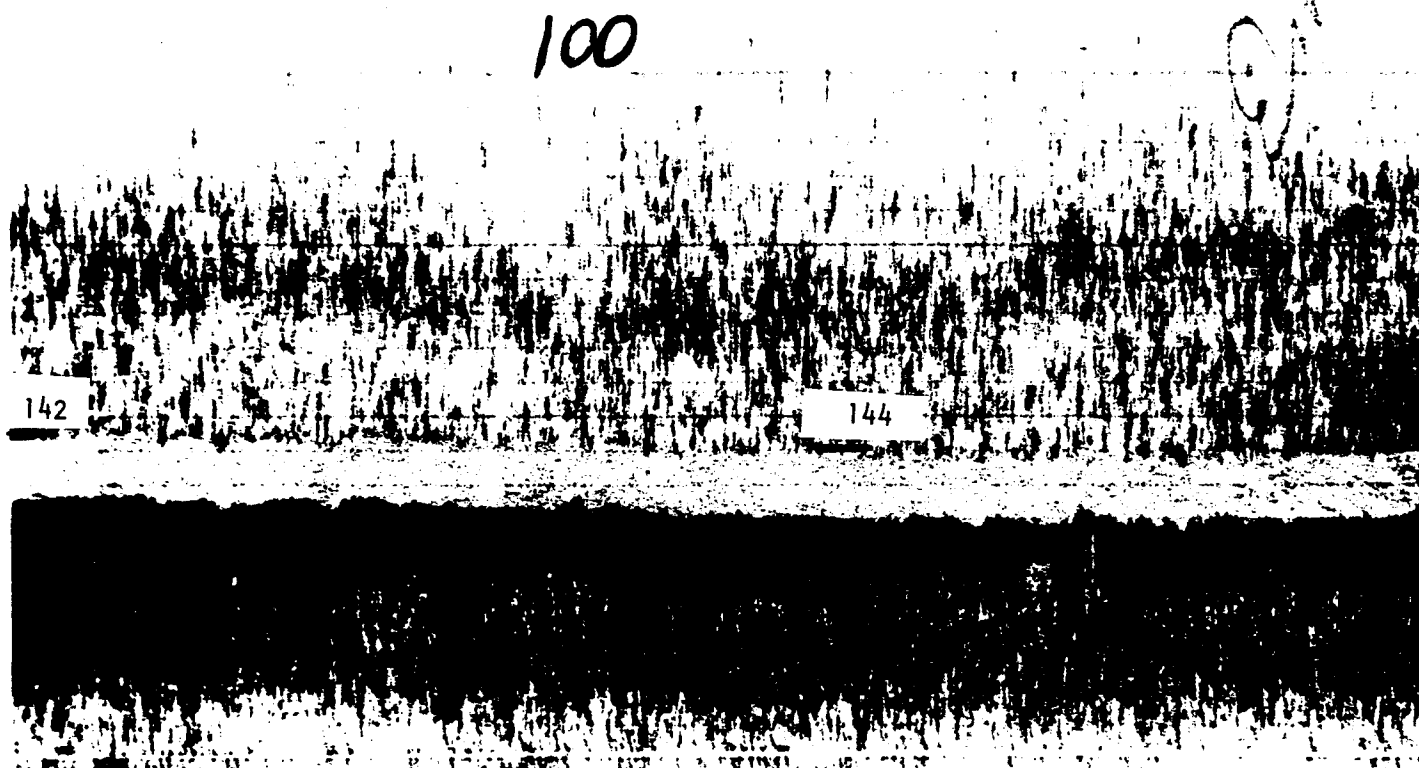


Fig. 8. Echo sounder record of Arctic cod concentration fishery by *Gadus Atlantica* during September 26, 1978 at 59°26'N, 62°45'W at a depth of 142-144 m. Arctic cod catch for this 30-minute tow was 19,320 (1958 kg.).

