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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

by Denise McKelvey, Taina Honkalehto, and Neal Williamson

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INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering Program of the Alaska Fisheries Science Center (AFSC) regularly conduct echo integration-trawl (EIT) surveys to estimate spawning walleye pollock (*Theragra chalcogramma*) abundance in the southeastern Aleutian Basin (Honkalehto et al. 2005). These surveys were conducted annually between 1988 and 2006 with the exception of 1990 and 2004. The biomass estimate for pollock within the Central Bering Sea (CBS) Convention Specific Area obtained during these surveys provides an index of abundance for the Aleutian Basin pollock stock[1]. The results presented here are from the EIT survey carried out 4-11 March 2006 aboard the NOAA ship *Miller Freeman*, Cruise MF2006-03. This report summarizes observed pollock distribution and biological composition, and provides a biomass estimate. It also summarizes oceanographic observations and acoustic system calibration results.

METHODS

Itinerary

3 Mar	Embark scientists in Dutch Harbor, AK.
4-9 Mar	Calibration of acoustic system in Captains Bay. EIT survey of the southeastern Aleutian Basin near Bogoslof Island.
9-10 Mar	Orthogonal transects and gear testing.
11 Mar	In port Dutch Harbor, AK.

[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.

Acoustic Equipment

Acoustic data were collected with a Simrad ER60[2] echo sounding system using 18, 38, 120, and 200 kHz split beam transducers (Simrad 2004, 1997; Bodholt and Solli 1992). The transducers were installed on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research, on the bottom of a retractable centerboard extending 9 m below the water surface. Data from all four frequencies were logged with SonarData EchoLog 500 (v. 3.45). 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). Results presented here were based on the 38 kHz data, which were analyzed using SonarData Echoview (v. 3.45.53) PC-based post-processing software.

Trawl Gear

Echosign was sampled using an Aleutian wing 30/26 trawl (AWT). 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 netsounder system attached to the trawl headrope. The net opening ranged from 23 to 37 m and averaged 29 m while fishing.

Oceanographic Equipment

Physical oceanographic data collected during the cruise included temperature/depth profiles obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope, and conductivity-temperature-depth (CTD) observations collected with a Sea-Bird CTD system at the calibration site. Sea surface temperature and salinity data were measured using the

[2] Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Miller Freeman's Sea-Bird Electronics SBE-21 probe located mid-ship, approximately 5 m below the water line. These and other environmental data were recorded using the ship's Scientific Computing System (SCS). Sea surface temperature data were subsampled and kriged for graphical representation.

Survey Design

The survey began 4 March north of Unalaska Island at about 167°W longitude, proceeded west to the Islands of Four Mountains near 170°W, and concluded on 9 March (Fig. 1). A random start position was generated for the first transect, which resulted in a new start location 0.5 nautical miles (nmi) west of the start location used in 2003. From that point, the survey followed 35 north-south parallel transects spaced 3 nmi apart that covered 1,803 nmi^2 of the CBS Convention Specific Area. The average transecting speed was 11 knots. Echo integration data were collected 24 hours a day between 14 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 system settings used during the collection (Table 1) were based on results from acoustic system calibrations from this and prior surveys. Trawl hauls were conducted to identify echosign and to provide biological samples. Average trawling speed was approximately 3 knots. Pollock were sampled to determine sex, fork length (FL), body weight, age, maturity, and ovary weight of selected females. Fork lengths were measured to the nearest centimeter. An electronic motion-compensating scale was used to weigh individual pollock specimens. For age determinations, 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[3]. All data were recorded electronically using the Fisheries Scientific Computing System (FSCS) v.1.6 and stored in a relational database. Pollock ovary samples were collected for on-going fecundity research by AFSC scientists[4]. Whole fish were retained for studies of forage fish and for training fisheries observers. Visual counts of seabird species were made after most trawl hauls.

[3] 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

[4] B. Megrey, Alaska Fisheries Science Center, NMFS, NOAA; 7600 Sand Point Way NE, Seattle WA 98115

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 data were collected. Transducer beam characteristics were modeled by moving each sphere through the acoustic beam while collecting target strength data using Simrad EKLOBES software.

Data Analysis

The abundance of pollock was estimated by combining echo integration and trawl data. Echosign that was identified as pollock was binned at 0.5 nmi horizontal by 20 m vertical resolution, and stored in a database. Pollock length data from the 13 hauls that captured sufficient numbers of pollock (more than 75 individuals/haul) were combined into two length strata based on geographic proximity of hauls, and similarity in size composition data. Mean target strength per fish (dB) was estimated for each stratum by using the pollock target strength (TS) to length relationship (TS = 20 log FL – 66, where FL is fork length (cm); Traynor 1996). Mean fish weight-at-length for each length interval (cm) was estimated from the trawl data when there were five or more pollock 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. Numbers and biomass for each stratum were estimated as:

$$\text{Numbers} = \sum N_i = \sum \frac{\bar{s}_A \times A}{4 \times \pi \times 10^{\overline{TS_i}/10}}, \text{ for length } i, \text{ and}$$

$$\text{Biomass} = \sum \left(N_i \times \frac{\overline{W_i}}{1000} \right), \quad \text{metric tons,}$$

where N_i is numbers at length i, $\bar{s}_A$ (m^2/nmi^2, nautical area scattering coefficient, NASC; MacLennan et al. 2002) is echo integrated backscatter from pollock in the water column, A is length stratum area (nmi^2), $\overline{TS}_i$ is mean target strength (dB, per fish) of pollock for length i (cm), and $\overline{W}i$ is mean weight of individual fish (kg) for length i. Total biomass or numbers were estimated by summing the strata estimates.

