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Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) in the Southeast Aleutian Basin During February and March, 1994

by
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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T. Honkalehto and N. Williamson

Alaska Fisheries Science Center
7600 Sand Point Way N.E., BIN C-15700
Seattle, WA 98115-0070

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary and Administrator
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

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ABSTRACT

Results from the winter 1994 echo integration-trawl survey of spawning walleye pollock (Theragra chalcoramma) near Bogoslof Island, covering an area between 166° W. and about 17°W. long., from the Aleutian chain north to 54°30‘N. lat. are presented. The eastern part of the survey area was inhabited mainly by non-spawning pollock from the 1989 year class that formed echo sign layers at depths of about 200-500 m. In the middle of the region, over deeper water, older pollock from a number of year classes and 1989 year class pollock formed dense spawning aggregations at depths of around 300-600 m. Although some pollock eggs were collected in one of five bongo net tows, little evidence of pollock spawning was observed before the end of the survey on 9 March. Despite some recruitment of the 1989 year class and the near absence of commercial fishing in the central and southeast Aleutian Basin, estimated spawning biomass declined from its winter 1993 level of about 0.63 million metric tons (t) to about 0.49 million t. The decline was most likely due to the natural mortality of aging year classes, which had supported the Bogoslof area spawning population at least since 1988.)

INTRODUCTION

Walleye pollock (Theraera chalogramma) are a semidemersal species of fish which inhabits the North Pacific Ocean from off central California to the Sea of Japan, and ranges throughout the Bering Sea. They support the largest single-species fishery in the world, with average annual catches of 5.3 million t since 1978 (FAO 1991, Wespestad 1993a). Until the early 1980s, pollock were harvested in coastal waters of the eastern Bering Sea shelf by countries other than the United States. Implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977 prompted a shift from foreign to domestic fleets inside the 200 mile fishery conservation zone (FCZ). In 1983, this area was renamed the U.S. exclusive economic zone (EEZ) and includes most of the Alaska continental shelf and the southeast Aleutian Basin. Catches on the eastern Bering Sea shelf, which peaked at about 1.9 million t in 1972, have averaged around 1.3 million t in recent years and are taken exclusively by U.S. vessels.

Subsequent to the MFCMA, new fisheries for pollock arose in the Aleutian Basin. The displaced foreign fleet initiated a fishery in the central Bering Sea outside both the U.S. and Russian EEZs (the donut hole (Fig. 1, inset)). Pollock catches in the donut hole rose to 1.45 million t in 1989, exceeding the U.S. EEZ catch but have declined sharply since then (Wespestad 1993a). In 1987, a new domestic fishery began harvesting spawning pollock in the southeast Aleutian Basin near Bogoslof Island. In 1991, Bogoslof area catches peaked at 264,000 t, while donut hole catches declined to about the same level.

During the latter half of the 1980s, scientists proposed that there was a connection between pollock inhabiting the donut hole and those spawning near Bogoslof Island, and were concerned about the effect of donut hole catches on pollock originating from U.S. and Russian EEZs. Responding to a drop in pollock biomass in the Bogoslof Island region, the North Pacific Fishery Management Council prohibited U.S. vessels from targeting pollock in the central Aleutian Basin after 1991, and set pollock bycatch limits near Bogoslof Island to 1,000 t (Wespestad 1993a).

In February 1991, prompted by a 1990 bilateral meeting between the U.S.S.R. and the U.S., four high-seas fishing nations (Japan, Korea, Poland, and China) met with the U.S. and U.S.S.R. to initiate discussions on establishment of a Convention on the Conservation and Management of the Living Marine Resources of the Central Bering Sea. Through a series of 10 conferences using information from research cruises and the fishery itself, the nations agreed that pollock populations in the Aleutian Basin were in decline and that unrestricted fishing was harmful to the entire Bering Sea ecosystem. They proposed a moratorium on fishing in the donut hole from 1992 to 1995, or until basin stocks recovered to a biomass greater than 1.67 million t. The Convention agreement, which also established research efforts, monitoring, and enforcement protocols for the central Bering Sea, was finalized in February 1994 and was signed by each of the countries that participated in negotiations. It was presented to the U.S. Senate Committee on Foreign Relations in September 1994, and awaits ratification'.

The relationship between pollock inhabiting the basin and those found associated with the U.S. and Russian Bering Sea shelves is still unclear. To address this and other management issues, U.S. scientists from the Alaska Fisheries Science Center (AFSC), in cooperation with

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[1]D. A Colson, Deputy Assistant Secretary of State for Oceans Affairs, U.S. Dept. of State, Washington D.C., testimony before the Committee on Foreign Relations, United States Senate, September 28, 1994.

scientists from Japan, Russia, Korea, Poland, and China, have conducted echo integration - trawl (EIT) surveys of spawning pollock in portions of the Aleutian Basin and Bering Sea shelf each winter since 1988, except 1990. In 1993, as part of the Convention agreement on the donut hole, participating nations decided that in the absence of other research data the results of the U.S. winter survey of the Bogoslof area would be used as an index of the total Aleutian Basin biomass. It was agreed to assume that the biomass of spawning pollock near Bogoslof represented 60% of the Aleutian Basin pollock biomass. The fishing moratorium will be in effect until the Bogoslof area spawning biomass exceeded 1 million t.

This report presents results from the 1994 survey of southeast Aleutian Basin waters near Bogoslof Island conducted between 27 February and 9 March (Fig. 1). The principal objectives were to collect echo integration data and trawl data necessary to determine the distribution, abundance, and biological composition of spawning walleye pollock.

METHODS

Sampling Equipment

The survey was conducted on board the NOAA ship Miller Freeman, a 66 m (216 A) stem trawler equipped for fisheries and oceanographic research. Acoustic data were collected with a Simrad EK500 quantitative echo sounding system (Bodholt et al. 1989). A Simrad 38 kHz split beam transducer was mounted on the bottom of the vessel's centerboard. With the centerboard fully extended, the transducer was 9 m below the water's surface. System electronics were housed in a portable laboratory mounted on the vessel's weather deck. Data from the Simrad EK500 echo sounder/receiver were processed using Simrad BI500 echo integration and target strength data analysis software (Foote et al. 1991) on a SUN workstation.

Midwater echo sign was sampled using a modified Northern Gold 1200 midwater rope trawl (NET Systems, Inc.). The trawl was constructed with ropes in the forward section and stretch mesh sizes ranging from 163 cm (64 in) immediately behind the rope section to 8.9 cm (3.5 in) in the codend. It was fished in a bridleless configuration and was fitted with a 3.2 cm (1.25 in) mesh codend liner. Headrope and footrope lengths were 94.5 m (310 ft) and 50 m (164 ft), respectively, and the breastlines measured 79.4 m (260.5 ft). Headrope length was measured between the points of attachment to the breastline; footrope length was measured between the points where the tom weights are attached, The net was fished with 1.8 m X 2.7 m (6 ft X 9 ft) steel V-doors (1,000 kg [2,200 lb]), and 227 kg (500 lb) tom weights on each side. Trawl mouth opening and depth were monitored with a Furuno wireless netsounder system attached to the headrope of the trawl.

Ichthyoplankton and zooplankton were sampled with a two-tiered bongo net system. A 20 cm bongo frame with 153 pm mesh nets was attached to a wire approximately 0.5 m above a 60 cm (23.6 in) bongo frame with 333 pm mesh nets. A 40 kg lead weight was used as a depressor. To monitor depth and oceanographic conditions, a Seabird conductivity/temperature/ depth (CTD) profiler was attached to the wire about 0.6 m above the 20 cm bongo frame.

Vertical profile measurements of water temperature and salinity were collected at trawl and calibration sites using a Seabird CTD system. Expendable bathythermographs (XBT) provided additional temperature profile data.

Sampling Techniques

From 27 February to 9 March, AFSC scientists surveyed westward from 165°51’ W to 169° 53’ W long. along parallel north-south transects (Fig. 1). On the eastern and western ends of the survey area, transects were spaced 10 nautical miles (nmi) apart. In the central area, pollock densities were higher and echo sign was distributed such that an adaptive sampling approach was used. After completing transects 1.0 through 9.0, we doubled back to run transects 6.5 through 10.5 between whole numbered transects, reducing spacing to 5 nmi (Fig. 2). For transects 11 .0 through 15.0, 10 nmi spacing was resumed. Transect 10.0 was cut short by severe weather. The southern end of each transect extended to the 100 m depth contour on the Aleutian shelf Northern transect endpoints were similar to those in previous years*, except in the western part of the survey area, where inclement weather prevented the vessel from conducting transects as far north. Lack of significant echo sign in the northwestern survey area (north of 54° N lat. and west of 168° W long.) during winter 1993, and the very low echo sign density along northwestern transects this year led us to believe that no significant portion of the Bogoslof area spawning population was missed. However, during the winter 1988-1992 EIT surveys, some pollock sign was observed in that area.

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[2] N. Williamson, Alaska Fisheries Science Center, NMFS, NOAA 7600 Sand Point Way NE, Seattle WA 98115, unpublished cruise reports MF88-1, MF89-1, MF91-1, MF92-2, MF93-1, November 1994.

Echo integration-trawl operations were conducted both day and night. While the vessel was transecting, its speed ranged between 4 and 13 knots depending upon weather conditions. The acoustic system collected echo integration data which, when properly scaled, is used to estimate pollock density. Midwater trawl hauls were made at selected locations (Fig. 2) to identify echo sign and to provide biological samples. The vertical net opening for the midwater rope trawl averaged 20 m at a trawling speed of about 3 knots. Standard catch sorting and biological sampling procedures, similar to those described in Wakabayashi et al. (1985), were used to provide weight and number by species for each haul. Pollock were further sampled to determine sex, fork length (FL), body weight, age, maturity, and gonad weight. Ovary tissue samples were collected from mature pollock and frozen for stock structure studies. Whole pollock were frozen for a calorimetric study. Gonadosomatic indices (GSIs) were computed for all pre-spawning female pollock. The GSI was defined as the ratio of ovaryweight to total body weight.

When weather permitted, a bongo net tow was conducted each night at approximately 2300 (MT) to collect macrozooplankton samples for the initial conditions of a numerical simulation model of Bering Sea plankton, The nets were deployed at a constant wire speed of 40 m/min to a maximum depth of 400 m. The winch was stopped and the nets allowed to stabilize for up to 30 sec. The nets were then retrieved at a wire speed of 20 m/min. The ship's speed was adjusted to attempt to maintain a wire angle of 45° during the entire tow. When the nets reached the surface, they were brought aboard and the samples were washed into the codends. By random selection, one half of the sample was preserved in formalin. The other half was sieved into three size classes and frozen for later analysis of nutritional content. Flow meters in the nets recorded the amount of water filtered and the attached CTD recorded the time/depth history of the tow.

