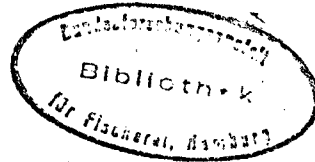


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Distribution and relative abundance of roundnose, roughhead
and common grenadiers in the Northwest Atlantic

by

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INTRODUCTION

Grenadiers, fishes of the family Macrouridae, are deep-water species, most of which dwell on the continental slopes. At least seven species have been reported to occur off the Canadian Atlantic coast. Only three of these - the roundnose (Coryphaenoides rupestris Gunnerus 1765), roughhead (Macrourus berglax Lacépède 1802) and common (Nezumia bairdii Goode and Bean 1877) - are plentiful and only one, the roundnose, is presently being exploited to any extent, chiefly by the USSR.

This paper presents information on research catches of roundnose, roughhead and common grenadiers in the Canadian area of the Northwest Atlantic in relation to area, depth and temperature and also reviews some aspects of the biology of these species. For taxonomic descriptions and distinctions, see Marshall and Iwamoto (1973).

MATERIALS AND METHODS

The information on distribution and relative abundance of the three grenadier species in relation to area, depth and temperature was obtained from the catches of the 168-foot Canadian research vessel A. T. Cameron during 1958-73. Only data from survey otter trawling sets of the A. T. Cameron, using a no. 41-5 Yankee otter trawl (24.1 m headrope), towed usually at $3\frac{1}{2}$ knots for 30 minutes, were used. All survey sets were at positions unselected for abundance of grenadiers. Numbers of successful fishing sets per $\frac{1}{2}$ degree latitude by 1 degree longitude rectangle are given in Figure 1. Fishing sets extended from the shallowest water of the banks to about 400 fathoms (730 metres) on the slopes and very occasionally deeper. Otter trawling on the slopes was generally carried out on a depth contour at predetermined depths in fathoms.

RESULTS

Distribution by areaRoundnose grenadier

Research vessel catches of roundnose grenadiers were restricted to deep water at the seaward edge of the continental shelf. Catches were greatest on the eastern edge of Funk Island Bank (3K), on the edge of Hamilton Inlet Bank (2J) and off the northern third of Labrador (Fig. 2 and 3). Some good catches were obtained in deep water on the western side of Davis Strait (Fig. 4). Only small quantities were obtained in deep water on the edge of the Flemish Cap, Grand Bank and St. Pierre Bank. The species was absent in the Gulf of St. Lawrence; a few specimens were taken in deep water on the seaward slope of the Scotian Shelf.

Roughhead grenadier

The roughhead grenadier appears to be somewhat more widely dispersed than the roundnose. Greatest catches of roughheads were obtained along the eastern edge of the Grand Bank (3L and 3N) where maximum catches of 343 to 544 kg per 30-minute tow were obtained (Fig. 5 and 6). Good catches were also obtained off northern Labrador and Baffin Island where maximum catches of 69-94 and 296 kg per 30 minute set were obtained. Catches in the area from Hamilton Bank to Funk Island Bank (maximum catches of 30-60 kg per 30-minute set) were intermediate between those to the south and the north. Moderate catches of roughhead grenadiers were obtained on the northeast Newfoundland Shelf in the Funk Island Bank and Deep areas, but the species was absent on the shallower portions of the Grand Bank, in 3P, in the Gulf of St. Lawrence and on the Scotian Shelf, with only a few specimens taken on the seaward slope of the Scotian Shelf. Maximum catches of roughhead grenadiers in $\frac{1}{2}$ degree latitude by 1 degree longitude rectangles where they were most abundant were considerably less than the maximum catches of roundnose grenadiers in areas where they were most abundant.

Common grenadier

The common grenadier was encountered in research vessel catches from northern Labrador to the southern Scotian Shelf (Fig. 7). The species was absent on the shallower portion of the Grand Bank, St. Pierre Bank and the Scotian Shelf, but unlike the roundnose and roughhead, was taken in deeper water of the Gulf of St. Lawrence. Catches of this species have been small in all areas fished, generally less than 5 kg per 30-minute set. Largest catches were obtained on the southwestern edge of the Grand Bank where, in one $\frac{1}{2}$ degree latitude by 1 degree longitude rectangle, an average catch of 36 kg per 30-minute tow was taken.

Distribution by depth and temperatureRoundnose grenadier

Very few roundnose grenadiers were caught at depths less than 200 fathoms (366 metres). In the area of greatest abundance (2G to 3K), the largest catches were generally obtained at depths greater than 275 fathoms (503 metres). Similarly, very few roundnose grenadiers were caught at bottom temperatures of less than

3.5°C. The temperature range in areas where they were encountered in quantity was very narrow - generally 3.5 to 4.5°C. However, the species was taken in only very small quantities in deep water on the seaward slopes of the Grand Bank and Flemish Cap at bottom temperatures of 3.1 to 4°C and generally absent on the seaward slopes of St. Pierre Bank and the Scotian Shelf and in the Gulf of St. Lawrence where average bottom temperatures at depths greater than 200 fathoms (366 metres) were slightly higher - 4.2 to 5.2 °C.

Roughhead grenadier

Roughhead grenadiers were caught at depths as shallow as 100 fathoms (183 metres) to the greatest depths fished (Table 2). Off northern Labrador (2Ii) greatest catches (> 15 kg per 30-minute tow) were obtained at depths of 100 to 250 fathoms (183 to 457 metres); in 2J-3K catches of approximately similar magnitude (10-20 kg) were taken at depths from 175 to 425 fathoms (320 to 775 metres). In 3L and 3N, the area of apparent greatest abundance of roughhead grenadiers, maximum catch rates were obtained at 175 to 275 fathoms (320 to 503 metres) but there was very little difference in catch rates at depths from 150 to 400 fathoms (274 to 732 metres).

Roughhead grenadiers were caught in quantity (10 kg and more per tow) at average bottom temperatures as low as about 1.0°C and as high as 4.0°C but the greatest catches (in excess of 20 kg per tow) were generally obtained at bottom temperatures of 2.0 to 3.5°C.

Common grenadier

In the area from 2H to 3L and 3M, common grenadiers were taken only infrequently at depths shallower than 200 fathoms (366 metres) but they occurred somewhat shallower in the area from the southwestern Grand Bank to the Scotian Shelf with moderate quantities being taken as shallow as 125 fathoms (229 metres) (Table 3). In almost all areas fished the species was caught at depths down to 425 fathoms (775 metres). Greatest catches on the southwestern Grand Bank were obtained at depths of 275 to 425 fathoms (503 to 775 metres).

This species was generally taken at bottom temperatures ranging from 3.0 to 5.0°C, with greatest catches (> 3 kg per tow) at temperatures of 3.0 to 4.0°C.

Fish size by depth and area

Roundnose grenadier

Average weights of roundnose grenadiers taken by otter trawl ranged from 0.04 to 1.7 kg (Table 4). In the areas of greatest abundance (2G and 3K) there was no apparent relationship between average weight of fish caught and depth. In 3K the largest fish (0.9 to 1.7 kg) were caught at the shallower depths (150 to 250 fathoms; 274 to 457 metres) and the smallest fish (0.2 to 0.4 kg) in deeper water (350 to 425 fathoms; 640 to 775 metres).

There were considerable area differences in average weight of fish caught with relatively small fish being taken in 3L, 3M, 3N and 3Ø where average weights, with one exception were less than 0.2 kg.

Roughhead grenadier

Average weights of roughhead grenadiers taken by otter trawl ranged from 0.1 to 2.3 kg

but were generally between 0.5 and 1.1 kg (Table 5). In Division 3N, the area of greatest abundance, the larger fish were shallower than the smaller fish. At depths less than 250 fathoms (457 metres) the average weight of fish caught was in excess of 1.0 kg with the largest fish (1.4 to 1.9 kg) at depths of less than 125 fathoms (229 metres). At depths greater than 250 fathoms (457 metres) the average weight was less than 1.0 kg with relatively small fish (0.5 to 0.7 kg) taken at depths greater than 300 fathoms (549 metres).

Common grenadier

The common grenadiers caught were small, with average weights generally ranging from 0.04 to 0.2 kg (Table 6).

There was an apparent geographic size difference. Off Labrador and Northeast Newfoundland, the average weight of fish caught was around 0.2 kg, whereas on the eastern Grand Bank and Flemish Cap it was generally 0.1 kg; from the southwestern Grand Bank west to the Gulf of St. Lawrence and south to the Scotian Shelf it was generally less than 0.1 kg, with the smallest fish (about 0.05 kg), on the average, being taken on the Scotian Shelf (4VWX).

DISCUSSION AND CONCLUSIONS

Distribution

Roundnose grenadier

The roundnose grenadier occurs on both sides of the Atlantic and has been taken at depths down to 1200 fathoms (2200 metres). It is distributed from about 37°N to Baffin Island and is also found off Greenland, Iceland and the Murman coast south to the Skaggerak and Irish Sea (Savvatimskii 1969). Research catches reported here indicate that the centre of abundance in the Canadian area of the Northwest Atlantic occurs off northeast Newfoundland and Labrador. This species is restricted to deep water at the edge of the continental shelf at depths greater than 200 fathoms (366 metres). Largest research catches were obtained at depths greater than 275 fathoms (503 metres). This species was not taken in quantity at bottom temperatures less than 3.5°C.