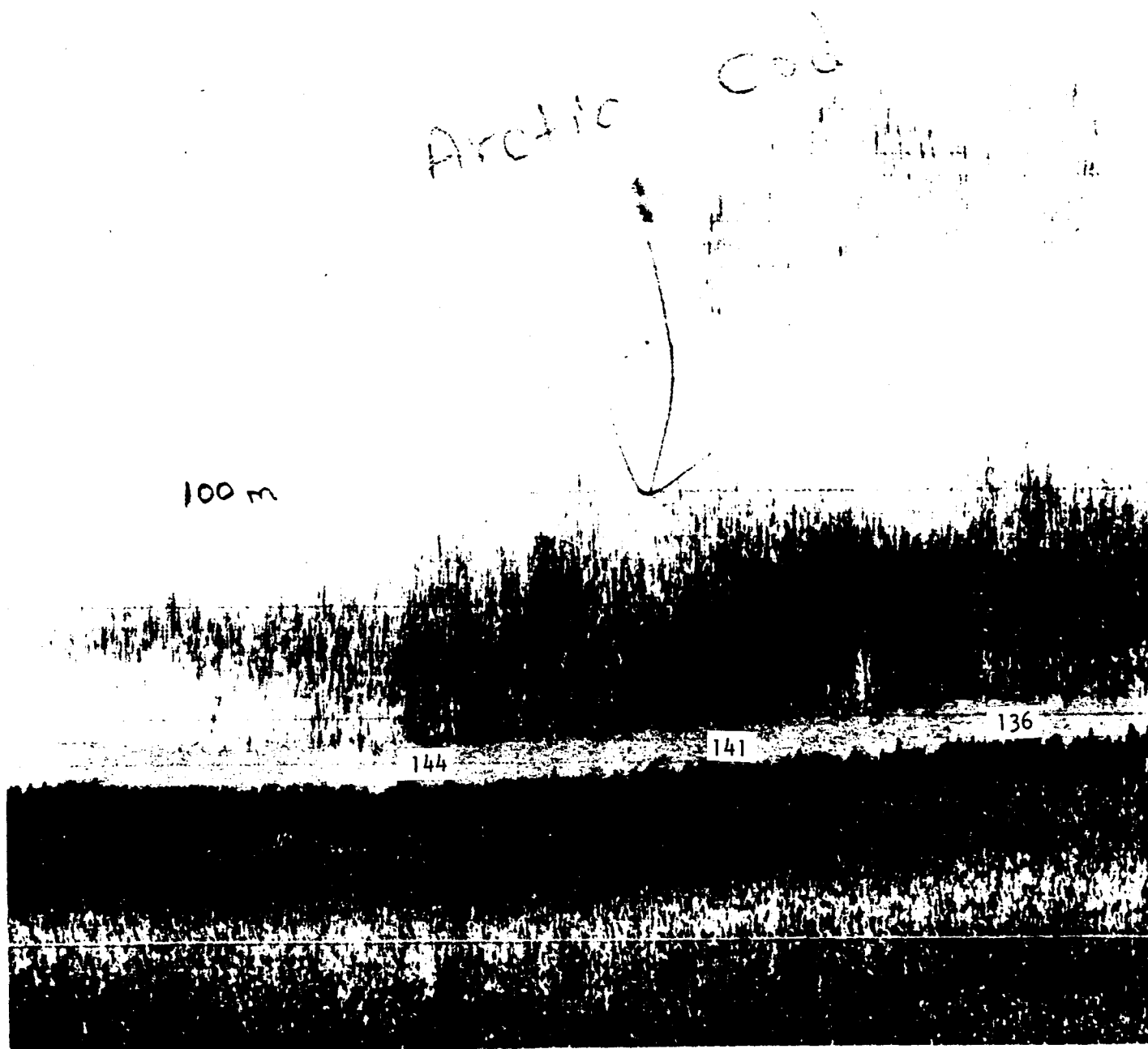


Fig. 9. Echo sounder record of a large concentration of fish (presumably Arctic cod) observed during September 26, 1978 between $59^{\circ}26'N$, $62^{\circ}45'W$ and $59^{\circ}14'N$, $62^{\circ}44'W$ at a depth from 136-144 m.

