Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2008-01

Results of the March 2007 Echo Integration-trawl Survey of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Southeastern Aleutian Basin Near Bogoslof Island, Cruise MF2007-03

January 2008

This document should be cited as follows:

Honkalehto, T., D. McKelvey, and K. Williams. 2008. Results of the March 2007 echo integration-trawl survey of walleye pollock *(Theragra chalcogramma)* conducted in the southeastern Aleutian Basin near Bogoslof Island, Cruise MF2007-03. AFSC Processed Rep. 2008-01, 37 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Reference in this document to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Results of the March 2007 Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Southeastern Aleutian Basin Near Bogoslof Island, Cruise MF2007-03

by Taina Honkalehto, Denise McKelvey, and Kresimir Williams

January 2008

Notice to Users of this Document

This document is being made available in .PDF format for the convenience of users; however, the accuracy and correctness of the document can only be certified as was presented in the original hard copy format.

INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) regularly conduct echo integration-trawl (EIT) surveys in late February and early March to estimate pre-spawning walleye pollock (*Theragra chalcogramma*) abundance in the southeastern Aleutian Basin (McKelvey et al. 2006). These surveys were conducted annually between 1988 and 2007 with the exception of 1990 and 2004. The biomass estimate for walleye pollock within the Central Bering Sea (CBS) Convention Specific Area obtained during these surveys provides an index of abundance for the Aleutian Basin walleye pollock stock[1]. This report summarizes observed walleye pollock distribution and biological composition from the winter 2007 EIT survey, and provides a biomass estimate. It also summarizes physical oceanographic observations and acoustic system calibration results.

METHODS

MACE scientists conducted the EIT survey (Cruise MF2007-03) between 28 February and 10 March 2007 (Table 1) aboard the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research.

Acoustic Equipment, Calibration, and Data Collection

Acoustic measurements were collected with a Simrad ER60 scientific echo sounding system using 18, 38, 120, and 200 kHz split beam transducers (Simrad 1997, 2004; Bodholt and Solli 1992). The transducers were installed on the bottom of a retractable centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics.

[1] Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, Annex (Part 1), Treaty Doc. 103-27. 1994. Hearing before the Committee on Foreign Relations U.S. Senate, 103rd Congress, 2nd Session. Washington: U.S. Government Printing Office.

Standard sphere acoustic system calibrations (Foote et al. 1987) were made before and after the Bogoslof Island area survey to measure acoustic system performance. During calibration, the *Miller Freeman* was anchored at the bow and stern. Weather, sea state conditions, and acoustic system settings were recorded. A tungsten carbide sphere (38.1 mm diameter) and a copper sphere (64 mm diameter) were suspended below the centerboard-mounted transducers. The tungsten carbide sphere was used to calibrate the 38, 120, and 200 kHz systems. The copper sphere was used to calibrate the 18 kHz system. After each sphere was centered on the acoustic axis, split beam target strength and echo integration measurements were collected to estimate transducer gains (Foote et al. 1987). Transducer beam characteristics were modeled by moving each sphere through a grid of angular coordinates and recording target-strength measurements using Simrad EKLOBES software (Simrad 2004).

Data from all four frequencies were logged with SonarData EchoLog 500 (v. 3.50). Raw data for each frequency were also logged using ER60 software (v. 2.1.2). Echo integration-trawl survey methods were similar to those described in Simmonds and MacLennan (2005). Acoustic system settings used during the survey (Table 2) were based on 38 kHz results obtained during the 2 March acoustic system calibration. Acoustic backscattering measurements were made 24 hours a day between 16 m from the surface and 0.5 m off the bottom, unless the bottom exceeded 1,000 m, the lower limit of data collection. Results presented here were based on the 38 kHz data, which were analyzed using SonarData Echoview (v. 3.50.54) software.

Trawl Gear and Oceanographic Equipment

The NOAA ship *Miller Freeman* was equipped with an Aleutian wing 30/26 trawl (AWT) to sample midwater organisms. This trawl was constructed with full-mesh nylon wings, and polyethylene mesh in the codend and aft section of the body. The headrope and footrope each measured 81.7 m (268 ft). Mesh sizes tapered from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend. The net was fitted with a 32-mm (1.25-in) nylon mesh codend liner. The AWT was fished with 82.3 m (270 ft) of 1.9-cm (0.75-in) diameter (8 H19 wire) non-

rotational dandylines, 226.8-kg (500-lb) or 340.2-kg (750-lb) tom weights on each side, and 5 m^2 Fishbuster trawl doors [1,247 kg (2,750 lb) each]. Vertical net opening and depth were monitored with a WESMAR third wire netsonde attached to the trawl headrope. During trawl deployment the vertical net opening ranged from 30 to 42 m and averaged 38.1 m, which was larger than it was during previous Bogoslof surveys. The larger opening readings may have resulted from the WESMAR netsonde flying at a steeper angle than usual, rather than from a change in actual net configuration.

Physical oceanographic measurements made during the cruise included temperature profiles obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope, and conductivity, temperature, and depth (CTD) measurements collected with a Sea-Bird CTD system at calibration sites. Continuous sea surface temperatures and salinity were measured using the *Miller Freeman's* Sea-Bird Electronics SBE-21 probe located mid-ship, approximately 5 m below the water line. These and other environmental information were recorded using the ship's sensors interfaced with the ship's Scientific Computing System (SCS).

Survey Design

The survey began 1 March north of Unalaska Island at about 167°W longitude, preceded west to the Islands of Four Mountains near 170°W, and concluded on 10 March (Fig. 1). A random start position was generated for the first transect, which resulted in a new start location 1.6 nautical miles (nmi) west of the start location used in 2003, the last year that start positions were not randomized. From that point, the survey followed 35 north-south parallel transects spaced 3 nmi apart that covered 1870 nmi^2 of the CBS Convention Specific Area. The average transecting speed was 10.9 knots.

Trawl hauls were conducted to identify observed acoustic scattering layers and to provide biological samples. Trawling speed averaged approximately 3.3 knots. Walleye pollock were sampled to determine sex, fork length (FL), body weight, age, maturity, and ovary weight of selected females. Walleye pollock fork lengths were measured to the nearest centimeter (cm). Smaller forage fish

such as lanternfish (family Myctophidae) were measured to the nearest millimeter (mm) standard length (SL). An electronic motion-compensating scale (Marel M60) was used to weigh individual walleye pollock specimens to the nearest 2 g. For age determinations, walleye pollock otoliths were collected and stored in 50% ethanol-water solution. Maturity was determined by visual inspection and categorized as immature, developing, pre-spawning, spawning, or post-spawning[2]. Gonado-somatic-indicies (GSI) were computed as ovary weight/body weight for pre-spawning mature female walleye pollock. All data were recorded electronically using the Fisheries Scientific Computing System (FSCS) v.1.6 and stored in a relational database. Live, fertilized walleye pollock eggs were spawned from adults collected during the cruise to examine larval walleye pollock feeding, behavior, physiology, and predation. Visual counts of seabird species were made after most hauls.

An additional objective of the 2007 Bogoslof survey was to conduct inter-vessel comparison acoustic measurements for the NOAA ships *Miller Freeman* and *Oscar Dyson*. The experimental design used during the Bogoslof survey involved obtaining both side-by-side acoustic measurements with the vessels separated 0.5-0.7 nmi and follow-the-leader measurements with the following vessel 1.0 nmi behind and 0.1 nmi to starboard. Approximately 250 nmi of north-south oriented side-by-side acoustic data and approximately 250 nmi of east-west follow-the-leader data were collected with fish present during the survey. These data will allow us to determine if there are significant differences in the acoustic backscatter observed by the two vessels.

Data Analysis

Backscattering identified as walleye pollock was binned at 0.5 nmi horizontal by 20 m vertical resolution and stored in a database. Walleye pollock length measurements from the eight hauls that captured sufficient numbers of fish (more than 75 individuals per haul) were combined into two length strata based on observed aggregation patterns, geographic proximity of hauls, and similarity in size composition data. Estimates of walleye pollock backscattering strength were calculated

[2] ADP Codebook. 2005. Unpublished document. Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NMFS, NOAA; 7600 Sand Point Way NE, Seattle, WA 98115

using a mean volume backscattering strength (S_v, MacLennan et al. 2002) threshold of –70 decibels (dB). For each length stratum, fish numbers-at-length were computed by first summing the echo integration backscatter values, then scaling them using a relationship between target strength (TS) and walleye pollock fork length (cm) (TS = 20 log FL – 66 (cm); Traynor 1996) and the stratum length composition. Mean fish weight-at-length for each length interval (nearest 1.0 cm) was estimated from the trawl catches when there were more than five fish for that length interval; otherwise weight at a given length interval was estimated from a linear regression of the natural logs of all the length and weight data. These weight-at-length estimates were then combined with numbers at length interval estimates to compute biomass at length. Total biomass and numbers were estimated by summing the strata estimates. Numbers and biomass at age were estimated by applying an age-length key from the trawl data to the numbers and biomass at length estimates.

In the Bogoslof Island area, pre-spawning walleye pollock aggregations are often densely packed and vertically stratified by sex (Schabetsberger et al. 1999). Therefore, it is rarely possible to obtain an unbiased sample of lengths from these aggregations to estimate population size composition. Past surveys have indicated that females were usually densely schooled in the shallower layers of large aggregations. Thus, hauls made to sample these aggregations contained mostly females and few males even though males were abundant in deeper layers. At ages older than about 5 years, female walleye pollock are longer than males. Biased estimates of sex composition from hauls can result in biased estimates of population size and age composition. As in previous Bogoslof surveys, the sample sex ratio was assumed to be 50:50. A male size composition was derived by averaging proportions-at-length for each haul in the length stratum. The same was done for female fish. The two resultant size compositions were averaged to provide a stratum (sexes combined) size composition.

Mean weighted depth of walleye pollock was computed for each 0.5 nmi along the transects by multiplying the biomass in each 20 m vertical layer of water column by mean layer depth, then dividing by the sum of biomass for the corresponding 0.5 nmi. Walleye pollock vertical distribution in Umnak area transects was compared with that in Samalga area transects.

Relative estimation errors for the acoustic-based estimates were derived using a one-dimensional (1D) geostatistical method (Petitgas 1993, Williamson and Traynor 1996, and Rivoirard et al. 2000). Relative estimation error is defined as the ratio of the square root of the estimation variance to the estimate of biomass. Geostatistical methods were used for computation of error because they account for the observed spatial structure. These errors quantify only transect sampling variability. Other sources of error (e.g., target strength, trawl sampling) are not included.

RESULTS

Calibration

Calibration results showed that the estimated gain parameters and transducer beam pattern characteristics for the ER60 38-kHz acoustic system were similar to the system settings both before and after the Bogoslof Island area survey, confirming that the acoustic system was stable throughout the survey (Table 2).

Physical Oceanography

Mean surface temperatures where most of the fish aggregations were observed ranged from 3.6 to 3.9ºC (Fig. 1), on the warm end of the range of surface temperatures observed during the survey (3.3-3.9ºC). Water temperature profiles at trawl sites indicated a well-mixed water column with little variation in temperature between the surface and deeper waters. Temperatures measured in the water column between 300 and 600 m, covering most of the vertical distribution of walleye pollock observed in the Bogoslof area in 2007 averaged between 3.7º and 3.9ºC (Fig. 2).

Trawl Samples

Biological data and specimens were collected from nine trawl sites (Tables 3 and 4; Fig. 1). Walleye pollock dominated all trawl catches and represented 99.5% of the total catch by weight and

72.2% by number (Table 5). Myctophids were also prevalent and contributed 24.3% by number to total catch.

Walleye pollock ranging between 39 and 72 cm FL were divided into two length strata for scaling the acoustic data and computing size-specific population estimates. Walleye pollock from hauls 2-4 ranged between 39 and 71 cm FL and were characterized by a dominant mode at 48 cm FL. These hauls were used to estimate walleye pollock TS in transects 1-18, the "Umnak" stratum. Individuals from hauls 5-9 ranged between 41 and 72 cm FL and had higher proportions of fish that were larger than 48 cm FL, generating a bi-modal distribution with major modes at approximately 50 and 62 cm FL. These hauls were used to estimate TS in transects 19 through 35, the "Samalga" stratum. Trawl catch sex ratios among hauls capturing more than 75 walleye pollock ranged from 14% to 54% male. As observed in previous years, higher proportions of male walleye pollock were captured in deeper layers of the water column.

