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Distribution and Abundance Patterns of Eggs and Larvae of Walleye Pollock (*Theragra chalcogramma*) in the Western Gulf of Alaska

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by

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INTRODUCTION

From 1972-1982, the Northwest and Alaska Fisheries Center (NWAFC) conducted, either singly or jointly with the U.S.S.R., 21 ichthyoplankton surveys in the western Gulf of Alaska. Additionally, in spring of 1978 and 1980, the U.S.S.R. conducted wide ranging ichthyoplankton surveys extending from west Prince William Sound to the Shumagin Islands (Boretz 1979, 1981). The principal goal of the early surveys (e.g., 1972-1980) was to assess the distribution and relative abundance of ichthyoplankton in the region. Later cruises (e.g., 1981 and 1982) were directed toward estimating the extent of spawning of walleye pollock (*Theragra chalcogramma*) in the area. Most of these surveys have been in waters contiguous to Kodiak Island, but some recent surveys extended both east and west of this area.

Results of some of these surveys have been previously documented: Dunn and Naplin (1974) reported on the spring 1972 survey; Kendall et al. (1980a,b) and Kendall and Dunn (MS 1983) reported on NWAFC cruises from fall 1977-winter 1979; and Bates and Clark (1983) presented ichthyoplankton data collected during cooperative U.S. and U.S.S.R. cruises in 1981.

This report summarizes the distribution and relative abundance of eggs and larvae of walleye pollock in the western Gulf of Alaska based on data from these 21 surveys. The purpose is to examine spatial and temporal patterns of distribution and relative abundance and to relate these patterns to bathymetry and known oceanographic features. These patterns are heavily influenced by the extensive sampling in spring 1981, but we feel that they may represent the patterns to be expected in other years also.

THE STUDY AREA

The topography of the western Gulf of Alaska (Fig. 1) is characterized by rugged configuration consisting of numerous troughs normal to the coastline that are separated by shallow banks. The shelf area (generally defined by the 200 m isobath) is wide (about 65-175 km); seaward of the 200 m break, the shelf drops abruptly to maximum depths of 5000-6000 m in the Aleutian Trench. The southwesterly flowing Alaska Stream (Fig. 1) is the dominant regional oceanographic feature that is approximately coincident with the shelf break. Mean speeds range from 50-100 cm/sec (Muench and Schumacher 1980; Reed et al. 1980). The Kenai Current flows westerly nearshore through Prince William Sound and into Shelikof Strait, where it then flows southwesterly at mean speeds of 10-70 cm/sec (Schumacher and Reed 1980). At least some water of the Kenai Current continues westward along the Alaska Peninsula and enters the Bering Sea through Unimak Pass (Schumacher and Reed 1983).

METHODS AND MATERIALS

Data collection

Of the 21 ichthyoplankton cruises considered here, most (12) were conducted in spring (March-May) as listed in Table 1. There were also three summer, four fall, and two winter cruises. Of the 1397 total stations considered here, 874 were occupied in spring 1981. The pattern of stations varied among cruises, depending upon the objectives of the survey. Station patterns for cruises with catches of eggs and larvae with their distribution are shown in Appendix Figures 1-16, while the distributions of stations sampled by month (all cruises combined) are illustrated in Figures 2-6.

Sampling gear normally consisted of paired bongo nets (Posgay and Marak 1980) and a surface neuston sampler. A standard MARMAP bongo tow (Smith and Richardson 1977) with a 60 cm frame and 0.505-mm mesh nets was made with a maximum of 300 m of wire out at each station. Flowmeters were used to determine the volume of water filtered by each net. A Sameoto neuston sampler (Sameoto and Jaroszynski 1969) measuring 0.3 m high by 0.5 m wide, with a 0.505 mm mesh net, was towed at 2.0 knots (1.03 m/sec) for 10 minutes at each station. Because neuston nets collected few walleye pollock eggs or larvae (Table 1), only catches in bongo nets are considered herein.

During a cooperative U.S.-U.S.S.R. survey in 1979 (1P079), the bongo array was lost on the third station occupied. A single 60-cm frame (termed a "bong") was fabricated at sea and used until a replacement bongo frame was obtained. No walleye pollock eggs or larvae were taken by any gear during this September-October cruise (Table 1).

At most stations occupied by U.S. research vessels, conductivity and temperature profiles were made from the surface to near bottom. On cruises aboard Soviet research vessels, hydrographic casts at standard depths (0, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500, and 600 m) were made as water depth permitted. Temperature and salinity, and in some cases oxygen, phosphate, and silicate determinations were made aboard ship. These data will be considered in subsequent reports.

Sampling processing

Fish eggs and larvae were sorted from the samples and identified to lowest taxa. Walleye pollock larvae (up to a maximum of 50 specimens per sample) were measured (standard length) under a binocular microscope to the nearest 0.1 mm.

Data analysis

Numbers of eggs and larvae collected in bongo nets are expressed as catch per 10 m^2 of sea surface (Smith and Richardson 1977). Catches of walleye pollock eggs and larvae are plotted in monthly or bimonthly periods. Relative abundance is contoured at six levels: 0, 1-100, 101-1000, 1001-10,000, 10,001-100,000, and >100,000 per 10 m^2 of sea surface. Distribution and relative abundance of walleye pollock eggs are shown in Figures 7-14 and of larvae in Figures 16-22.

Relative changes in abundance of walleye pollock eggs and larvae as the spawning season progresses are illustrated by combining catches for all spring cruises. Frequency distributions of logarithms (base 10) of egg and larval station abundances (numbers/10 m^2) in each 10-day interval were generated (Figs. 15, 23). The means of the logarithms of abundance are shown to indicate relative differences in abundance with time.

The distribution of lengths of larvae collected in bongo samples with day of the year is depicted in Figure 24. Data were grouped by 0.4 mm intervals of length and 2 day intervals of time.

RESULTS

Through our studies and those of others (Nunallee, pers comm.) we have found that a major life history feature of walleye pollock in the Gulf of Alaska is a winter spawning migration into Shelikof Strait via the gully that runs between the Semidi and Chirikof Islands. By early spring the fish have moved into the deeper water of Shelikof Strait to spawn there. For convenience in this report we will define Shelikof Strait as the ocean area bounded by 58°30'-56°00'N latitude and 157°00'-153°00'W longitude, realizing that this area extends southwest of the area normally considered within the Strait.

Eggs

Walleye pollock eggs were collected during February through June and in October and November (Figs. 7-14). Sampling was not conducted in January, August, or December, and eggs were not taken in July and September.

Most of the sampling effort was concentrated to the south and east of Kodiak Island in February, yielding one collection at the shelf break and another in Shelikof Strait at the western limit of sampling effort (Fig. 7).

In early March (i.e., March 1-15), eggs were encountered in shelf waters northeast of Kodiak Island and in Shelikof Strait (Fig. 7); sampling, however, did not extend west of Shelikof Strait during this period. In Shelikof Strait, 80% of the catches were positive for walleye pollock eggs, however all catches throughout the survey area had abundances less than 100 per 10 m^2 of sea surface. In late March (i.e., March 16-31), a few eggs were collected northeast of Kodiak Island (Fig. 8), throughout Shelikof Strait, and at a few scattered locations south and west of Shelikof Strait. In Shelikof Strait 82% of collections were positive for walleye pollock eggs; 38% had catches between 101 and 1,000 per 10 m^2. There were also two heavier concentrations in this area, one with catches between 1000 to 10,000 and one with catches greater than 100,000 eggs per m^2.

In early April, eggs were taken throughout Shelikof Strait as well as in adjacent waters to the east, south, and southwest (Fig. 9). In the northwest portion of Shelikof Strait, catches at several locations exceed 100,000 per 10 m^2. Concentrations of eggs at one station in slope waters at 156°W also were >100,000 per 10 m^2. Walleye pollock eggs in late April (Fig. 10) occurred across the shelf and upper slope throughout the sampling area. Abundance reached 10,001-100,000 eggs per 10 m^2 in the center and at the west end of Shelikof Strait, but abundance ranged from 1,001-10,000 over broad areas of the Strait. To the west of Shelikof Strait, abundance did not exceed 10,000 eggs per 10 m^2.

Sampling did not cover much of Shelikof Strait nor areas further west along the Alaskan Peninsula in early May (Fig. 11). Walleye pollock eggs were found southwest of Shelikof Strait, at nearby shelf and slope areas to the south and east, and at the northeast end of Shelikof Strait. Catches did not exceed 10,000 eggs per 10 m^2. In late May only a few stations east of Kodiak Island yielded eggs (Fig. 12), but eggs were found throughout Shelikof Strait, and were widely distributed in shelf and upper slope waters southwest of Shelikof Strait. Abundance was uniformly low in all areas sampled, not exceeding 1,000 eggs per 10 m^2.

In June (Fig. 13) only one station yielded walleye pollock eggs. Sampling in July and September (no sampling in August) did not encounter walleye pollock eggs, although sampling was restricted to shelf and slope areas south and east of Kodiak Island (Figs. 4 and 5). However, when this same general area was sampled in October and November, small numbers of eggs occurred nearshore (Fig. 14).

The seasonal cycle of abundance for walleye pollock eggs derived from the spring collections shows a wide range of abundance by station (Fig. 15). The mean of logarithms of station abundances by 10-day periods indicate that abundance increased from mid March to a peak during April and declined thereafter. Abundances for the intervals 10-19 April and 10-19 May are less than in adjacent intervals, because Shelikof Strait was not sampled during these periods.

In summary, walleye pollock eggs were encountered in low abundance in late fall and winter (October, November, and February). In the spring (March-June), abundance increased with time, peaking in late March and April, and declining in May. Few walleye pollock eggs were encountered in June, July, or September. Abundance was consistently greater in Shelikof Strait than elsewhere and there peaked during the period 16 March-30 April, when catches at several stations exceeded 100,000 per 10 m^2. A secondary area of abundance at the edge of the shelf south of the Trinity Islands was also indicated. Differences in the seasonal cycle of abundance of walleye pollock eggs within the area studied could not be detected.

Larvae

Walleye pollock larvae were taken in the months of March-July and in October and November. Sampling was not conducted in August, December and January. They were not encountered in February or September. Larvae were collected throughout the area sampled, but the extent of distribution and abundance varied by month (Figs. 16-22).

In March (Fig. 16), a few larvae were encountered at three widely disjunct shelf stations, both east and west of Kodiak Island. They were not taken in Shelikof Strait. In early April, larvae were found in Shelikof Strait and adjacent shelf waters, as well as shelf and upper slope areas east and southwest of Shelikof Strait. Relative abundance was low in all areas sampled, exceeding 100 per 10 m^2 only in portions of Shelikof Strait (Fig. 17). In late April (Fig. 18), they occurred widely over the shelf and at some upper slope stations. Most stations sampled in Shelikof Strait yielded pollock larvae where abundance of larvae ranged from 10,001-100,000 throughout much of the central Strait and exceeded 100,000 per 10 m^2 in one collection. Abundance was lower east and west of Shelikof Strait, not exceeding 1,000 larvae per 10 m^2. South of the Trinity Islands (near 154°30'W), abundance reached 1,001-10,000 per 10 m^2 at one location.

The geographical extent of sampling in early May was somewhat limited (Fig. 19). Walleye pollock larvae were encountered at scattered nearshore and upper slope areas to the east of Shelikof Strait, and were abundant southwest of Kodiak Island. The area inside Shelikof Strait was not sampled in early May, nor was the area along the Alaska Peninsula. Abundance was low south and east of Kodiak Island (<100 larvae per 10 m^2). Southwest of Kodiak Island, abundance of larvae ranged up to 10,001-100,000 per 10 m^2. During the latter half of May (Fig. 20), larvae were found throughout Shelikof Strait and in shelf and some upper slope waters. South of Shelikof Strait and east of 153°W (Fig. 20), larvae were encountered at only a few scattered stations. Abundance of larvae was relatively high throughout Shelikof Strait, ranging up to 10,001-100,000 larvae per 10 m^2. Abundance was low to the east of Kodiak Island and west of about 158°W.

From June through November, a few larvae were taken at scattered locations. Sampling during this period was mainly restricted to the shelf southeast of Kodiak Island. In June (Fig. 21) walleye pollock larvae were taken near the eastern and western ends of Kodiak Island. In July, October, and November (Figs. 21-22), larvae were encountered at scattered locations only, occurring both in nearshore and upper slope waters.

The seasonal cycle of abundance of walleye pollock larvae from collections in the spring indicates a wide range of abundance by station (Fig. 23). The mean of logarithms of station abundances by 10-day periods, from late March to May, indicates that abundance increased from late March, peaked in April and May and declined thereafter. Station patterns during the intervals 10-19 April and 10-19 May, however, did not include high abundance stations from Shelikof Strait and thus the means are biased downward.

Figure 24 depicts the range and modes of larval lengths for walleye pollock from March through May. Hatching evidently occurs over an extended period of time, since larvae less than 4 mm were found from late March to late May. Mean lengths of larvae at individual stations during April were about

4 mm long with a standard deviation of about 0.5 mm (CV=1/8) and mean lengths for stations in May were approximately 8 mm with a standard deviation of typically about 2 mm (CV=1/4). This high at-station variability makes it unreasonable to investigate differences in lengths in samples taken at different localities at the same time, or in samples from the same locality separated in time by less than a few weeks. Changes in modal lengths and the increasing range of lengths of larvae with time (Fig. 24) reflect the combined effects of hatching over an extended period, mortality, net avoidance, and growth.

In summary, walleye pollock larvae are found from March to June throughout the western Gulf of Alaska. Abundance increases from March to April, peaks in April and declines thereafter. They are encountered in greatest abundance in Shelikof Strait where catches exceeded 100,000 per 10 m^2 at one station in late April (Fig. 18). Larvae are found in lesser abundance east and west of Shelikof Strait. At stations sampled east of Shelikof Strait, catches were uniformly low, never exceeding 100 per 10 m^2. In the area south of Shelikof Strait, however, catches of walleye pollock larvae in late April and late May exceeded 10,000 per 10 m^2 at some stations and ranged from 1,000-10,000 per 10 m^2 at a number of others (Figs. 18, 20). In the areas sampled west of Shelikof Strait, abundance only ranged up to 1,000 per 10 m^2 (Figs. 18, 20). Hatching appears to extend over a 3 month period, begining in February, peaking in April, and ending in May.

Depth distribution

Data from the 1981 and 1982 cruises were used to investigate the relationship between water depth and abundance of walleye pollock eggs and larvae. The pattern for larvae is similar to that for eggs, although larval abundances were less clearly related to water depth (Fig. 25). In tows over water depths of less than 180 m most catches were less than 100 individuals per 10 m^2. At depths of 180-300 m higher percentages of tows contained eggs and larvae, and catches of between 100-10,000 individuals per 10 m^2 dominated. Few catches in water deeper than 300 m were made, but some of these catches contained over 10,000 individuals per 10 m^2. Catches of over 100,000 per 10 m^2 were only made in depths of 220-300 m. It should be noted that water depths of 180-300 m are common in Shelikof Strait, where many of the larger catches of eggs and larvae occurred.

DISCUSSION

Based on the data presented herein, it is evident that in the western Gulf of Alaska (from about 147°-164°W) Shelikof Strait is the major spawning area of walleye pollock. Most of the detailed information on the Shelikof Strait area comes from the extensive sampling there in spring 1981. Most spawning in this area occurs from late March through April and major concentrations of larvae occur from late April through May. The highest concentrations of eggs (>100,000 per 10 m^2 of sea surface) occurred in a restricted area near 57°45'N and 155°00'W, and there was a consistent pattern of decreasing abundance away from this center (Figs. 7 and 8). In late April there was a dense concentration of larvae (>100,000 per 10 m^2) at 57°25'N and 155°35'W in the center of a larger pattern which covered most of lower Shelikof Strait (Fig. 18). By late May, the next time the area was sampled, an area of dense larval concentration (10,000-100,000 per 10 m^2) was found at about 56°40'N and 156°20'W (Fig. 20). This was in a larger area of 1,001-10,000 larvae per 10 m^2 that was considerably more spread out than the concentrations of eggs and larvae seen earlier. The mean lengths of larvae in these areas of concentration in late April were 4.1 mm, and in late May were 7.5 mm. It thus appears that spawning occurred primarily in a restricted area in lower Shelikof Strait and the eggs and larvae drifted to the southwest in the prevailing Kenai Current.

The ages of the eggs from the 1981 work were determined and will be reported in detail elsewhere although some data were made available to help interpret the distributional patterns described here (Matarese, pers.

comm.). These data indicate that the major concentration of eggs was spawned between about 5 and 8 April. This concentration was seen as one to four day-old eggs on 8 April and as recently hatched larvae on 20 April. These concentrations were 50 km apart, so a drift of 3.6 cm/sec to the southwest is implied. This direction and rate of drift is consistent with expectations in this area (J.D. Schmacher, pers. comm.). When the concentration was next sampled on 24-25 May, the larvae were 7.5 mm long, and had drifted at 2.6 cm/sec from their last sighting, again a rate to be expected in the less confined area just west of narrow part of Shelikof Strait. The implied growth of from 4.1 mm to 7.5 mm in 28 days (0.13 mm/day) is much slower than that determined by otolith increments in Bering Sea walleye pollock larvae (Walline 1980: 0.39 mm per day). This apparent difference is an obvious area for further research.

Besides the major spawning in Shelikof Strait, it appears that some spawning occurs throughout the area surveyed. No regular geographic patterns of abundance outside the Shelikof Strait area could be seen. Spawning seemed to occur across the width of the shelf, and areas of concentration did not seem associated with obvious topographic features of the area. Except for one area, egg densities outside of the Shelikof Strait area never exceeded 10,000 per 10 m^2. The exceptional area was along the shelf break south of Chirikof Island in early April (Fig. 9). Relatively high abundances of eggs and larvae occurred near the shelf break between Chirikof and the Trinity Islands in April (Figs. 9, 10, and 18).

We find as much or more variability in lengths at individual stations as between stations taken during the same time period. Thus the variability in length with date shown in Figure 24 is not merely the result of combining data from different cruises or stations from different areas. Also, length variability both at a station and over combinations of stations increases as the spawning season progresses. As a consequence it is not possible to use length data to infer differences in time of spawning in various parts of the sampling area or to follow drift of cohorts of larvae.

The Soviets conducted an extensive ichthyoplankton survey of the Gulf of Alaska from 4 April-24 May 1978, and sampled at 199 stations from Unimak Island to 138°W (Cape Fairweather) aboard the R/V Seskar (Boretz 1979). They reported no walleye pollock eggs and mainly scattered occurrences of larvae. There was one well-marked concentration of larvae near Amatulli Trough, an area not well sampled in the present study. Although they used different sampling gear and procedures from ours, it is unlikely that they would not have found any pollock eggs, had there been substantial numbers in the area. Their sampling pattern did not include Shelikof Strait or the areas just southwest of there, the areas where we found major concentrations of eggs and larvae.

In 1980, a year not sampled in the present study, the Soviets conducted a survey of 249 ichthyoplankton stations between Unimak Pass and 148°W from 12 March-17 April aboard the RV Academician Berg (Boretz 1980). This cruise worked from east to west, and thus may have sampled from Kodiak east too early for pollock spawning. They did find four concentrations of walleye pollock eggs in waters off the Alaska Peninsula. The easternmost one appears to be part of the Shelikof Strait spawning, while the others seem likely to be associated with other troughs or gullys in the continental shelf. Apparently no walleye pollock larvae were collected during this cruise, which may have been conducted too early in the season for their widespread occurrence.

CONCLUSIONS

1.--Shelikof Strait is the principal spawning area for walleye pollock in the western Gulf of Alaska, with moderate concentrations of spawning products also appearing near the shelf break to the east of Chirikof Island.

2.--Limited spawning of walleye pollock appears to occur throughout the western Gulf of Alaska.

3.--Most large catches of pollock eggs and larvae occurred over water depths of 180-300 m.

4.--Eggs and larvae from the Shelikof spawning are transported along the Alaskan Peninsula at speeds consistent with hydrographic estimates.

5.--There is little variability in mean larval length between stations sampled at approximately the same time. At station variability is relatively high and increases as the larvae grow.

6.--Spawning of walleye pollock in the region occurs over at least a 3 month period (March-May) and some spawning occurs in June, October, and November. The peak in spawning appears to be in April.

7.--No difference in time of spawning in different parts of the survey area could be detected from the distribution of spawning products, nor from analysis of larval lengths.

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Table 1.--Dates of ichthyoplankton surveys, number of stations occupied by gear type, and number of stations positive for pollock eggs and larvae by gear type.

