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THE NEKTON OF THE COASTAL AND SHELF WATERS OF NEWFOUNDLAND

by

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Abstract

A large scale, two ship survey was carried out in the late summer of 1994 and 1995, sampling the pelagic environment of the southern Labrador Shelf, the Northeast Newfoundland Shelf, the Northern and Southern Grand Banks and the inshore bays along the northeast coast of Newfoundland. Copepods dominated the macro-plankton, with *Calanus finmarchicus* being the dominant species throughout most of the area, whereas *Centropages hamatus* dominated on the Southern Grand Bank. The seasonal production cycle of *C. finmarchicus* was more advanced in the inshore area than on the adjacent shelf. On the Southern Grand Bank, *C. hamatus* was dominated by adults, indicating that a late summer spawning was underway. There was little evidence of late summer spawning by fish, where fish eggs were in low abundances. The only spawning that occurred was primarily witch flounder (*Glyptocephalus cynoglosus*) and yellowtail flounder/cunner (*Limanda ferruginea* and *Tautoglabrus adspersus*). The dominant fish larvae were capelin (*Mallotus villosus*), which accounted for 52% and 87% of the ichthyoplankton each year, respectively. The nekton was dominated by juvenile Arctic cod (*Boreogadus saida*), juvenile squids and one year old capelin, which together accounted for 93% and 84% of the nektonic species captured in 1994 and 1995, respectively. The inshore bays along the northeast coast of Newfoundland appeared to be the most important spawning areas for fish during these two years. There was notably little evidence of spawning on the southern Grand Bank, particularly for capelin. However, the shelf waters may be important feeding areas for planktivorous juvenile fish, evidenced by high copepod biomass and the dispersal of capelin from inshore spawning areas to offshore waters. We categorize the pelagic environment within the survey area into four distinct zoogeographic domains: 1) the shelf waters of the Northeast Newfoundland Shelf and the Southern Labrador Shelf; 2) the Northern Grand Bank; 3) the Southern Grand Bank; and, 4) the inshore bays along the northeast coast of Newfoundland.

Résumé

Un important relevé à deux navires a été réalisé à la fin des étés de 1994 et 1995. Il a été procédé à des échantillonnages pélagiques dans la partie sud du plateau du Labrador, la partie nord-est du plateau de Terre-Neuve, les parties nord et sud des Grands Bancs et les baies de la côte nord-est de Terre-Neuve. Le macroplancton était dominé par les copépodes. *Calanus finmarchicus* était l'espèce dominante dans la plus grande partie de l'aire étudiée et *Centropages hamatus* dominait dans la partie sud du Grand Banc. Le cycle de production saisonnier de *C. finmarchicus* était plus avancé dans la partie côtière, comparativement au plateau voisin. Dans le sud du Grand Banc, la population de *C. hamatus* était dominée par les adultes, ce qui indique une période de reproduction de fin d'été. Il y avait peu d'indices d'un frai de fin d'été chez les poissons, les oeufs étant peu abondants. Les seuls frais notés se résumaient à ceux de la plie grise (*Glyptocephalus cynoglosus*) et de la limande à queue jaune et de la tanche-tautoque (*Limanda ferruginea* et *Tautoglabrus adspersus*). Les larves de poisson étaient dominées par celles du capelan (*Mallotus villosus*) qui représentaient, respectivement à chaque année, 52 % et 87 % de l'ichthyoplancton. Le necton était dominé par des juvéniles de la morue polaire (*Boreogadus saida*) et du calmar et des capelans d'un an qui, ensemble, représentaient respectivement 93% et 84% des espèces nectoniques prélevées en 1994 et 1995. Les baies de la côte nord-est de Terre-Neuve semblent avoir été les plus importantes zones de frai au cours de ces deux années. Il y avait très peu d'indices de frai dans la partie sud du Grand Banc, notamment en ce qui concerne le capelan. Les eaux du plateau pourraient cependant constituer une importante zone d'alimentation pour les poissons juvéniles planctivores, comme le montrent l'importante biomasse de copépodes et la dispersion des capelans des zones de frai côtières vers les zones de haute mer. Nous avons divisé le milieu pélagique de la zone étudiée en quatre domaines zoogéographiques : 1) le nord-est du plateau de Terre-Neuve et le sud du plateau du Labrador; 2) le nord du Grand Banc; 3) le sud du Grand Banc et 4) les baies côtières de la côte nord-est de Terre-Neuve.

Introduction

To improve the regional assessments of Atlantic cod (*Gadus morhua)* and capelin (*Mallotus villosus*) a research program was undertaken during the period 1991-1993, as part of the Northern Cod Science Program, to develop pre-recruit indices based on a single broad-scale survey in the fall. Previous work on cod in Norway, Iceland and the Faroe Islands had demonstrated that pre-recruit surveys of pelagic juvenile was a good predictor of recruitment in most years (Sundby et al. 1989, Assthorsson et al. 1994, Jakupsstovu and Reinert 1994). The pelagic juvenile stage of cod occurs following metamorphosis from the larval stage and prior to settlement to a demersal habitat. Previous work on capelin in the NW Atlantic demonstrated that recruitment was primarily determined within the first few months of life (Leggett et al. 1984). Good recruitment was dependent on the successful release of larvae from spawning beaches followed by good conditions for larval survival related to warm ocean temperatures.

Beginning in 1994, a broad-scale survey was implemented using two ships, sampling inshore and offshore areas from Hamilton Bank off southern Labrador to the southern Grand Bank (NAFO Div. 2J3KLNO). The inshore area is defined by the large bays along the northeast coast of Newfoundland, as well as a zone within < 50 km of the coast (Figure 1). It is necessary to use two gear types due to the large range of fish sizes encountered in the fall, from recently released capelin larvae (3-5 mm) up to pre-settlement juvenile cod (80-100 mm) and 1-2 year old capelin (60-180 mm). In addition to the target species, Atlantic cod and capelin, data are collected on physical oceanography and phytoplankton and zooplankton biomass as well as species composition of the zooplankton, ichthyoplankton and nektonic fish.

The purpose of this paper is to describe, for the first time, the dominant macro-plankton and nekton which occurred in the waters of Newfoundland during late summer 1994 and 1995. We interpret our results in relation to fish spawning areas within the survey area and patterns of dispersal inferred from circulation models. We compare differences among three areas, the Northeast Newfoundland Shelf, the Grand Banks and the inshore area along the northeast coast of Newfoundland.

Study Area

The survey covers a broad zoo-geographical area spanning approximately 11 degrees of latitude and 5 degrees of longitude (Figure 1). In the north the survey reaches Hamilton Bank, on the southern part of the Labrador Shelf. To the south, this is followed by the broad and deep Northeast Newfoundland Shelf. The Northeast Newfoundland Shelf includes Belle Isle Bank and Funk Island Bank, deepwater fishing banks defined by the 300 m contour, and the Inner Shelf which extends to depths > 400 m. The inshore area includes the major bays along the northeast coast of Newfoundland, including White Bay, Notre Dame Bay, Bonavista Bay, Trinity Bay and Conception Bay. The Grand Banks form the southern part of the survey area and contrast sharply with the Northeast Newfoundland Shelf, being characterized as a shallow, flat and wide shelf area. The northern Grand Bank is typically 80-100 m deep, while the southern Grand Bank is dominated by shallow waters lying over the Southeast Shoal (60 m depth).

The dominant oceanographic feature is the Labrador Current, which splits into distinct inner and outer branches over the Northeast Newfoundland Shelf and flows around the edges of the Grand Bank. Current speeds in the core are 50 cm/s while over the Northeast Newfoundland Shelf currents average 30 cm/s and over the Northern Grand Bank 10 cm/s (Petrie et al. 1992). On the Southern Grand Bank there is a weak anti-cyclonic circulation associated with the Southeast Shoal (Loder et al. 1988).

Materials and Methods

The survey captures macro-plankton (0.4 - 10 mm) and nekton (10 - 200 mm) across almost three orders of magnitude in size. These data represent a broad-scale measure of the macro-plankton and nekton communities in late summer, following the spring and summer spawning periods. In 1994 the survey was carried out from August 22 to September 3 using the Wilfred Templeman (north ship) and the Gadus Atlantica (south ship). In 1995, the survey was carried out from September 5-22 using the Wilfred Templeman (north ship) and the Teleost (south ship). The survey design is based on a systematic random survey grid at 54 km (30 nm) station spacing. This design is equivalent to a systematic stratified sampling design, where the first station was selected randomly from one 54x54 km stratum (Snedcor and Cochrane 1967). Within the bays stations were positioned approximately 54 km apart through the center of each bay, as much as possible.

At each station a SeaBird 25 CTD with a fluorometer was lowered to a maximum depth of 500 m, followed by a plankton tow (0-100 m) and finally a mid-water trawl (20-60 m). Chlorophyll ***a*** calibration samples were collected using a 5 l Niskin bottle, with samples being taken between 5-30 m depth at alternate stations. Three replicate samples were taken from each sample, filtering 100 ml of seawater through a Whatman GF filter, and stored frozen at -20°C. In the laboratory, the samples were extracted in 90% acetone and read in using a Turner Designs 10 calibrated fluorometer. Note, however, that results reported here are uncorrected fluorescence values. Plankton were sampled using a bongo sampler (61 cm, 0.333 mm mesh) towed at 1.25-1.5 m s^{-1} using a double oblique haul 0-100 m with payout and retrieval rates of approximately 0.8 and 0.4 m s^{-1}. The bongo sampler was instrumented and transmitted data in real time to the ship, including sampler speed, volume filtered (left and right), distance towed, sampling time, salinity, temperature and depth. The IYGPT (International Young Gadoids Pelagic Trawl) is a pelagic mid-water trawl designed to catch pelagic juvenile gadoids with an effective opening of approximately 10x10 m, (Koeller and Carrothers 1981, Koeller et al. 1986, McCullum and Walsh 1995). The IYGPT trawl was towed at 1.25-1.5 m s^{-1} for 30 minutes, slowly oscillating the head rope between 20-50 m depth through two complete cycles, such that the trawl sampled the 20-60 m depth stratum. The trawl depth and configuration were monitored using acoustic net sensors (Scanmar) to measure net depth, net opening, wing and door widths. For both samplers, the net performance data were used to estimate the volume of water (m^3) filtered during the tow, in order to standardize catch rates.

The IYGPT trawl catches were processed at sea, identifying all fish to species level, where possible, and recording total length for dominant fish species. Sorted samples of Atlantic cod (*Gadus morhua*) and Arctic cod (*Boreogadus saida*) were preserved in alcohol (1994) or frozen (1995) while all other species were preserved in 5% buffered formalin. Total trawl wet weight was also estimated (g). In 1994 this weight included jelly fish, whereas in 1995 the jelly fish were weighed separately from the remainder of the catch. Wet weight was also determined for the dominant species sorted from the catch. Squid were counted and weighed but not speciated. Samples of squid were preserved in formalin and returned to the laboratory for taxonomic identification.

Samples from one side of the bongo were subsampled at sea for identification and measurement of capelin and herring, without replacement. Sorted samples were preserved in alcohol. The remainder of the sample was processed in the laboratory to identify and enumerate total ichthyoplankton, following standard procedures. From the other bongo sample, the plankton was split into two equal halves using a Motoda plankton splitter. One half of this sample was divided into three size categories (< 1 mm, 1-2 mm, > 2 mm), dried for 24 h at 55-60°C and weighed to the nearest milligram. Selected zooplankton samples from 1994 (n=29) and 1995 (n=29) were processed for full taxonomic classification following standard laboratory procedures. These samples were selected to constitute four transects which crossed from the inshore seaward across the adjacent shelves for the NE Newfoundland Shelf and Grand Banks.

Results and Discussion

Physical Oceanography

Surface temperatures ranged from approximately 5°C in the northern part of the survey over the Northeast Newfoundland Shelf to 17-20°C on the Southern Grand Bank. Surface temperatures also tended to be warmer within the bays along the northeast coast of Newfoundland. The upper mixed layer ranged from near-surface (4-6 m) down to 32-44 m depth each year, averaging 16 m in 1994 and 22 m in 1995.