Standard sphere calibrations were conducted in Port Susan, Washington, on 10 February, in Inanudak Bay, Umnak Island, Alaska, on 25 February, and in Kuliak Bay, Alaska, on 26 March 1994 (Table 1). Acoustic measurements of a copper sphere suspended below the transducer were made. The standard sphere (60.0 mm diameter) had a known target strength of -33.6 dB. Split beam target strength and echo integration data were collected with the Simrad EK500 system to describe transducer beam pattern characteristics and other acoustic system parameters. System parameters were adjusted so that target strength and echo integration measurements matched the known responses of the standard sphere. No significant changes in the acoustic system parameters were observed between calibrations.

Data Analysis

Absolute estimates of pollock abundance were derived from acoustic data as follows. Echo integration data with a horizontal resolution of about 9 m (at 12 knots ship speed) and a vertical resolution of l-2 m from the transducer to 0.5 m off bottom, or to the lowest extent of the fish sign, were examined for pollock sign. Estimates of total backscattering strength in the area represented by each transect were generated. These values were then summedand scaled to estimate the numbers and weight of pollock for each length (cm) and age (years) category using pollock size compositions, length-weight relationships derived from trawl catches, a previously derived relationship between target strength (TS) and fish length (TS = 20 Log FL - 66; Foote and Traynor 1988), and an age-length key. Although the raw haul size compositions indicated a higher abundance of females in the population, past experience in sampling the Bogoslof area spawning schools has shown that we cannot easily obtain a representative sex ratio because these pollock are highly aggregated and stratified by sex. Historical data from Japanese summer surveys (1977-79) of the entire Aleutian Basin do not support the argument that there are more females than males in the population. For example, Yoshimura (1992) reports finding a higher percentage of males in his basin-wide survey conducted during summer 1988. We thus assumed a 50:50 sex ratio for population size compositions and the length-weight relationship. A male length-weight regression equation obtained by pooling all trawl data was averaged with a pooled female length-weight regression equation by minimizing the sum of squares between the two curves using an iterative non-linear approach. Estimates of length-specific numbers and biomass were summed to produce total estimates for Bogoslof Island pollock aggregations.

RESULTS

Biological and Oceanographic Results

‘Biological data were collected and specimen and tissue samples preserved from 13 midwater rope trawl stations and 5 bongo net tows (Fig. 2, Tables 2 and 3). Pollock was the dominant fish species captured in midwater trawl hauls (Table 4). Significant numbers of lanternfish (Myctophidae) and northern smoothtongues (Leuroglossus schmidti) were also captured. Biological data collected (Table 5) included pollock length and maturity characteristics, whole pollock, and whole specimens of several other fish species.

Pollock caught **in trawl** hauls ranged from 38 to 67 cm FL. Two size modes **were** observed. Pollock catches from bottom depths less than 500 m were dominated by 40-50 cm fish, whereas those from bottom depths greater than 500 m were composed mostly of 50-60 cm fish. A single haul (haul 12, 987 m bottom depth, Fig. 2) caught fish with a bimodal length distribution. Sex composition varied with each haul ranging from 28% to 98% female. In some areas where two layers of echo sign were observed, each layer was sampled (hauls 3-4 ,7-8). The proportion of males was higher in the deeper layers, implying that vertical stratification by sex was occurring. Throughout the survey more females were caught than males, but this was considered a sampling anomaly (see Methods). For the two nearshore hauls (<500 m bottom depth), the larger females (>51 cm) were all in a pre-spawning stage whereas 58% of the females less than or equal to 51 cm were in a developing stage and not expected to spawn soon (Fig. 3a). Maturity data from the 11 offshore hauls (>500 m bottom depth) indicated that 90% of the female pollock greater than or equal to 40 cm were in a pre-spawning stage (Fig. 3b). Gonadosomatic indices from these pre-spawning females exhibited a positive correlation with length (Spearman $r = 0.424$, $p < 0.00l$), with a mean of 0.19 (Fig. 4). Few actively spawning females had been observed by the time the **survey** ended on 9 March. We examined all bongo net tows for further evidence of spawning. Only one, cast 4 (Table 3, Fig. 2) contained a visible quantity of pollock eggs. We also observed a few female pollock with fairly full ovaries that looked as though they had partially spawned and **were** either preparing to spawn again or were resorbing the remainder of their eggs.

Oceanographic data included 11 CTD casts and 12 XBT casts (Tables 6 and 7, Figs. 5-7). Most of the temperature data in the area surveyed showed a well-mixed water column with a slight decline in temperature from 4° C near the surface to about 3.5° C at 300 m and deeper.

Salinity increased with depth from about 32 ppt near the surface to 34 ppt at 600 m (Fig. 6). In the eastern portion of the survey area XBT profiles 6 and 7 (Figs. 5 and 7a,b) indicated a uniform 5° C water column. XBT profiles 20 and 24 showed an influx of cooler water (2° - 3.5° C) between the surface and 450 m on the western end of the survey area (Fig. 7c).

Pollock Distribution and Abundance

Pollock echo sign was observed throughout the survey area (Fig. 1). In the eastern portion of the survey area (transects 1 .0-5.0) moderate densities of pollock were distributed slightly off bottom in water depths averaging around 600 m. They formed a layer from about 200-500 m, deepening to 400-600 m as the water depth increased. Age and maturity data from haul 1 indicated that these pollock were primarily from the 1989 year class, and were non-spawning. Echo sign on the north end of transect 6.0 resembled echo sign from transects 1.0-5.0. To the south along transect 6.0, as water depths increased, the sign became denser and remained well off bottom, which is more typical of southeast Aleutian basin spawning pollock aggregations. From transect 6.0 westward to transect 10.0, south of 54°N lat., dense concentrations of pollock echo sign were observed mainly 300-500 m from the surface, but ranging vertically from 250 to 750 m in depth (Fig. 8, “spawners”). Pollock were distributed mostly along the southern third of each transect **within** approximately 30 nmi of the Aleutian chain. In shallower water adjacent to the Aleutian chain, pollock echo sign appeared different than that observed over deeper water, and consisted of layers at 150-400 m (Fig. 8, “non-spawners”). Information from haul 9 indicated that these fish were largely from the 1989 year class. In the western portion of the survey area, echo sign density diminished from transects 10.0 to 12.0, increased significantly along transect 13.0, then decreased again along transects 14.0 and 15.0 (Fig. 1).

Beginning at the eastern end of the survey area, pollock sign was usually accompanied by a thinner scattering layer above at about 200-300 m which was presumed to be a mixture of small fish and macrozooplankton based on evidence from midwater trawls. We did not specifically sample this micronekton scattering layer, but we consistently caught lanternfish and northern smoothtongues in trawls targeting the deeper pollock layer. Along transects 7.0-10.0, pollock and micronekton layers overlapped. Trawl hauls 4,5, 8 and 13, made in that vicinity (Fig. 2), caught the largest bycatch of lanternfish and northern smoothtongues. Along the north half of transect 11.0 and on transects to the west, the micronekton echo sign persisted while pollock sign dished. The relationship between the two layers is **not** known. Although evidence exists that pollock prey on lanternfish and bathylagids during the late summer in nearby slope waters’, pollock stomach samples during past Bogoslof area surveys have shown little evidence of predation. Stomachs were usually empty, due either to lack of feeding or to regurgitation after being trawled from great depths,

Two types of pollock echo sign were identified and quantified from this region. The first formed the typical spawning aggregations found over deep **water** in the region surrounding Bogoslof Island, surveyed since 1988. “These mainly pre-spawning pollock (hauls 2-8 and 10-l 3) had an estimated biomass of 0.49 million t and numbered around 478 million fish (Table 8). They ranged in length from 39 to 67 cm with a major mode at 52 cm and a minor mode at 45 cm (Fig. 9a). Their ages ranged from 4 to 24 years with one pronounced mode at 5 years accounting for 19% of the spawning population (Fig. 9b). The second sign type was characterized by pollock caught in hauls 1 and 9 inhabiting shallower waters along transects 1.0-5.0, the northern portion

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[3] G. Lang, Alaska Fisheries Science Center, NMFS, NOAA 7600 Sand Point Way NE, Seattle WA 98115. pers. commun., November, 1994.

of transect 6.0, and near the Aleutian chain. They were categorized as a non-spawning portion of pollock echo sign found near Bogoslof Island but outside of the main spawning area. They had an estimated biomass of 0.05 million t and numbered 71 million fish (Table 8). Their predominant length mode was 44 cm (Fig. 9a), and they were mainly in developing maturity stages in contrast with fish from the other hauls. Most were age 5 from the 1989 year class, accounting for 50% of the non-spawning fish (Fig. 9b).

DISCUSSION

In the region surrounding Bogoslof Island, estimated spawning biomass of walleye pollock has been decreasing since the first survey in 1988 (Fig. 10). The current level is 0.49 million t--down from 2.4 million t in 1988. Age data from surveys conducted in 1988, 1989, and 1991 indicate that 1978 has been the dominant year class (Fig. 11), while 1992 survey age data showed the 1978 year class' dominance less distinctly. Age data collected in 1994 show that the 1989 year class, an above-average year class on the eastern Bering Sea shelf (Wespestad 1993b), is relatively strong in the Bogoslof area population. No age data were available from the 1993 survey at the time of the writing of this report. The average length of fish increased steadily from 47.2 cm in 1988 to 5 1.4 cm in 1993, underlining the 1978 year class' dominance of the spawning stock (Figs. 10 and 12). In 1994, the average length among spawners was 5 1 .0 cm. The decrease in average length is due to the entry of the 1989 year class in conjunction with the continuing decline of the 1978+ year class fish.

Age determination for Bogoslof area pollock has become extremely difficult since the first EIT surveys in 1988 due to the numbers of older fish currently composing the population

(Fig. 11). The difficulty in ageing older fish is related to the fact that as fish age, growth slows, and annual otolith rings crowd closer and closer together. Counting rings becomes more difficult and therefore is subject to larger errors. While 1988-1991 population-at-age data show a progression of strong 1978, 1982, and 1984 year classes; the 1992 and 1994 data blurred these year class relationships for older pollock. For example, in survey year 1994 the pollock population-at-age curve shows a dip at age 10. We believe the actual numbers representing the “strong” 1984 year class should be higher and are instead spread over surrounding age classes. The 1994 Bogoslof area population ages for older fish should thus be used with caution in modeling and forecasting.