USSR investigations have shown that the roundnose occurs in commercial concentrations on the edge of the northeast Newfoundland Shelf at depths from 250 to 550 fathoms (457 to 1006 metres) and deeper (Savvatimskii 1969; Pechenik and Troyanovskii 1970). According to Savvatimskii (1971), at present only feeding concentrations of immature grenadiers are exploited, these being found at shallower depths than the adult fish. Stanek (1971) reports that the roundnose or rock grenadier is the dominant species in commercial grenadier catches, with yields at the inception of commercial exploitation of up to 10 tons per hour of trawling. The proportion of roundnose grenadier in the catches increases with depth; at a depth of 800 metres it is the only grenadier species caught (Stanek 1971). ICNAF statistics since 1967 indicate that, with the exception of 1971, more than 80% of the roundnose grenadier catch has been taken in Division 3K. In 1971, 72% of the catch was taken in 2G. Our catch records suggest that the greatest concentrations of roundnose grenadier occur during the second half of the year but we have not fished this area to any great extent during the January-March period. An examination of monthly catch records for Division 3K during 1972-73 shows that 83% of the catches were taken during the June-October period. According to Savvatimskii (1969) the roundnose grenadier is encountered in commercial concentrations during the autumn.

Farther to the south, exploratory deep-sea otter trawling by the Woods Hole Oceanographic Institution vessel Caryn in 1952 and 1953 yielded catches of 220 to 535 roundnose grenadiers per haul (one-half hour to one hour duration) at depths of 300 to 550 fathoms (549 to 1006 metres) off the southeastern edge of the Nova Scotian Shelf, extending from longitude 63°16' W to 65°39' W (Schroeder 1955). The shoalest capture of this species was in the 201 to 250 fathoms (386 to 457 metres) zone and the deepest around 700 fathoms (1280 metres). Markle and Musick (1974) report the capture of Coryphaenoides rupestris at depths of 800-950 metres in the middle Atlantic Bight (approximately 39°30' to 39°50' N) but Nezumia spp. (particularly Nezumi bairdii) were the dominant grenadiers in terms of numbers.

Roughhead grenadier

The roughhead grenadier has been reported to occur in deep water on both sides of the North Atlantic, along the continental slope of North America south to Georges Bank, in Davis Strait, off southern Greenland, Iceland, Spitzbergen and northern Norway (Savvatimskii 1969).

Research surveys indicate that the roughhead is more widely dispersed than the roundnose and, although also a deep-water species, occurs in greatest numbers at somewhat shallower depths (100 to 275 fathoms; 183 to 503 metres) than the roundnose. Largest catches of roughhead grenadiers were taken during July to September along the eastern and northern edge of the Grand Bank (3L and 3N), but even there average catch rates were considerably less than the average catches of roundnose grenadier obtained in their area of greatest abundance off northeast Newfoundland and Labrador. Greatest catches of roughheads have been generally taken at bottom temperatures between 2.0 and 3.5°C, as contrasted with roundnose grenadiers, very few of which were caught at bottom temperatures of less than 3.5°C. Marshall and Iwamoto (1973), citing Andriashev (1964) note that Macrourus berglax is more of a cold water form than Coryphaenoides rupestris occurring in the Norwegian and Barents seas at temperatures close to 0°C, but has yet to be found in waters below 0°C.

Common grenadier

Greatest catches of this species were obtained on the southwestern edge of the Grand Bank at bottom temperatures of 3.0 to 4.0°C. Unlike the roundnose and roughhead, it is present in the Gulf of St. Lawrence. Average catches per set have been very small in comparison with those for the other two species.

Size, age, food and migrations

Because relatively little is known of the biology and life history of the roughhead and common grenadiers, the following comments pertain only to the roundnose.

The commercial fishery for roundnose grenadiers off northeast Newfoundland-Labrador has been reported to be based on 9- to 14-year-old fish, 60-70 cm in length and 0.36 to 0.75 kg in weight (Savvatimskii 1972). The females grow somewhat more rapidly than the males in length as well as weight. The roundnose is apparently long-lived and attains sexual maturity relatively late. The fishery in the Northwest Atlantic is based on feeding concentrations of sexually immature fish. Roundnose grenadiers are primarily bathypelagic feeders, as contrasted with roughhead grenadiers which are primarily bottom feeders (Konstantinov and Pondrazhanskaya 1972). Euphausiids and copepods, squid and such fish species as lanternfish and redfish are prominent in the diet of the roundnose. Polychaetes, Ophiura and crabs in the diet of the roughhead.

Knowledge of stock relationships and migrations of roundnose grenadiers is scanty.

USSR scientists have proposed conflicting hypotheses on the extent of migrations exhibited by the roundnose. Zakharov and Mokuau (1970) suggested that the roundnose grenadier spawns in Iceland waters, the eggs and larvae are transported passively by the currents around West Greenland to Baffin Island and thence by the Labrador Current to the Northeast Newfoundland Shelf where the young settle to bottom at depths of 330 to 500 fathoms (603 to 914 metres); as the fish grow larger, they migrate back to the Icelandic spawning areas. More recently, this hypothesis has been discounted by Savvatinskii (1972), who, from a consideration of external body structure, considers the roundnose grenadier to be a poor swimmer. It appears more likely that concentrations of sexually mature grenadiers in the Northwest Atlantic occur at depths greater than those normally fished commercially. This has been confirmed by capture during exploratory fishing of large sexually mature fish at depths of about 1470-1520 metres off central Labrador and of spawning and post-spawning fish at depths of 850 to 1270 metres off Nova Scotia (Savvatinskii 1972). The percentage of mature fish increases with depth.

Information about time of spawning is very sparse. It has been suggested (Grigorev 1972) that spawning is non-intermittent and occurs year round. According to Grigorev (1972), juvenile roundnose grenadiers, approximately 8 cm long, are encountered along the continental slope of North America from the Grand Bank to Cumberland Peninsula, also along West Greenland and south of Iceland. In research catches by the A. T. Cameron, roundnose grenadiers taken in 3L, 3M, 3N and 3Ø generally had average weights of less than 0.2 kg and, in some instances, as little as 0.04 to 0.05 kg. It seems reasonable to assume that juveniles caught on the continental slope off Newfoundland, Labrador and West Greenland have a local origin with spawning occurring in these regions at depths greater than 1000 metres - at the bottom or in the bathypelagic zone. Marshall and Iwamoto (1973) suggest that both Coryphaenoides rupestris and Nezumia bairdii are summer-autumn spawners.

Marshall (1965) suggests that the movements of grenadiers along the continental slope do not exceed a hundred miles while such movements are even less across the continental slope.

There is evidence that the roundnose grenadier, a bathypelagic feeder, undertakes diurnal vertical migrations (Savvatinskii 1969). Haedrich (1974) reports the capture of forty-nine specimens of Coryphaenoides rupestris (7-94 cm in length) during mid-water trawling by the German research vessel Walter Herwig off Iceland. These specimens were caught in seven midwater hauls, both day and night, 270-1440 metres off the bottom at depths between 1000 and 2100 metres. Modal distance off the bottom was about 480 metres. Haedrich (1974) concluded from these captures, and recent studies showing that Coryphaenoides feed largely on pelagic animals, that slope dwelling members of this genus normally move off the bottom and feed in midwater.

Resource potential

Fishes of the family Macrouridae are dominant, both in biomass and numbers, on the continental slopes and abyssal plains of many regions of the world (Grey 1956; Marshall 1965; Kort 1967; Iwamoto 1970; Percy and Ambler 1974). In all, about 300 species of grenadiers have been described, of which approximately 65 species occur in the Atlantic (Marshall and Iwamoto 1973), half of which occur in the Gulf of Mexico and the Caribbean Sea. Only the three species discussed here are commonly taken in trawl catches on the continental slopes off the Canadian Atlantic coast.

Of these, only the roundnose grenadier has been caught in commercial quantities and it has been subjected to exploitation since about 1967. Catches fluctuated between 13,000 and 32,000 metric tons from 1967 to 1973, except for 1971 when 75,000 metric tons were caught (Fig. 8). Estimates of 24,000 and 37,000 metric tons have been recently derived as preliminary lower and upper limits of maximum sustainable yield for roundnose grenadiers in ICNAF Subareas 2 and 3 (Pinhorn 1974). To date, the fishery has apparently only exploited concentrations of immature fish and these are apparently fully exploited at the present time. However, these estimates of maximum sustainable yield probably represent the potential of only the immature portion of the stock. The potential of the total stock may be substantially higher if the fishery were extended to mature fish at greater depths.

The roughhead grenadier probably occurs in limited numbers in commercial grenadier catches off northeast Newfoundland and Labrador but the proportion of roughheads in these grenadier catches is probably small. From its depth distribution, which overlaps that of redfish, it appears likely that roughheads are taken frequently as a by-catch in the redfish fishery in Divisions 3L-N.

Because of its limited biomass and small size (generally 0.1-0.2 kg) the common grenadier is unsuitable for commercial exploitation.

Moiseev (1973) gives the 1970 world catch of Macrurids as about 300,000 metric tons and estimates a worldwide potential catch of about one million metric tons, a large proportion of this from the southern Hemisphere, Suda (1973) estimates the potential catch of Macrurids and morids in the northern hemisphere as about 150,000 metric tons. Gulland (1970) estimates a potential catch of 100,000 metric tons of macrurids from the northeast Pacific.