Cruise	Dates	No. of stations	No. neuston tows	No. bongo hauls	No. positive hauls for pollock Neuston eggs	Neuston larvae	bongo eggs	bongo larvae
2 KE 72	26 Apr - 9 May	67	0	67	-	-	29	24
4 MF 77	31 Oct - 14 Nov	59	59	59	9	2	8	4
4 DI 78	28 Mar - 20 Apr	80	80	80	23	0	29	17
2 MF 78	19 Jun - 9 Jul	88	88	88	3	4	1	15
3 MF 78	9 Sep - 21 Sep	25	25	24	0	0	0	0
4 MF 78	26 Sep - 7 Oct	66	45	66	0	0	0	0
5 MF 78	19 Oct - 1 Nov	19	11	19	0	0	1	0
6 MF 78	8 Nov - 16 Nov	44	20	43	0	0	0	0
1 WE 78	25 Oct - 17 Nov	86	86	86	1	0	3	0
1 MF 79	13 Feb - 11 Mar	88	88	88	1	0	3	0
5 TK 79	16 May - 24 May	58	0	58	-	-	17	16
1 PO 79	2 Sep - 11 Oct	48	48	18(30)1/	0	0	0	0
1 SH 81	5 Mar - 30 Mar	133	130	133	6	0	20	2
1 MF 81	12 Mar - 17 Apr	31	0	31	-	-	25	0
2 MF 81	30 Mar - 8 Apr	89	0	89	-	-	82	21
2 SH 81	16 Apr - 24 Apr	60	60	60	21	3	31	36
3 MF 81	26 Apr - 2 May	79	0	79	-	-	76	77
4 MF 81	20 May - 24 May	75	0	75	-	-	67	75
3 SH 81	20 May - 28 May	57	0	57	-	-	17	39
1 DA 82	4 Apr - 23 Apr	83	83	83	0	0	62	27
2 DA 82	21 May - 31 May	62	62	62	0	0	47	50

1/ Number of "bong" hauls in parentheses

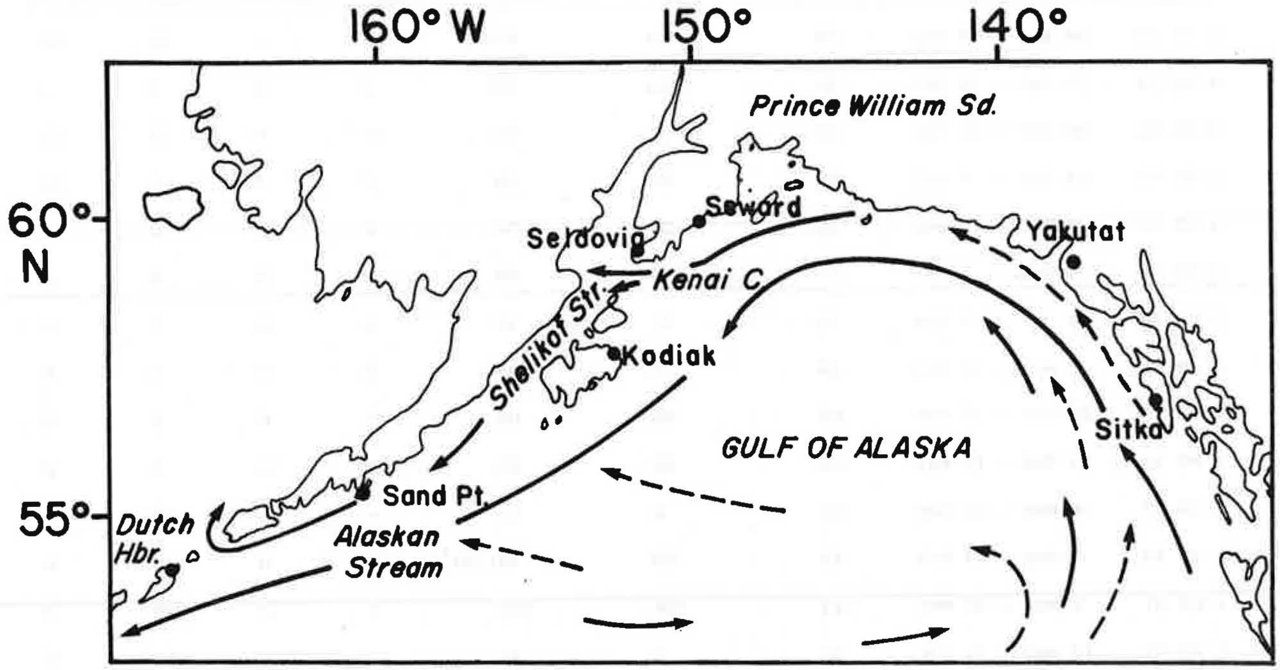


Figure 1.--Schematic of long-term mean circulation in the Gulf of Alaska based on direct current measurements, inferred baroclinic flow, and model results. Note that the dashed arrows on the Coastal Current indicate regions where baroclinic flow is less vigorous while those in the Gulf of Alaska represent anomalous behavior in the Alaskan Stream (from Schumacher and Reed 1983).

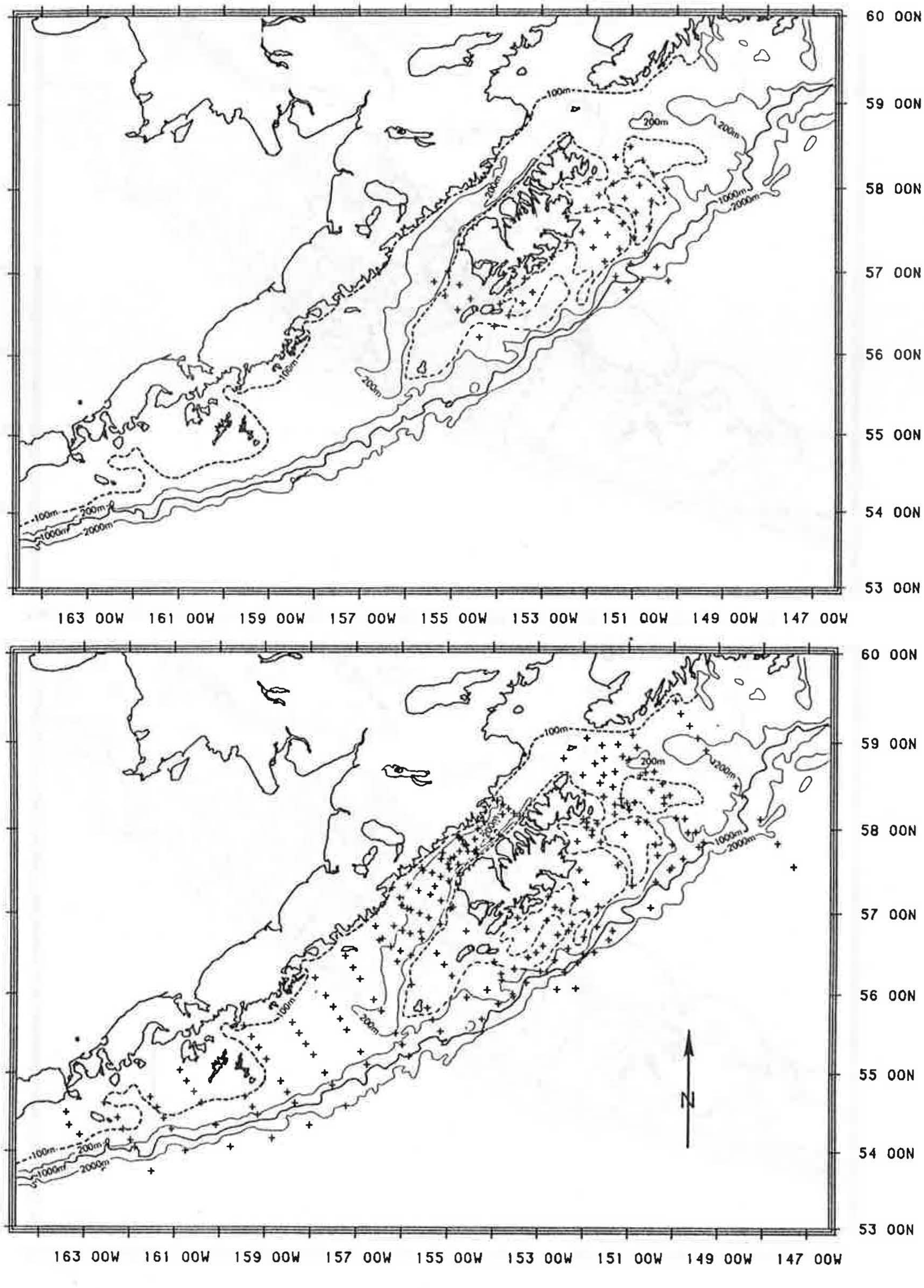


Figure 2.--Locations of bongo stations in February (top) and March (bottom).

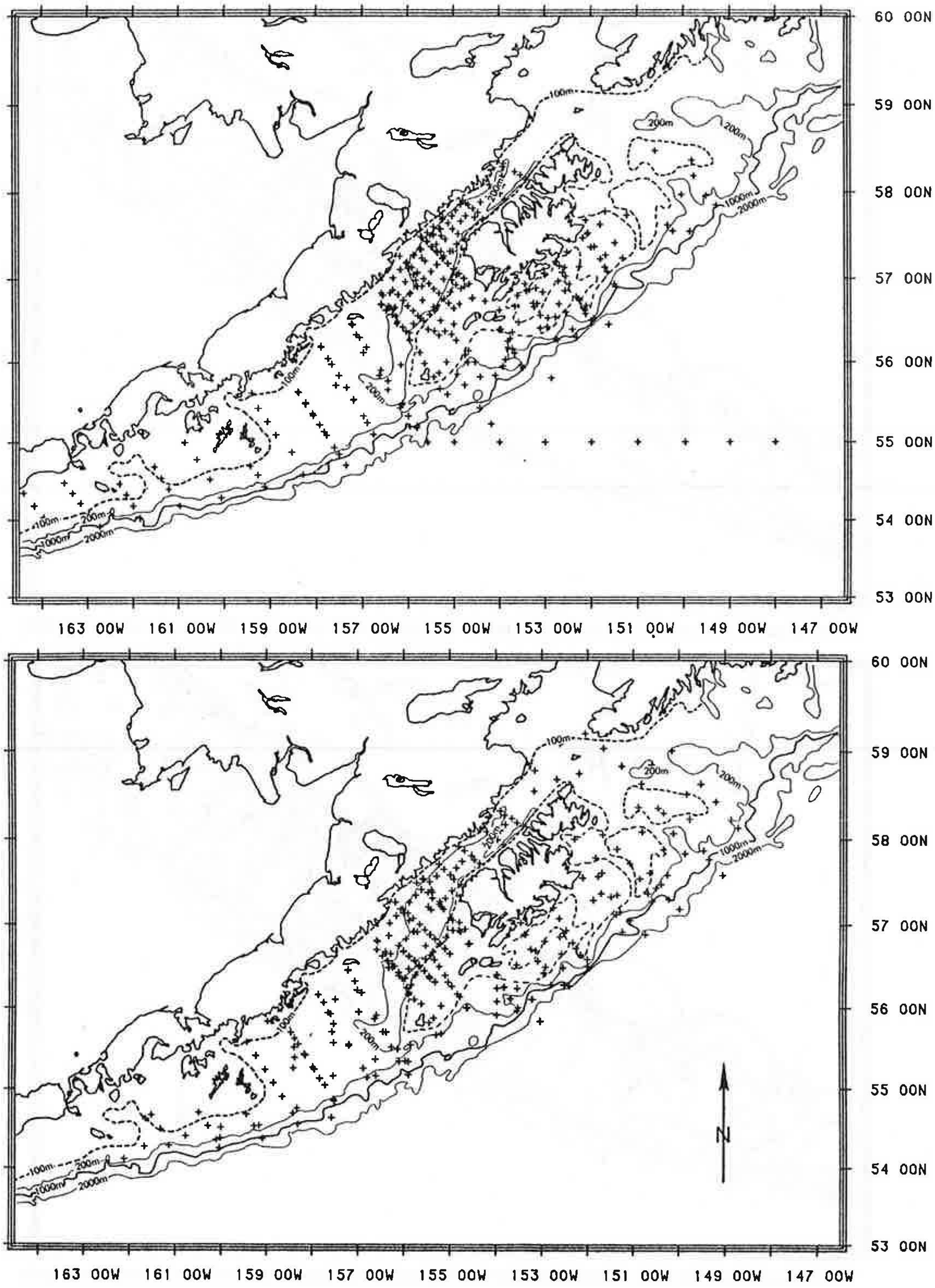


Figure 3.--Locations of bongo stations in April (top) and May (bottom).

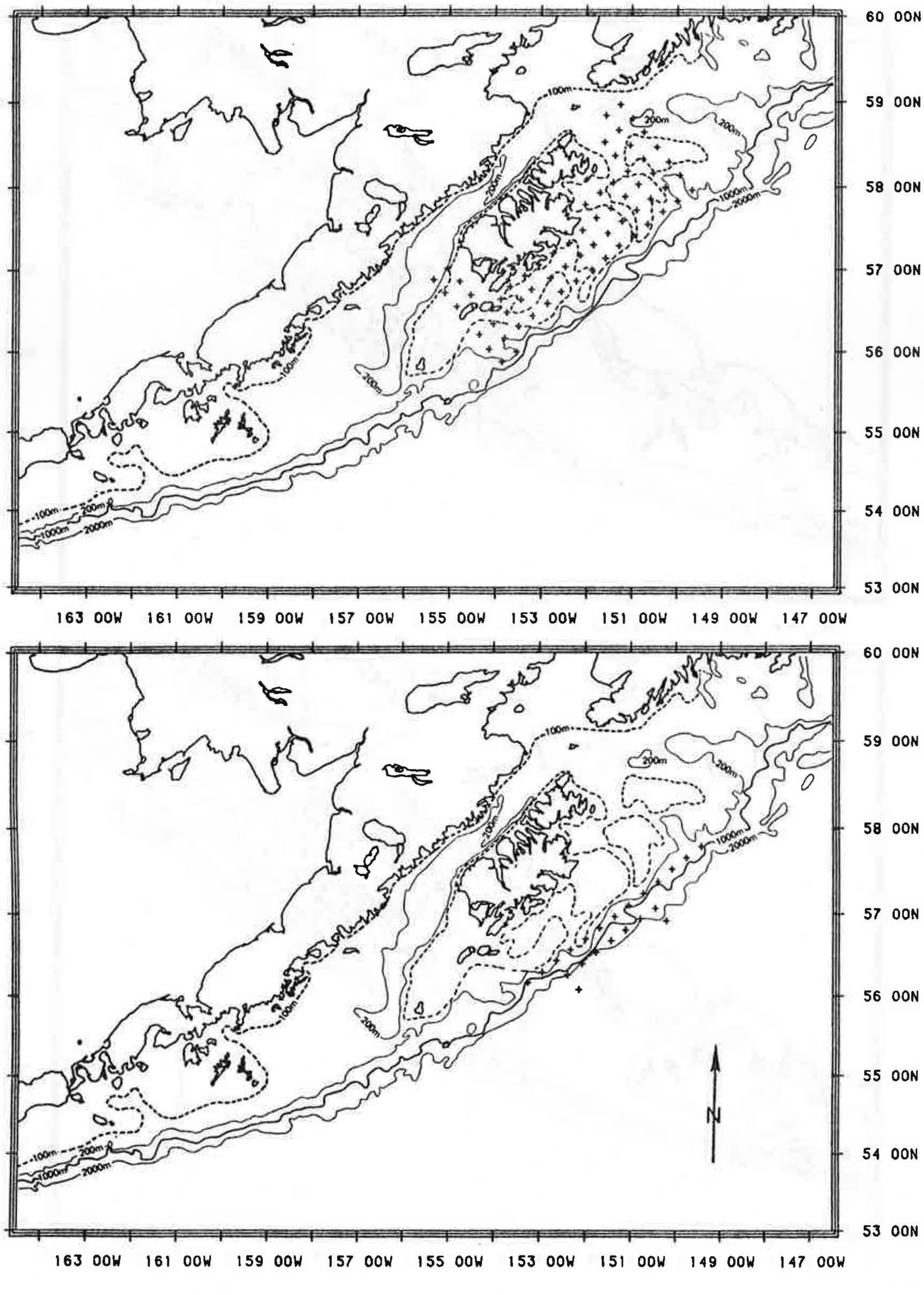


Figure 4.--Locations of bongo stations in June (top) and July (bottom).

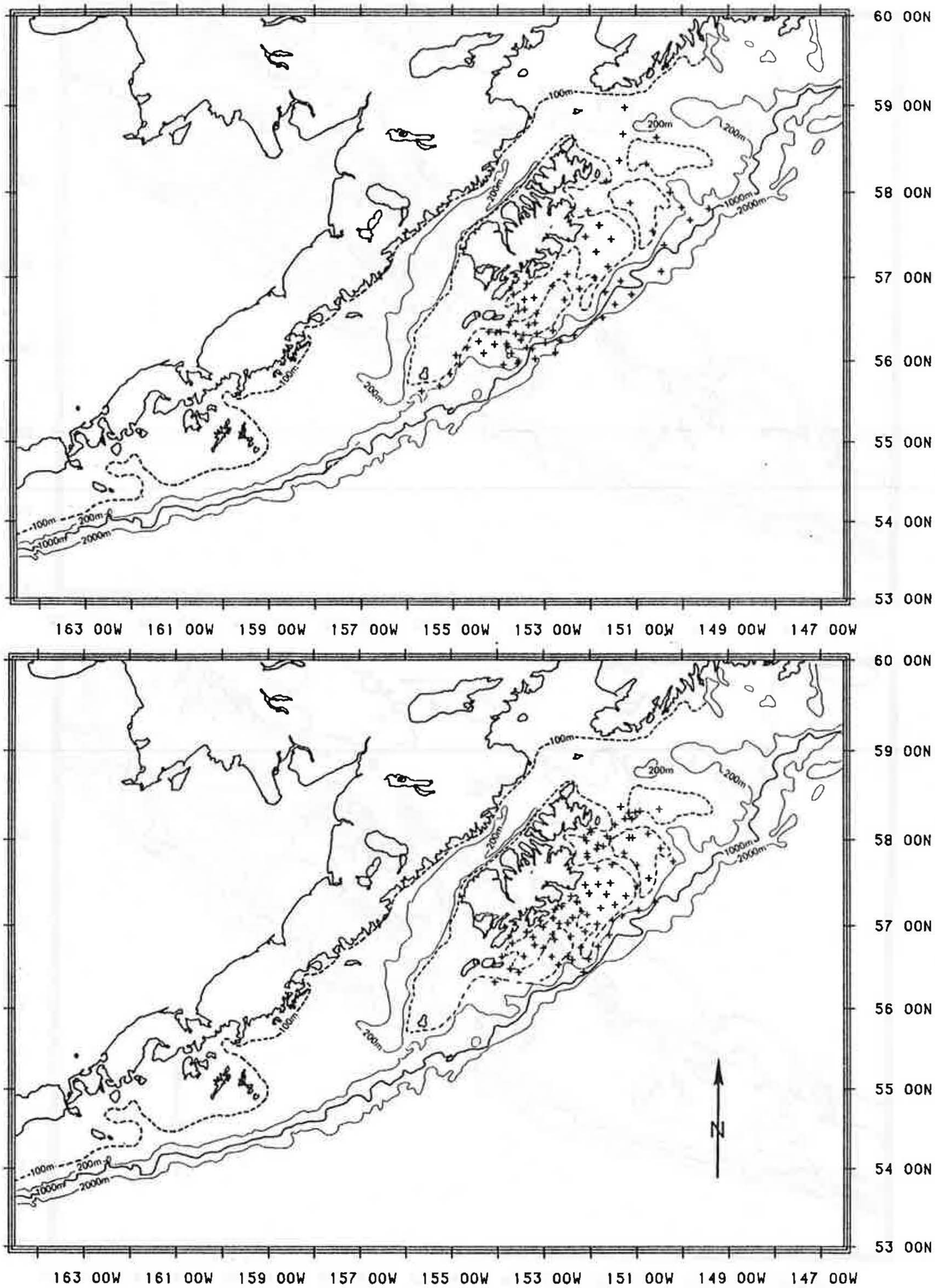


Figure 5.--Locations of bongo stations in September (top) and October (bottom).

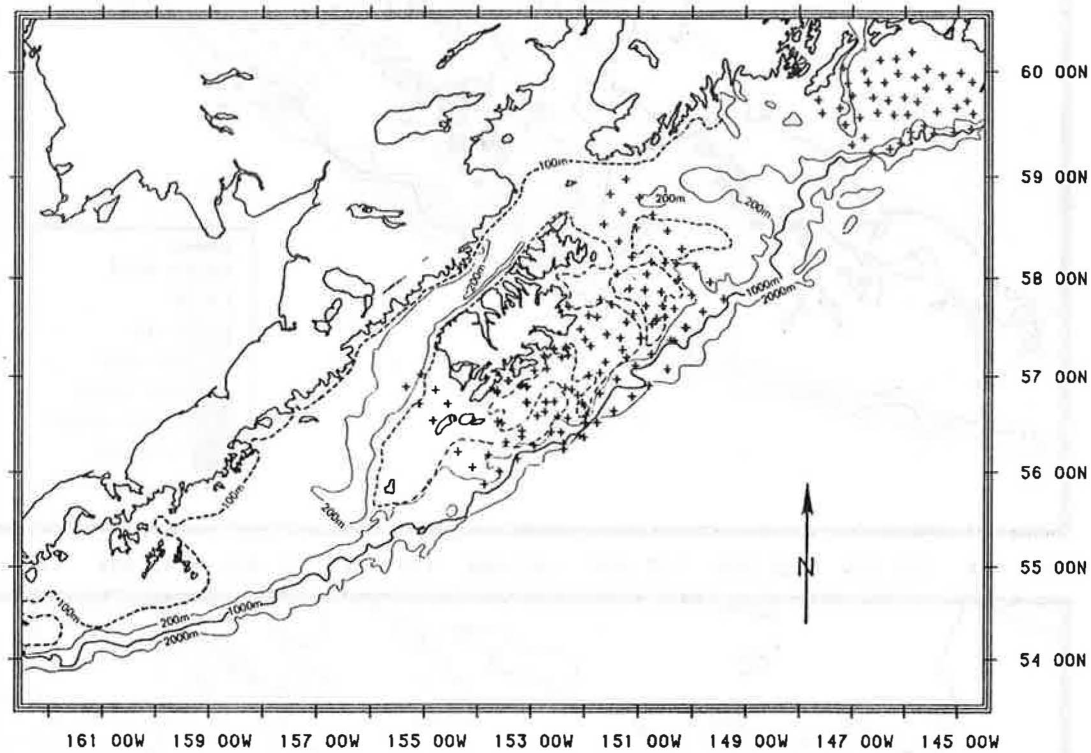


Figure 6.--Locations of bongo stations in November.