How, when, and from where younger pollock recruit to the Bogoslof area spawning population is not well understood. The southeast Aleutian Basin is characterized by a near absence of juvenile pollock compared with surrounding shelf areas, and recruitment to the Bogoslof spawning stock is not estimated to occur until ages 4-5 (Dawson 1989). By its relative strength compared with surrounding year classes, the 1989 year class potentially provides the first chance to track recruitment to the area since the 1984 year class. Cruise results from the winter of 1991 indicated a few 1989 year class pollock were caught east of the main Bogoslof spawning area over water greater than 1000 m deep’. During the winter 1992 survey, a few 30-40 cm pollock were caught in two hauls from greater than 500 m deep waters. In winter 1993, aggregations of non-spawning pollock that appeared to be mostly the 1989 year class were observed south and east of the Bogoslof area spawning aggregations. They ranged from 24 to 64 cm with a length mode at 40 cm. This year, non-spawning 1989 year class fish were observed

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[4] N. Williamson, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle WA 98115, unpublished cruise report MF91-1, November 1994.

in the eastern end of the Bogoslof survey area and along the Aleutian shelf over shallower water than the spawning aggregation. Pollock caught on the western end of the spawning area over deep water exhibiteda bimodal length distribution, with the smaller mode at 45 cm. These largely pre-spawning fish were a portion of the 1989 year class that recruited to the spawning population (Figs. 11 and 12). Why some of the 1989 year class recruited to the Bogoslof area spawning population while some did not remains unclear, as well as why the two groups were distributed over different depth habitats. They seemed to inhabit similar temperature and salinity regimes. Perhaps those that recruited were the first segment of that year class to reach maturity, and others will follow as they continue to mature. Some of these younger fish may never join the Bogoslof spawners but remain outside the main aggregations or return to the shelf Others may be part of an Aleutian Islands “stock’‘-associated with shallow waters near the island chain rather than with deeper basin waters. Prior to 1993, no large concentrations of non-spawners had been observed east of the main spawning area in the Aleutian Basin.

Observer catch data from the winter 1994 pollock roe fishery indicated fishing in the Aleutian Islands region (west of 170° W long.) began in January (Fig. 13). Observer length frequency data taken on board vessels fishing that location in January matched that from the Bogoslof area spawning population. Perhaps these vessels were targeting pollock moving into the Bogoslof area. During the first 2 weeks in February, fishing was concentrated on the Bering Sea shelf until the offshore roe fishery closed on 18 February, followed by closure of the inshore roe fishery on 2 March. The Bering Sea offshore closure is reflected by increased fishing in the Aleutians after 17 February, with peak catches occurring between 17 February and 16 March. The Aleutian offshore fishery closed on 1 March, and the inshore fishery on 18 March. Pollock fishing iii the Aleutians after 18 March was attributed to community development quotas (CDQs).

Total catch from 20 January through 13 April in the Aleutians between 170° and 177° W long. was over 57,000 t[5]. Of that, about 19,000 t was captured during the survey period between 27 February and 9 March.

Although pollock spawning has been observed in the Aleutian Basin from January through March (Hinckley 1987), spawning in the Bogoslof Island region usually occurs in late February to early March (Traynor et al. 1990, Teshima et al. 1991). In 1994, most pollock were in a pre spawning stage, and pollock eggs were only observed at a single bongo net location, Among spawners, this year's average GSI (0.19, Fig. 4) was slightly lower (not significant) than last year's (0.22), but so was the average length of fish. The positive correlation between FL and GSI may account for the difference. Given high average GSI values (compared with GSIs during other times of the year) and few eggs in the water column in early March, we estimated that most spawning began shortly after the survey ended on 9 March-similar to spawning timing in 1993, but later than in previous years. Temperature was probably not a factor in the delay, as water temperatures were similar to those from past observations for pollock spawning in the southeast Aleutian Basin (Honkalehto 1990).

In summary, the Bogoslof area spawning walleye pollock population continues to decline with the biomass now at 0.49 million t. Population decline has been attributed to high fishing pressure in the Bogoslof region (1987-91), and in the donut hole (1984-91), where fish are presumed to be part of the same spawning stock (Dawson 1989), as well as to lack of strong recruitment, and to natural mortality of aging year classes which had supported the population for

[5]M. Guttormsen, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle WA 98115, pers. commun., November 1994.

many years. Since 1991, although fishing is no longer a major source of mortality, the population has declined due to poor recruitment and senescence. This year, we observed some recruitment of the relatively strong 1989 year class, consistent with projected strength of that year class on the eastern Bering Sea shelf. Evidence of increased recruitment supports the hypothesis that the Bogoslof /Aleutian Basin areas are populated by density-dependent pollock population spill-over from the shelf during years of strong year classes (Wespestad 1993a).

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Table 1. Summary of sphere calibrations conducted before, during, and after the 1994 echo Integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

Date	Location	Water Temp (deg. C)		Sphere Range From Transducer (m)*	TS Gain	SV Gain	3db Beam Width	Angle Offset	
		at Transducer*	at Sphere					Along	Athwart
10 Feb	Port Susan	7.7	9.0	20.4	27.4	27.3	7.2	-0.14	-0.03
25 Feb	Inanudak Bay	4.2	4.3	19.8	27.4	----	7.3	-0.11	-0.05
26 Mar	Kuliak Bay	2.7	3.1	27.0	27.3	27.1	7.3	-0.10	-0.02

Note: Gain and beam pattern terms are defined in the "Operator Manual for Simrad EK500 Scientific Echo Sounder (1993)' available from Simrad Subsea A/S, Standpromenaden 50, P.O. Box 111, N-3191 Horten, Norway.

'The transducer is located approximately 9 m below the water surface.

Table 2. Summary of midwater rope trawl station and catch data from the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

Haul No.	Date (1994)	Time (AST)	Start Position		Depth (m)		Temp (deg. C)		Catch (kgs/nos)	
			Latitude (N)	Longitude (W)	Gear	Bottom	Gear	Surface	Pollock	Other
1	28 Feb	0125-0155	54 22.3	165 51.8	341	394	3.8	3.9	64 / 96	9 / 19
2	1 Mar	1837-1847	53 52.5	167 17.2	460	850	3.7	4.0	80 / 68	12 / 310
3	2 Mar	0405-0414	53 43.7	167 34.2	400	1,043	3.8	4.1	1,609 / 1,258	2 / 36
4	2 Mar	0746-0809	53 43.6	167 34.3	521	925	3.7	4.1	154 / 137	13 / 403
5	3 Mar	0832-0907	53 40.9	168 09.0	399	1,086	3.2	3.9	309 / 261	10 / 819
6	3 Mar	1731-1748	54 05.4	167 25.3	320	1,656	3.8	3.7	1,200 / 1,224	1 / 3
7	4 Mar	0554-0610	53 54.9	167 42.6	251	1,671	3.5	4.2	1,130 / 995	7 / 5
8	4 Mar	0820-0859	53 53.9	167 39.0	412	1,659	3.5	4.0	630 / 583	15 / 546
9	4 Mar	2133-2202	53 34.4	168 17.2	245	487	4.2	4.2	128 / 155	6 / 191
10	5 Mar	0105-0134	53 41.3	168 17.2	459	1,403	4.0	4.2	694 / 647	4 / 171
11	6 Mar	2302-2341	53 31.9	169 02.0	367	1,640	4.1	4.5	678 / 587	7 / 15
12	7 Mar	1114-1214	53 03.1	169 19.0	536	987	3.4	4.0	1,346 / 1,344	21 / 264
13	8 Mar	2354-0044	53 56.9	167 55.9	258	1,663	3.6	4.4	255 / 230	5 / 410

Table 3. Summary of bongo net tow stations from the winter 1994 pollock integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

Bongo Cast	Date (1994)	Time (AST)	Latitude (N)	Longitude (W)	Depth (m)		Comments
					Cast	Bottom	
1	1 Mar	2251	53 54.3	167 17.2	408	957	
2	2 Mar	2314	54 02.5	167 51.0	412	1,695	
3	4 Mar	2314	53 39.7	168 15.6	-	1,166	Haul 9 and 10
4	7 Mar	0118	53 35.3	168 59.0	408	1,778	Haul 11, pollock eggs
5	8 Mar	0148	53 16.9	169 54.1	401	1,279	

Table 4. Summary of catch by species in 13 midwater rope trawls from the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island, Miller Freeman cruise 94-02.

Species	Weight (kg.)	Percent	Numbers	Percent
Walleye Pollock (Theragra chalcogramma)	8,277.1	98.7	7,585	70.4
Smooth Lumpsucker (Aptocyclus ventricosus)	46.2	0.6	24	0.2
Lanternfish (Myctophidae)	15.3	0.2	1,528	14.2
Jellyfish Unidentified (Scyphozoa)	14.6	0.2	24	0.2
Northern Smoothtongue (Leuroglossus schmidti)	11.1	0.1	1,484	13.8
Arrowtooth Flounder (Atheresthes stomias)	10.3	0.1	2	<0.1
Squid Unidentified (Teuthoidea)	5.9	0.1	47	0.4
Giant Grenadier (Albatrossia pectoralis)	4.2	0.1	1	<0.1
Pacific Lamprey (Lampetra tridentata)	3.6	<0.1	9	0.1
Prowfish (Zaprora silenus)	0.3	<0.1	1	<0.1
Atka Mackerel (Pleurogrammus monopterygius)	0.2	<0.1	4	<0.1
Popeye Grenadier (Coryphaenoides cinereus)	0.2	<0.1	1	<0.1
Sergestid Shrimp (Sergestidae)	0.2	<0.1	45	0.4
Pacific Viperfish (Chauliodus macouni)	0.2	<0.1	7	0.1
Shrimp Unidentified (Natantia)	<0.1	<0.1	9	0.1
Bigscales (Melamphaidae)	<0.1	<0.1	1	<0.1
Northern Shrimp (Pandalus borealis)	<0.1	<0.1	4	<0.1
Deepsea Smelt (Bathylagidae)	<0.1	<0.1	1	<0.1
Totals	8,389.7	100.0	10,777	100.0

Table 5. Summary of pollock biological samples and measurements from the winter 1994 echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

Haul No.	Length	Maturity	Otolith	Fish Wt	Ovary Wt	Genetics	Caloric Study	NMML* Diet Study	Pollock Spawned
1	96	96	96	96	43	-	-	x	-
2	68	68	68	68	54	-	-	x	-
3	287	116	116	116	105	10	5	x	-
4	137	108	108	108	50	14	-	x	-
5	261	103	103	103	71	18	-	x	-
6	269	130	100	130	30	19	5	-	-
7	321	100	100	100	74	20	-	-	-
8	301	100	100	100	55	-	-	x	-
9	155	155	120	155	46	-	-	x	-
10	296	101	101	101	49	19	-	x	-
11	362	100	100	100	77	-	-	x	x
12	379	146	146	146	63	-	-	x	x
13	230	100	100	100	62	-	6	x	-
Total	3,162	1,423	1,358	1,423	779	100	16		

*These samples for the National Marine Mammal Laboratory (NMML) include squid, bathylagidae, and myctophidae.

Table 6. Conductivity/temperature/depth (CTD) casts conducted during the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

CTD Cast*	Haul	Transect	Date (1994)	Time (AST)	Latitude (N)	Longitude (W)	Depth (m) Cast	Bottom
1	1	1.0	28 Feb	0405	54 23.7	165 50.4	383	392
2	2	6.0	1 Mar	2114	53 52.4	167 16.7	586	843
B1	-	6.0	1 Mar	2251	53 54.3	167 17.2	408	957
3	3 and 4	7.0	2 Mar	0553	53 44.2	167 34.3	684	1,100
B2	-	8.0	2 Mar	2314	54 02.5	167 51.0	412	1,695
4	6	6.5	3 Mar	2041	54 07.8	167 23.1	588	1,855
B3	9 and 10	9.5	4 Mar	2314	53 39.7	168 15.6	-	1,166
B4	11	12.0	6 Mar	0118	53 35.3	168 59.0	408	1,778
5	12	13.0	7 Mar	1322	53 06.8	169 22.1	815	1,219
B5	-	15.0	8 Mar	0148	53 16.9	169 54.1	401	1,279
C6	-	-	8 Mar	1506	54 50.6	168 36.8	-	2,286

* B_ indicates bongo/CTD combination.
C_ indicates CTD conducted at the Peggy Mooring.