Biomass

Phytoplankton biomass was usually highest at and below the pycnocline. Peak chlorophyll depths each year ranged from 10-70 m, averaging 36 m in 1994 and 34 m in 1995 throughout the survey area. Peak chlorophyll fluorescence values ranged from 0.5-10 mg m^{-3} each year, averaging 3.3 mg m^{-3} in 1994 and 3.0 mg m^{-3} in 1995. Surface chlorophyll values were typically low, averaging < 1.0 mg m^{-3} each year. Spatially, peak chlorophyll values almost always occurred over the deep water channels (> 400 m) on the Northeast Newfoundland Shelf.

The zooplankton biomass, sampled by the bongos, was highest over the Northeast Newfoundland Shelf for all three size fractions, in both 1994 and 1995 (Figures 2-5). We note that the micro-zooplankton, < 1 mm in size, were not sampled in these surveys and, as such, we describe the distribution of the larger, macro-zooplankton only. Biomass tended to be lower both inshore and, especially, on the Grand Banks. There was a clear tendency for the highest biomass to occur over the deep water channels of the Northeast Newfoundland Shelf and at the shelfbreak. Zooplankton biomass was approximately four times greater in 1995, averaging 14.2 g/1000m^3, than in 1994, averaging 5.9 g/1000m^3. While this was true for all three size fractions, the largest difference occurred for the 1-2 mm size fraction (Table 1).

Total biomass of the nekton sampled by the IYGPT, exclusive of jellyfish, is only available for 1995. The nekton biomass was greatest over the Northeast Newfoundland Shelf and lower both inshore and over the Grand Banks (Figure 6).

Together, these data demonstrate that biomass of the macro-plankton and nekton was consistently higher over the Northeast Newfoundland Shelf. The distributions of biomass suggests that pelagic production may be greater over the Northeast Newfoundland Shelf. The relatively high zooplankton biomass, dominated by copepods, suggests the Northeast Newfoundland Shelf may provide more favourable feeding conditions for planktivorous fishes than either the inshore or the Grand Banks. Therefore, we describe two contrasting shelf systems which lie adjacent to each other: the Northeast Newfoundland Shelf as deep and cold with a high level of pelagic biomass, and the Grand Banks as shallow and warm with a low level of pelagic biomass.

Dominant Species

Plankton, sampled by the bongos, were dominated copepods (Figure 7). On the NE Newfoundland Shelf the most abundant species, inshore and offshore, was *Calanus finmarchicus*. Peak abundances were ~1600/m^3. Inshore areas sampled included Notre Dame Bay and Bonavista Bay. Inshore, *C. finmarchicus* copepodite stage IV dominated in all stations, extending out to the near shelf waters, followed by stage III. Offshore, *C. finmarchicus* copepodite stage III dominated, indicating that the seasonal production of C. finmarchicus was more advanced within inshore waters. In no instance was stage V dominant, or very abundant, indicating that diapause had not begun and that the zooplankton community was still within its production phase. Inshore, *Temora longicornis* and *Pseudocalanus* also occurred at high abundances in some instances (>10,000/m^3). Offshore, *Oithona similis* and the Pteropod *Limacina helicina* were also dominant species, with peak abundance's of ~1500/m^3.

To the south, including the Northern Grand Bank, Conception Bay and the Avalon Channel, *C. finmarchicus* was still the dominant species. Stage IV was again dominant inshore, followed by stage III, whereas offshore stage III was dominant. However, on the southern Grand Banks the dominant copepod was *Centropages hamatus*. The dominant stages of *C. hamatus* were females, followed by males. This indicates that spawning may have been occurring during the survey period. While abundances were generally lower on the Grand Banks, typically 100-500/m^3 for all species, the peak abundance of *C. hamatus* on the Southeast Shoal was ~3500/m^3. *Oithona similis* was notably absent or in very low numbers, while *T. longicornis, Pseudocalanus* and *Limacina helicina* were the next most abundant species.

Fish eggs, larvae and juveniles occurred through the entire size range sampled during the surveys. However, there were three distinct size ranges where the majority of the fish biomass occurred (Figure 8). The dominant ichthyoplankton component both years was capelin (*Mallotus villosus*) larvae. In 1994, capelin represented 52% of all ichthyoplankton sampled, and 87% in 1995 (Table 2a). Both years capelin larvae occurred in approximately 43-45% of all samples. In addition, the presence of small capelin larvae (< 5 mm) demonstrates that release from spawning beach was ongoing during the surveys.

The dominant fish eggs sampled each year were CYT eggs, where we cannot distinguish between cunner (*Tautoglabrus adspersus*) and yellowtail flounder (*Limanda ferruginea*) eggs. However, CYT eggs occurred primarily on the Southeast Shoal, indicating that these eggs were most likely yellowtail flounder. Inshore, both yellowtail flounder and cunner larvae were present in our samples, indicating the Cunner-YellowTail egg classification was mixed inshore. The next most abundant fish eggs were CHW eggs. Again, we cannot distinguish between cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and witch flounder (*Glyptocephalus cynoglossus*) eggs at early stages of development. However, we interpret that these eggs are primarily witch flounder due to the absence of cod and haddock larvae in our samples and the late summer spawning period of witch flounder. Therefore, our results demonstrate that the only fish spawning which occurred in the late summer each year was limited primarily to witch, yellowtail and cunner.

Other ichthyoplankton which occurred in the bongo samples are listed in Table 2. However, all species occurred in relatively low abundances either throughout the survey area or in localized distributions.

Euphausiids and amphipods were an important component of the smallest size range of the nekton sampled by the IYGPT (Figure 7). These taxa were not processed as part of our sampling protocol. The larger nekton was dominated primarily by juvenile capelin (*Mallotus villosus*), Arctic cod (*Boreogadus saida*) and juvenile Arctic squid (*Gonatus fabricii*), in the 40-60 mm size range (Figure 8). The largest size range of the nekton (70-120 mm) was dominated by one year old capelin (Figure 8). The largest species caught in our surveys was 2 year old capelin, although these were typically in low abundance.

In 1994, capelin was the dominant species caught (75%), followed by Arctic cod (15%) and squid (3%) (Table 3a). In 1995, Arctic cod predominated (55%), followed by capelin (17%) and squid (13%) (Table 3a). Atlantic cod (*Gadus morhua*) was a rare species in the nekton. In 1994 it occurred at a relative abundance of <0.1% while in 1995 it represented 0.9% (Table 3a,b). Redfish and herring were abundant only within certain areas (see below).

Larval Fish Distributions

Capelin larvae ranged in size primarily from 5-15 mm in 1994 and 5-23 mm in 1995 (Figure 9). Their distributions were similar each year, being highest inshore and decreasing to zero on the outer shelf and on the Grand Banks (Figure 9). The abundant distribution inshore is expected, given the inshore spawning of capelin. The broad distribution onto the adjacent shelf demonstrates the relatively high degree of dispersal which occurs for capelin larvae, once they are flushed from spawning beaches. Larval capelin were noticeably absent on the southern Grand Bank. Surveys carried out during September in the mid-1980's sampled larval capelin on the southern Grand Bank (Frank and Carscadden 1989). The absence of larval capelin in our surveys may result from an absence of spawning, or a very late spawning on the southern Grand Bank where larvae had yet to be released from bottom sediments. Capelin spawning has been delayed by 3-4 weeks in recent years (Carscadden et al. 1997). However, the total absence of larval capelin compared to the inshore areas suggests there may have been little spawning on the southern Grand Bank.

Herring larvae occurred in low abundance each year and they were restricted to the inshore area in the vicinity of Notre Dame and Bonavista Bays (Figure 10). In 1994, herring were predominantly < 20 mm in length, whereas in 1995 they were predominantly > 40 mm (see below). The distribution of larval herring contrasted with capelin. While both species spawn benthically inshore, herring larvae were not widely dispersed from the inshore onto the shelf.

Nekton Distributions

Arctic cod ranged in size primarily from 35-60 mm in 1994 and 40-65 mm in 1995 (Figure 11). In 1994, they were abundant both over the NE Newfoundland Shelf and inshore (Figure 11). In 1995, Arctic cod were most abundant inshore, particularly off southern Labrador. Arctic cod were notably absent on the Grand Bank each year, although their distribution along the outer margins indicated a southward drift in the Labrador Current. However, the warm and shallow waters of the Grand Banks seemed to represent a limit to their southward distribution. The distributions indicate that spawning occurred both inshore and offshore on the Northeast Newfoundland Shelf, although the predominant spawning appeared to occur inshore off southern Labrador.

Juvenile squid occurred most abundantly over the Northeast Newfoundland Shelf each year, and off southern Labrador in 1995 (Figure 12). In both years squid also occurred on the Southern Grand Bank, although in lower abundances. Finally, the low abundances of squid within the inshore bays indicates that spawning occurred offshore on the Northeast Newfoundland Shelf. We do not speciate the squid samples as part of our standard sampling protocol. However, examination of a limited number of samples in the laboratory indicates that the squid on the NE Newfoundland Shelf were dominated by the Arctic squid, *Gonatus fabricii*. A second Arctic squid species also occurred in our samples, but so far it has not been identified. These are juvenile stages of squid, ranging in size from approximately 25-60 mm in mantle length. Many species of squid can occur in North Atlantic waters and squid sampled on the Southern Grand Bank may represent different species than those sampled on the Northeast Newfoundland Shelf.

Atlantic cod (*Gadus morhua*) ranged in size primarily from 30-60 mm in 1994 and from 35-70 mm in 1995 (Figure 13). In 1994, Atlantic cod were distributed broadly over the NE Newfoundland Shelf and throughout the inshore area (Figure 13). There was also a distinct concentration sampled on the southern Grand Bank in 1994. These distributions indicate that there were three distinct spawning areas: 1) offshore in shelf waters off southern Labrador; 2) inshore within the bays along the northeast coast of Newfoundland; and 3) on the Southern Grand Bank. In contrast in 1995, Atlantic cod only occurred sporadically offshore on the NE Newfoundland Shelf and were mostly absent on the southern Grand Bank, indicating that spawning had occurred predominantly inshore (Figure 13). Juvenile Atlantic cod occurred throughout the inshore in 1995, being most abundant in Notre Dame Bay.

Juvenile redfish (*Sebastes* spp.) occurred over Funk Island Bank and the southern Grand Bank each year, as well as a small concentration on the eastern slope of the Northern Grand Bank in 1995 (Figure 14). Redfish ranged in length primarily from 30-65 mm, being more abundant in 1995. Redfish are oceanic spawners and their distributions on the outer shelf areas each year may reflect advection onto the shelf in these areas.

The largest nekton was dominated by one year old capelin. They ranged in size primarily from 55-100 mm in 1994 and 70-120 mm in 1995 (Figure 15). They were distributed most abundantly over the Northern Grand Bank and throughout the inshore area each year and were notably absent on the outer part of the NE Newfoundland Shelf and the Southern Grand Bank (Figure 15). The largest capelin caught, estimated as 2 years old, ranged in size from 120-160 mm length (Figure 16). In 1994, two year old capelin (1992 year-class) were almost absent, whereas they were distributed quite widely in 1995 (1993 year-class) (Figure 16). It is noteworthy that the distributions of the 1993 year-class as one year old (in 1994) and as two year-old (in 1995) were very similar, indicating similar life history requirements.

Juvenile herring (*Clupea harrengus*) were sampled by the IYGPT each year, although their geographic distributions were restricted to Notre Dame Bay (Figure 17). These data demonstrate that dispersal of herring onto the shelf was limited, compared to capelin, and that there was a detectable spring herring spawning in 1995, which was virtually absent in 1994.

Juvenile turbot (*Glyptocephalus cynoglossus*) were only caught at one station, near Notre Dame Bay, in 1994. In contrast, turbot were sampled throughout the offshore area of the Northeast Newfoundland Shelf in 1995, but remained absent from the inshore bays and on the Grand Banks. Abundances were highest in the vicinity of Hamilton Bank and Belle Isle Bank. The 1995 distribution was consistent with spawning occurring over deep water, both on the shelf and beyond the shelfbreak.

Juvenile American plaice (*Hippoglossoides platessoides*) occurred in low abundances inshore and on the Southern Grand Bank each year. They were totally absent offshore on the Northeast Newfoundland Shelf, and occurred at one or two stations only on the Northern Grand Bank. These distributions are consistent with spawning within the bays and on the Southern Grand Bank.