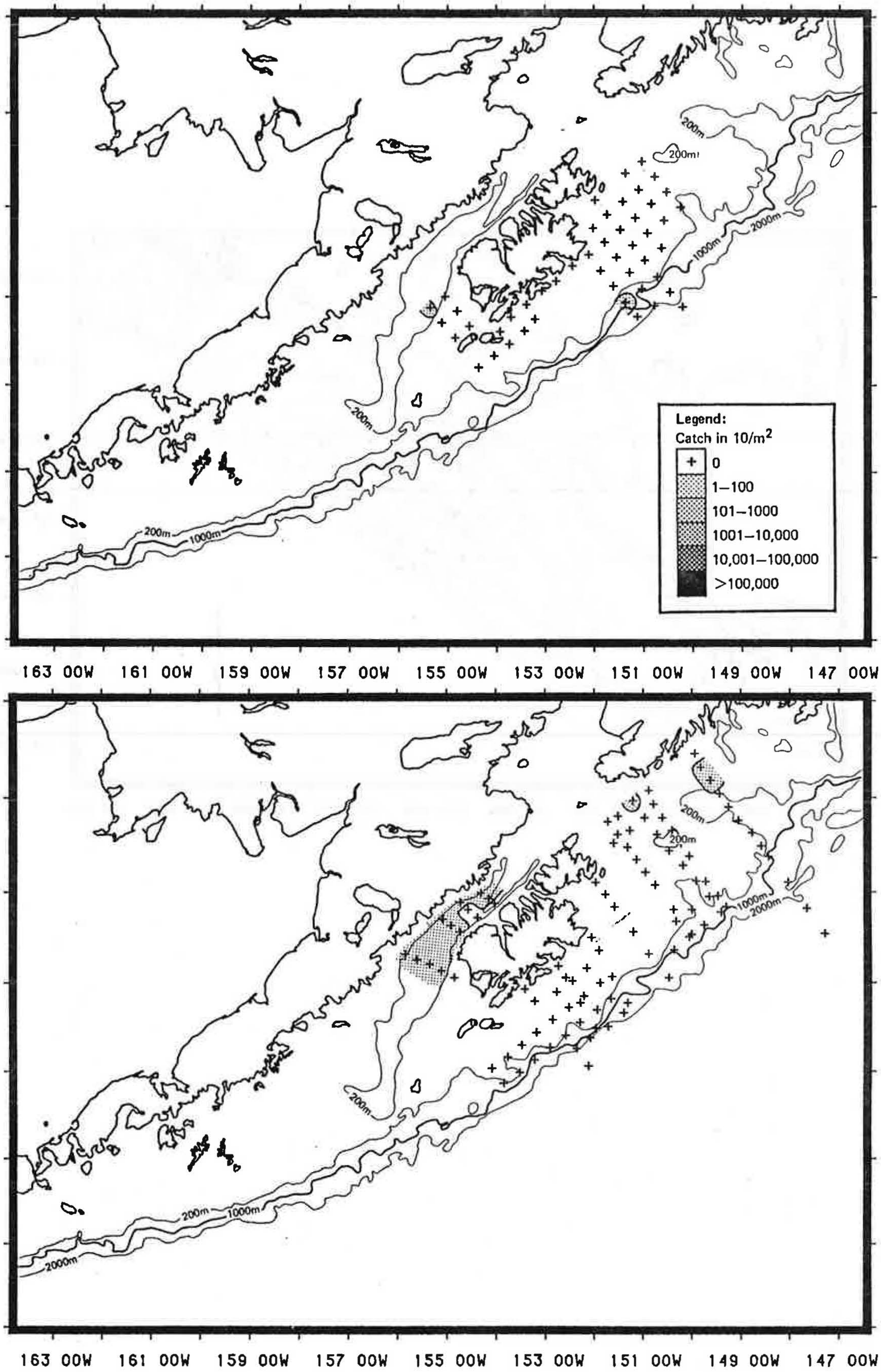


Figure 7.--Distribution and relative abundance of walleye pollock eggs in February (top) during March 1-15 (bottom).

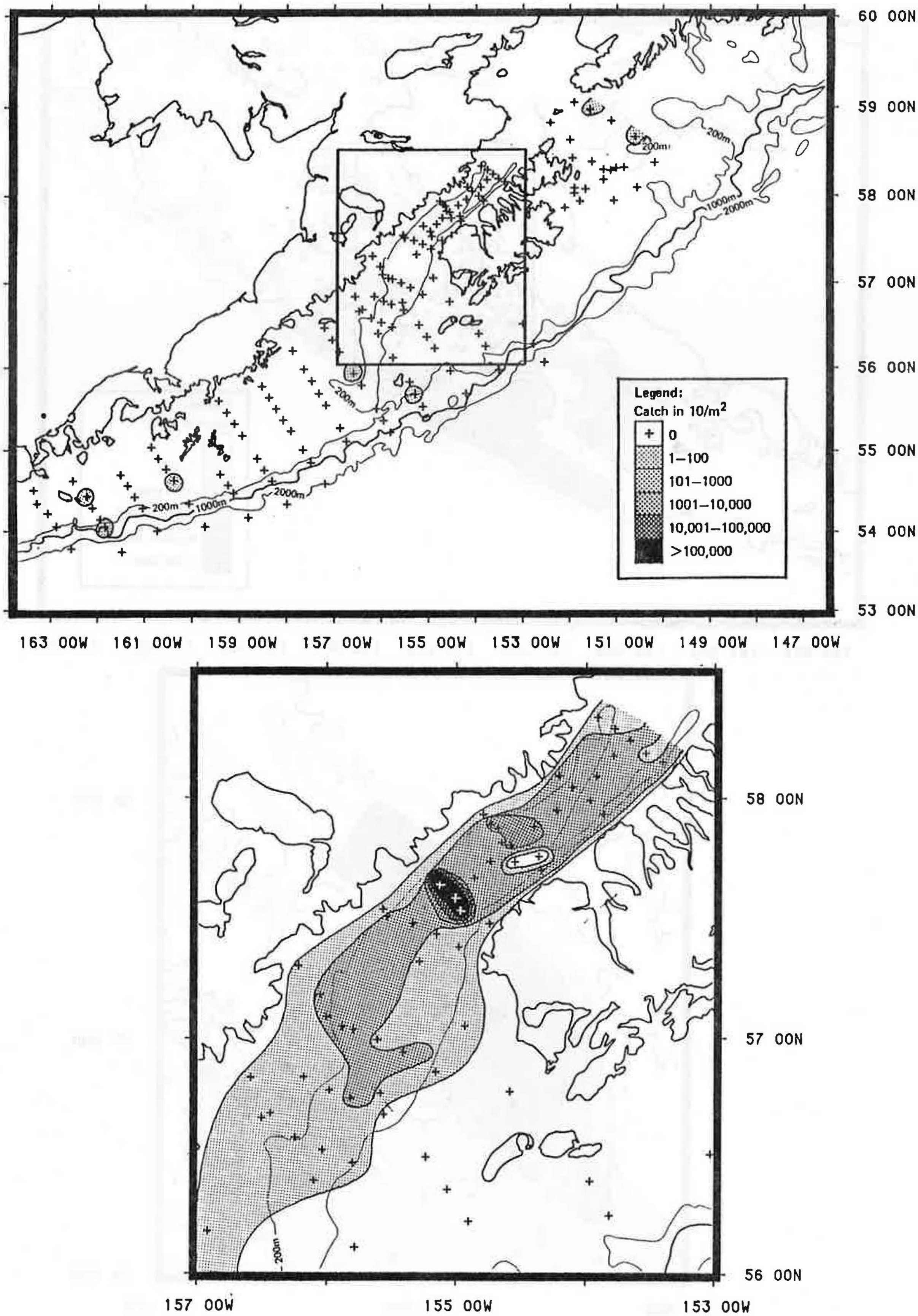


Figure 8.--Distribution and relative abundance of walleye pollock eggs during March 16-31.

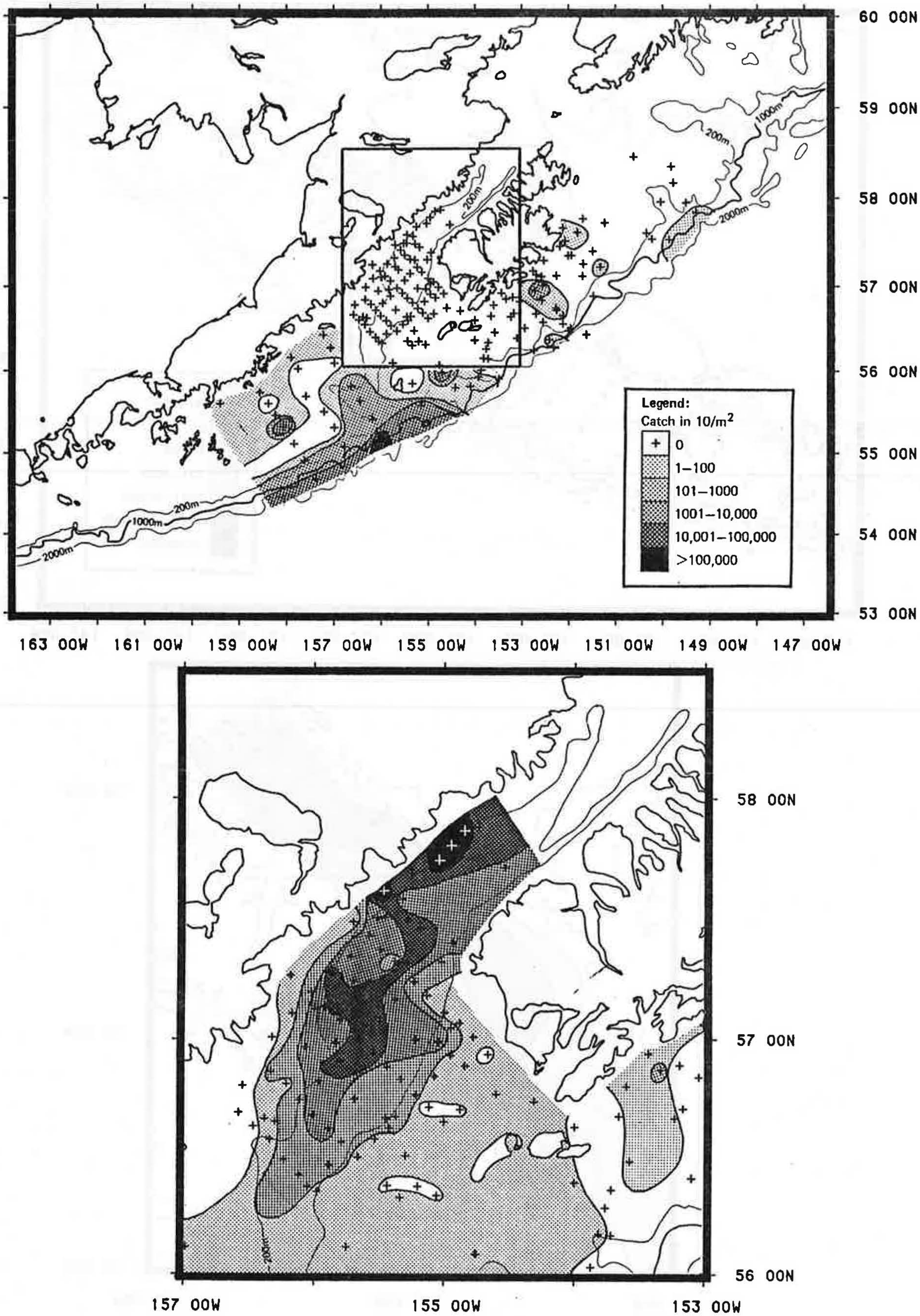
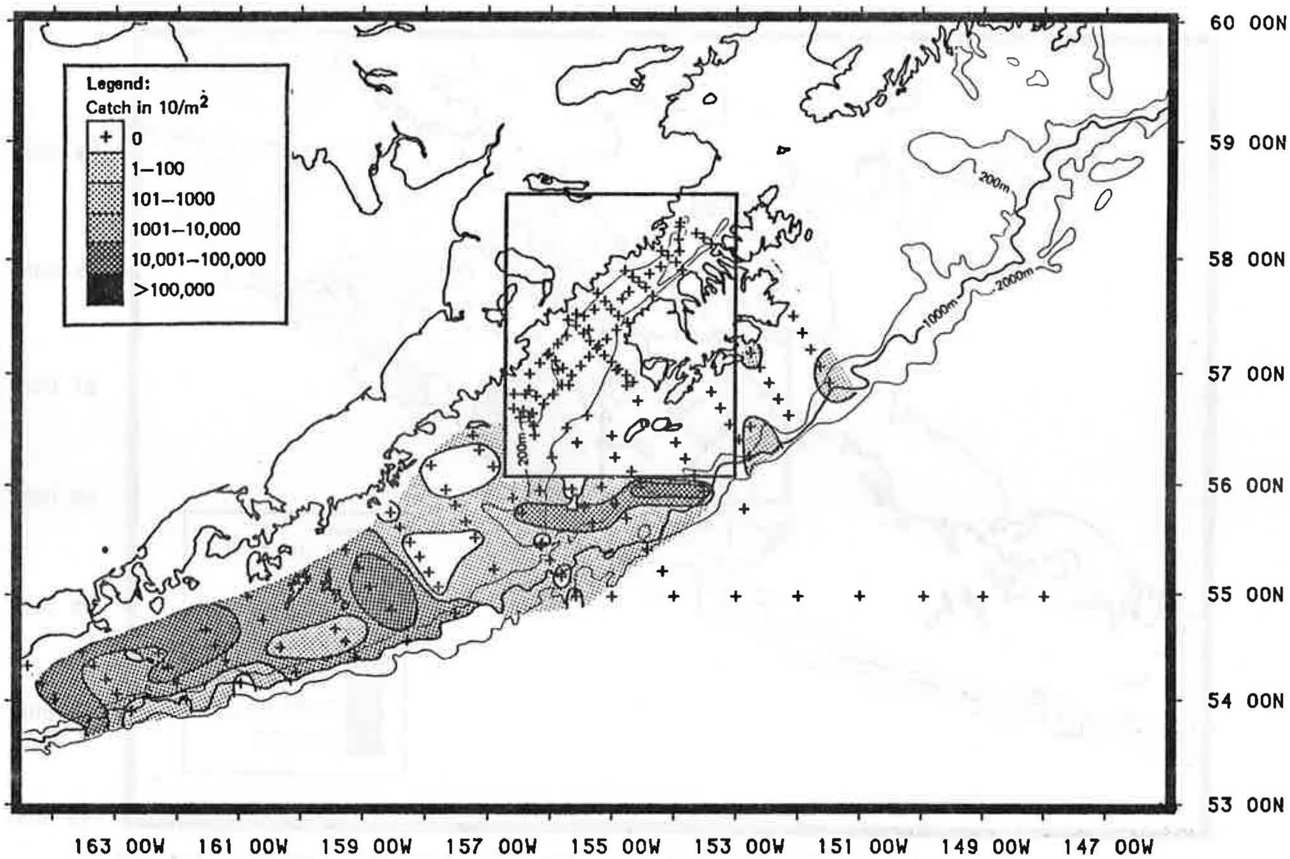


Figure 9.--Distribution and relative abundance of walleye pollock eggs during April 1-15.



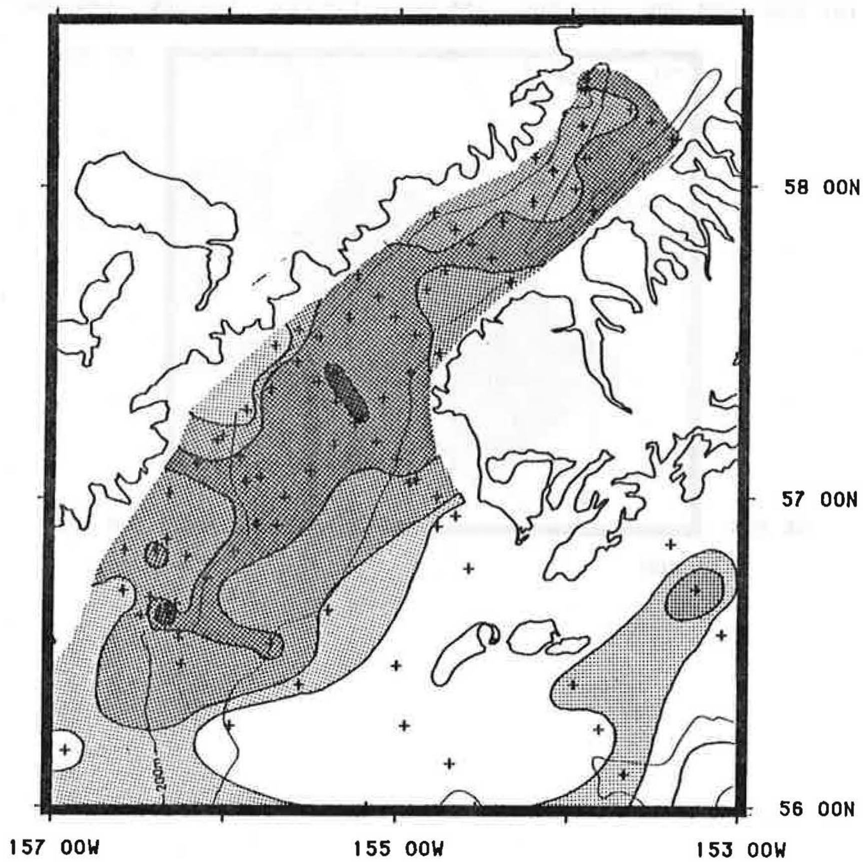


Figure 10.--Distribution and relative abundance of walleye pollock eggs during April 16-30.

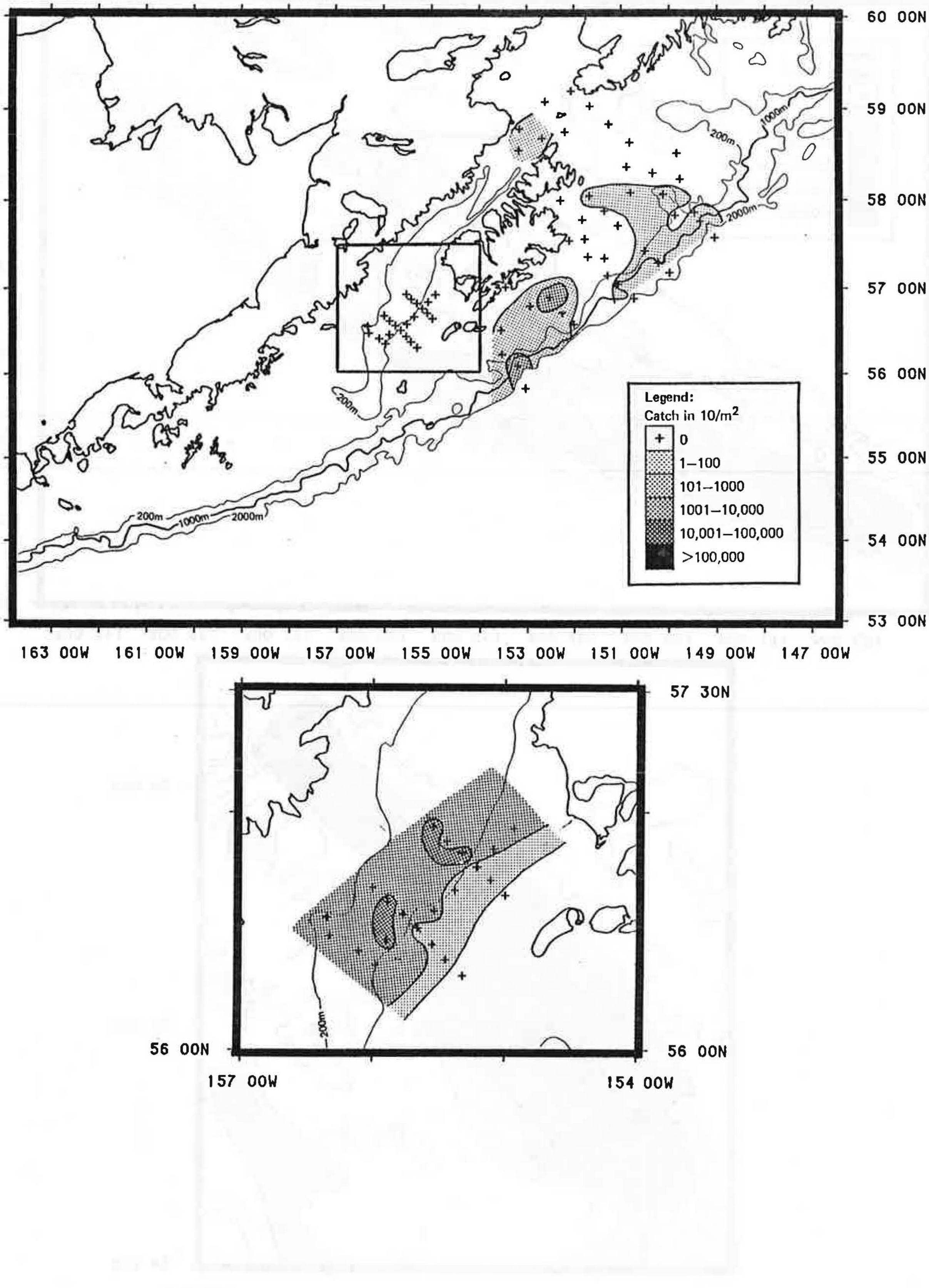


Figure 11.--Distribution and relative abundance of walleye pollock eggs during May 1-15.

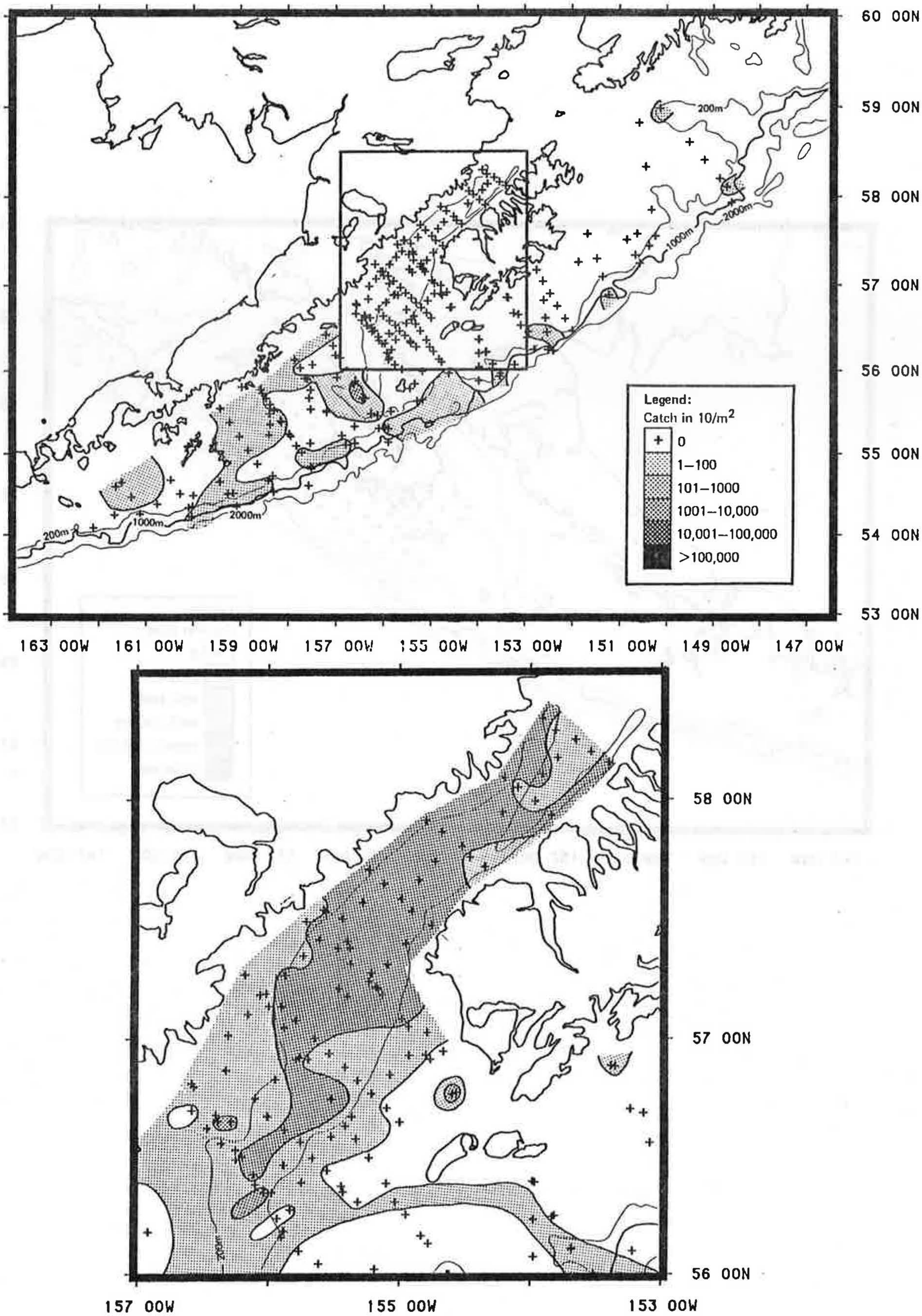


Figure 12.--Distribution and relative abundance of walleye pollock eggs during May 16-31.