Before Set # 86
after Set # 85

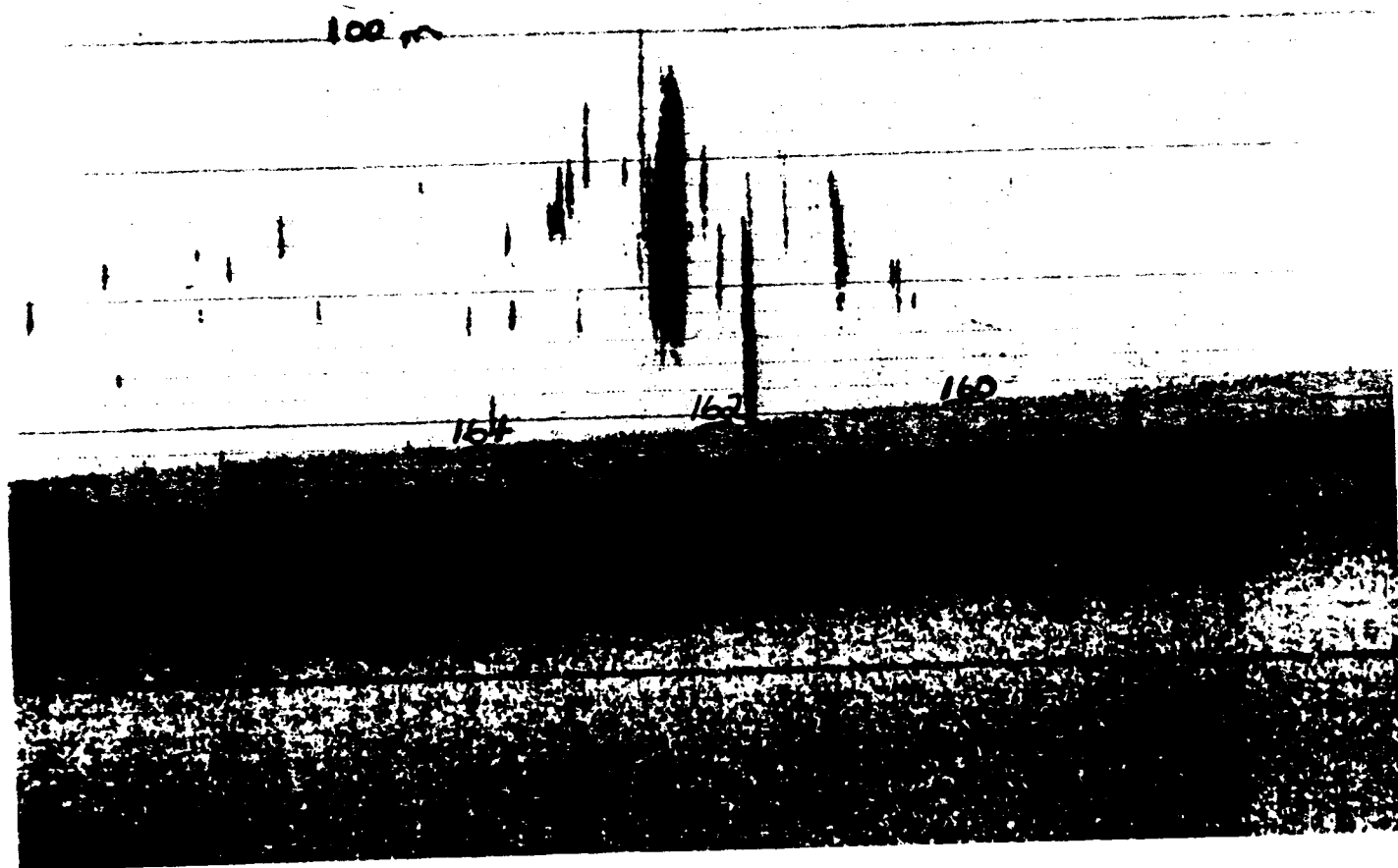


Fig. 10. Echo sounder record of schools of fish (presumably Arctic cod) observed during September 26, 1978 between 60°04'N, 62°10'W and 60°06'N, 62°40'W over a bottom depth of 160-164 m.

