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Distribution and Abundance of Demersal Juvenile Cod (*Gadus morhua*) from Inshore to Offshore Locations on the Northern Grand Bank and Northeast Newfoundland Shelf in December, 1992

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Abstract

The preliminary results of the first systematic survey to examine inshore and offshore distribution of demersal juvenile Atlantic cod (*Gadus morhua*), carried out in December 1992, is presented. The sampling gear used was a 3-bridle Campelen 1 800 shrimp trawl outfitted with 14 inch rockhopper ground gear. Juvenile cod were found to be widely distributed in each of the large bays in the Northeast coast of Newfoundland and on six transects across bathymetry from inshore areas to the shelf break. There were no distributional differences observed between males and females. Length groups used to approximate ages 0–3 indicated that length group 0 (LG0) was restricted to inshore bays. LG1 and LG2 were more abundant inshore with distribution extending onto the shelf away from shore, more so for LG2 than LG1. LG3 was more widely distributed on the shelf than in the bays with some of the highest catch rates occurring near the shelf break. The results indicate that in 1992 smaller juvenile cod (LG0 and LG1) were restricted to inshore areas and that with increasing size (LG2 and LG3) there was an increasing utilization of the shelf area.

Key words: Abundance, demersal, distribution, inshore, juveniles, Northern cod, offshore

Introduction

One result of recent reviews of the state of the northern cod (*Gadus morhua*) stock as reported in the Harris Report (Harris, 1990) is that the paucity of biological information available on this species, particularly its early life stages, was highlighted. A recommendation of the Harris Report was that scientific efforts be expanded to understand the integrity and interrelationship of spawning aggregations as they relate to recruitment. There has been little research carried out to link progeny of specific spawning units to subsequent recruitment to the fisheries. This remains a near impossible task at this stage since the preferred nursery areas of juveniles of this large stock complex have not been delineated.

The Northern Cod Science Program (NCSP) was initiated by the Canadian Department of Fisheries and Oceans in response to recommendations of the Harris Report. Prior to the commencement of NCSP, many outstanding questions concerning the early life history of cod had not been addressed. Existing models of the drift of cod eggs and larvae had not been tested, nor had there ever been a systematic survey to delineate nursery areas of pelagic and demersal early life history stages. Even basic information on the preferred habitats has been wanting.

Some small cod (younger than age 4) are captured by the Engels high lift trawl (180 mm mesh in wings tapering to 110 mm in the codend) and large light weight bobbin ground gear used during the annual Department of Fisheries and Oceans resource surveys for northern cod (Anderson, MS 1993). However, the Engels trawl was designed to capture larger (commercial-size) fish, and consequently allows the smaller length groups to pass through large meshes or otherwise escape capture by the gear (Godo and Walsh, 1992). In addition to this, the resource surveys have not examined any of the large inshore bays, or within twelve miles of the headlands.

The Juvenile Initiative of NCSP was introduced to provide advice regarding the feasibility of conducting surveys to monitor abundance of juvenile cod. At a workshop on northern cod juveniles held by the Canadian Department of Fisheries and Oceans, in Newfoundland in March 1991, it was recommended that surveys be carried out to determine the distribution and abundance of both pelagic and demersal juvenile cod over the extensive geographic range of the species. As a result of this recommendation, the first systematic survey to determine distribution and abundance of demersal juvenile northern cod, was carried out in December 1992. The survey extended from the large inshore bays of Newfoundland, out to the edge of the continental shelf. Preliminary results of this survey are reported here. Distribution and abundance data are presented for all size groups combined, as well as for length groups approximating age groups 0 to 3 years.

Materials and Methods

In considering a design for the demersal survey, a trade-off was necessary between (1) more intensive spatial coverage to examine spatial variability within any given area, and (2) the necessity to cover a large geographic area in a relatively short time. A line transect method was thus utilized to sample from inshore bays and headlands at Newfoundland to offshore areas (Fig. 1). An effort was made to sample as many depths as possible along each transect, and generally the distance between stations on a line did not exceed 30 naut. miles. Sampling was also carried out in the five large bays