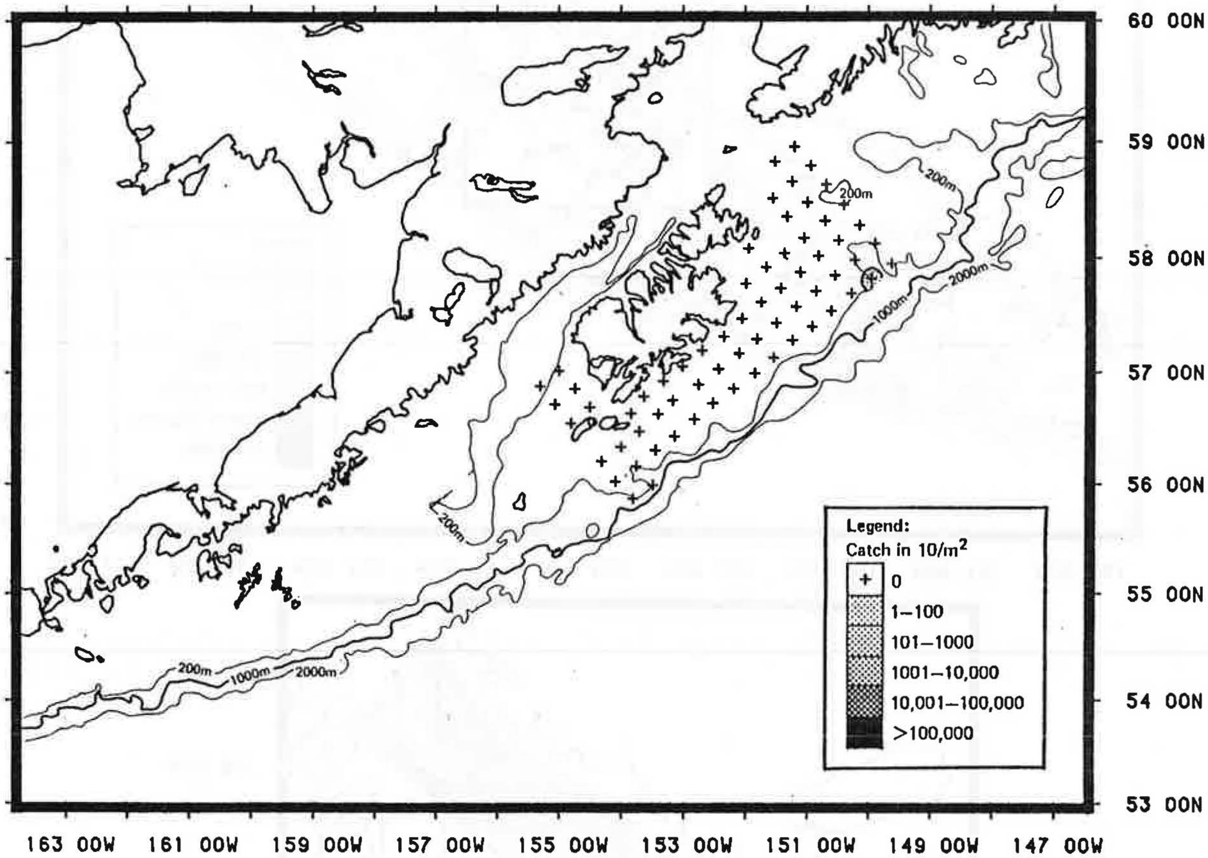
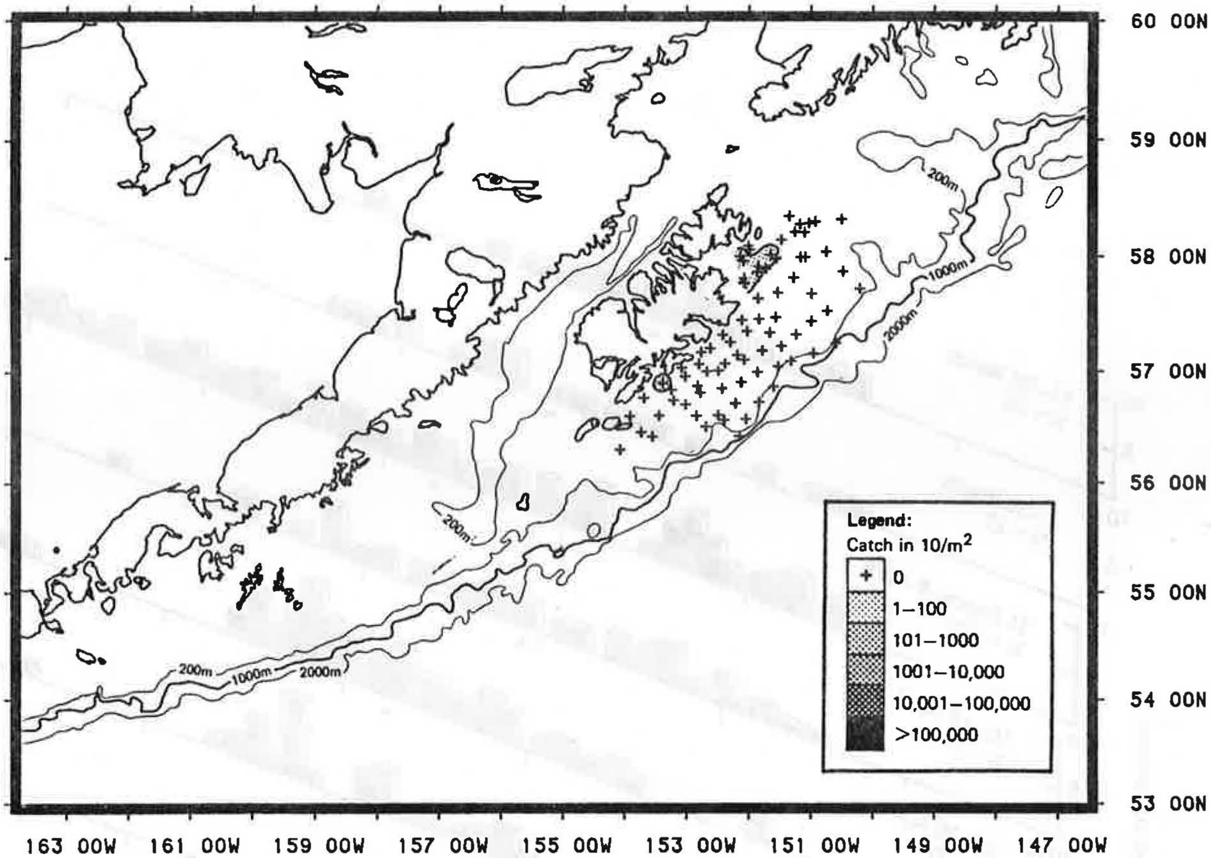


Figure 13.--Distribution and relative abundance of walleye pollock eggs during June.



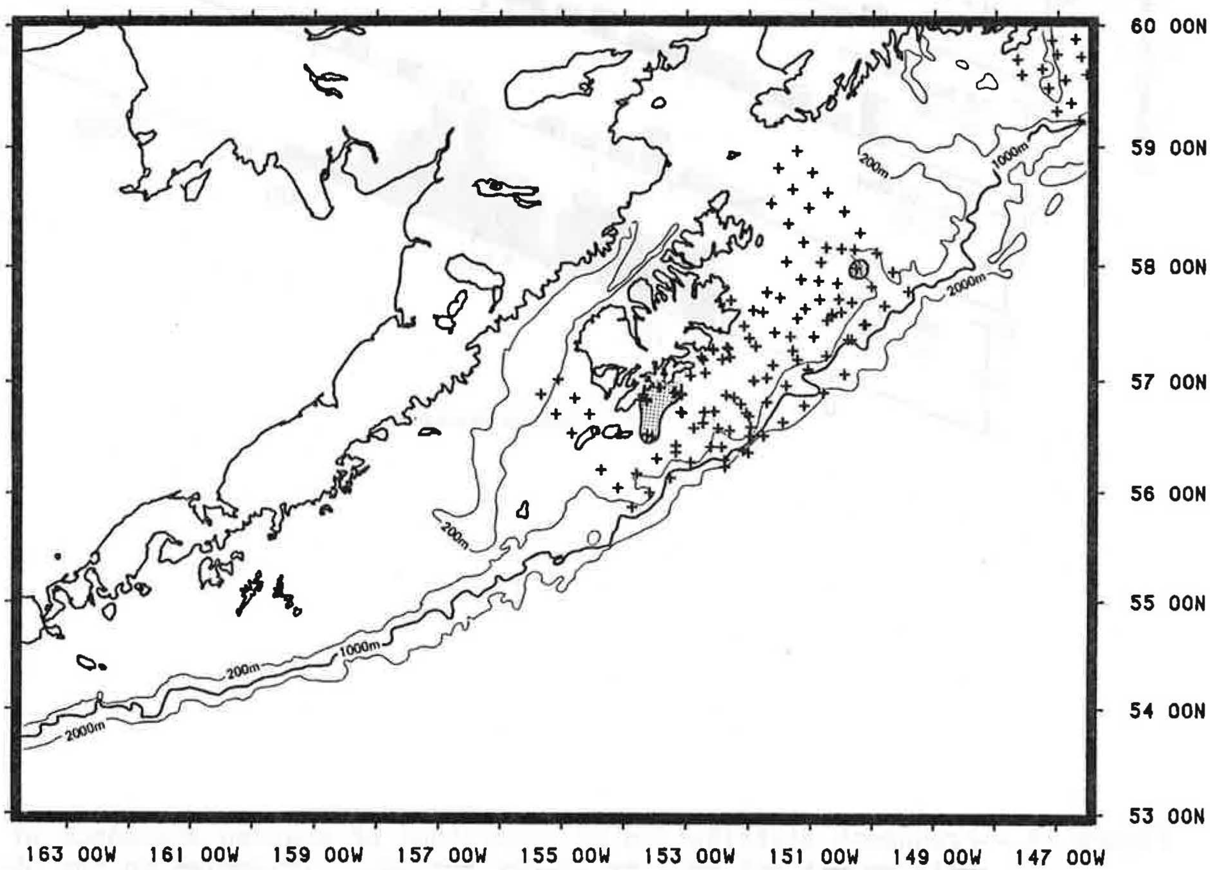


Figure 14.--Distribution and relative abundance of walleye pollock eggs during October (top) and November (bottom).

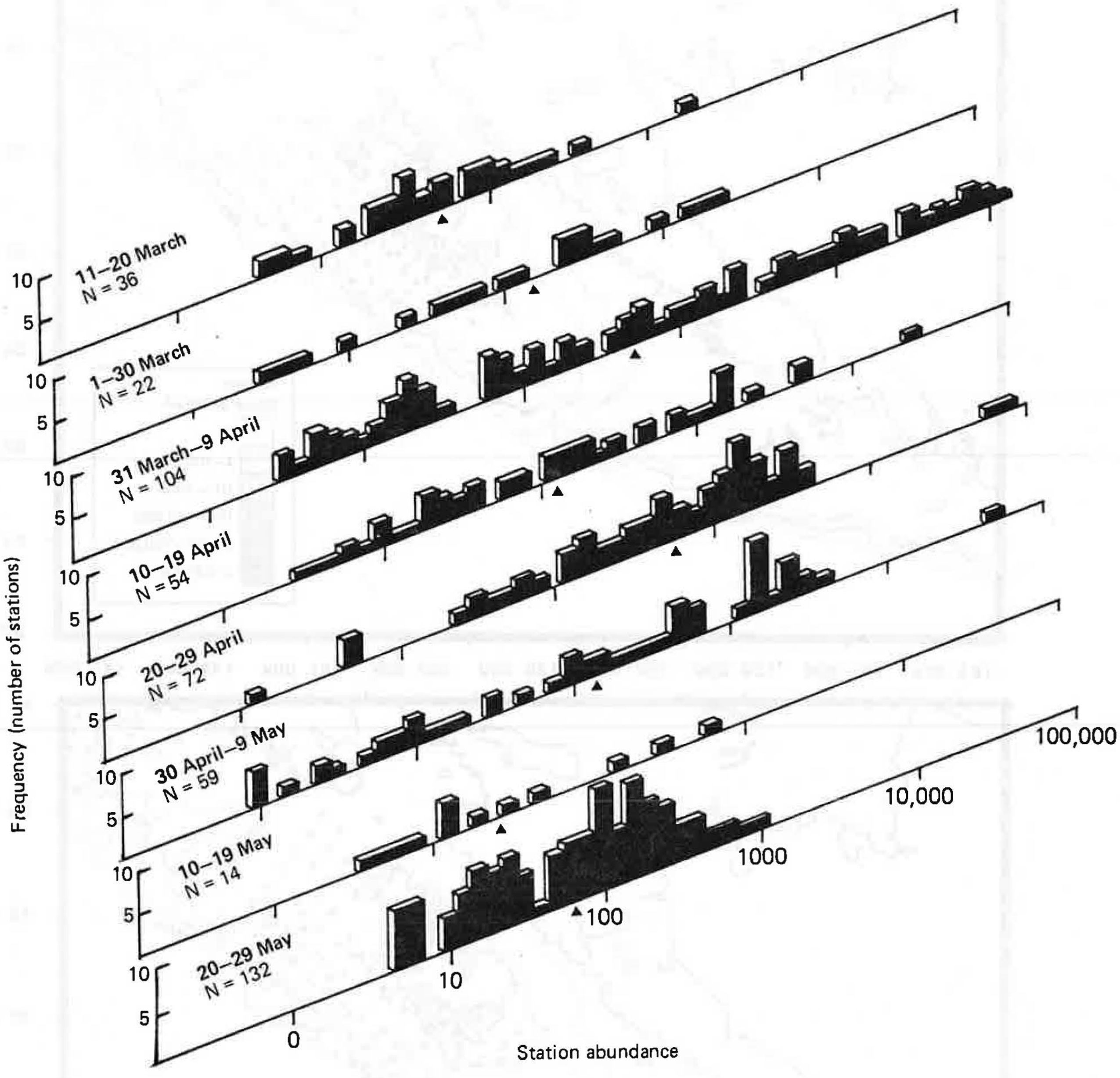


Figure 15.--Frequency distribution of logarithms of station abundance of walleye pollock eggs by 10-day periods. Triangles on the abscissa denote the means of logarithmic data.

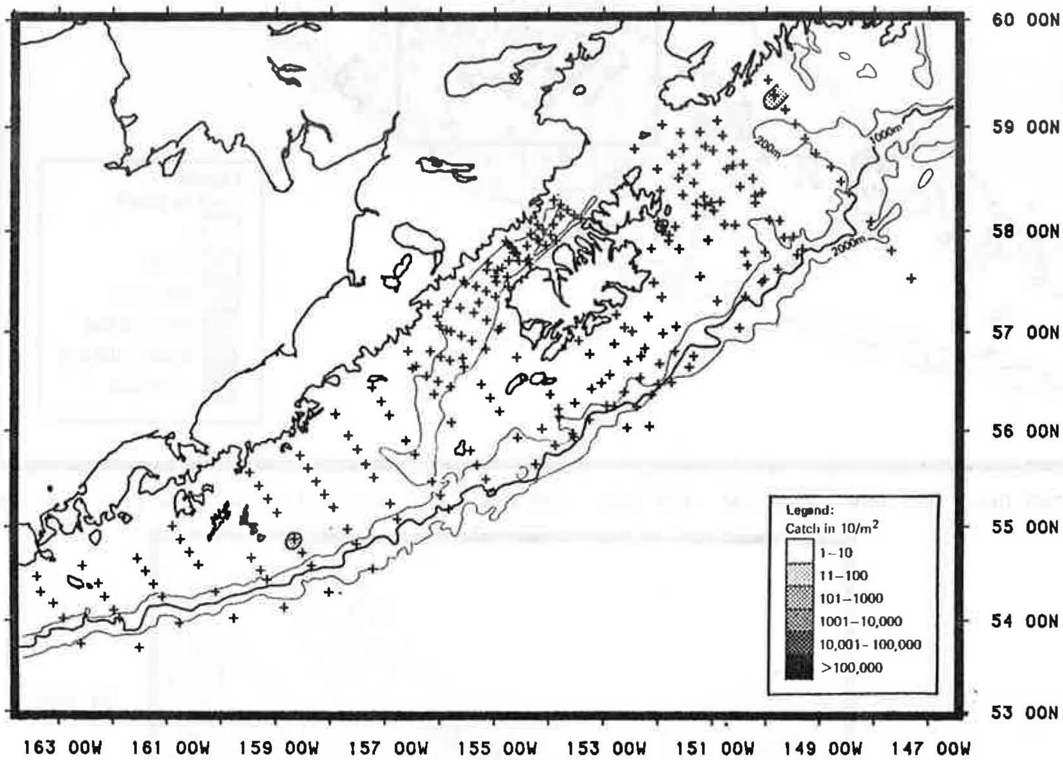


Figure 16.--Distribution and relative abundance of walleye pollock larvae during March.

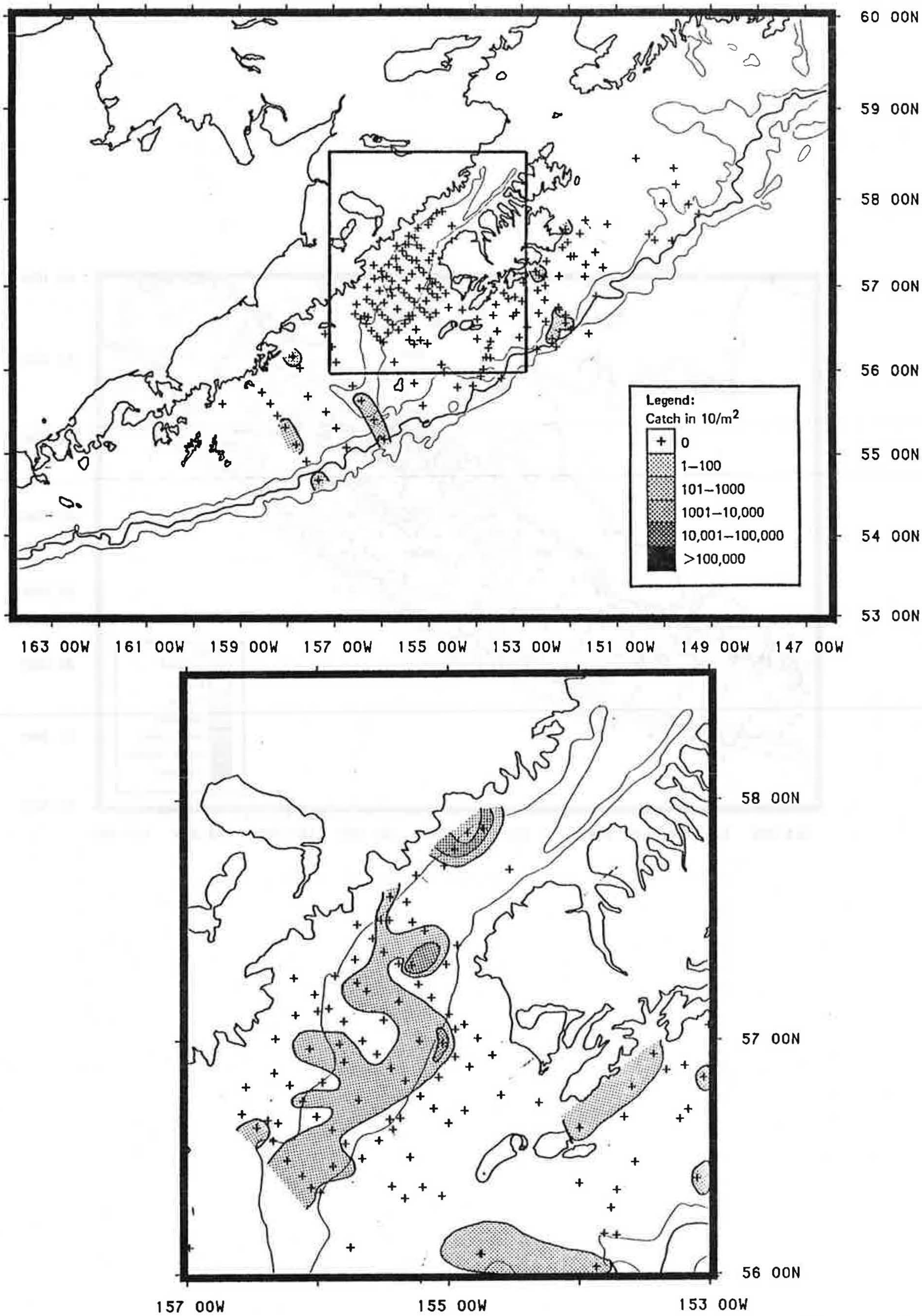


Figure 17.--Distribution and relative abundance of walleye pollock larvae during April 1-15.

