Results of the March 2009 Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Southeastern Aleutian Basin Near Bogoslof Island, Cruise DY2009-03

by Denise McKelvey

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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 (Honkalehto et al. 2008). These surveys were conducted annually between 1988 and 2007 (with the exception of 1990 and 2004), and biennially starting in 2009. 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 information from the winter 2009 EIT survey, and provides an abundance estimate. It also summarizes physical oceanographic observations and acoustic system calibration results.

METHODS

MACE scientists conducted the EIT survey between 7-11 March 2009 (Cruise DY2009-03) aboard the NOAA ship *Oscar Dyson*, a 64-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, 70, 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.

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[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 were conducted to measure acoustic system performance. During calibration, the *Oscar Dyson* 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, 70, 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).

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. Acoustic telegram data from all frequencies were logged with Myriax EchoLog 500 (v. 4.40) and raw data were logged using ER60 software (v. 2.2.0). Acoustic system settings used during the survey were based on 38 kHz results obtained during the 12-February acoustic system calibration (Table 1). Acoustic measurements were analyzed using Myriax Echoview post-processing software (Version 4.60.49). The sounder detected bottom line used in analysis was a mean value derived from 3-5 frequency-dependent sounder detected bottom lines (Jones, in prep.). Results presented in this report were based on the 38 kHz echo integration telegram data with a post processing S_v threshold of -70dB.

Trawl Gear and Oceanographic Equipment

The NOAA ship *Oscar Dyson* 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, where it was fitted with a single 12 mm (0.5 in) 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) 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 Simrad FS70 third-wire netsonde attached to the trawl headrope. During trawl deployment the vertical net opening ranged from 20 to 30 m and averaged 26.3 m.

Physical oceanographic measurements were made throughout the cruise. Temperature-depth profiles were obtained at trawl sites with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope, and conductivity-temperature-depth (CTD) measurements were collected with a Sea-Bird CTD system at calibration sites. Salinity was measured continuously using the vessel's Sea-Bird Electronics SBE-45 external probe located at the bow, and surface temperature was measured continuously using the Furuno T-2000 external probe located mid-ship, approximately 1.4 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). Surface temperatures were averaged to 0.5 nmi intervals for plotting purposes.

Survey Design

The survey occurred during 7-13 March and proceeded westward from Unalaska Island at about 167°W longitude to the Islands of Four Mountains near 170°W (Fig. 1). A random start position was generated for the first transect. From that point, the survey followed 35 north-south parallel transects spaced 3 nmi apart to cover 1870 nmi^2 of the CBS Convention Specific Area. The average transecting speed was 11.4 knots.

Trawl hauls were conducted to identify the species composition of 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, gonad maturity, and ovary weight of selected females. Walleye pollock fork lengths were measured to the nearest centimeter (cm). Smaller forage fish such as lanternfishes (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.

Walleye pollock otoliths were collected and stored in 50% ethanol-water solution for age determinations. Gonad 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.

Data Analysis

Walleye pollock abundance was estimated by combining acoustic backscatter and trawl information. Acoustic backscatter identified as either walleye pollock, fish, or an undifferentiated mixture of primarily macro-zooplankton were binned at 0.5 nmi horizontal by 20 m vertical resolution and stored in a database. Trawl information provided walleye pollock length compositions and mean weight-at-length data necessary to scale acoustic measurements. In the Bogoslof Island area, pre-spawning walleye pollock aggregations are often densely packed and vertically stratified by sex (Schabetsberger et al. 1999). Past surveys have indicated that females were usually densely schooled in the shallower layers, while males were abundant in deeper layers. This stratification makes sampling the deeper layers difficult without over sampling the shallower layer. Because female walleye pollock are longer than males after about 5 years of age, biased estimates of sex composition from hauls can result in biased estimates of population size and age composition. For this reason, the sample sex ratio was assumed to be 50:50 as in previous Bogoslof surveys. Thus, walleye pollock length measurements were combined into length strata based on the similarity in size composition data. 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 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

[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

length and weight data (De Robertis and Williams 2008). Walleye pollock numbers and biomass for the Bogoslof length stratum were estimated as follows:

The echo sounder measured nautical area scattering coefficient s_A (MacLennan et al. 2002), which is proportional to fish abundance. The acoustic return from an individual fish is referred to as its backscattering cross-section (σ_{bs}), or in more familiar (logarithmic) terms as its target strength (TS), where

$$TS = 10 \log \sigma_{bs}.$$

The estimated TS to length relationship for walleye pollock (Traynor 1996) is

$$TS = 20 \log_{10} L - 66.$$

Biological information available from the trawl hauls included:

length composition, where P_i is the proportion at length L_i,

mean weight-at-length, $\overline{W}_i$,.

For a given length stratum of area (A), backscatter attributed to walleye pollock were scaled to abundance using a weighted mean backscattering cross-section and the biological information as follows:

$$\overline{\sigma}_{bs} = \Sigma_i (P_i \times \sigma_{bsi}), \text{ where } \sigma_{bsi} = 10^{((20 \log L_i - 66)/10)};$$

Numbers at length $L_i = N_i = P_i \times \overline{s}_A \times A / 4\pi \overline{\sigma}_{bs}$;

Biomass at length $L_i = B_i = \overline{W}_i \times N_i$;

Relative estimation errors associated with spatial structure observed in the acoustic data were derived using a one-dimensional (1D) geostatistical method (Petitgas 1993, Walline 2007, Williamson and Traynor 1996). 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) were not included.

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.

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 1).

Physical Oceanography

Water temperatures measured during the survey were slightly cooler than temperatures measured in 2007. In 2009, mean surface temperatures ranged from 2.8 to 4.0ºC, with the coolest temperatures observed on the western transects 30-35 (Fig. 1). In 2007, surface temperatures ranged between 3.3 to 3.9 ºC, with the coolest temperatures observed on the eastern transects 1-4 (Honkalehto et al. 2008). Water temperature profiles at trawl sites indicated a well-mixed water column. Water column temperatures were generally cooler than temperatures observed in 2007 (Fig. 2). Temperatures measured in the water column between 300 and 600 m, where most of the walleye pollock were vertically distributed in the Bogloslof area in 2009, averaged between 3.5º and 3.8ºC (Fig. 2).

Trawl Samples

Biological data and specimens were collected from five trawl sites (Tables 2 and 3; Fig. 1). By weight, walleye pollock dominated all trawl catches and represented 94.3% of the total catch (Table 4). However by number, pollock accounted for only 8.8% of the total catch. This year, a 0.5 inch codend liner was implemented, replacing the 1.25 inch liner used in historical surveys. Hence, numerous small fishes and shrimp were captured. Myctophid species accounted for 86.6% and shrimp accounted for 4.1% of the total catch by number.

Walleye pollock length measurements ranging between 41 and 70 cm FL were collected from 1,707 fish. The size composition was characterized by a dominant mode at 55 cm FL. Because of the similarity in size compositions between the Umnak (transects 1-18) and Samalga regions (transects 19-35), all lengths were grouped into one length stratum. Trawl catch sex ratios among hauls ranged from 9% to 72% 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, otoliths, and weights were collected from 387 walleye pollock specimens (Table 3). For the Umnak and Samalga regions, few fish were immature or spent, most were in pre-spawning condition (Fig. 4a). In the Umnak area, the maturity composition (unweighted) for males was 51% pre-spawning, 47% spawning, and 1% spent. The female maturity composition was 95% pre-spawning, 2% spawning, and 3% spent. In the Samalga area, the maturity composition for males was 93% pre-spawning, 7% spawning, and <1% spent. The female maturity composition was 1% developing, 98% pre-spawning, and 1% spawning. The average GSI for pre-spawning mature female walleye pollock was 0.167 for both regions combined, 0.195 for Umnak and 0.143 for Samalga (Fig. 3b). The combined average GSI estimate was similar to that observed during surveys between 2002 and 2007 (i.e., 0.17 – 0.18 for the entire area; Honkalehto et al. 2008). The mean body weight-at-length for sexes combined was estimated using observed measurements for all but thirteen length intervals (Fig. 3c). The mean weight-at-length for the remaining length intervals was estimated by Weight (g) = 0.0016327 × Fork Length (cm) $^{3.4161}$ and corrected for a small bias due to back transformation (Miller 1984).