Individual maturity stages, lengths, and weights were collected for 870 walleye pollock specimens; otoliths were taken from 753 specimens (Table 4). No immature fish and very few developing fish were observed (Fig. 3a). In the Umnak area, the maturity composition (unweighted) for males was 18% pre-spawning, 80% spawning, and 2% spent. The female maturity composition was 73% pre-spawning, 22% spawning, and 5% spent. In the Samalga area, the maturity composition for males was <1% developing, 24% pre-spawning, 66% spawning, and 10% spent. The female maturity composition was <1% developing, 78% pre-spawning, 14% spawning, and 8% spent. The average GSI for pre-spawning mature female walleye pollock was 0.186 for Umnak and 0.173 for Samalga (Fig. 3b). The GSI values were significantly different by area (two-tailed Student's *t*-test, P=0.00247), although average GSI did not appear to vary significantly with length in either area. Overall, GSIs were similar to that observed during recent years (i.e., 0.17 – 0.18 for the entire area, between 2002 and 2006; McKelvey et al. 2006, Honkalehto et al. 2005, and references therein), suggesting that the survey's timing was similar in relation to peak spawning. The mean body weight-at-length for sexes combined was estimated using observed measurements for all but nine length intervals (Fig. 3c). The mean weight-at-length for the remaining length intervals was

estimated by Weight (g) = 0.0018442 × Fork Length (cm) $^{3.3725}$, corrected for a small bias due to back transformation (Miller 1984).

Distribution and Abundance

As in recent years, walleye pollock were mainly concentrated in two regions, northeast of Umnak Island and Umnak Pass, and just north of Samalga Pass (Fig. 4). About 35% of the survey biomass was observed in the Umnak area and 65% in the Samalga Pass area. In each region, pollock were concentrated mainly along four transects. Walleye pollock were distributed in midwater between about 300 and 650 m (Fig. 5). They tended to stay close to the seafloor in both regions until bottom depths reached about 400 m. As the seafloor descended, fish depths continued to increase slightly with increasing bottom depths, until they were between about 475-650 m, where most remained. This was deeper than most walleye pollock observed in 2006 (~400-550 m), particularly in the Umnak area. Also in the Umnak area, few walleye pollock were encountered where bottom depths exceeded 1,000 m, whereas in the Samalga area, many walleye pollock were encountered beyond 1,000 m bottom depths (Figs. 4 and 5).

The abundance estimate for walleye pollock in the Bogoslof area was 236 million fish weighing 0.292 million metric tons (t) (Tables 6, 7, 8; Fig. 6). The size composition was bimodal (Figs. 7 and 8) with major modes at 48 and 61-62 cm FL. The average fork length for the population was 52.3 cm, (Fig. 6). Based on the 1D analysis, the relative estimation error of the abundance estimate was 11.5% (Table 6).

Age composition data from recent Bogoslof Island area surveys (Fig. 9) showed that average length at age was greater for females than males for most ages. After about age 10, Bogoslof walleye pollock growth slowed with increasing age, the difference in size between females and males appeared to become more pronounced, and both sexes gradually increased in average length at age over time. The estimated 2006 age composition (Tables 9 and 10; Fig. 10) illustrated increased recruitment of the 2000 year class in 2006, at age 6. The remainder of the population consisted primarily of the 2001 and 1999 year classes, with some contribution from older year classes. The

estimated 2007 age composition indicated that the 2001 year class, at age 6, surpassed the 7-year old 2000 year class in numbers (but not total biomass). Together, the two year classes dominated the population. The remainder consisted of the 1999 and older year classes.

DISCUSSION

The 2007 survey results revealed both similarities and differences compared with results from 2006 and 2005 (McKelvey et al. 2006, Honkalehto et al. 2005). In 2007, the estimated total biomass (0.292 million t) increased over that in both 2006 and 2005 (0.240 and 0.253 million t, respectively), but the biomass growth did not correspond to an increase in numbers of fish—estimated numbers remained the same as in 2006. Compared to 2005, there was a 38% increase in numbers for walleye pollock less than 50 cm FL in 2006 (107.5 increased to 148.3 million). This was largely due to continued recruitment of the 2000 year class (Tables 9, 10; Fig. 10), which in 2006 contributed an estimated 104.0 million fish compared to 81.0 million in 2005. Full recruitment to the survey for dominant year classes in the Bogoslof spawning area has typically occurred at ages 6 to 7, marked by a peak in estimated pollock numbers at age for a given dominant year class (Fig. 11). At age 6, the 2000 year class appeared to be stronger than recent strong year classes (1999, 1996, 1992), but not as strong as the 1989 and earlier dominant year classes. Population at age estimates from 2006 and 2007 (Table 9, Fig. 11) indicated that full recruitment of the 2000 year class, and thus peak numbers, occurred in 2006. Fewer 2000 year class fish were present in 2007. The 2001 year class contributed nearly as many fish to the population in 2007 as the 2000 year class had contributed in 2006.

The estimated walleye pollock biomass inside the CBS Convention Specific Area has been increasingly focused into two main regions since the late 1990s: off the northeast end of Umnak Island and in the Samalga Pass area. In the 2000-2003 surveys, the Umnak component accounted for a relatively small portion ($\leq$26%) of the CBS Convention Specific Area biomass. In 2005, the Umnak region accounted for 34%, and in 2006, 58% of the biomass. In 2007, estimated Umnak biomass decreased to 35% of the population and there was a decrease in numbers of walleye pollock

from the 2000 year class, compared with 2006, noted above. In 2006, the Umnak region had smaller walleye pollock with a higher proportion of spent individuals than the Samalga area. This was likely due to a greater proportion of the 2000 year class (74% of the total number) recruiting to the Umnak region than to the Samalga area (Fig. 13). In 2007 the female maturity composition was similar between the two areas (Figs. 3a and 12), although the GSI values were slightly higher in the Umnak area (Fig. 3b). Perhaps the greater similarity in maturity composition between areas in 2007 was due to a greater similarity in age composition than in the previous two years. The majority of the population in both areas was composed of the 2001 and 2000 year classes, with more 2001 fish present overall compared to 2005 and 2006 (Fig. 13).

In 2007, the walleye pollock depth distribution seemed to have shifted somewhat compared with that in 2006, both in relation to bottom depth and in estimated vertical location in midwater. Walleye pollock tended to be more offshore in 2007 than in 2006. This could be partially explained by the shift in biomass distribution back to Samalga Pass, where with more fish present the range of bottom depths they inhabited was expanded from that in 2006. In 2006, we noted that the vertical fish depths and their relationship to bottom depth appeared to be different between the two areas (Umnak aggregations' vertical distribution was shallower than Samalga's). In 2007, fish depth distribution in both areas was similar to Samalga's in 2006. Thus, in the Umnak area, walleye pollock aggregations appeared to be centered ~100 m deeper (and a little farther offshore) than they were in 2006. Perhaps the changes in walleye pollock depth distribution between years was related to age composition (Fig. 13), or spawning progression—there were proportionally more pre-spawning than spent Umnak females sampled in 2007 whereas there were more spent than pre-spawning females sampled there in 2006. This could be tested by examination of maturity composition and weighted depth distribution from prior Bogoslof surveys.

ACKNOWLEDGMENTS

The authors would like to thank the officers and crew of the NOAA ship *Miller Freeman* for their contribution to the successful completion of this work.

CITATIONS

Bodholt, H., and H. Solli. 1992. Split beam techniques used in Simrad EK500 to measure target strength, p.16-31. *In* World Fisheries Congress, May 1992, Athens, Greece.

Honkalehto, T., D. McKelvey, and N. Williamson. 2005. Results of the March echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) conducted in the southeastern Aleutian Basin near Bogoslof Island, cruise MF2005-03. AFSC Processed Rep. 2005-05, 37 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle WA 98115.

Foote, K. G., H. P. Knudsen, G. Vestnes, D. N. MacLennan, and E. J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep., No. 144, 69 p.

MacLennan, D.N., P. G. Fernandez, and J. Dalen. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES J. Mar. Sci. 59:365-369.

McKelvey, D., T. Honkalehto, and N. Williamson. 2006. Results of the March 2006 echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) conducted in the southeastern Aleutian Basin near Bogoslof Island, Cruise MF2006-03. AFSC Processed Rep. 2006-14, 30 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115.

Miller, D. M. 1984. Reducing transformation bias in curve fitting. The American Statistician 38:124-126.

Petitgas, P. 1993. Geostatistics for fish stock assessments: a review and an acoustic application. ICES J. Mar. Sci. 50: 285-298.

Rivoirard, J., J. Simmonds, K.G. Foote, P. Fernandez, and N. Bez. 2000. Geostatistics for estimating fish abundance. Blackwell Science Ltd., Osney Mead, Oxford, England. 206 p.

Schabetsberger, R., R.D. Brodeur, T. Honkalehto, and K. L. Mier. 1999. Sex-biased cannibalism in spawning walleye pollock: the role of reproductive behavior. Environ. Biol. Fishes 54:175-190.

Simmonds, E.J., and D. N. MacLennan. 2005. Fisheries acoustics: theory and practice, 2nd ed. Fish and Aquatic Resources Series 10. Blackwell Science, Oxford. 456 p.

Simrad. 2004. Operator manual for Simrad ER60 Scientific echo sounder application. Simrad AS, Strandpromenenaden 50, Box 111, N-3191 Horten, Norway.

Simrad. 1997. Operator Manual for Simrad EK500 Scientific echo sounder – Base version. Simrad AS, Strandpromenenaden 50, Box 111, N-3191 Horten, Norway.

Traynor, J. J. 1996. Target strength measurements of walleye pollock (*Theragra chalcogramma*) and Pacific whiting (*Merluccius productus*). ICES J. Mar. Sci. 53: 253-258.

Williamson, N., and J. Traynor. 1996. Application of a one-dimensional geostatistical procedure to fisheries acoustic surveys of Alaskan pollock. ICES J. Mar. Sci. 53: 423-428.

Table 1.--Itinerary and scientific personnel for the 2007 walleye pollock echo integration-trawl (EIT) survey of the Bogoslof Island area.

Itinerary

28 Feb	Embark scientists in Dutch Harbor, AK
1 March	Calibration of acoustic system in Captains Bay.
2-7 March	EIT survey of the Bogoslof Island area and inter-vessel comparison with NOAA ship *Oscar Dyson*
8-10 March	Inter-vessel comparison transects and calibration of acoustic system in Anderson Bay.
10 March	Inport Dutch Harbor, AK

Scientific Personnel	Position	Organization[1]	Nation
Taina Honkalehto	Chief Scientist	AFSC	USA
Denise McKelvey	Fishery Biologist	AFSC	USA
Scott Furnish	Info. Tech. Specialist	AFSC	USA
Annette Dougherty	Fishery Biologist	AFSC	USA
William Floering	Fishery Biologist	AFSC	USA
Sun-Do Hwan	Fishery Biologist	NFRDI	Korea
Tian Siquan	Fishery Biologist	SFU	China

[1]AFSC - Alaska Fisheries Science Center, Seattle, WA

NFRDI - National Fisheries Research and Development Institute, Distant Water Fisheries Resources Team, Busan City, Republic of Korea

SFU - Shanghai Fisheries University, Shanghai, China.

Table 2.--Simrad ER60 38 kHz acoustic system description and settings during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area and results from standard sphere acoustic system calibrations conducted before and after the survey.

		Calibrations			
	Survey system settings	7-Feb Three Saints Bay, Alaska	2-Mar Captains Bay, Alaska	9-Mar Anderson Bay, Alaska	23-Mar Uyak Bay, Alaska
Echosounder:	Simrad ER 60	--	--	--	--
Transducer:	ES38B	--	--	--	--
Frequency (kHz):	38	--	--	--	--
Transducer depth (m):	9.15	--	--	--	--
Pulse length (ms):	1.024	--	--	--	--
Transmitted power (W):	2000	--	--	--	--
Angle sensitivity:	21.9	--	--	--	--
2-Way beam angle (dB):	-21.0	--	--	--	--
Gain (dB)	26.41	26.43	26.41	26.40	26.43
Sa correction (dB)	-0.57	-0.58	-0.57	-0.58	-0.60
3 dB beamwidth (deg)					
Along:	7.00	7.06	7.00	7.04	7.02
Athwart:	7.08	7.04	7.08	6.97	7.00
Angle offset (deg)					
Along:	0.03	0.02	0.03	0.03	0.02
Athwart:	0.02	0.00	0.02	0.03	0.02
Post-processing S_v threshold (dB):	-70	--	--	--	
Reference standard sphere TS (dB):	--	-42.13	-42.14	-42.14	-42.10
Sphere range from transducer (m):	--	21.57	19.41	18.91	20.12
Absorption coefficient (dB/m):	0.009931	0.0099028	0.0099783	0.0100013	0.0099079
Sound velocity (m/s)	1467.0	1459.1	1460.7	1460.0	1455.8
Water temp at transducer (^{o}C):	3.3-3.9	3.0	3.1	3.2	2.3

Note: "Gain" and "beam"-related terms are defined in the "Operator Manual for Simrad ER60 Scientific echo sounder application (2004)" available from Simrad AS, Strandpromenaden 50, Box 111, N-3191 Horten, Norway.