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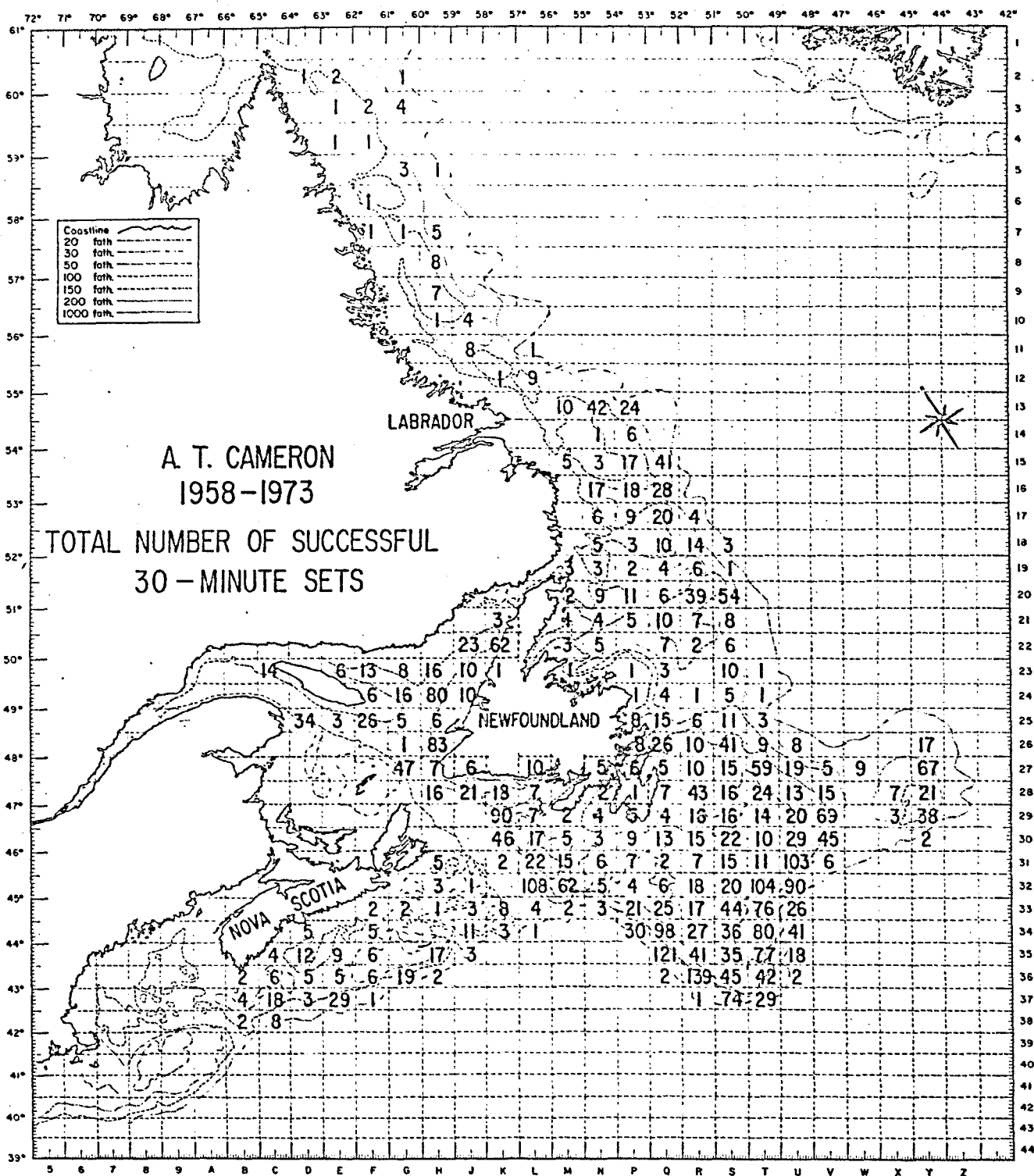


Fig. 1. Number of successful survey otter-trawling sets (No. 41-5 otter trawl) of the research vessel A. T. Cameron in various rectangles, 1958-73.

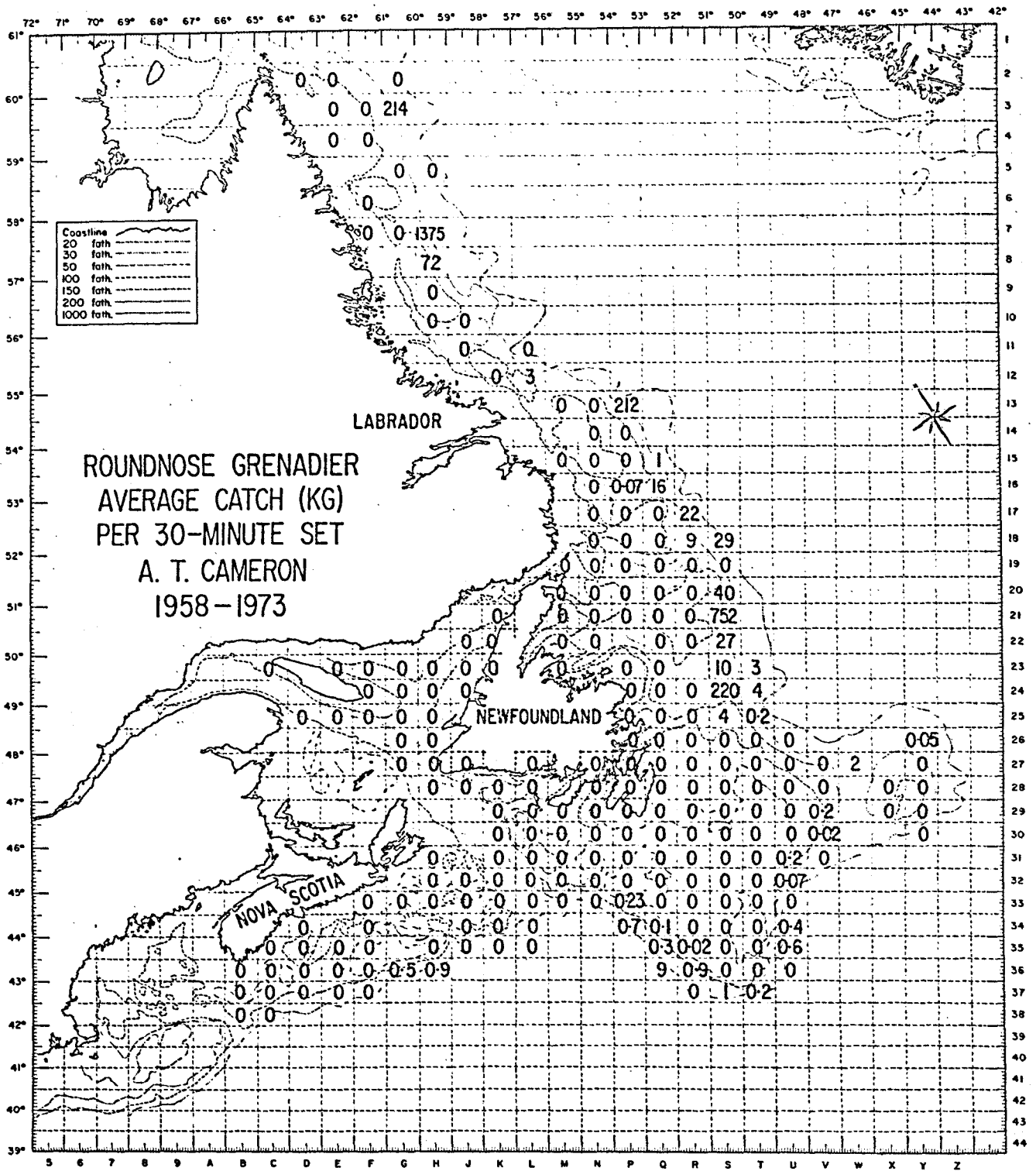


Fig. 2. Average catch of roundnose grenadier, kg whole weight, by $\frac{1}{2}$ degree latitude, 1 degree longitude rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron during 1958-73.