Distribution and Abundance

Walleye pollock were mainly concentrated in one region just north of Samalga Pass (Fig. 4). About 86% of the survey biomass was observed in the Samalga area leaving only 14% in the Umnak area (northeast of Umnak Island and Umnak Pass). Three transects in the Samalga area accounted for 71% of the total biomass. Walleye pollock were distributed in midwater between about 150 and 600 m (Fig. 5). Fish generally stayed close to the seafloor 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 425-525 m. This was similar to what was observed in 2006 (~400-550 m) but slightly shallower than what was observed in 2007 (~475-650 m).

The abundance estimate for walleye pollock in the Bogoslof area was 73 million fish weighing 0.110 million metric tons (t) (Tables 5, 6, 7; Fig. 6). The size composition was unimodal (Figs. 7 and 8) with a mean of 55.3 cm FL (Fig. 6). Based on the 1D analysis, the relative estimation error of the abundance estimate was 19.2% (Table 6).

Research Projects

Ancillary research efforts focused on opportunistic deployment of a lowered acoustic system (LAS) during the cruise. The primary components of this system include a frame assembly housing a 38-kHz transducer (Simrad ES38DD) on a gimbaled mount, and a Simrad EK60 echo sounder. Lowering the LAS system closer to the fish will allow in situ TS measurements of targets in aggregations or currently out of range of the centerboard system. Seven deployments were successfully completed, six occurred in the Samalga Pass region and one in the Umnak region (Table 8).

DISCUSSION

The 2009 Bogoslof EIT survey estimate for walleye pollock was 73 million fish, down from 236 million fish in 2007. Most of the decreased abundance was observed for fish less than 50 cm FL Although age-at-length results for the 2009 EIT survey were not yet available, age data from previous years suggest that fish 41-49 cm FL were about 4-6 years old (Honkalehto et al. 2008). This decrease was likely due to weak recruitment from the 2003-2005 year classes, which were also relatively weak year classes on the Bering Sea shelf (Ianelli et al. 2008). Without the recruiting year classes, the population in Umnak and Samalga were primarily composed of older fish from the 1999-2002 year classes. The predominance of larger fish in the Umnak and Samalga regions shifted the unweighted female maturity composition from 77% developing and pre-spawning observed in 2007 to 97% in 2009 (Fig 9).

Honkalehto et al. (2008) noted that 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 of the overall biomass ($\leq$26%), while in the 2005-2007 surveys, the Umnak component accounted for an increased portion of the overall biomass (34% in 2005, 58% in 2006, and 35% in 2007). In the 2009 survey, the Umnak portion was once again a relatively small portion of the overall biomass at 14%.

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Itinerary

6 March	Embark scientists in Dutch Harbor, AK
7 March	Calibration of acoustic system in Broad Bay, Alaska
7-13 March	EIT survey of the Bogoslof Island area, DTS research
13-15 March	Transit to Kodiak Island
15 March	Inport Kodiak, AK

Scientific Personnel

Name	Position	Organization
Denise McKelvey	Chief Scientist	AFSC
Michael Guttormsen	Fishery Biologist	AFSC
Scott Furnish	Info. Tech. Specialist	AFSC
Abigail McCarthy	Fishery Biologist	AFSC
Darin Jones	Fishery Biologist	AFSC
William Floering	Fishery Biologist	AFSC
Robb Kaler	Seabird Observer	USFWS

AFSC	Alaska Fisheries Science Center, Seattle WA
USFWS	United States Fish and Wildlife Service, Juneau, AK

Table 1. -- Simrad ER60 38 kHz acoustic system description and settings used during the winter 2009 echo integration-trawl surveys of walleye pollock in the Bogoslof Island area, and results from standard sphere acoustic system calibrations conducted before and after the survey.

	Bogoslof Survey system settings	12-Feb Three Saints Bay Alaska	8-Mar Broad Bay, Alaska	29-Mar Kizhuyak Bay, Alaska
Echosounder:	Simrad ER60	--	--	--
Transducer:	ES38B	--	--	--
Frequency (kHz):	38	--	--	--
Transducer depth (m):	9.15	--	--	--
Pulse length (ms):	1.024	--	--	--
Transmitted power (W):	2000	--	--	--
Angle sensitivity along:	22.83	--	--	--
Angle sensitivity athwart:	21.43	--	--	--
2-way beam angle (dB):	-20.77	--	--	--
Gain (dB)	22.95	22.95	22.98	23.07
S_a correction (dB)	-0.60	-0.60	-0.63	-0.69
S_v gain (dB)	22.35	22.35	22.35	22.38
3 dB beamwidth along	6.84	6.84	6.73	6.78
3 dB beamwidth athwart	7.28	7.28	7.18	7.11
Angle offset along	-0.08	-0.08	-0.06	-0.06
Angle offset athwart	-0.11	-0.11	-0.10	-0.09
Measured standard sphere TS (dB)	--	-42.20	-42.09	-41.86
Sphere range from transducer (m):	--	19.25	19.25	24.35
Absorption coefficient (dB/m):	0.0099	0.0100	0.0100	0.0099
Sound velocity (m/s)	1466.0	1456.9	1461.5	1454.5
Water temp at transducer (^{o}C):	--	2.9	3.0	2.8

Note: Gain and beam pattern terms are defined in the "Operator Manual for Simrad ER60 Scientific echo sounder application (2004)," which is available from Simrad Strandpromenaden 50, Box 111,

Table 2.--Trawl station and catch data summary from the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul		Date	Time	Duration	Start position		Depth (m)		Water temp. (°C)		Catch		
											Pollock		Other
No.	Region	(GMT)	(GMT)	(minutes)	Latitude (N)	Longitude (W)	Footrope	Bottom	Headrope	Surface[1]	(kg)	Number	(kg)
1	Umnak	9-Mar	1:39	21	53° 35.32'	167° 45.73'	453	691	3.8	3.8	1,033	760	32.7
2	Samalga	10-Mar	17:35	13	53° 00.63'	169° 16.69'	500	745	-	3.6	1,158	690	27
3	Samalga	11-Mar	3:36	12	53° 03.68'	169° 22.71'	498	755	3.7	3.4	754	505	59.6
4	Samalga	11-Mar	9:35	46	53° 04.66'	169° 22.52'	549	855	3.5	3.5	1,155	909	240.4
5	Umnak	13-Mar	0:09	17	53° 35.53'	167° 43.94'	471	600	3.8	3.8	2,608	1,608	44

[1]Temperature from hull mounted Furuno T-2000, 1.4 m below surface

Table 3.--Numbers of fish measured and biological samples collected during the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul	Walleye pollock				Myctophid
	Random	Weights and		Ovary	
no.	lengths	maturities	Otoliths	weights	lengths
1	376	110	80	63	-
2	306	80	79	37	-
3	304	81	81	40	-
4	411	80	80	40	85
5	310	67	67	37	-
Totals	1,707	418	387	217	85