Table 3.--Trawl station and catch data summary from the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul No.	Gear Type[1]	Date (GMT)	Time (GMT)	Duration (minutes)	Start position		Depth (m)		Water temp. (°C)		Profile No.	Catch		
					Latitude (N)	Longitude (W)	Footrope	Bottom	Gear depth[2]	Surface[3]		Pollock (kg)	Pollock Number	Other (kg)
1	AWT	3-Mar	10:09	4.5	53 35.78	167 39.78	435	927	4.0	3.7	301	5	4	5
2	AWT	4-Mar	2:22	6.0	53 37.06	167 47.45	442	806	4.0	3.7	301	408	404	7
3	AWT	4-Mar	4:48	6.7	53 34.67	167 48.84	478	722	4.0	3.6	301	3,991	3,323	9
4	AWT	4-Mar	9:28	16.5	53 35.13	167 43.41	587	939	3.7	3.7	301	1,737	947	51
5	AWT	5-Mar	23:16	11.3	53 07.46	169 08.04	451	878	3.9	3.7	301	1,415	1,256	13
6	AWT	6-Mar	1:21	2.5	53 09.58	169 05.97	466	1069	3.7	3.8	301	12,500	9,871	-
7	AWT	6-Mar	9:35	15.6	53 00.76	169 16.60	528	913	3.6	3.8	301	1,000	670	23
8	AWT	6-Mar	15:35	23.7	53 02.14	169 16.37	460	826	3.8	3.8	301	466	308	5
9	AWT	7-Mar	10:18	8.6	53 05.68	169 09.91	434	853	3.9	3.8	301	869	542	5

[1]Gear type: AWT = Aleutian wing trawl

[2]Average Sea-Bird Electronics (SBE) temperature measured at the trawl headrope depth (about 38 m above the footrope) while fishing.

[3]SBE temperature measured at 1 m.

Table 4.--Numbers of fish measured and biological samples collected during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

	Walleye pollock				Fertilized		
Haul no.	Random lengths	Weights and maturities	Age	Ovary weights	pollock eggs	Seabird counts	Myctophid lengths
1	4	4	4	2	-	-	96
2	404	195	195	99	8,000	-	-
3	343	76	76	42	-	x	-
4	235	97	97	-	-	-	-
5	458	130	80	60	-	x	-
6	362	123	91	49	-	x	-
7	306	77	77	39	-	-	-
8	308	90	55	63	-	-	-
9	299	78	78	34	-	-	-
Totals	2,719	870	753	388	8,000		96

"x" indicates counts were taken

Table 5.--Catch by species from 9 midwater trawl hauls during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Species name	Scientific name	Weight (kg)	%	Number	%
walleye pollock	*Theragra chalcogramma*	22,390.3	99.5	17,325	72.2
lanternfish unidentified	Myctophidae (family)	89.3	0.4	5,830	24.3
chum salmon	*Oncorhynchus keta*	8.8	<0.1	6	<0.1
northern smoothtongue	*Leuroglossus schmidti*	4.1	<0.1	546	2.3
squid unidentified	Teuthoidea (order)	4.1	<0.1	72	0.3
smooth lumpsucker	*Aptocyclus ventricosus*	4	<0.1	2	<0.1
Pacific lamprey	*Lampetra tridentata*	3	<0.1	10	<0.1
jellyfish unident	Scyphozoa (class)	1.4	<0.1	24	0.1
salmon and trouts unident	Salmonidae (family)	1.2	<0.1	5	<0.1
salps unident	Thaliacea (family)	1	<0.1	38	0.2
arrowtooth flounder	*Atheresthes stomias*	0.5	<0.1	1	<0.1
viperfish spp.	Chauliodus (genus)	0.4	<0.1	18	<0.1
shrimp unident.	Decapoda (order)	0.2	<0.1	109	0.5
eulachon	*Thaleichthys pacificus*	<0.1	<0.1	1	<0.1
Totals		22,508.3		23,989	

Table 6.--Estimates of walleye pollock biomass (in metric tons (t)) by survey area and management area from February-March echo integration-trawl surveys in the Bogoslof Island area between 1988 and 2007.

	Bogoslof Survey Area			Central Bering Sea Specific Area	
Year	Biomass (million t)	Area (nmi^2)	Relative estimation error (%)	Biomass (million t)	Relative estimation error (%)
1988	2.396	--	--	2.396	--
1989	2.126	--	--	2.084	--
1990	--	No survey	--	--	--
1991	1.289	8,411	11.7	1.283	--
1992	0.940	8,794	20.4	0.888	--
1993	0.635	7,743	9.2	0.631	--
1994	0.490	6,412	11.6	0.490	--
1995	1.104	7,781	10.7	1.020	--
1996	0.682	7,898	19.6	0.582	--
1997	0.392	8,321	14.0	0.342	--
1998	0.492	8,796	19.0	0.432	19.0
1999	0.475	Conducted by Japan Fisheries Agency		0.393	--
2000	0.301	7,863	14.3	0.270	12.7
2001	0.232	5,573	10.2	0.208	11.8
2002	0.226	2,903	12.2	0.226	12.2
2003	0.198	2,993	21.5	0.198	21.5
2004	--	No survey	--	--	--
2005	0.253	3,112	16.7	0.253	16.7
2006	0.240	1,803	11.8	0.240	11.8
2007	0.292	1,871	11.5	0.292	11.5

Table 7.--Numbers-at-length estimates (millions) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No surveys were conducted in 1990 or 2004. The 1999 survey was conducted by the Japan Fisheries Agency. Lengths are in centimeters.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
10	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0	--	0	0	0
11	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0	--	0	0	0
12	0	0	--	0	0	0	0	1	0	0	0	0	0	0	0	0	--	0	0	0
13	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0	--	0	0	0
14	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0	--	0	0	0
15	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
16	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
17	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
18	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
19	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
20	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
21	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
22	0	0	--	<1	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
23	0	0	--	2	0	0	0	0	0	0	0	0	0	0	<1	0	--	0	0	0
24	0	0	--	1	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
26	0	0	--	<1	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
27	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
28	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
29	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	<1	0	--	0	0	0
31	0	0	--	0	<1	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
32	0	0	--	0	<1	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
33	0	0	--	0	<1	0	0	0	0	0	0	0	0	0	<1	<1	--	0	0	0
34	0	0	--	0	0	0	0	<1	<1	0	<1	0	0	0	<1	<1	--	0	0	0
35	0	0	--	0	0	0	0	<1	0	<1	0	0	0	0	<1	0	--	0	0	0
36	0	0	--	0	<1	0	0	<1	<1	<1	<1	0	0	0	1	0	--	0	0	0
37	9	3	--	<1	0	0	0	<1	<1	<1	<1	0	0	0	1	<1	--	<1	0	0
38	6	0	--	2	<1	1	0	1	1	<1	1	0	0	<1	1	<1	--	1	<1	0
39	16	4	--	5	0	2	<1	4	1	1	3	<1	<1	<1	2	<1	--	2	<1	<1
40	24	3	--	7	1	4	3	12	4	1	7	1	<1	1	3	<1	--	7	2	0
41	27	4	--	19	3	5	6	20	8	2	9	6	1	1	4	<1	--	11	5	1
42	48	23	--	23	7	7	9	40	14	3	11	8	1	1	2	<1	--	12	10	2
43	118	33	--	31	14	6	14	40	17	4	11	13	3	1	5	1	--	11	16	4
44	179	54	--	36	18	7	21	41	21	5	10	13	3	2	5	2	--	11	20	8
45	329	159	--	46	28	8	21	50	23	7	9	17	4	3	7	3	--	13	23	11
46	488	177	--	55	32	13	21	53	31	10	11	19	5	4	5	5	--	11	23	17
47	547	389	--	79	42	22	18	40	36	14	9	14	6	5	9	5	--	11	18	17
48	476	434	--	130	68	28	17	55	36	15	12	11	6	5	7	7	--	10	17	20
49	389	431	--	168	102	46	16	47	37	18	15	10	5	6	6	6	--	8	14	14
50	248	366	--	205	129	69	39	52	40	21	20	16	6	6	5	7	--	8	9	18
51	162	279	--	189	144	76	46	58	45	24	23	11	8	6	5	4	--	9	9	15
52	80	168	--	160	118	73	52	78	52	26	28	20	10	7	4	4	--	7	7	13

Table 7.--Continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
53	48	85	--	122	106	73	49	81	52	26	35	17	13	8	6	4	--	7	5	12
54	19	50	--	63	67	66	43	88	53	31	41	21	16	9	7	3	--	7	5	10
55	12	13	--	40	41	50	37	81	48	28	38	33	21	13	9	5	--	8	3	9
56	4	5	--	17	27	29	26	69	40	24	35	38	20	13	12	7	--	6	6	8
57	3	8	--	8	13	14	17	58	37	22	30	33	24	16	13	7	--	7	5	6
58	1	1	--	4	6	9	10	47	28	17	27	36	23	14	14	10	--	6	7	7
59	0	0	--	1	5	3	6	31	19	13	18	23	16	12	12	9	--	8	5	7
60	0	0	--	1	1	1	3	17	12	12	13	15	13	12	12	13	--	7	7	6
61	2	0	--	1	<1	1	2	7	6	6	8	18	10	10	8	9	--	9	5	8
62	0	0	--	<1	<1	<1	1	4	2	3	5	13	7	6	6	7	--	7	5	7
63	0	0	--	0	0	0	<1	2	1	1	3	4	4	4	4	5	--	7	4	4
64	0	0	--	0	1	<1	0	1	<1	1	1	3	2	3	3	5	--	5	2	4
65	0	0	--	<1	0	0	0	<1	<1	<1	1	1	1	1	1	3	--	4	2	3
66	0	0	--	0	0	0	0	<1	0	<1	1	<1	<1	<1	1	1	--	2	2	3
67	0	0	--	0	0	0	0	0	0	0	0	1	<1	<1	<1	1	--	2	1	2
68	0	0	--	0	0	0	0	1	0	0	<1	0	<1	<1	<1	<1	--	1	1	1
69	0	0	--	0	0	0	0	0	0	0	0	0	0	<1	0	<1	--	<1	<1	1
70	0	0	--	0	0	0	0	0	0	0	0	0	0	<1	<1	0	--	<1	<1	<1
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	<1	<1
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0	<1
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0	0
Total	3,236	2,687	--	1,419	975	613	478	1,081	666	337	435	416	229	170	181	134	--	225	239	236

Table 8.--Biomass-at-length estimates (metric tons) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No surveys were conducted in 1990 or 2004. The 1999 survey was conducted by the Japan Fisheries Agency. Lengths are in centimeters.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
10	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0	--	0	0	0
11	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0	0	--	0	0	0
12	0	0	--	0	0	0	0	5	0	0	0	0	0	0	0	0	--	0	0	0
13	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0	0	--	0	0	0
14	0	0	--	0	0	0	0	1	0	0	0	0	0	0	0	0	--	0	0	0
15	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
16	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
17	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
18	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
19	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
20	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
21	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
22	0	0	--	13	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
23	0	0	--	70	0	0	0	0	0	0	0	0	0	0	37	0	--	0	0	0
24	0	0	--	61	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
26	0	0	--	26	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
27	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
28	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
29	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	6	0	--	0	0	0
31	0	0	--	0	37	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
32	0	0	--	0	42	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
33	0	0	--	0	48	0	0	0	0	0	0	0	0	0	9	2	--	0	0	0
34	0	0	--	0	0	0	0	53	35	0	29	0	0	0	47	2	--	0	0	0
35	0	0	--	0	0	0	0	93	0	29	0	0	0	0	72	0	--	0	0	0
36	0	0	--	0	68	0	0	42	96	18	32	0	0	0	202	0	--	0	0	0
37	3,199	846	--	115	0	0	0	113	109	84	92	0	0	0	451	16	--	39	0	0
38	2,304	0	--	768	84	260	0	435	465	173	395	0	0	19	503	6	--	323	29	0
39	6,365	1,461	--	1,843	0	634	202	1,697	562	507	1,250	258	168	149	814	7	--	942	145	214
40	10,573	1,116	--	2,801	451	1,776	1,190	5,510	1,857	634	3,208	1,242	195	307	1,699	80	--	3,143	869	0
41	12,697	1,532	--	7,940	1,235	2,276	2,855	9,777	3,637	851	4,484	5,598	575	419	1,899	170	--	5,257	2,326	402