Spatial Relationships

These broad-scale, multi-gear surveys have created an unique data set to describe the pelagic ocean conditions in late summer, following the spring and summer spawning periods. These surveys suggest that there are four distinct oceanic domains sampled by the survey: 1) the Northeast Newfoundland Shelf and the Southern Labrador Shelf; 2) the Northern Grand Banks; 3) the Southern Grand Banks; 4) the inshore bays along the northeast coast of Newfoundland. The Northeast Newfoundland Shelf is characterized by high copepod biomass and abundant juvenile fish and squid populations which are feeding on the copepods. Here the planktivores occurred primarily from 40-120 mm in size. Surface waters are relatively cold while water depths are deep, exceeding 300-400 m, compared to the Grand Banks. In contrast, the Grand Banks had a low biomass of large copepods and an extremely low abundance of juvenile fish and squids. Instead, the pelagic community was predominantly composed of one and two year old capelin. This suggests the larger capelin were not feeding on copepods, or that they preferred the warmer waters of the Grand Banks. The Southern Grand Bank was distinguished by the highest water temperatures and the dominance of *Centropages hamatus*, compared to *Calanus finmarchicus* to the north. The low abundance, to total absence, of larval and juvenile fish on the Southern Grand Bank was not expected. The Southern Grand Bank has traditionally been an important spawning area for cod, capelin, American plaice, and yellowtail flounder. Inshore there was lower copepod biomass than the adjacent shelf, but here we observed the highest concentrations of larval fish. It appears the inshore area was the most important spawning area for fish, with the exception of turbot. However, the offshore shelf remains an important area for the distribution of pelagic juvenile fish, where feeding conditions may be better.

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Table 1. Summary of zooplankton dry weight (mgDW 10^3m^{-3}) data, from 1994 and 1995, for different size fractions.

	< 1mm	1-2 mm	>2 mm	Total
1994				
Mean	1.14	2.46	2.51	5.88
Minimum	0.05	0	0.14	0.22
Maximum	9.63	17.25	22.01	25.73
1995				
Mean	2.62	5.96	9.03	17.61
Minimum	0.10	0.03	1.02	1.38
Maximum	19.21	95.28	42.64	102.48

Table 2a. Relative overall abundance and incidence of occurrence of dominant fish species caught in the bongos during the pelagic 0-group survey in 1994.

Species	Scientific Name	Relative Abundance(%)	Incidence(%)
Capelin	*Mallotus villosus*	52.0	43.4
CYT eggs	Yellowtail-cunner	11.7	35.3
Yellowtail flounder	*Limanda ferruginea*	9.4	23.2
Cunner	*Tautoglabrus adspersus*	9.1	31.3
CHW eggs	Cod-Haddock-Witch	8.2	43.4
Witch flounder	*Glyptocephalus cynoglossus*	1.9	23.2
4beard Rockling	*Enchelyopsus cimbrus*	0.7	20.2
American plaice	*Hippoglossoides platessoides*	0.7	12.1
Seasnails	*Liparus* sp.	0.5	12.1
Sandlance	*Ammodytes* sp.	0.5	9.0

Table 2b. Relative overall abundance and incidence of occurrence of dominant fish species caught in the bongos during the pelagic 0-group survey in 1995.

Species	Scientific Name	Relative Abundance(%)	Incidence(%)
Capelin	*Mallotus villosus*	86.8	45.3
Cunner	*Tautoglabrus adspersus*	2.7	13.7
CYT eggs	Yellowtail-Cunner	2.4	16.6
CHW eggs	Cod-Haddock-Witch	1.4	27.3
Sand lance	*Ammodytes* sp.	0.5	7.2
Fish eggs	Unidentified	0.4	8.6
Lanternfish	Myctophidae	0.3	9.4
Seasnails	*Liparus* sp.	0.2	0.7
Alligatorfish	*Aspidophoroides* sp.	0.2	0.8
Herring	*Clupea harrengus*	0.2	4.3

Table 3a. Relative overall abundance and incidence of occurrence of dominant fish species caught in the IYGPT during the pelagic 0-group survey in 1994.

Species	Scientific Name	Relative Abundance(%)	Incidence(%)
Capelin	*Mallotus villosus*	74.9	65.7
Arctic cod	*Boreogadus saida*	15.5	64.7
Squid	Cephalopoda	2.8	53.5
Sand lance	*Ammodytes* sp.	2.7	20.2
Redfish	*Sebastes* sp.	2.2	8.1
Alligatorfish	Agonidae	0.7	60.6
Atlantic cod	*Gadus morhua*	0.5	52.5
Seasnails	*Liparus* sp.	0.2	42.4
Sculpins	Cottidae	0.2	46.5
Shannies Blennies	Stichaeidae	0.1	26.3

Table 3b. Relative overall abundance and incidence of occurrence of dominant fish species caught in the IYGPT during the pelagic 0-group survey in 1995.

Species	Scientific Name	Relative Abundance(%)	Incidence(%)
Arctic cod	*Boreogadus saida*	54.9	76.3
Capelin	*Mallotus villosus*	16.6	50.4
Squid	Cephalopoda	12.5	84.2
Sand lance	*Ammodytes* sp.	4.6	33.1
Herring	*Clupea harengus*	3.1	0.1
Alligatorfish	Agonidae	2.0	73.4
Redfish	*Sebastes* sp.	1.9	25.9
Seasnails	*Liparus* sp.	1.3	59.0
Atlantic cod	*Gadus morhua*	0.9	30.9
Sculpins	Cottidae	0.2	36.7

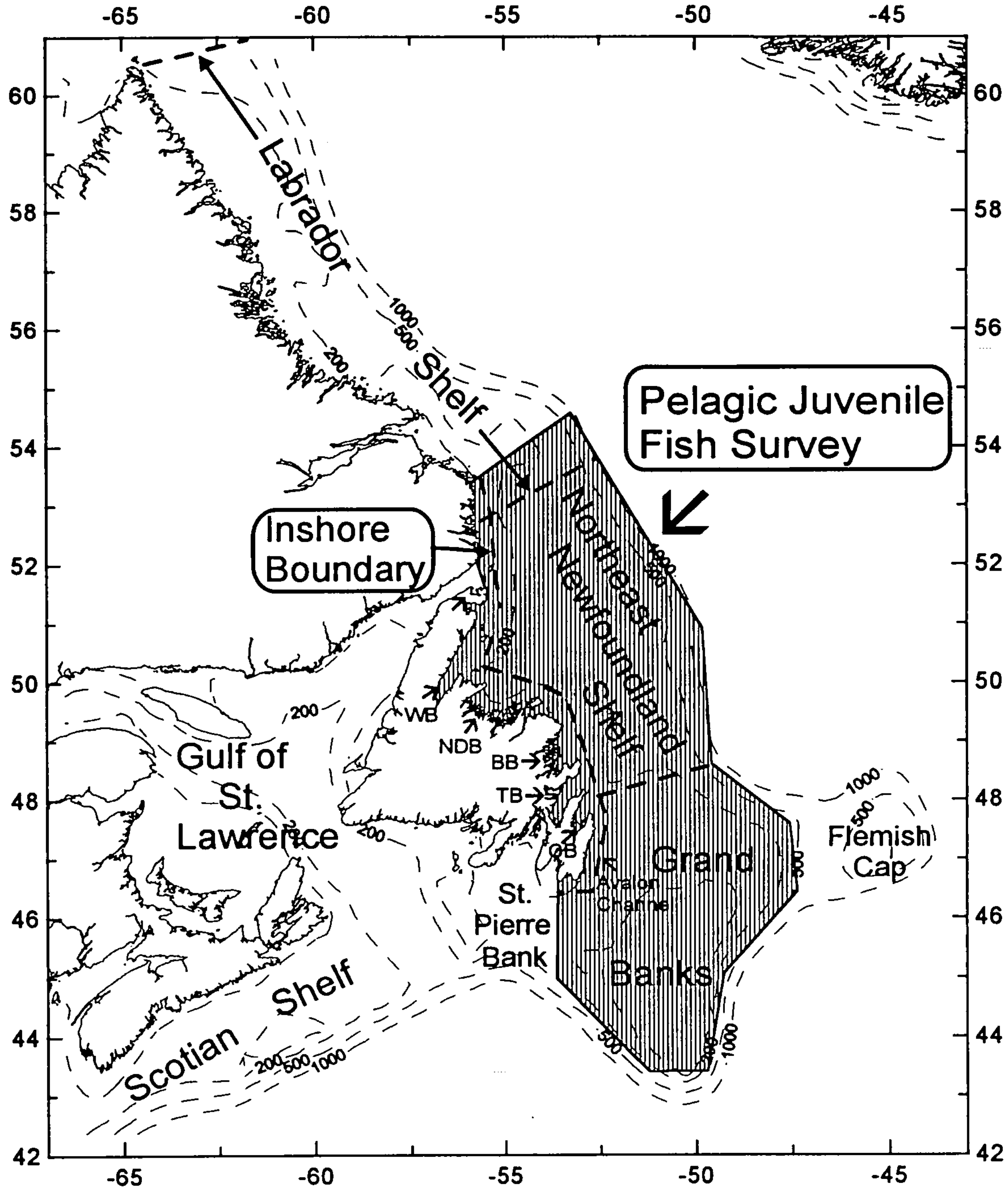

Figure 1. Survey area outlining the main sampling features on the southern Labrador Shelf, the entire Northeast Newfoundland Shelf and Grand Banks. The inshore area along the northeast coast of Newfoundland and off southern Labrador lies within the dashed line indicated. Major inshore bays include: WG - White Bay; NDB - Notre Dame Bay; BB - Bonavista Bay; TB - Trinity Bay; CB - Conception Bay.

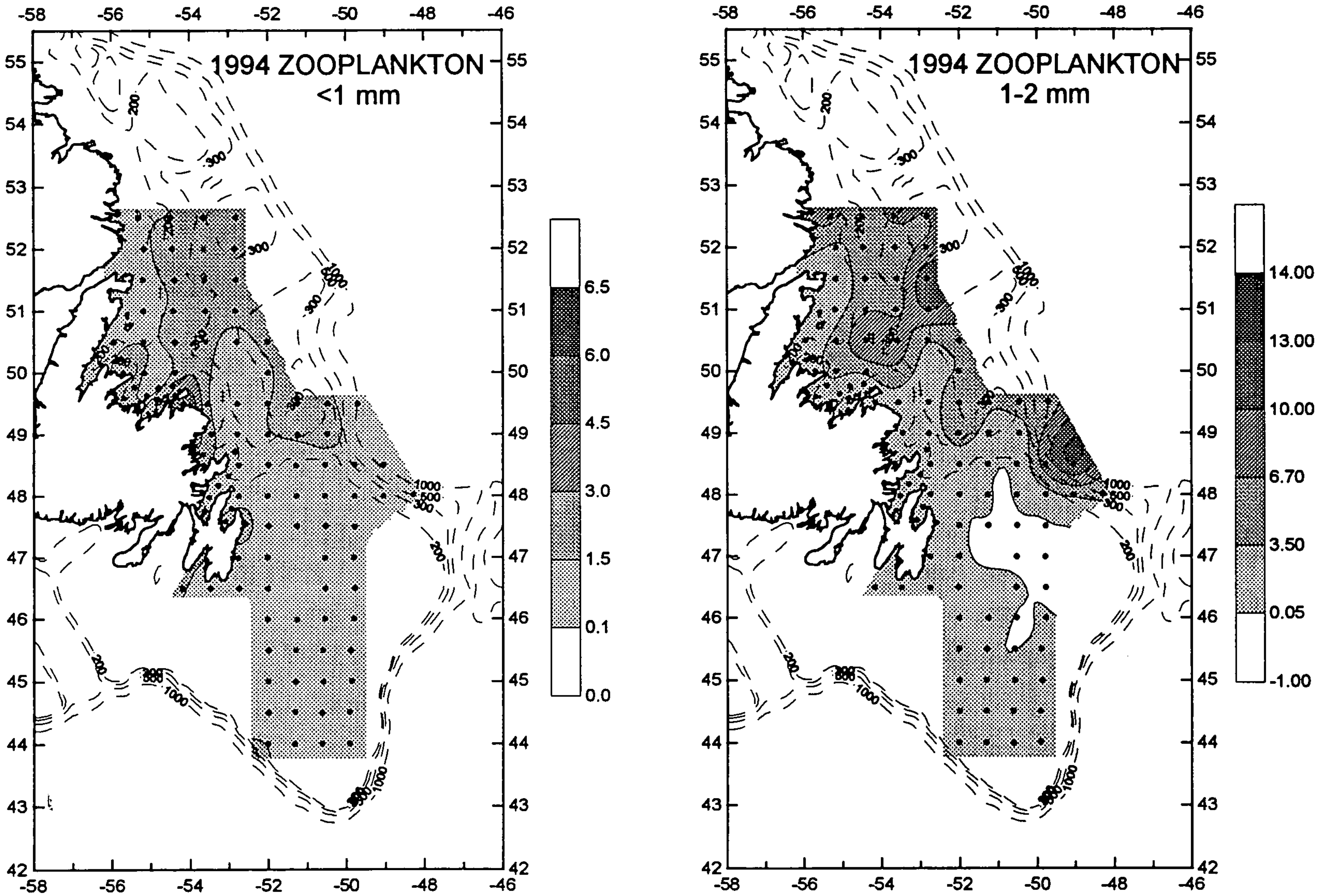

Figure 2. Distributions of invertebrate zooplankton biomass (mgDW/m^3) for size fractions 0.15-0.33 mm and 1-2 mm, 1994.