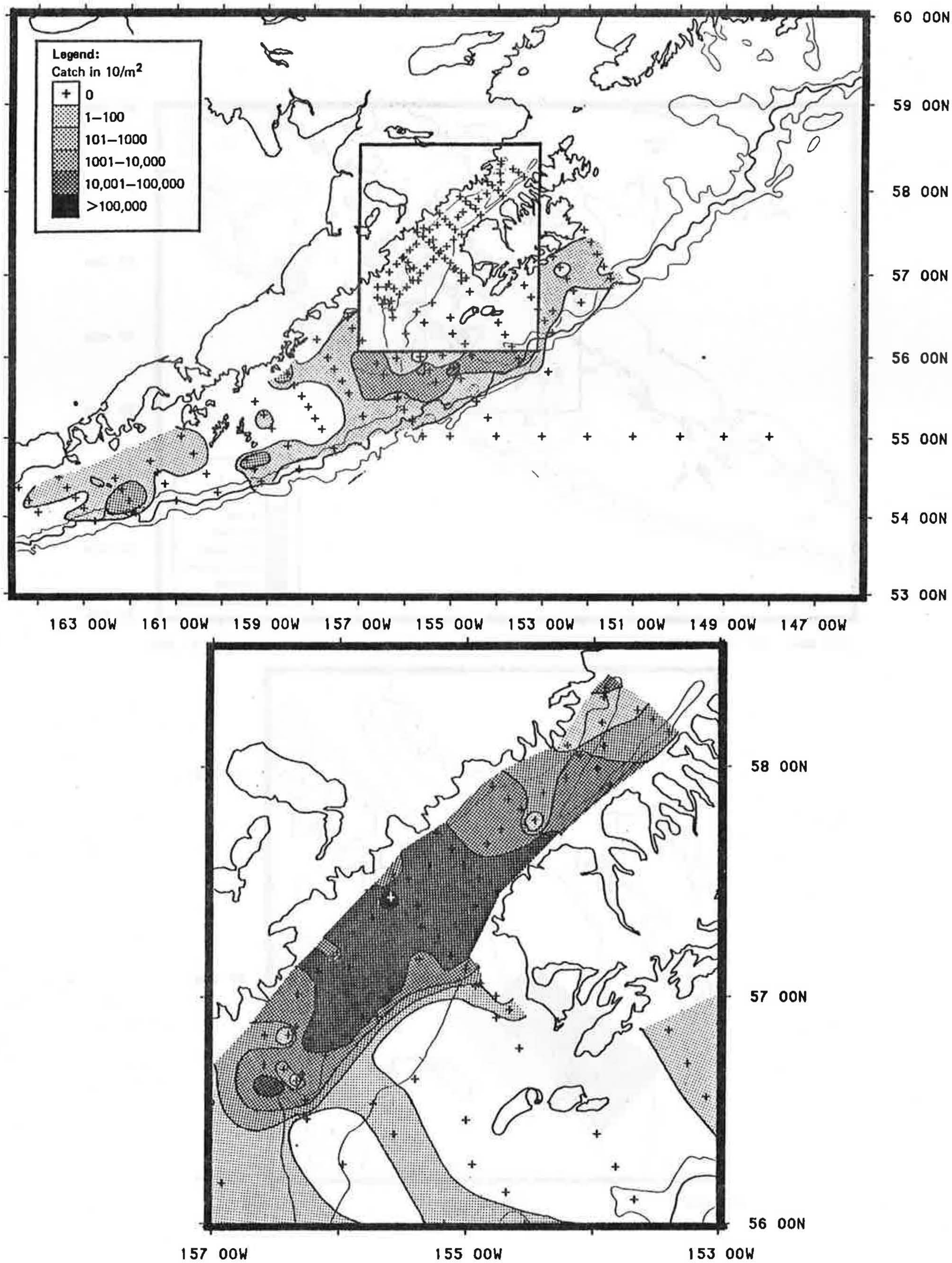


Figure 18.--Distribution and relative abundance of walleye pollock larvae during April 16-30.

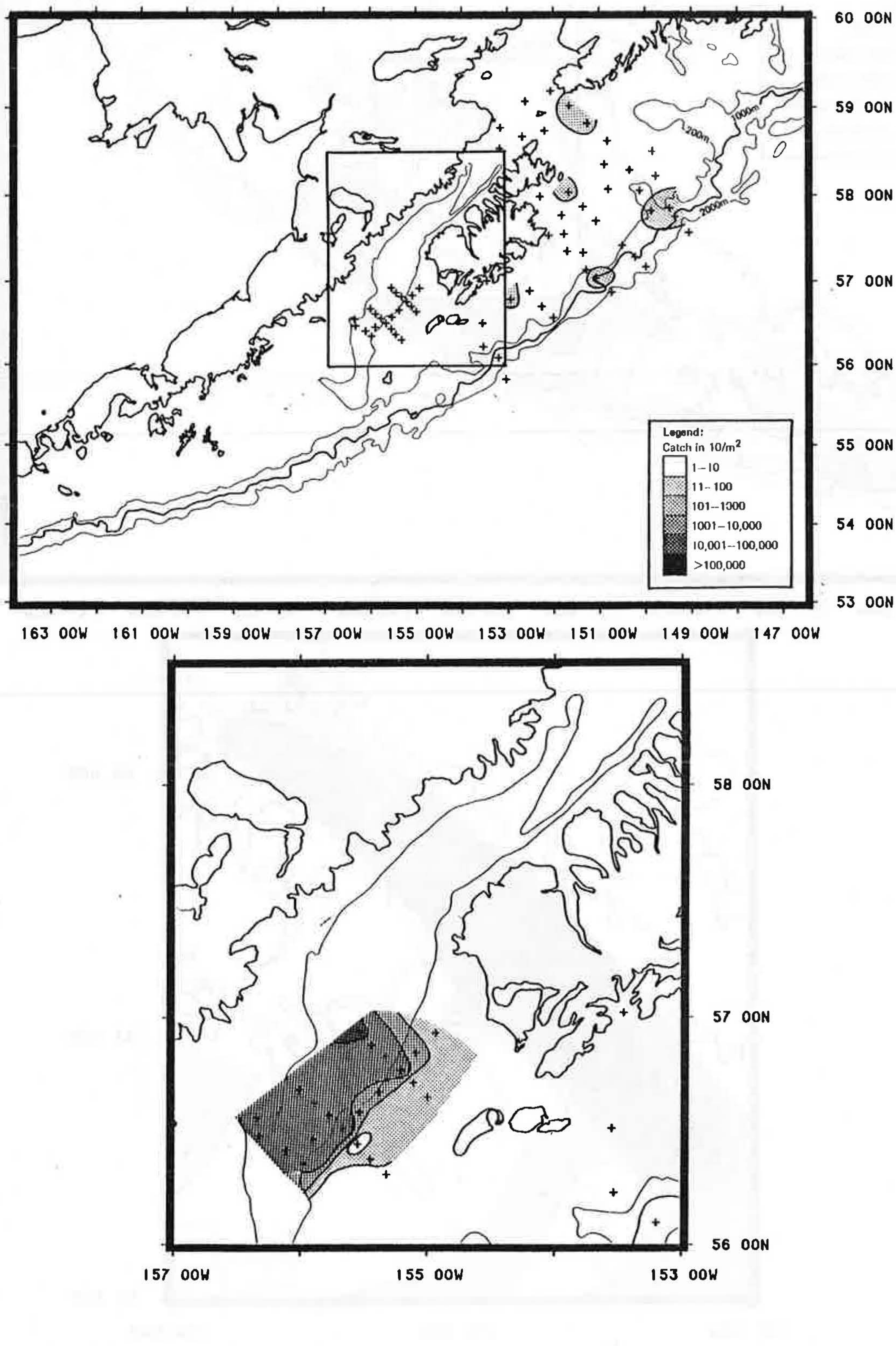


Figure 19.--Distribution and relative abundance of walleye pollock larvae during May 1-15.

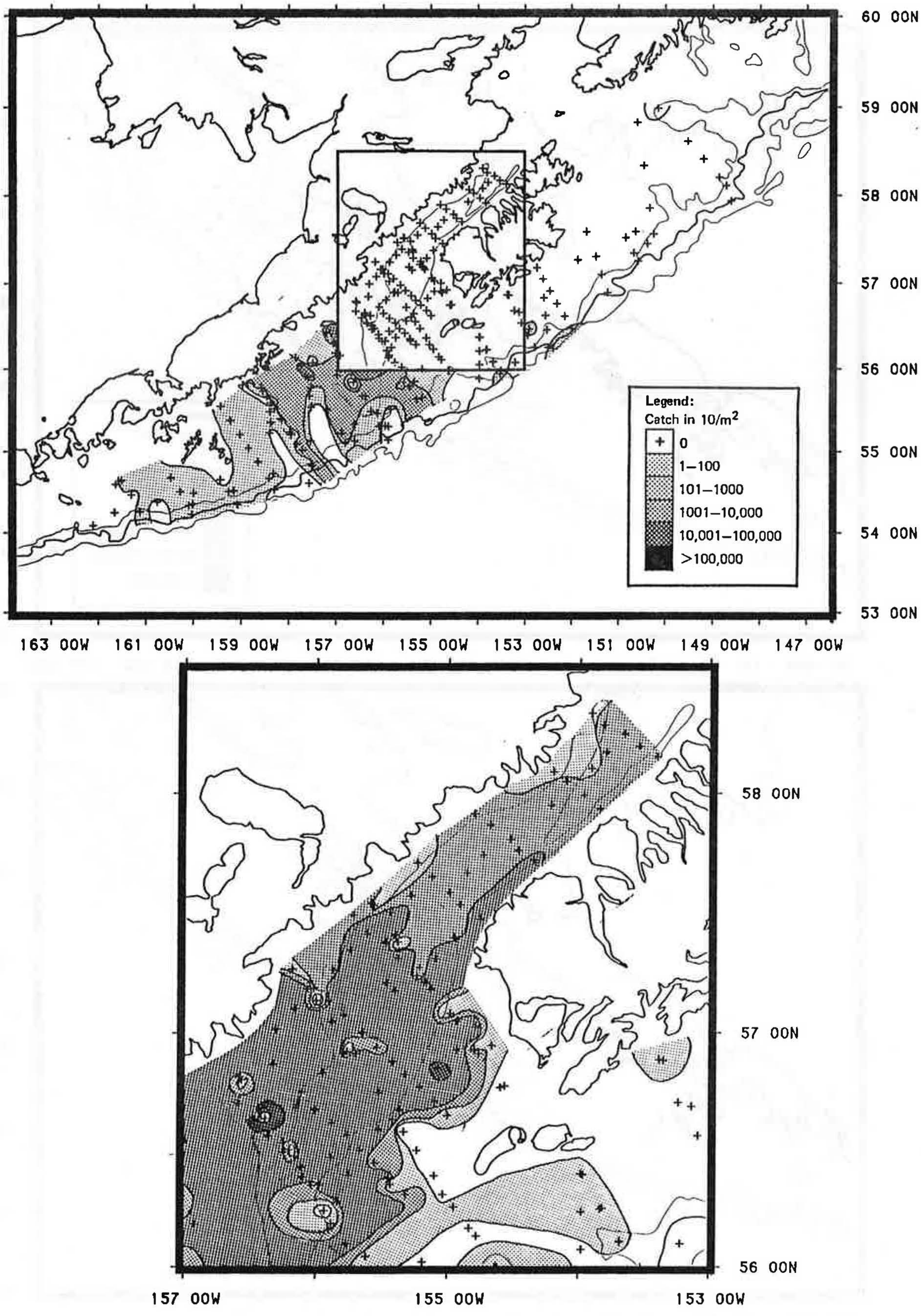


Figure 20.--Distribution and relative abundance of walleye pollock larvae during May 16-31.

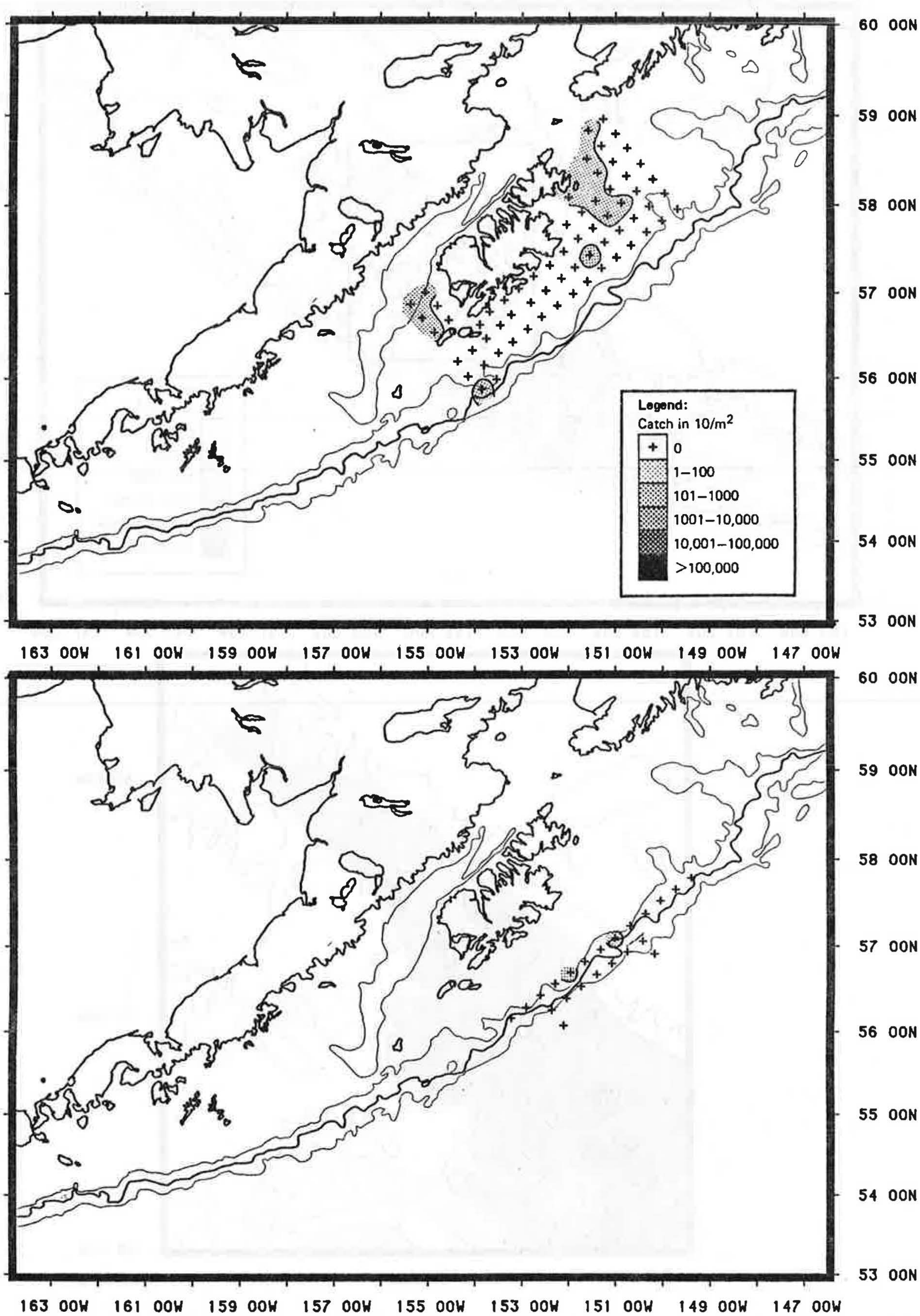


Figure 21.--Distribution and relative abundance of walleye pollock larvae in June (top) July (bottom).

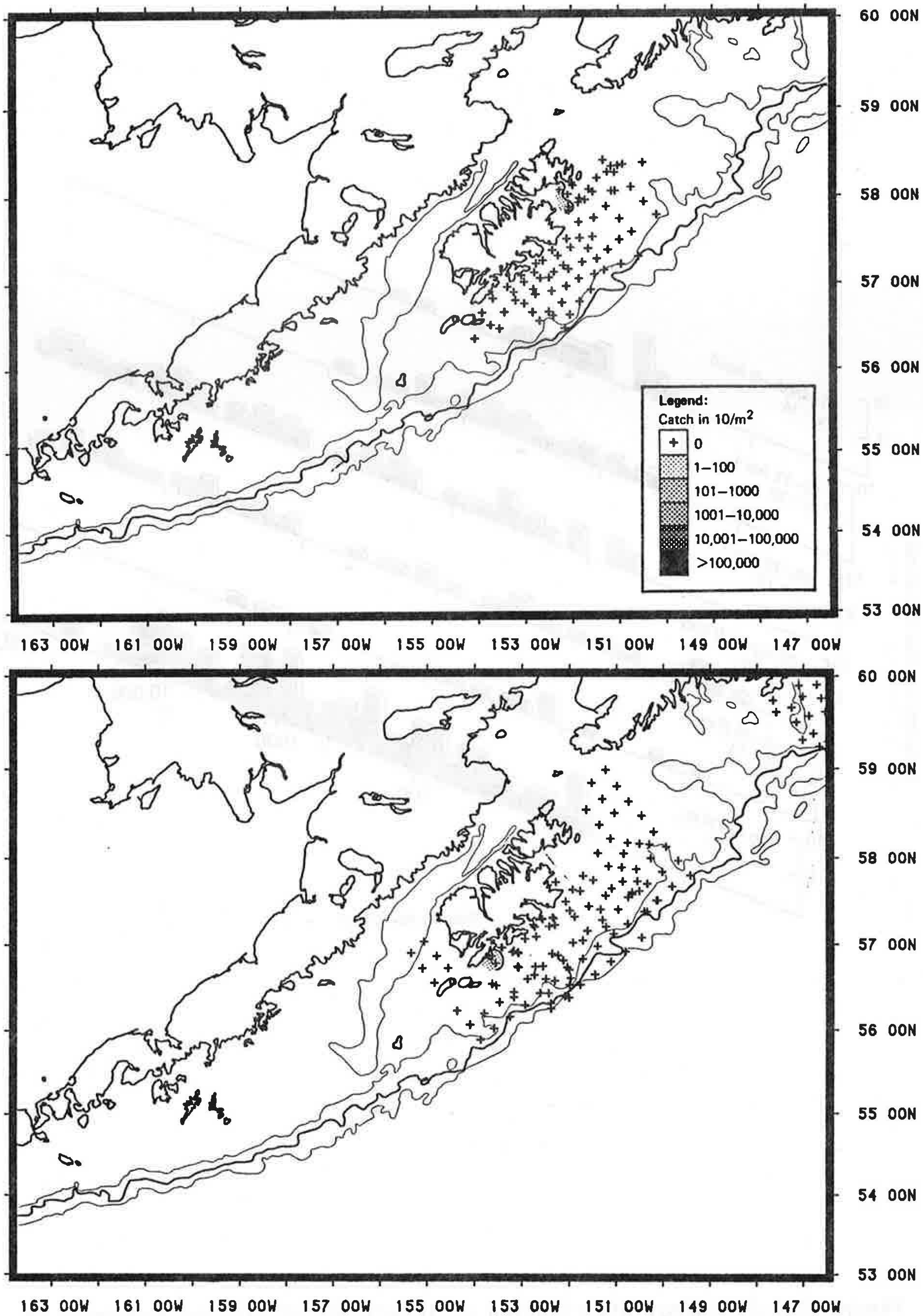


Figure 22.--Distribution and relative abundance of walleye pollock larvae in October (top) and November (bottom).

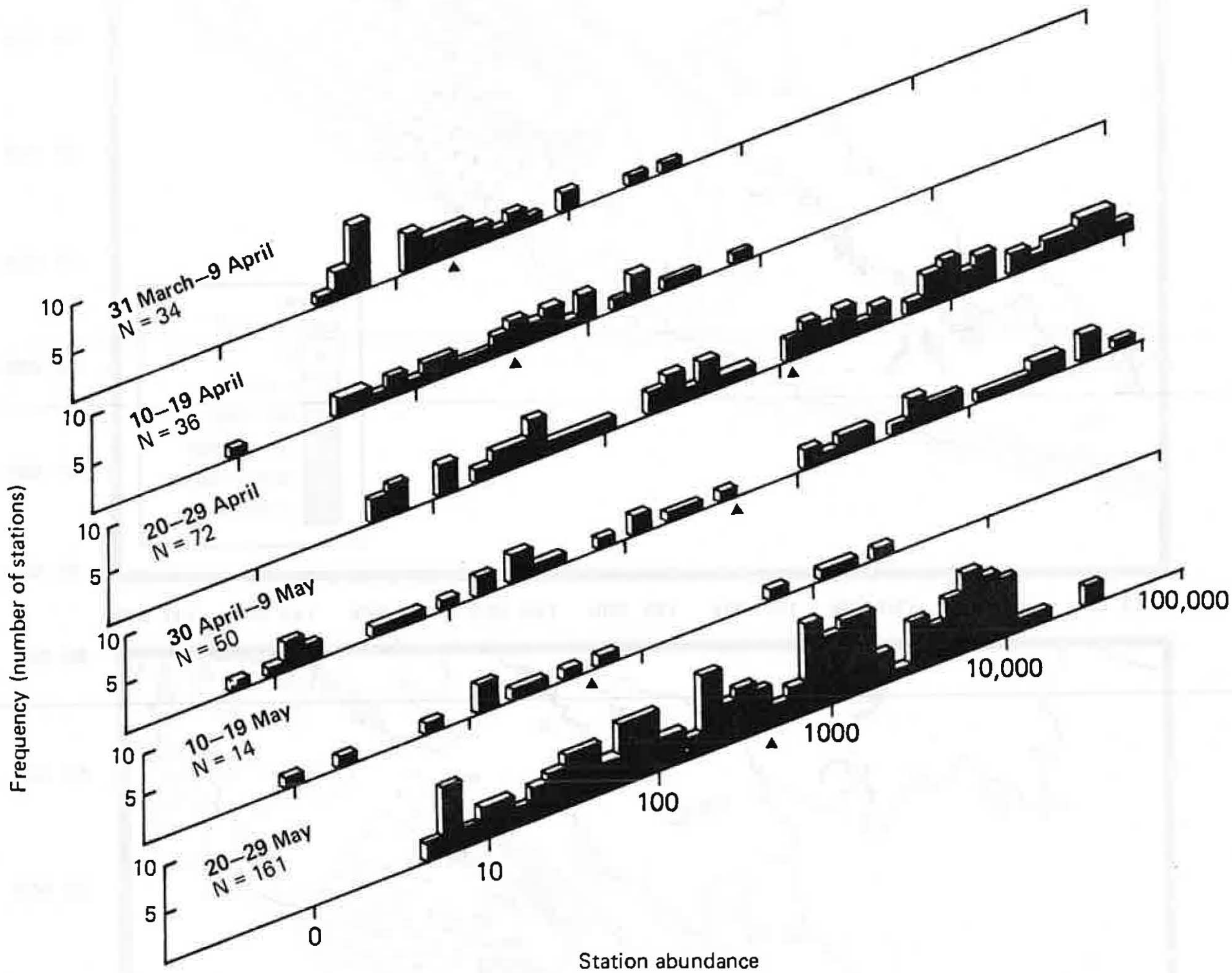


Figure 23.--Frequency distribution of logarithms of station abundance of walleye pollock larvae by 10-day periods. Triangles on the abscissa denote the means of logarithmic data.