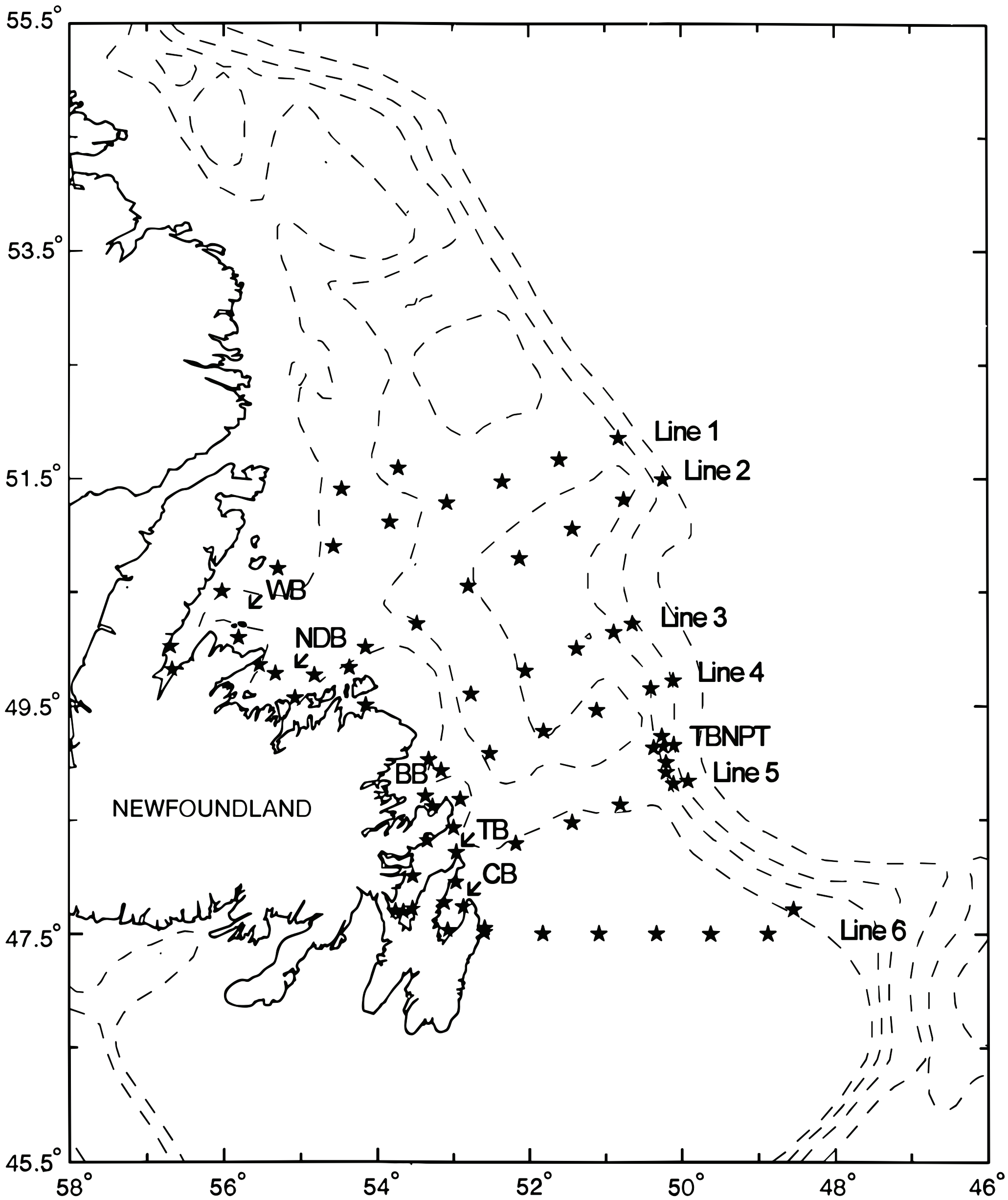

Fig. 1. Map of the Northeast Newfoundland shelf area showing the positions (stars) of stations sampled during the RV *Wilfred Templeman* cruise 131 in December 1992. (WB, NDB, BB, TB, CB = White, Notre Dame, Bonavista, Trinity and Conception Bays, respectively; TBNPT = Tobin's Point).

along the Northeast coast of Newfoundland where again an effort was made to sample the range of bottom depths available.

The sampling was done on board the RV *W. Templeman* using a 3-bridle Campelen 1 800 mesh shrimp trawl, with 80 mm stretched meshes in the front which gradually decrease to 40 mm in the codend (Engås and Godø, 1989). The capture efficiency of the Campelen trawl is higher for smaller fish than the Engels, which has a close to zero efficiency for individuals less than 20 cm (Godø and Walsh, 1992). The Campelen was outfitted with 14 inch rubber disc rockhopper ground gear and 1 400 kg polyvalent doors. The headline height, wing spread and door spread were monitored using Scanmar. On average, the vertical height of the trawl was approximately 4.5 m, the wing spread was approximately 13 m and the door spread was approximately 38–40 m.

Effort was standardized by fishing for 30 min along bottom once the trawl had settled, as observed from the Scanmar readings. Depths and temperature along the tow path were monitored using a trawl mounted CTD from which mean temperature at station was obtained. All cod were sorted from the catch prior to onboard length and weight measurements, sex determination, and otolith and stomach samples were collected. Catch by species was determined by sorting, enumerating and weighing the entire catch, or a representative sample.

The catch of cod in number for each set were transformed into $\log_{10}$ values to obtain relative abundance patterns for the survey. These preliminary presentations assume the data are normally distributed.

Results and Discussion

Juvenile cod were caught in all but five trawl sets and the largest catch was 554 individuals. The numbers and weights of juveniles and larger cod caught are tabulated in relation to depth and bottom temperature in Table 1. Bottom depth of the sets ranged from 60 to 637 m, mean bottom temperature ranged from –1.26 to +3.76°C. A simple correlation analysis indicated no correlation between juvenile cod catch, and either bottom depth or temperature.

Of the total 2 338 cod that were sampled, 1 188 (50.8%) were males and 1 150 (49.2%) were females, indicating a sex ratio that was not different from the expected 1:1.

The distribution and abundance of juvenile cod (all juvenile sizes ≤390 mm combined), for males is shown in Fig. 2 and for females is shown in Fig. 3. The male and female distributions indicated quite striking similarities over the entire survey area, and hence used as the basis to combine both sexes in subsequent examinations. Figure 4 shows the abundance distribution of the total catch of juvenile cod of both sexes.

Figure 5 shows the length frequency of combined catch (both sexes) from all sets combined, and indicates that the sampling trawl was capable of capturing young cod as small as 55 mm. While a few larger cod were caught during the survey, an upper limit of size for juvenile cod was set at 390 mm. This upper size limit was chosen from available age-length keys from historical research survey data to ensure the inclusion of age 3 fish. From this frequency distribution, modes for ages 0+ and

TABLE 1. Summary of fishing sets on RV *W. Templeman* 131 showing depths, mean temperature along bottom and catch in numbers (N) and weight (W) of juvenile (J) and larger (>390 mm) (L) cod at each station. (Location codes are given in Fig. 1)

Station	Location	Depth (m)	Temp (°C)	NJCOD	WJCOD (kg)	NLCOD	WLCOD (kg)
1	stn. 27	170	–1.14	25	5.76	1	1.34
2	In 6–2	176	–0.87	10	1.75	0	0
3	In 6–3	126	–0.97	1	0	3	2.3
4	In 6–4	114	–0.98	4	0.75	1	0.65
5	In 6–5	97	–0.96	0	0	0	0
6	In 6–6	143	–0.79	5	2.05	2	2.5
7	In 6–7	209	–0.74	1	0.58	2	4.6
8	CB – 1	181	–1.26	1	0.78	2	2.6
9	CB – 2	76	2.23	341	30.83	8	6.9
10	CB – 3	94	–1.10	554	21.9	0	0
11	CB – 4	120	0.16	31	1.76	0	0

TABLE 1. (Continued). Summary of fishing sets on RV *W. Templeman* 131 showing depths, mean temperature along bottom and catch in numbers (N) and weight (W) of juvenile (J) and larger (>390 mm) (L) cod at each station. (Location codes are given in Fig. 1).