Table 4.--Catch by species from 5 midwater trawl hauls during the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Species name	Scientific name	Weight (kg)	%	Number	%
walleye pollock	*Theragra chalcogramma*	6,706.8	94.3	4,472	8.8
lampfish sp	*Stenobrachius* sp.	319.7	4.5	38,566	76.3
brokenline lanternfish	*Lampanyctus jordani*	23.5	0.3	798	1.6
northern smoothtongue	*Leuroglossus schmidti*	13.3	0.2	3,778	7.5
squid unidentified	Teuthoidea (order)	11.9	0.2	169	0.3
giant grenadier	*Albatrossia pectoralis*	8.7	0.1	3	<0.1
California headlightfish	*Diaphus theta*	8.0	0.1	598	1.2
Pacific lamprey	*Lampetra tridentata*	7.7	0.1	15	<0.1
chum salmon	*Oncorhynchus keta*	3.4	<0.1	1	<0.1
shrimp unident.	Decapoda (order)	2.6	<0.1	2,082	4.1
Pacific viperfish	*Chauliodus macouni*	1.9	<0.1	70	0.1
Pacific ocean perch	*Sebastes alutus*	1.4	<0.1	1	<0.1
arrowtooth flounder	*Atheresthes stomias*	0.6	<0.1	1	<0.1
sockeye salmon	*Oncorhynchus nerka*	0.3	<0.1	1	<0.1
popeye grenadier	*Coryphaenoides cinereus*	0.2	<0.1	1	<0.1
vampire squid	*Vampyroteuthis infernalis*	0.2	<0.1	1	<0.1
longfin dragonfish	*Tactostoma macropus*	0.2	<0.1	1	<0.1
Japanese spineyridge shrimp	*Notostomus japonicus*	0.1	<0.1	3	<0.1
lanternfish unidentified	Myctophidae (family)	<0.1	<0.1	11	<0.1
Total		7,110.5		50,572	

Table 5.--Walleye pollock biomass (metric tons (t)) estimated by survey area and management area from February-March echo integration-trawl surveys in the Bogoslof Island area between 1988 and 2009.

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
2008	--	No survey	--	--	--
2009	0.110	1,803	19.2	0.110	19.2

Table 6.--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, 2004, or 2008. 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	2008	2009
10	0	0	--	0	0	0	0	<1	0	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	--	0
12	0	0	--	0	0	0	0	1	0	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	--	0
14	0	0	--	0	0	0	0	<1	0	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	--	0
16	0	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	--	0
18	0	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	--	0
20	0	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	--	0
22	0	0	--	<1	0	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	--	0
24	0	0	--	1	0	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	--	0
26	0	0	--	<1	0	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	--	0
28	0	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	--	0
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	<1	0	--	0	0	0	--	0
31	0	0	--	0	<1	0	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	--	0
33	0	0	--	0	<1	0	0	0	0	0	0	0	0	0	<1	<1	--	0	0	0	--	0
34	0	0	--	0	0	0	0	<1	<1	0	<1	0	0	0	<1	<1	--	0	0	0	--	0
35	0	0	--	0	0	0	0	<1	0	<1	0	0	0	0	<1	0	--	0	0	0	--	0
36	0	0	--	0	<1	0	0	<1	<1	<1	<1	0	0	0	1	0	--	0	0	0	--	0
37	9	3	--	<1	0	0	0	<1	<1	<1	<1	0	0	0	1	<1	--	<1	0	0	--	0
38	6	0	--	2	<1	1	0	1	1	<1	1	0	0	<1	1	<1	--	1	<1	0	--	0
39	16	4	--	5	0	2	<1	4	1	1	3	<1	<1	<1	2	<1	--	2	<1	<1	--	0
40	24	3	--	7	1	4	3	12	4	1	7	1	<1	1	3	<1	--	7	2	0	--	0
41	27	4	--	19	3	5	6	20	8	2	9	6	1	1	4	<1	--	11	5	1	--	<1
42	48	23	--	23	7	7	9	40	14	3	11	8	1	1	2	<1	--	12	10	2	--	<1
43	118	33	--	31	14	6	14	40	17	4	11	13	3	1	5	1	--	11	16	4	--	<1
44	179	54	--	36	18	7	21	41	21	5	10	13	3	2	5	2	--	11	20	8	--	<1
45	329	159	--	46	28	8	21	50	23	7	9	17	4	3	7	3	--	13	23	11	--	<1
46	488	177	--	55	32	13	21	53	31	10	11	19	5	4	5	5	--	11	23	17	--	<1
47	547	389	--	79	42	22	18	40	36	14	9	14	6	5	9	5	--	11	18	17	--	1
48	476	434	--	130	68	28	17	55	36	15	12	11	6	5	7	7	--	10	17	20	--	1
49	389	431	--	168	102	46	16	47	37	18	15	10	5	6	6	6	--	8	14	14	--	2
50	248	366	--	205	129	69	39	52	40	21	20	16	6	6	5	7	--	8	9	18	--	2
51	162	279	--	189	144	76	46	58	45	24	23	11	8	6	5	4	--	9	9	15	--	5
52	80	168	--	160	118	73	52	78	52	26	28	20	10	7	4	4	--	7	7	13	--	5

Table 6.--Continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
53	48	85	--	122	106	73	49	81	52	26	35	17	13	8	6	4	--	7	5	12	--	6
54	19	50	--	63	67	66	43	88	53	31	41	21	16	9	7	3	--	7	5	10	--	8
55	12	13	--	40	41	50	37	81	48	28	38	33	21	13	9	5	--	8	3	9	--	8
56	4	5	--	17	27	29	26	69	40	24	35	38	20	13	12	7	--	6	6	8	--	8
57	3	8	--	8	13	14	17	58	37	22	30	33	24	16	13	7	--	7	5	6	--	6
58	1	1	--	4	6	9	10	47	28	17	27	36	23	14	14	10	--	6	7	7	--	6
59	0	0	--	1	5	3	6	31	19	13	18	23	16	12	12	9	--	8	5	7	--	5
60	0	0	--	1	1	1	3	17	12	12	13	15	13	12	12	13	--	7	7	6	--	2
61	2	0	--	1	<1	1	2	7	6	6	8	18	10	10	8	9	--	9	5	8	--	2
62	0	0	--	<1	<1	<1	1	4	2	3	5	13	7	6	6	7	--	7	5	7	--	1
63	0	0	--	0	0	0	<1	2	1	1	3	4	4	4	4	5	--	7	4	4	--	2
64	0	0	--	0	1	<1	0	1	<1	1	1	3	2	3	3	5	--	5	2	4	--	1
65	0	0	--	<1	0	0	0	<1	<1	<1	1	1	1	1	1	3	--	4	2	3	--	<1
66	0	0	--	0	0	0	0	<1	0	<1	1	<1	<1	<1	1	1	--	2	2	3	--	<1
67	0	0	--	0	0	0	0	0	0	0	0	1	<1	<1	<1	1	--	2	1	2	--	<1
68	0	0	--	0	0	0	0	1	0	0	<1	0	<1	<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	--	<1
70	0	0	--	0	0	0	0	0	0	0	0	0	0	<1	<1	0	--	<1	<1	<1	--	<1
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	<1	<1	--	<1
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0	<1	--	<1
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0	0	--	<1
Total	3,236	2,687	--	1,419	975	613	478	1,081	666	337	435	416	229	170	181	134	--	225	239	236	--	73

Table 7.--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, 2004, or 2008. 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	2008	2009
10	0	0	--	0	0	0	0	<1	0	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	--	0
12	0	0	--	0	0	0	0	5	0	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	--	0
14	0	0	--	0	0	0	0	1	0	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	--	0
16	0	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	--	0
18	0	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	--	0
20	0	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	--	0
22	0	0	--	13	0	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	--	0
24	0	0	--	61	0	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	--	0
26	0	0	--	26	0	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	--	0
28	0	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	--	0
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	6	0	--	0	0	0	--	0
31	0	0	--	0	37	0	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	--	0
33	0	0	--	0	48	0	0	0	0	0	0	0	0	0	9	2	--	0	0	0	--	0
34	0	0	--	0	0	0	0	53	35	0	29	0	0	0	47	2	--	0	0	0	--	0
35	0	0	--	0	0	0	0	93	0	29	0	0	0	0	72	0	--	0	0	0	--	0
36	0	0	--	0	68	0	0	42	96	18	32	0	0	0	202	0	--	0	0	0	--	0
37	3,199	846	--	115	0	0	0	113	109	84	92	0	0	0	451	16	--	39	0	0	--	0
38	2,304	0	--	768	84	260	0	435	465	173	395	0	0	19	503	6	--	323	29	0	--	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	--	0
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	--	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	--	40

