NOAA Technical Memorandum NMFS-AFSC-65

Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) in the Southeastern Aleutian Basin During February and March 1995

by
T. Honkalehto and N. Williamson

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

August 1996

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The new NMFS-NWFSC series will be used by the Northwest Fisheries Science Center.

This document should be cited as follows:

> Honkalehto, T., and N. Williamson. 1996. Echo integration-trawl survey of walleye pollock (Theragra chalcogramma) in the Southeastern Aleutian Basin during February and March 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-65, 57 p.

NOAA Technical Memorandum NMFS-AFSC-65

Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) in the Southeastern Aleutian Basin During February and March 1995

by
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
Michael Kantor, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary and Administrator
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

August 1996

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Notice to Users of this Document

ABSTRACT

Results from the winter 1995 echo integration-trawl survey of spawning walleye pollock ***(Theragra chalcogramma)*** in the south&stem Aleutian Basin near Bogoslof Island are presented. The survey, conducted in two passes between 26 February and 9 March, covered an area between 165° 51'W and 170° 27'W long., from the Aleutian chain north to between 53° 45' N and 54° 40' N lat. Isolated pollock aggregations were encountered off the edge of the shelf north of Akutan Island and over deep water northeast of Bogoslof Island. Extremely dense pollock aggregations were observed along the north side of Umnak Island from 168° W to 169° 30' W long. Pollock vertical distribution ranged from 250 m to 750 m below the surface; their average depth was higher in the water column during pass 2 than during pass 1. Sex composition in hauls ranged from 8% to 94% female, averaging around 60% female. Evidence of vertical stratification by sex showed males inhabiting lower depth layers than females. Little evidence of a "non-spawner" component of the pollock biomass (as had been observed in 1993 and 1994) was observed, and most female pollock were in a pre-spawning reproductive state. The spawning biomass estimate, 1 .l0 million metric tons (t), was more than twice the March 1994 estimate of 0.49 million t. This large increase in the Bogoslof spawning population can be partially explained by strong recruitment of pollock from the 1989 year class. However, population and biomass increases also occurred across most of the age groups. Potential reasons for the population increase are discussed.

CONTENTS

ABSTRACT .... **iii**

INTRODUCTION 1

METHODS 2

Sampling Equipment 2

Sampling Techniques 4

Data Analysis 6

RESULTS 9

Biological and Oceanographic Results 9

Pollock Distribution and Abundance 11

DISCUSSION 13

ACKNOWLEDGMENTS 17

CITATIONS l9

INTRODUCTION

Walleye pollock (***Theragra chalcogramma)*** is a semi-demersal fish species inhabiting much of the North Pacific Ocean that supports one of the largest single species fisheries in the world; World-wide annual catches averaged 5.3 million metric tons (t) between 1978 and 1991 (FAO 1991) and were just under 5 million t in 1992 (FAO 1994). In the eastern Bring Sea, where catches have averaged around 1.3 million t in recent years, the pollock fishery has evolved over three decades from a completely non-U.S. fishery to an exclusively domestic fishery. In the late 198Os, displaced foreign fleets initiated a new fishery in the central Aleutian Basin, known as the "donut hole", and a new U.S. fishery arose in the southeastern Aleutian Basin near Bogoslof Island (Fig. 1, inset). In the early 199Os, declining catches in the donut hole and a drop in biomass in the Bogoslof area prompted the North Pacific Fishery Management Council (NPFMC) to restrict pollock catch to 1,000 t for bycatch only near Bogoslof Island and to discourage U.S. vessels from targeting pollock in the donut hole. After 1991, there was no directed domestic fishery for pollock in the Bogoslof region. In ,1991, six nations (Russia, the United States, Japan, Republic of Korea, China and Poland) initiated discussions to establish a Convention on the Conservation and Management of Living Marine Resources of the central Bering Sea (referred to as the CBS Convention). They agreed to place a moratorium on fishing in the donut hole from 1992 to 1995, pending ratification of the CBS Convention. Ratified in December 1995, the CBS Convention outlined a three-step process for estimating the biomass of Aleutian Basin pollock. The last step, an agreed "default" to be invoked only in the absence of an agreement on a biomass estimate, was that the spawning pollock biomass in a "specific area"' (referred to as the CBS area) near Bogoslof Island represented 60% of the basin-stock. Echo integration-trawl (EIT) surveys have been conducted in the southeastern Aleutian Basin near Bogoslof Island, including the CBS area, annually since 1988, with the exception of 1990, to

---

[1]The "specific area" is defined in the Annex to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea as "the area south of a straight line between a point at 55° 46' N lat. and 170° W long. and a point at 54° 30' N lat., 167° W long. and between the meridian 167° W long. and the meridian 170° W long. and the north of the Aleutian Islands and straight lines between the islands connecting the following coordinates in the order listed: 52° 49.2 N 169° 40.4 W, 52° 49.8 N 169° 06.3 W, 53° 23.8 N 167° 50.1 W, 53° 18.7 N 167° 51.4 W.

determine the distribution, abundance and biological composition of spawning walleye pollock. This report describes results from the pollock survey carried out 26 February-9 March 1995 and compares them to results from previous years.

METHODS

Sampling Equipment

Acoustic data were collected with a Simrad EK500 quantitative echo-sounding system (Bodholt et ***al.*** 1989) on the NOAA ship ***Miller Freeman,*** a 66-m stem trawler equipped for' fisheries and oceanographic research. Simrad 38 kHz and 120 kHz split-beam transducers were mounted on the bottom of the vessel's centerboard. With the centerboard fully extended, the transducers were 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. Results presented in this report were based on the 38 kHz data..

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 immediately behind the rope section to 8.9 cm in the codend. It was fished in a bridleless configuration and was fitted with a 3.2 cm mesh codend liner. Headrope and footrope lengths were 94.5 m and 50 m, respectively, and the breastlines measured 79.4 m. The headrope length was measured between the points of attachment to the breastline. The 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 steel V-doors (1,000 kg) and 227 kg tom weights on each side. Vertical net opening and depth were monitored with a Furuno wireless netsounder system attached to the headrope of the trawl.

Fish on and near bottom were sampled with a polyethylene Nor'eastern ,high-opening bottom trawl equipped with roller gear. The trawl net had stretch mesh sizes that ranged from 13 cm forward to 8.9 cm in the codend. It was fitted with a 3.2 cm nylon codend liner. The 27.2 m headrope held 21 floats (30 cm diameter). A 24.7 m chain fishing line was attached to-a 24.9 m footrope made of 1 cm 6 x 19 wire rope wrapped with polypropylene rope. The roller gear (24.2 m) consisted of 36 cm rubber bobbins spaced 1.5-2.1 m apart, with a solid string of 10 cm rubber disks separating some of the bobbins in the center section. Two 5.9 m wire rope extensions with 10 and 20 cm rubber disks spanned the two lower flying wing sections and were attached to the roller gear. The chain fishing line and roller gear were attached with chain toggles (2.9 kg each) composed of five links and one ring. The trawl was rigged with triple 54.9 m galvanized wire rope dandylines and was fished with 1.8 m x 2.7 m steel V-doors (1,000 kg). Vertical net opening and depth were monitored with a Furuno wireless net sounder system attached to the headrope.

A Methot trawl and a bongo net were used to sample micronekton and macrozooplankton at two sampling sites, respectively. The mouth of the Methot trawl was a square frame measuring 2.27 m on each side. Mesh size was 2 mm x 3 mm in the main part of the net and 1 mm in the codend. A 1.83 m dihedral depressor modified from an Isaacs-Kidd midwater trawl was used. The Methot trawl was attached to a single cable fed through a stem-mounted A-frame and deployed off the stem ramp. Tow depth profiles were obtained by attaching a micro-bathythermograph (microBT; a small, retrievable temperature: profiler) to the frame. The bongo net system consisted of a 60 cm bongo frame with 333 pm mesh nets and a 40 kg lead weight used as a depressor. It was deployed from the starboard winch. To monitor depth and oceanographic conditions, a Seabird conductivity/temperature/depth (CTD) profiler was attached to the wire about 0.6 m above the bongo frame.

Water temperature and salinity profile data were collected at trawl and calibration sites with a Seabird CTD system. Additional temperature profile data were obtained by launching an expendable bathythermograph (XBT) and by attaching microBTs to most trawls. Sea surface oceanographic data and environmental data were collected using ***the Miller Freeman's*** Scientific Collection System (SCS). Ocean current profile data were collected with an acoustic Doppler current profiler system with a centerboard-mounted transducer.

Sampling Techniques

Two EIT survey passes were made through the main Bogoslof spawning area covering a total of 1,782 nauticalmiles (nmi) of transects. Pass 1, completed between 26 February and 4 March, consisted of north-south transects beginning at 165° 5 1'W long. westward to 170° 27'W long. (Fig. 1): Transect spacing at the eastern and western ends of the survey area was 10 nmi. In the central survey area where pollock densities were higher, transect spacing was decreased to 5 nmi. Southern transect endpoints were at about 100 m bottom depth on the Aleutian shelf. Northern transect endpoints were similar to those on previous winter surveys in the Bogoslof region, between 53° 45' N and 54° 40' N lat., except for transect 17 which ended farther south. Because Domestic Observer Program data[2] indicated that a substantial amount of pollock fishing had occurred in early March 1994 at around 170° W long., the 1995 survey area was extended farther west than in previous years. Pass 2, completed between March 5-8, consisted of parallel north-south transects at 5 nmi spacing from 169° 32' W long. (west of fish sign observed during pass 1) eastward to about 167° 38' W long. (Fig. 2). The southern ends of pass 2 transects were similar to those from pass 1; northern ends were shifted slightly to the south to focus effort in the area of highest pollock concentration.

Echo integration data were collected continuously, day and night, at vessel speeds ranging between 7 and 12 knots, depending upon weather conditions. After being properly scaled, these data were used to provide estimates of pollock density.

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

Midwater trawl hauls were made at selected locations to identify echo sign and provide biological samples used to scale the echo integration data. Trawling speed averaged about 3 knots. Vertical opening for the midwater rope trawl averaged about 23 m. For each haul, standard catch sorting and enumeration procedures similar to those described in Wakabayashi et al. (1985) were used to provide total weights and numbers of individuals by species. Pollock were further sampled to determine sex, length (fork length measurement was used in all cases), body weight, age, maturity, and ovary weight. An electronic scale was used to determine individual pollock body weights, and lengths were determined to the nearest centimeter with a Polycorder measuring device (a combination of a bar code reader and a hand-held computer). Maturity stages on a scale from 1 to 5 (immature, developing, pre-spawning, spawning and post-spawning, respectively) were assigned from visual inspection of gonad tissue. Gonadosomatic indices (GSIs) were computed for pre-spawning female pollock. GSI was defined as the ratio of ovary weight to total body weight. Ovary tissue samples were collected from mature (pre-spawning) females and preserved in Gilson's solution for fecundity studies. Pollock stomachs were collected and preserved in formalin for food habits studies.

Four standard sphere calibrations were conducted in conjunction with this survey (Table 1). Two occurred before the cruise began on January 26 in Port Susan, Washington, and on February 13 in Ugak Bay, Kodiak Island, Alaska, and two after the cruise on March 8, in Skan Bay, and on April 13, in Anderson Bay, Unalaska Island, Alaska. No significant differences in the 38 kHz acoustic system parameters were observed between the four calibrations. The 120 kHz transducer experienced some acoustic parameter changes between the first, second, and third calibrations. The SV (scattering volume) gain for the 120 kHz dropped from 25.1 to 24.2 dB, and the TS (target strength) gain dropped from 25.0 to 24.2 dB (Table 1). Between the third and fourth calibration TS and SV gain remained the same.

Data Analysis

Absolute estimates of pollock abundance were derived by combining information from acoustic and trawl data. Echo integration data with a horizontal resolution of about 9 m (at 12 knots ship speed) and a vertical resolution of 1-2 m from the transducer to 0.5 m off bottom, or the lowest extent of fish sign, were examined for-pollock echo sign and stored at a SV threshold of -69 decibels (dB). Estimates of pollock backscattering strength in the area represented by each transect were generated. These values were then summed and scaled with a previously derived relationship between target strength and fish length (TS = 20 Log FL - 66; Foote and Traynor 1988) to estimate the numbers and weight of pollock for each length and age category using pollock size compositions, a length-weight relationship, and an age-length key all derived from trawl catch information.

Weighted mean depth of the pollock echo sign was computed for each 0.5 nmi of transect by multiplying the midpoint depth for each 20-m depth channel by the pollock density for that channel, then summing the weighted depths and dividing by total density. A weighted mean for each transect was obtained by multiplying the mean for each 0.5 nmi segment by density in that segment, summing all segments in each transect, then dividing by total transect density.

Echo integration data were classified by echo sign characteristics, geographic location, length composition in the hauls, and bottom depth (Pig. 3). Pollock aggregations observed during pass 1 along transects 1-6, described by hauls 1-3, were classified as the “east” portion of the spawning population. Pollock found near the Aleutian chain and northward along transects 7-17 (pass 1) and 19-32 (pass 2) over bottom depths shallower than about 1,000 m (hauls 5-7, 9, 10, 12, 14, 18, and 19) were categorized as the “slope” group. Pollock observed along transects 7-17 and 19-32 north of the 1,000 m contour were classified as “basin” (hauls 4, 11, 15-17). There were no pass 2 transects in the “east” region. On a few occasions, aggregations in the “slope” area extended over water depths deeper than the 1,000 m contour. This classification scheme differed from that used in 1994 (Honkalehto and Williamson 1995) because in 1995 there was no significant "non-spawner" component of the population.

In order to properly scale the echo integration data, separate male and female size compositions were derived for each analytical area (east, slope, and basin). For each area and sex, length data from trawl hauls in that area were weighted by sample numbers in the haul as follows. Using hauls 1,2, and 3 from the "east" area of pass 1 as an example:

$$\male_w = \frac{(m_1/n_1)*\male_1 + (m_2/n_2)*\male_2 + (m_3/n_3)*\male_3}{(m_1/n_1)+(m_2/n_2)+(m_3/n_3)},$$

where

m_i = number of male lengths in haul i,

n_i = total number of lengths in haul i,

$\male_i$ = proportional male size composition (vector) for haul i, and

$\male_w$ = weighted male size composition (vector).

The same procedure was repeated for females, resulting in six initial size compositions.

Trawl sampling of spawning pollock in the Bogoslof region does not produce a representative sample sex ratio because of the high degree of aggregation and vertical stratification by sex (Honkalehto and Williamson 1995). The sex ratio affects size composition because at any given age, males are usually smaller than females. During spawning, males often form deeper layers in the water column than females, and thus are-often underrepresented in

Bogoslof area trawls. In winter 1995, more females than males were captured during the survey. However, it is not thought that there were more females than males in the Bogoslof population. Yoshimura (1992) and Chinese scientists (Anon. 1993) reported finding a higher percentage of males in central-eastern Aleutian Basin surveys conducted in the summers of 1988 and 1993, respectively. Korean data from a summer 1994 Aleutian Basin survey also showed a higher percentage of males (Anon. 1995). To correct our 1995 winter trawl data for potential sampling limitations, a 50:50 sex ratio was assumed. Thus the six male and female weighted size compositions, initially derived separately (above), were averaged into three combined size compositions, one for each area, to scale the pollock, echo integration data into population numbers at length.

Collection of individual pollock for maturity, weight, and age information was stratified by sex in order to obtain comparable samples for scaling the echo integration data. A length-weight regression equation for males and females combined was obtained by minimizing the sum of squares to solve for a and b in the equation $W = aL^b$ using an iterative non-linear least squares approach. To generate an age-length key for the population assuming a 50:50 male:female sex ratio, we first created separate age-length keys for males and females. In the key with fewer samples (the male key), numbers of males were weighted to match the total number of samples in the female key. The male and female keys were added together. The resultant age-length key and length-weight regression equations were applied to the population numbers at length data to generate population numbers at age and biomass at age and length.

Due to different domestic and international requirements for defining the Bogoslof area pollock spawning stock, the acoustic data were analyzed in five ways (Fig. 4). Pass 1 (transects 1-17) spanned the entire geographic area covered during the survey. The areas covered by pass 2 (transects 19-32) and the CBS area are both subsets of the total pass 1 area. First, biomass estimates were made for passes 1 and 2. Next, pollock biomass occurring within the CBS area was estimated for pass 1 by excluding pass 1 transects that fell outside of the CBS area. Estimates also were made for pass 2 expanded to the CBS area, and for pass 2 expanded to cover the same area as pass 1 by combining pass 2 data with the portion of pass 1 not surveyed in pass 2. Expansion of pass 2 using pass 1 information assumed little or no migration between the outer areas covered by pass 1 and the smaller pass 2 area. The assumption was supported by data from previous Bogoslof EIT surveys in which concentrations of pollock observed north of Bogoslof Island on the first pass through the area were encountered again during the second pass in approximately the same location. Trawl haul data from passes 1 and 2 were combined with acoustic data to estimate each of the biomasses. Preliminary confidence intervals (CI) were estimated using a one-dimensional geostatistical technique first proposed by Petitgas (1993) and as applied by Williamson and Traynor (1996).

RESULTS

Biological and Oceanographic Results

Biological data were collected and specimen and tissue samples preserved from catches of 17 midwater rope trawls, one bottom trawl, one Methot trawl, and one bongo net tow (Figs. 5 and 6, Tables 2 and 3). Pollock dominated the midwater and bottom trawl catches in both weight and numbers (Tables 4 and 5). Numerous lantemfish (Myctophidae) and northern smoothtongues (Leuroelossus schmidti) were also captured. Euphausiids and a Pacific lamprey accounted for most of the Methot trawl catch by weight (Table 6). For midwater trawls, the number of biological samples for pollock length varied between 97 and 490, while the number of samples of pollock weights, otoliths and maturity characteristics ranged between 58 and 107 (Table 7):

Pollock caught during the survey had fork lengths ranging from 10 to 68 cm, with the majority between 40 and 60 cm (Fig. 7). With the exception of several young pollock estimated to be age 1 s, no pollock with lengths less than 34 cm were encountered. Pollock in the “east” region had shorter average lengths than those in other areas, and a modal length of 44 cm.