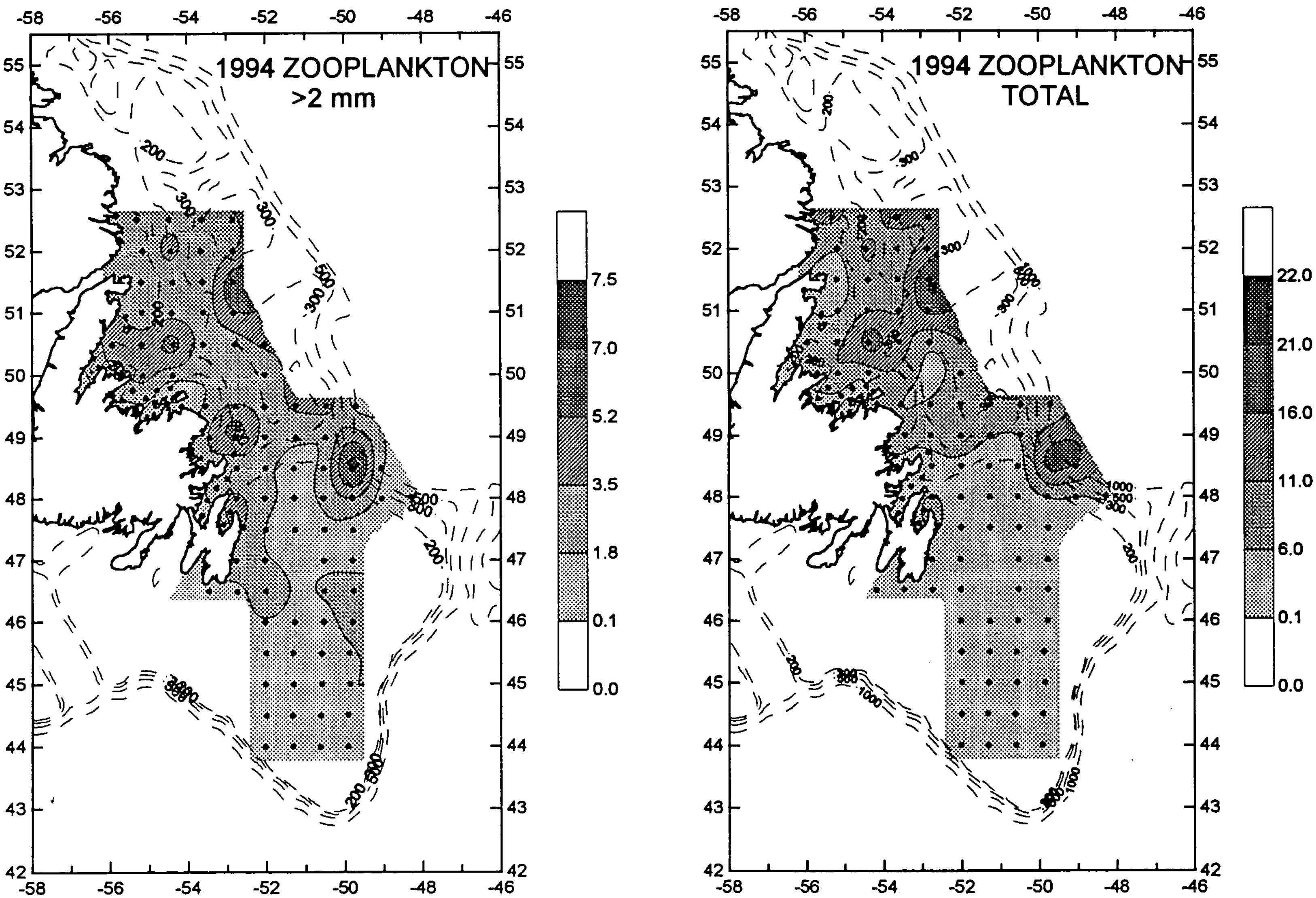

Figure 3. Distributions of invertebrate zooplankton biomass (mgDW/m^3) for size fractions > 2 mm in size and the total biomass of all sizes combined, 1994.

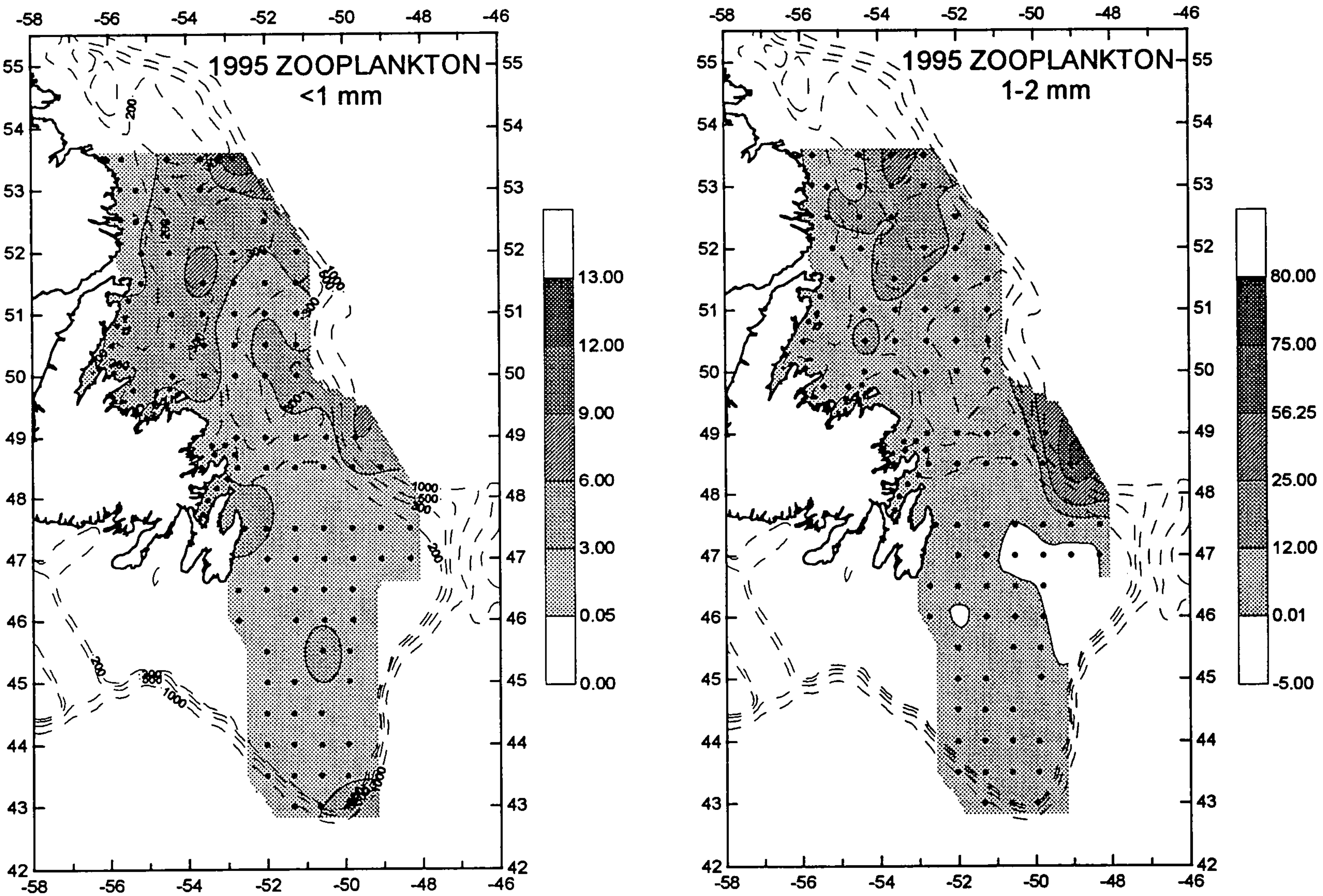

Figure 4. Distributions of invertebrate zooplankton biomass (mgDW/m^3) for size fractions < 1 mm and 1.2 mm in size, 1995.

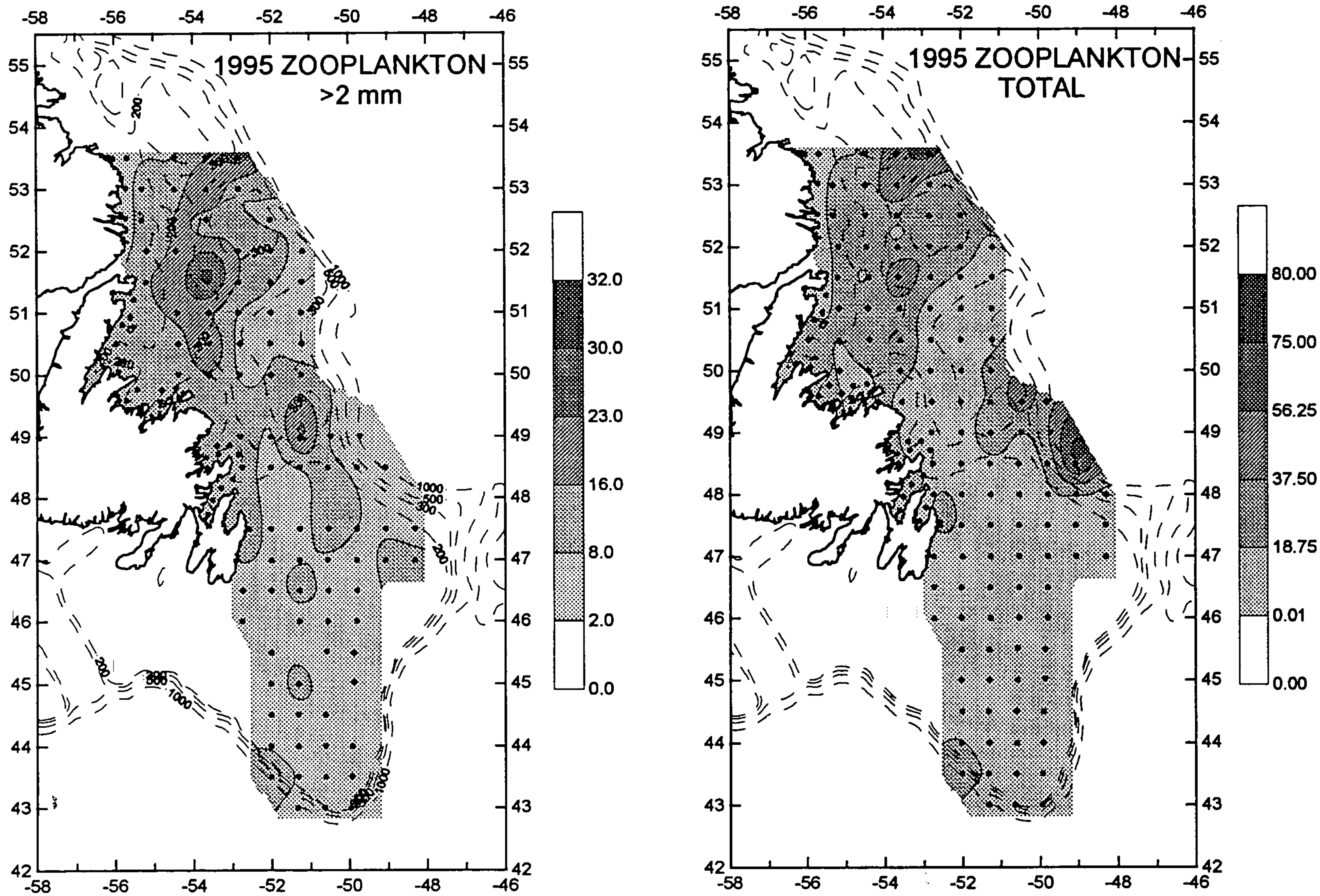

Figure 5. Distributions of invertebrate zooplankton biomass (mgDW/m^3) for size fractions > 2 mm in size and the total biomass of all sizes combined, 1995.