Table 8.--Continued

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
42	24,360	10,704	--	10,812	3,316	3,571	4,990	20,730	7,012	1,387	5,652	7,223	674	469	1,299	251	--	6,158	5,378	1,231
43	64,253	16,516	--	15,540	6,760	3,089	8,021	22,332	9,190	2,158	6,407	12,079	1,511	857	2,855	436	--	6,318	9,034	2,426
44	104,733	29,588	--	20,103	9,877	4,006	12,963	24,863	12,735	3,018	6,048	11,877	1,622	1,546	3,609	1,163	--	6,398	11,836	5,213
45	206,586	93,899	--	28,059	16,329	4,818	13,823	32,817	14,927	4,824	5,592	16,278	2,848	2,362	5,071	2,123	--	8,145	15,091	7,254
46	328,735	113,092	--	36,235	20,645	8,835	15,081	37,303	21,637	7,399	7,774	17,678	3,289	3,071	4,101	4,069	--	8,122	16,667	12,192
47	394,741	268,496	--	56,880	29,146	16,669	13,565	30,184	26,425	10,786	6,653	13,933	5,002	4,338	7,361	3,814	--	8,682	14,277	13,072
48	367,368	323,170	--	101,488	51,983	22,214	13,658	44,572	28,658	12,233	9,528	11,280	5,191	4,275	6,022	5,859	--	7,934	14,524	16,572
49	320,630	345,632	--	141,399	84,329	39,811	14,414	40,477	31,599	15,951	12,766	10,698	4,659	5,443	5,611	5,733	--	7,115	12,801	12,604
50	217,890	314,778	--	187,006	115,614	63,571	36,256	47,785	35,907	19,593	18,837	18,373	5,466	5,617	4,865	6,939	--	7,453	8,940	17,819
51	152,084	258,067	--	186,358	140,004	75,524	46,297	57,291	43,272	23,896	23,203	12,204	8,364	5,794	4,973	4,221	--	9,035	9,558	16,112
52	79,654	166,322	--	170,855	124,034	77,721	55,851	81,793	53,696	28,549	29,109	23,427	10,816	7,683	3,970	4,871	--	7,711	7,312	15,141
53	50,739	89,721	--	139,671	120,309	83,189	55,151	90,342	57,294	29,783	39,234	20,486	14,509	8,970	6,471	4,752	--	8,074	5,941	15,492
54	21,211	56,681	--	77,905	82,110	79,461	52,329	104,021	61,504	38,168	48,567	25,270	19,059	11,429	8,210	4,104	--	8,735	6,430	12,804
55	14,191	16,270	--	52,506	53,286	64,342	47,770	102,318	59,033	35,853	47,461	39,463	27,179	17,342	12,450	6,418	--	11,061	4,877	12,723
56	5,580	6,059	--	23,541	38,564	39,556	35,451	91,962	52,765	33,144	47,627	46,764	27,212	17,388	16,211	10,715	--	8,930	9,602	13,235
57	3,886	10,681	--	12,470	19,710	20,781	24,453	81,885	52,000	31,736	42,594	40,641	34,562	24,019	19,343	10,821	--	9,814	6,813	9,537
58	1,395	1,220	--	6,603	9,188	14,391	15,826	70,522	40,581	26,309	41,160	44,788	34,255	22,069	21,745	15,656	--	9,735	10,528	11,442
59	0	0	--	1,284	7,872	4,376	9,546	48,878	28,918	21,031	28,241	28,362	26,252	19,904	19,100	14,863	--	13,976	8,888	10,445
60	0	0	--	2,743	2,631	1,989	4,716	28,240	19,749	20,509	21,604	18,174	22,075	20,044	20,516	22,945	--	13,186	11,377	12,562
61	2,561	0	--	2,195	562	1,756	3,644	11,855	10,762	11,428	14,301	22,618	18,519	17,588	14,619	17,276	--	16,771	8,337	14,111
62	0	0	--	780	600	372	1,826	7,951	3,578	6,439	9,748	15,120	12,972	11,689	12,279	14,910	--	13,268	9,718	14,699
63	0	0	--	0	0	0	200	3,978	2,835	2,999	6,344	5,181	7,033	8,482	8,188	11,207	--	14,025	7,997	9,066
64	0	0	--	0	1,363	415	0	1,074	863	1,489	1,777	3,198	4,277	5,940	5,711	10,509	--	10,001	5,553	9,172
65	0	0	--	938	0	0	0	495	578	1,096	1,156	1,833	1,660	2,860	2,465	7,259	--	9,033	4,367	7,187
66	0	0	--	0	0	0	0	163	0	329	1,251	403	534	1,095	1,509	3,571	--	5,120	4,679	5,988
67	0	0	--	0	0	0	0	0	0	0	0	863	520	420	591	1,948	--	5,161	3,264	5,323
68	0	0	--	0	0	0	0	2,570	0	0	276	0	403	426	765	744	--	2,157	1,716	2,716
69	0	0	--	0	0	0	0	0	0	0	0	0	0	63	0	390	--	933	644	2,774
70	0	0	--	0	0	0	0	0	0	0	0	0	0	95	64	0	--	381	467	880
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	99	74	796
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	118	0	375
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	109	0	0
Total	2,395,735	2,125,851	--	1,289,008	940,197	635,403	490,078	1,104,118	682,279	392,403	492,398	475,311	301,402	232,170	225,712	197,851	--	253,459	240,059	291,580

Table 9.--Numbers-at-age estimates (millions) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No surveys were conducted in 1990 or 2004. The 1999 survey was conducted by the Japan Fisheries Agency.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1	0	0	--	0	0	0	0	1	0	0	0	0	0	0	0	0	--	0	0	0
2	0	0	--	4	0	0	0	0	0	0	0	0	0	0	<1	0	--	0	0	0
3	0	0	--	0	1	1	0	2	0	0	0	0	0	0	9	<1	--	0	0	0
4	0	6	--	2	2	33	21	6	<1	<1	<1	2	1	1	5	8	--	5	4	1
5	28	15	--	12	27	17	86	75	6	4	11	5	6	14	3	6	--	81	55	8
6	327	58	--	46	54	44	26	278	96	16	61	29	4	12	41	7	--	31	104	92
7	247	363	--	213	97	46	38	105	187	55	34	77	14	10	11	25	--	13	18	70
8	164	147	--	93	74	48	36	68	85	88	70	34	30	10	8	11	--	11	6	17
9	350	194	--	160	71	42	36	80	40	38	77	50	16	14	6	4	--	22	6	3
10	1,201	91	--	44	55	28	17	53	37	28	32	75	28	12	7	5	--	7	9	3
11	288	1,105	--	92	57	51	27	54	24	16	25	29	45	18	8	4	--	3	3	8
12	287	222	--	60	33	25	23	19	24	16	21	27	21	31	14	10	--	5	2	4
13	202	223	--	373	34	27	13	59	12	13	19	25	16	13	30	8	--	4	4	1
14	89	82	--	119	142	42	9	32	36	7	18	16	11	7	9	26	--	5	5	5
15	27	90	--	41	164	92	45	12	18	13	9	12	11	9	7	6	--	11	8	5
16	17	30	--	38	59	47	36	31	4	5	15	10	9	8	9	5	--	12	5	3
17	7	60	--	29	8	25	28	103	16	4	5	8	3	5	5	3	--	6	7	6
18	3	0	--	32	15	11	16	60	35	12	8	6	6	1	4	5	--	4	2	4
19	0	0	--	56	22	11	4	18	26	12	10	3	3	3	2	1	--	3	1	3
20	0	0	--	4	42	11	4	5	12	7	15	4	2	1	2	<1	--	1	2	1
21	0	0	--	2	13	10	8	5	3	2	4	3	1	0	0	1	--	<1	<1	<1
22	0	0	--	0	3	1	2	6	2	1	1	2	1	0	0	0	--	0	0	1
23	0	0	--	0	1	1	2	6	1	<1	0	<1	0	<1	<1	0	--	0	0	0
24	0	0	--	0	0	0	1	2	0	1	0	0	<1	<1	<1	0	--	<1	0	1
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0	<1	0	--	0	0	0
Total	3,236	2,687	--	1,419	975	613	478	1,081	666	336	435	416	229	170	181	134	--	225	239	236

Table 10.--Biomass-at-age estimates (metric tons) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No surveys were conducted in 1990 or 2004. The 1999 survey was conducted by the Japan Fisheries Agency.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1	0	0	--	0	0	0	0	10	0	0	0	0	0	0	0	0	--	0	0	0
2	0	0	--	170	0	0	0	0	0	0	0	0	0	0	40	0	--	0	0	0
3	0	0	--	0	162	284	0	681	0	0	0	0	0	0	4,598	4	--	0	0	0
4	0	2,184	--	715	782	18,809	13,028	3,411	322	87	78	1,809	324	437	2,551	7,084	--	3,176	1,986	707
5	14,997	7,275	--	6,067	21,455	11,939	59,938	48,690	3,668	2,083	6,771	5,688	4,060	11,581	2,004	5,348	--	52,268	35,924	6,349
6	192,324	41,140	--	24,911	38,081	39,100	21,530	208,409	69,106	10,598	37,697	28,096	2,884	11,166	34,118	6,229	--	25,162	85,399	80,269
7	155,569	241,301	--	143,024	67,027	43,049	39,768	82,680	165,354	49,598	29,637	77,751	12,065	9,698	10,107	26,066	--	13,540	18,570	86,324
8	114,725	111,156	--	74,575	59,445	46,874	39,107	72,294	75,658	94,580	73,714	37,210	30,361	11,576	8,993	12,179	--	14,542	7,315	24,902
9	251,417	149,143	--	149,035	67,358	43,976	39,539	96,260	45,732	44,076	94,394	59,688	17,797	18,033	8,020	6,085	--	28,927	8,428	4,236
10	910,016	68,495	--	43,519	56,969	30,688	20,520	64,202	45,360	37,822	40,417	90,284	39,852	16,273	9,149	8,361	--	10,152	14,591	6,168
11	226,380	894,895	--	94,020	61,394	59,294	31,589	70,646	31,116	22,942	35,706	35,240	63,335	26,491	12,298	7,257	--	5,999	3,996	13,616
12	232,810	187,280	--	59,273	36,293	27,008	27,506	26,482	33,262	22,497	29,180	32,724	31,891	49,843	22,821	18,366	--	9,132	3,110	7,091
13	167,054	193,548	--	377,521	37,218	29,947	17,038	77,225	16,950	18,074	26,690	29,864	24,979	20,032	47,965	14,288	--	7,966	6,417	1,246
14	81,596	71,920	--	116,171	150,237	46,997	10,896	42,417	48,990	10,713	26,304	18,915	17,620	11,025	14,573	47,035	--	9,890	8,615	11,498
15	22,969	81,447	--	38,750	168,966	107,062	52,899	16,595	24,443	19,768	13,230	14,207	16,150	14,340	12,209	11,354	--	20,887	14,806	11,564
16	16,336	24,342	--	37,870	63,304	54,401	42,771	37,907	5,538	6,659	21,631	12,723	14,740	13,925	14,701	8,207	--	24,633	9,190	5,511
17	6,681	51,725	--	30,696	9,342	27,577	32,128	131,396	20,782	5,470	8,218	9,635	5,637	7,351	8,186	5,448	--	11,130	12,900	12,274
18	2,863	0	--	32,392	15,467	10,736	17,911	74,010	43,092	16,894	10,212	7,020	8,460	2,106	6,112	10,134	--	8,390	3,459	8,159
19	0	0	--	55,116	23,380	13,607	4,768	22,292	31,760	17,174	13,047	3,357	4,798	5,264	3,425	1,804	--	5,338	1,696	6,040
20	0	0	--	3,840	43,605	11,963	5,081	5,902	14,486	9,228	19,016	4,343	2,547	2,043	2,545	782	--	1,464	3,115	2,066
21	0	0	--	1,341	15,240	10,167	8,866	5,433	4,023	1,885	5,376	3,574	1,566	0	0	1,820	--	425	542	735
22	0	0	--	0	3,186	1,329	2,011	7,728	1,974	947	1,078	2,668	1,810	0	0	0	--	0	0	1,782
23	0	0	--	0	1,287	598	2,323	6,696	661	419	0	514	0	493	470	0	--	0	0	0
24	0	0	--	0	0	0	860	2,758	0	888	0	0	526	493	572	0	--	437	0	1,044
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0	255	0	--	0	0	0
Total	2,395,737	2,125,851	--	1,289,006	940,198	635,405	490,077	1,104,124	682,277	392,402	492,396	475,311	301,402	232,170	225,712	197,851	--	253,459	240,059	291,580