Pollock from the "basin" area had a length distribution that peaked at 54 cm. "Slope" area pollock comprised most of the Bogoslof population. Their length distribution had a dominant mode at 54 cm,-and weaker modes at 46 cm and 42 cm. Length-weight regression analysis estimated values for the equation $W = aL^b$ as

	a	b	n
male	0.00459	3.118646	578
female	0.00396	3.173104	612
sexes combined[3]	0.00238	3.289159	1,190.

The sex ratio by haul from all 17 midwater rope trawls ranged from 8% to 94% female and averaged around 60% female. During previous Bogoslof area surveys[4], observations from paired midwater tows on shallow and deep echo sign layers have shown that the proportion of males captured is higher in deeper layers, implying that vertical stratification by sex occurs. The 1995 midwater trawl data again indicate that male pollock usually inhabit deeper layers in the water column than females. The three deepest rope trawls (haul 3 at 497 m, haul 15 at 545 m, and haul 12 at 722 m) caught 83%, 75%, and 92% males, respectively.

Maturity composition for female pollock 38 cm to 68 cm in length indicated that 5% were in a developing stage and not expected to spawn soon, 80% were in a pre-spawning stage, 8% were actively spawning, and 7% were post-spawning (Fig. 8). Twenty of the 27 developing stage females (and 18 of 22 developing stage males) encountered during passes 1 and 2 were caught in haul 1. The mean GSI for pre-spawning females was 0.19 (Fig. 9).

---

[3] Length-weight regression parameters used in these analyses.

[4] N. Williamson, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle WA 98 115, unpublished cruise reports MF93- 1, MF94-2, September 1994.

Mean length at age differed between the sexes (Fig. 10). For ages 5 and older, female pollock were 1arger than males. Growth slowed at about age 9, and the female-male size difference remained relatively constant at about 3 cm.

Oceanographic data were collected from 16 CTD casts, 1 XBT cast, and 18 microBT casts (Tables 8-10). Temperature and salinity profiles showed a fairly well-mixed water column.' Temperaturesranged between 2.5° and 4.0° C from 0 to 700 m indepth (Fig. 11). Near-surface water (0-100 m) was a little cooler (2.7° C) on the eastern Bering Sea shelf side of the survey area, and a little warmer (4° C) on the western (Aleutian Basin) side. Salinity increased with depth from about 32.5 ppt at the surface to 34 ppt at depths below 500 m.

Pollock Distribution and Abundance

Pollock echo sign was observed throughout most of the survey area, but its distribution was patchy and fluctuated widely in density (Figs. 1 and 2). The first six transects of pass 1 (the "east" analytical area) included some isolated high-density aggregations off the edge of the shelf north of Akutan Island. Most of the pollock in this area formed low-density layers contiguous with the bottom. Along transects l-2 where bottom depths were less than 1,000 m, echo sign was characterized by a 150-200 m thick layer located near bottom, usually at around 400-600 m. Transects 3 and 4 had thin pollock layers at the north end that gradually thickened towards the south until they formed one or two layers, at around 500 m and 200 m, near the Aleutian Islands shelf. Transects 5 and 6 had relatively thin pollock layers at 400-500 m. The first "typical" Bogoslof echo sign--thick, dense sign between 300 and 500 m depth--occurred mid-way along transects 7.5 and 8, over deep water northeast of Bogoslof Island. From transect 9 westward, pollock aggregations often consisted of dense schools at 200-300 m, with horizontal layers between 300 and 600 m near the shelf break, and extended northward at depths between 300 and 500 m along the north side of Umnak Island from 168° W long. to 169° 30' W long. ("slope" analytical area, Figs. 1 and 2). The largest aggregations, along transects 11.5, 12, and 12.5, over bottom depths ranging from 500 to 900 m, were west of where the largest aggregations had been observed in previous years. Pollock observed well beyond the shelf break over depths greater than 1,000 m ("basin" analytical area) had patchy distributions both horizontally and vertically compared with pollock echo sign from the other two areas. They formed aggregations at depths anywhere between 200 and 500 m. At transect 13.0, pollock sign became more diffuse, and by transect 15.0 only weak traces of echo sign remained.

Pollock distribution during pass 2 was similar to that from pass 1, but the largest pollock aggregations appeared farther west (transects 19 and 20 , Fig. 2), and were more concentrated than they were in pass 1. In addition, some of the pollock sign that had appeared along the north side of Umnak (transects 9 through 12.5, Fig. 1) had diminished; and more was distributed in the central part of the survey area along the north ends of transects 22 - 25 (Fig. 2).

Vertical distribution of pollock echo sign ranged from 250 m to 750 m below the surface. Pollock depth was positively correlated with bottom depths shallower than 500 m (Fig. 12). At bottom depths greater than 500 m, the pollock remained at 400-500 m regardless of bottom depth. Comparing the average pollock depth for each transect from two passes in 1995 revealed similar trends, from east to west across the survey area (Fig. 13). For transects between 169° W and 169° 30' W long., pollock layers were deeper than in other parts of the survey area. The vertical distribution of pollock biomass (Fig. 14) was bimodal during pass 1, with peak depths at around 290 m and 410 m. During pass 2 the vertical biomass profile was composed of a much more pronounced peak at 290 m, with a smaller secondary mode at around 530 m, indicating that some of the spawning population had moved up in the water column during the survey period.

Five different estimates were made to describe biomass and numbers of pollock in the Bogoslof Island region (Table 11, Fig. 4). Assuming that the fish surveyed were all part of the Bogoslof spawning aggregation, evidenced by very few observations of "non-spawners", and that they did not migrate substantially during the time period between completion of passes 1 and 2, the best estimate for the entire area, averaging estimates 1 and 5 (Table 1 1), is 1.10 million t. An average biomass from estimates 3 and 4 for the CBS area, a subset of the entire area surveyed, is 1.02 million t.

The estimated 1.10 million t of pollock was distributed among three analytical areas, each with pollock of different length characteristics inhabiting different bottom depth regimes, as discussed previously (Figs. 3 and 7). Pollock biomass in the “east” area was 96 thousand t and the population numbered 127 million fish. In the “basin” area, the estimated pollock biomass was 163 thousand t and numbered 142 million fish, Most of the pollock echo sign was distributed in the “slope” area, with an estimated biomass of 845 thousand t, numbering 811 million fish.

Population and biomass at age results from survey year 1995 (Tables 12 and 13, Figs. 15 and 16) indicated that the 1989 year class was the most abundant of the Bogoslof area spawning population. The 1978 year class also contributed significantly. Pollock from the relatively strong 1982 and 1984 year classes were still evident, and the 1990 year class continued to recruit to the population.

DISCUSSION

From 1988 to 1994, the biomass of walleye pollock spawning in late February-early March over deep waters of the southeastern Aleutian Basin near Bogoslof Island declined (Fig. 17). Average length increased steadily from 47 to 51 cm through 1993 as the population, dominated by the 1978 year class, aged. In 1994, with an influx of smaller 1989 year class fish and continued growth and mortality of older age groups, the average length stayed about 51 cm, but the population length frequency was bimodal for the first time since the Bogoslof area EIT surveys had begun (Figs. 18 and 19).

In winter 1995, many more pollock were present in the Bogoslof spawning grounds and the biomass estimate was double that estimated in 1994 (Fig. 17). Average length of the population remained the same as 1993-94, around 5 1 cm, and the length range was similar. Recruitment of 1989 year class fish, noticeable as a length mode at around 46 cm, continued in 1995 and the population length frequency remained bimodal (Figs. 18 and 19). Although a few 10-14 cm fish wereencountered, none in the 15-33 cm length range were captured. Bogoslof area population and biomass at length since 1988 indicate that very few fish less than 34 cm have been observed over these survey years (Tables 14 and 15). This is consistent with observations that few young pollock are found in the Aleutian Basin. In contrast, most age groups can be observed on the Bering Sea shelf throughout the year.

Ageing older pollock is difficult, and problems in assigning correct ages throughout the survey years could bias the historical age composition of the Bogoslof population. Trends in the major pollock year classes-- 1978, 1982, 1984--can be traced fairly reliably from 1988 to 1991 and in 1993 (Tables 12 and 13, Figs. 15 and 16). However, in survey years 1992 and 1994, some blurring of strong year classes occurred. The age distribution of Bogoslof pollock in 1995 indicates that the 1989 year class contributed the most fish in numbers to the population, followed by nearly equal contributions from the 1978 and 1988 year classes. The 1988 year class was not thought to be strong, and age readers reported some difficulty with the ageing of age 6 (1989) and 7 (1988) fish.

Maturity composition of female pollock observed in 1995 indicated that most were in a pre-spawning stage (Fig. 8). The relative proportion of pre-spawning stage female pollock and average GSI were very similar to those observed in winter 1994 (Honkalehto and Williamson 1995), suggesting that survey timing relative to peak spawning was about the same in the two survey years. Evidence from previous EIT surveys in the Bogoslof region has shown female maturity stages to be a good indicator of timing of major spawning activity (Teshima et al. 1991). In 1994, although many 1989 year class fish had recruited to the population, some "non-spawners”, defined as pollock in developing maturity stages, were present east of the main spawning population. Based on historical recruitment patterns, it was speculated that the “non-spawners” would continue to recruit to the Bogoslof area as-spawners in 1995. This appeared to have occurred, as the numbers of mature 1989 year class pollock increased in 1995, and aggregations of “non-spawners” were no longer evident. Only 49 developing stage pollock were caught, 38 of which were from a single haul in the eastern-most portion of the survey area.

Bogoslof EIT surveys conducted each year since 1988 (except 1990) have provided direct information on a portion of the Aleutian Basin pollock stock. There is no direct estimate of the total Aleutian Basin stock, and the proportion that spawns in the Bogoslof area is not known. The doubling of Bogoslof pollock biomass between 1994 and 1995 intensified discussion in the NPFMC about the potential of reopening pollock fisheries within U.S. waters near Bogoslof Island. It also fueled discussion among delegates to the 1995 CBS Convention about the relationship, if any, between an increase in biomass of Bogoslof pollock and an increase of pollock biomass in the donut hole. These results were obtained with methods identical to those in all previous Bogoslof EIT surveys, but because of the estimated stock increases, they attracted more attention and scrutiny than in the past. In order to elucidate and discuss any potential sources of error, attention was focussed on several factors influencing both the point estimate of biomass and the shapes of the population length and age distributions. These are discussed in ensuing paragraphs.

The 1995 biomass increase can be partially explained by continued recruitment of the 1989 year class, and to a lesser extent by the 1988 and 1990 year classes. Trends in recruitment to the spawning population for dominant year classes suggest that the 1989 year class was of similar magnitude at age 6 to the 1982 year class at the same age (Fig. 20). Historically, recruitment has increased each year up through about age 7 and then declined. However, much of the increase in the Bogoslof biomass estimate in 1995 was due to increases in age 7 and older “fully recruited” year classes (Fig. 21).

There was no reason for concern about trawl sampling errors in 1995, but because of increased interest in the Bogoslof spawning population, their potential effects on biomass estimation were investigated. More effort was allocated towards trawl sampling in 1995 than in recent survey years. As described previously, sampling to determine size composition in the Bogoslof region can be difficult. The Bogoslof spawning population is composed of fish aggregations characterized by extensive, dense, vertical structure and patchy horizontal distribution throughout the survey area. When a dense aggregation is encountered, it is difficult to trawl through the center without catching excessive quantities of fish. Large catches are difficult to subsample properly on deck to obtain a representative sample. These sampling conditions could lead to error in representing the length composition of the population. Since length composition data are used to scale the acoustic data (through the TS-length equation), an error in the length composition would introduce an error in the biomass estimate. Additionally, the population age distribution would be in error because it is derived from an age-length key and the length composition data. For example, if we assumed that the younger, recruiting year classes were under-represented in the length composition data, the average length of pollock in the population would approach the modal length (46 cm) of the 1989 year class rather than 51 cm as reported in this document. The estimated age distribution would change. Numbers of recruiting fish would increase and numbers of older fish from fully recruited year classes would decrease, resulting in a younger age composition more comparable with that observed in 1994. However, biomass estimation under these conditions is relatively robust; this hypothetical reduction in mean length would result in only a 12% reduction of total biomass; 1 .l0 million t reduced to 0.97 million t.

Confidence intervals were estimated for 1995 and 1994 data using a one-dimensional geostatistical technique (Petitgas 1993) to determine whether acoustic sampling variability could have accounted for the apparent biomass increase. The applicability of this variance estimation technique to echo integration surveys is currently being evaluated (Williamson and Traynor 1996). The 95% confidence intervals were 0.86 to 1.34 million t for 1995 and 0.38 to 0.60 for 1994. Since the confidence intervals do not overlap, the two point estimates of biomass are significantly different. Thus acoustic sampling variability does not appear to account for the entire difference between the two estimates.

Migration of greater numbers of older fish into the survey area in 1995 could also explain the observed population increase from 1994. Oceanographic evidence indicated that during winter 1994-95, ice on the eastern Bering Sea shelf advanced more rapidly and farther south than in the previous 20 years. Adult pollock tend to avoid inner-shelf waters during spring after heavy ice years, concentrating in the outer domains of the shelf (Wyllie-Echeverria 1995). Perhaps migration of older adults to the basin was prompted by suboptimal conditions in the physical oceanographic environment on the shelf. It is also possible that proportionately more Aleutian Basin fish migrated into the area to spawn in 1995 compared to previous years. However, there is no direct evidence available to support or refute either of these hypotheses.

In summary, the Bogoslof spawning pollock population doubled in biomass in 1995 compared with its level in 1994. Survey timing was identical to previous years and trawling effort was higher. Several sources of population increase and potential sources of error were investigated. The conclusions were that increased recruitment of younger fish from the 1989 year class contributed to the biomass increase, and that migration of older pollock from either the Aleutian Basin or adjacent shelf may also have occurred. Acoustic sampling variability alone is not responsible for the difference in biomass. Trawl sampling error could have influenced the biomass estimate, but would not have changed it more than about 12% in the most extreme case. However, trawl sampling error may explain some of the apparent increases among older age groups.

ACKNOWLEDGMENTS

Dennis Benjamin, Tom Wilderbuer, and Jill McKay assisted with biological and oceanographic data collection. Dan Twohig was instrumental in acoustic data collection and analyses. Jim Traynor, Dave Somerton, and Lowell Fritz reviewed the final manuscript. James Lee and Gary Duker provided editorial assistance. The captain and crew of the NOAA ship

Miller Freeman provided an essential work platform. This work was funded by the National Marine Fisheries Service, NOAA.

CITATIONS

Anon. 1993. Outline of biological information obtained ‘from summer pollock survey in the Aleutian Basin by “Bei Dou” in 1993. Yellow Sea Fisheries Research Institute, Qingdao, P.R.China. Contrib. paper at the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, Meeting of the Scientific and Technical Committee. Feb. 7-l 1, 1995, AFSC, 7600 Sand Point Way NE, Seattle WA 98115.

Anon. 1995. Report of the summer 1994 echo integration and midwater trawl survey for the Bering Sea walleye pollock by the R/V Pusan 85 1, National Fisheries Research and Development Agency. Republic of Korea. Contrib. paper at the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, Meeting of the Scientific and Technical Committee. Feb. 7-11, 1995, AFSC, 7600 Sand Point Way NE, Seattle WA 98 115.

Bodholt, H., H. Nes, and H. Solli. 1989. A new echo sounder system. Proceedings of the Institute of Acoustics 11(3):123-130.

FAO (Food and Agriculture Organization of the United Nations). 1991. Yearbook of Fishery Statistics. FAO, Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations). 1994. Yearbook of Fishery Statistics. FAO, Rome, Italy.

Foote, K. G., and J. J. Traynor. 1988. Comparison of walleye pollock target strength estimates determined from in situ measurements and calculations based on swimbladder form. J. Acoust. Soc. Am. 83(l): 9-17.

Foote, K.G., H. P. Knudsen, R., J. Komeliussen, P. E. Nordbo, and K. Roang. 1991. Postprocessing system for echo sounder data. J. Acoust. Soc. Am. 90:37-47.

Honkalehto, T., and N. Williamson. 1995. Echo integration-trawl survey of walleye pollock (Theraera chalcoeramma) in the southeast Aleutian Basin during February and March, 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-52,39 p.

Petitgas, .P. 1993. Geostatistics for fish stock assessments:A review and an acoustic application. ICES Journal of Marine Science 50:285-298.

Teshima, K., T. Honkalehto, and T. Yoshimura. 1991. Maturity condition of pelagic walleye pollock from the Aleutian Basin of the Bering Sea. Nippon Suisan Gakkaishi 57(8): 1,495-1,499.

Wakabayashi, K., R. G. Bakkala, and M. S. Alton. 1985. Methods of the U.S.-Japan demersal trawl surveys. In R. G. Bakkala and K. Wakabayashi (eds.), Results of cooperative U.S.-Japan groundfish investigations in the Bering Sea during May-August 1979. Int. North Pac. Fish. Comm. Bull. 44:7-26.

Williamson, N., and J.J. Traynor. 1996. Application of a one-dimensional geostatistical procedure to fisheries acoustic surveys of Alaskan pollock. ICES Journal of Marine Science, 53(2):423-428.

Wyllie-Echeverria, T. 1995. Seasonal sea ice, the cold pool, and gadid distribution on the Bering sea shelf. Ph.D. Thesis, Univ. of Alaska, Fairbanks, AK, 283 p.

Yoshimura, T. 1992. III. Biological sampling. In Sasaki, T. (ed.), Report of cooperative Japan-U.S. pelagic pollock investigation in the Aleutian Basin during August-October in 1988. Special Publication of the National Research Institute of Far Seas Fisheries No. 2 1,103 p.