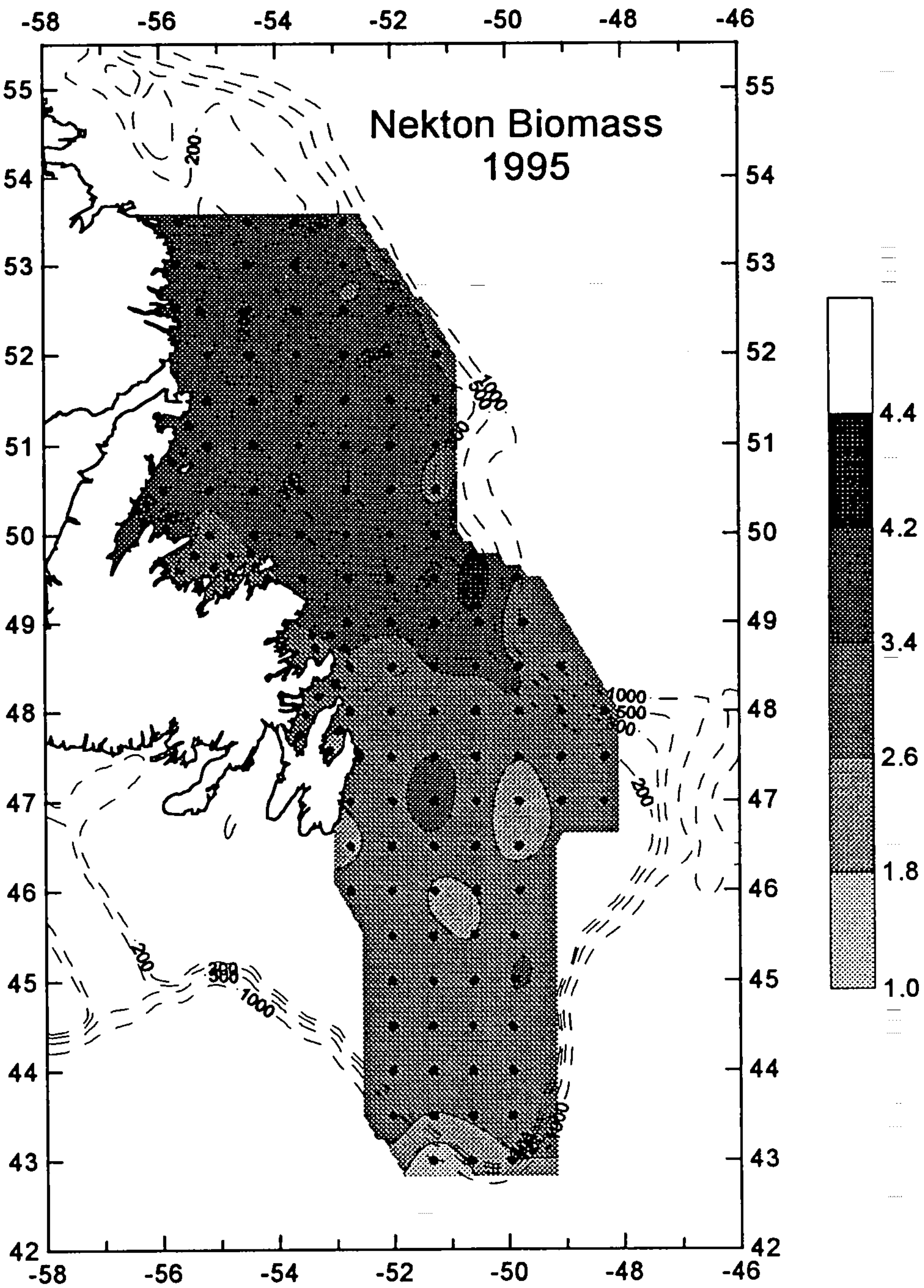

Figure 6. Distribution of nekton biomass (g Wet Weight/tow) sampled by the IYGPT, in 1995.

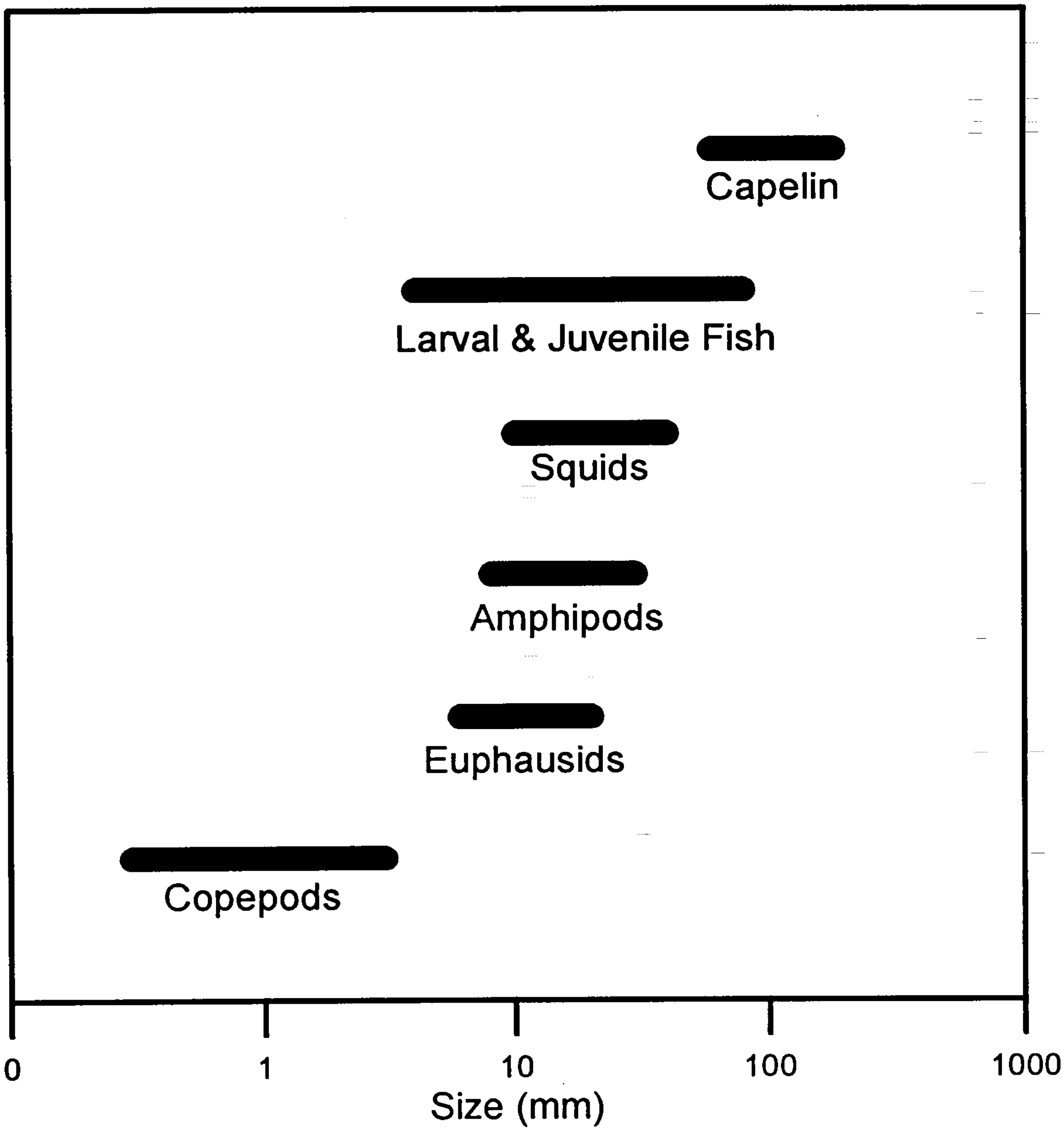

Figure 7. Scehmatic representation of predominant taxa caught during the surveys and their approximate size rages. Capelin refers to one and two year old capelin.

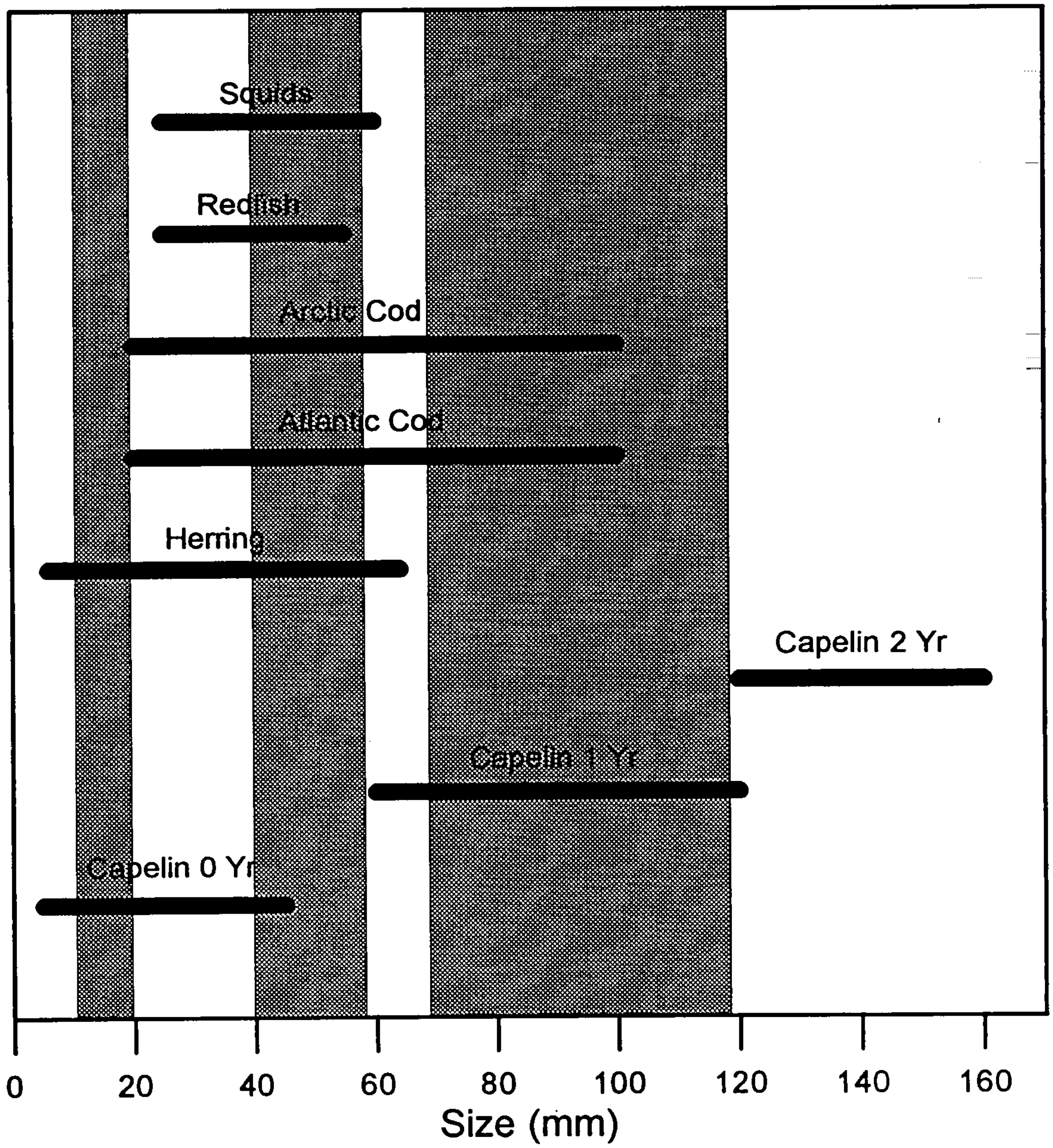

Figure 8. Schematic representation of the dominant species sampled in the surveys and their approximate size ranges. The shaded vertical bars represent the size ranges where most of the biomass occurred. Biomass in the smallest size range is primarily due to larval capelin, in the mid-size range it is primarily due to Arctic cod and squids, while in the largest size range it is due to one year old capelin.