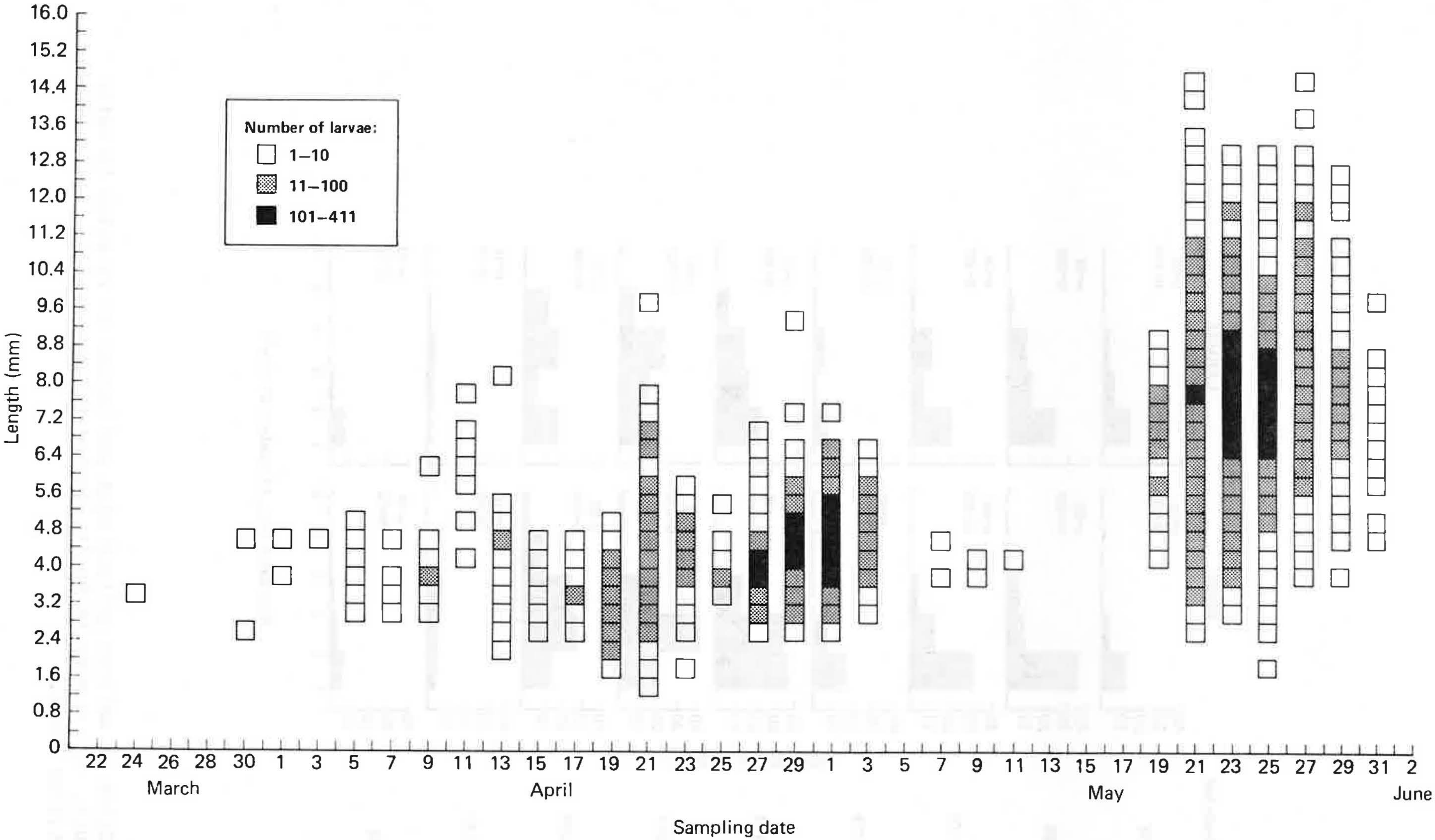


Figure 24.--Lengths of walleye pollock larvae by date of capture.

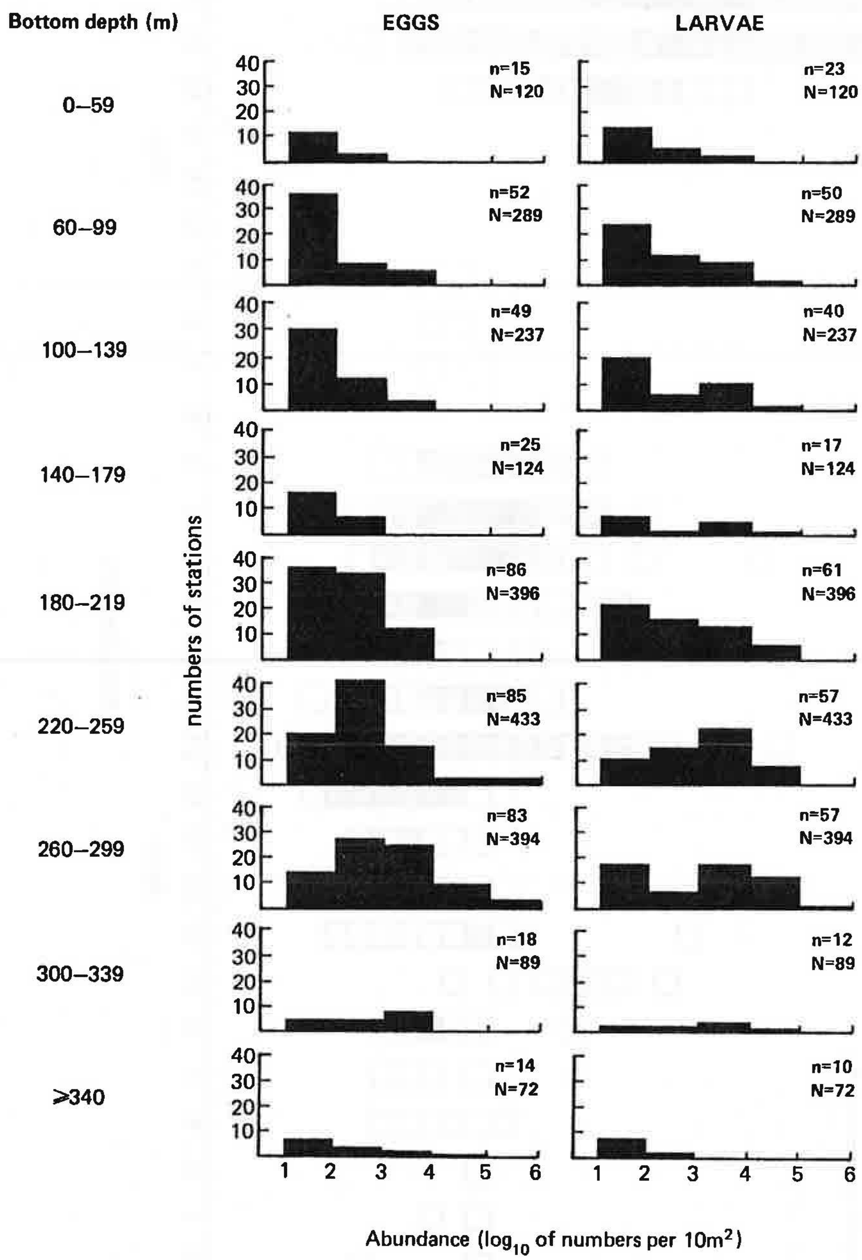
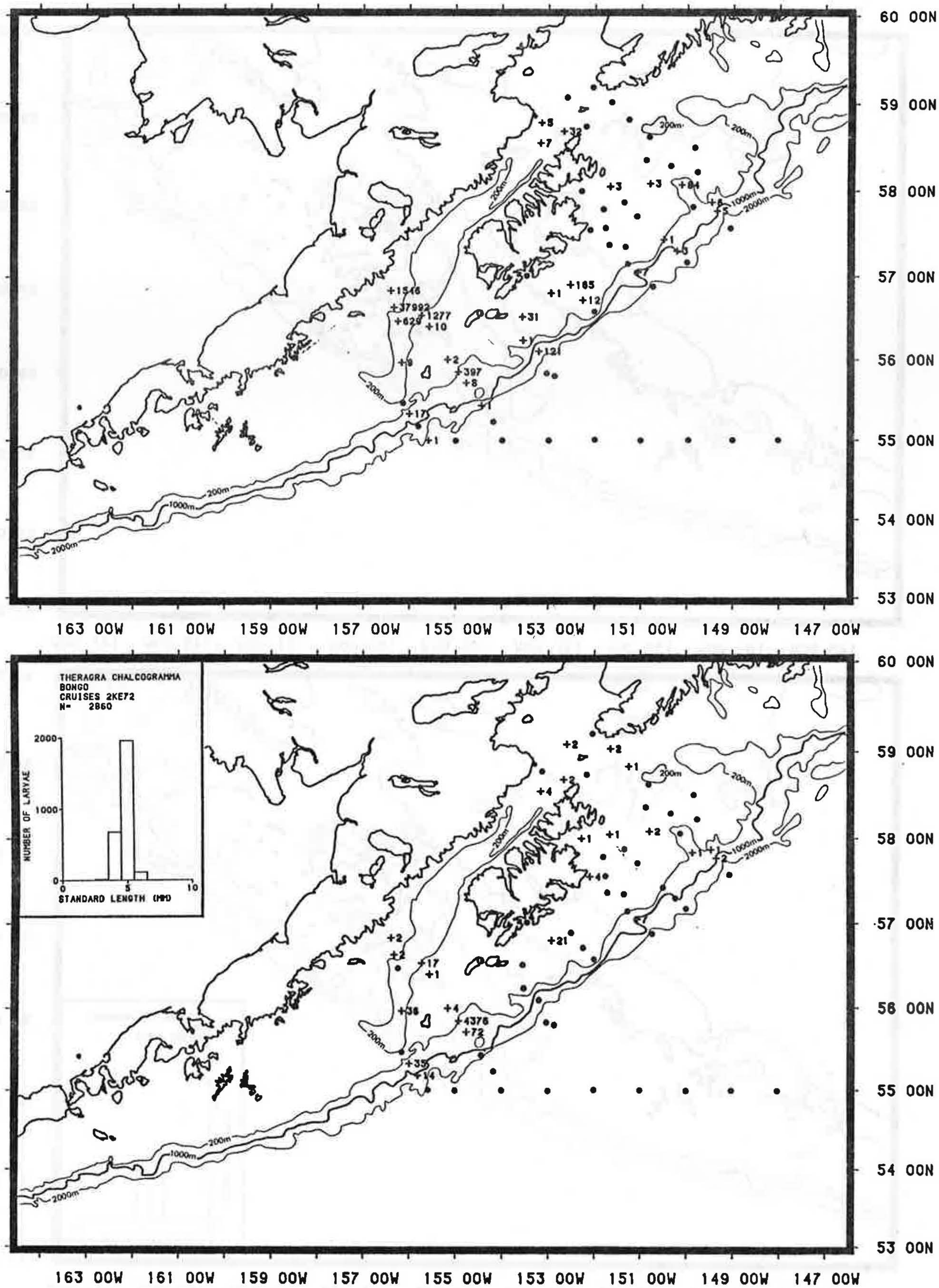
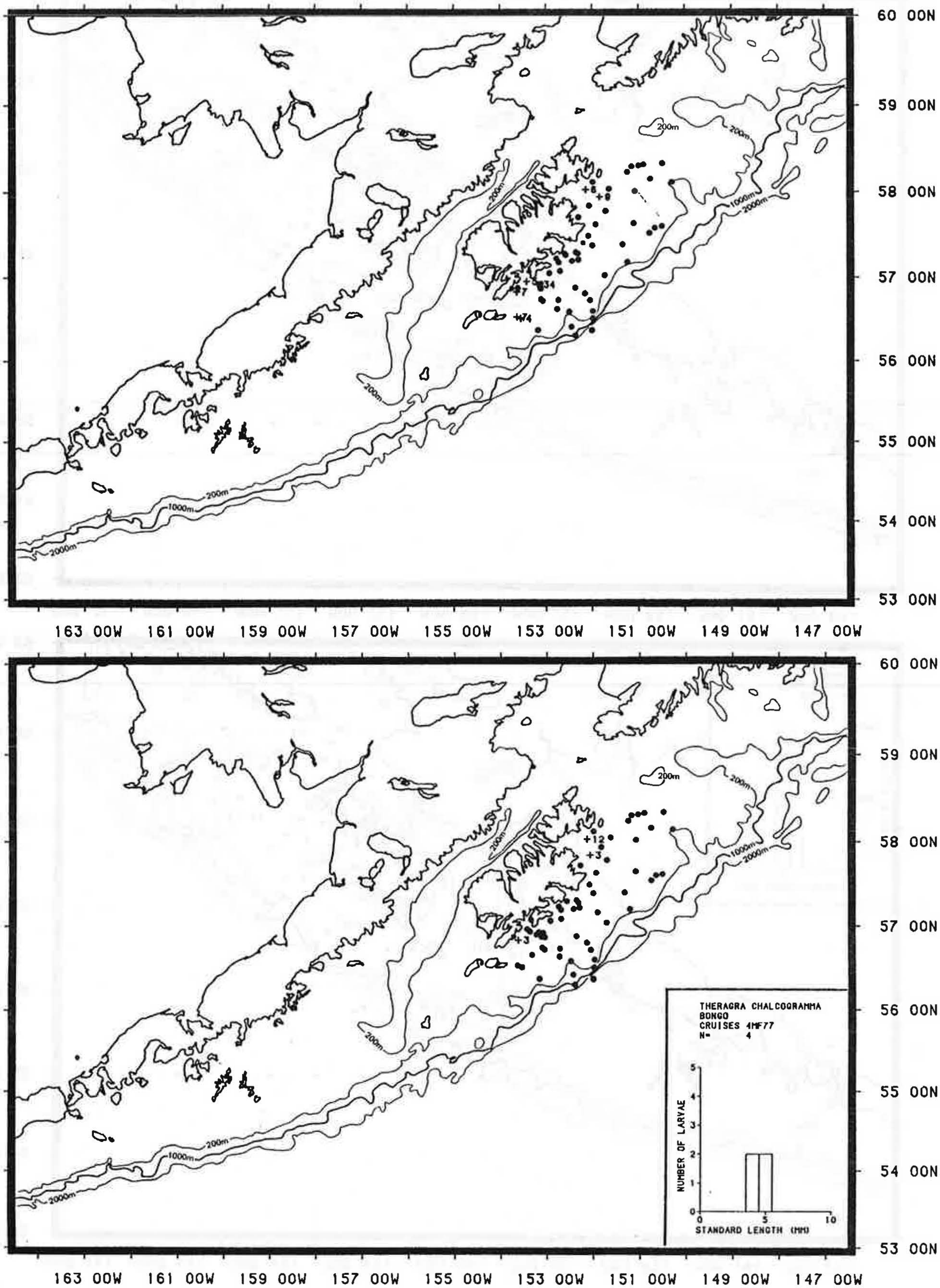


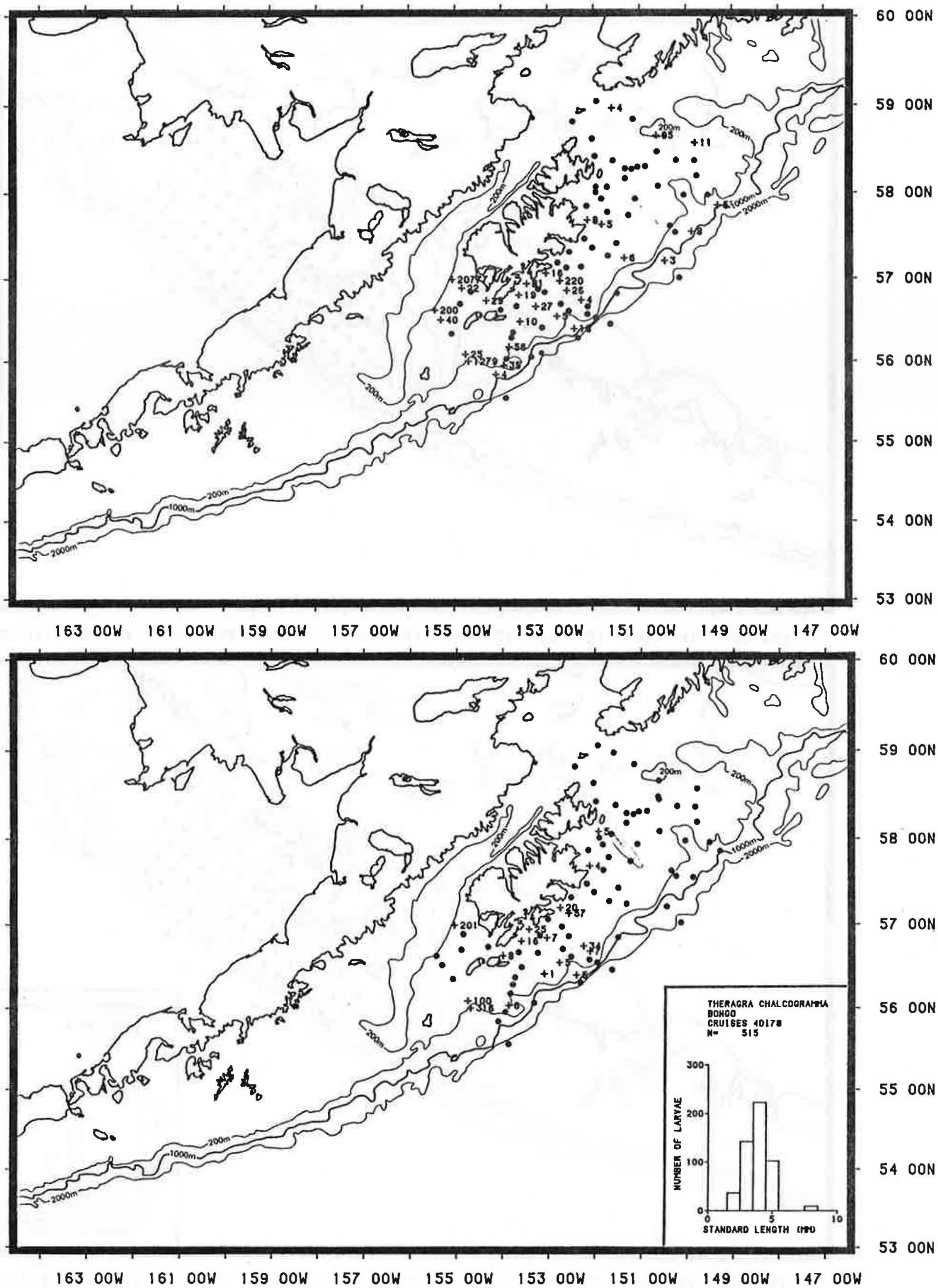
Figure 25.--Catches of walleye pollock eggs and larvae in relation to water depth. N = number of hauls sampled in depth range. n = number of positive hauls.



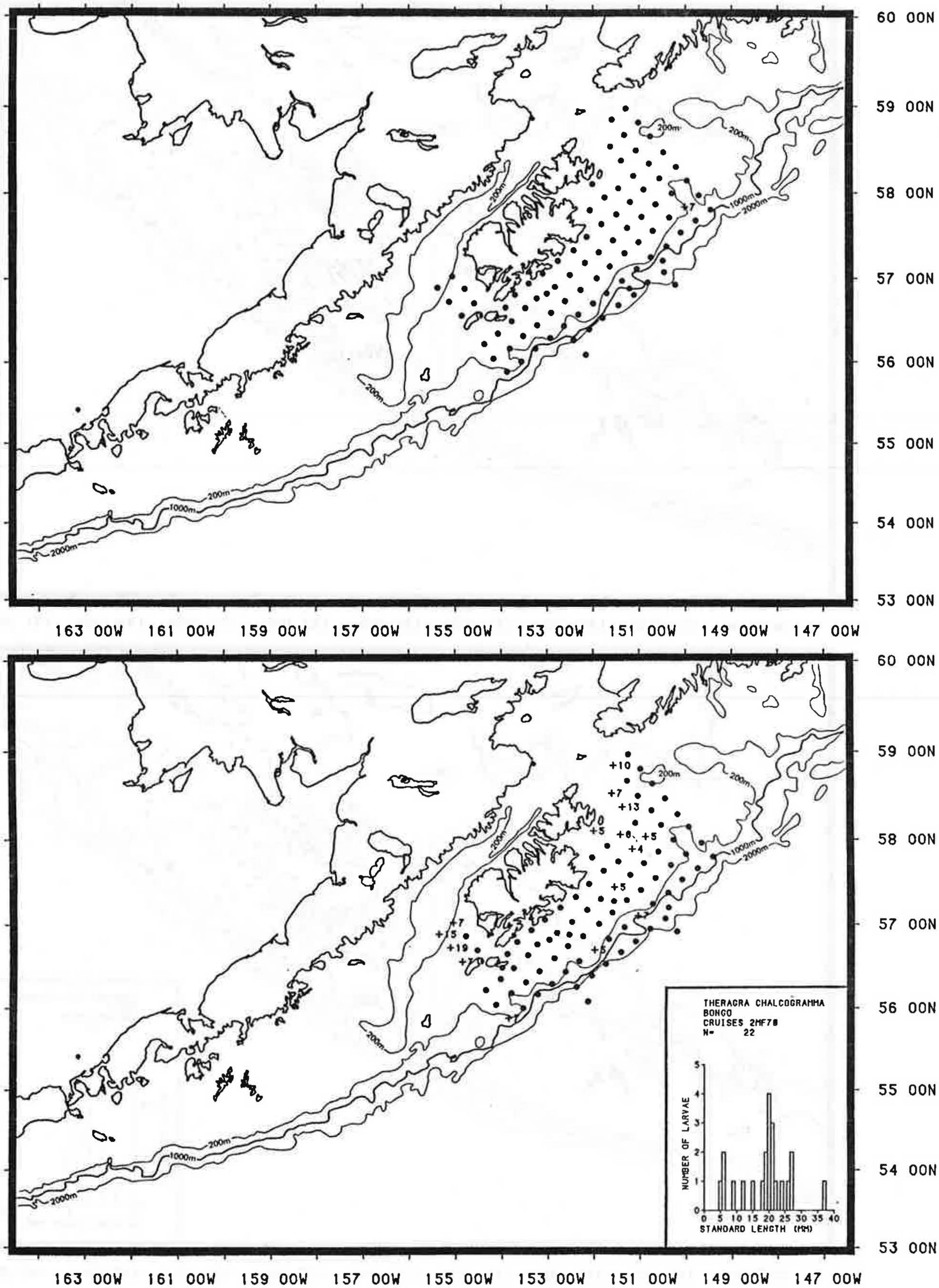
Appendix Figure 1.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 2KE72. Numbers represent catch per 10 m^2 of sea surface.