Table 1. Summary of sphere calibrations conducted before and after the 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Date	Location	Freq kHz	Water Temp (deg. C) at Transducer*	Water Temp (deg. C) at Sphere	Sphere Range from Transducer (m)	TS Gain	SV Gain	3db Beam Width	Angle Offset Along	Angle Offset Athwart
26 Jan 95	Port Susan	38	8.4	9.1	23.9	27.4	27.1	7.13	-0.10	-0.06
		120	8.4	9.0	19.5	25.0	25.1	8.81	-0.62	-0.14
13 Feb 95	Ugak Bay	38	3.7	3.5	26.7	27.3	27.0	7.16	-0.12	-0.05
		120	3.7	3.5	21.9	24.5	24.5	8.81	-0.73	-0.04
08 Mar 95	Skan Bay	38	3.0	3.0	26.7	27.3	27.1	7.13	-0.14	-0.05
		120	3.0	3.0	22.2	24.1	24.1	9.29	-0.85	-0.40
13 Apr 95	Anderson Bay	38	2.9	2.8	26.2	27.3	27.1	7.14	-0.09	-0.06
		120	2.9	2.8	21.4	24.2	24.2	9.36	-0.54	-0.72

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

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.

Table 2. Summary of trawl stations and catch data from the 1995 pollock echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Haul No.	Date (1995)	Gear * Type	Time (GMT)	Start Position Latitude (N)	Start Position Longitude (W)	Depth (m) Gear	Depth (m) Bottom	Temp (C) Gear	Temp (C) Surface	Pollock Weight (kg)	Pollock Numbers	Other Weight (kg)	Other Numbers
1	26 Feb	R	0446-0456	54 21.07	165 51.88	165	236	3.7	2.9	527.7	765	0.2	1
2	26 Feb	R	1553-1645	54 23.85	166 09.79	487	620	3.8	2.6	265.9	277	9.9	1262
3	26 Feb	R	2232-2257	54 17.06	166 08.75	497	692	3.7	2.8	323.0	491	10.8	964
4	28 Feb	R	0413-0430	54 12.87	167 52.37	429	1419	3.8	3.6	790.2	653	0.8	25
5	28 Feb	R	2120-2153	53 35.00	167 50.86	413	603	3.8	3.6	373.1	399	6.5	212
6	1 Mar	R	0426-0456	53 42.16	168 08.49	444	1048	3.8	3.9	295.1	249	7.5	425
7	1 Mar	R	0628-0648	53 39.38	168 08.90	442	999	3.8	3.7	839.0	672	6.1	23
8	1 Mar	M	1012-1015	53 41.43	168 09.83	778	1143	3.3	3.8	--	--	1.4	--
9	2 Mar	R	2228-2237	53 12.94	169 01.82	300	825	3.7	3.9	5454.5	3976	--	--
10	3 Mar	R	0125-0126	53 10.55	169 01.34	350	825	3.7	4.0	2755.4	2060	3.6	1
11	3 Mar	R	0634-0639	53 32.44	168 53.97	282	1500	3.7	3.7	428.0	307	1.4	3
12	3 Mar	R	1837-1917	53 08.82	169 15.04	722	1179	3.2	3.8	2829.8	3021	15.7	1381
13	5 Mar	B	0812-0815	52 29.84	172 07.39	270	270	3.7	3.1	60.9	40	13.1	12
14	6 Mar	R	1040-1048	53 02.65	169 24.19	311	585	3.5	3.5	1540.9	1271	3.3	1
15	6 Mar	R	1742-1800	53 16.11	169 26.85	545	1285	3.5	3.5	807.4	772	2.7	75
16	7 Mar	R	0027-0053	53 40.12	169 12.28	244	1762	3.6	3.3	6818.1	5225	--	--
17	7 Mar	R	1850-1920	53 42.64	168 42.13	362	1735	3.7	3.7	914.4	821	5.9	69
18	8 Mar	R	0321-0332	53 34.58	168 23.84	401	963	3.8	3.8	5431.2	5479	23.4	11
19	8 Mar	R	2053-2128	53 37.64	167 39.51	464	894	3.7	3.3	92.0	97	9.6	400

* R indicates rope trawl, M indicates Methot trawl, and B indicates bottom trawl.

Table 3. Bongo net tow station from the 1995 pollock echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Bongo Cast	Date (1995)	Time (GMT)	Start Position Latitude (N)	Start Position Longitude (W)	Depth (m) Cast	Depth (m) Bottom	Comments
1	8 Mar	0158	53 34.28	168 22.17	501	932	eggs present

Table 4. Summary of catch by species in 17 midwater rope trawls during the 1995 echo Integration-trawl survey of the southeastern Aleutian Basin near Bogoslof island.

Common Name	Scientific Name	Weight (kg)	Weight (%)	Numbers
Walleye Pollock	*Theragra chalcogramma*	30,485.7	99.6	26,535
Smooth Lumpsucker	*Aptocyclus ventricosus*	43.0	0.1	21
Lanternfish Unidentified	*Myctophidae Unidentified*	25.0	0.1	2,392
Pacific Lamprey	*Lampetra tridentata*	9.9	<0.1	24
Northern Smoothtongue	*Leuroglossus schmidti*	8.0	<0.1	1,533
Squid Unident	Teuthoida	7.0	<0.1	97
Chinook Salmon	*Oncorhynchus tshawytscha*	4.8	<0.1	2
Jellyfish Unidentified	Scyphozoa	3.8	<0.1	-
Rougheye Rockfish	*Sebastes aleutianus*	2.6	<0.1	1
Shrimp Unidentified	*Pasiphaea pacifica*	1.2	<0.1	589
Deepsea Smelt Unidentified	*Bathylagidae Unidentified*	0.8	<0.1	32
Viperfish Unidentified	*Chauliodontidae Unidentified*	0.8	<0.1	27
Salps Unidentified	*Thaliacea Unidentified*	0.3	<0.1	-
Octopus Unidentified	Octopodidae	0.2	<0.1	1
Atka Mackerel	*Pleurogrammus monopterygius*	0.1	<0.1	2
Eelpout Unidentified	*Zoarcidae Unidentified*	0.0	<0.1	2
Totals		30,593.0	100.0	31,258

Table 5. Summary of catch by species in one bottom trawl during the 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof island.

Common Name	Scientific Name	Weight (kg)	Weight (%)	Numbers
Walleye Pollock	*Theragra chalcogramma*	60.9	82.3	40
Pacific Ocean Perch	*Sebastes alutus*	10.8	14.6	11
Soft Coral Unidentified	Alcyonacea	1.8	2.4	-
Jellyfish Unidentified	Scyphozoa	0.3	0.4	-
Spectacled Sculpin	*Triglops scepticus*	0.1	0.2	1
Sponge Unidentified	Porifera	0.1	0.1	-
Totals		74.0	100.0	52

Table 6. Summary of catch by species in one Methot trawl during the 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Common Name	Scientific Name	Weight (kg)	Weight (%)	Numbers
Euphausiid Unidentified	Euphausiacea	0.56	38.5	-
Pacific Lamprey	*Lampetra tridentata*	0.43	29.5	2
Jellyfish Unidentified	Scyphozoa	0.14	9.6	0
Lanternfish Unidentified	*Myctophidae Unidentified*	0.11	7.5	49
Shrimp Unidentified	*Pasiphaea pacifica*	0.09	6.1	6
Salps Unidentified	*Thaliacea Unidentified*	0.07	4.8	-
Northern Smoothtongue	*Leuroglossus schmidti*	<0.10	2.6	46
Deepsea Smelt Unidentified	*Bathylagidae Unidentified*	<0.10	1.1	1
Fish Larvae Unidentified	Pisces	<0.10	0.1	13
Squid Unidentified	Teuthoida	<0.10	0.1	1
Amphopod Unidentified	Amphipoda	<0.10	0.1	-
Copepods Unidentified	Copepoda	<0.10	0.1	-
Totals		1.46	100.0	118

Table 7. Summary of biological samples and measurements collected during the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

HAUL	LENGTH FREQUENCY	MATURITY	OTOLITHS	BODY WT	OVARY WT	STOMACH COLLECTION	FECUNDITY	FISH LARVAE
1	293	96	96	96	19	20	--	--
2	277	66	66	66	38	--	--	--
3	491	70	70	70	26	20	--	--
4	450	83	83	83	40	20	12	--
5	399	73	73	73	24	20	--	--
6	249	83	83	83	37	20	--	--
7	331	--	--	--	--	--	9	--
8	--	--	--	--	--	--	--	13
9	281	72	72	72	31	--	--	--
10	303	--	--	--	--	20	13	--
11	307	58	58	58	32	20	--	--
12	426	74	74	74	19	20	--	--
13	40	40	40	40	22	--	21	--
14	480	69	69	69	35	--	2	--
15	327	80	80	80	38	20	--	--
16	424	84	84	84	35	20	1	--
17	338	107	107	107	44	20	--	--
18	490	80	80	80	30	20	--	--
19	97	97	97	97	38	20	5	--
	6,003	1,232	1,232	1,232	508	260	63	13

Table 8. Summary of conductivity-temperature-depth (CTD) casts conducted during the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Cast	Haul	Transect	Date (1995)	Time (GMT)	Latitude (N)	Longitude (W)	Depth (m) CTD cast	Depth (m) Bottom
1	1	1.0	26 Feb	0548	54 21.15	165 51.19	182	198
2	2	2.0	26 Feb	1441	54 23.98	166 08.83	539	592
3	3	3.0	27 Feb	0018	54 17.30	166 08.64	673	686
4	4	8.0	28 Feb	0537	54 12.49	167 50.57	540	1402
5	5	8.5	28 Feb	2326	53 34.83	167 50.76	596	645
6	6,7	9.0	01 Mar	0814	53 40.08	168 07.31	365	969
7	9,10	12.0	03 Mar	0250	53 10.97	169 00.25	681	688
8	11	11.5	03 Mar	0848	53 33.09	168 53.63	629	1762
9	PMEL*	18.3	05 Mar	1017	52 21.64	172 08.82	395	402
10	PMEL*	18.3	05 Mar	1140	52 22.61	171 58.45	322	327
11	PMEL*	18.3	05 Mar	1315	52 23.85	171 44.07	304	310
12	PMEL*	18.3	05 Mar	1433	52 26.13	171 33.16	504	532
13	14	20.0	06 Mar	1219	53 02.80	169 23.73	301	637
14	17	25.0	07 Mar	2027	53 42.56	168 40.77	549	1737
15	19	32.0	08 Mar	2238	53 37.53	167 39.13	498	930
16	cal	-	09 Mar	0633	53 38.61	167 01.92	71	84

* Pacific Marine Environmental Laboratory (PMEL) casts taken in Amukta Pass , Alaska.

Table 9. Expendable bathythermograph (XBT) cast taken during the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

XBT Drop	Haul	Transect	Date (1995)	Time (GMT)	Latitude (N)	Longitude (W)	Depth (m) XBT cast	Depth (m) Bottom
1	16	21.1	06 Mar	2302	53 40.3	169 11.8	459	1874

Table 10. Summary of micro-bathythermograph casts conducted during the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

Drop	Haul	Date (1995)	Time (GMT)	Position		Depth (m)		Transect	Trawl Type
				Latitude (N)	Longitude (W)	MBT Cast	Bottom		
1	1	26 Feb	0437-0507	54 21.07	165 51.88	163	236	1.0	Rope
2	2	26 Feb	1540-1700	54 23.85	166 09.79	496	620	2.0	Rope
3	3	26 Feb	2210-2312	54 17.06	166 08.75	485	692	3.0	Rope
4	4	28 Feb	0358-0447	54 12.87	167 52.37	452	1419	8.0	Rope
5	5	28 Feb	2105-2215	53 35.00	167 50.86	413	603	8.5	Rope
6	7	1 Mar	0612-0703	53 39.38	168 08.90	440	999	9.0	Rope
7	8	1 Mar	0922-1115	53 41.43	168 09.83	786	1143	9.0	Methot
8	9	2 Mar	-	53 12.94	169 01.82	-	825	12.0	Rope
9	10	3 Mar	0104-0148	53 10.55	169 01.34	321	825	12.0	Rope
10	11	3 Mar	0612-0654	53 32.44	168 53.97	264	1500	11.5	Rope
11	12	3 Mar	1812-1940	53 08.82	169 15.04	739	1179	13.0	Rope
12	13	5 Mar	0753-0824	52 29.84	172 07.39	280	281	18.3	Bottom
13	14	6 Mar	1008-1104	53 02.65	169 24.19	291	585	20.0	Rope
14	15	6 Mar	1728-1822	53 16.11	169 26.85	563	1285	21.0	Rope
15	16	6 Mar	-	53 40.12	169 12.28	-	1762	21.1	Rope
16	17	7 Mar	1832-1942	53 42.64	168 42.13	449	1735	25.0	Rope
17	18	8 Mar	0310-0350	53 34.58	168 23.84	398	963	27.0	Rope
18	19	8 Mar	-	53 37.64	167 39.51	-	894	32.0	Rope

Cast 8, 15, and 18 were unsuccessful.

Table 11. Biomass and, numbers of pollock for five different estimates of the spawning aggregations near Bogoslof Island from the 1995 echo integration-trawl survey.

Estimate	Biomass (million tons)	Numbers (billions)	Transects
1 Pass 1	1.02	0.99	1-17
2 Pass 2	1.05	1.00	19-32
3 Pass 1 bounded	0.93	0.88	5-14
4 Pass 2 expanded and bounded	1.11	1.06	19-32, 5-14
5 Pass 2 expanded not bounded	1.19	1.17	19-32, 1-17
Average of 1 and 5	1.10	1.08	Best estimate for entire region
Average of 3 and 4	1.02	0.97	Best estimate for CBS area ("specific area" of the Central Bering Sea Convention)

Table 12. Bogoslof spawning pollock population estimates (millions of fish) from February-March echo integration-trawl surveys. No survey was conducted in 1990. Numbers for 1991-1995 were reanalyzed and may vary slightly from those in previous reports.

0	0	0	--	0	0	0	0	0
1	0	0	--	0	0	0	0	1
2	0	0	--	4	0	0	0	0
3	0	0	--	0	1	1	0	2
4	0	6	--	2	2	33	21	6
5	28	15	--	12	27	17	86	75
6	327	58	--	46	54	44	26	278
7	247	363	--	213	97	46	38	105
8	164	147	--	93	74	48	36	68
9	350	194	--	160	71	42	36	80
10	1201	91	--	44	55	28	17	53
11	288	1105	--	92	57	51	27	54
12	287	222	--	60	33	25	23	19
13	202	223	--	373	34	27	13	59
14	89	82	--	119	142	42	9	32
15	27	90	--	41	164	92	45	12
16	17	30	--	38	59	47	36	31
17	7	60	--	29	8	25	28	103
18	3	0	--	32	15	11	16	60
19	0	0	--	56	22	11	4	18
20	0	0	--	4	42	11	4	5
21	0	0	--	2	13	10	8	5
22	0	0	--	0	3	1	2	6
23	0	0	--	0	1	1	2	6
24	0	0	--	0	0	0	1	2
25	0	0	--	0	0	0	0	0
Totals	3236	2687	--	1419	975	613	478	1081

Table 13. Bogoslof spawning pollock biomass estimates (metric tons) from February-March echo integration-trawl surveys. No survey was conducted in 1990. Numbers for 1991-1695 have been reanalyzed and may vary slightly from those in previous reports.

Age	1988	1989	1990	1991	1992	1993	1994	1995
0	0	0	--	0	0	0	0	0
1	0	0	--	0	0	0	0	10
2	0	0	--	170	0	0	0	0
3	0	0	--	0	162	284	0	681
4	0	2184	--	715	782	18809	13028	3411
5	14997	7275	--	6067	21455	11939	59938	48690
6	192324	41140	--	24911	38081	39100	21530	208409
7	155569	241301	--	143024	67027	43049	39768	82680
8	114725	111156	--	74575	59445	46874	39107	72294
9	251417	149143	--	149035	67358	43976	39539	96260
10	910016	68495	--	43519	56969	30688	20520	64202
11	226380	894895	--	94020	61394	59294	31589	70646
12	232810	187280	--	59273	36293	27008	27506	26482
13	167054	193548	--	377521	37218	29947	17038	77225
14	81596	71920	--	116171	150237	46997	10896	42417
15	22969	81447	--	38750	168966	107062	52899	16595
16	16336	24342	--	37870	63304	54401	42771	37907
17	6681	51725	--	30696	9342	27577	32128	131396
18	2863	0	--	32392	15467	10736	17911	74010
19	0	0	--	55116	23380	13607	4768	22292
20	0	0	--	3840	43605	11963	5081	5902
21	0	0	--	1341	15240	10167	8866	5433
22	0	0	--	0	3186	1329	2011	7728
23	0	0	--	0	1287	598	2323	6696
24	0	0	--	0	0	0	860	2758
25	0	0	--	0	0	0	0	0
Totals	2395737	2125851	--	1289006	940198	635405	490077	1104124

a

Table 14. Population at length estimates (millions of fish) from February-March echo integration-trawl surveys of spawning pollock in the Bogoslof Island area. No survey was conducted in 1990.