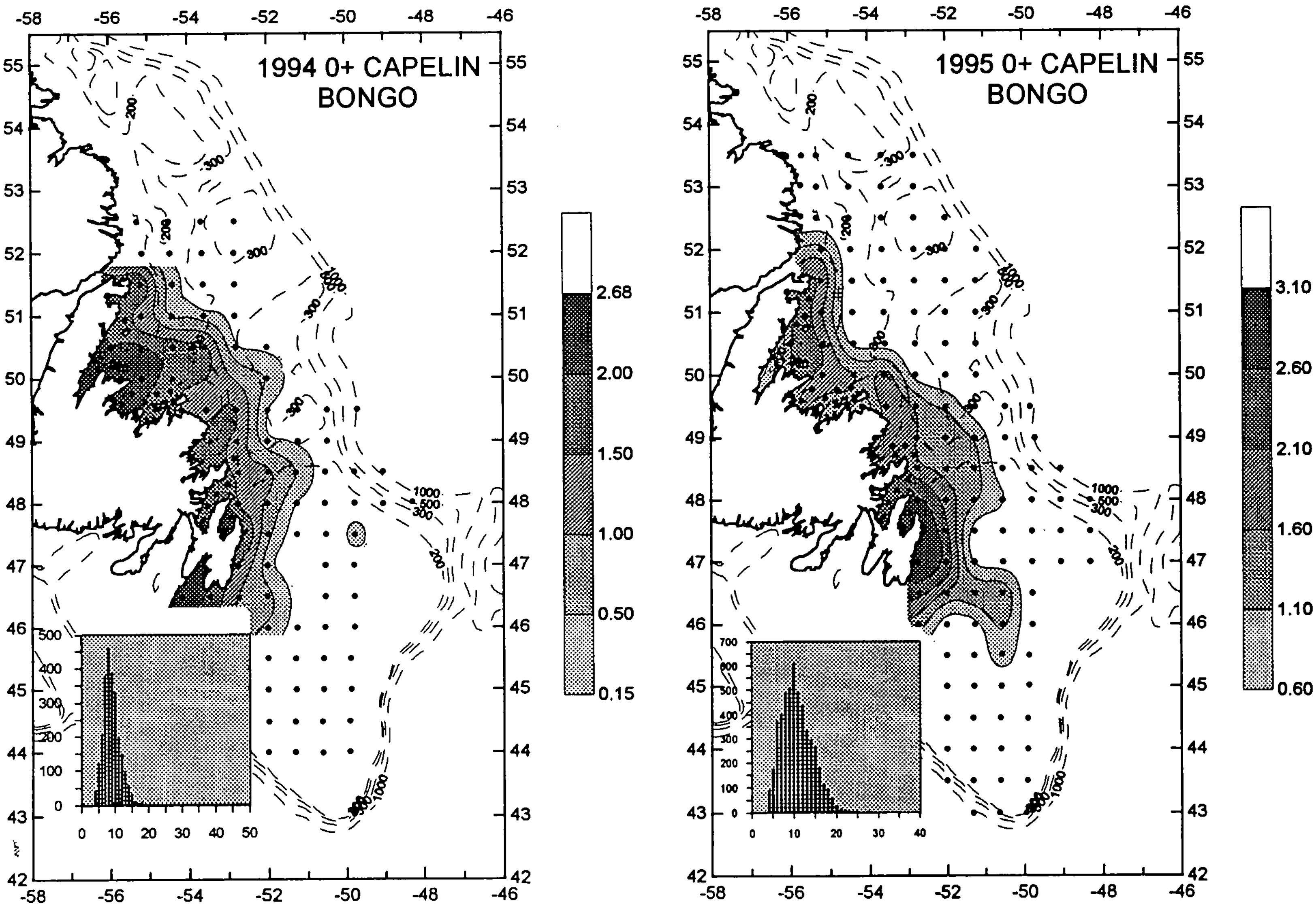

Figure 9. Distribution of larval capelin (Mallotus villosus) (log_10 number/1000 m^3) caught in the bongos in 1994 and 1995. The length frequency distributons (number sampled by length (mm)) are plotted in the lower left corner of each map.

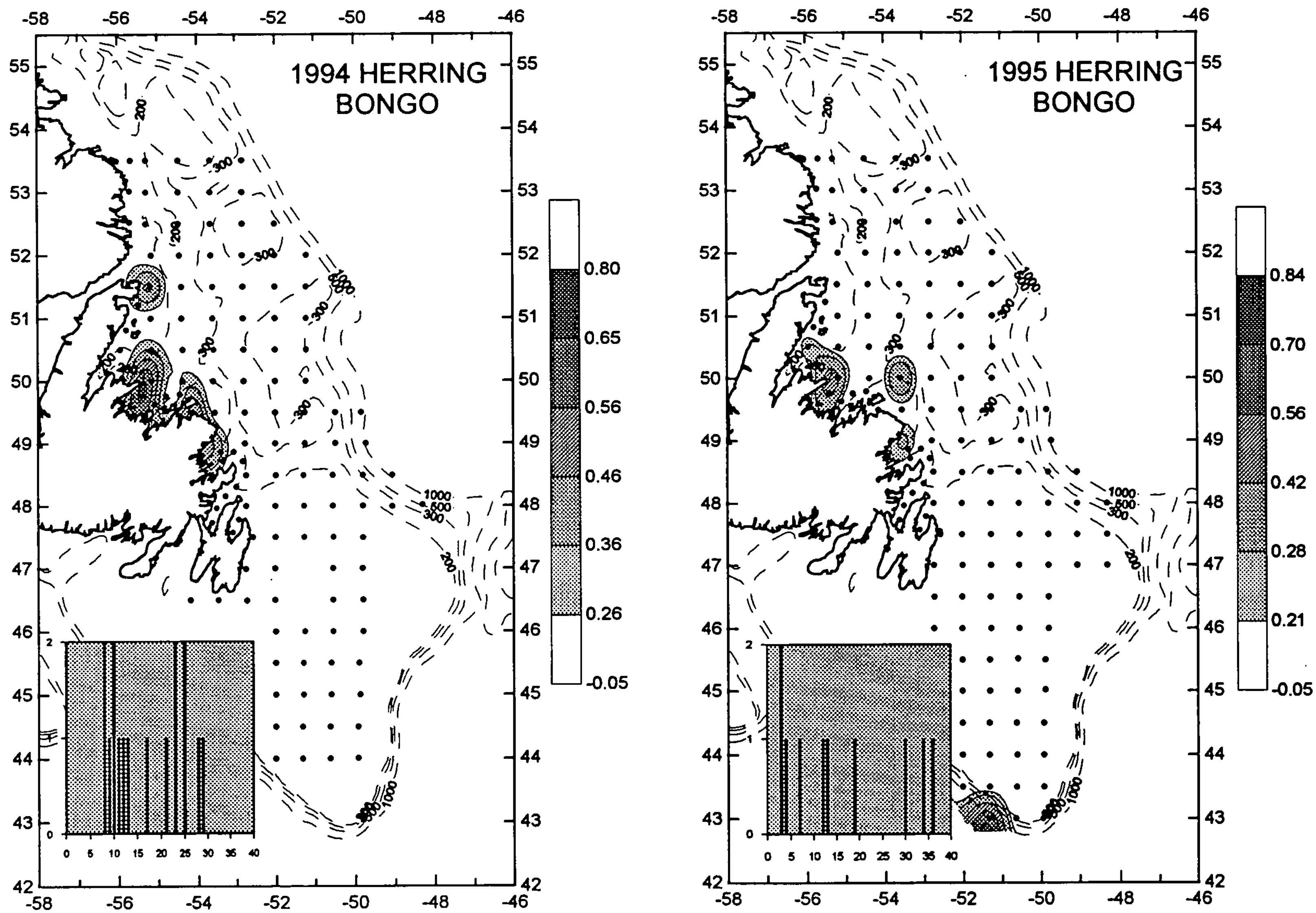

Figure 10. Distribution of larval Atlantic herring (Clupea harrengus) (log_10 number/10^3 m^3) caught in the bongos in 1994 and 1995. The length frequency disributions (number sampled by length (mm)) are plotted in the lower left corner of each map.

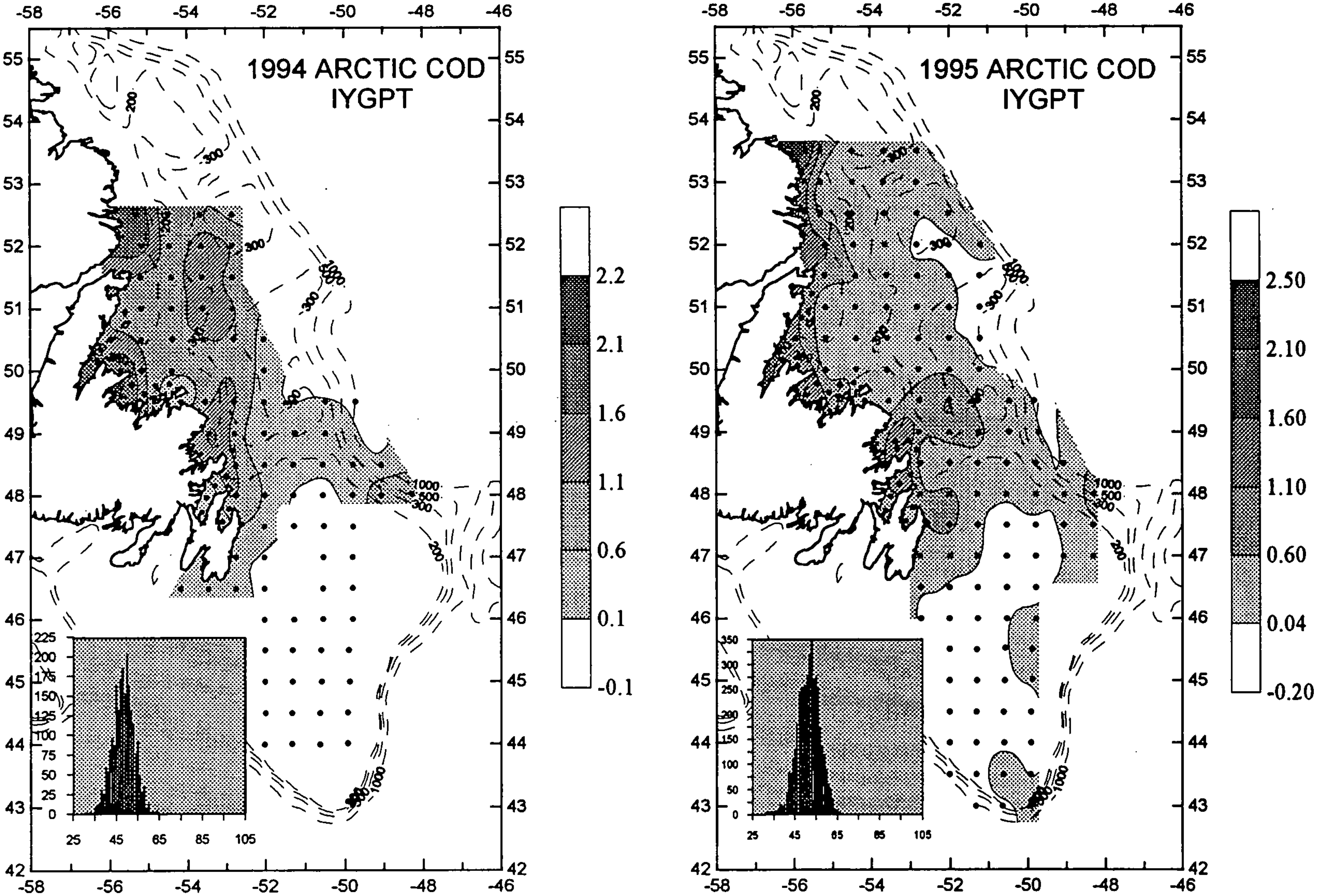

Figure 11. Distribution of juvenile Arctic cod (Boreogadus saida) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.