Table 7.--Continued

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
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	--	37
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	--	32
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	--	190
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	--	206
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	--	244
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	--	630
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	--	1,037
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	--	1,704
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	--	2,274
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	--	5,008
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	--	6,218
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	--	7,889
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	--	10,821
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	--	12,592
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	--	11,674
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	--	9,419
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	--	10,094
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	--	9,084
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	--	4,605
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	--	4,627
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	--	2,380
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	--	4,095
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	--	2,290
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	--	1,146
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	--	1,108
67	0	0	--	0	0	0	0	0	0	0	0	863	520	420	591	1,948	--	5,161	3,264	5,323	--	414
68	0	0	--	0	0	0	0	2,570	0	0	276	0	403	426	765	744	--	2,157	1,716	2,716	--	112
69	0	0	--	0	0	0	0	0	0	0	0	0	0	63	0	390	--	933	644	2,774	--	117
70	0	0	--	0	0	0	0	0	0	0	0	0	0	95	64	0	--	381	467	880	--	103
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	99	74	796	--	0
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	118	0	375	--	0
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	109	0	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	--	110,191

Table 8.—Lowered acoustic system deployments during the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Cast No.	Date (GMT)	Time (GMT)	Transducer	Location Latitude °N	Location Longitude °W	Maximum Depth (m)
1	11-Mar	0530	MACE	53 06.59	169 19.66	450
2	11-Mar	1207	NE	53 03.31	169 20.81	450
3	12-Mar	0400	MACE	53 03.73	169 22.33	370
4	12-Mar	1005	MACE	53 19.71	168 51.67	450
5	12-Mar	1229	MACE	53 21.08	168 47.39	450
6	12-Mar	1610	NE	53 20.45	168 47.16	450
7	13-Mar	0250	NE	53 35.43	167 44.84	450

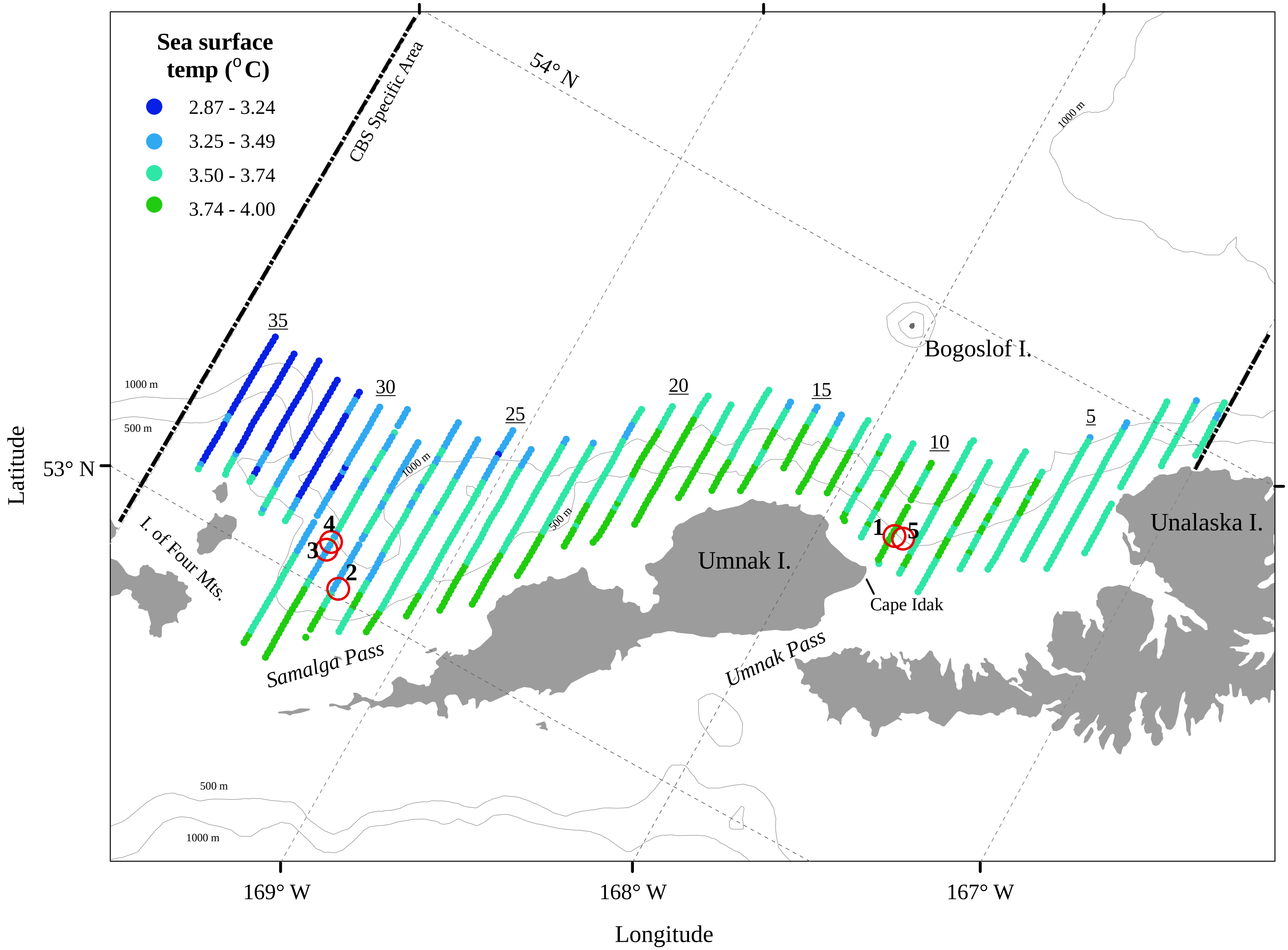

Figure 1.--Transects, haul locations, and sea surface temperatures measured from the ship's hull sensor and recorded during the winter 2009 echo integration-trawl survey of walleye pollock in the southeast Aleutian Basin near Bogoslof Island. Transect numbers are underlined, trawl haul locations are indicated by circles, and the Central Bering Sea Convention area is indicated by a dash-dotted line.