Length	1988	1989	1990	1991	1992	1993	1994	1995
10	0	0	--	0	0	0	0	<1
11	0	0	--	0	0	0	0	<1
12	0	0	--	0	0	0	0	1
13	0	0	--	0	0	0	0	<1
14	0	0	--	0	0	0	0	<1
15	0	0	--	0	0	0	0	0
16	0	0	--	0	0	0	0	0
17	0	0	--	0	0	0	0	0
18	0	0	--	0	0	0	0	0
19	0	0	--	0	0	0	0	0
20	0	0	--	0	0	0	0	0
21	0	0	--	0	0	0	0	0
22	0	0	--	<1	0	0	0	0
23	0	0	--	2	0	0	0	0
24	0	0	--	1	0	0	0	0
25	0	0	--	0	0	0	0	0
26	0	0	--	<1	0	0	0	0
27	0	0	--	0	0	0	0	0
28	0	0	--	0	0	0	0	0
29	0	0	--	0	0	0	0	0
30	0	0	--	0	0	0	0	0
31	0	0	--	0	<1	0	0	0
32	0	0	--	0	<1	0	0	0
33	0	0	--	0	<1	0	0	0
34	0	0	--	0	0	0	0	<1
35	0	0	--	0	0	0	0	<1
36	0	0	--	0	<1	0	0	<1
37	9	3	--	0	0	0	0	<1
38	6	0	--	2	0	1	0	1
39	16	4	--	5	0	2	0	4
40	24	3	--	7	1	4	3	12
41	27	4	--	19	3	5	6	20
42	48	23	--	23	7	7	9	40
43	118	33	--	31	14	6	14	40
44	179	54	--	36	18	7	21	41
45	329	159	--	46	28	8	21	50
46	488	177	--	55	32	13	21	53
47	547	389	--	79	42	22	18	40
48	476	434	--	130	68	28	17	55
49	389	431	--	168	102	46	16	47
50	248	366	--	205	129	69	39	52
51	162	279	--	189	144	76	46	58
52	80	168	--	160	118	73	52	78
53	48	85	--	122	106	73	49	81

Table 14. continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995
54	19	50	--	63	67	66	43	88
55	12	13	--	40	41	50	37	81
56	4	5	--	17	27	29	26	69
57	3	8	--	8	13	14	17	58
58	1	1	--	4	6	9	10	47
59	0	0	--	1	5	3	6	31
60	0	0	--	1	1	1	3	17
61	2	0	--	1	<1	1	2	7
62	0	0	--	<1	<1	<1	1	4
63	0	0	--	0	0	0	<1	2
64	0	0	--	0	1	<1	0	1
65	0	0	--	<1	0	0	0	<1
66	0	0	--	0	0	0	0	<1
67	0	0	--	0	0	0	0	0
68	0	0	--	0	0	0	0	1
Totals	3236	2687	--	1419	975	613	478	1081

Table 15. Biomass at length estimates (metric tons) from February-March echo integration-trawl surveys of spawning pollock in the Bogoslof Island area. No survey was conducted in 1990.

Length	1988	1989	1990	1991	1992	1993	1994	1995
10	0	0	--	0	0	0	0	<1
11	0	0	--	0	0	0	0	2
12	0	0	--	0	0	0	0	5
13	0	0	--	0	0	0	0	2
14	0	0	--	0	0	0	0	1
15	0	0	--	0	0	0	0	0
16	0	0	--	0	0	0	0	0
17	0	0	--	0	0	0	0	0
18	0	0	--	0	0	0	0	0
19	0	0	--	0	0	0	0	0
20	0	0	--	0	0	0	0	0
21	0	0	--	0	0	0	0	0
22	0	0	--	13	0	0	0	0
23	0	0	--	70	0	0	0	0
24	0	0	--	61	0	0	0	0
25	0	0	--	0	0	0	0	0
26	0	0	--	26	0	0	0	0
27	0	0	--	0	0	0	0	0
28	0	0	--	0	0	0	0	0
29	0	0	--	0	0	0	0	0
30	0	0	--	0	0	0	0	0
31	0	0	--	0	37	0	0	0
32	0	0	--	0	42	0	0	0
33	0	0	--	0	48	0	0	0
34	0	0	--	0	0	0	0	53
35	0	0	--	0	0	0	0	93
36	0	0	--	0	68	0	0	42
37	3199	846	--	115	0	0	0	113
38	2304	0	--	768	84	260	0	435
39	6365	1461	--	1843	0	634	202	1697
40	10573	1116	--	2801	451	1776	1190	5510
41	12697	1532	--	7940	1235	2276	2855	9777
42	24360	10704	--	10812	3316	3571	4990	20730
43	64253	16516	--	15540	6760	3089	8021	22332
44	104733	29588	--	20103	9877	4006	12963	24863
45	206586	93899	--	28059	16329	4818	13823	32817
46	328735	113092	--	36235	20645	8835	15081	37303
47	394741	268496	--	56880	29146	16669	13565	30184
48	367368	323170	--	101488	51983	22214	13658	44572
49	320630	345632	--	141399	84329	39811	14414	40477
50	217890	314778	--	187006	115614	63571	36256	47785
51	152084	258067	--	186358	140004	75524	46297	57291
52	79654	166322	--	170855	124034	77721	55851	81793
53	50739	89721	--	139671	120309	83189	55151	90342

Table 15. continued.

54	21211	56681	--	77905	82110	79461	52329	104021
55	14191	16270	--	52506	53286	64342	47770	102318
56	5580	6059	--	23541	38564	39556	35451	91962
57	3886	10681	--	12470	19710	20781	24453	81885
58	1395	1220	--	6603	9188	14391	15826	70522
59	0	0	--	1284	7872	4376	9546	48878
60	0	0	--	2743	2631	1989	4716	28240
61	2561	0	--	2195	562	1756	3644	11855
62	0	0	--	780	600	372	1826	7951
63	0	0	--	0	0	0	200	3978
64	0	0	--	0	1363	415	0	1074
65	0	0	--	938	0	0	0	495
66	0	0	--	0	0	0	0	163
67	0	0	--	0	0	0	0	0
68	0	0	--	0	0	0	0	2570
Totals	2395735	2125851	--	1289008	940197	635403	490078	1104118

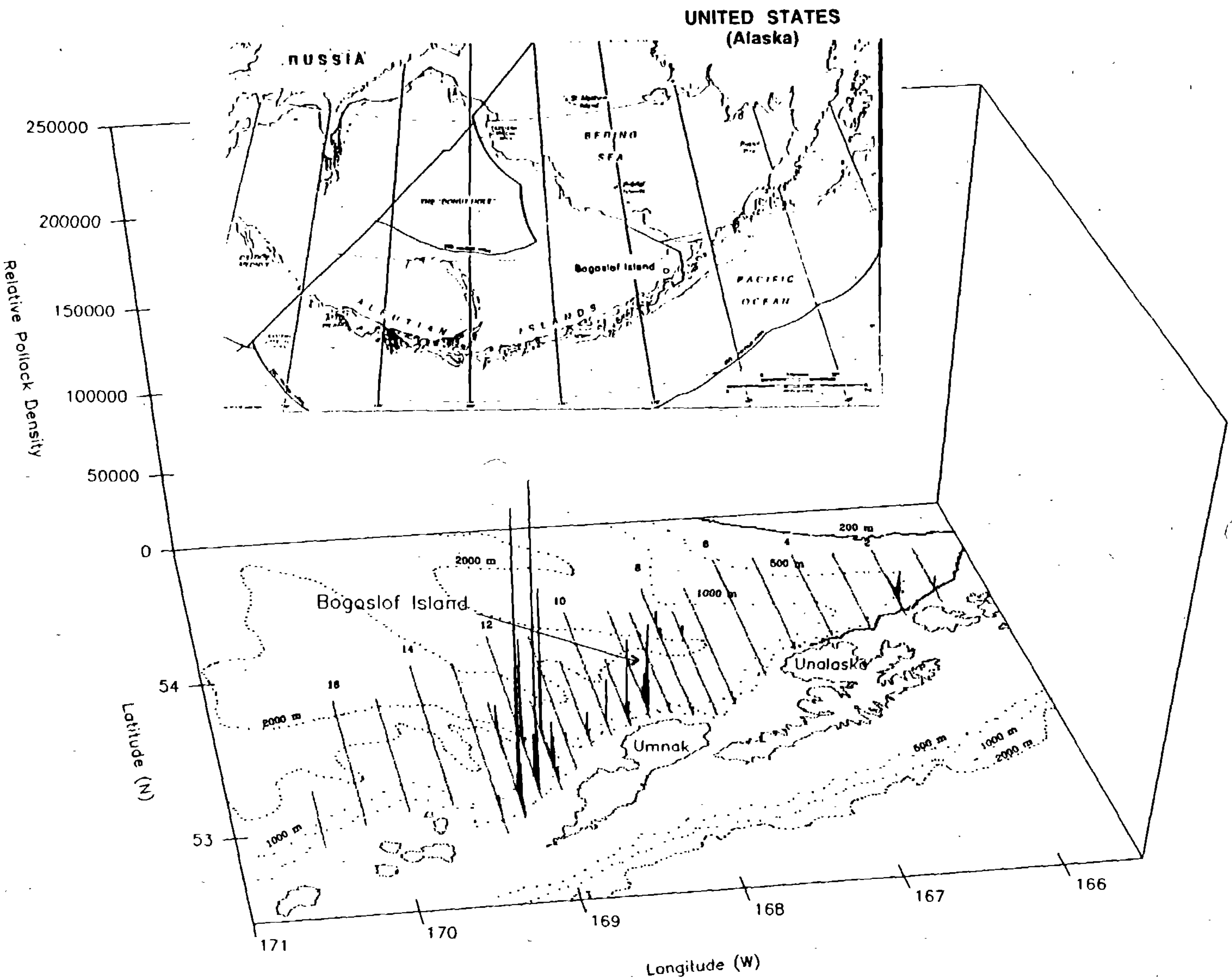


Figure 1 Relative pollock density along trackline from pass 1 of the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Transect numbers are indicated.

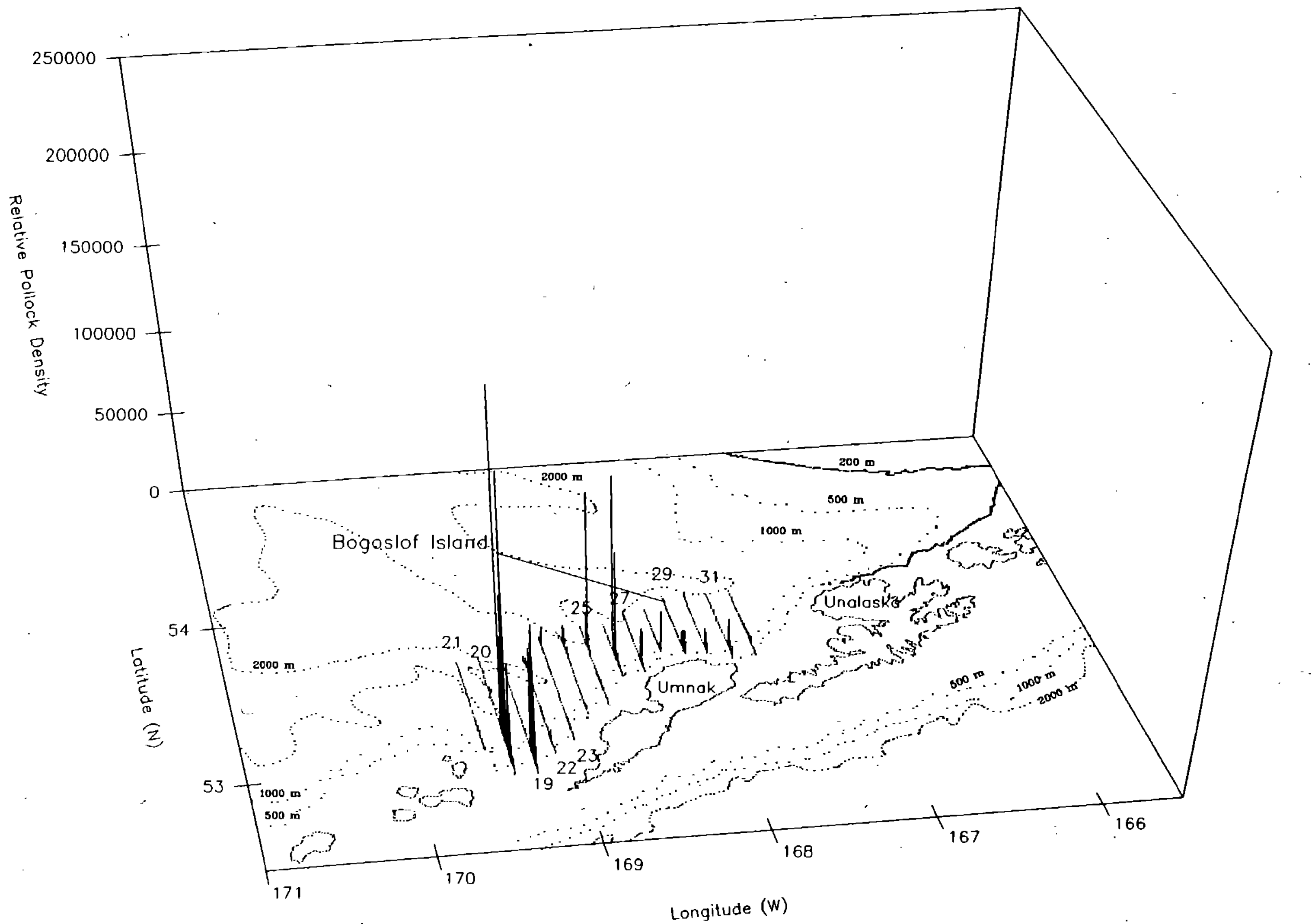


Figure 2. Relative pollock density along trackline from pass 2 of the winter 1995 echo integration–trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Transect numbers are indicated.

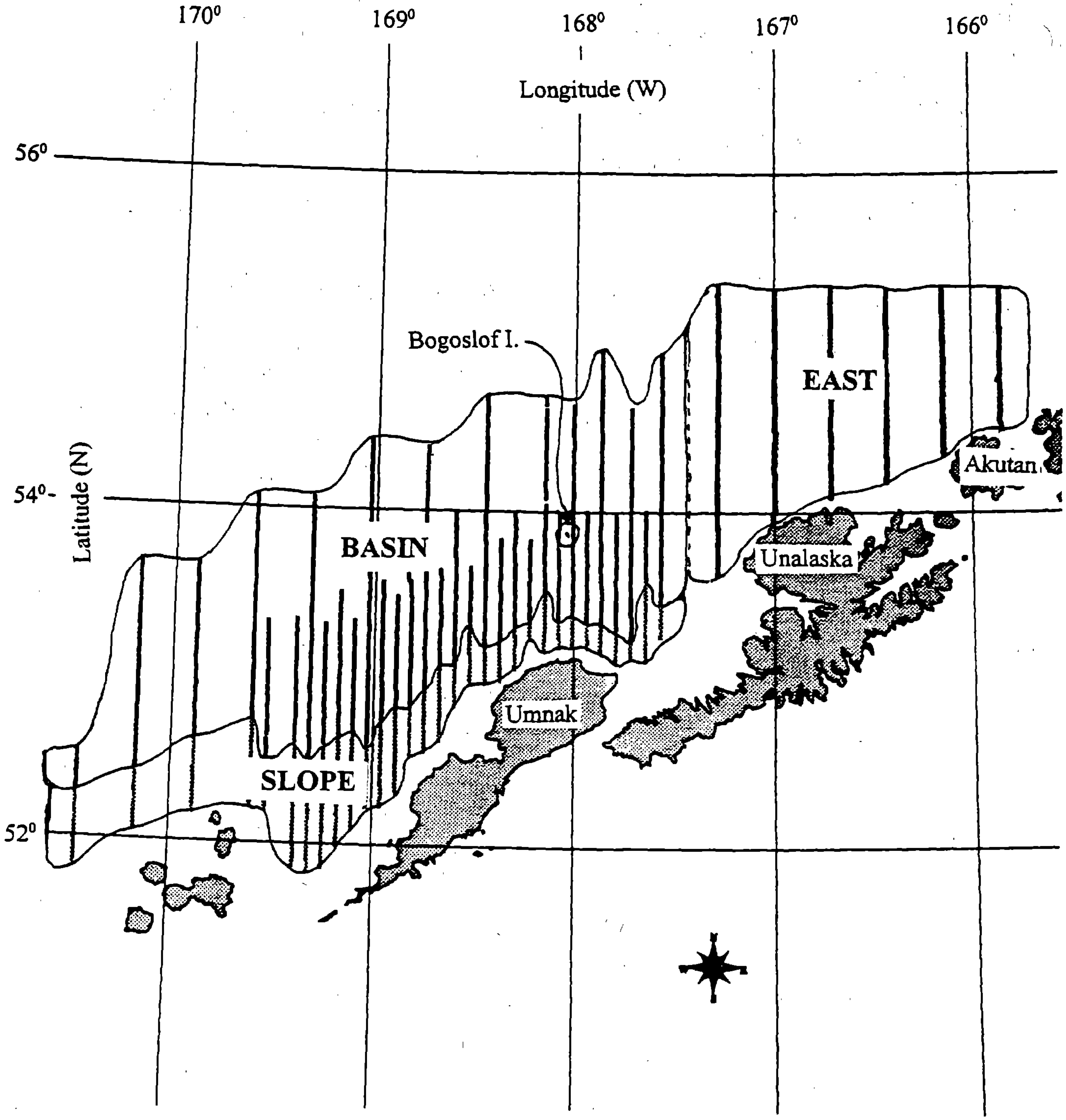


Figure 3. Echo sign sample points along transects from passes 1 and 2 of the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Acoustic data analytical areas EAST, SLOPE, and BASIN are indicated.