Station	Location	Depth (m)	Temp (°C)	NJCOD	WJCOD (kg)	NLCOD	WLCOD (kg)
12	TB – 1	325	0.35	5	0.8	1	0.75
13	TB – 2	251	–0.96	6	1.6	1	1.0
14	In 5–1	185	–1.14	6	1.7	4	3.5
15	In 5–2	122	–1.19	11	3.09	3	3.56
16	In 5–3	207	–0.91	10	3.01	2	1.05
17	TB – 3	116	–0.51	32	3.35	0	0
18	TB – 4	90	1.47	522	33.5	0	0
19	TB – 5	127	–0.68	111	4.75	3	3.35
20	TB – 6	91	–0.32	351	37.9	4	3.25
21	TB – 7	144	–0.83	290	23.4	9	6.9
22	TB – 8	99	0.52	49	3.98	0	0
23	In 4–1	307	0.80	38	6.89	2	1.8
24	In 4–2	327	1.70	38	4.15	7	8.15
25	In 4–3	366	2.63	40	0.55	3	2.05
26	In 4–4	347	2.97	9	1.65	3	2.0
27	In 4–5	458	3.76	9		3	
28	In 3–6	405	2.92	9	2.7	3	2.85
29	In 3–5	315	2.12	16	4.65	6	4.45
30	In 3–4	313	1.75	10	2.5	2	1.7
31	In 3–3	276	0.73	8	1.9	1	0.75
32	In 3–2	428	1.94	93	14.95	3	2.45
33	BB – 1	280	–0.27	0	0	0	0
34	BB – 2	320	–0.62	3	0.21	0	0
35	BB – 3	154	–0.27	47	4.55	0	0
36	BB – 4	122	–0.45	3	0.23	0	0
37	NDB – 1	60	0.96	47	2.11	0	0
38	In 2–3	308	0.54	23	3.33	1	0.85
39	In 2–4	274	0.47	4	0.4	0	0
40	In 2–5	227	0.47	0	0	0	0
41	In 2–6	254	0.85	0	0	1	0.65
42	In 2–7	261	1.77	8	3.25	4	3.3
43	In 2–8	546	3.63	5	1.75	4	2.85
44	In 1–7	335	3.20	26		14	
45	In 1–6	468	2.45	26	8.2	10	7.35
46	In 1–5	441	2.74	12	3.05	4	3.4
47	In 1-4	376	2.28	32	3.83	0	0
48	In 1–3.5	401	2.57	44	3	0	0
49	In 1–3	210	–0.78	3	0.49	0	0
50	In 1–2.5	275	–0.70	5	0.65	0	0
52	In 1–2	185	–0.80	3	0.2	0	0
53	In 1–1	184	–0.70	2	0.05	0	0
54	WB – 1	199	–0.53	7	2.56	0	0
55	WB – 2	161	–0.27	40	1.7	0	0
56	WB – 3	152	0.20	24	3.5	0	0
57	BVPEN	214	–1.02	2	0.28	0	0
58	NDB – 2	170	–0.78	63	3.1	0	0
59	NDB – 3	376	–1.08	27	3.02	2	1.64
60	NDB – 4	200	–0.98	25	3.25	0	0
61	In 2–1	239	–1.26	11	1.25	0	0
62	NDB – 5	187	–0.83	77	4.75	1	0.95
63	In 2–2	286	–1.08	27	3.1	0	0
64	In 5–4	276	1.81	12	1.98	3	2.4
65	In 5–5	637	3.58	0	0	0	0
66	TBNPT1	277	1.49	27	6.3	6	5.0
67	TBNPT2	399	2.79	44	12.1	6	4.95
68	TBNPT3	292	1.9	35	8.6	6	7.45
69	TBNPT4	270	1.47	52	10.2	9	9.0
70	TBNPT5	251	1.32	30	6.1	1	1.2
71	TBNPT6	242	0.16	11	1.95	3	2.65