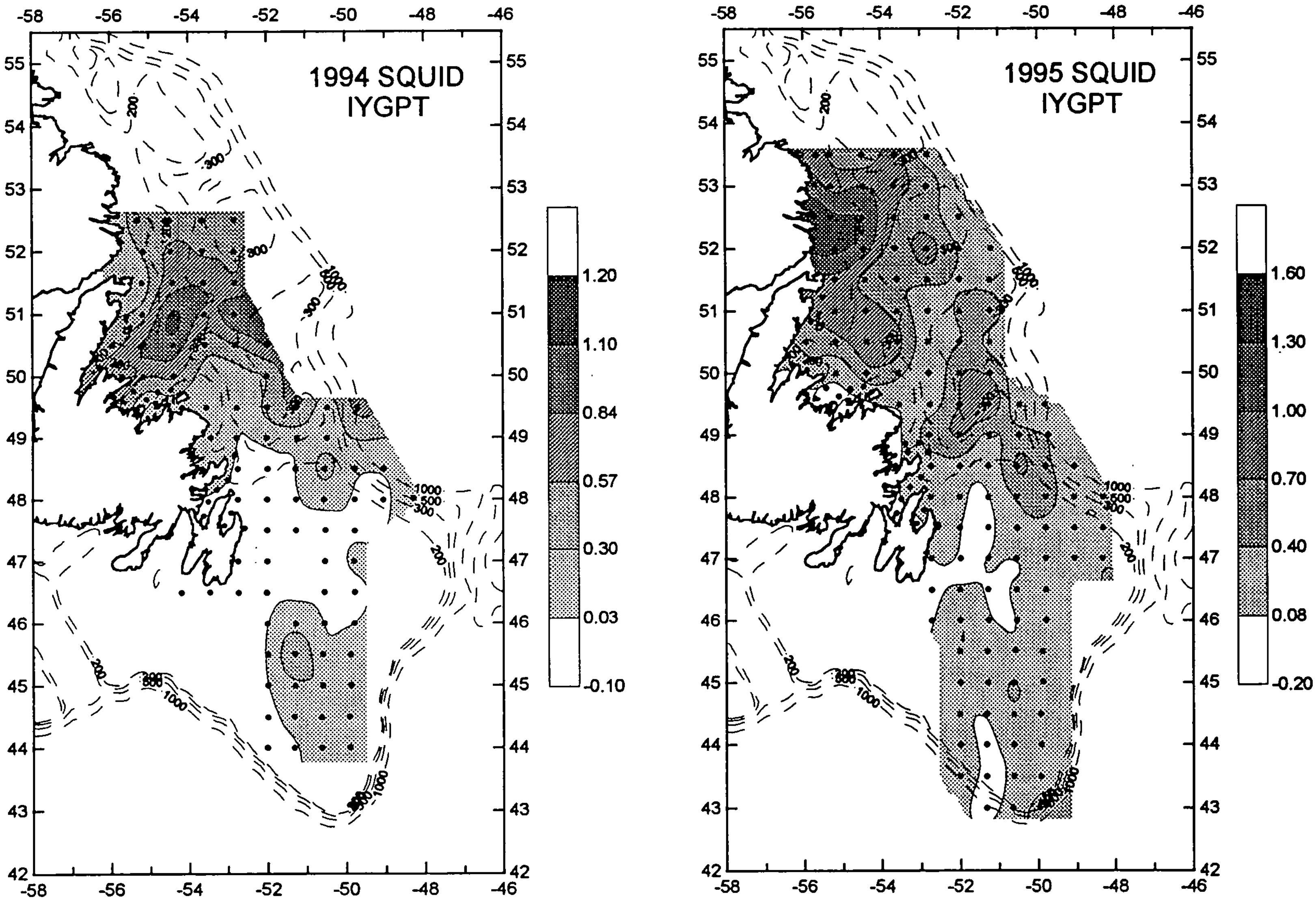

Figure 12. Distribution of juvenile squids (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995.

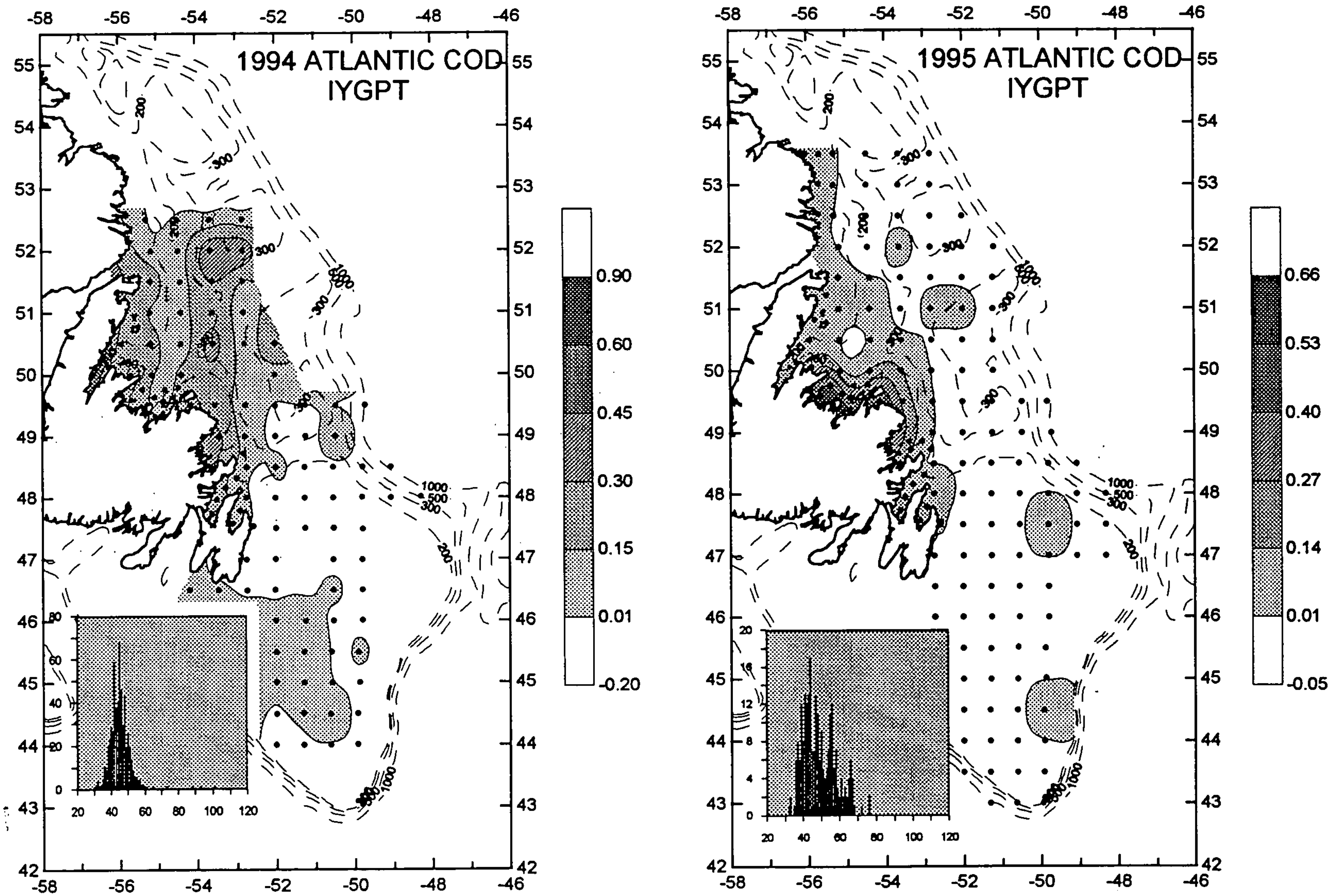

Figure 13. Distribution of juvenile Atlantic cod (Gadus morhua) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.

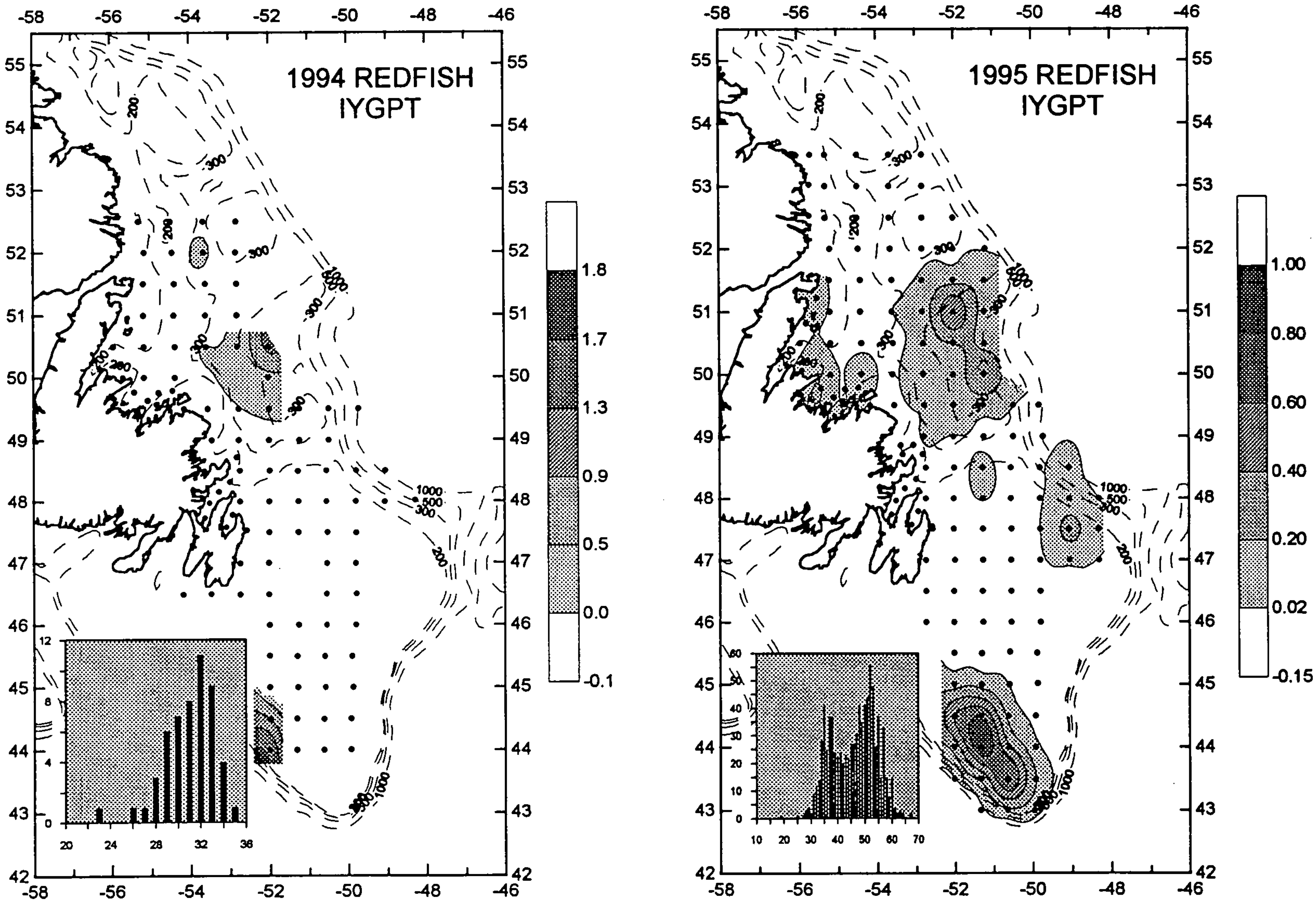

Figure 14. Distribution of juvenile redfish (Sebastes sp.) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.