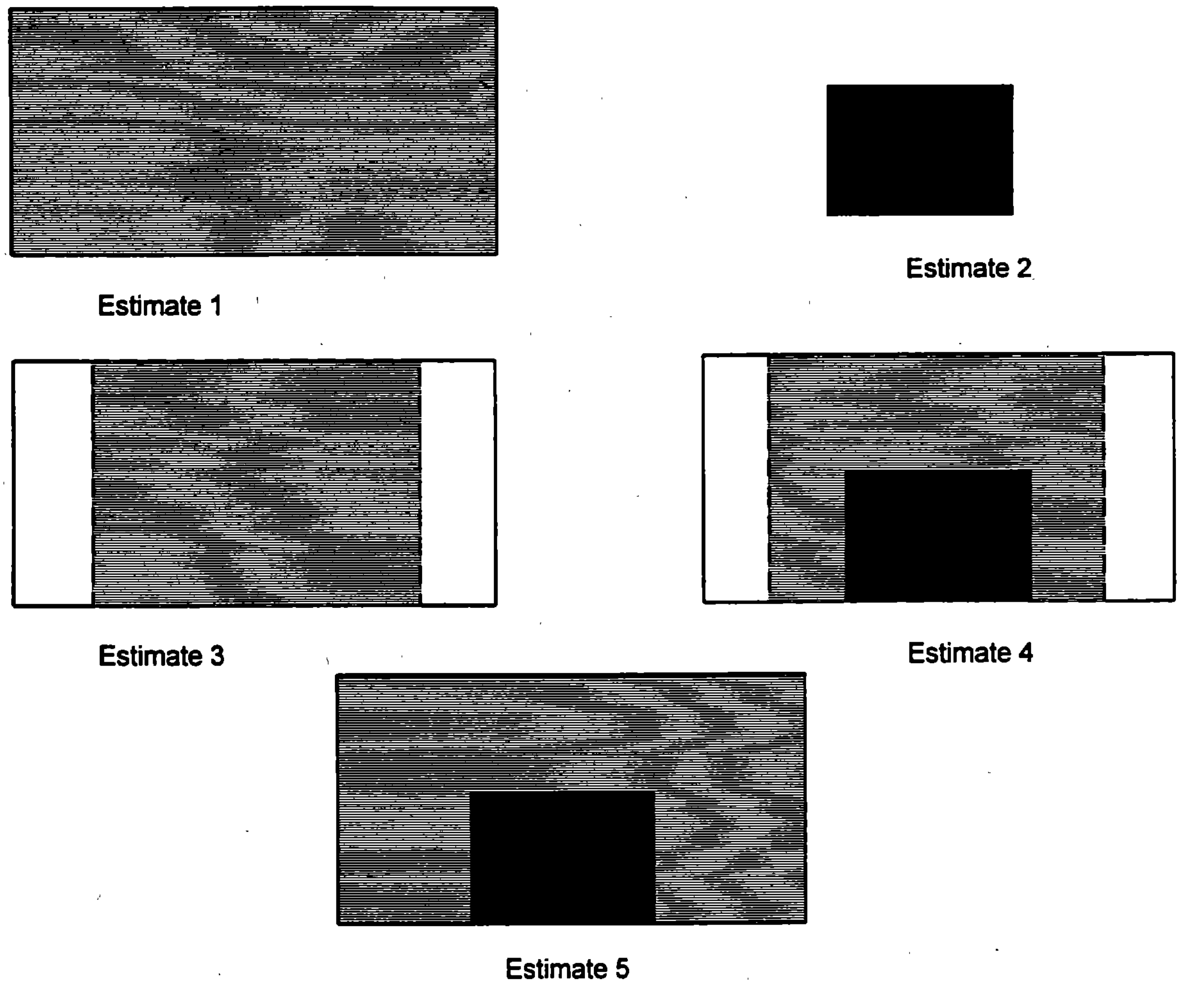


Figure 4. Schematic aerial view of 5 biomass estimates of Bogoslof area pollock. Estimate 1 = pass 1, estimate 2=pass 2, estimate 3= pass1 bounded by the CBS area ("specific area" of the Central Bering Sea convention), estimate 4= pass 2 expanded to the total area of pass 1 and bounded by the CBS area, and estimate 5= pass 2 expanded to the total area of pass 1.

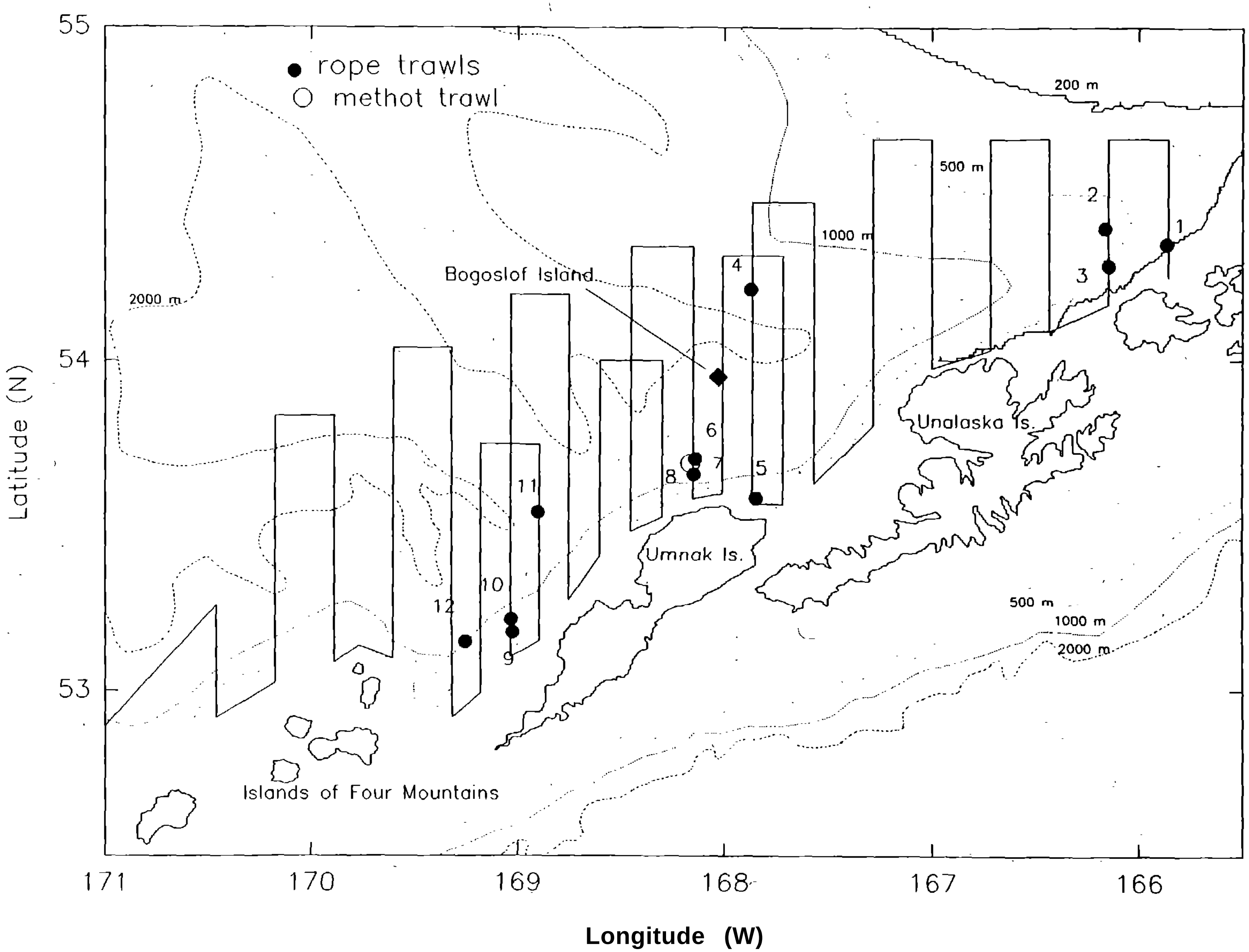


Figure 5. Rope trawl and Methot trawl locations during pass 1 of the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Cruise trackline is indicated.

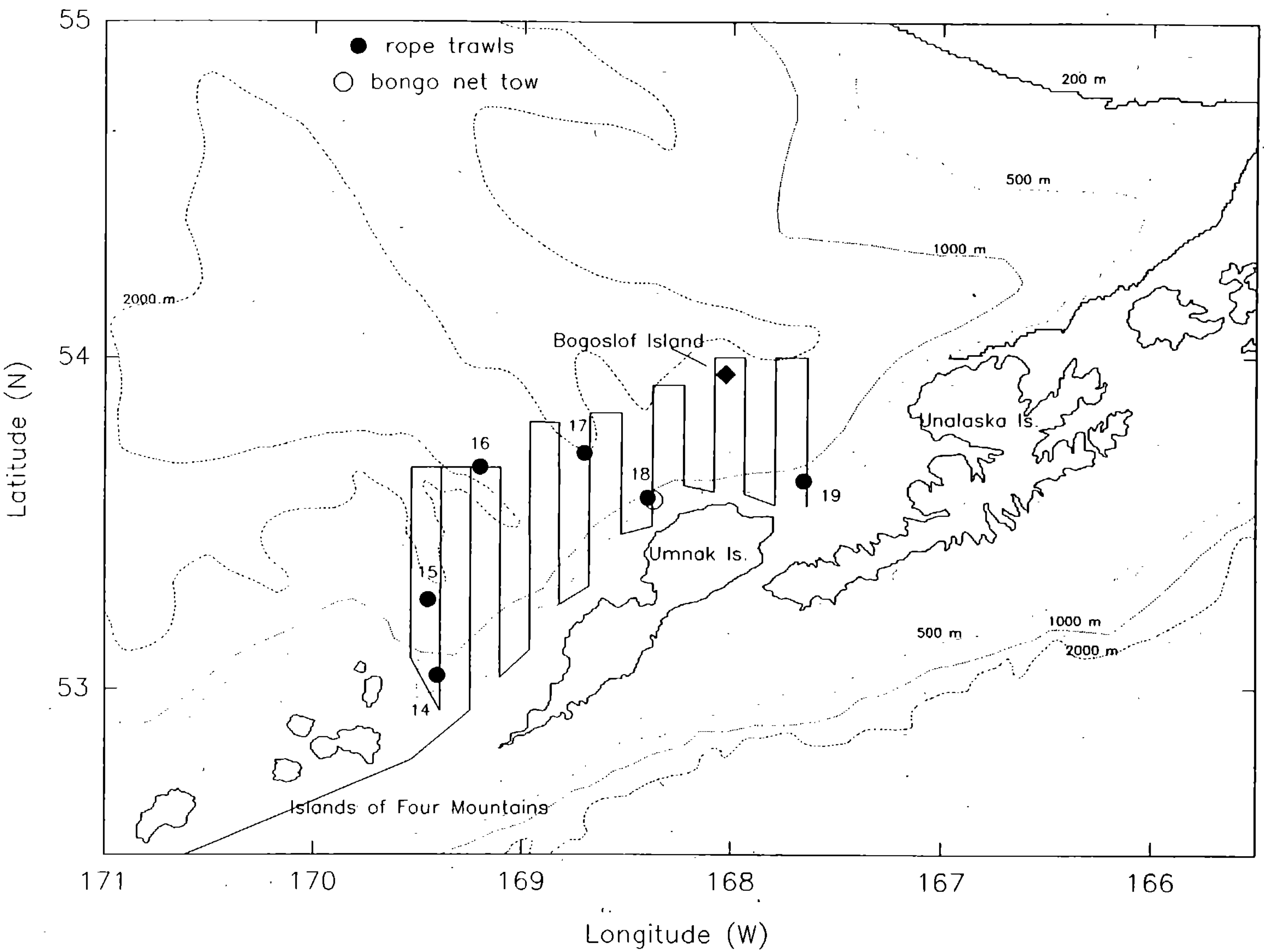


Figure 6. Rope trawl and bongo net tow locations during pass 2 of the winter 1995 echo integration–trawl survey of the southeastern Aleutian Basin near Bogoslof Island. Cruise trackline is indicated.

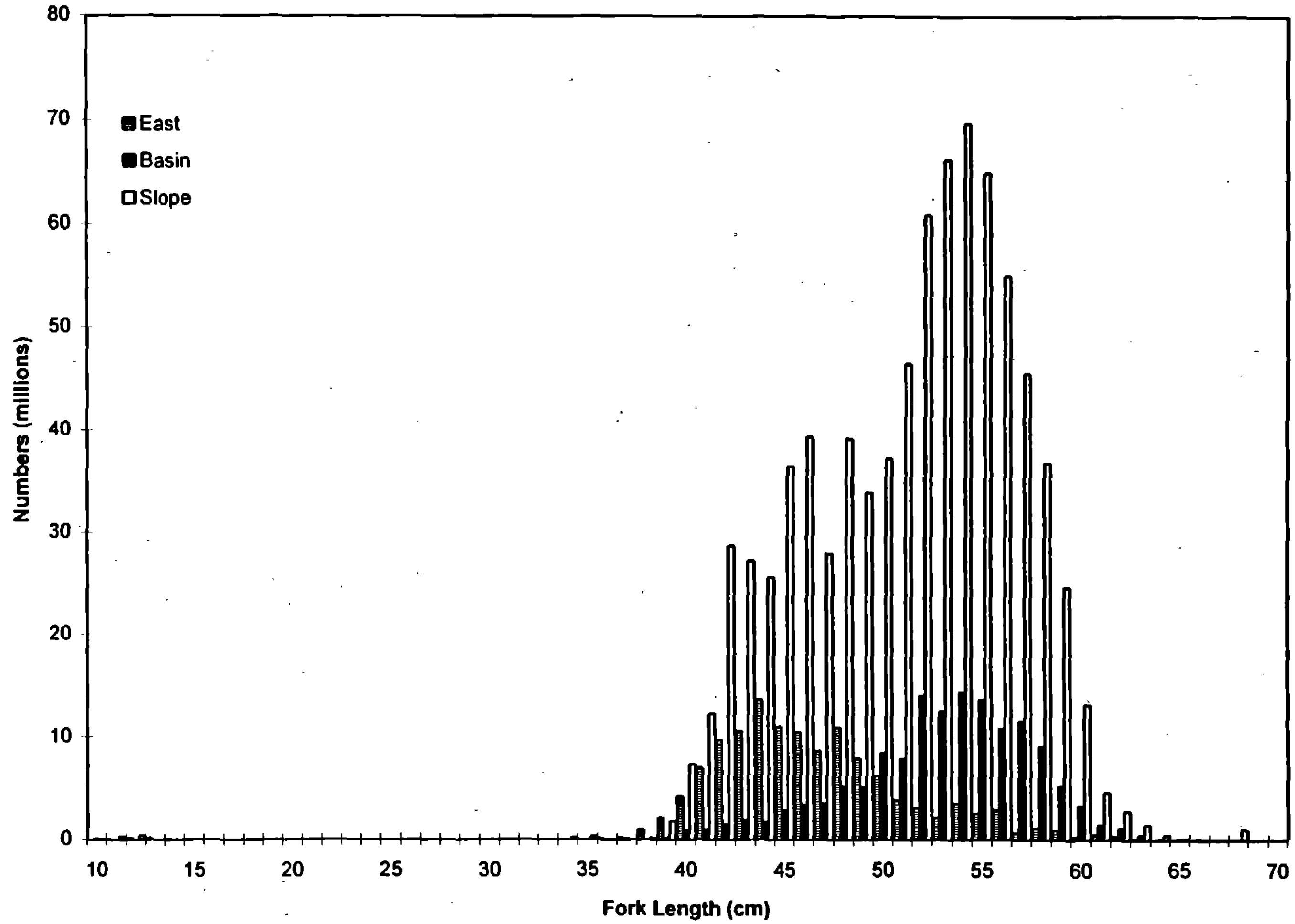


Figure 7. Pollock numbers at length for "east", "basin", and "slope" analytical areas from the 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

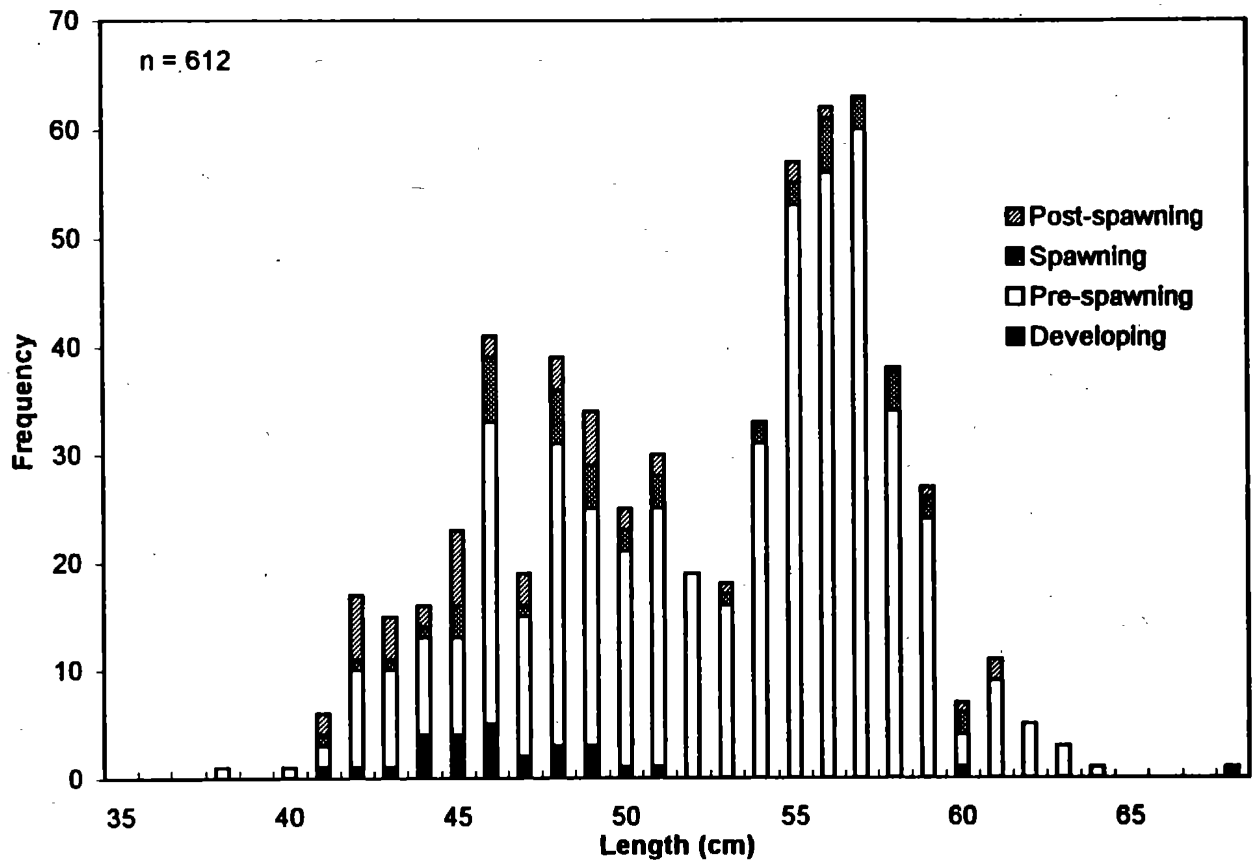


Figure 8. Female pollock maturity-length composition from midwater trawl catches during the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