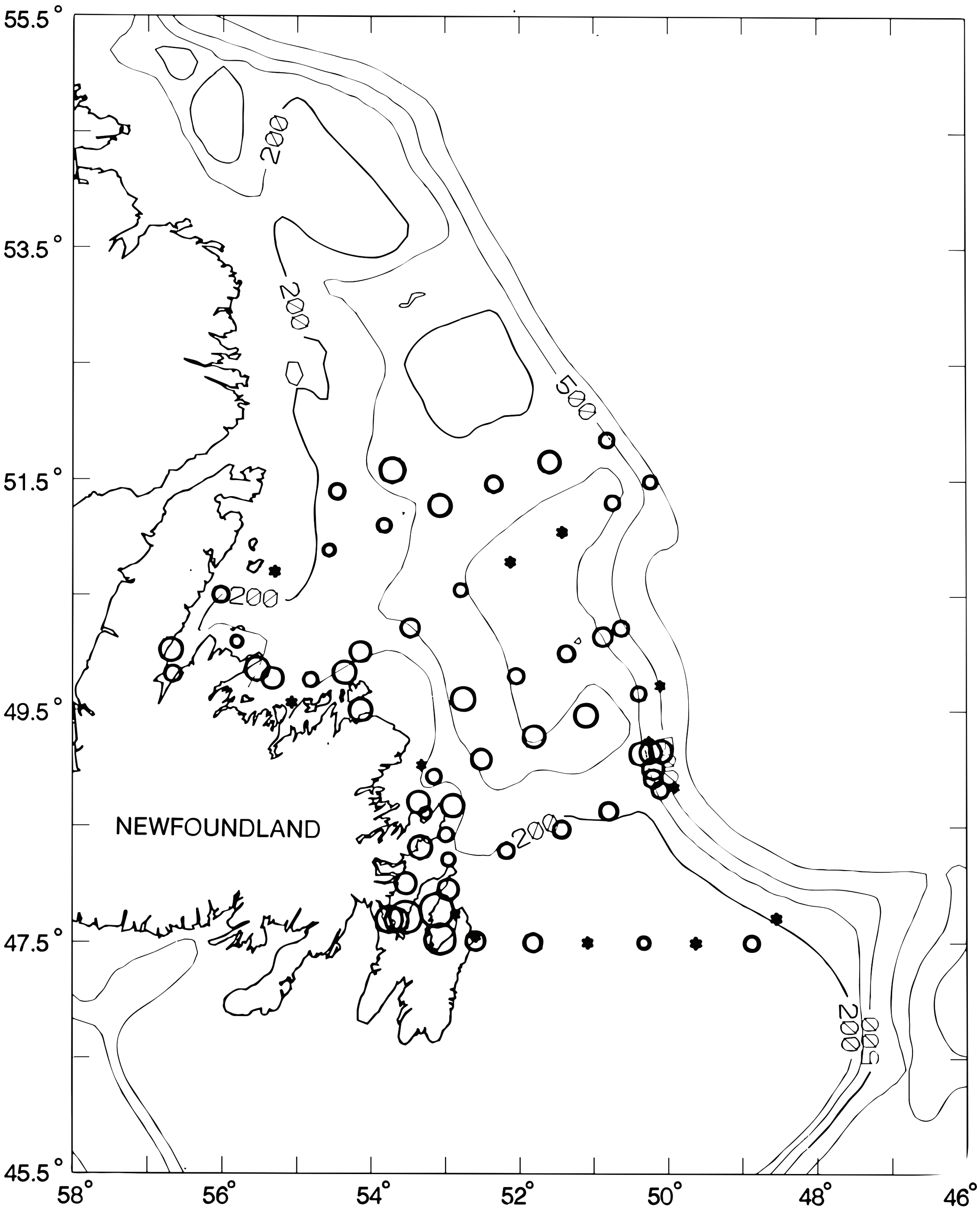

Fig. 2. Abundance and distribution of male juvenile cod (all length groups <390 mm) captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 2.42. Largest symbol equals 263 fish. Stars represent zero catches.

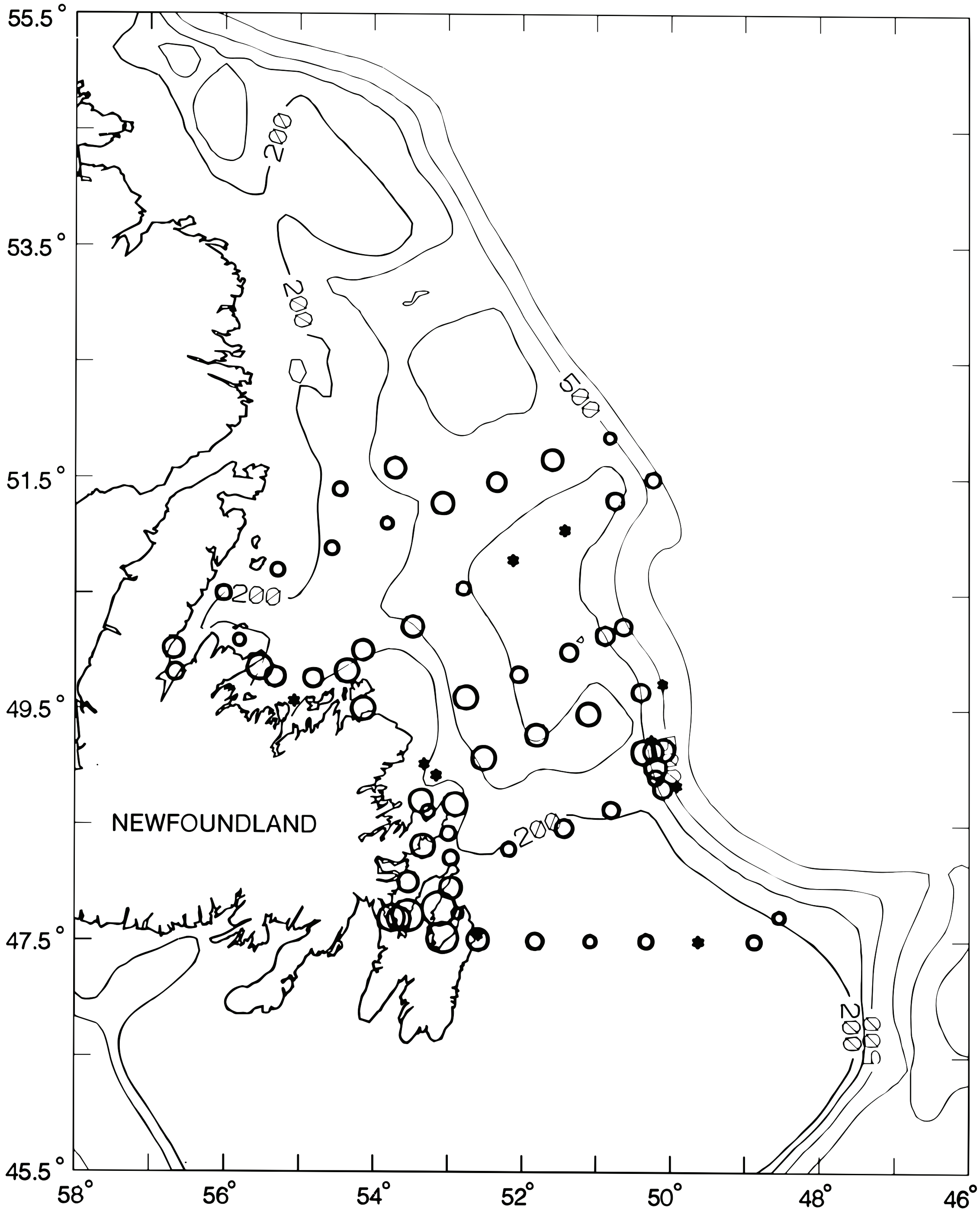

Fig. 3. Abundance and distribution of female juvenile cod (all length groups <390 mm) captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 2.41. Largest symbol equals 258 fish. Stars represent zero catches.