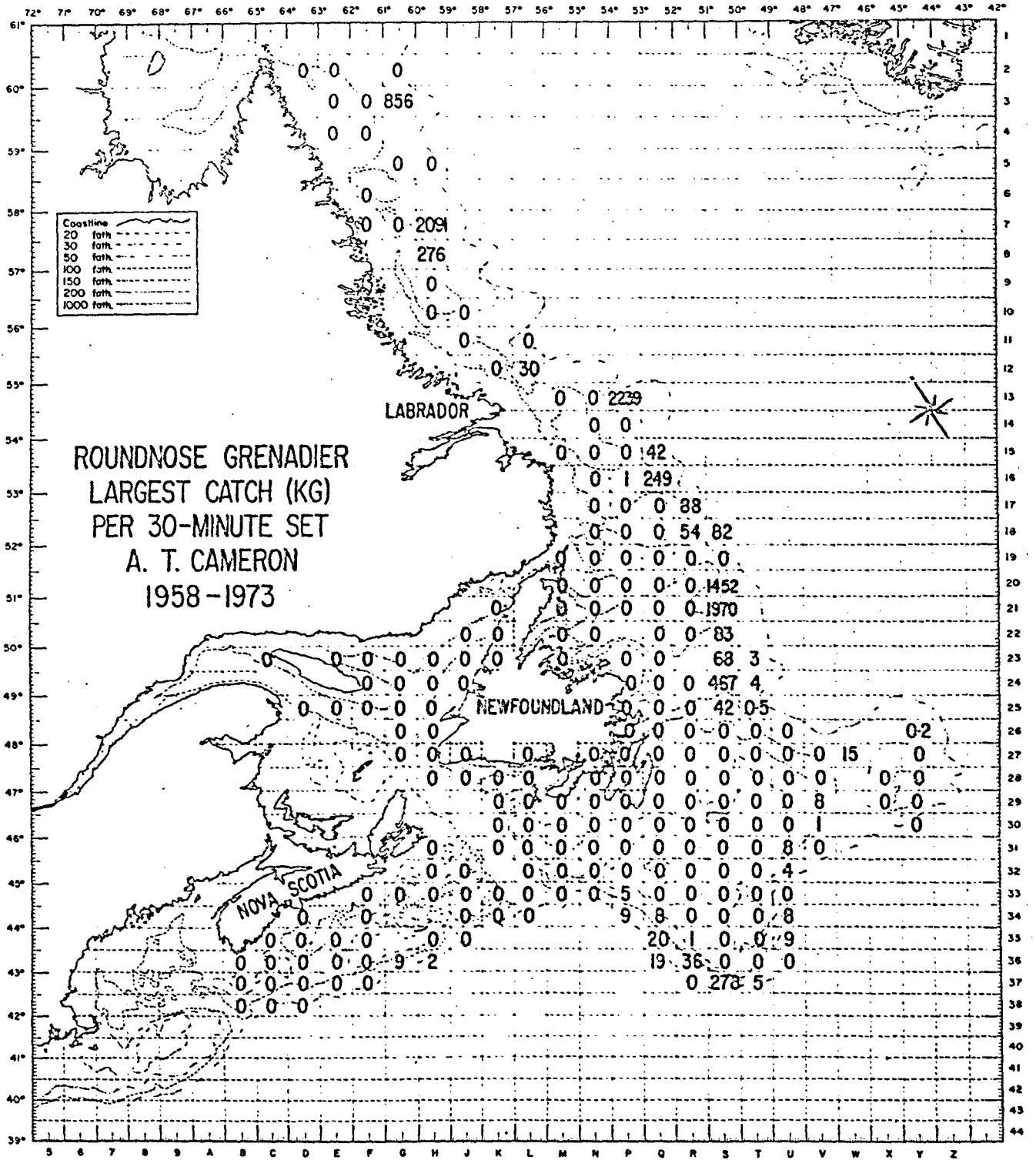


Fig. 3. Largest catch of roundnose grenadier, kg whole weight, by 1/2 degree latitude, 1 degree longitude rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron during 1958-63.

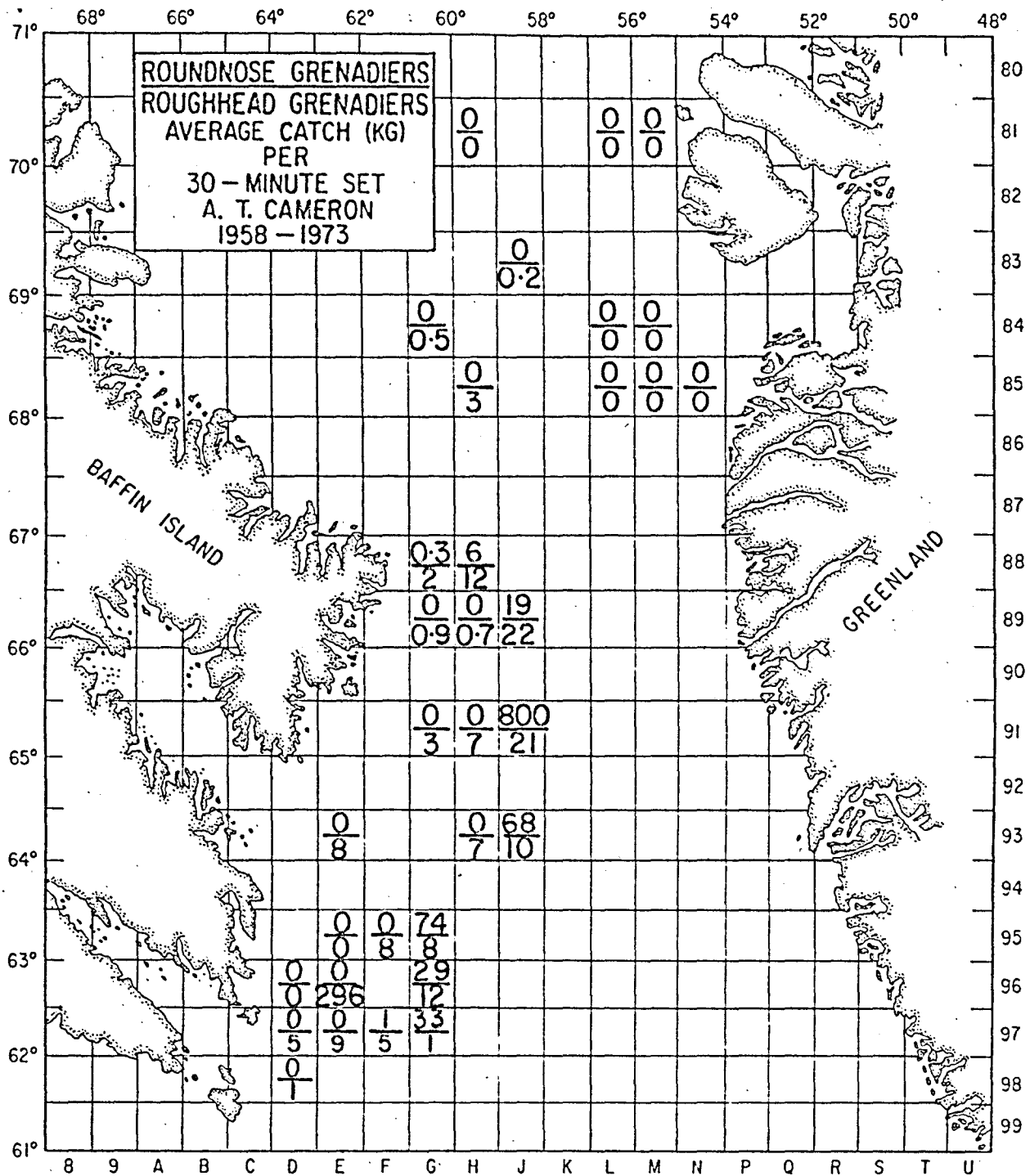


Fig. 4. Average catches of roundnose and roughhead grenadiers, kg whole weight, by $\frac{1}{2}$ degree latitude, 1 degree longitude rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron in the Baffin Island-Greenland area.