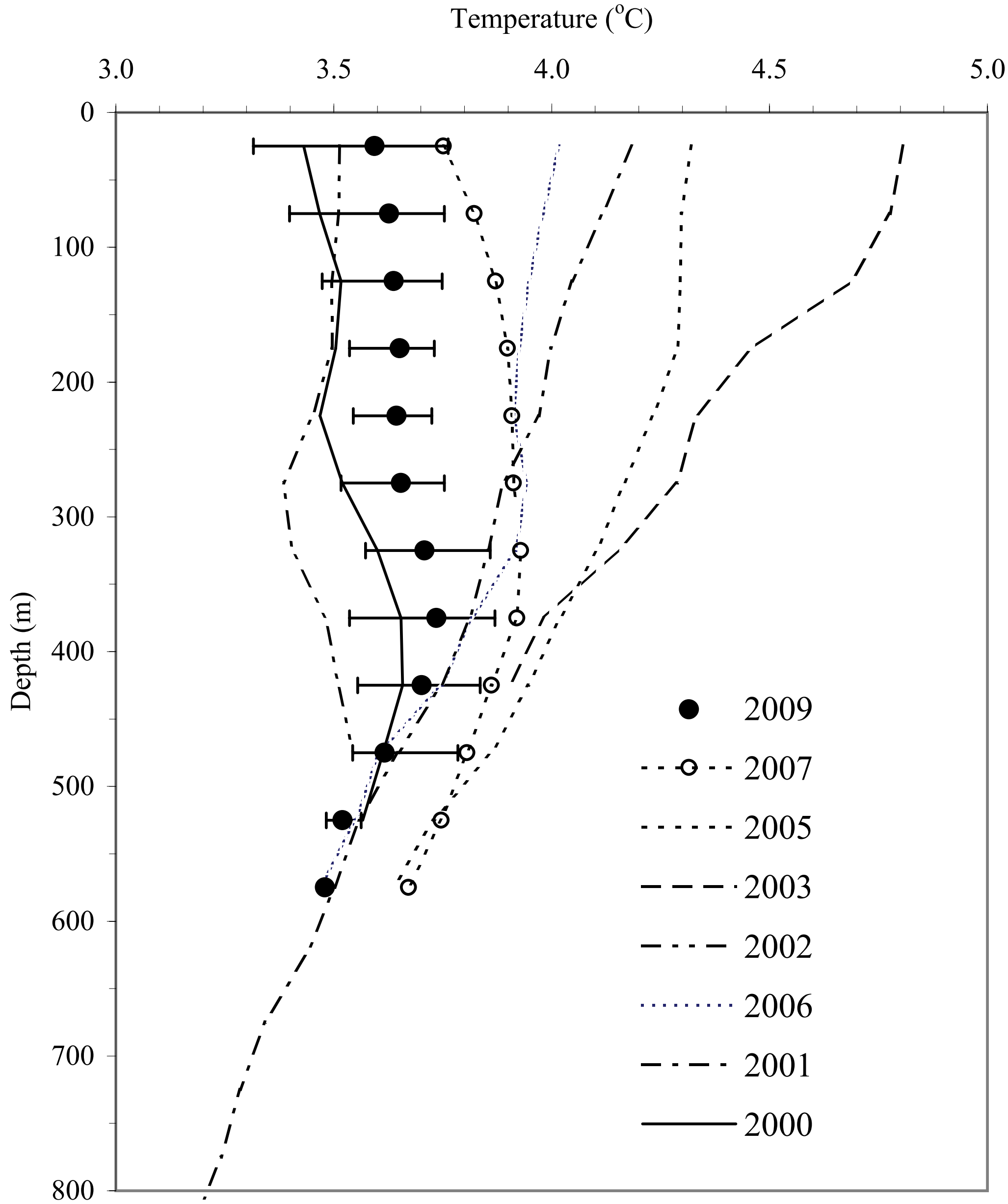

Figure 2.--Average temperature (°C) (symbols) by 50-m depth intervals observed during hauls from the winter 2000-2003, 2005-2007, and 2009 echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. The horizontal bars represent temperature ranges observed during the 2009 survey. Note: Temperature data from the 2003 survey were collected from only three locations.

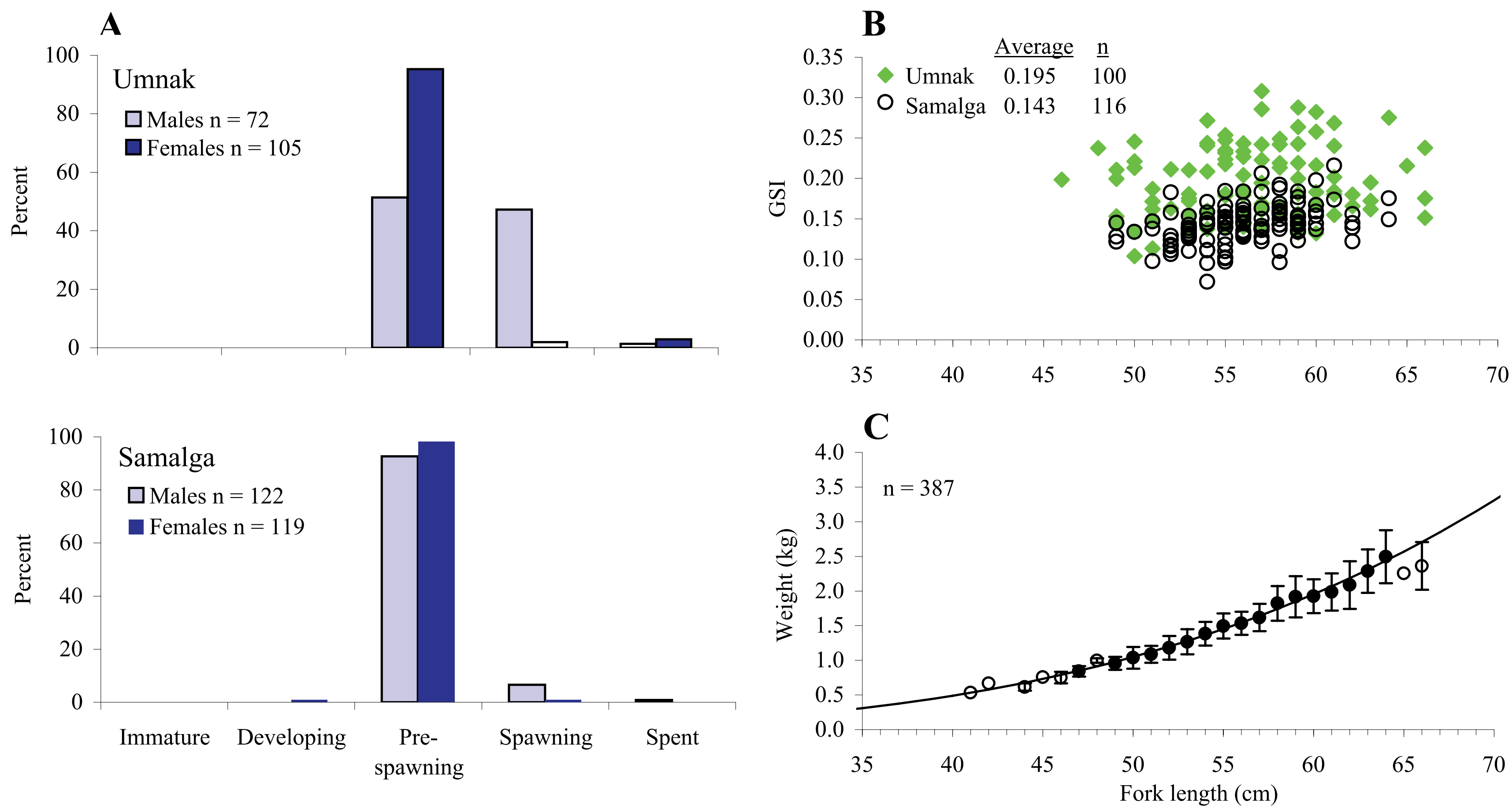

Figure 3.--Walleye pollock maturity stages by region and sex (A), gonado-somatic index (GSI) by region for pre-spawning females as a function of fork length (cm) (B), and observed mean weight-at-length with a fitted regression line for regions combined and sexes combined (C), observed during the winter 2009 echo integration-trawl survey of the Bogoslof Island area. In figure C, hollow circles indicate fewer than five fish were measured and vertical bars indicate +/- one standard deviation.