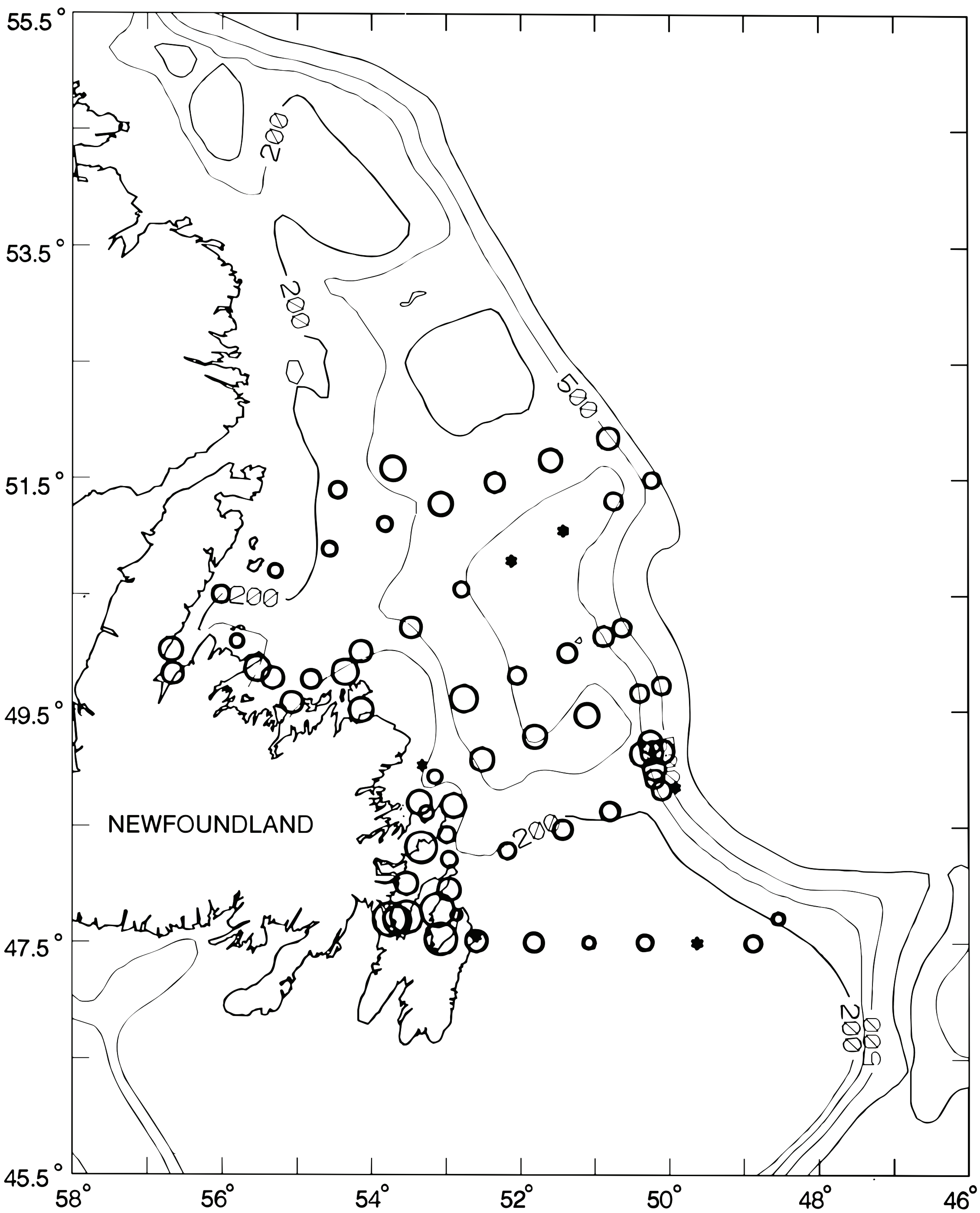

Fig. 4. Abundance and distribution of all juvenile cod (<390 mm) captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 2.74. Largest symbol equals 554 fish. Stars represent zero catches. Total number of cod (sexes combined) is larger than the sum of males and females since some of the smaller fish were not sexed.

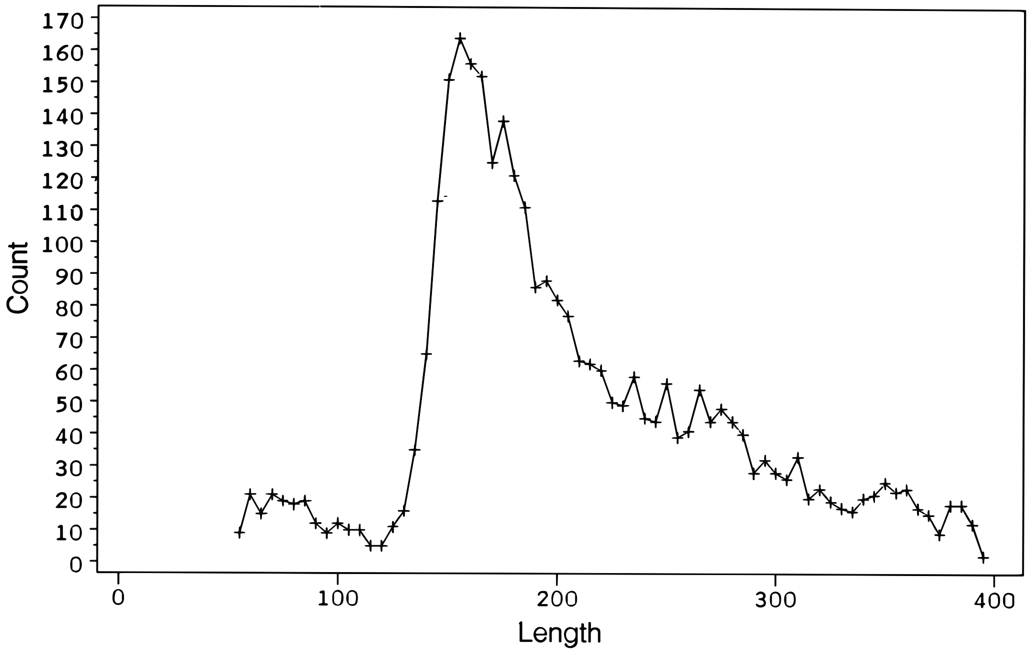

Fig. 5. Length frequency of the total combined catch of juvenile cod (<390 mm) from all sets of the RV *Wilfred Templeman* survey in December, 1992.