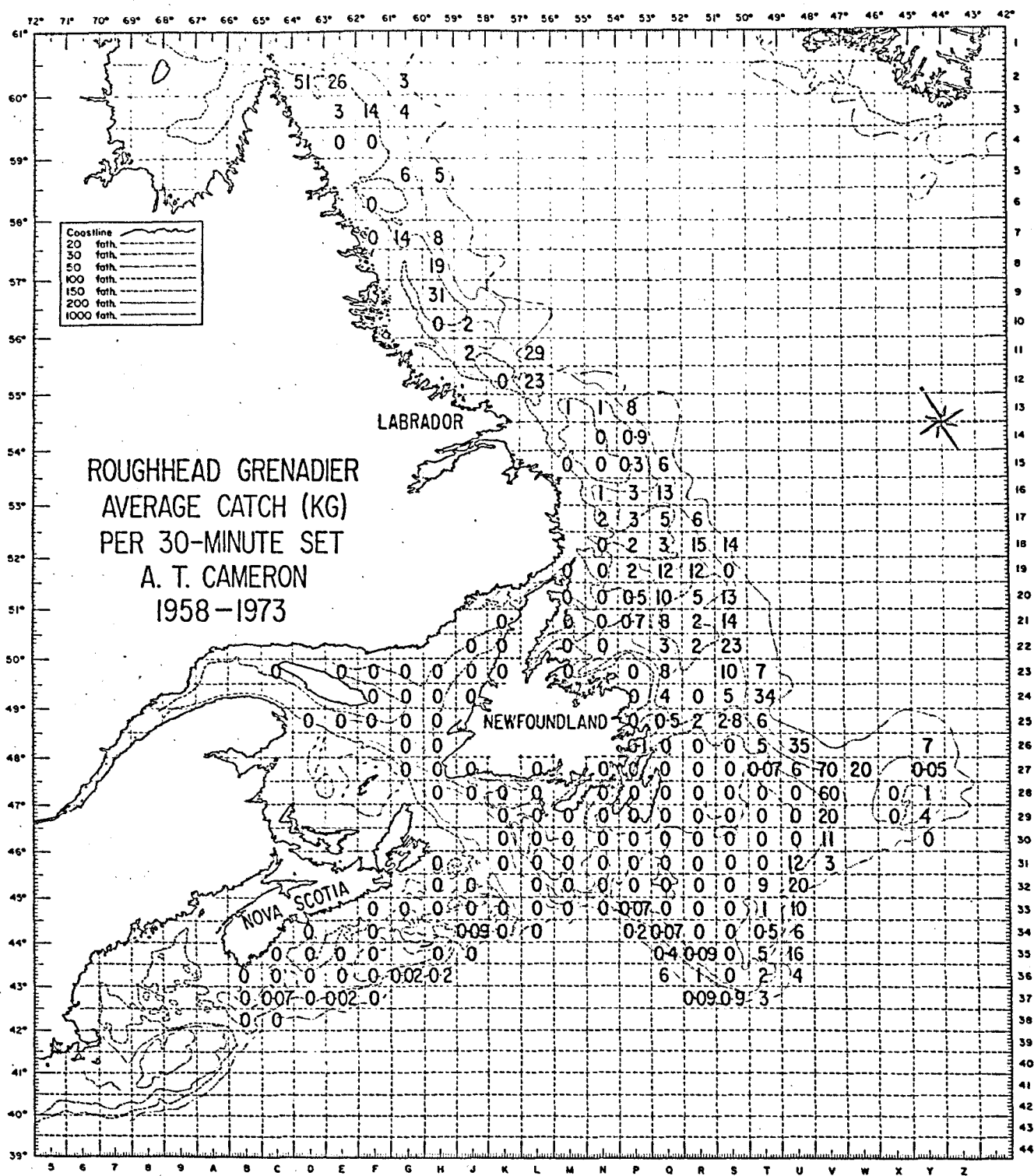


Fig. 5. Average catch of roughhead grenadier, kg whole weight, by $\frac{1}{2}$ degree latitude, 1 degree longitude rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron during 1958-73.

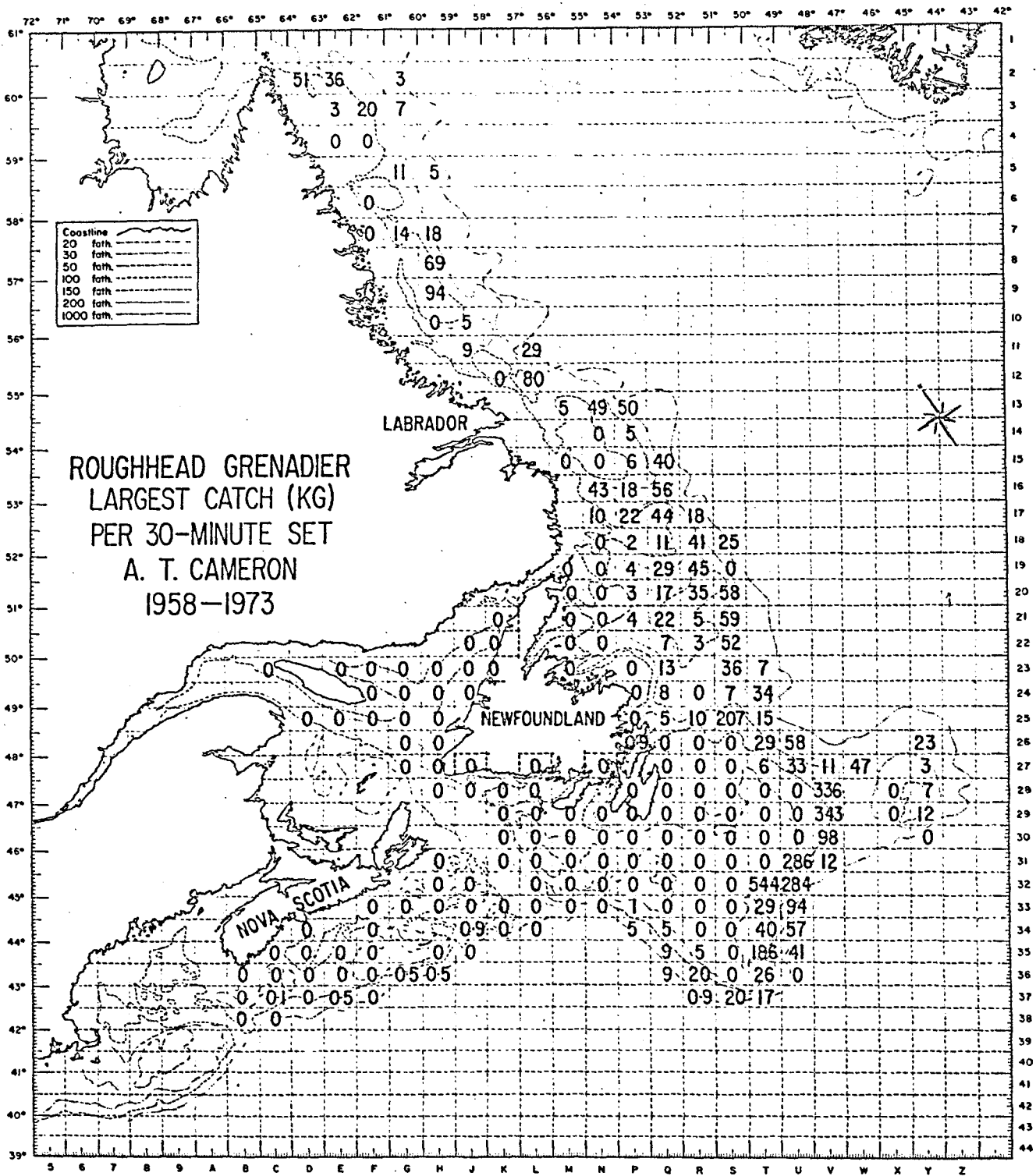


Fig. 6. Largest catch of roughhead grenadier, kg whole weight, by 1/2 degree latitude, 1 degree longitude of rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron during 1958-73.

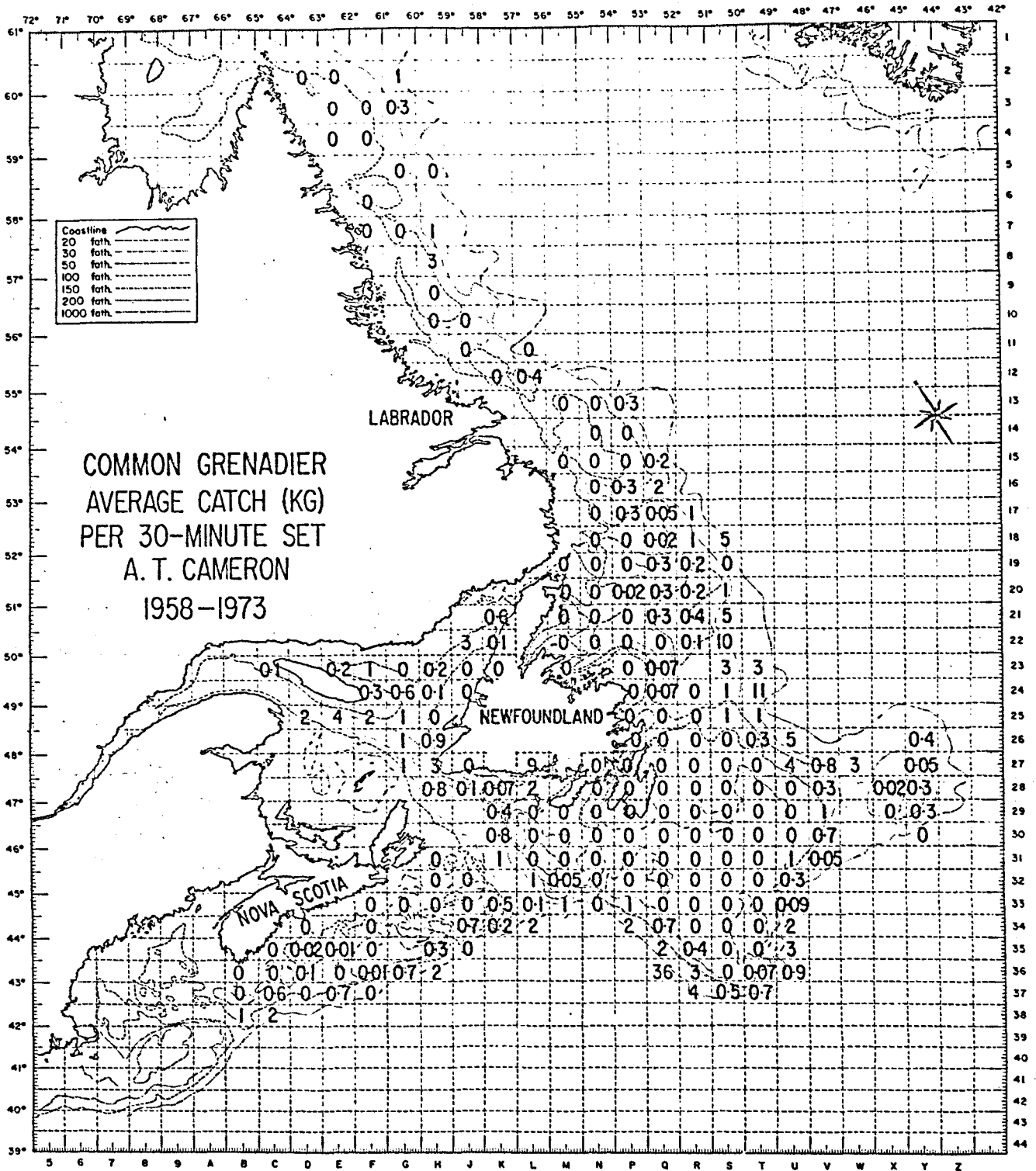


Fig. 7. Average catch of common grenadier, kg whole weight, by 1/2 degree latitude, 1 degree longitude rectangle per 30-minute on bottom otter-trawling set of the A. T. Cameron during 1958-73.