Table 7. Expendable bathythermograph (XBT) casts conducted during the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

XBT Drop	Haul	Transect	Date (1994)	Time (AST)	Latitude (N)	Longitude (W)	Probe	Bottom Depth (m)	Comments
3	-	1.1	28 Feb	0628	54 40.0	165 58.0	T-4	329	
4	-	2.0	28 Feb	0927	54 15.8	166 08.9	T-4	639	
5	-	3.0	28 Feb	1525	54 18.0	166 25.9	T-7	1,250	
6	-	3.0	28 Feb	1855	54 39.0	166 26.1	T-4	346	
7	-	5.0	1 Mar	0543	54 18.3	167 00.0	T-7	1,107	
8	-	5.0	1 Mar	0929	54 39.5	166 59.7	T-4	412	
9							T-7		Bad probe
10	-	7.0	2 Mar	1516	54 18.6	167 34.0	T-4	880	
11	-	7.1	2 Mar	1854	54 35.9	167 42.3	T-4	818	
12							T-7		Bad probe
13	5	9.0	3 Mar	1043	53 47.0	168 09.0	T-6	1,341	
14							-		Bad probe
15	7-8, 13	7.5	4 Mar	0702	53 56.3	167 43.2	T-4	1,726	
16							T-7		Bad probe
17							T-7		Bad probe
18							T-6		Bad probe
19							T-6		Bad probe
20	-	11.0	6 Mar	1617	53 49.7	168 45.0	T-6	2,034	
21							-		Bad probe
22							T-4		Bad probe
23							-		Bad probe
24	-	15.0	8 Mar	0546	53 48.6	169 53.2	T-7	2,359	

Note: XBT drops 1 and 2 occurred prior to the survey.
The maximum depth for probes T-4 , T-6 is 460 m and T-7 is 767 m.

Table 8. Population and biomass estimates obtained during echo integration-trawl survey of the pollock population near Bogoslof Island in winter 1994.

	Biomass (metric tons)		Population (thousands)	
Age	Non-Spawners	Spawners	Non-Spawners	Spawners
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	6,843	13,101	12,080	21,505
5	22,997	62,006	35,536	88,721
6	4,629	22,614	6,884	26,690
7	3,383	43,808	4,066	41,676
8	1,891	40,814	2,042	38,054
9	1,765	41,322	1,790	37,425
10	858	21,729	763	17,817
11	1,082	33,562	889	28,654
12	1,033	24,881	825	20,818
13	643	17,154	454	12,786
14	479	10,444	329	8,048
15	2,067	49,633	1,505	42,184
16	1,572	39,614	1,243	33,639
17	1,029	29,954	864	25,645
18	572	16,292	532	14,448
19	215	5,193	171	3,940
20	130	4,874	118	4,237
21	297	8,093	287	6,990
22	92	1,839	99	1,864
23	89	2,191	99	2,094
24	47	958	35	707
25	0	0	0	0
Total	51,713	490,076	70,608	477,940

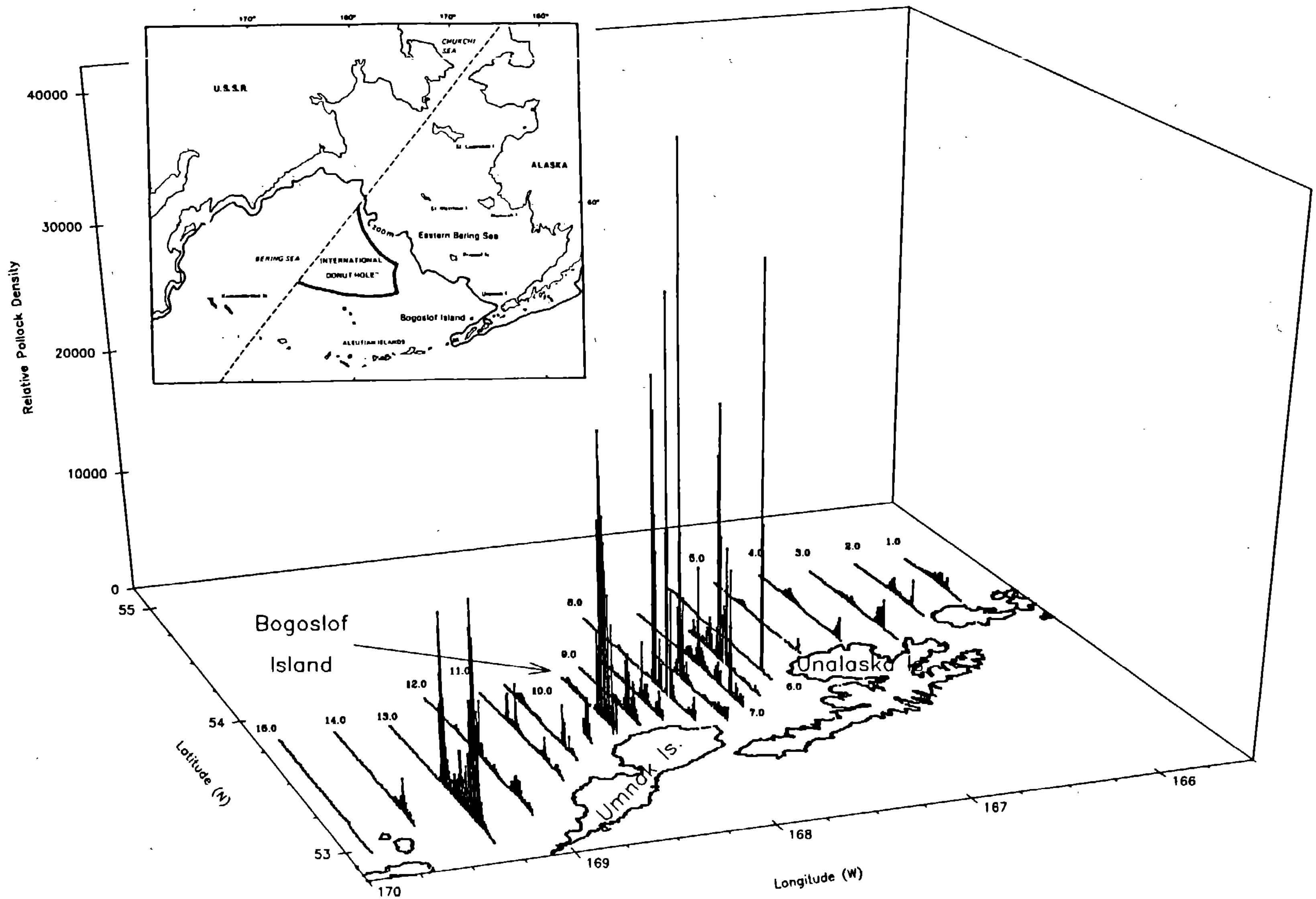

Figure 1. Relative pollock density along trackline from the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island. Transect numbers are indicated. Inset: Major features of the Bering Sea, showing location of the Donut Hole, from Wespestad (1993a).

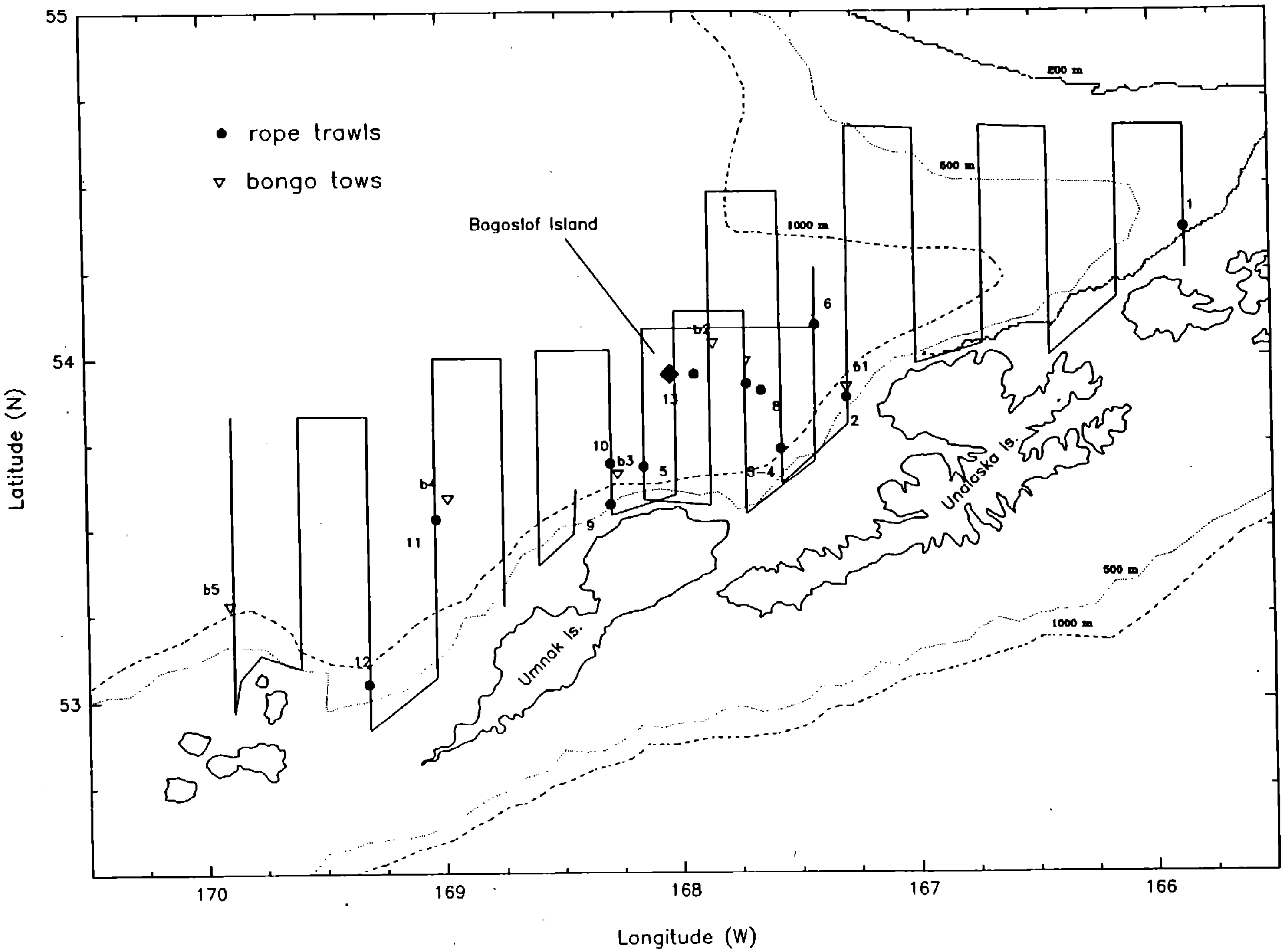

Figure 2. Rope trawl and bongo tow locations during the winter 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island. Cruise trackline is indicated.