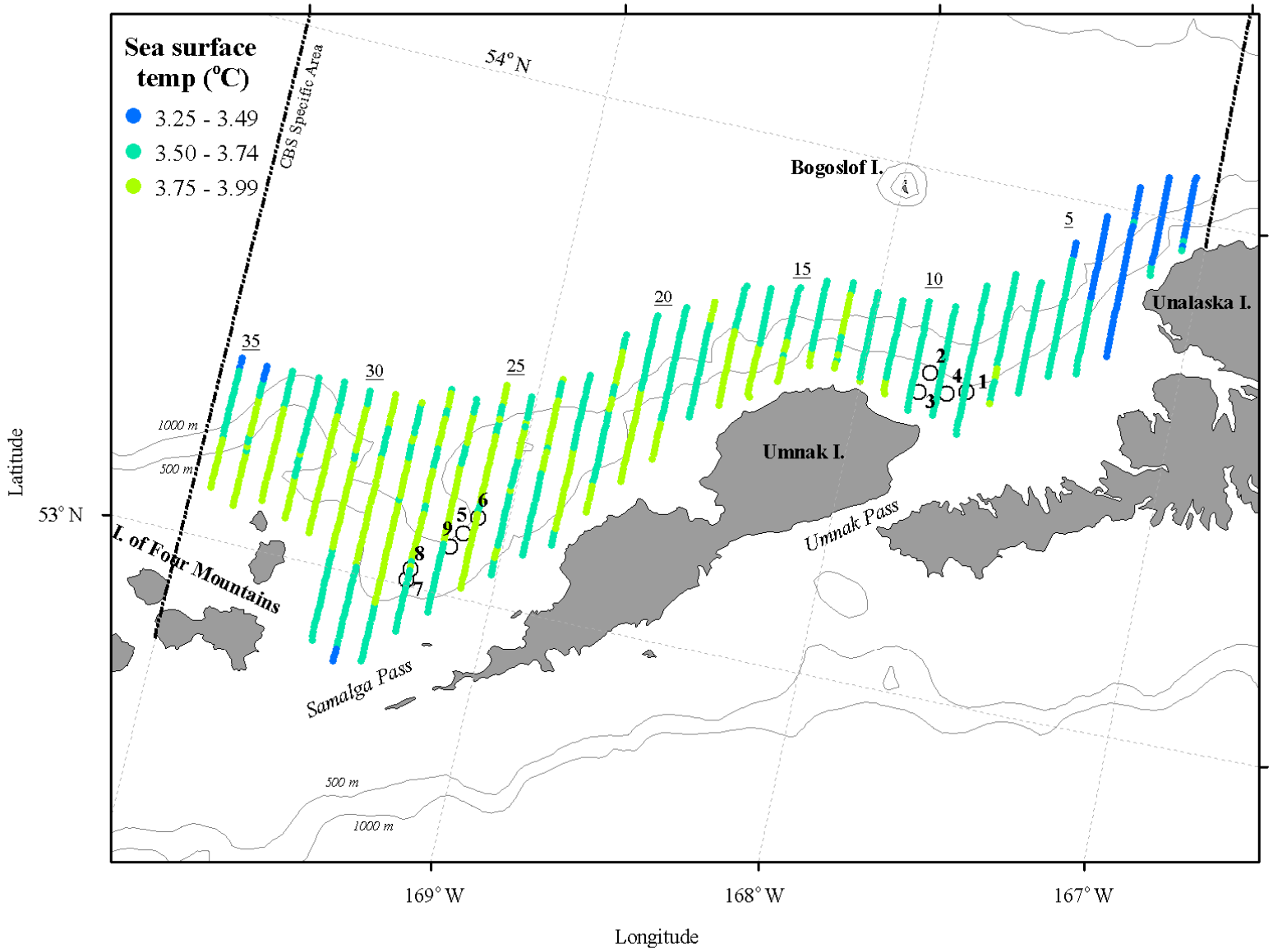

Figure 1.--Transects, haul locations, and sea surface temperatures measured from the ship's sensor and recorded during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Hauls are indicated by circles and transect numbers are underlined. The dash-dotted line indicates the Central Bering Sea Specific Area.

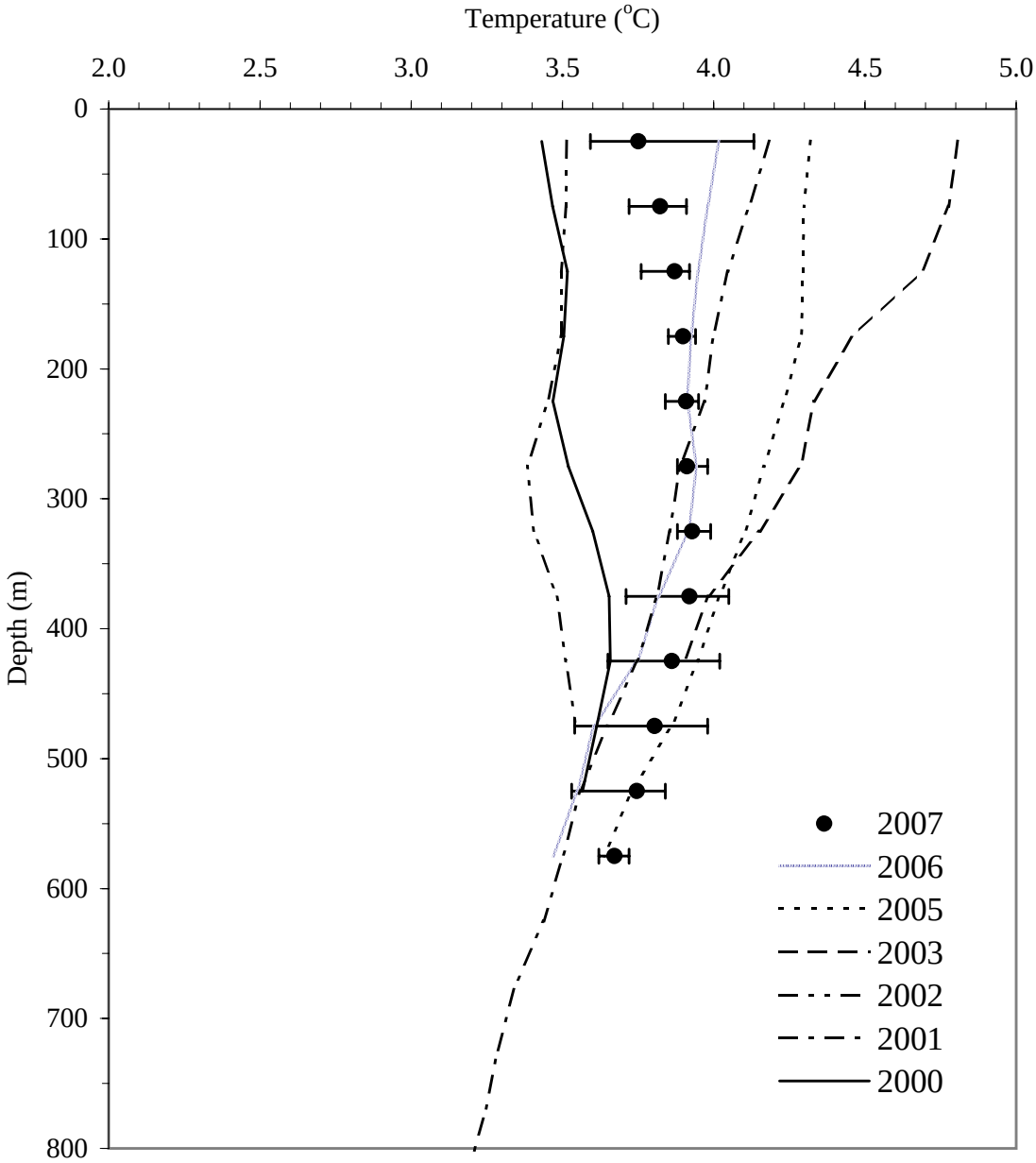

Figure 2.--Average temperature (°C) (symbols) by 50-m depth intervals observed during hauls from the winter 2000-2003, and 2005-2007 echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. The horizontal bars represent temperature range observed during the 2007 survey.
Note: Temperature data from the 2003 survey were collected from only three locations.

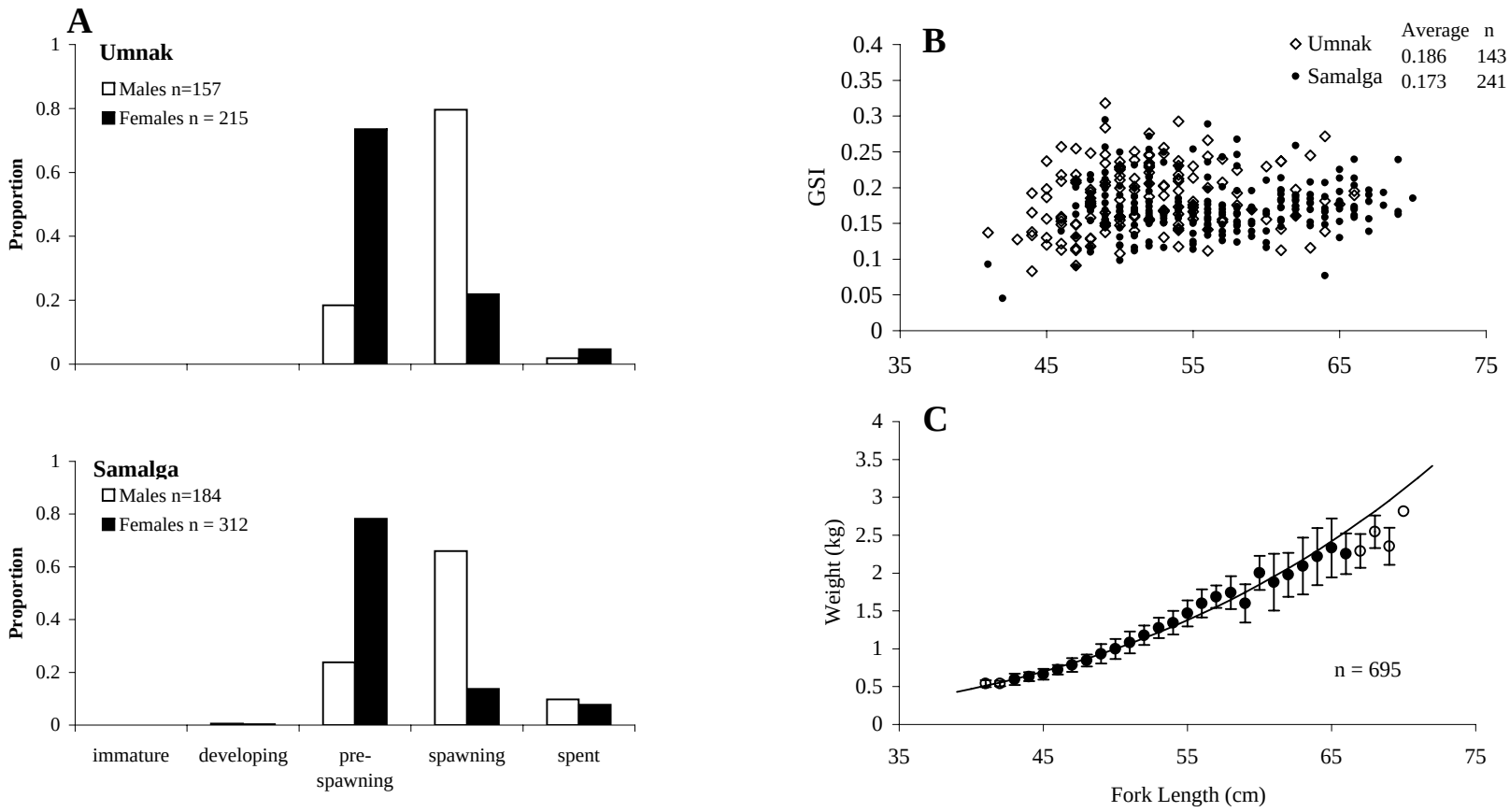

Figure 3.--Pollock maturity stages for Umnak and Samalga length strata (A), gonado-somatic index (GSI) for pre-spawning females as a function of fork length (cm) (B), and observed mean weight-at-length with a fitted regression line (sexes combined; hollow circles indicate fewer than six fish were measured) (C) observed during the winter 2007 echo integration-trawl survey of the Bogoslof Island area. Vertical bars indicate +/- one standard deviation.