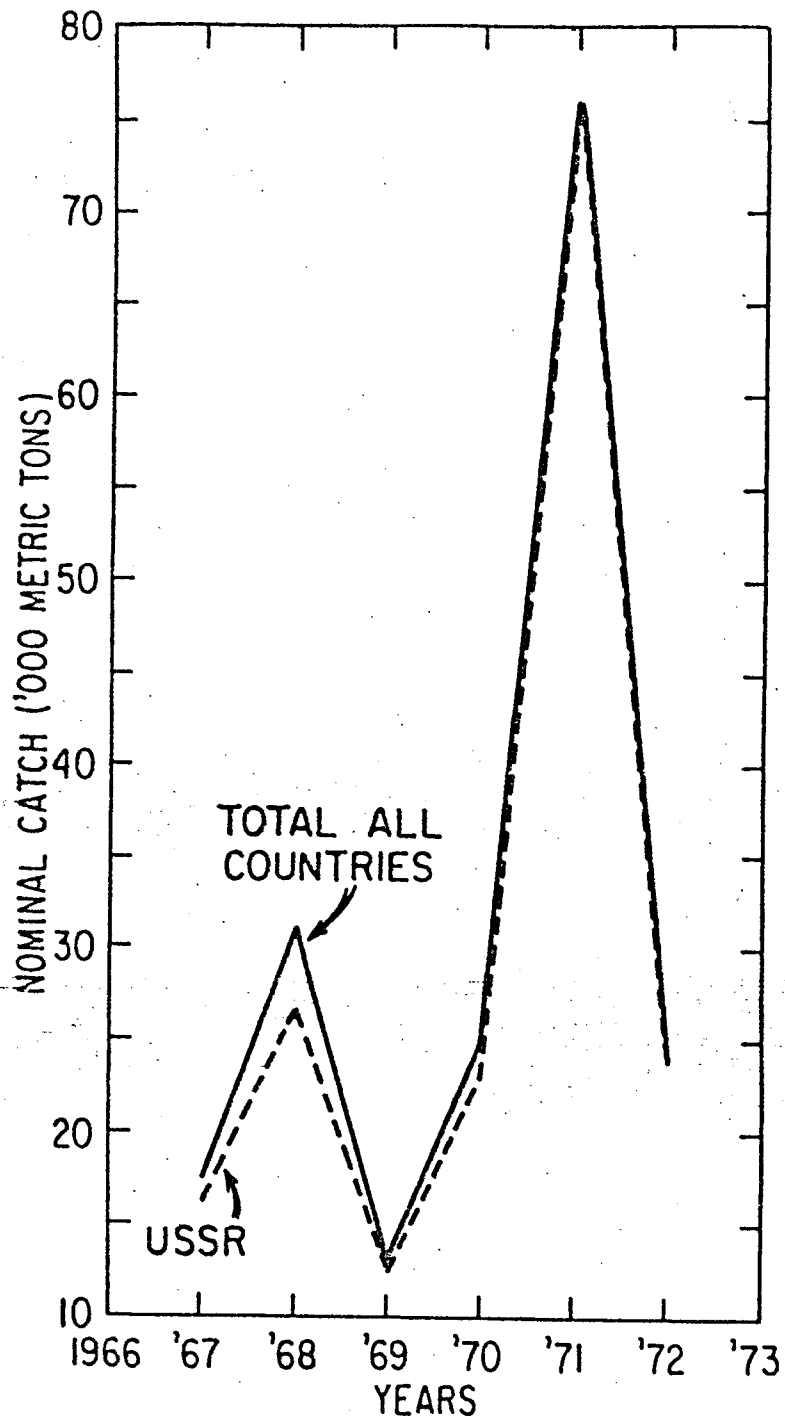


Fig. 8. Nominal catches of roundnose grenadiers from ICNAF Subareas 2 and 3. Note: Catches of this species were first recorded in ICNAF statistics for 1967 although quantities were probably taken before then and included under unspecified groundfish.

Table 1. Average weight (kg) of roundnose grenadier catches per successful 30-minute trawl set in relation to depth and bottom temperature by ICNAF Division (2G-4X), based on A. T. Cameron catches during 1958-73 (number of sets in parentheses).

Depth Fathoms (Metres)	Area O		Subarea I		2G		2H		2J		3K		3L		3M		3N		3O		3P		4RST		4VWX				
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	
0-25 (0-47)			0(2)	4.9													0(36)	2.5			0(14)	1.7	0(8)	1.3	0(2)	6.3			
26-50 (48-92)			0(1)	1.7									0(127)	0.1			0(362)	1.2	0(138)	1.7	0(74)	1.0	0(21)	0.9	0(13)	3.4			
51-75 (93-138)			0(2)	-0.3	0(1)	-0.3	0(3)	0.8	0(1)	-0.2	0(3)	-0.4	0(102)	-0.5			0(86)	0.6	0(72)	3.7	0(66)	0.8	0(25)	1.0	0(40)	4.3			
76-100 (139-184)			0(1)	2.4	0(5)	0.4	0(11)	0.7	0(17)	0.8	0(9)	-0.4	0(120)	0.0	0(11)	3.8	0(88)	0.9	0(80)	4.4	0(72)	2.6	0(65)	2.4	0(37)	5.2			
101-125 (185-229)	0(2)	-0.9	0(1)	3.0	0(5)	2.0	0(7)	0.5	0(35)	1.7	0(24)	1.3	0(74)	0.9	0(9)	4.1	0(73)	1.5	0(60)	4.3	0(78)	4.5	0(82)	3.6	0(23)	6.0			
126-150 (230-275)	0(1)	-1.1	0(2)	0.8	0(6)	3.5	0(4)	1.2	0(51)	2.6	0(37)	2.1	0(33)	1.4	0(12)	4.2	0(40)	1.8	0(43)	4.2	0(69)	5.0	0(82)	4.4	0(18)	5.5			
151-175 (276-321)	0(5)	0.7			0(1)	3.9	0(5)	2.2	0(39)	3.3	0(55)	3.0	0(33)	2.3	0(64)	4.2	0(32)	2.2	0.1(27)	3.9	0(35)	4.9	0(46)	4.6	0(9)	5.7			
176-200 (322-366)	0(5)	1.3	0(2)	3.2			0(2)	2.0	0(23)	3.6	0.2(27)	3.1	0(19)	3.3	0(8)	4.0	0(14)	2.7	1(9)	3.8	0(22)	4.8	0(39)	4.6	0(10)	5.7			
201-225 (368-412)	0(2)	2.4	0(1)	-	1046(2)	3.9	52(1)	4.3	0(10)	3.6	0(13)	3.3	14(3)	3.4	0(4)	3.9	0(3)	2.9	0(3)	3.4	0(4)	4.9	0(5)	4.9	0(4)	5.2			
226-250 (413-458)	0(1)	1.8	0(3)	2.3	0(1)	4.0	92(3)	3.5	0.4(11)	3.9	30(14)	3.7	0(9)	3.5	0(5)	3.8	0(6)	3.2	2(4)	3.8	0(4)	4.5	0(4)	4.4	0(9)	4.6			
251-275 (459-504)	0(1)	3.9							0.6(4)	3.9	0.7(9)	3.4	0(4)	3.4	0(4)	3.9	0(2)	3.5	3(5)	3.4			0(5)	4.5	0(4)	4.7			
276-300 (505-549)	6(5)	2.1	4(2)	2.3	2756(1)	4.1			60(8)	3.9	131(8)	3.8	0(6)	3.7	0(25)	3.9	0.7(6)	3.4	5(6)	3.7					0(5)	4.4			
301-325 (550-595)	1(1)	4.1	19(1)	1.0	855(1)	4.1	48(2)	4.4	215(7)	3.8	121(6)	4.0	0.2(2)	2.8	0(7)	3.8	0(2)	3.3							0(4)	4.5			
326-350 (596-641)	0(1)	1.0							52(5)	3.7	316(6)	3.8	1(3)	3.7	0(4)	3.7	4(4)	3.7	5(2)	3.8					0(1)				
351-375 (642-685)			0(2)	0.9					1145(1)	4.0	29(3)	3.9	1(3)	3.1			0(1)	3.4	2(2)	3.7					0.1(5)	4.3			
376-400 (686-732)	74(3)	3.0	200(1)	3.5			0(1)	3.5	26(4)	3.5	280(3)	3.7			0(5)	3.7	6(4)	3.6	22(4)	3.9					0(1)	4.3			
401-425 (733-778)			2319(1)	3.4	1114(1)	4.1	184(1)	4.3	25(3)	3.9	32(4)	3.5	8(1)	3.6	0.5(3)	3.5	0(1)	3.5	14(2)	4.1					0(4)	4.3			
426-450 (779-824)									2239(1)	3.7							278(1)	3.8											
451-475 (825-869)																													
476-500 (870-914)																				17(1)						0(1)			

Table 2. Average weight (kg) of roughhead grenadier catches per successful 30-minute trawl set in relation to depth and bottom temperature by ICNAF Division (2G-4X), based on A. T. Cameron catches during 1958-73 (number of sets in parentheses).