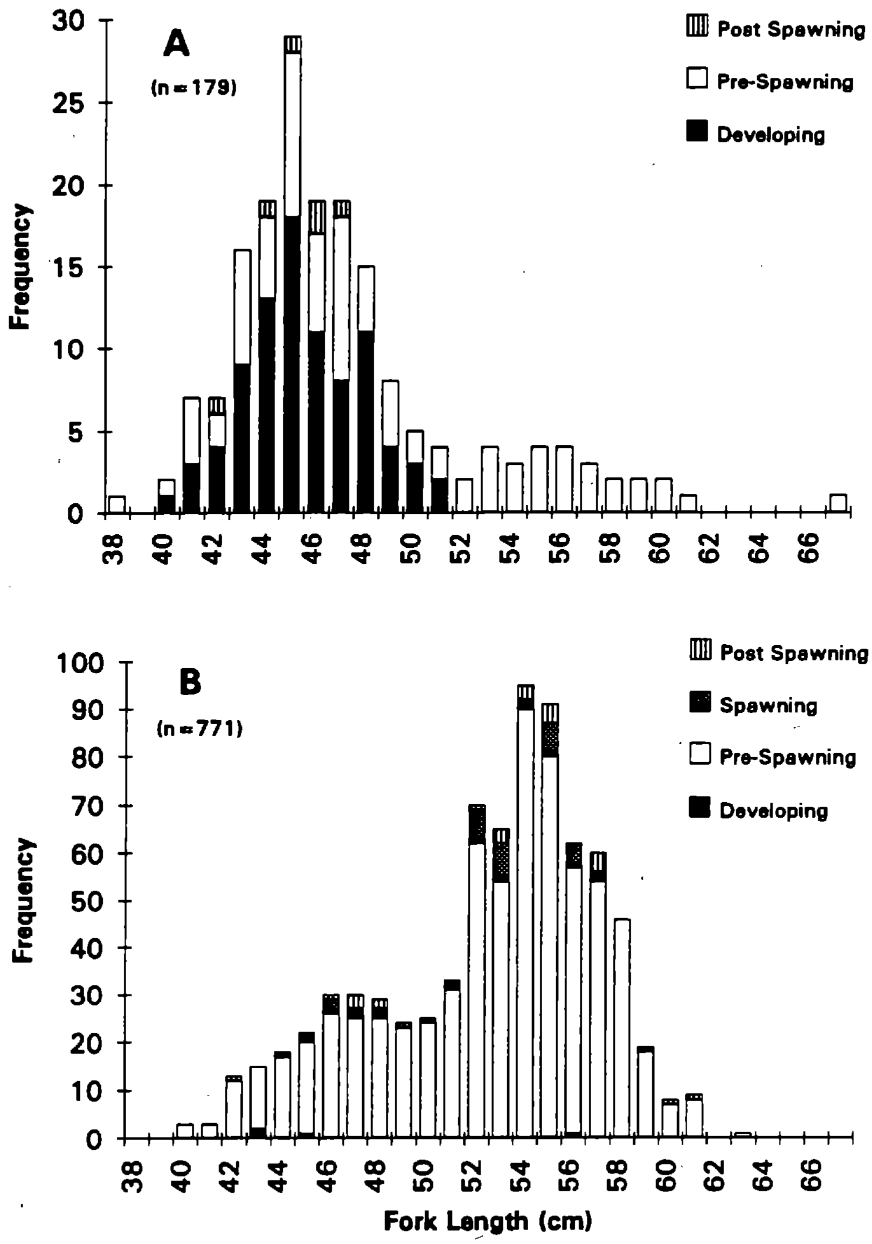

Figure 3. Female pollock maturity-length composition from trawl catches A) in bottom depths less than 500 m, and B) in bottom depths greater than 500 m during the 1994 pollock echo integration-trawl survey of the southeast Aleutian Basin near Bogoslof Island.

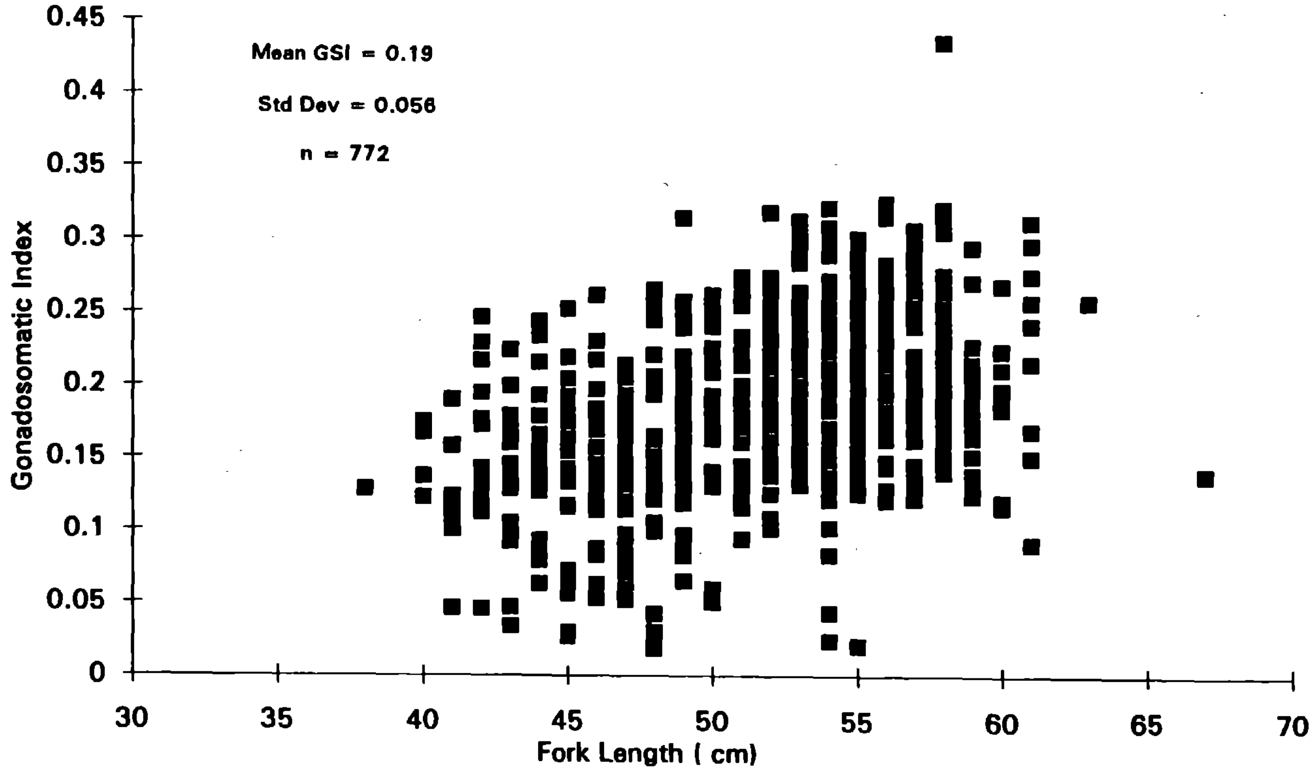

Figure 4. Pollock gonadosomatic indices plotted as a function of length for pre-spawning females from the Bogoslof Island area during the winter 1994 echo integration-trawl survey.

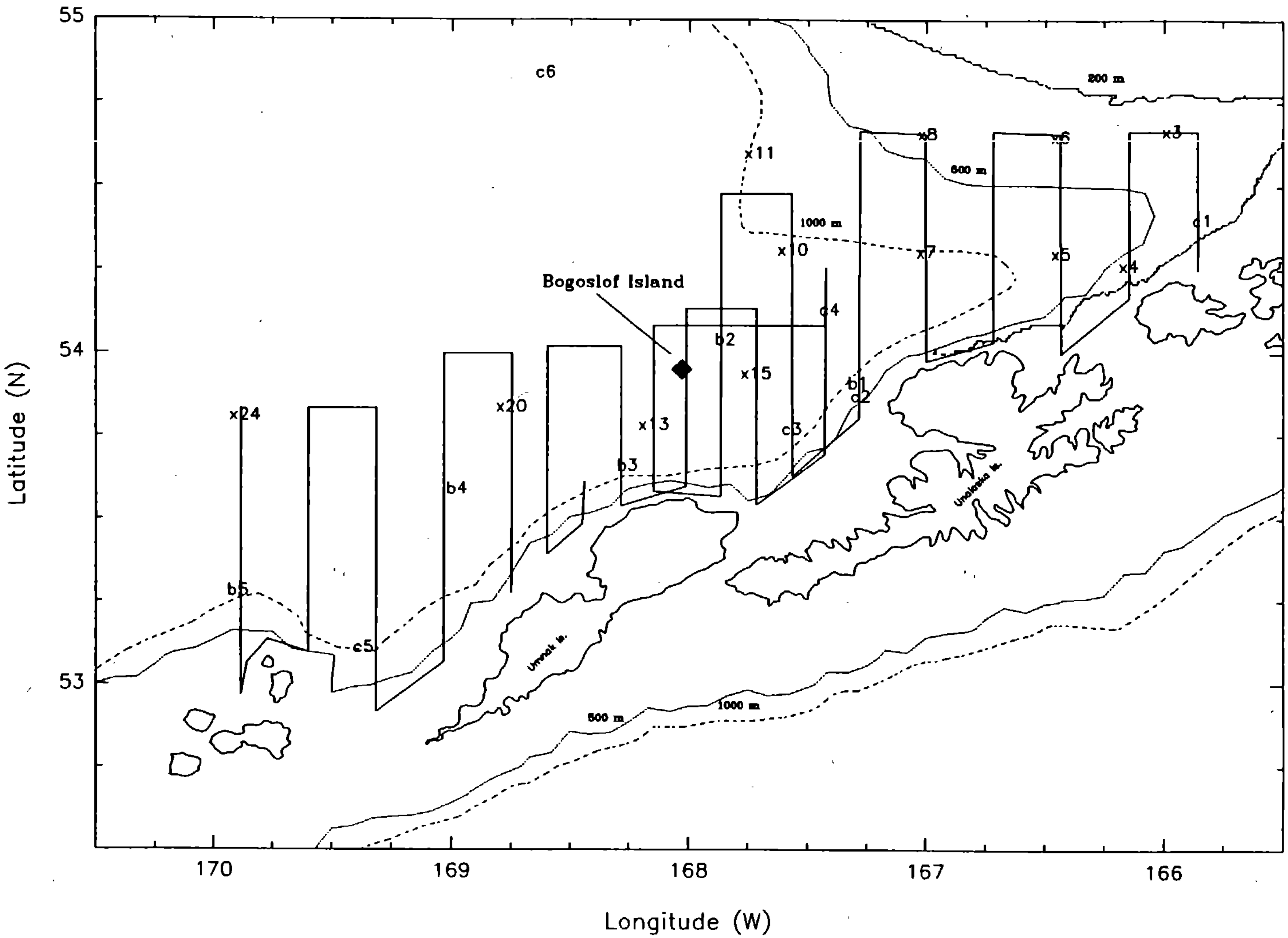

Figure 5. Locations of XBT casts, CTD casts, and CTD–bongo casts (x, c, and b, respectively, followed by station number) during the winter 1994 pollock echo integration–trawl survey of the southeast Aleutian Basin near Bogoslof Island. Cruise trackline is indicated.