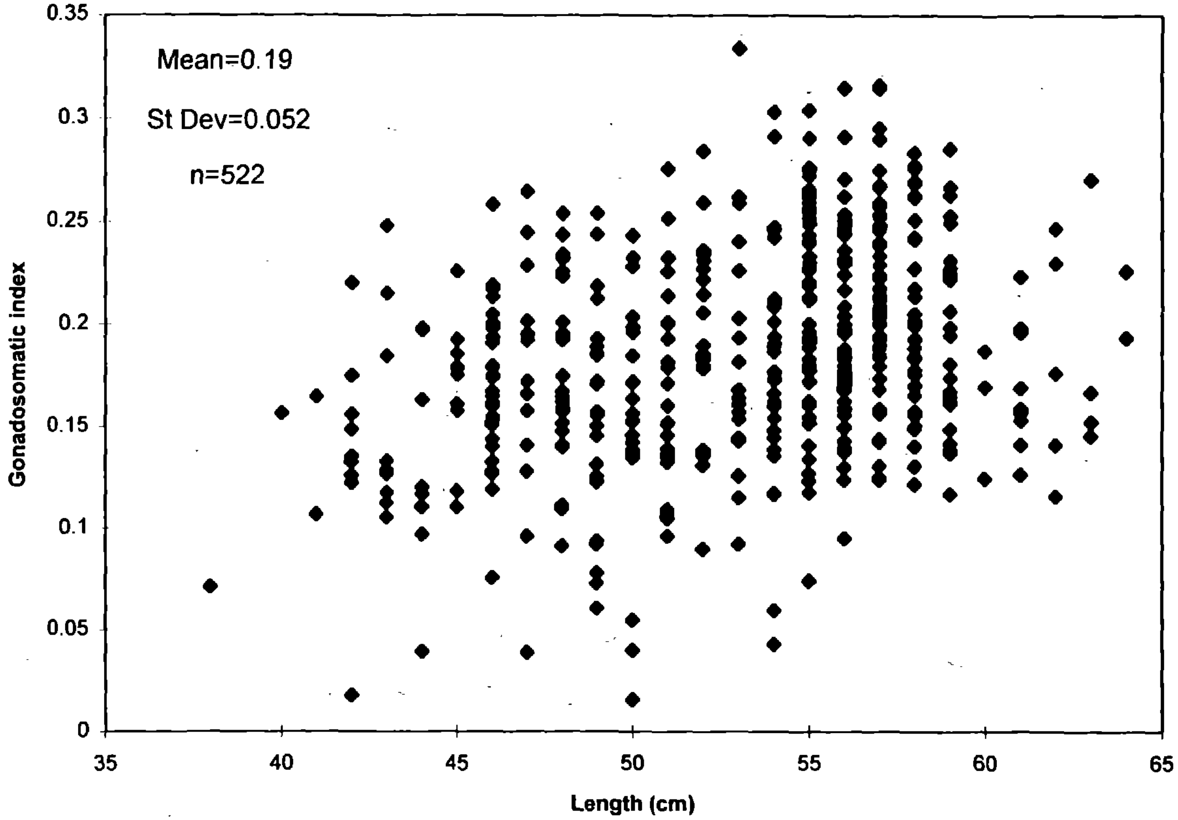


Figure 9. Pollock gonadosomatic indices plotted as a function of length for pre-spawning females from the winter 1995 echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island.

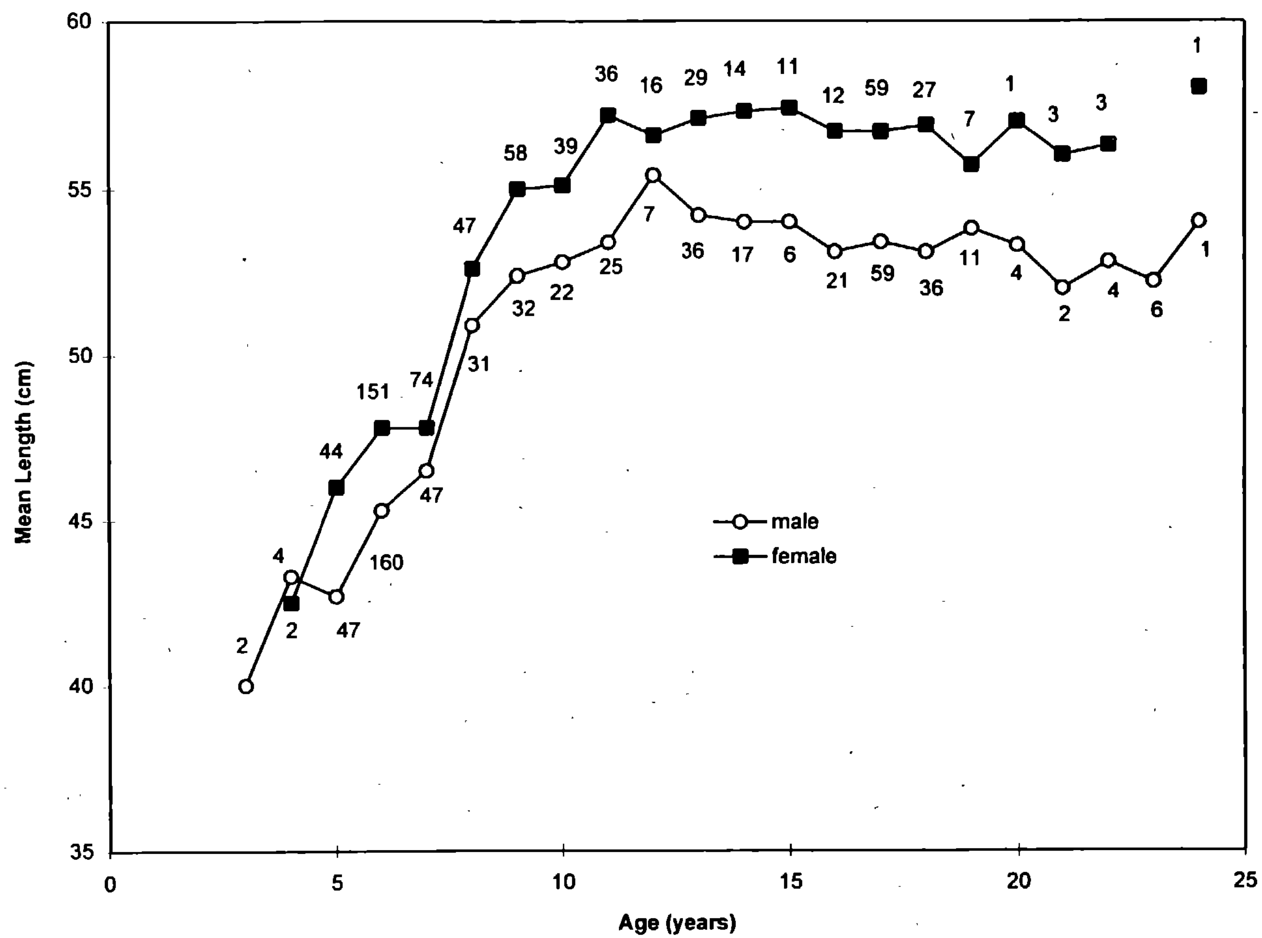


Figure 10. Mean length at age of pollock obtained from midwater trawls in the southeastern Aleutian Basin near Bogoslof Island during the winter 1995 echo integration-trawl survey. Numbers indicate sample size.

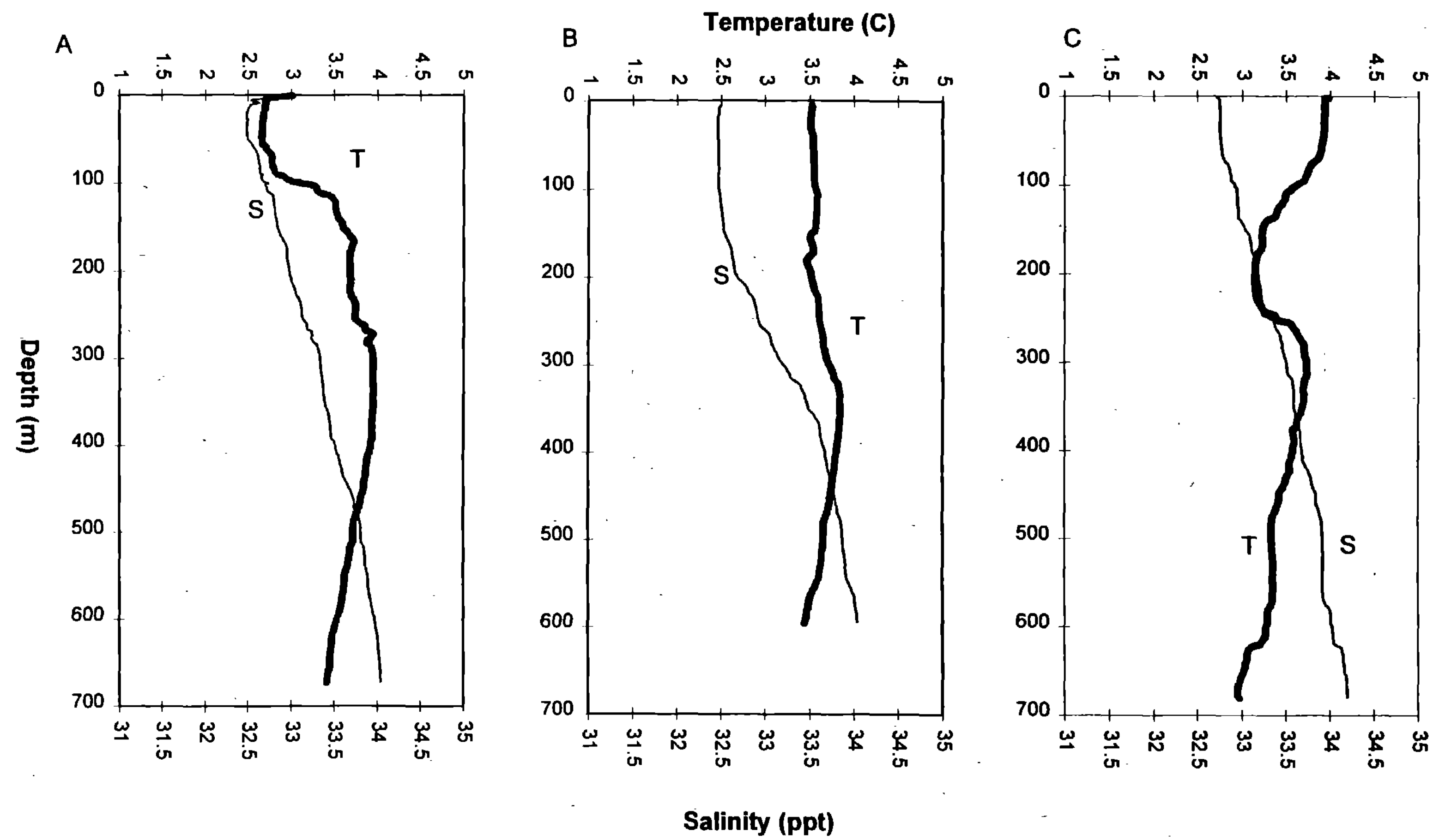


Figure 11. Temperature and salinity profiles of *conductivity-temperature-depth* (CTD) casts made in the southeastern Aleutian Basin near Bogoslof Island during the winter 1995 echo integration-trawl survey. Representative profiles from A) eastern, B) central, and C) western sections of the survey area, respectively.

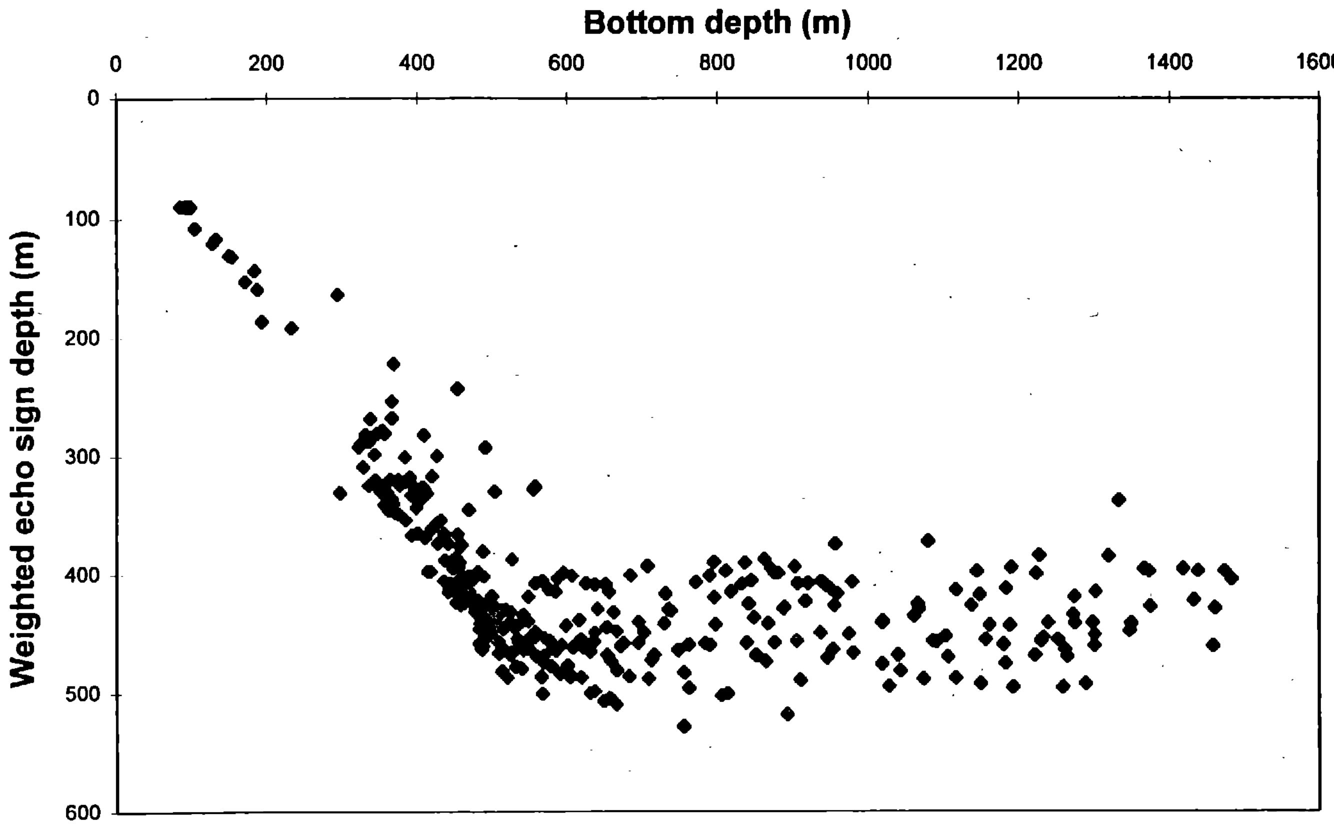


Figure 12. Weighted echo sign depth versus bottom depth for 0.5 nmi transect segments from the "east" analytical area during pass 1 of the Bogoslof island echo integration-trawl survey. Points were plotted for relative pollock densities greater than 25 SA .

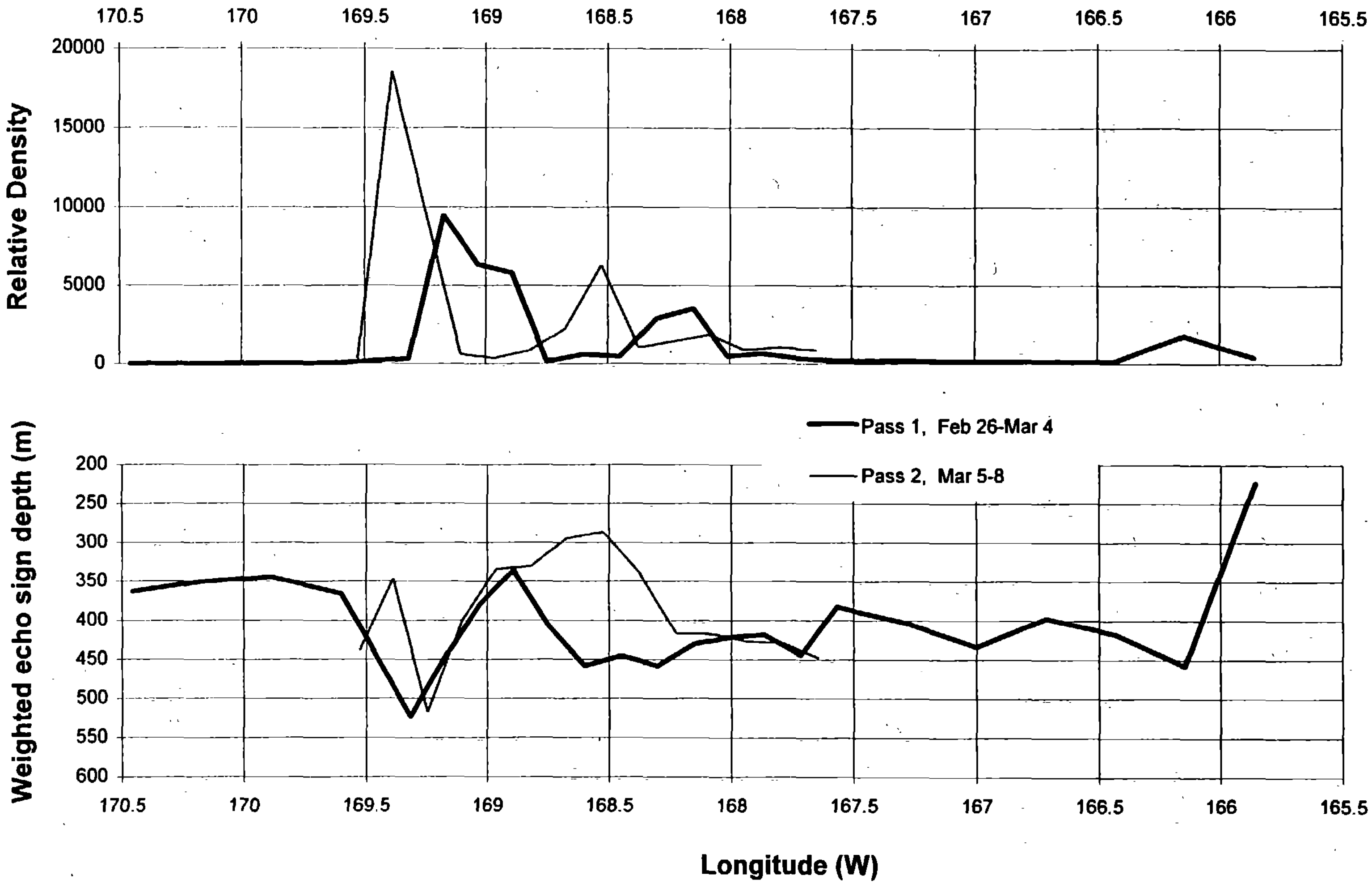


Figure 13. Weighted echo sign depth and relative pollock density along transects from passes 1 and 2 of the winter 1995 echo integration-trawl survey near Bogoslof Island.