1+ groups were apparent at 75–80 mm and 155–160 mm, respectively. From this length frequency distribution, and age-length keys obtained from unpublished inshore juvenile trap data, four length groups (LG0–LG3) were chosen to approximate age groups 0–3 as follows: LG0 = ≤115 mm, LG1 = 116–215 mm, LG2 = 216–310 mm and LG3 = ≥311 mm.

Figures 6 to 9 show the distribution and abundance of the four length groups throughout the survey area. The LG0, with the exception of one individual captured approximately 90 miles from the coast on the most southern line, was restricted to the inshore bays and not distributed further out on the shelf (Fig. 6).The LG1 on the other hand was widely distributed throughout the survey area (Fig. 7), from the inshore areas out to the edge of the shelf, with the highest abundances being found in Conception and Trinity Bays. Occurrence of LG1 was generally more frequent in the northern transect lines than in the south and, except for one area (around 49°N), occurred more frequently on the shelf than near the edge. The LG2 which also had highest abundances in Conception and Trinity Bays (Fig. 8), was found in the other bays and, except for the most southerly line, was widespread on the shelf with the center of distribution extending further offshore than the LG1 group, and extending to the shelf edge. The LG3 was found to be abundant at one station in Conception Bay (Fig. 9), but highest abundances were found to be near the shelf edge on the most northern transect and on the transect off from Bonavista Bay.

In summary the results indicated a tendency for the smallest fish (LG0), and to a lesser extent the LG1, to be more restricted to the inshore than offshore areas. With increasing size there was a tendency for the juveniles to be more widely distributed on the shelf, and in the case of LG3, some of the larger catches were taken near the shelf edge. The fact that nearly all LG0 were restricted to the inshore area, supports the hypothesis that the inshore area harbours the early life history stages of the cod. However, these young may have originated from spawning areas on the edges of more northerly offshore banks, as hypothesized by Templeman (1981) or they may well have originated from more local inshore spawning (Templeman, 1989). The overall distribution of juveniles suggest that the whole of this survey area is a nursery area for northern cod. It is therefore fair to assume that the area would be more heavily utilized as a nursery area when the spawning stock biomass is above its present low levels. In 1981, for example, which produced a relatively good year-class, pelagic juveniles were widely distributed over the survey area in September (Anderson *et al.*, in press) and likely resulted in a more widespread settling of demersal age 0+ juveniles. Further investigations are required to determine the variability in spatial distribution by more intensive sampling within given areas.

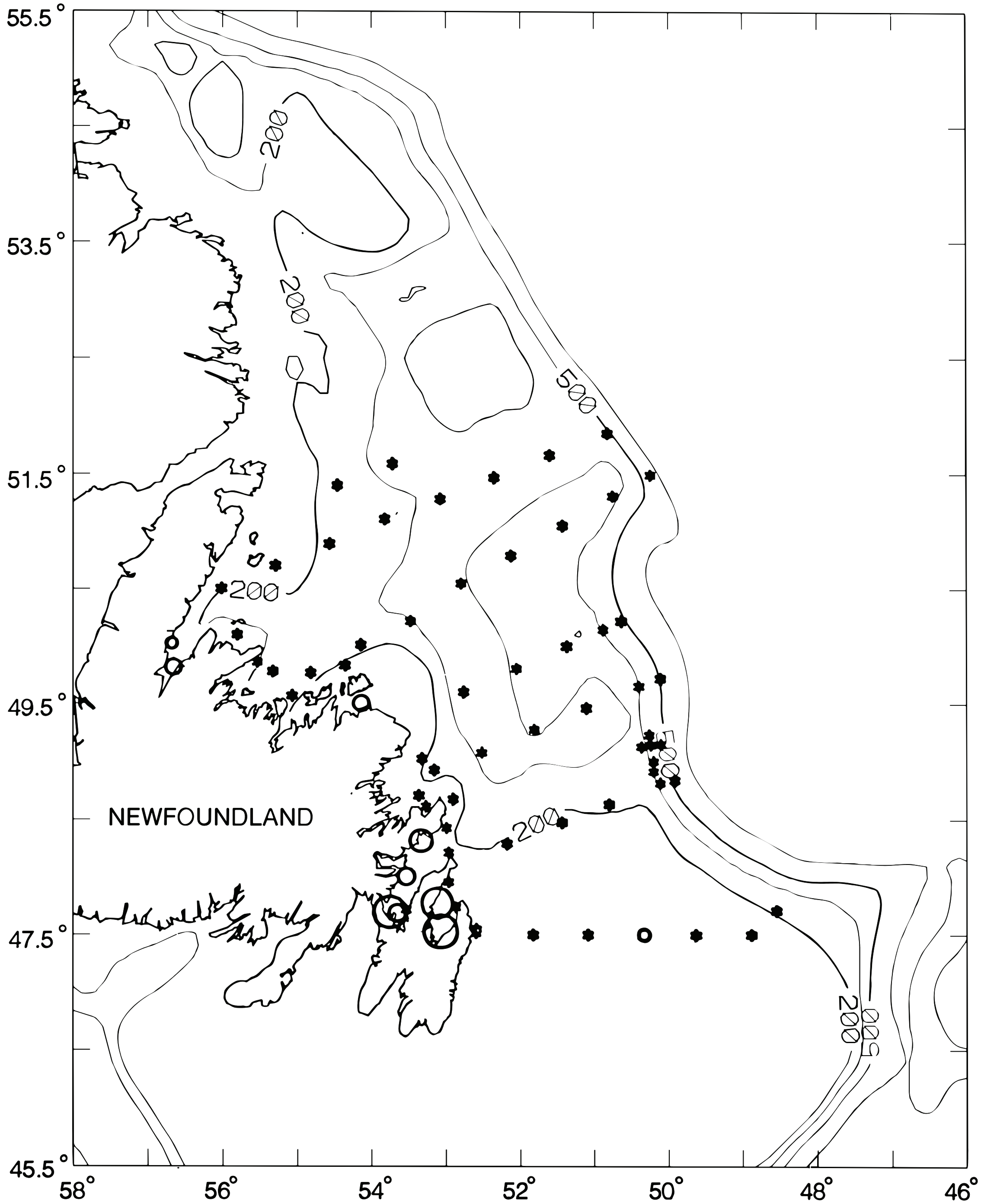

Fig. 6. Abundance and distribution of LG0 group juvenile cod captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 1.89. Largest symbol equals 76 fish. Stars represent zero catches.