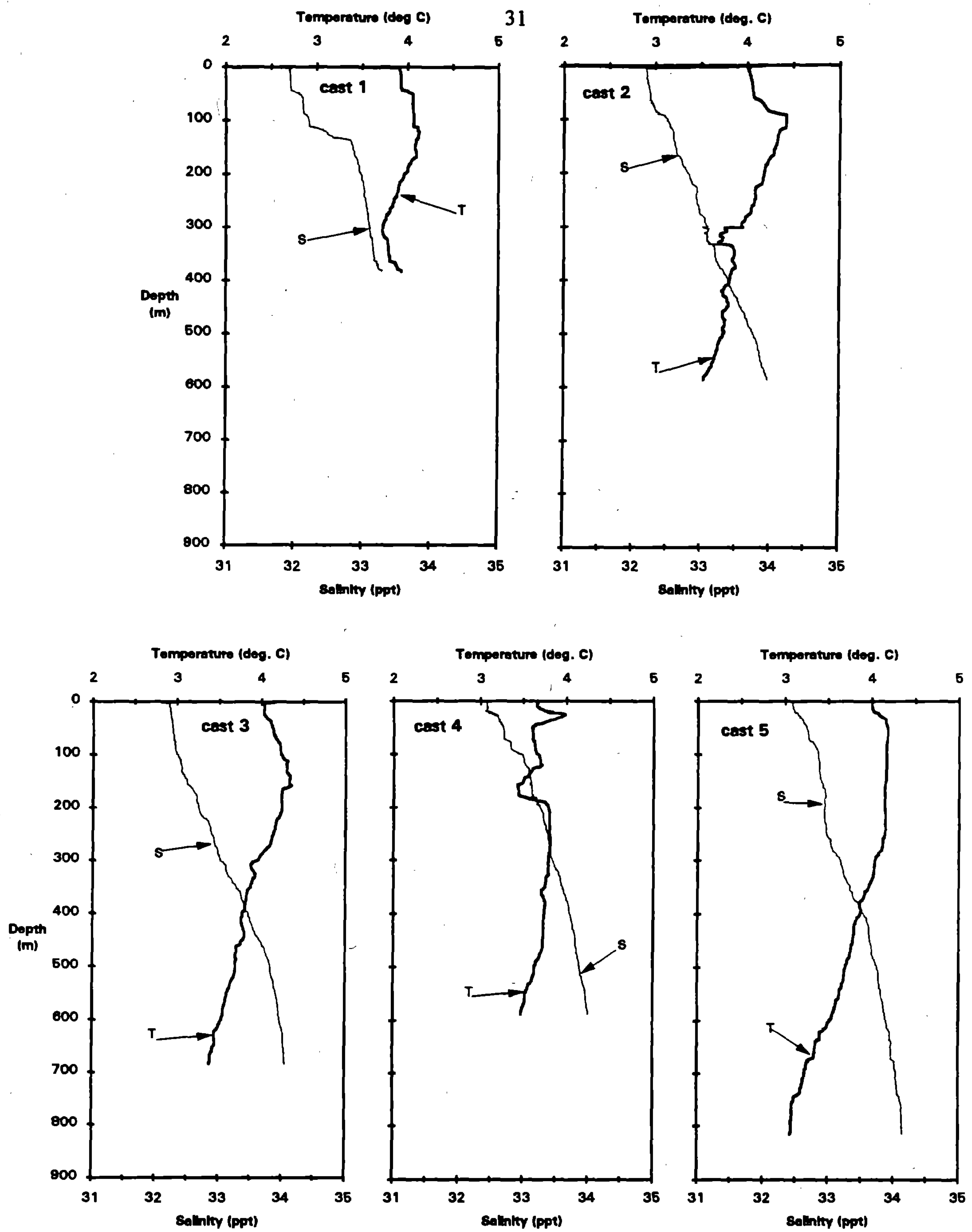

Figure 6. Temperature and salinity profiles of CTD casts made in the southeastern Aleutian Basin near Bogoslof Island during the winter 1994 echo integration-trawl survey.

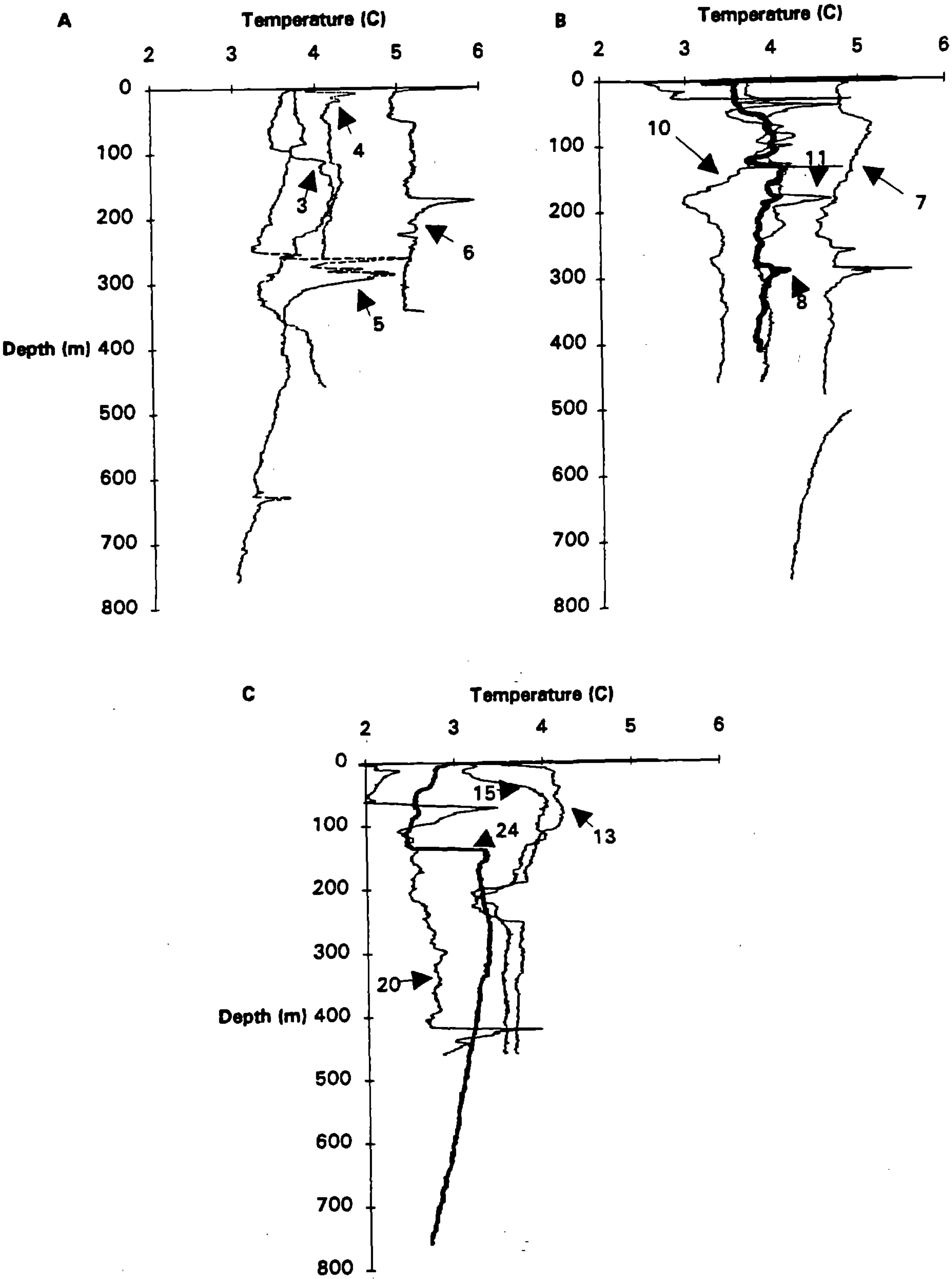

Figure 7. Temperature profiles from XBT casts made in the southeastern Aleutian Basin near Bogoslof Island during the winter 1994 echo integration-trawl survey.