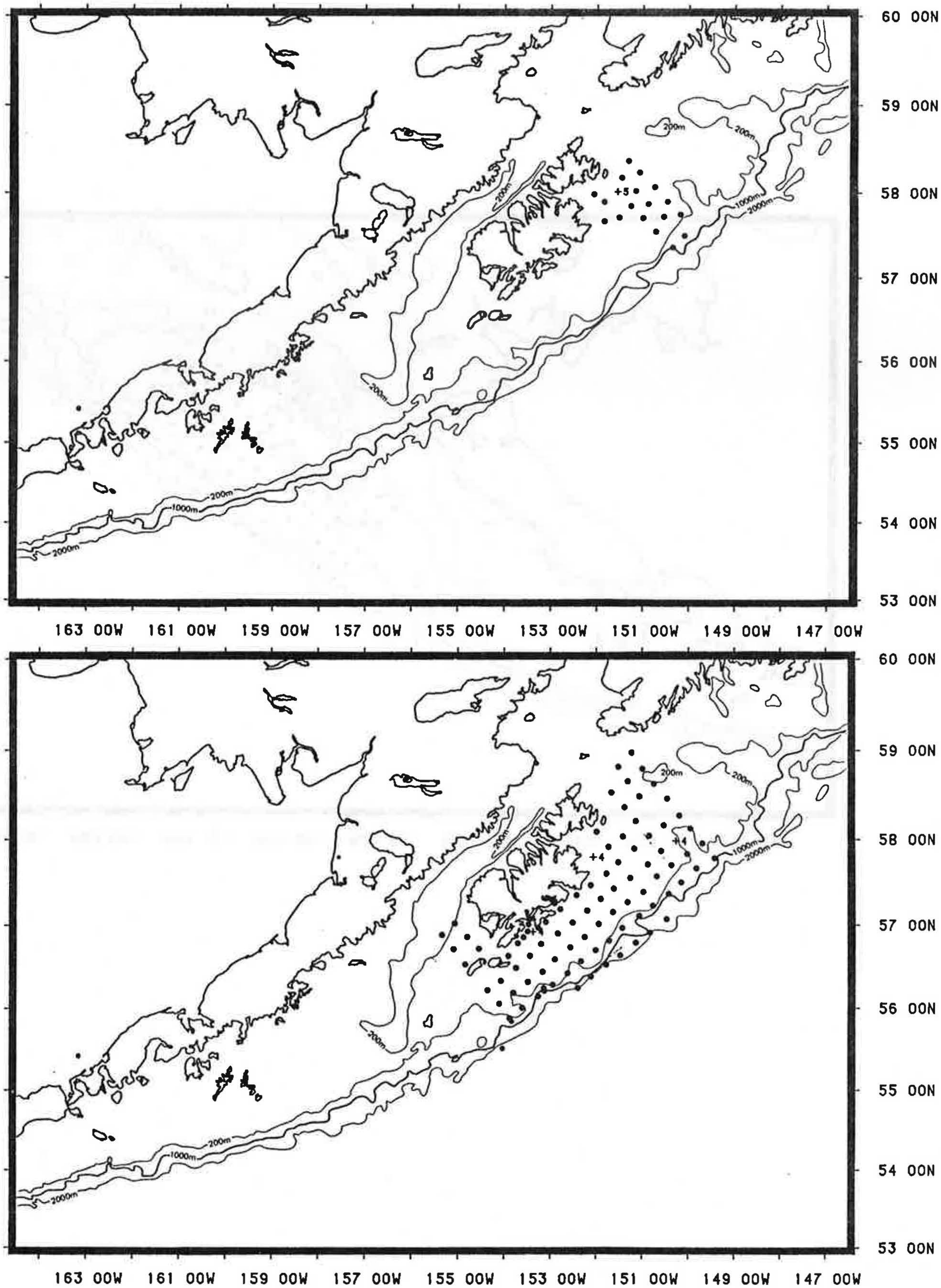
Appendix Figure 2.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 4MF77. Numbers represent catch per 10 m^2 of sea surface.



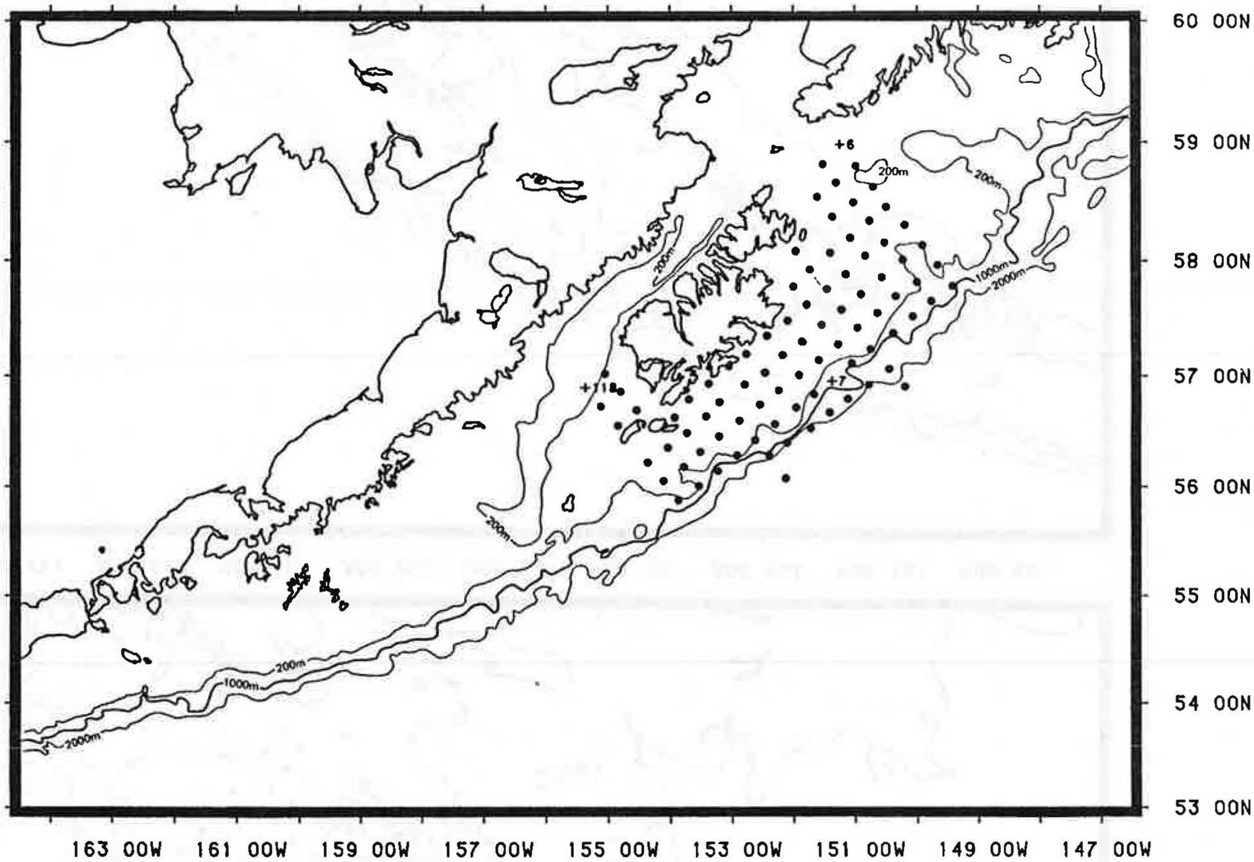
Appendix Figure 3.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 4DI78. Numbers represent catch per 10 m^2 of sea surface.



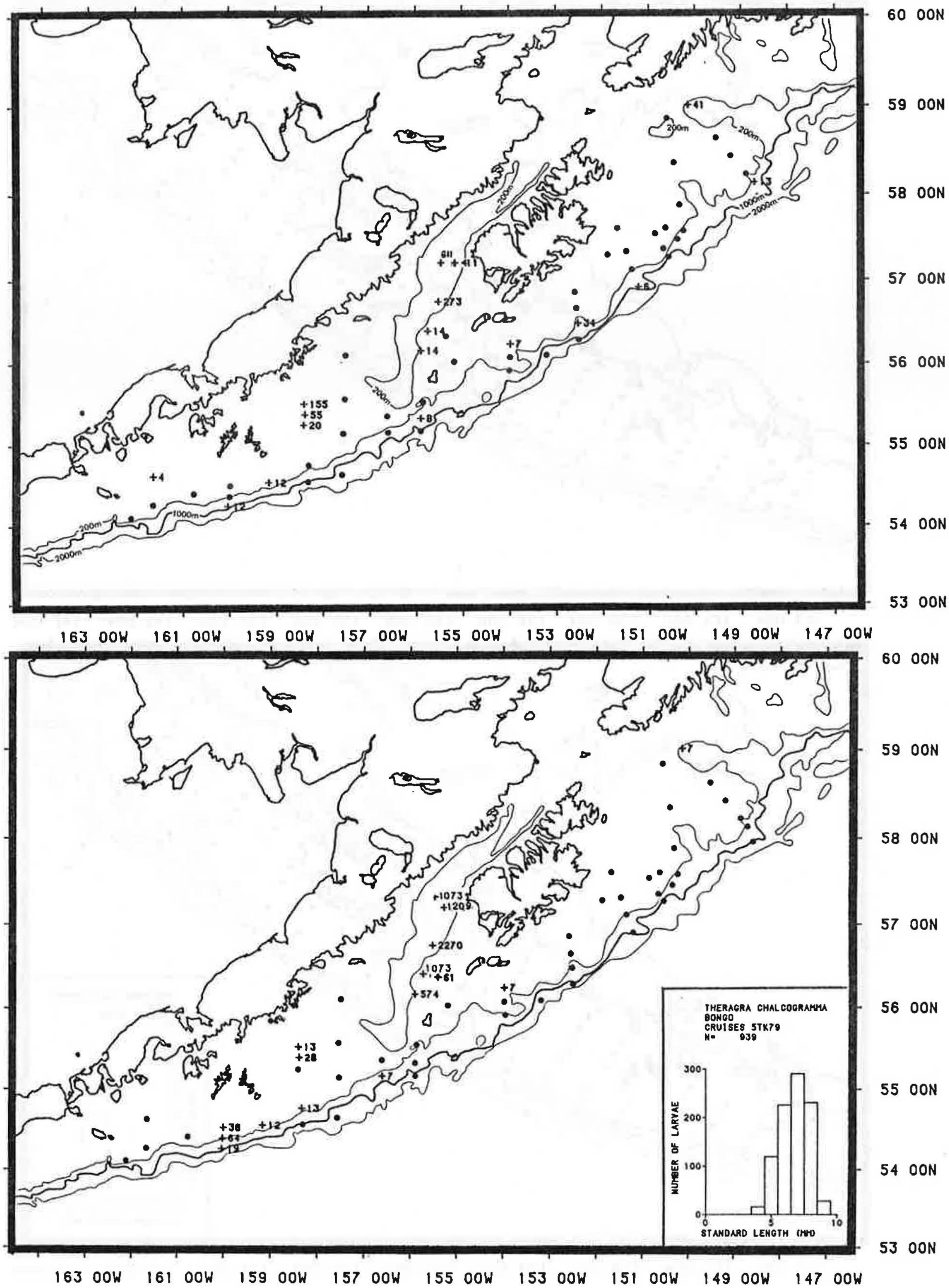
Appendix Figure 4.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 2MF78. Numbers represent catch per 10 m^2 of the sea surface



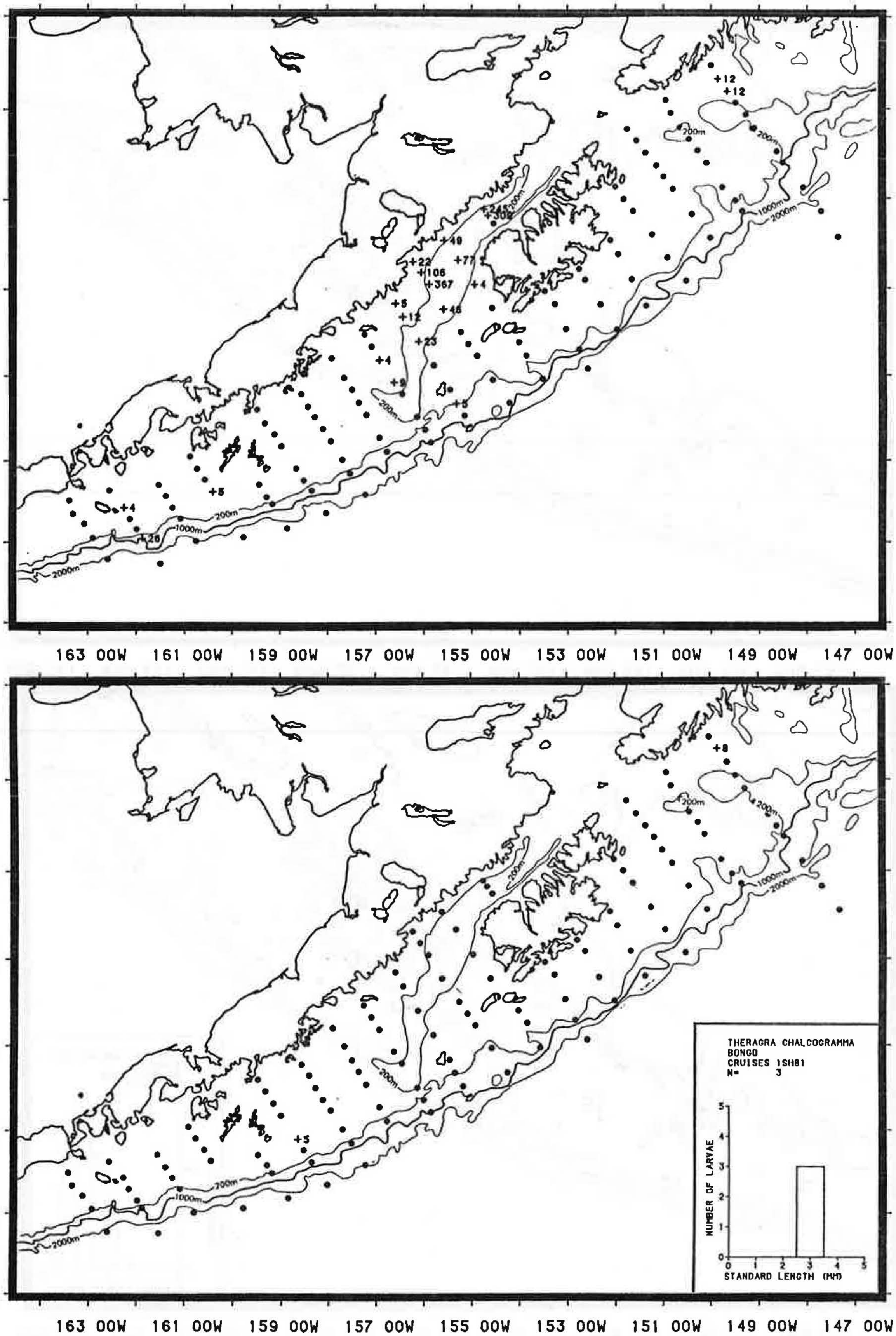
Appendix Figure 5.--Distribution and relative abundance of walleye pollock eggs during cruise 5MF78 (top) and cruise 1WE78 (bottom). Numbers represent catch per 10 m^2 of sea surface.



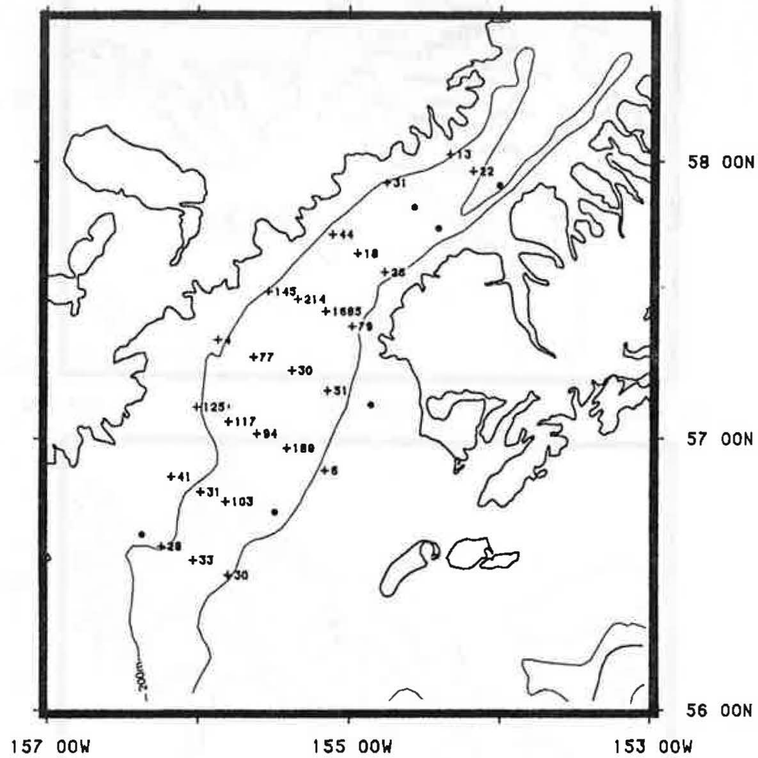
Appendix Figure 6.--Distribution and relative abundance of walleye pollock eggs during cruise 1MF79.



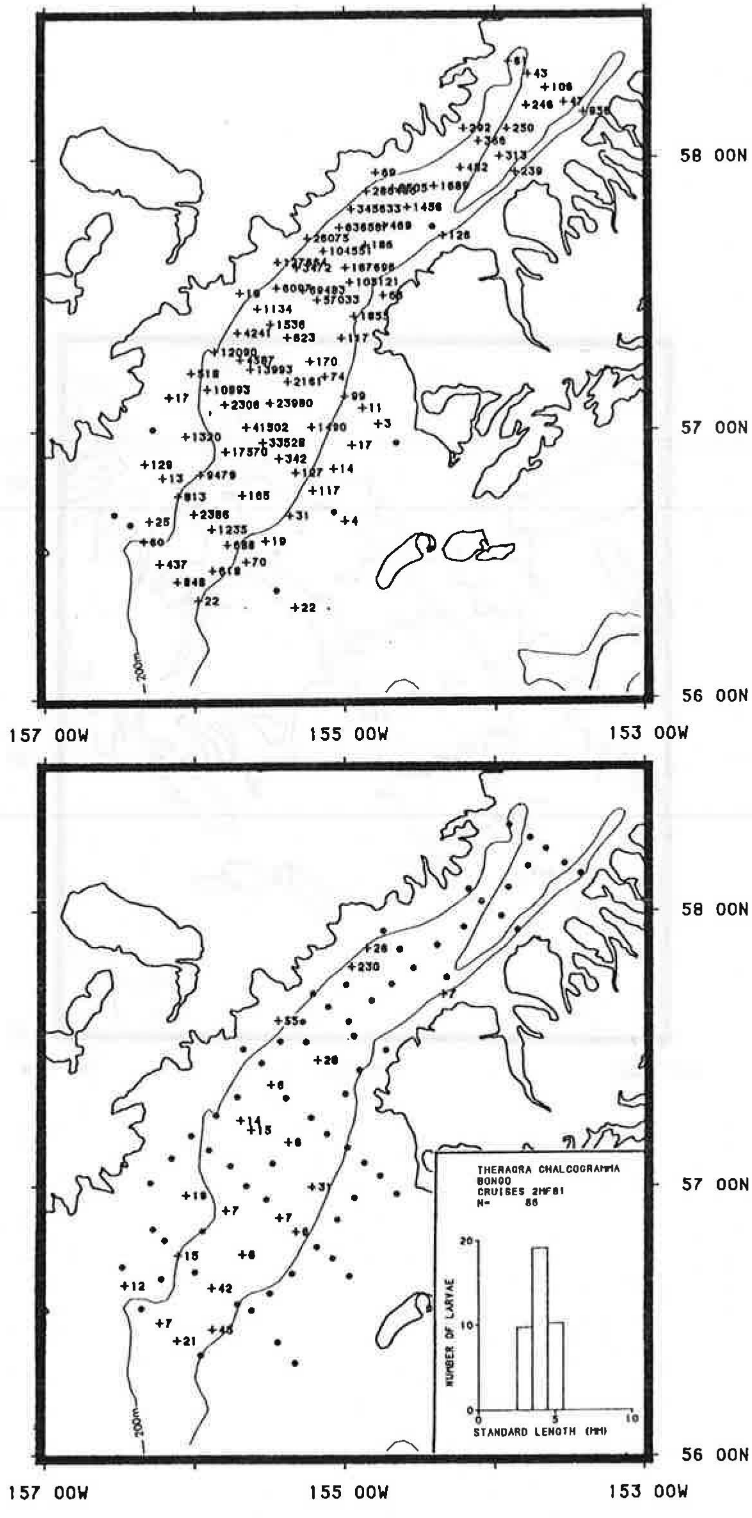
Appendix Figure 7.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 5TK79. Numbers represent catch per 10 m^2 of sea surface.