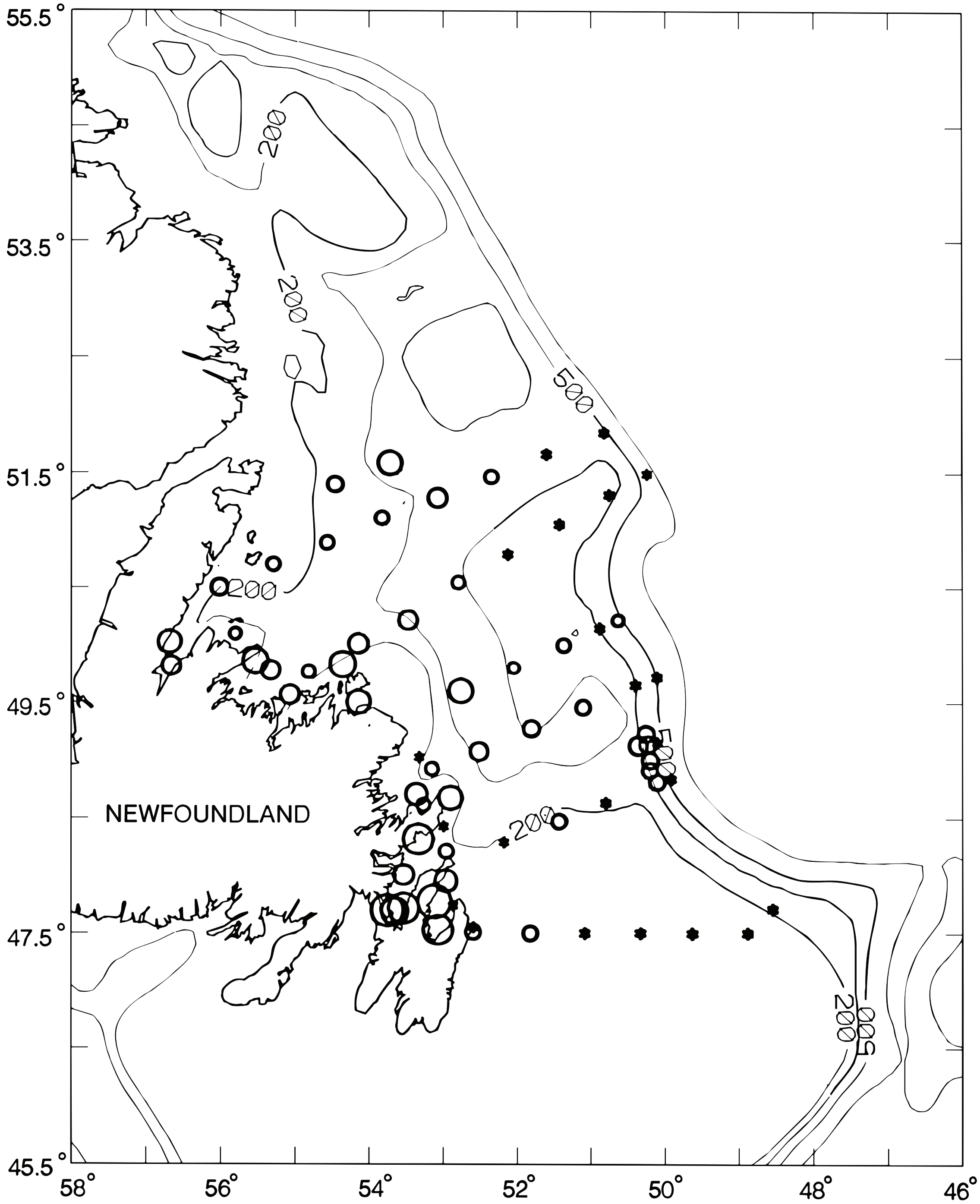

Fig. 7. Abundance and distribution of LG1 group juvenile cod captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 2.66. Largest symbol equals 456 fish. Stars represent zero catches.