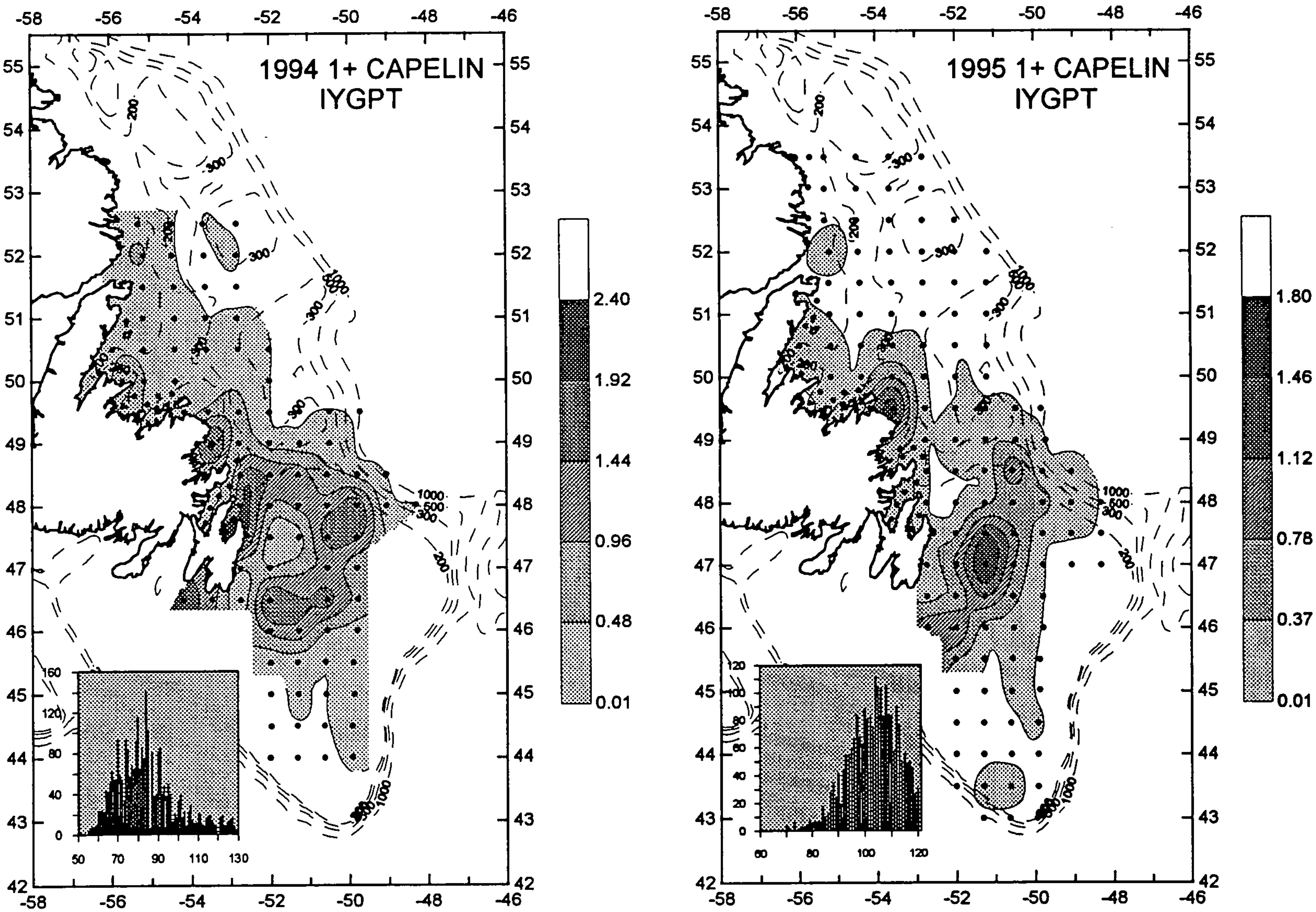

Figure 15. Distribution ofone year old capelin (Mallotus villosus) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.

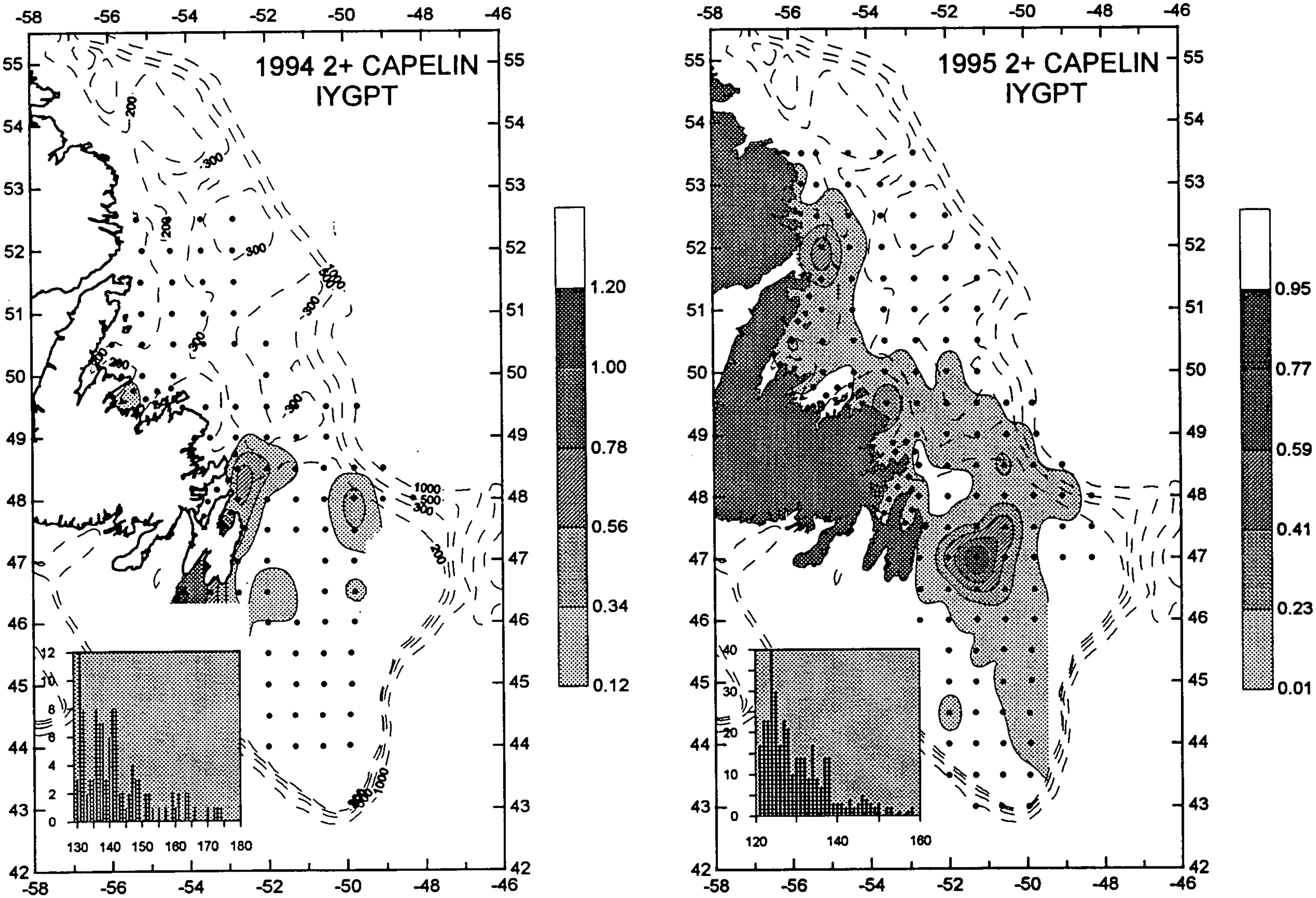

Figure 16. Distribution of two year old capelin (Mallotus villosus) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.

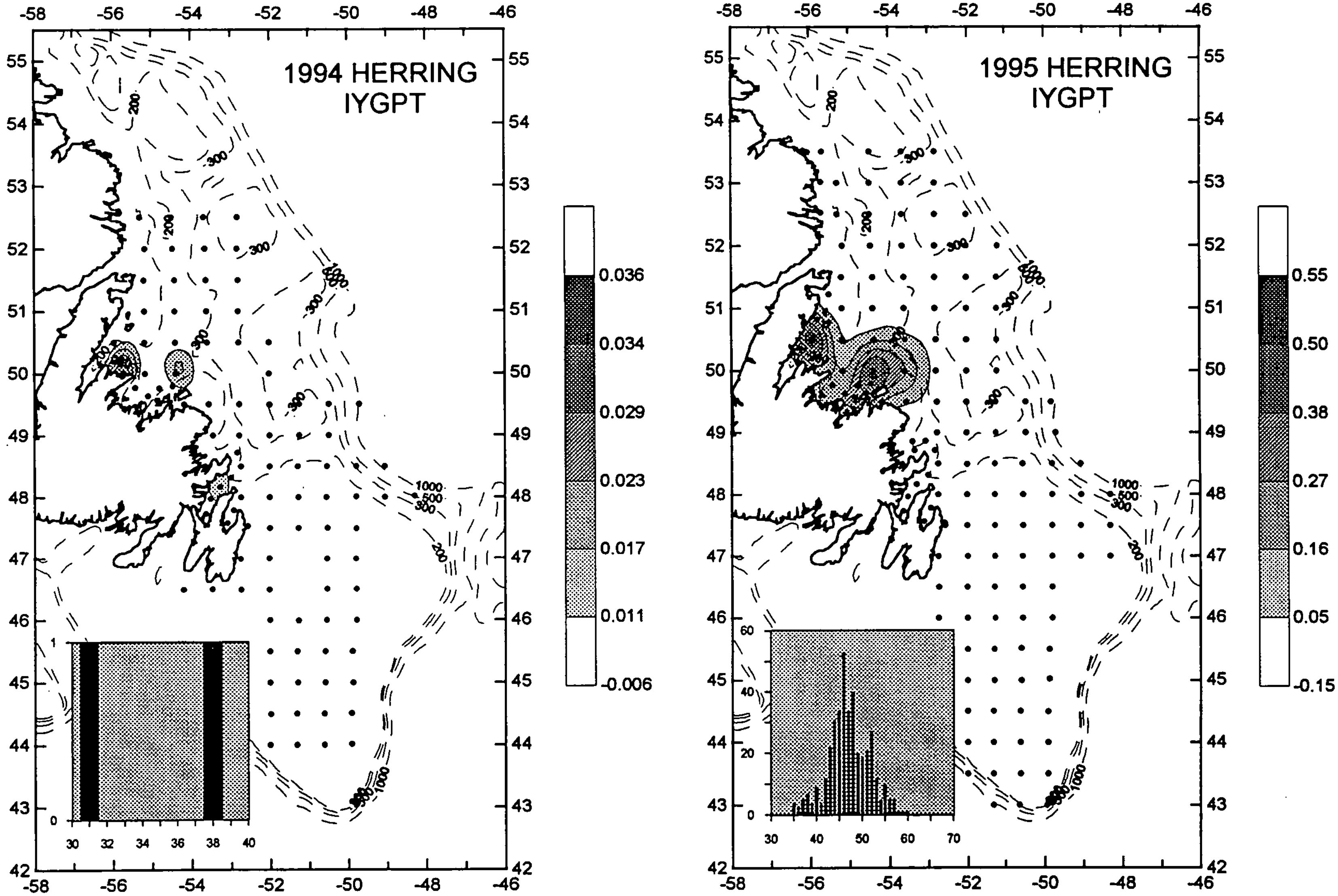

Figure 17. Distribution of juvenile (0-group) Atlantic herring (Clupea harrengus) (log_10 number/10,000m^3) caught in the IYGPT trawls in 1994 and 1995. The length frequency distributions (number measured by length (mm)) are plotted in the lower left corner of each map.