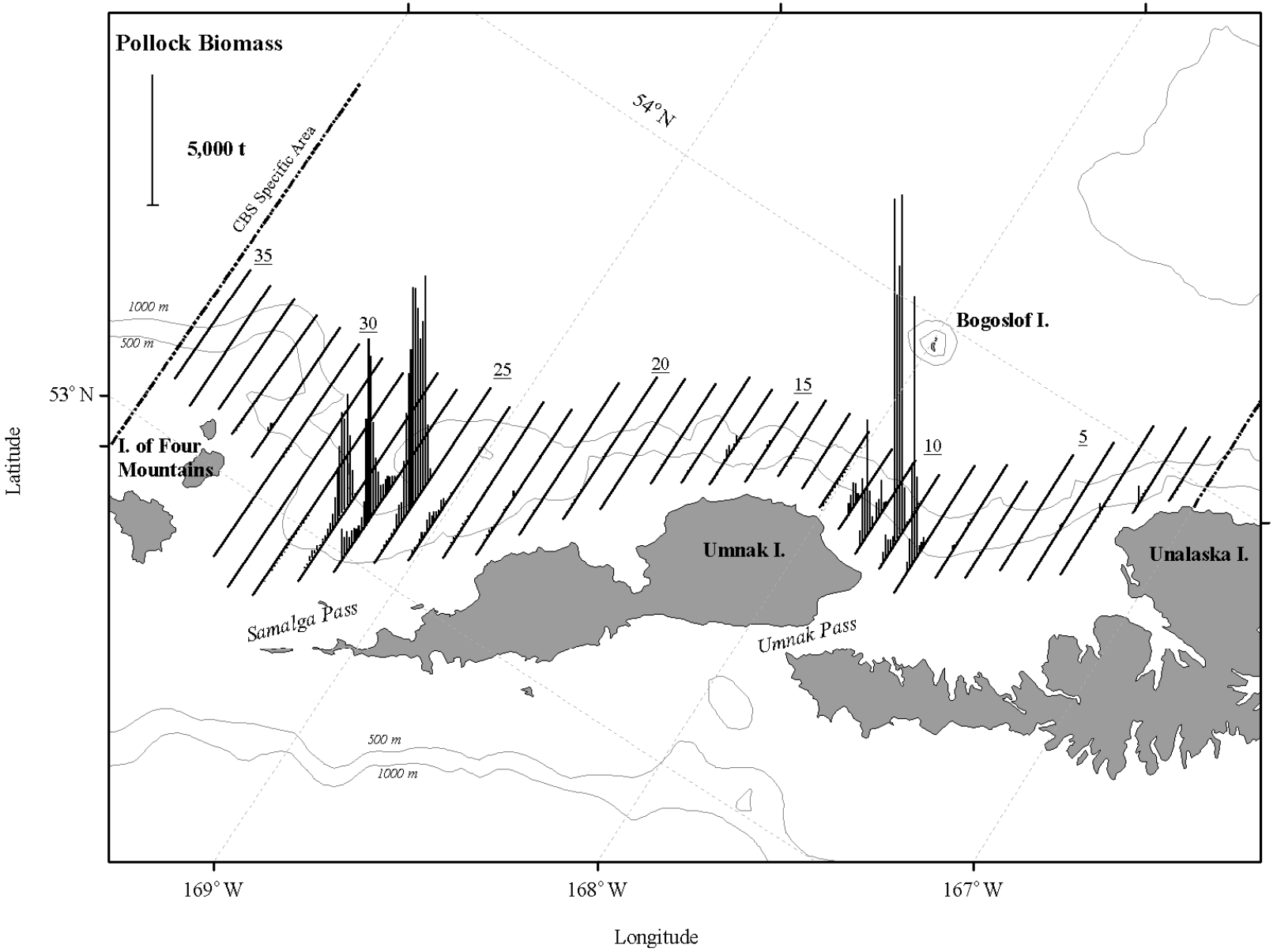

Figure 4.--Pollock biomass in metric tons (t) along tracklines during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. The dash-dotted line indicates the Central Bering Sea Specific Area.

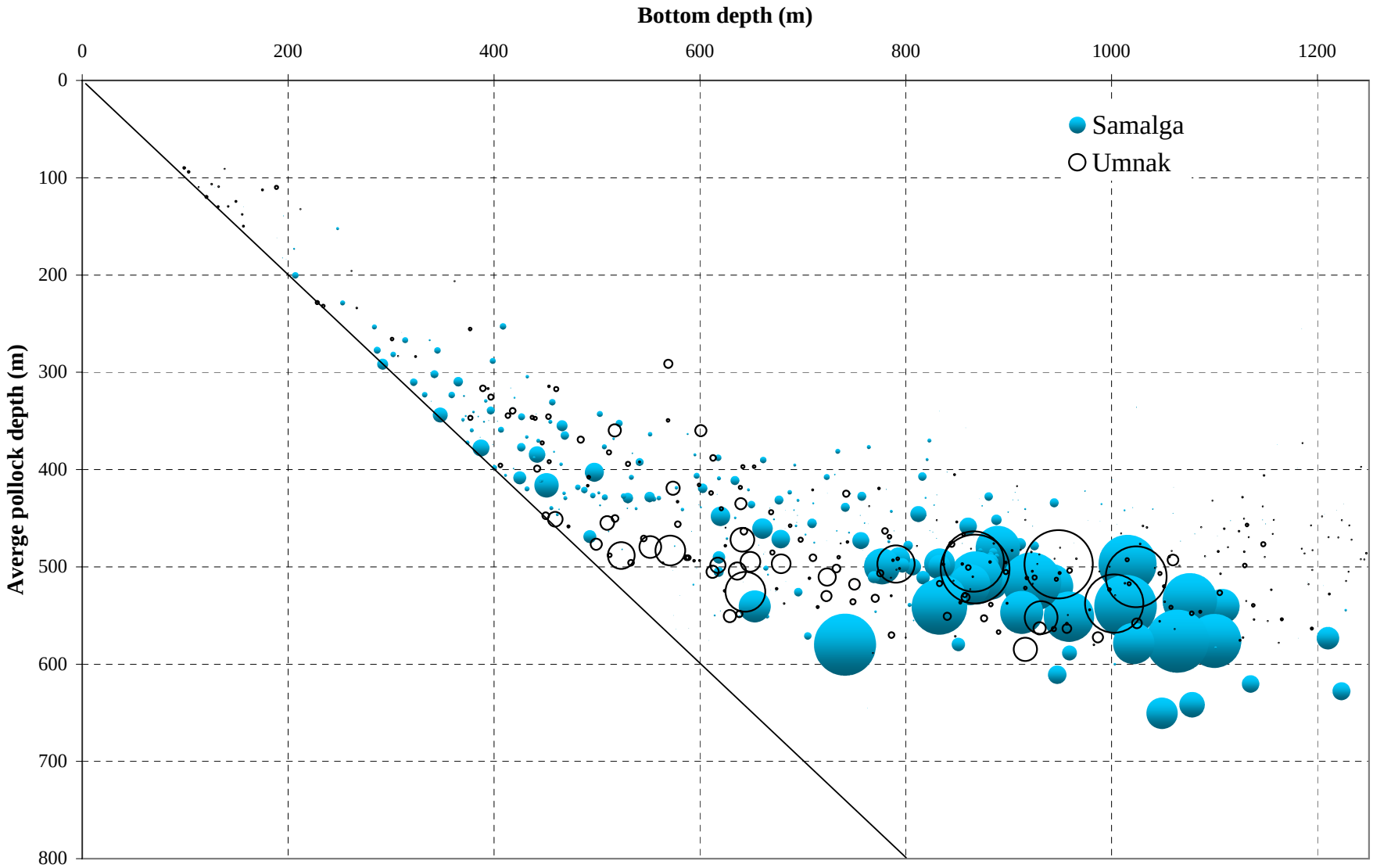

Figure 5.--Average pollock depth (weighted by biomass) versus bottom depth (m), per 0.5 nmi sailed distance for the Umnak and Samalga regions during the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Bubble size was scaled to the maximum biomass/0.5 nmi interval (Umnak region, 13,710 t). The diagonal line indicates where the average pollock depth equals bottom depth.

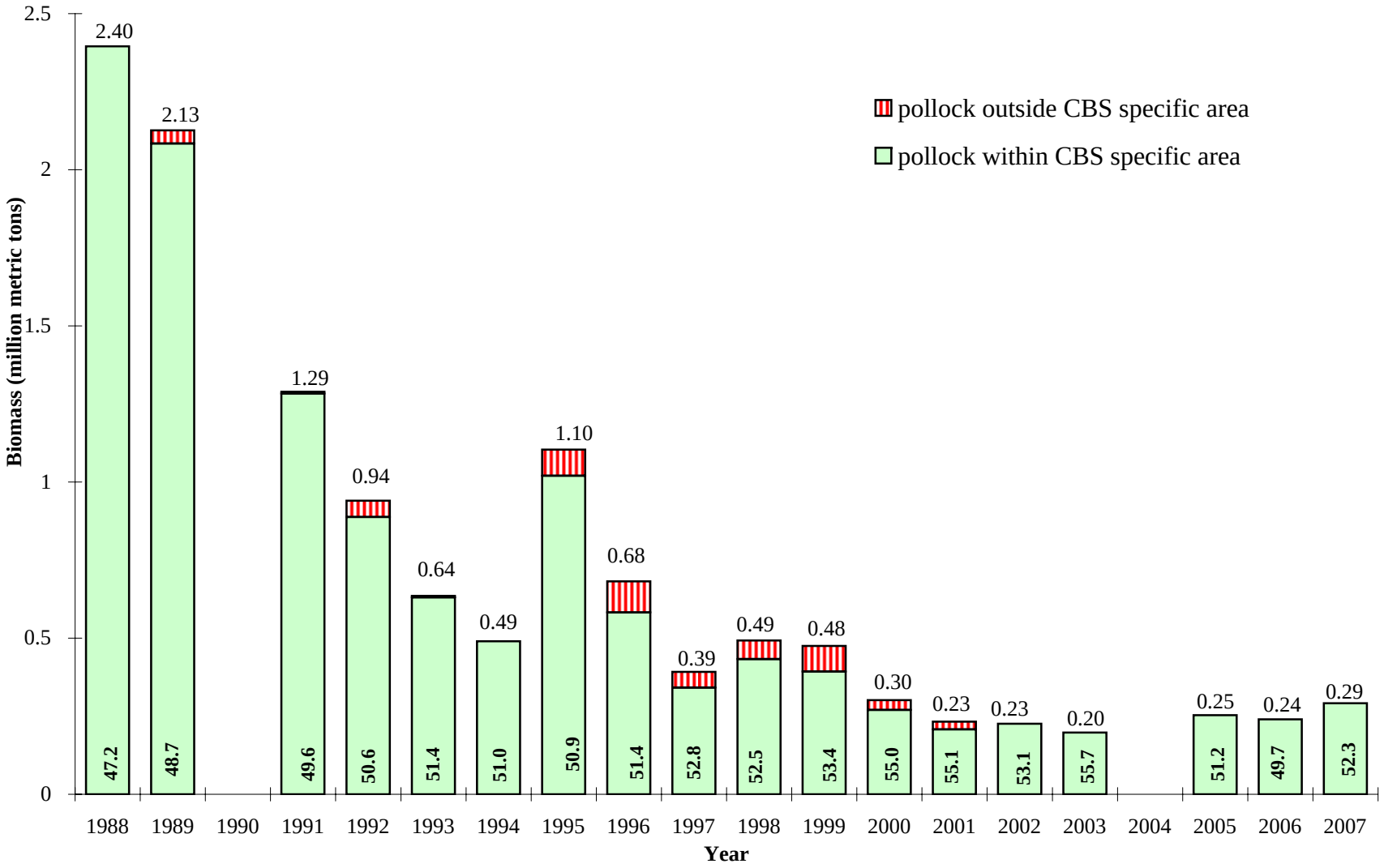

Figure 6.--Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2007. The United States conducted all but the 1999 survey, which was conducted by Japan. There were no surveys in 1990 or 2004. Total pollock biomass for each survey year is indicated on top of each bar and average fork length (cm) is indicated inside each bar.

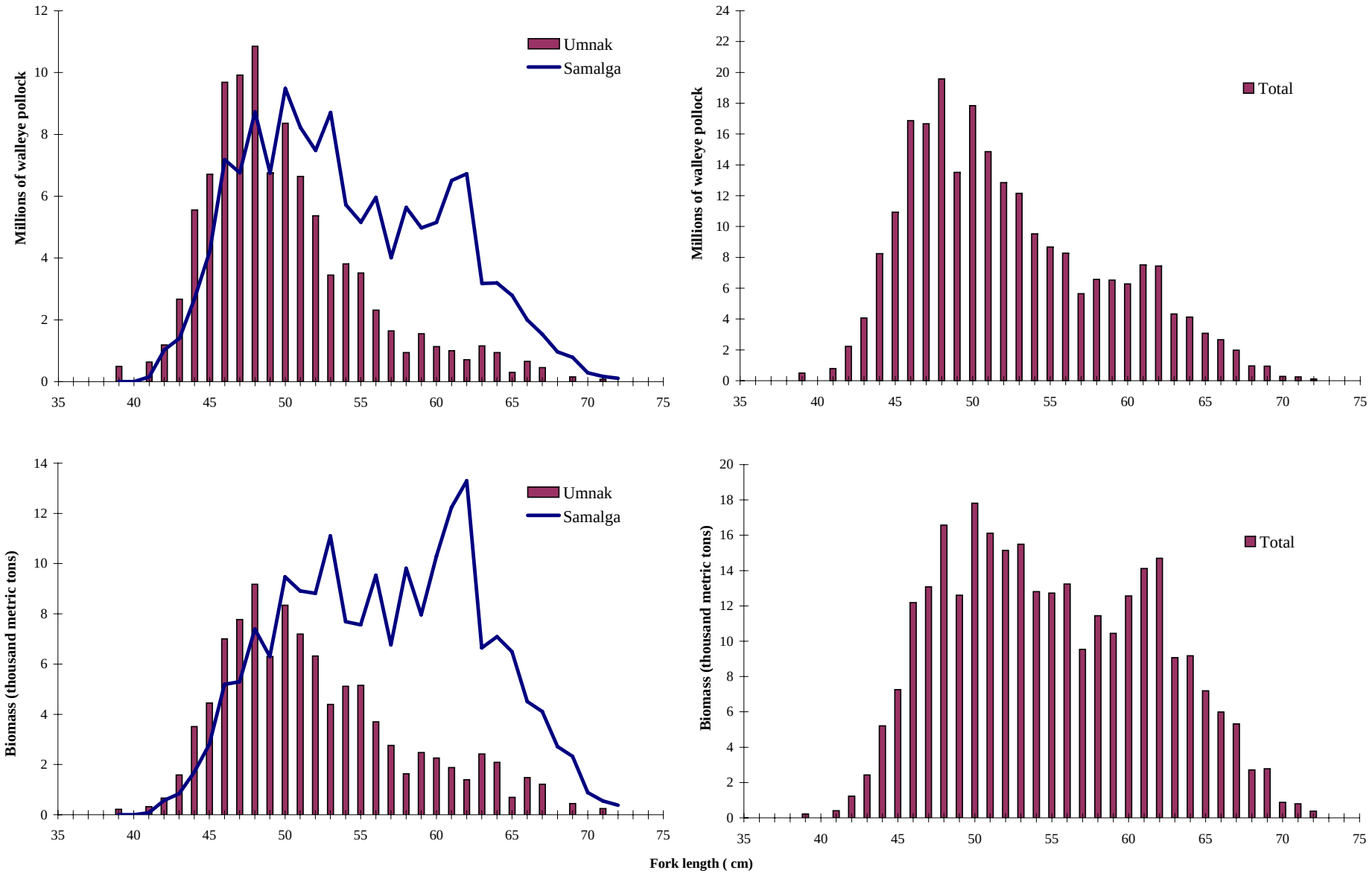

Figure 7.--Population at length (top) and biomass at length (bottom) estimates from the winter 2007 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Note Y-axis differences.