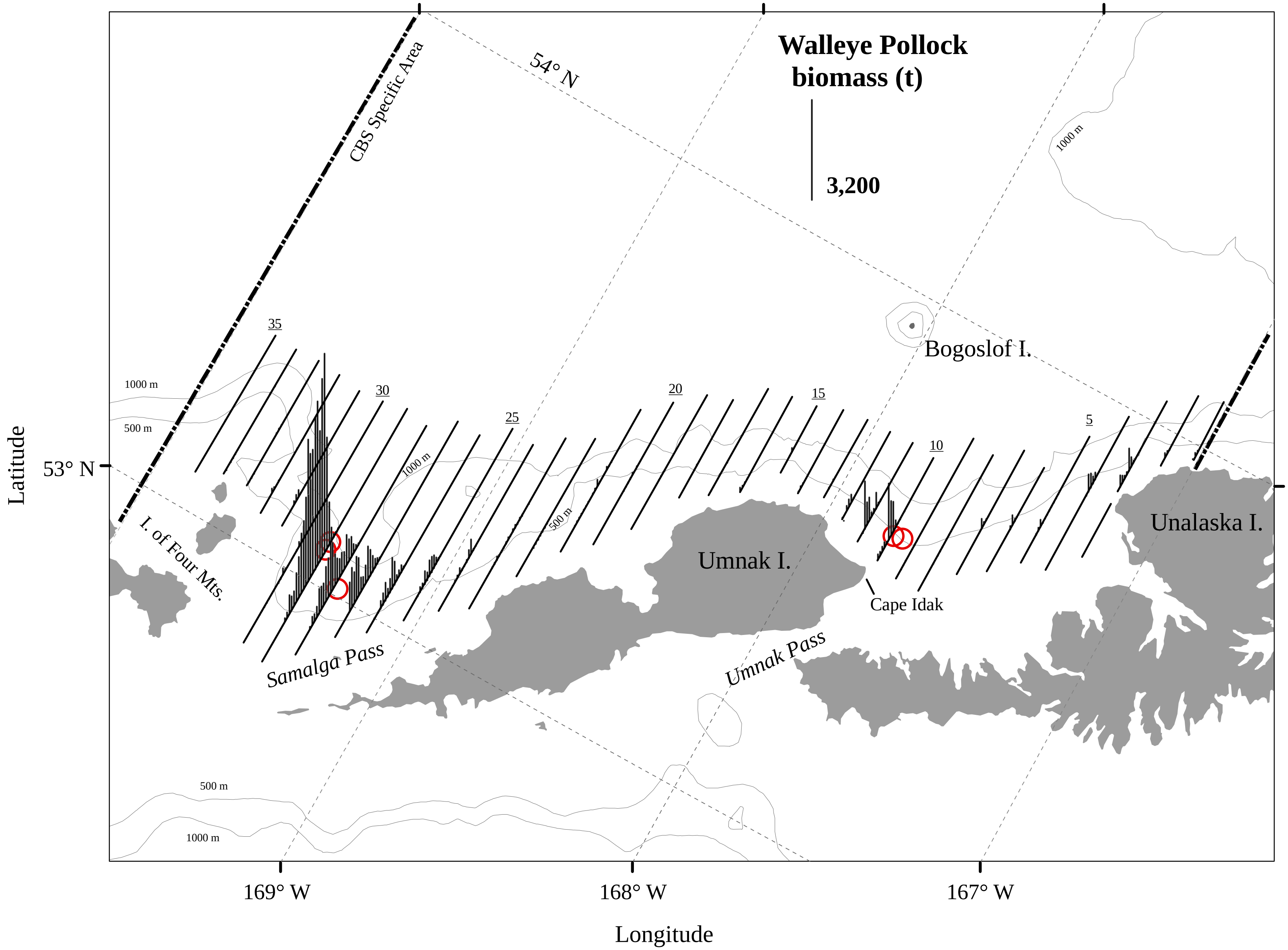

Figure 4.--Walleye pollock biomass in metric tons (t) observed along tracklines from the winter 2009 echo integration-trawl survey of walleye pollock in the southeast Aleutian Basin near Bogoslof Island. Trawl haul locations are indicated by circles and the Central Bering Sea Convention area is indicated by a dash-dotted line.

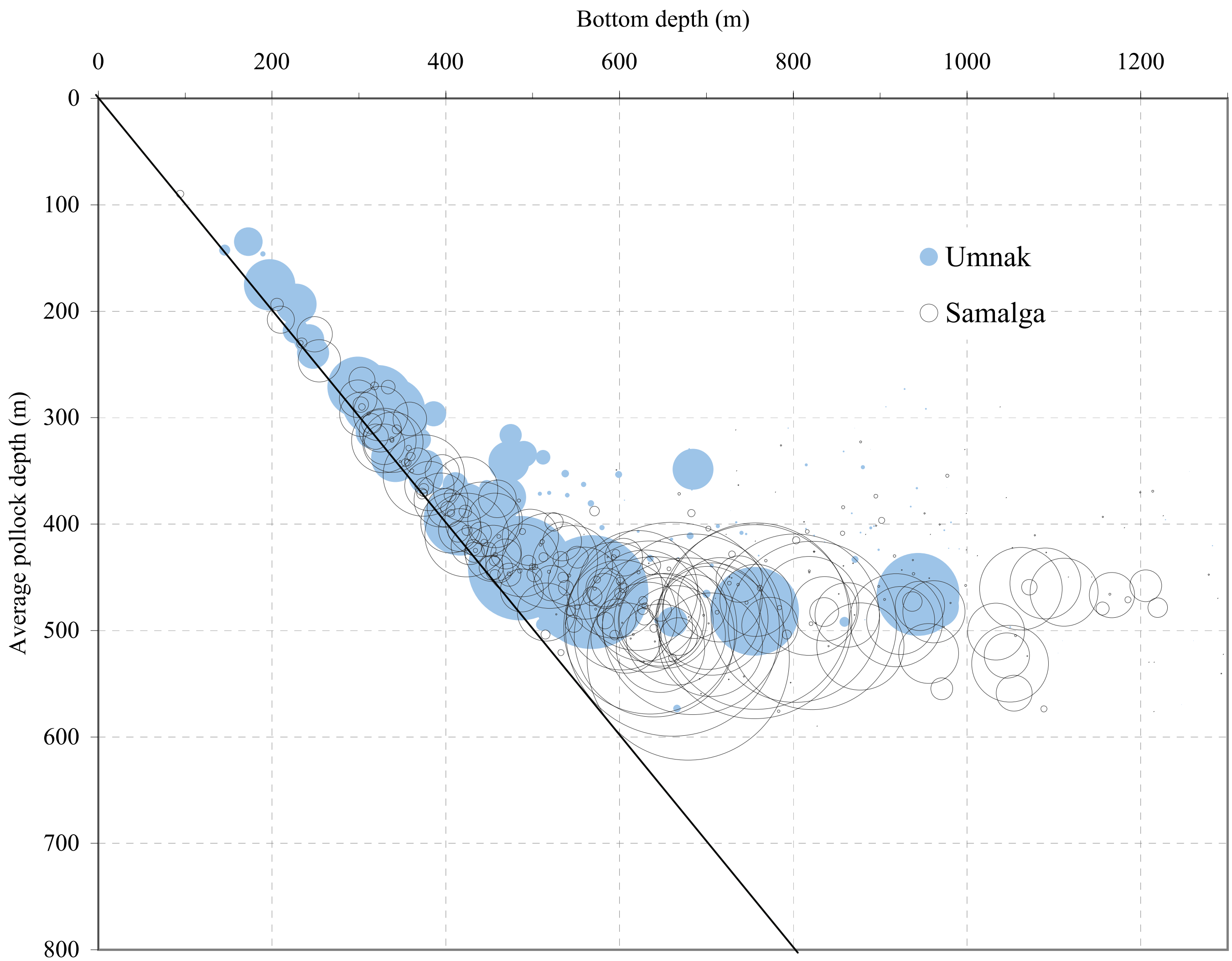

Figure 5.--Average pollock depth (weighted by biomass) versus bottom depth (m), per 0.5 nmi sailed distance for the Umnak and Samalga regions during the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Bubble size was scaled to the maximum biomass/0.5 nmi interval (Samalga region, 6,306 t). The diagonal line indicates where the average pollock depth equals bottom depth.