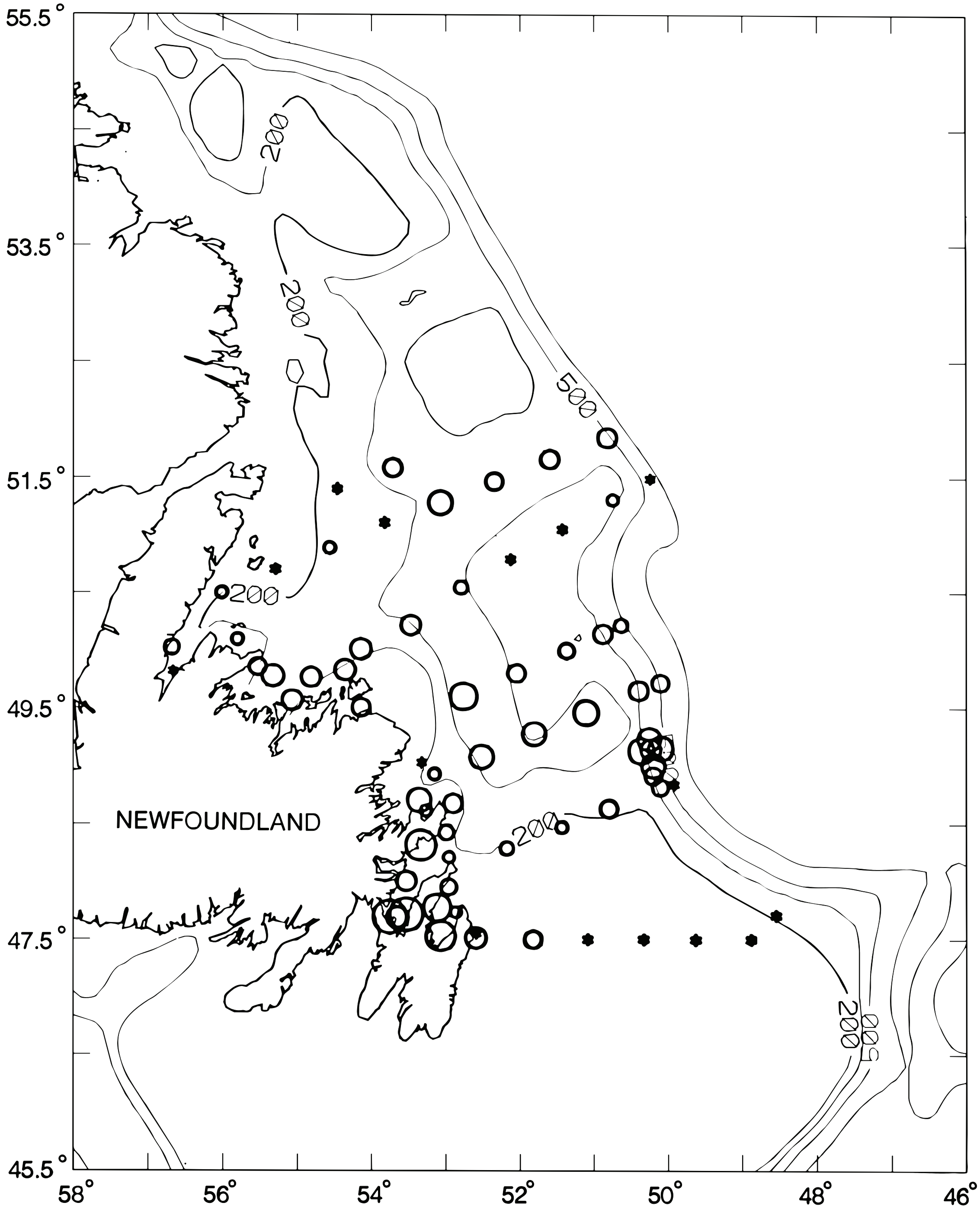

Fig. 8. Abundance and distribution of LG2 group juvenile cod captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 2.14. Largest symbol equals 138 fish. Stars represent zero catches.

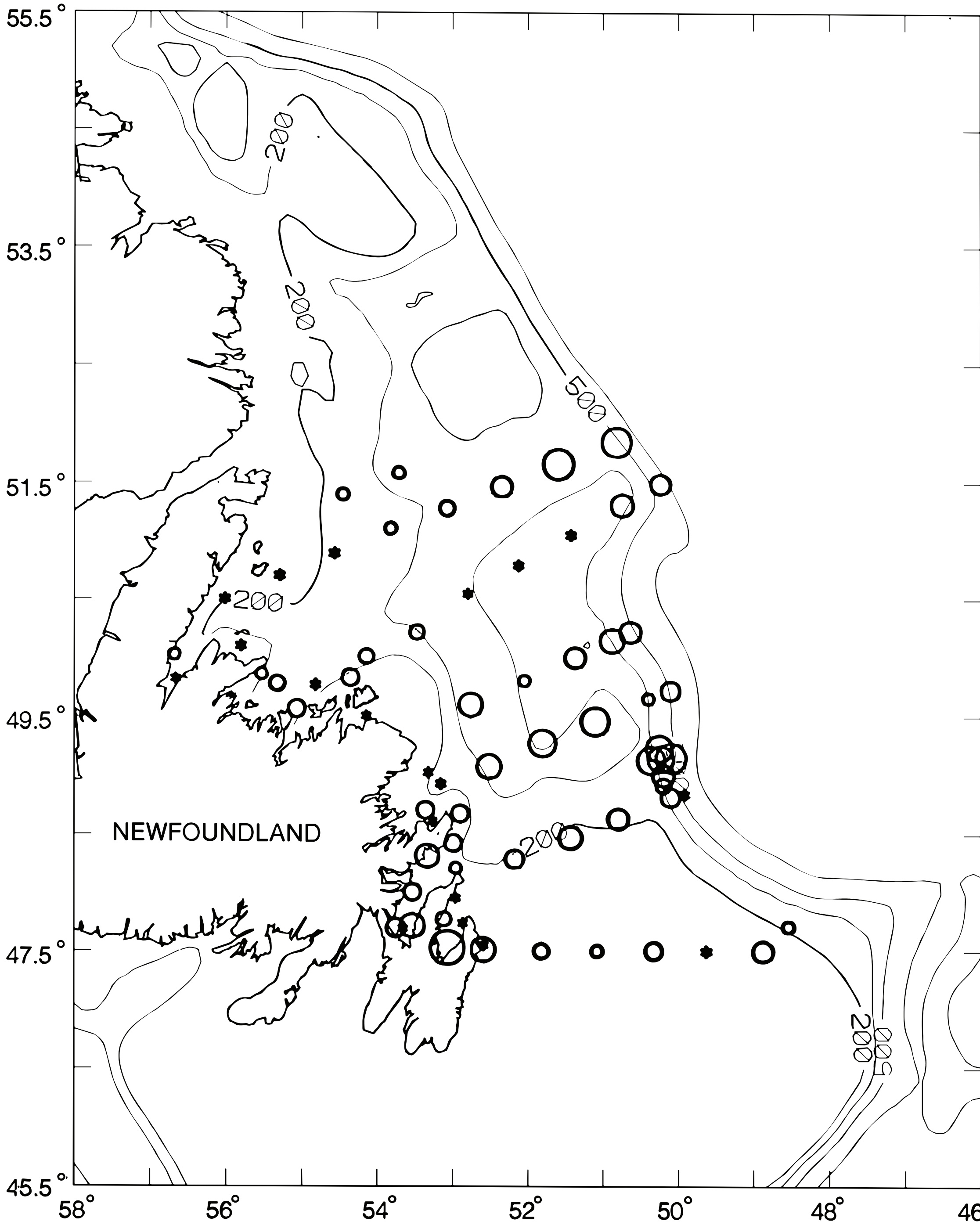

Fig. 9. Abundance and distribution of LG3 group juvenile cod captured during the RV *Wilfred Templeman* survey in December 1992. The expanding symbols represent a linear scale based on $\log_{10}$ of catch in numbers per 30 min tow, scaled from 0.30 to 1.52. Largest symbol equals 33 fish. Stars represent zero catches.

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