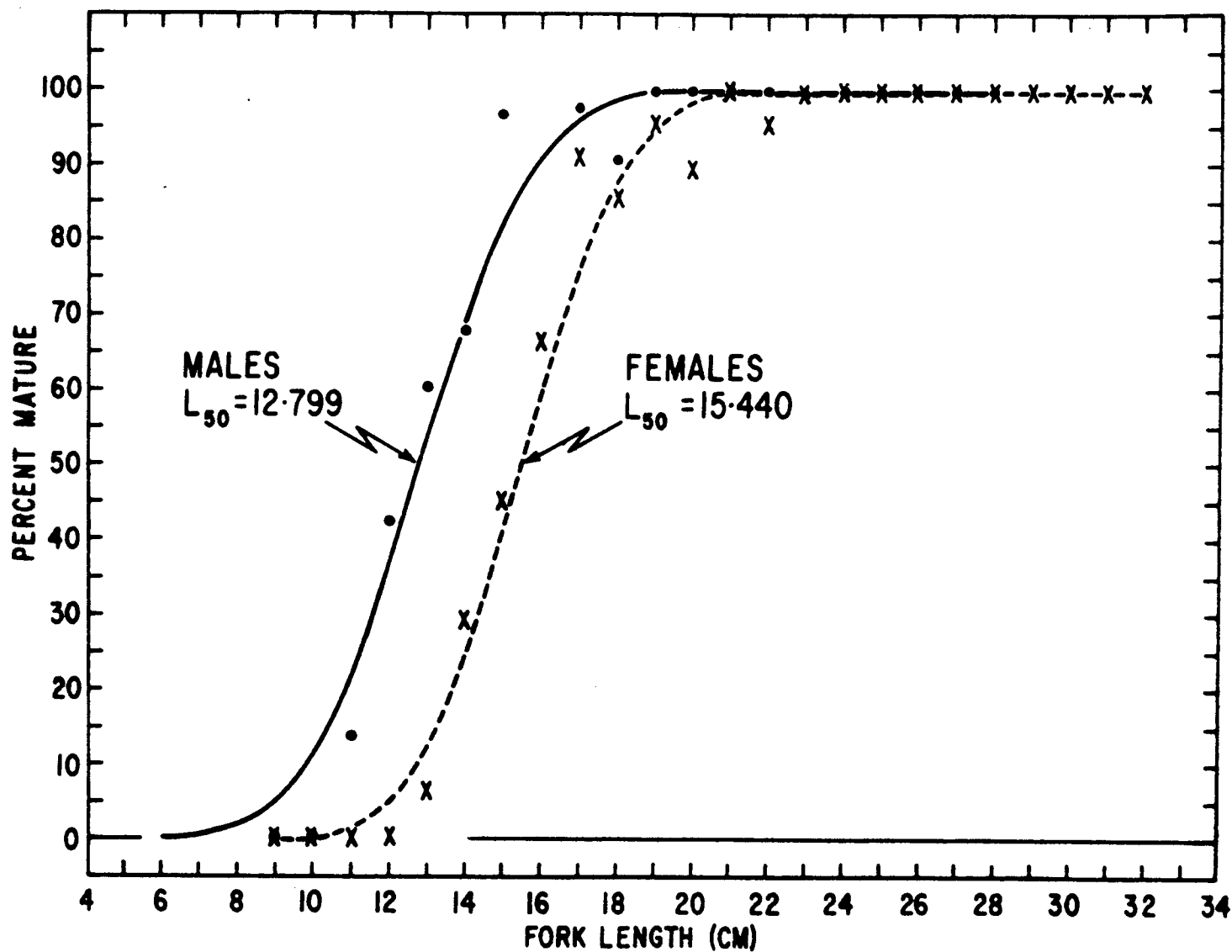


Fig. 11. Maturity ogives of male and female Arctic cod collected from ICNAF Divisions 2G and 2H during September, 1978.



Fig. 12. Gonad of maturing male Arctic cod (ca 25 cm fork length) collected from ICNAF Division 2G during September, 1978.

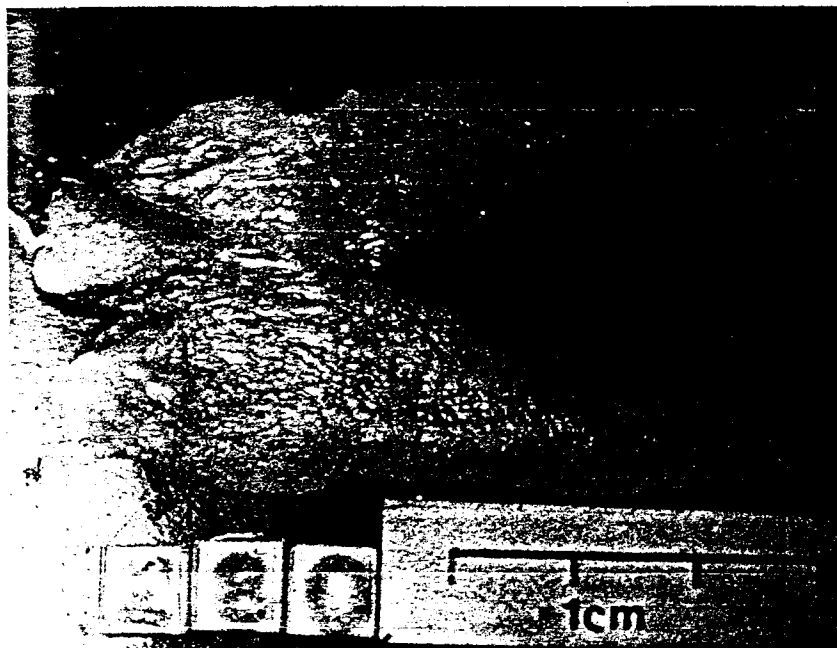


Fig. 13. Gonad of maturing female Arctic cod (28 cm fork length)
collected from ICNAF Division 2G during September, 1978.