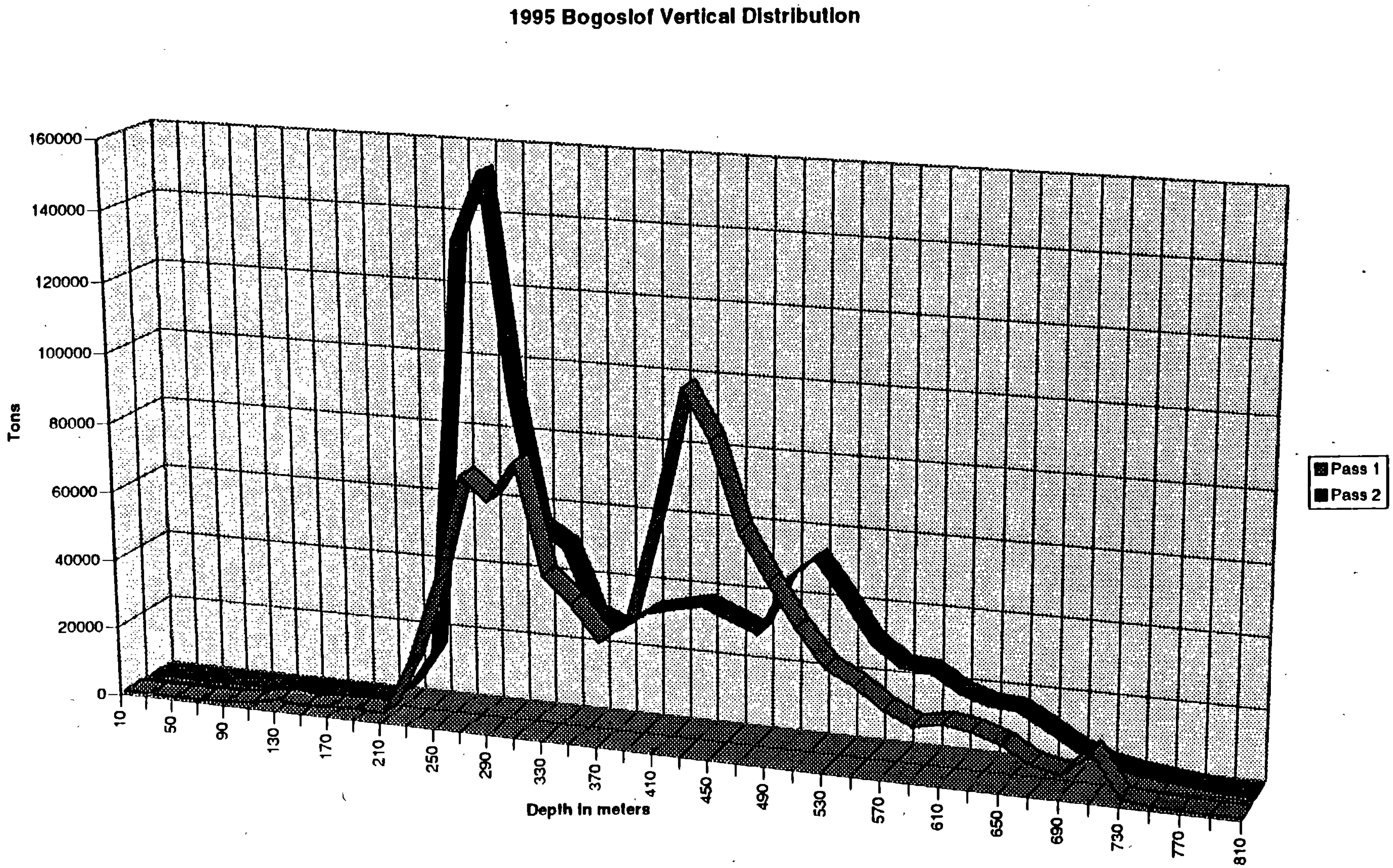


Figure 14. Vertical distribution of pollock biomass (metric tons) in the Bogoslof Island area during passes 1 and 2 of the winter 1995 echo integration-trawl survey.

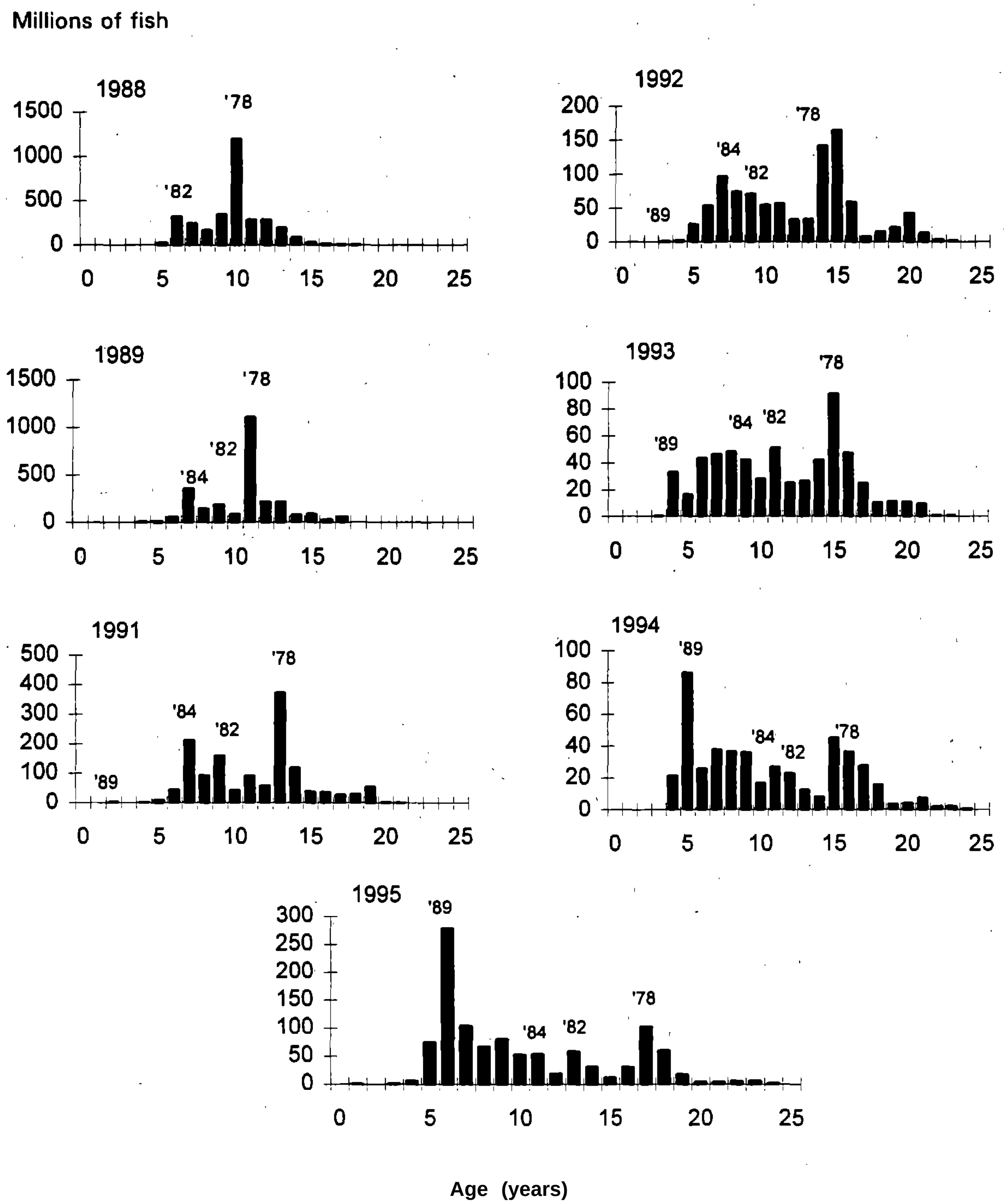


Figure 15. Population-at-age estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-89,1991-95. Major year classes are indicated. No survey was conducted in 1990. Note y-axis scale differences.

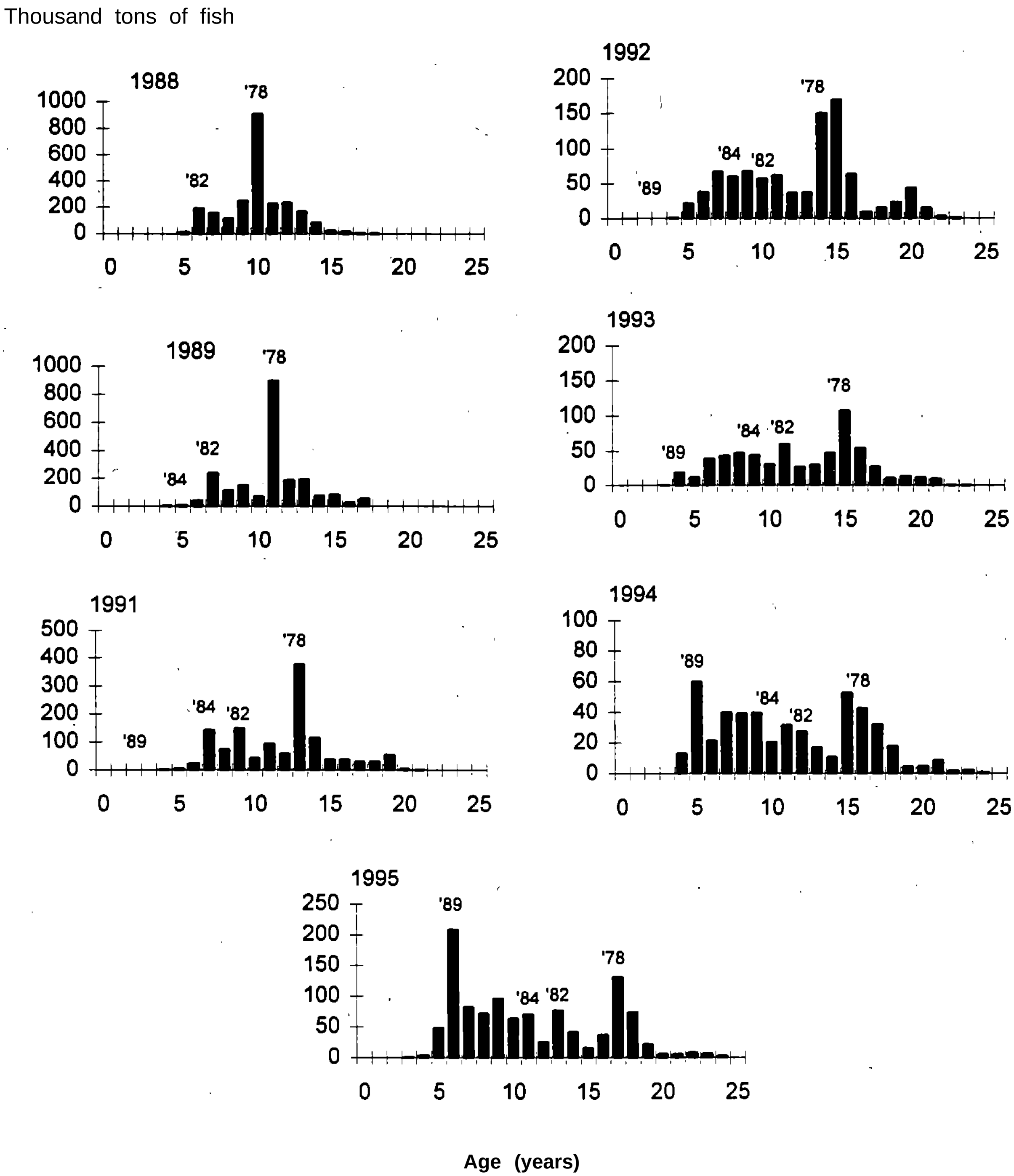


Figure 16. Biomass-at-age estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-89,1991-95. Major year classes are indicated. No survey was conducted in 1990. Note y-axis scale differences.

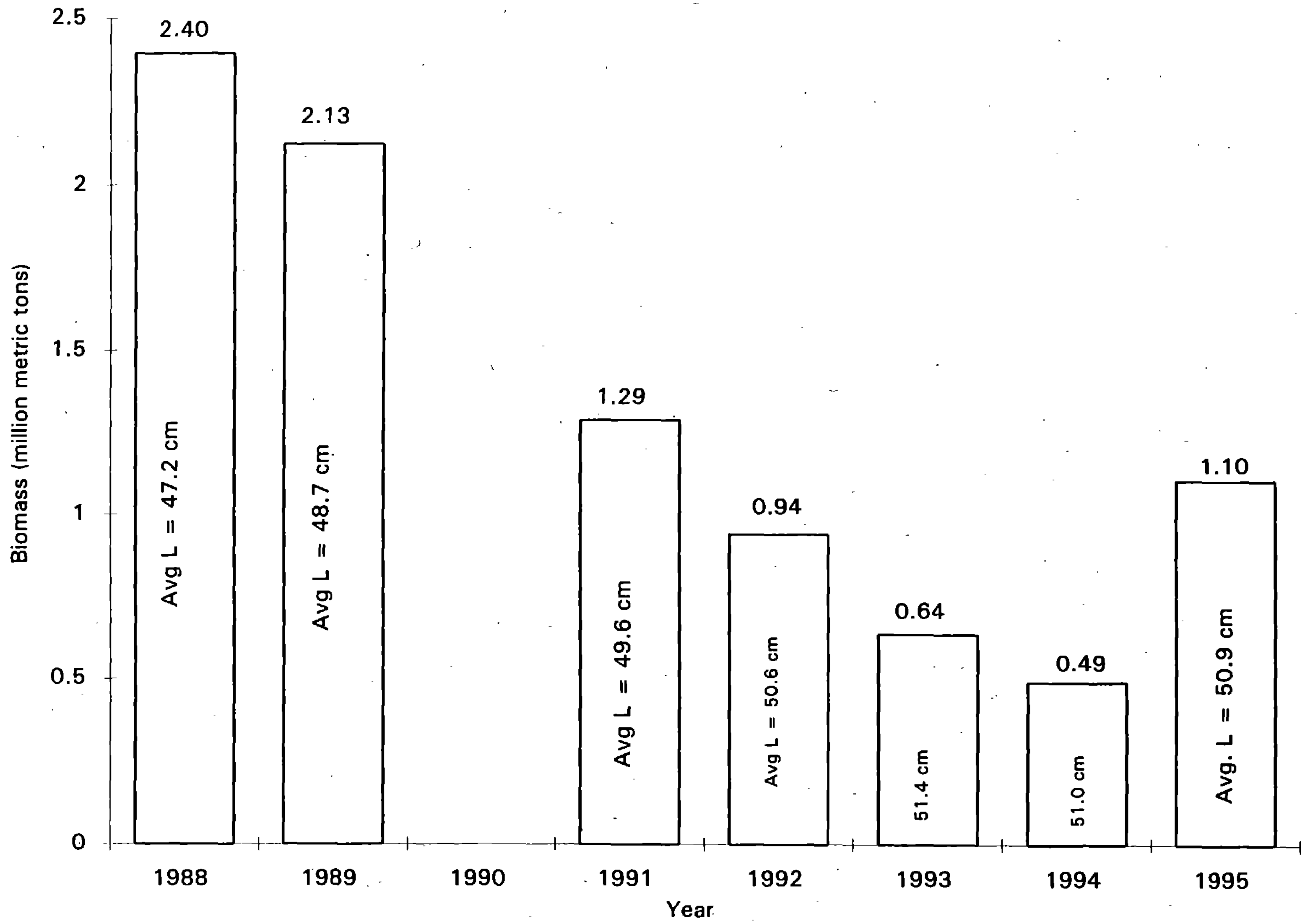


Figure 17. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for spawning walleye pollock near Bogoslof Island, 1988-95. No survey was conducted in 1990.