Depth Fathoms (Metres)	Area 0		Subarea 1		2G		2H		2J		3K		3L		3M		3N		3O		3P		4RST		4VWX					
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C		
0-25 (0-47)			0(2)	4.9													0(36)	2.5			0(14)	1.7	0(8)	1.3	0(2)	6.3				
26-50 (48-92)			0(1)	1.7									0(127)	0.1			0(362)	1.2	0(138)	1.7	0(74)	1.0	0(21)	0.9	0(13)	3.4				
51-75 (93-138)			0(2)	-0.3	0(1)	-0.3	0.2(3)	0.8	0(1)	-0.2	0(3)	-0.4	0(102)	-0.5			2(86)	0.6	0(72)	3.7	0(66)	0.8	0(25)	1.0	0(40)	4.3				
76-100(139-184)			0(1)	2.4	1(5)	0.4	0.3(11)	0.7	0(17)	0.8	0(9)	-0.4	0(120)	0.0	0(11)	3.8	10(83)	0.9	0(80)	4.4	0(72)	2.6	0(65)	2.4	0(37)	5.2				
101-125(185-229)	0(2)	-0.9	0(1)	3.0	13(5)	2.0	17(7)	0.5	2(35)	1.7	0.1(24)	1.3	1(74)	0.9	0(9)	4.1	22(73)	1.5	0.2(60)	4.3	0(78)	4.5	0(82)	3.6	0(23)	6.0				
126-150(230-275)	0(1)	-1.1	0(2)	0.8	17(6)	3.5	35(4)	1.2	4(51)	2.6	0.9(37)	2.1	2(33)	1.4	0(12)	4.2	14(40)	1.8	1(43)	4.2	0(69)	5.0	0(82)	4.4	0(18)	5.5				
151-175(276-321)	63(5)	0.7			2(1)	3.9	29(5)	2.2	4(39)	3.3	5(55)	3.0	20(33)	2.3	0(64)	4.2	32(32)	2.2	1(27)	3.9	0(35)	4.9	0(46)	4.6	0(9)	5.7				
176-200(322-366)	5(5)	1.3	0(2)	3.2			61(2)	2.0	11(23)	3.6	9(27)	3.1	26(19)	3.3	0.1(8)	4.0	36(14)	2.7	2(9)	3.8	0(22)	4.8	0(39)	4.6	0(10)	5.7				
201-225(368-412)	4(2)	2.4	0(1)	-	3(2)	3.9	23(1)	4.3	14(10)	3.6	15(13)	3.3	28(3)	3.4	3(4)	3.9	17(3)	2.9	4(3)	3.4	0(4)	4.9	0(5)	4.9	0(4)	5.2				
226-250(413-458)	7(1)	1.8	13(3)	2.3	3(1)	4.0	18(3)	3.5	11(11)	3.9	11(14)	3.7	32(9)	3.5	4(5)	3.8	31(6)	3.2	1(4)	3.8	0(4)	4.5	0(4)	4.4	0(9)	4.6				
251-275(459-504)	1(1)	3.9							9(4)	3.9	9(9)	3.4	25(4)	3.4	3(4)	3.9	28(2)	3.5	5(5)	3.4			0(5)	4.5	0(4)	4.7				
276-300(505-549)	4(5)	2.1	21(2)	2.3	7(1)	4.1			8(8)	3.9	13(8)	3.8	17(6)	3.7	1(25)	3.9	26(6)	3.4	6(6)	3.7					0.1(5)	4.4				
301-325(550-595)	5(1)	4.1	22(1)	1.0	7(1)	4.1	7(2)	4.4	5(7)	3.8	11(6)	4.0	7(2)	2.8	0.6(7)	3.8	12(2)	3.3							0(4)	4.5				
326-350(596-641)	9(1)	1.0							14(5)	3.7	19(6)	3.8	9(3)	3.7	12(4)	3.7	25(4)	3.7	7(2)	3.8					0(1)					
351-375(642-685)			0.5(2)	0.9					0(1)	4.0	6(3)	3.9	32(3)	3.1			8(1)	3.4	8(2)	3.7					0.2(5)	4.3				
376-400(686-732)	7(3)	3.0	4(1)	3.5			5(1)	3.5	19(4)	3.5	19(3)	3.7			6(5)	3.7	24(4)	3.6	3(4)	3.9					0(1)	4.3				
401-425(733-778)			.18(1)	3.4	18(1)	4.1	6(1)	4.3	11(3)	3.9	15(4)	3.5	16(1)	3.6	4(3)	3.5	0(1)	3.5	7(2)	4.1					0(4)	4.3				
426-450(779-824)									0(1)	3.7							6(1)	3.8												
451-475(825-869)																														
476-500(870-914)																				5(1)	-					0(1)				

Table 3. Average weight (kg) of common grenadier catches per successful 30-minute trawl set in relation to depth and bottom temperature by ICNAF Division (2G-4X), based on A. I. Cameron catches during 1958-73 (number of sets in parentheses).

Depth	Area O	Subarea 1	2G	2H	2J	3K	3L	3M	3N	3O	3P	4RST	4VWX
Fathoms (Metres)	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C	Catch °C
0-25 (0-47)		0(2) 4.9								0(36) 2.5		0(14) 1.7	0(8) 1.3 0(2) 6.3
26-50 (48-92)		0(1) 1.7					0(127) 0.1			0(362) 1.2	0(138) 1.7	0(74) 1.0	0(21) 0.9 0.1(13) 3.4
51-75 (93-138)		0(2) -0.3	0(1) -0.3	0(3) 0.8	0(1) -0.2	0(3) -0.4	0(102) -0.5			0(86) 0.6	0(72) 3.7	0(66) 0.8	0(25) 1.0 0(40) 4.3
76-100 (139-184)		0(1) 2.4	0(5) 0.4	0(11) 0.7	0(17) 0.8	0(9) -0.4	0(120) 0.0	0(11) 3.8	0(88) 0.9	0(80) 4.4	0(72) 2.6	0(65) 2.4	0(37) 5.2
101-125 (185-229)	0(2) -0.9	0(1) 3.0	0(5) 2.0	0(7) 0.5	0(35) 1.7	0(24) 1.3	0(74) 0.9	0(9) 4.1	0.1(73) 1.5	0.5(60) 4.3	0.5(78) 4.5	0.2(82) 3.6	0.1(23) 6.0
126-150 (230-275)	0(1) -1.1	0(2) 0.8	0(6) 3.5	0(4) 1.2	0(51) 2.6	0(37) 2.1	0(33) 1.4	0(12) 4.2	0.4(40) 1.8	3(43) 4.2	2(69) 5.0	0.7(82) 4.4	0.3(18) 5.5
151-175 (276-321)	0(5) 0.7		0(1) 3.9	0.3(5) 2.2	0.1(39) 3.3	0.1(55) 3.0	0.4(33) 2.3	0(64) 4.2	0.4(32) 2.2	4(27) 3.9	2(35) 4.9	1(46) 4.6	0.6(9) 5.7
176-200 (322-366)	0(5) 1.3	0(2) 3.2		0(2) 2.0	0(23) 3.6	0.5(27) 3.1	1(19) 3.3	0.1(8) 4.0	3(14) 2.7	4(9) 3.8	0.8(22) 4.8	3(39) 4.6	0.2(10) 5.7
201-225 (368-412)	0(2) 2.4	0(1) -	0(2) 3.9	8(1) 4.3	0.2(10) 3.6	0.2(13) 3.3	0.5(3) 3.4	2(4) 3.9	0.5(3) 2.9	12(3) 3.4	4(4) 4.9	2(5) 4.9	0.4(4) 5.2
226-250 (413-458)	0.5(1) 1.8	0(3) 2.3	0(1) 4.0	4(3) 3.5	1(11) 3.9	0.9(14) 3.7	6(9) 3.5	0.1(5) 3.8	5(6) 3.2	6(4) 3.8	5(4) 4.5	6(4) 4.4	0.5(9) 4.6
251-275 (459-504)	0(1) 3.9				1(4) 3.9	4(9) 3.4	5(4) 3.4	0.2(4) 3.9	3(2) 3.5	11(5) 3.4		3(5) 4.5	0.8(4) 4.7
276-300 (505-459)	0.2(5) 2.1	0(2) 2.3	0(1) 4.1		2(8) 3.9	2(8) 3.8	5(6) 3.7	0(25) 3.9	21(6) 3.4	8(6) 3.7			0.6(5) 4.4
301-325 (550-595)	0(1) 4.1	0(1) 1.0	0(1) 4.1	0.7(2) 4.4	5(7) 3.8	3(6) 4.0	0.3(2) 2.8	0(7) 3.8	4(2) 3.3				0.9(4) 4.5
326-350 (596-641)	0(1) 1.0				3(5) 3.7	2(6) 3.8	3(3) 3.7	1(4) 3.7	8(4) 3.7	61(2) 3.8			2(1)
351-375 (642-685)		0(2) 0.9			0(1) 4.0	3(3) 3.9	5(3) 3.1		16(1) 3.4	5(2) 3.7			2(5) 4.3
376-400 (686-732)	0(3) 3.0	0(1) 3.5		0(1) 3.5	0.1(4) 3.5	0.3(3) 3.7		0.4(5) 3.7	14(4) 3.6	18(4) 3.9			0(1) 4.3
401-425 (733-778)		0(1) 3.4	0(1) 4.1	0.5(1) 4.3	0.7(3) 3.9	3(4) 3.5	8(1) 3.6	0.1(3) 3.5	0(1) 3.5	50(2) 4.1			0.8(4) 4.3
426-450 (779-824)					0(1) 3.7				0(1) 3.8				
451-475 (825-869)										0(1)			
476-500 (870-914)													0(1)

Table 4. Average weight (kg per fish) of roundnose grenadier taken by A. T. Cameron, 1958-73, in a no. 41-5 otter trawl on bottom at various depths (number of fish included in averages in parentheses).