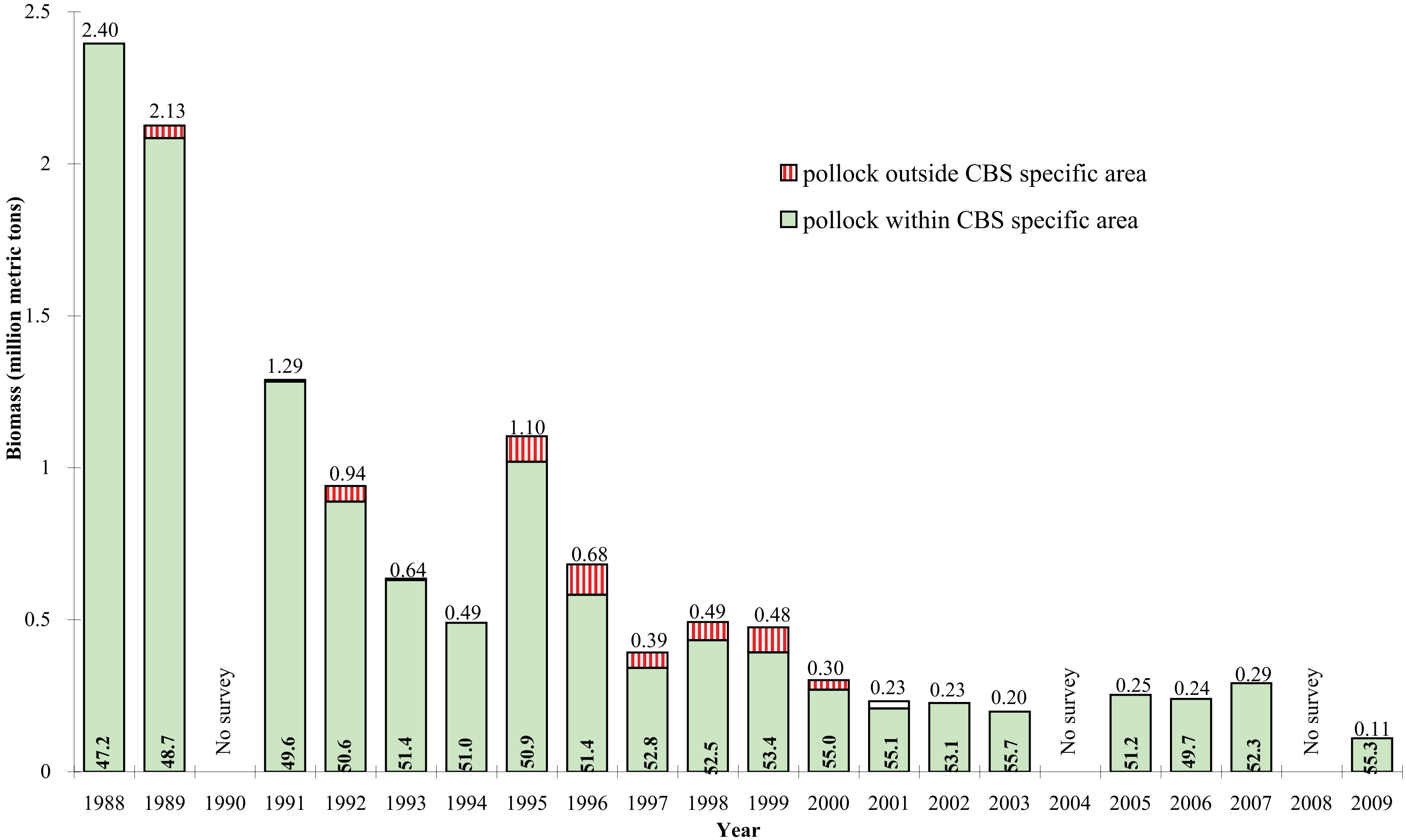

Figure 6.--Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2009. The 1999 survey was conducted by Japan. There were no surveys in 1990, 2004, or 2008. Total pollock biomass for each survey year is indicated on top of each bar and average fork length (cm) is indicated inside each bar.

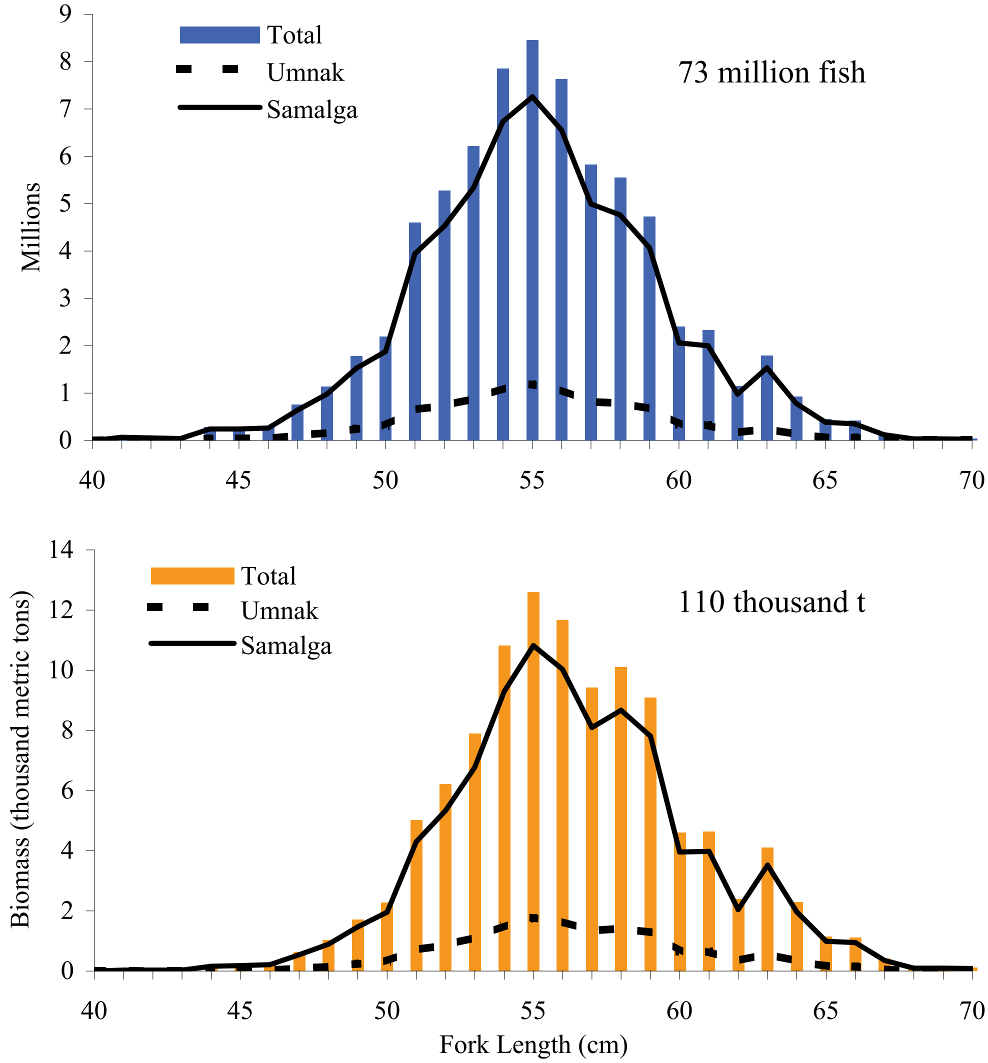

Figure7.- - Population at length (top) and biomass at length (bottom) estimates by region and total from the winter 2009 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Note Y-axis differences.