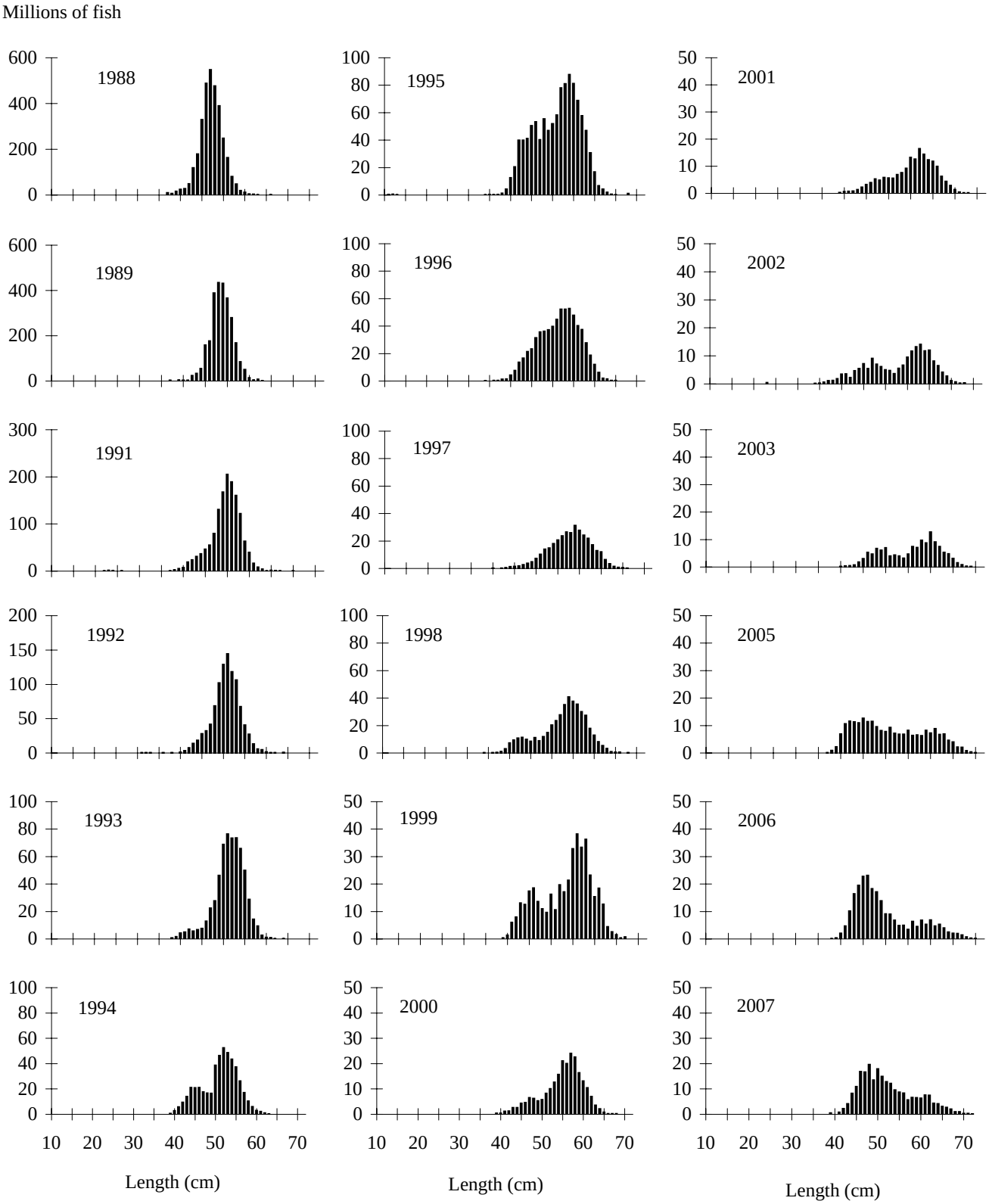

Figure 8.--Numbers-at-length estimates (millions) from winter echo integration-trawl surveys of spawning pollock near Bogoslof Island. The United States conducted all but the 1999 survey, which was conducted by Japan. There were no surveys in 1990 or 2004. Note: Y-axis scales differ.

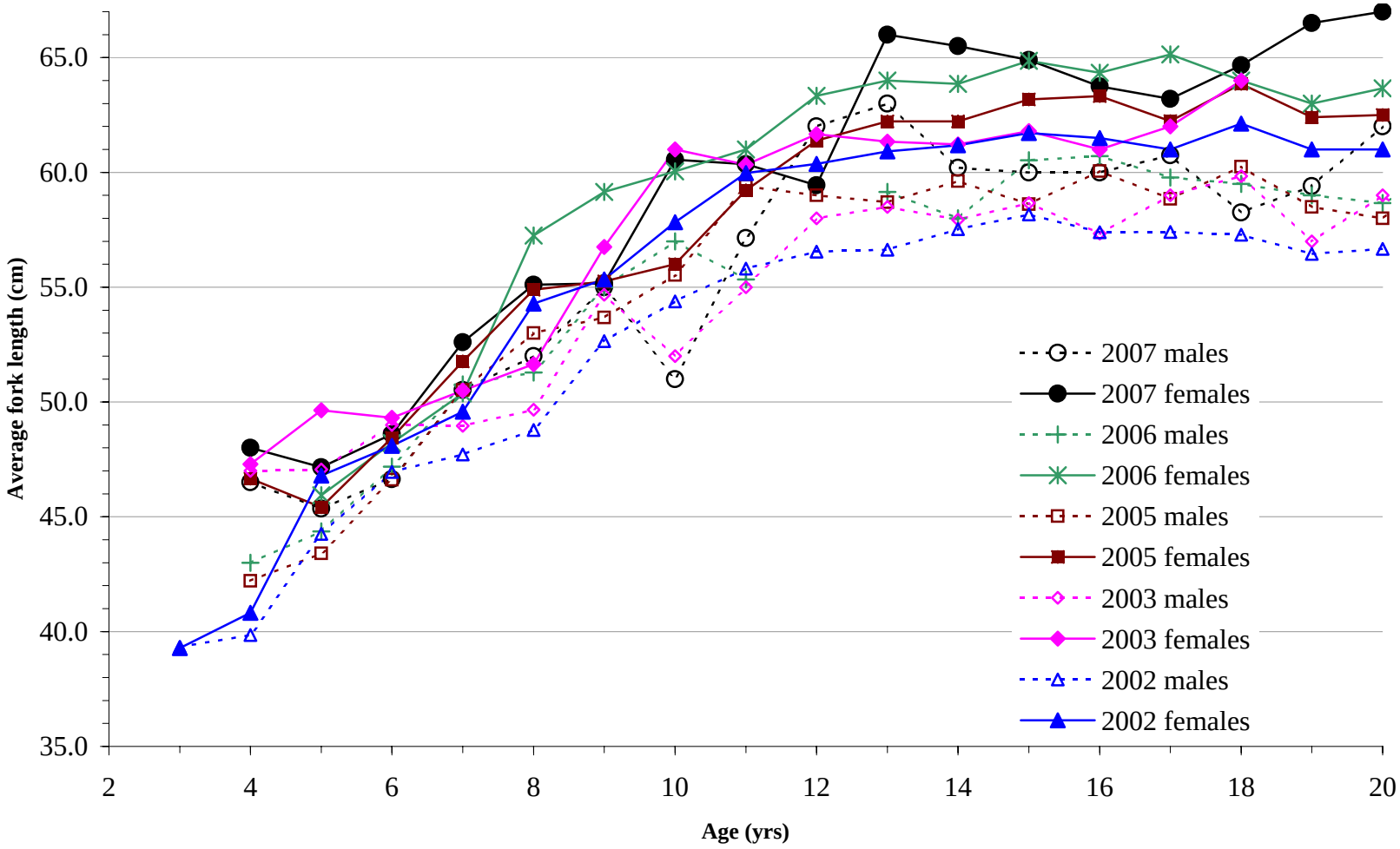

Figure 9.--Average length at age for pollock from the winter 2002, 2003, 2005, 2006 and 2007 echo integration-trawl surveys of the Bogoslof Island area.

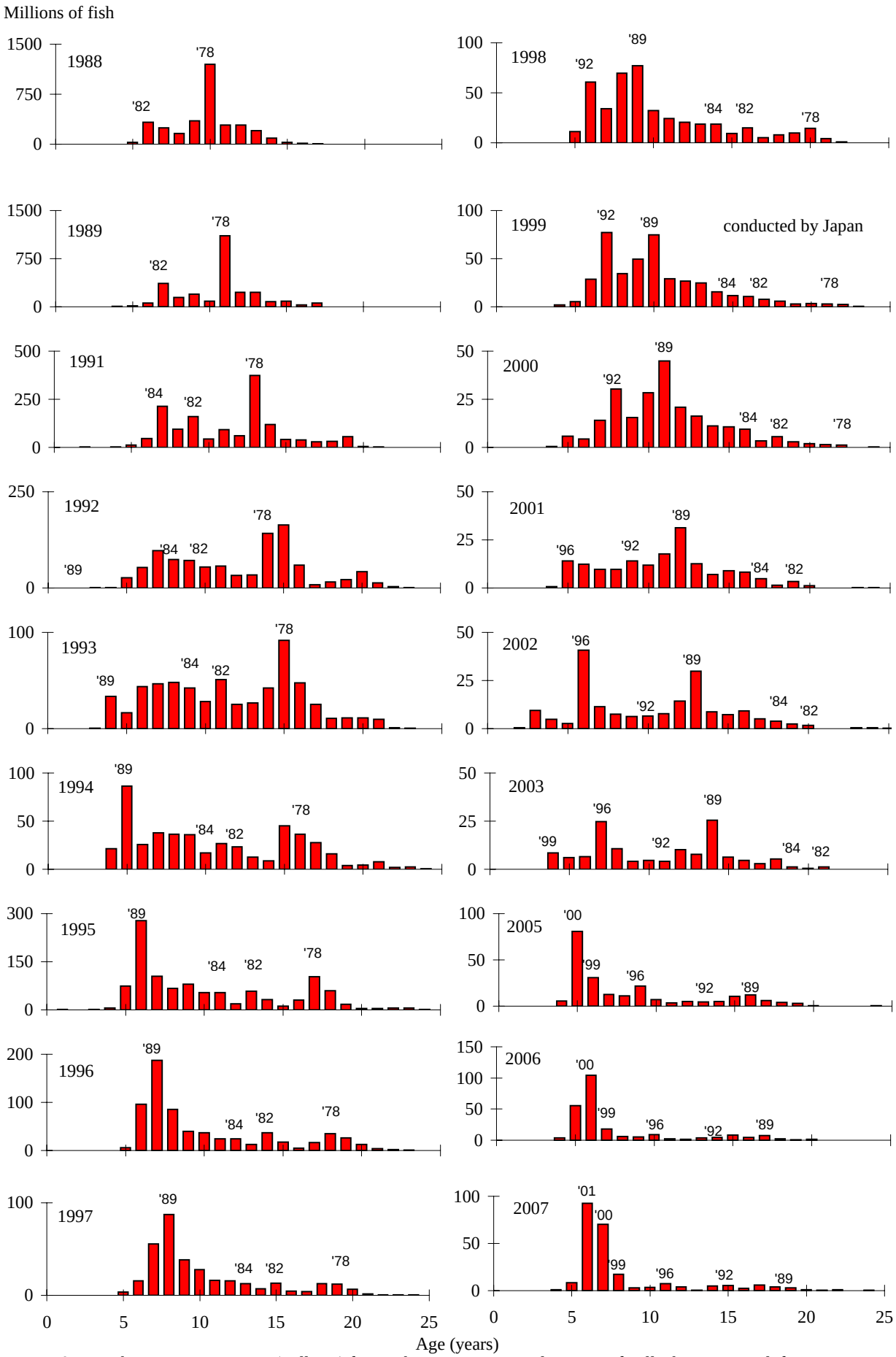

Figure 10.--Numbers-at-age estimates (millions) from echo integration-trawl surveys of pollock near Bogoslof Island. Major Bering Sea shelf year classes are indicated. No surveys were conducted in 1990 or 2004.