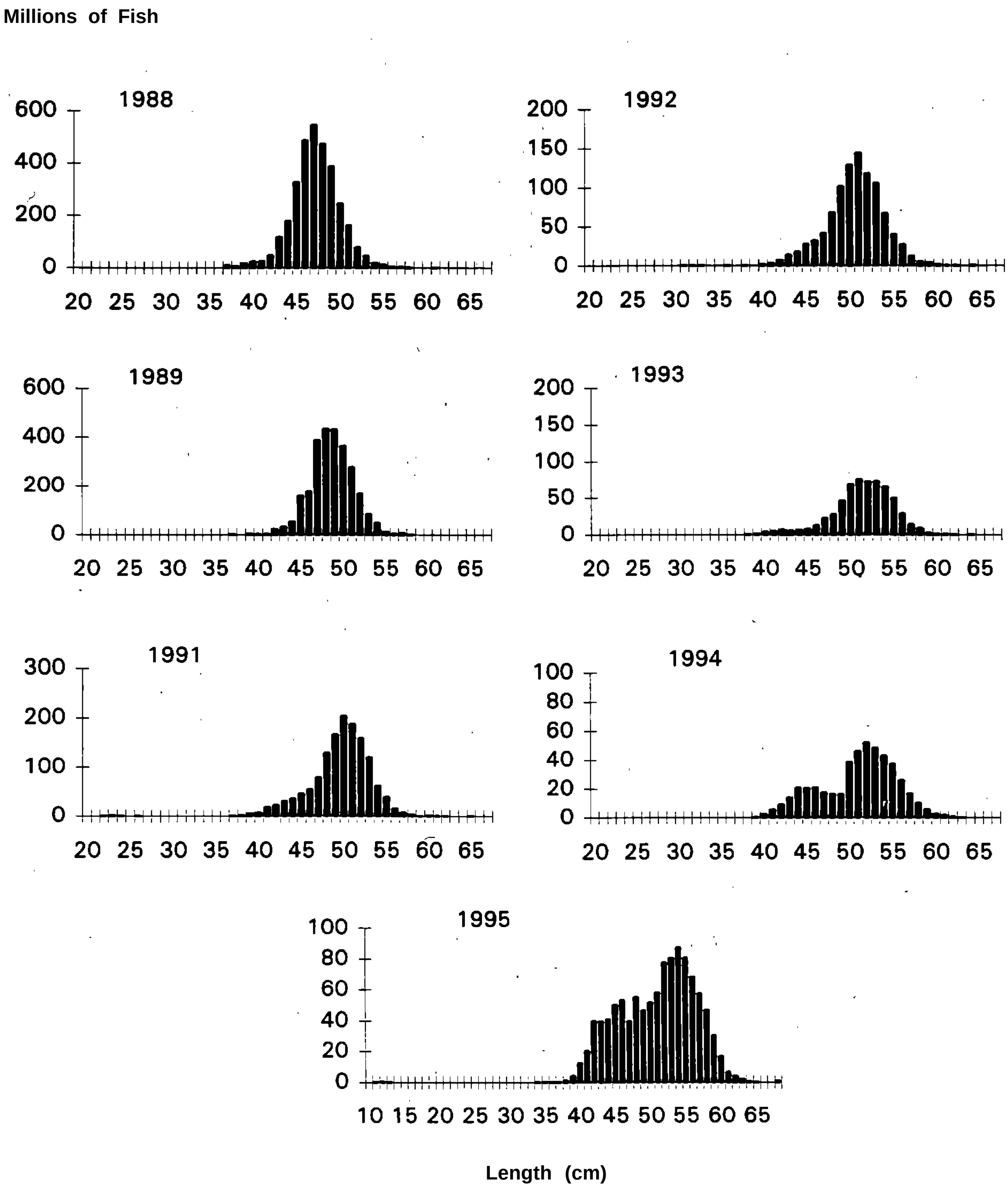


Figure 18. Population-at-length estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-95. Note y-axis scale differences. No survey was conducted in 1990.

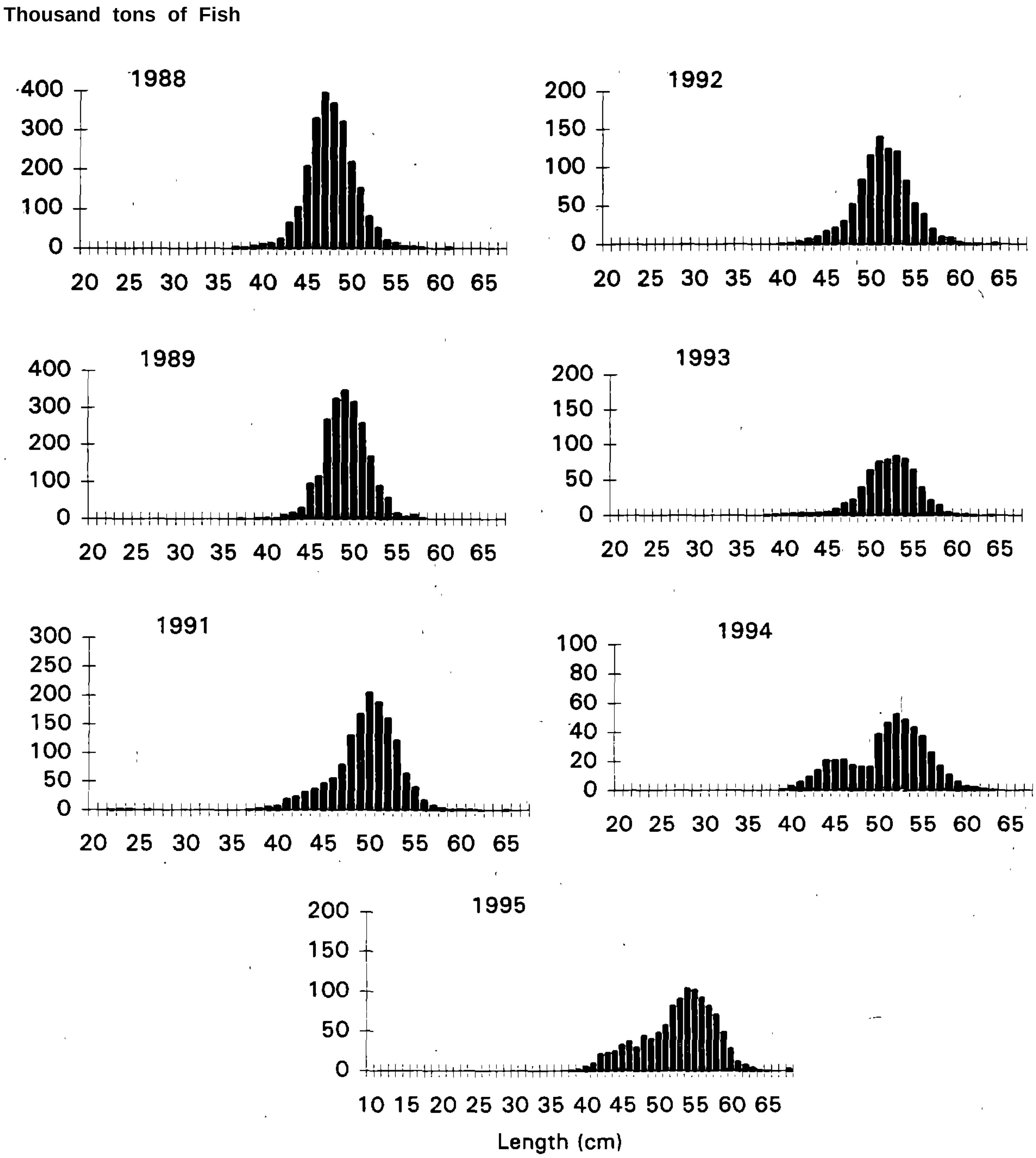


Figure 19. Biomass-at-length estimates obtained during echo integration-trawl surveys of spawning walleye pollock near Bogoslof Island in winter 1988-95. Note y-axis scale differences. No survey was conducted in 1990.

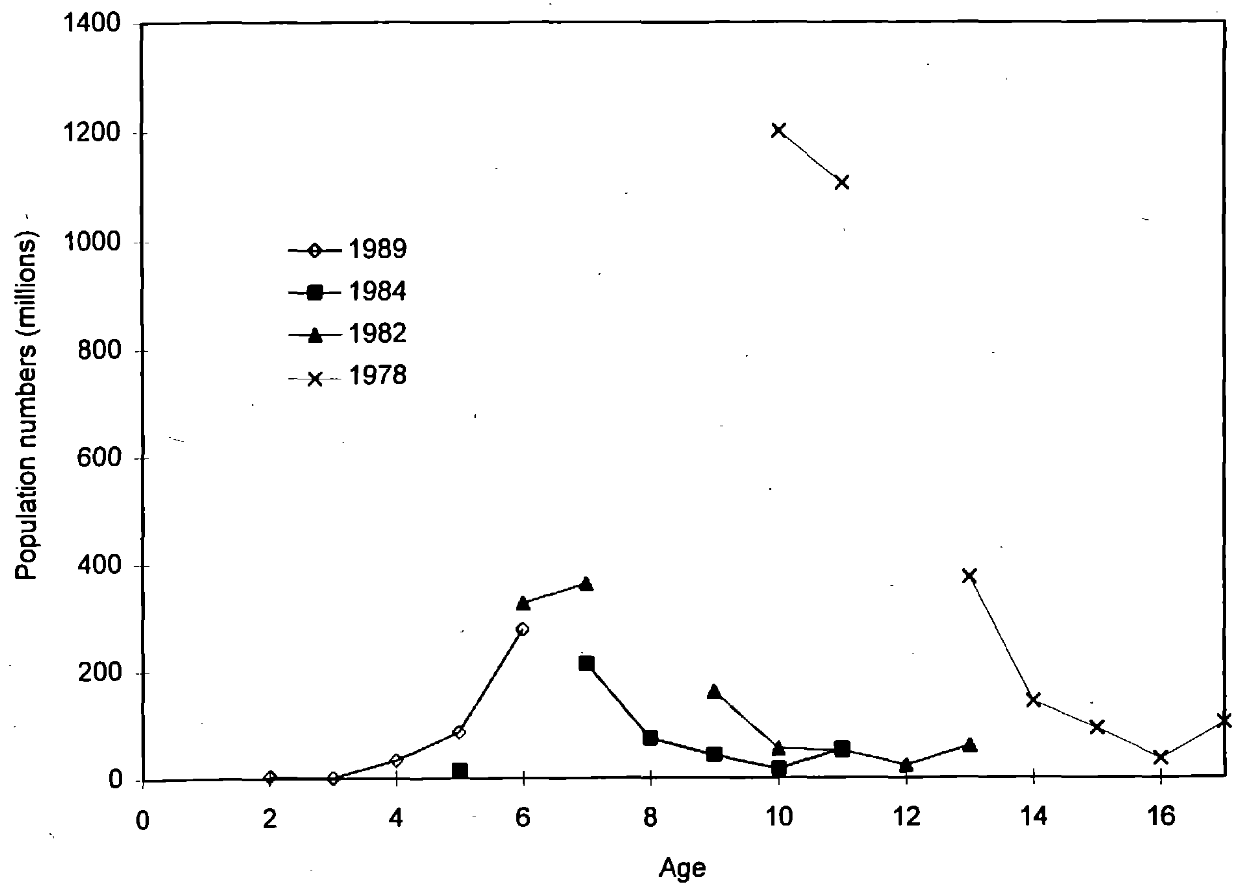
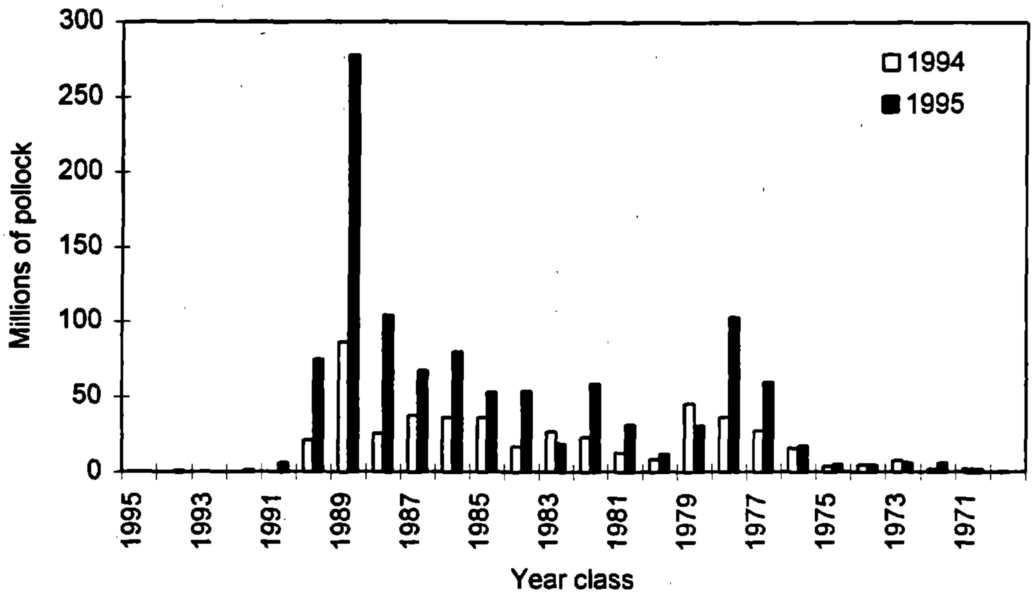


Figure 20. Population numbers at age for dominant year classes observed in winter echo integration-trawl surveys of Bogoslof area spawning pollock. Data are from surveys conducted in 1988-89 and 1991-1995.



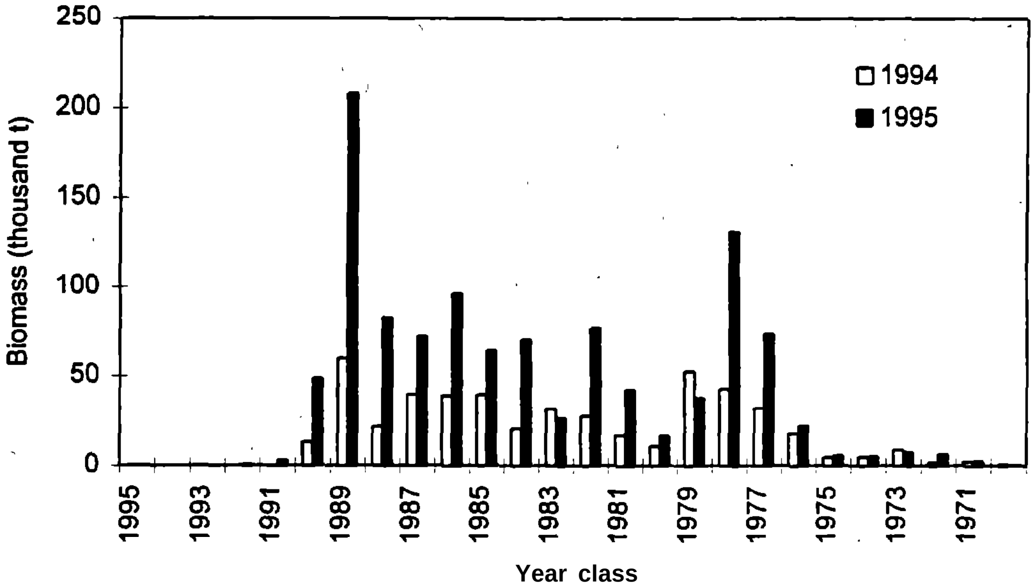


Figure 21. Population numbers and biomass for pollock year classes encountered during the 1994 and 1995 echo integration-trawl surveys of the Bogoslof Island region.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and microfiche copies vary in price.

<u>AFSC-</u>

64 TYNAN, C. 1996. Characterization of oceanographic habitat of cetaceans in the Southern Indian Ocean between 82° - 115° E: Cruise report from World Ocean Circulation Experiment (WOCE) I8S and I9S, 53 p. NTIS No. PB96-192786.

63 KINOSHITA, R. K., and J. M. TERRY. 1996. Oregon, Washington, and Alaska exports of edible fishery products, 1994, 49 p. NTIS No. PB96-183553.

62 KINOSHITA, R. K., A. GRIEG, and J. M. TERRY. 1996. Economic status of the groundfish fisheries off Alaska, 1994, 108 p. NTIS No. PB96-178595.

61 PELLA, J., M. MASUDA, and S. NELSON. 1996. Search algorithms for computing stock composition of a mixture from traits of individuals by maximum likelihood, 68 p. NTIS No. PB96-154653.

60 YANG, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991, 105 p. NTIS No. PB96-147582.

59 MARTIN, M. H., and D. M. CLAUSEN. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey, 217 p. NTIS No. PB96-135561.

58 QUEIROLO, L. E., L. W. FRITZ, P. A. LIVINGSTON, M. R. LOEFFLAD, D. A. COLPO, and Y. L. DEREYNIER. 1995. Bycatch, utilization, and discards in the commercial groundfish fisheries of the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands, 148 p. NTIS No. PB96-125547.

57 SMALL, R. J., and D. P. DEMASTER. 1995. Alaska marine mammal stock assessments 1995-57, 93p. NTIS No. PB95-274734.

56 DORN, M. W., S. M. FITZGERALD, M. A. GUTTORMSEN, and M. R. LOEFFLAD. 1995. An evaluation of North Pacific groundfish observer program methods of haul weight estimation, 31 p. NTIS No. PB95-271151.

55 PELLA, J., R. RUMBAUGH, and M. DAHLBERG. 1995. Incidental catches of salmonids in the 1991 North Pacific squid driftnet fisheries, 33 p. NTIS No. PB95-252722.

54 KINOSHITA, R. K., A. GRIEG, and J. M. TERRY. 1995. Economic status of the groundfish fisheries off Alaska, 1993, 108 p. NTIS No. PB95-252714.

53 WING, B. L., and D. J. KAMIKAWA. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990, 48 p. NTIS No. PB95-241519.

52 HONKALEHTO, T., and N. WILLIAMSON. 1995. Echo integration-trawl survey of walleye pollock (<u>Theragra</u> <u>chalcogramma</u>) in the southeast Aleutian Basin during February and March, 1994, 39 p. NTIS No. PB95-219424.

51 CLARY, J. C. (editor). 1995. Poster abstracts and manuscripts from the Third International Conference on Marine Debris, May 8-13, 1994, Miami, Florida, 108 p. NTIS No. PB95-210837.

50 MUNRO, P. T., and R. Z. HOFF. 1995. Two demersal trawl surveys in the Gulf of Alaska: Implications of survey design and methods, 139 p. NTIS No. PB95-195061.