Fig. 14. Gonads of maturing female (top) and male (bottom) Arctic cod (both about 25 cm fork length) collected from Division 2G during September, 1978.

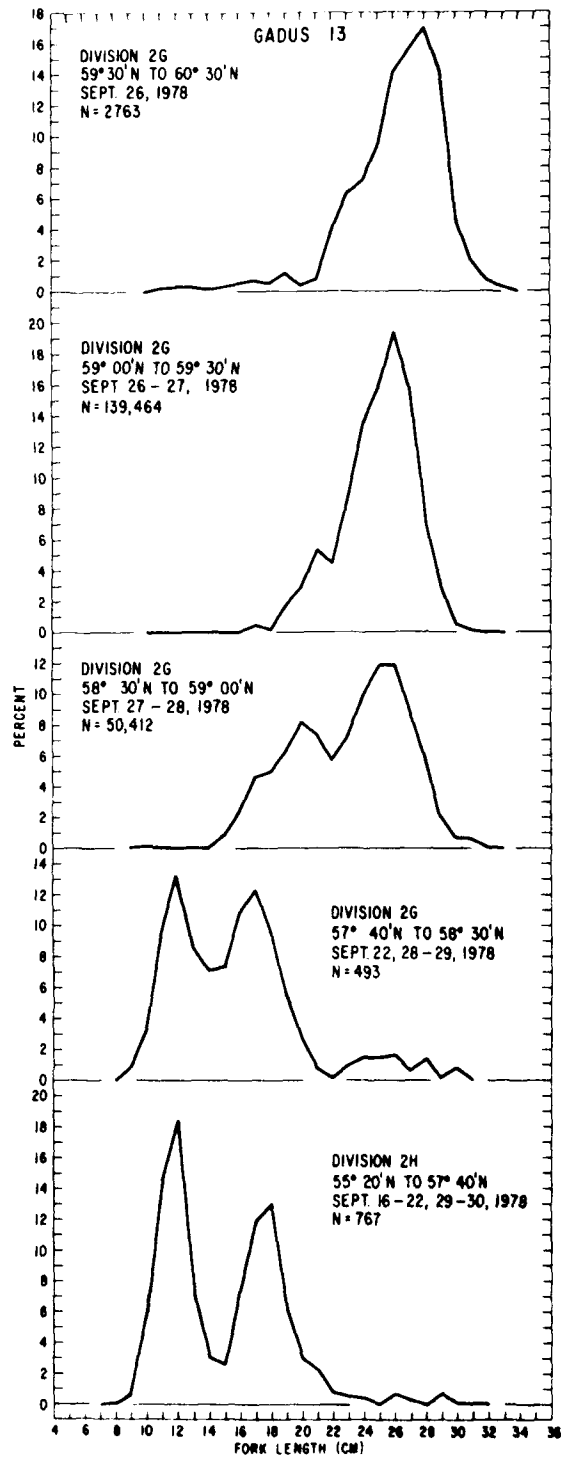


Fig. 15. Fork length distributions (cm) of Arctic cod caught during September 16-29, 1978 in ICNAF Divisions 2G and 2H by the Gadus Atlantica.