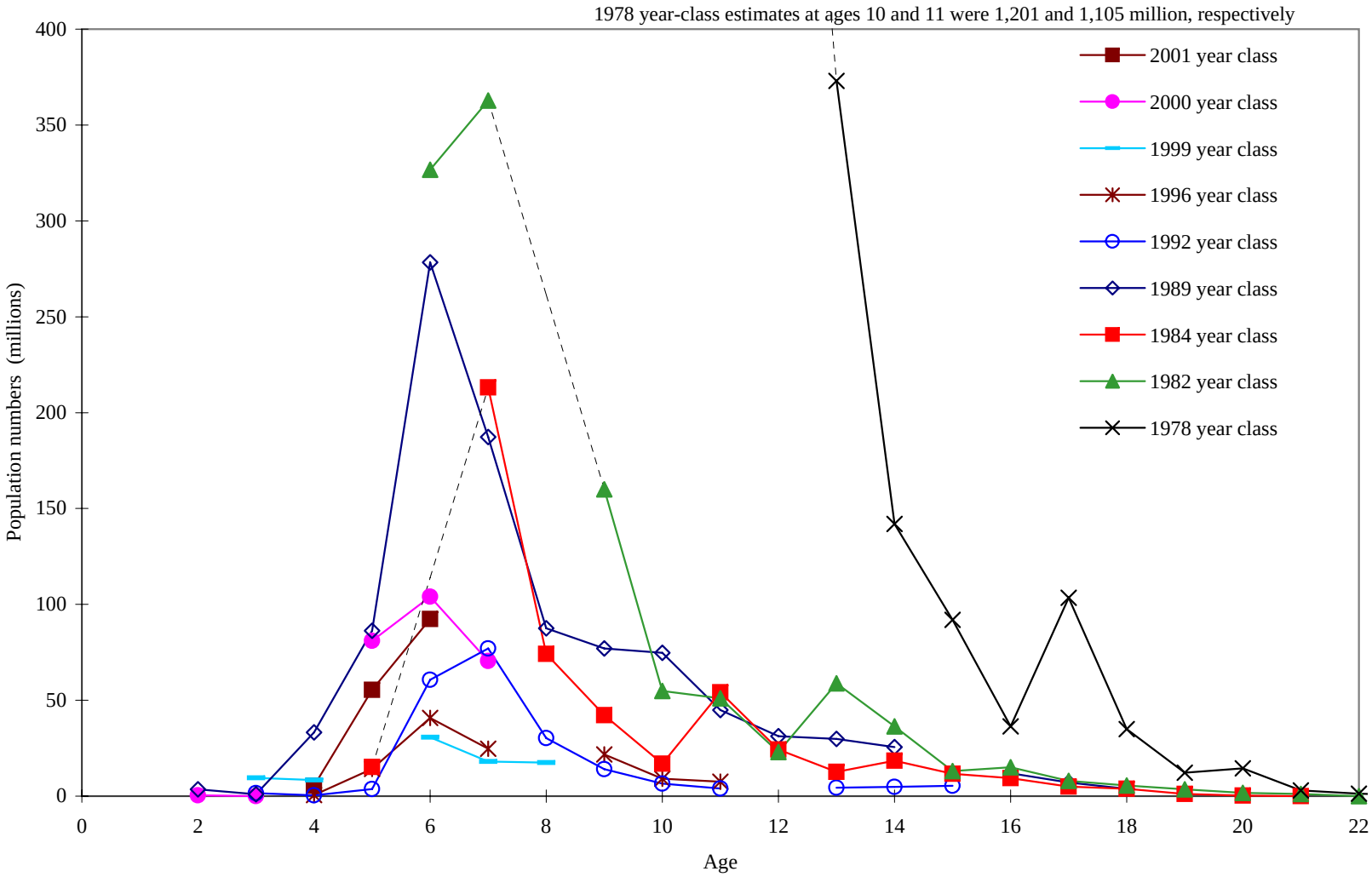

Figure 11.--Estimated population numbers at age for dominant year classes observed in winter echo integration-trawl surveys of Bogoslof Island area spawning pollock. Data are from surveys conducted between 1988 and 2007. The United States conducted all but the 1999 survey, which was conducted by Japan. No surveys were conducted in 1990 (dashed lines) or 2004.

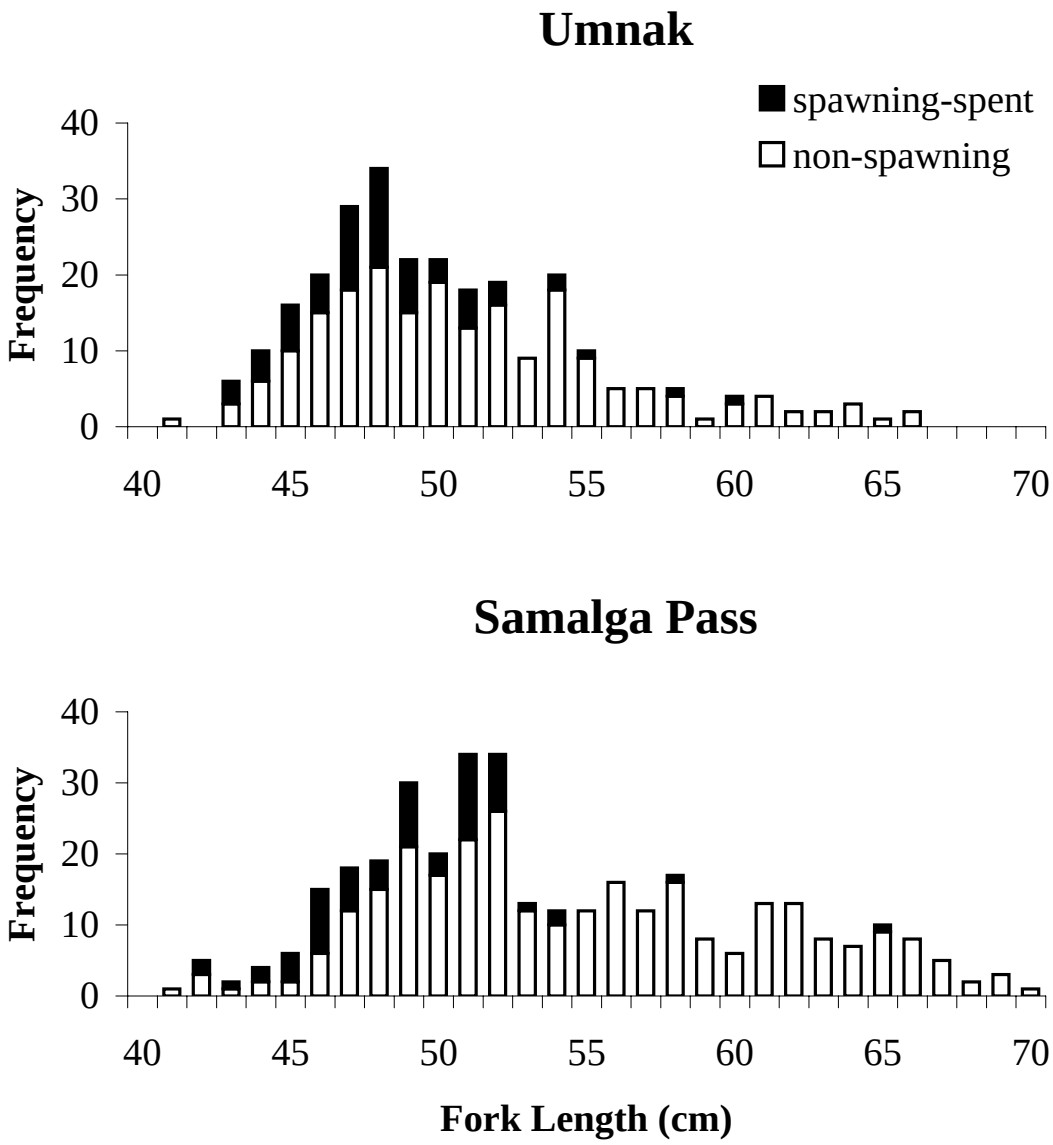

Figure 12.--Unweighted female pollock maturity at length for non-spawning and spawning-spent maturity stages observed in the Umnak and Samalga Pass regions during the winter 2007 echo integration-trawl survey of the Bogoslof Island area.

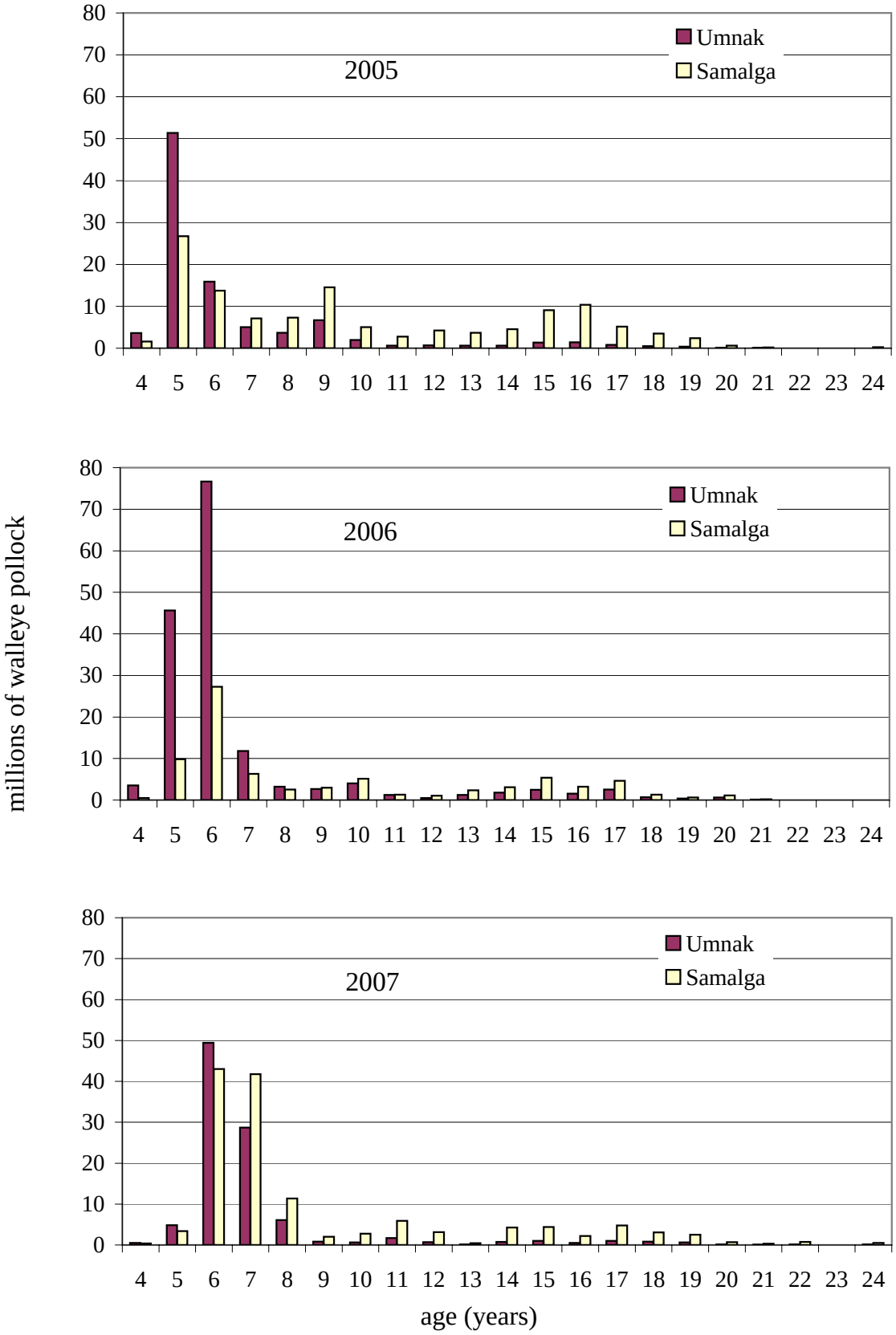

Figure 13.--Estimated age composition (millions of walleye pollock) of the two main spawning regions in the Bogoslof Island area from echo integration-trawl surveys between 2005 and 2007.