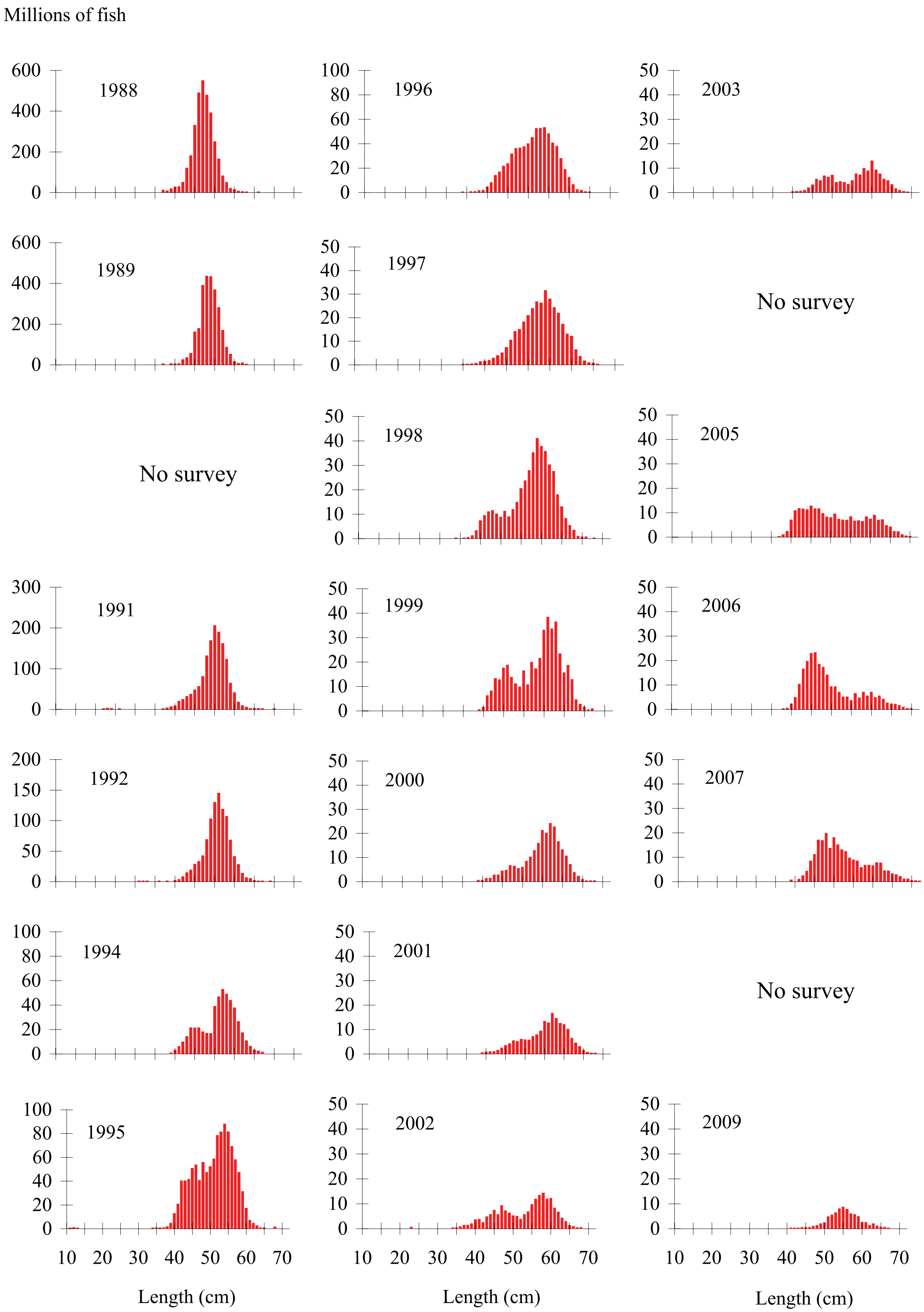

Figure 8.--Numbers-at-length estimates (millions) from winter echo integration-trawl surveys of spawning pollock near Bogoslof Island. The 1999 survey was conducted by Japan. Note: Y-axis scales differ.

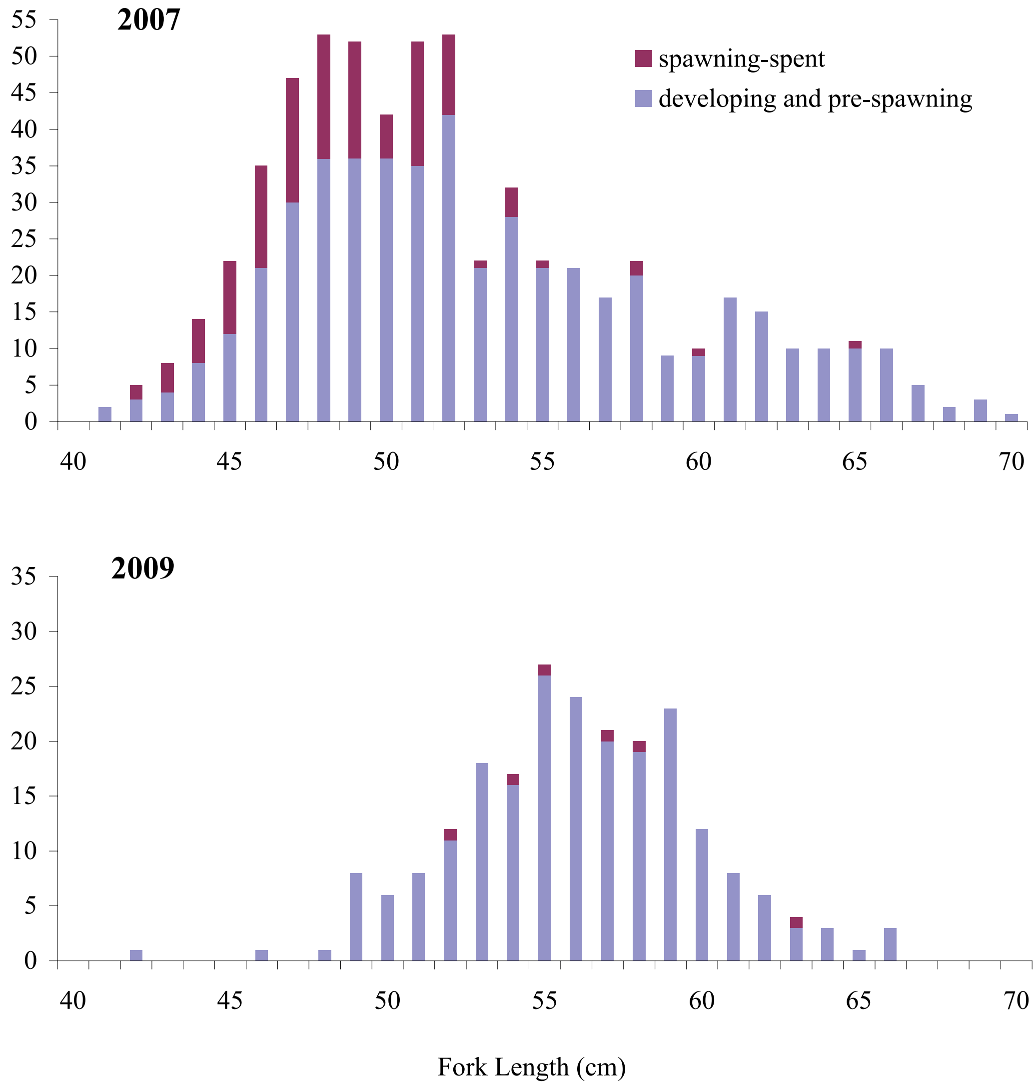

Figure 9.--Unweighted female pollock maturity at length for developing and pre-spawning maturity stages , and spawning-spent maturity stages observed during the 2007 and 2009 echo integration-trawl survey of the Bogoslof region.