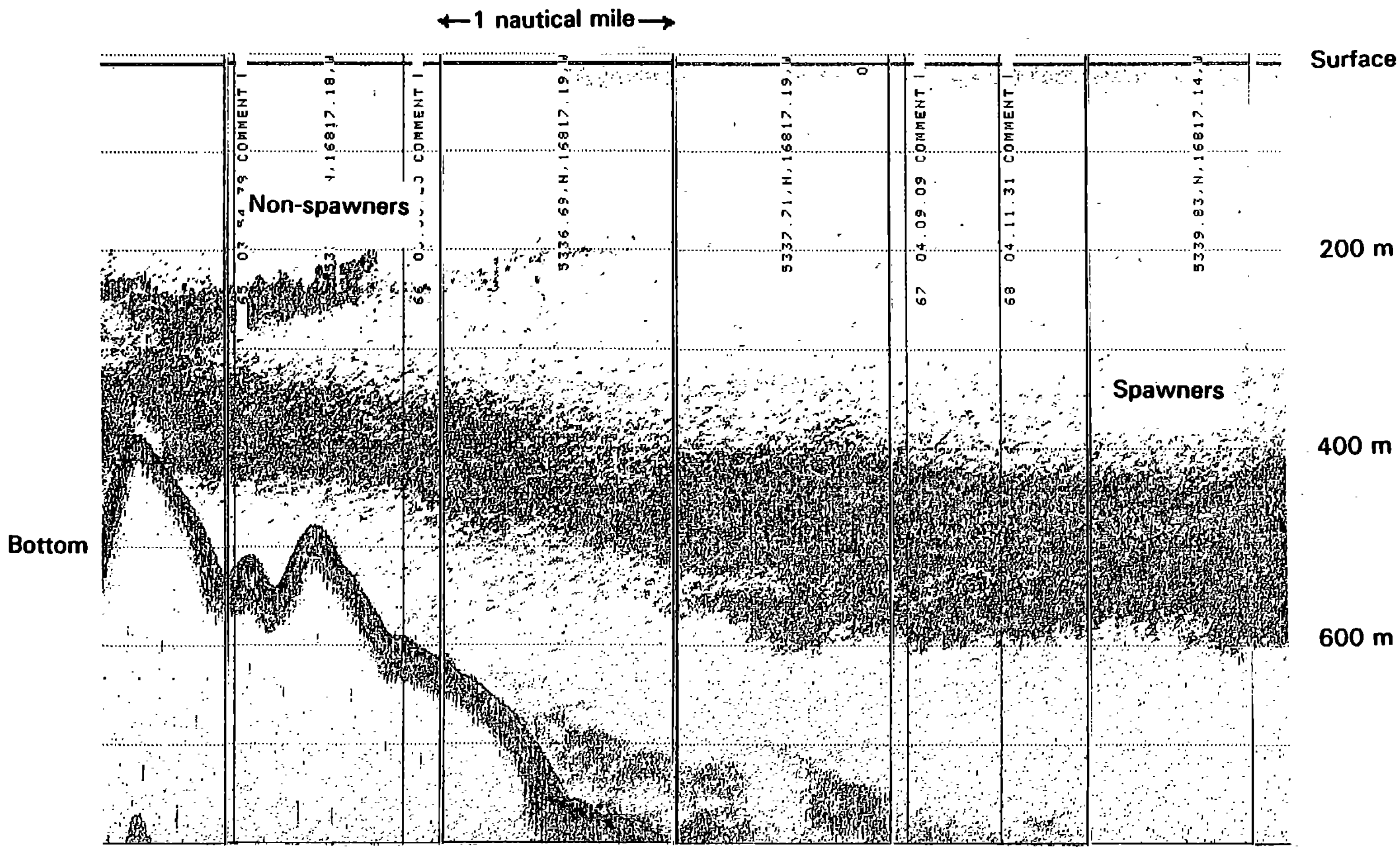

Figure 8. Echogram of typical pollock scattering layers from the winter 1994 Bogoslof echo integration-trawl survey. Color gradation from blue to red corresponds to increasing pollock density, with red indicating the highest density concentrations.

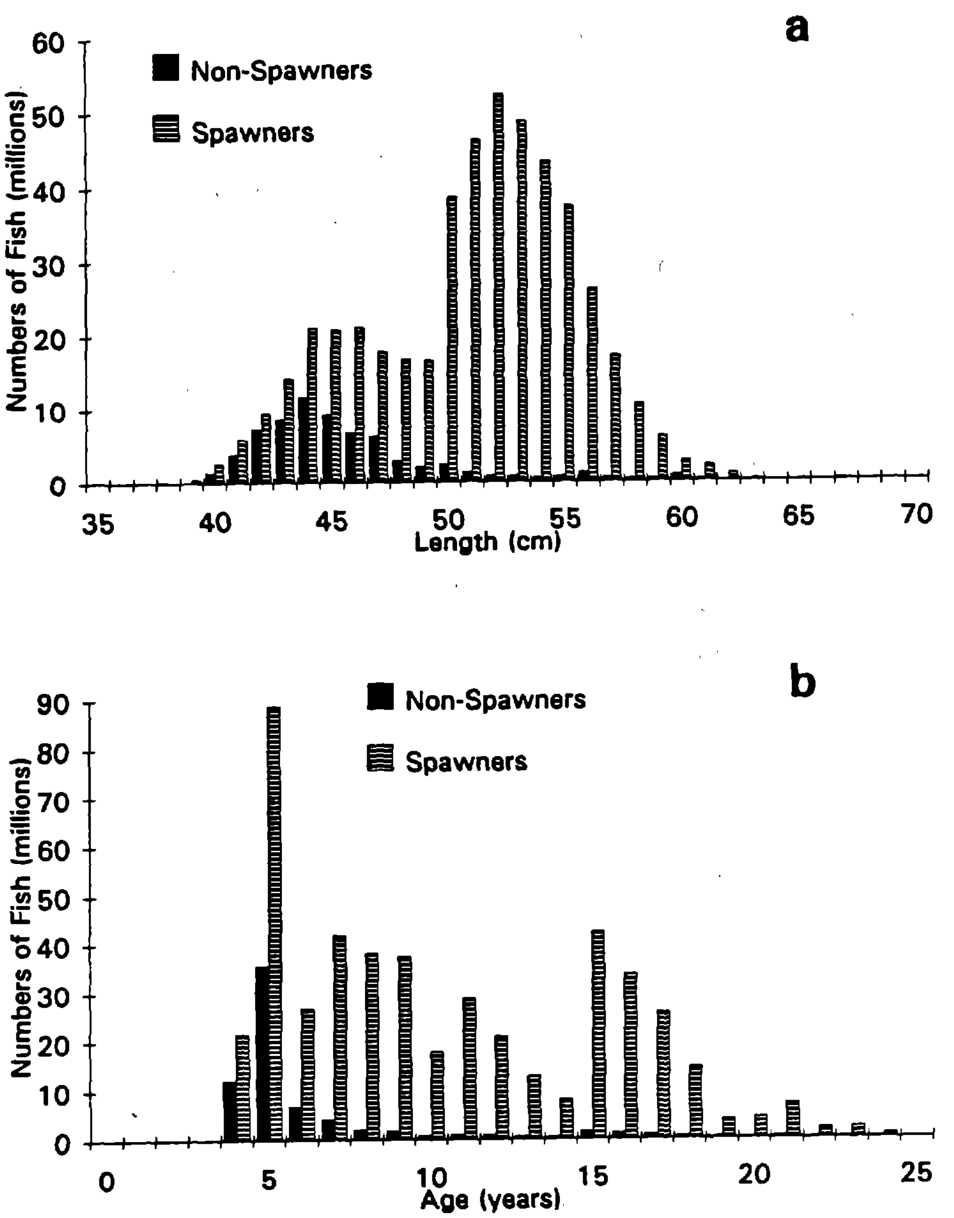

Figure 9. Pollock (a) numbers at length and (b) numbers at age from the 1994 winter echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

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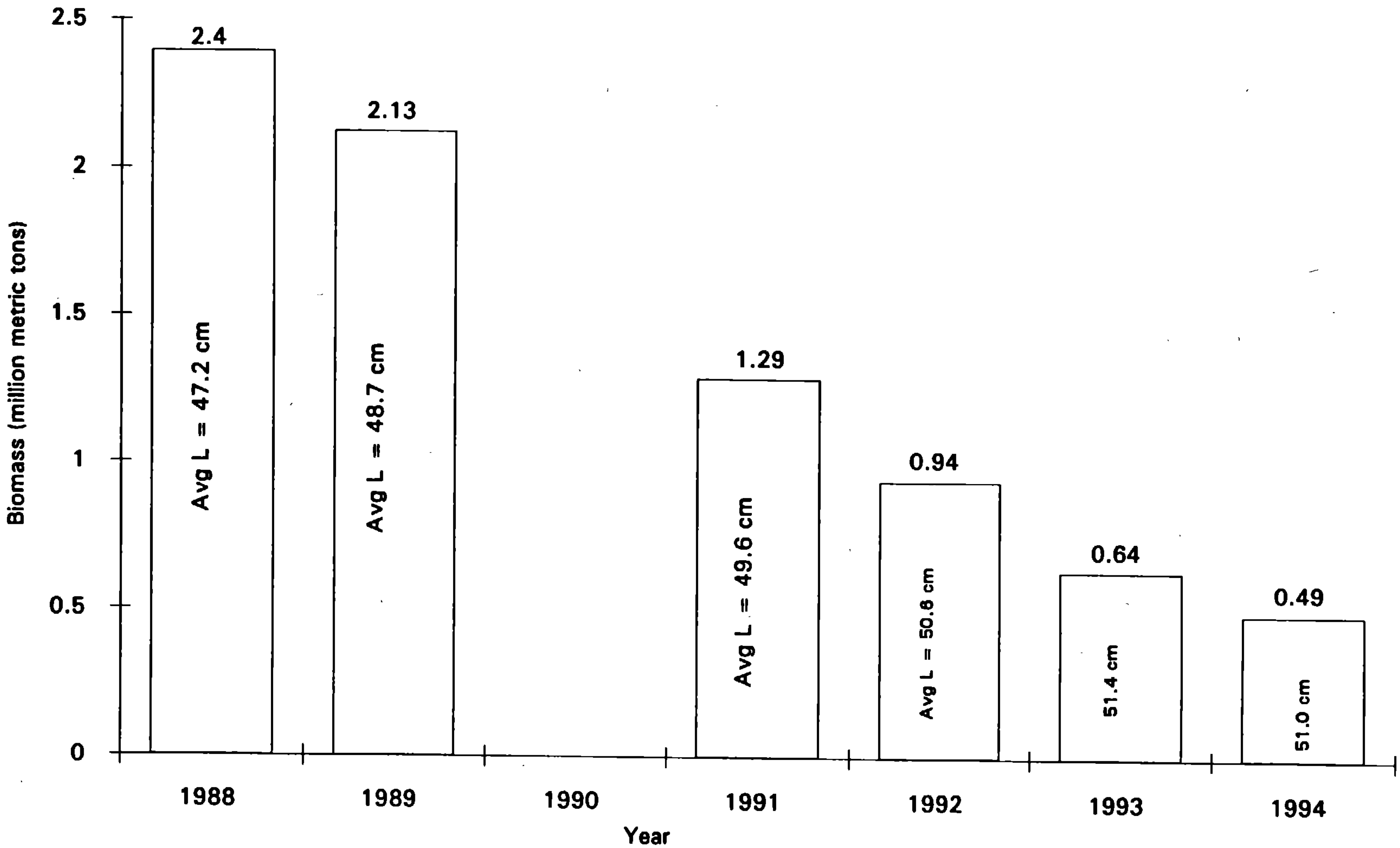

Figure 10. Biomass estimates and average fork lengths obtained during winter echo integration -trawl surveys for spawning walleye pollock near Bogoslof Island, 1988-94. No survey was conducted in 1990.