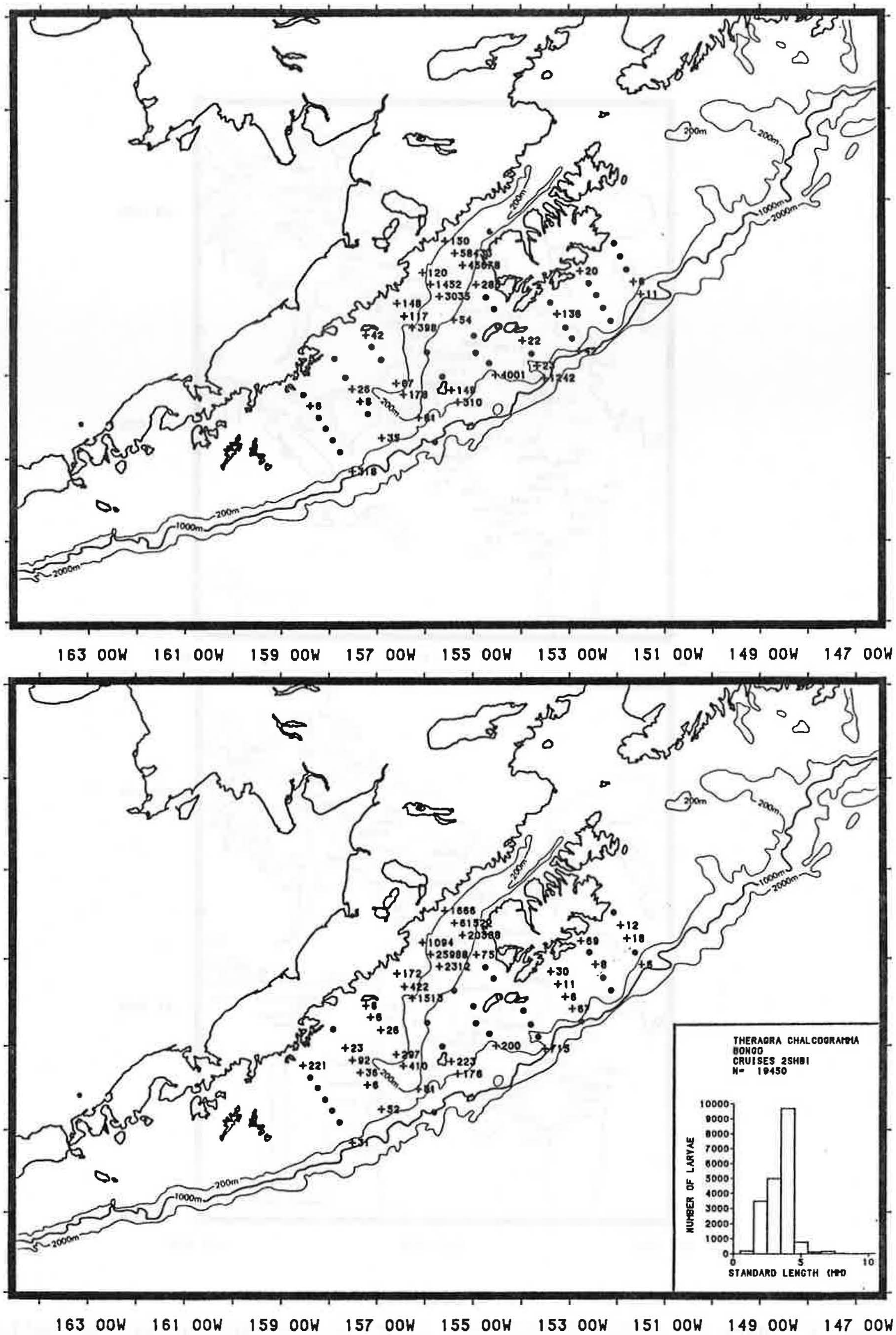
Appendix Figure 8.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 1SH81. Numbers represent represent catch per 10 m^2 of sea surface.



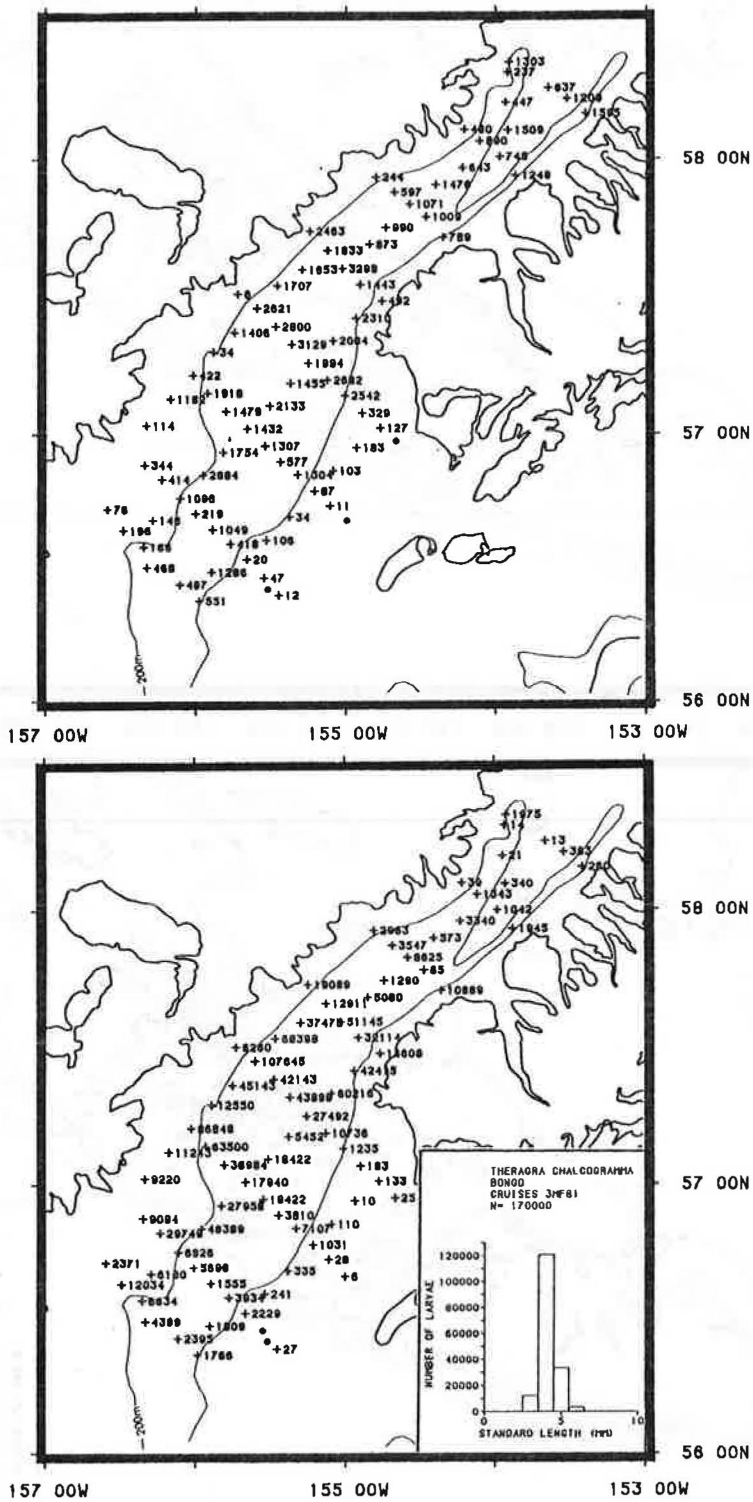
Appendix Figure 9.--Distribution and relative abundance of walleye pollock eggs, cruise 1MF81. Numbers represent catch per 10 m^2 of sea surface.



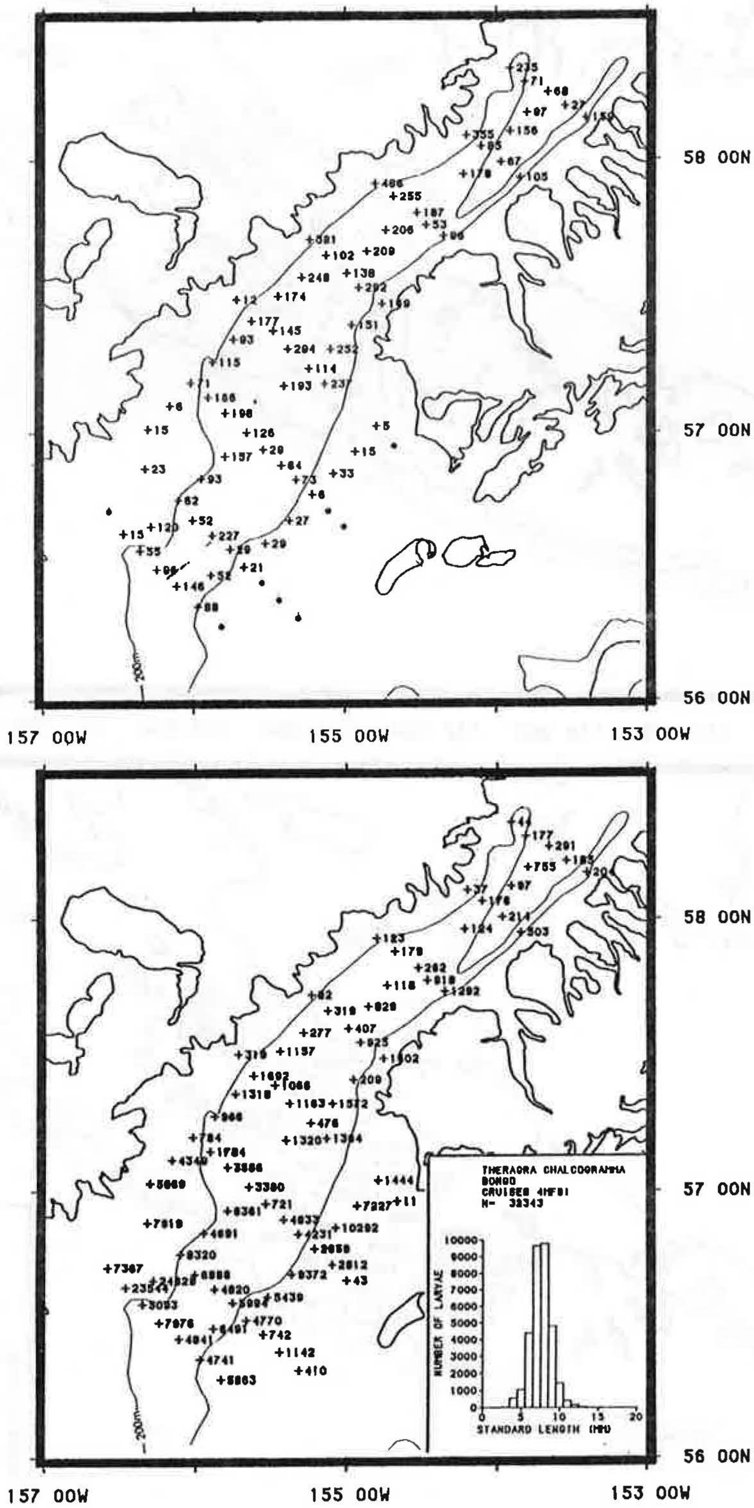
Appendix Figure 10.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 2MF81. Numbers represent catch per 10 m^2 of sea surface.



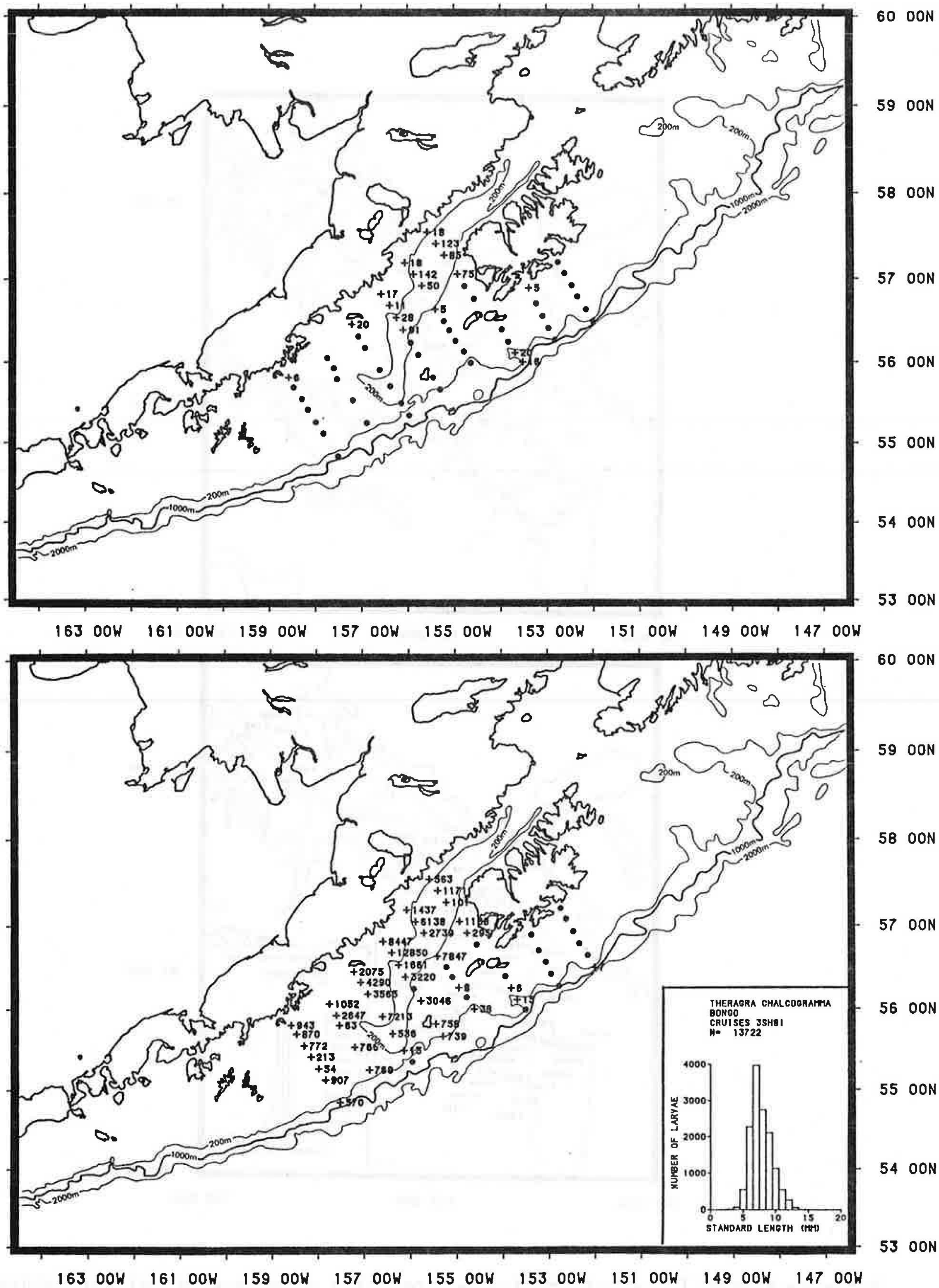
Appendix Figure 11.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 2SH81. Numbers represent catch per 10 m^2 of sea surface.



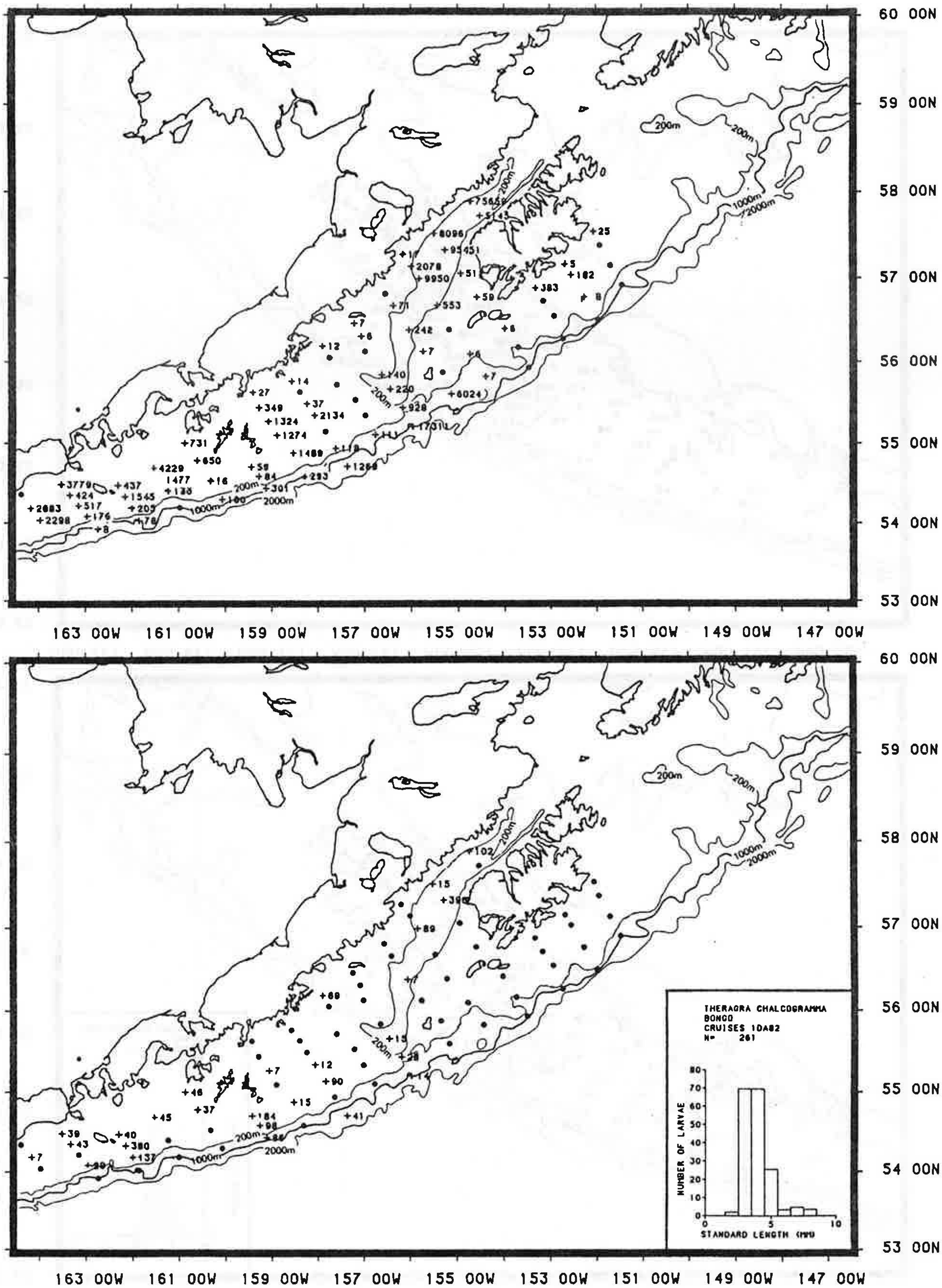
Appendix Figure 12.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 3MF81. Numbers represent catch per 10 m^2 of sea surface.



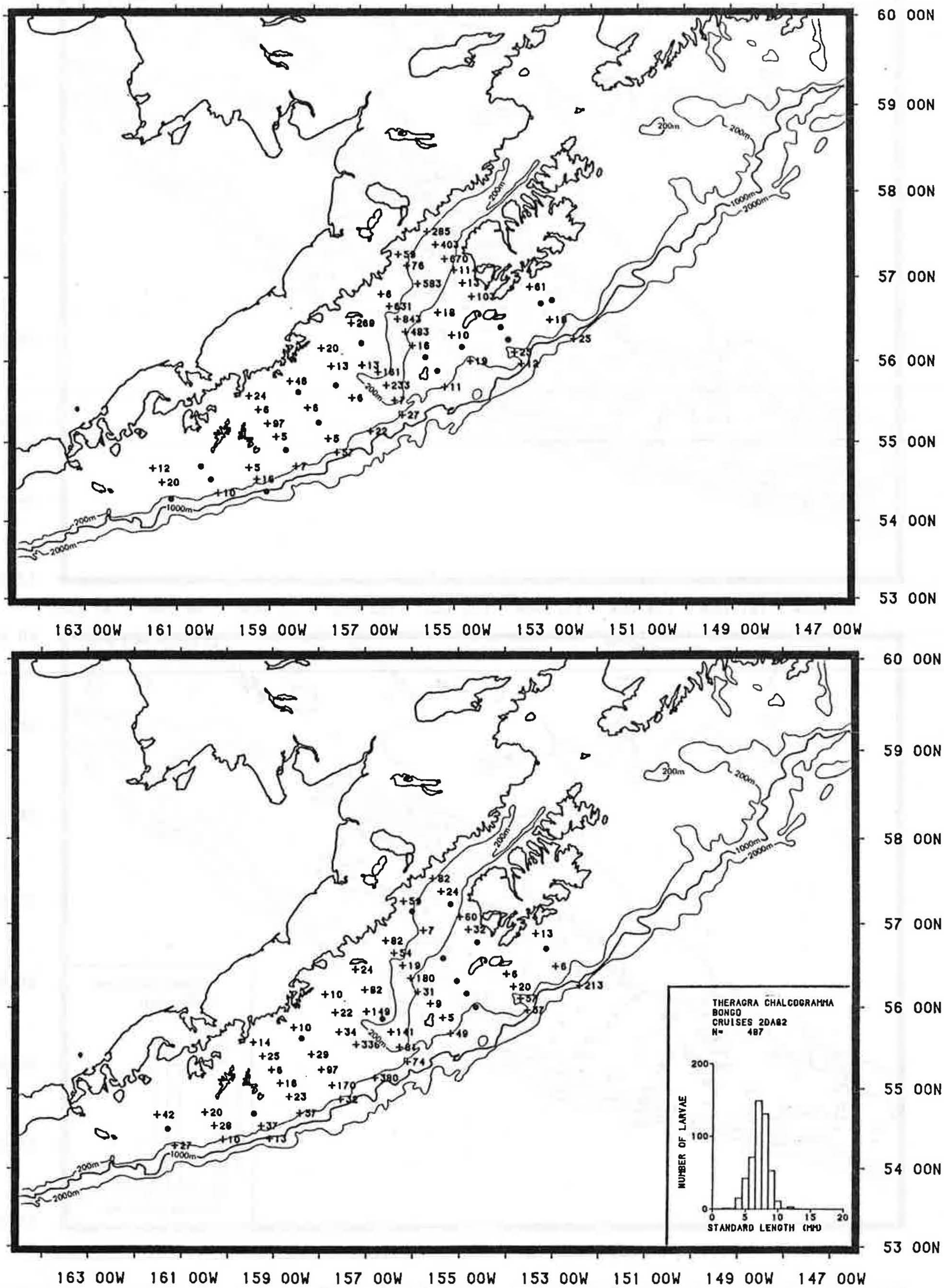
Appendix Figure 13.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 4MF81. Numbers represent catch per 10 m^2 of sea surface.



Appendix Figure 14.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 3SH81. Numbers represent catch per 10 m^2 of sea surface.



Appendix Figure 15.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 1DA82. Numbers represent catch per 10 m^2 of sea surface.



Appendix Figure 16.--Distribution and relative abundance of walleye pollock eggs (top) and larvae (bottom), cruise 2DA82. Numbers represent catch per 10 m^2 of sea surface.