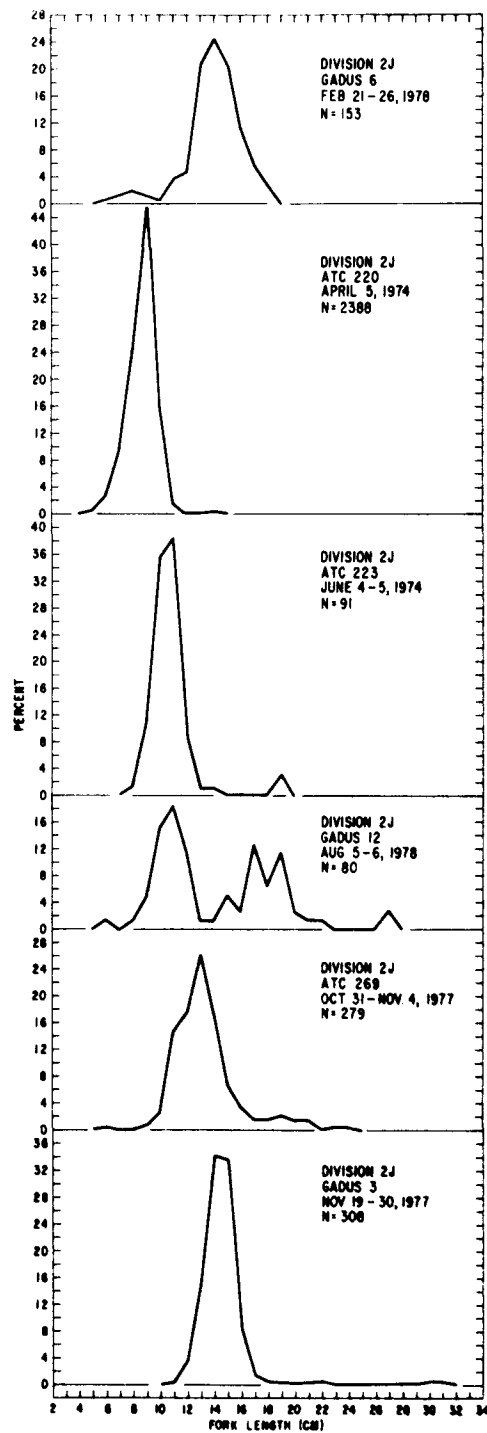


Fig. 16. Fork length distributions (cm) of Arctic cod collected by various research vessels and at various seasonal intervals from ICNAF Division 2J during 1974, 1977-78.

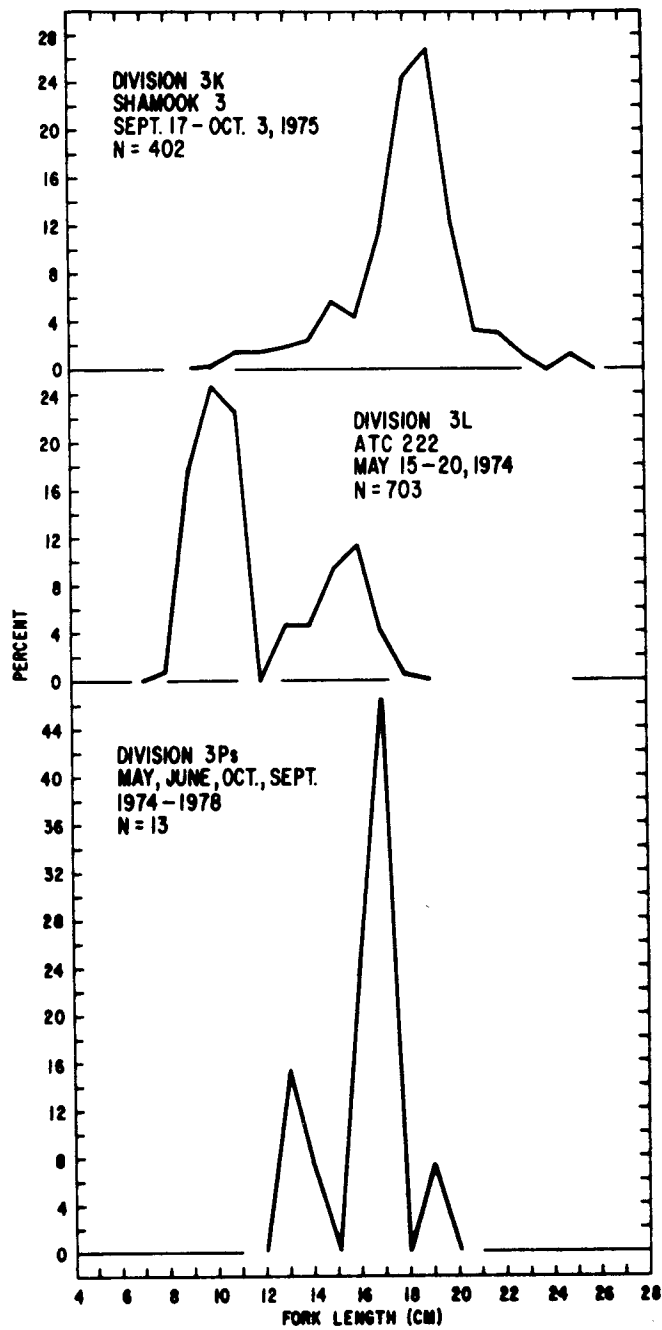


Fig. 17. Fork length distributions of Arctic cod collected from ICNAF Division 3K during September 17-October 3, 1975 from Div. 3L during May 15-20, 1974 and from Division 3Ps during May-October, 1974-78.