Depth	Area 0	Subarea 1	2G	2H	2J	3K	3L	3M	3N	3O	4W
Fathoms (Metres)	Aug-Sept.	Aug.	Sept.	July-Aug.	April-Oct.	March-Dec.	May-Oct.	Sept.	July-Nov.	May	Nov.
0-25 (0-47)											
26-50 (48-92)											
51-75 (93-138)											
76-100 (139-184)											
101-125 (185-229)											
126-150 (230-275)											
151-175 (276-321)							0.9 (1)			0.2 (15)	
176-200 (322-366)							0.9 (5)			0.1 (70)	
201-225 (368-412)			0.8 (2500)	-	-			0.9 (47)			
226-250 (413-458)				-	-	0.6 (7)	0.8 (537)	0.1 (3)			0.1 (45)
251-275 (459-504)						0.6 (4)	0.5 (13)				0.1 (80)
276-300 (504-549)	0.9 (32)	0.6 (14)	-	-	0.5 (80)	0.5 (6024)		0.05 (5)	0.08 (54)	0.2 (175)	
301-325 (550-595)	1.4 (1)	0.6 (32)	0.9 (1012)	0.6 (47)	0.5 (22)	0.7 (1099)	0.2 (3)				
326-350 (596-641)					0.6 (19)	0.8 (2071)	0.04 (87)		0.1 (129)	0.2 (60)	
351-375 (642-685)							0.2 (582)	0.1 (27)			0.5 (1)
376-400 (686-732)	0.2 (1046)	0.5 (438)			0.3 (194)	0.4 (1910)			0.4 (202)	0.1 (360)	
401-425 (733-778)		0.6 (4185)	-	0.6 (304)	0.8 (75)	0.3 (443)				0.1 (276)	
426-450 (779-824)											
451-475 (825-869)											

Table 5. Average weight (kg per fish) of roughhead grenadier taken by A. T. Cameron, 1958-73, in a no. 41-5 otter trawl on bottom at various depths (number of fish included in average, in parentheses).

Depth	Area 0	Subarea 1	2G	2H	2J	3K	3L	3M	3N	3O	4V	4W	4X
Fathoms (Metres)	Aug-Sept.	Aug.	Sept-Oct.	July-Oct.	April-Nov.	Feb-Dec.	Feb-Nov.	March-Sept.	Feb-Nov.	Feb-Dec.	Nov.	Nov.	Nov.
0-25													
26-50 (48-92)									1.4 (5)				
51-75 (93-138)				0.5 (1)					1.6 (59)				
76-100 (139-184)			1.4 (4)	0.5 (7)			0.8 (6)		1.9 (432)	0.6 (2)			
101-125 (185-229)			1.3 (24)	1.0 (127)	0.8 (29)	0.8 (3)	1.0 (59)		1.6 (886)	0.9 (15)			
126-150 (230-275)			0.6 (25)	0.9 (155)	1.0 (133)	0.8 (45)	1.0 (59)		0.7 (262)	0.8 (66)			
151-175 (276-321)	0.9 (18)		0.6 (10)	1.2 (127)	0.8 (111)	0.8 (166)	0.7 (904)		1.2 (344)	0.9 (35)			
176-200 (322-366)	0.4 (66)			0.8 (152)	0.7 (75)	0.8 (216)	1.0 (504)	0.9 (1)	1.0 (151)	0.8 (22)			
201-225 (368-412)	0.5 (16)		0.5 (14)	-	0.9 (126)	1.0 (129)	0.8 (110)	0.6 (25)	1.0 (53)	0.5 (23)			
226-250 (413-458)	0.4 (18)	0.4 (65)	0.7 (4)	0.5 (98)	0.6 (124)	0.6 (196)	0.9 (342)	1.0 (40)	1.1 (173)	0.3 (12)			
251-275 (459-504)	0.2 (6)				0.6 (32)	0.8 (113)	0.8 (114)	1.1 (38)	0.9 (61)	0.9 (19)			
276-300 (505-549)	0.5 (48)	0.7 (61)	0.5 (9)		0.6 (107)	0.7 (100)	0.6 (181)	0.7 (166)	0.9 (176)	1.2 (29)		0.2 (2)	
301-325 (550-595)	0.3 (19)	1.4 (16)	2.3 (3)	0.4 (37)	0.5 (26)	0.7 (72)	1.0 (14)	1.1 (117)	0.7 (36)				
326-350 (596-641)	1.8 (5)				0.9 (74)	0.9 (102)	0.5 (57)	0.9 (52)	0.6 (169)	0.6 (11)			
351-375 (642-685)		0.5 (1)				0.7 (75)	0.7 (141)		0.5 (16)		0.5 (2)		
376-400 (686-732)	0.5 (47)	0.4 (10)		0.3 (14)	0.7 (101)	1.1 (75)		1.1 (58)	0.7 (142)	0.7 (27)			
401-425 (733-778)		0.8 (23)	0.6 (29)	0.5 (13)	0.8 (45)	0.6 (94)	0.6 (26)	1.0 (54)		1.0 (14)			0.1 (1)
426-450 (779-824)									0.6 (4)				
451-475 (825-869)													

Table 6. Average weight (kg per fish) of common grenadier taken by A. T. Cameron, 1958-73, in a no. 41-5 otter trawl on bottom at various depths (number of fish included in average, in parentheses).

Depth	Area O	2H	2J	3K	3L	3M	3N	3O	3P _s	3P _n	4R	4S	4T	4V	4W	4X
Fathoms (Metres)	Aug.- Sept.	July- Aug.	April- Oct.	Feb-Dec.	March- Nov.	March- Sept.	Feb-Nov.	Feb-Dec.	Jan-Dec.	Feb-May	Jan-Nov.	May-Nov.	May-Nov.	Nov-Dec.	May-Nov.	Nov.
0-25 (0-47)																
26-50 (48-92)								0.05 (1)						0.05(15)		
51-75 (93-138)								0.1 (2)								
76-100(139-184)								0.1 (15)	0.05 (40)	0.1 (11)	0.1 (1)	0.1 (4)	0.1 (7)	0.05 (3)		0.05 (1)
101-125(185-229)			0.2 (1)					0.3 (47)	0.06 (480)	0.07 (439)	0.09 (4)	0.1 (36)	0.1 (25)	0.1 (48)	0.08 (6)	0.03(40) 0.05 (5)
126-150(230-275)				0.2 (1)	0.3 (1)			0.08(118)	0.07(1242)	0.06(1166)	0.1 (4)	0.09(274)	0.09(134)	0.08(281)	0.09(24)	0.08(23) 0.08(15)
151-175(276-321)		0.2(9)	0.6 (4)	0.1 (47)	0.2 (95)	0.1 (2)		0.09(162)	0.09 (535)	0.09 (544)	0.09 (8)	0.08(347)	0.08(101)	0.07(209)	0.06(40)	0.07(37) 0.04 (6)
176-200(322-366)			0.2 (5)	0.2 (74)	0.1(147)	0.1 (8)		0.2 (52)	0.1 (215)	0.09 (162)	0.1 (24)	0.08(383)	0.06(259)	0.09(443)	0.06 (7)	0.08 (9) 0.07 (8)
201-225(368-412)		-	0.2 (9)	0.3 (29)	0.09(18)	0.1(93)		0.1 (12)	0.1 (90)	0.07 (221)		0.1 (10)		0.07 (30)		0.08(20)
226-250(413-458)	0.2(2)	0.2(57)	0.2(104)	0.2 (94)	0.1(270)	0.06(11)		0.1 (77)	0.1 (131)	0.09 (103)	0.09(107)	0.1 (28)	0.05 (22)	0.08 (60)	0.04(32)	0.1 (33) 0.07(10)
251-275(459-504)			0.2 (27)	0.2(240)	0.1(127)	0.1(68)		0.08 (77)	0.08 (230)			0.09 (73)	0.08 (36)	0.08 (70)	0.07(10)	0.08(11) 0.1 (12)
276-300(505-549)	0.2(1)		0.2 (96)	0.2(179)	0.2(147)	0.1(49)		0.1 (896)	0.2 (180)							0.07(30) 0.04(23)
301-325(550-595)		0.2(6)	0.2 (21)	0.2 (85)	0.1 (5)	0.2(95)		0.1 (63)								0.08(18) 0.05(44)
326-350(596-641)			0.2 (70)	0.2(111)	0.2 (67)	0.1(39)		0.2 (150)	0.2 (550)							
351-375(642-685)				0.2 (86)	0.2 (80)											0.04(43)
376-400(686-732)			0.2 (2)	0.1 (26)		0.07(64)		0.1 (224)	0.2 (395)							0.04(87) 0.08(44)
401-425(733-778)		0.5(1)	0.2 (11)	0.3 (10)	-	0.2(59)			0.2 (500)							
426-450(779-824)																0.08(28) 0.06(14)
451-475(825-869)																