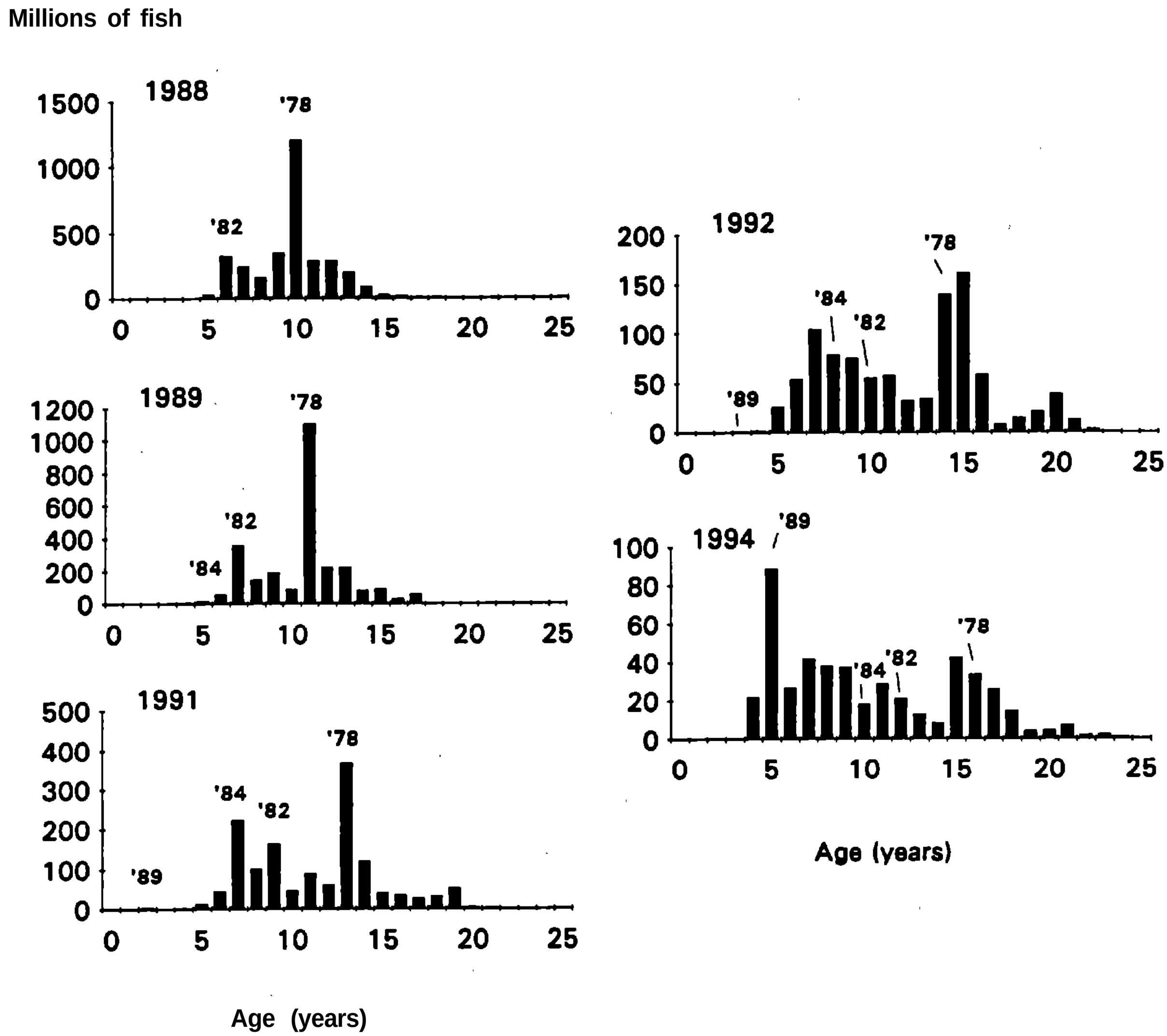

Figure 11. Population-at-age estimates obtained during echo integration trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-89,1991-92 and 94. Major year classes are indicated. No survey was conducted in 1990, and ages were not available for 1993. Note y-axis scale differences.

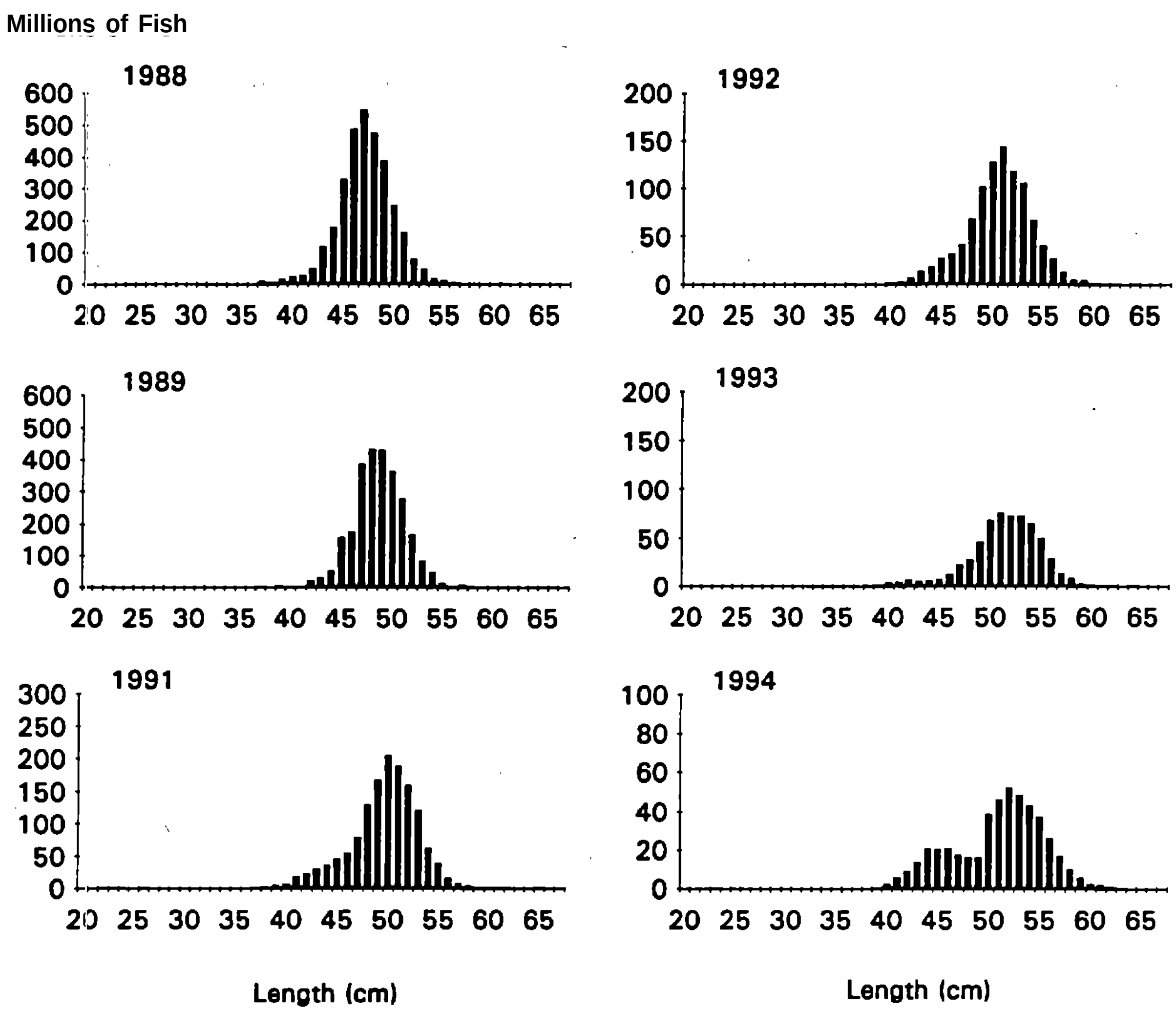

Figure 12. Population-at-length estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-94. Note y-axis scale differences. No survey was conducted in 1990.

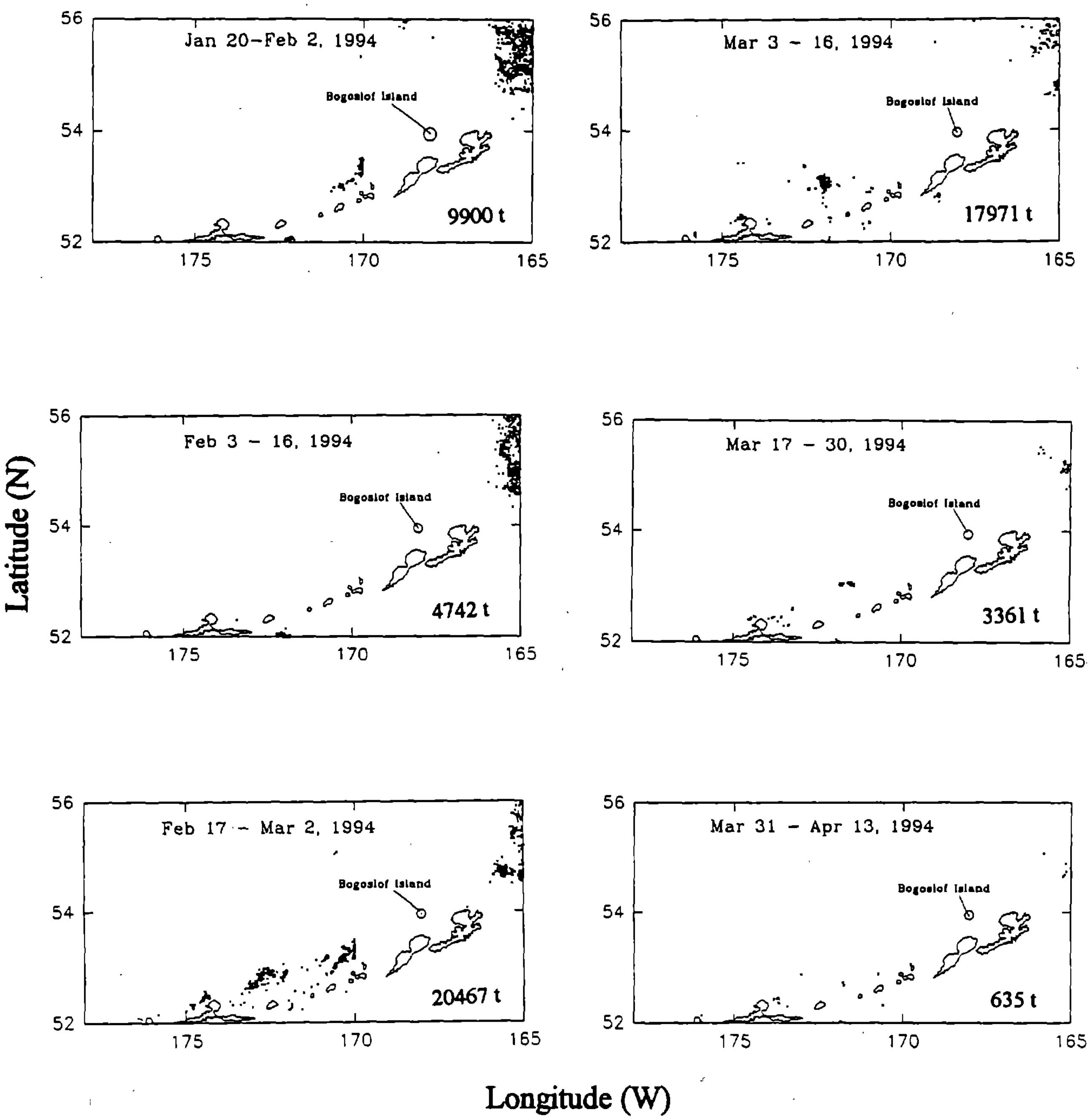

Figure 13. U.S. Domestic Observer Program data showing haul positions where pollock were caught by the commercial fishing fleet during the Bering Sea / Aleutian pollock season, 20 January-13 April, 1994. For each 2-week period, total catch between 170°and 177°W long. is indicated.

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