In the Bogoslof Island area, pre-spawning pollock aggregations are often densely packed and vertically and/or horizontally stratified by sex (Schabetsberger et al. 1999). Therefore it is not always possible to obtain an unbiased sample of lengths from these aggregations to estimate population size composition. For example, if females are densely schooled across the top of the aggregation, the trawl haul may contain mostly females and few males even though males were abundant in lower layers. At ages older than about 5 years, female pollock are longer than male pollock. Thus, biased estimates of sex composition from trawl 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.

Relative estimation errors for the acoustic data were derived using a one-dimensional (1D) geostatistical method as described by 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 acoustic abundance. Geostatistical methods are 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

Acoustic system calibrations were conducted before, between, and after the winter EIT surveys in the Bering Sea and Gulf of Alaska (Table 1). The ER60 38-kHz collection system showed no significant differences in gain parameters or transducer beam pattern characteristics before and after the Bogoslof Island area survey, thus confirming that the acoustic system was stable throughout the survey.

Oceanographic Conditions

Most trawl haul sites occurred towards the southern end of the transects, where surface waters were warmer than 4.0ºC (Fig. 1). Water temperature profiles at these sites indicated a well-mixed water column with little variation in temperature between the surface and deeper waters. Temperatures in the upper 615 m of the water column ranged from about 3.2º to 4.3ºC, averaging 3.9ºC, and where pollock traditionally occur in Bogoslof (300-600 m), temperatures averaged between 3.5º and 3.9ºC (Fig. 2).

Biological Sampling

Biological data and specimens were collected from 14 trawl hauls (Tables 2 and 3; Fig. 1). Walleye pollock dominated all trawl catches and represented 99.4% of the total catch by weight and 89.6% by number (Table 4). Myctophids were the most common bycatch and contributed 8% by number (Table 4).

Length measurements ranging between 38 and 71 cm FL were collected from 3,681 pollock specimens (Table 3) to create the two length strata for scaling the acoustic data and computing size-specific population estimates. Pollock from hauls 1-5 ranged between 39-67 cm FL and were characterized by a dominant mode at 45 cm FL. These hauls were used to scale the acoustic data in transects 1-18, the “Umnak” stratum. Pollock from hauls 7-14 ranged between 40-71 cm FL and had higher proportions of fish larger than 55 cm FL generating a bimodal distribution with modes at 47 and 60 cm FL. These hauls were used to scale the acoustic data in transects 19 through 35, the

"Samalga" stratum. Trawl catch sex ratios among hauls capturing more than 75 pollock ranged from 12% to 90% male. As observed in previous years, higher proportions of male pollock were captured in deeper layers of the water column.

Maturity stage data and length-weight data were collected for 963 pollock specimens, and otoliths from 593 specimens (Table 3). The unweighted maturity composition for males was 0% immature, 1% developing, 60% pre-spawning, 39% spawning, and less than 1% spent. The female maturity composition was 0% immature, 1% developing, 72% pre-spawning, 6% spawning, and 21% spent. Pollock maturity composition by length stratum indicated a larger percentage of spent females in the Umnak region than in the Samalga region (Fig. 3a), even though the average gonado-somatic index (GSI: ovary weight/body weight) for pre-spawning mature female pollock was similar for the two regions (0.18 for Umnak; 0.17 for Samalga). The average GSI for both regions combined was 0.17 (Fig. 3b), which was similar to the average GSI observed during recent years, and suggests that the survey's timing was similar to previous years in relation to peak spawning. The mean body weight-at-length for sexes combined was estimated using observed measurements for all but three length intervals (Fig. 3c). The mean weight-at-length for the remaining three length intervals was estimated by $\text{Weight (g)} = 0.002616 \times \text{Fork Length (cm)}^{3.3272}$.

Pollock Distribution and Abundance

As in recent years, pollock were concentrated in two regions, northeast of Umnak Island, and just north of Samalga Pass at fish depths ranging from about 300-600 m (Fig. 4). About 58% of the survey biomass was observed in the Umnak area and 42% in the Samalga Pass area. Pollock in the Umnak region were primarily aggregated off Cape Idak along three transects, while pollock in the Samalga Pass region were concentrated mainly along four transects. Pollock tended to stay close to the sea floor in both regions until bottom depths reached about 350 m (Fig. 5). As the seafloor descended, pollock in the Umnak region maintained a pelagic depth of 400-475 m whereas in Samalga Pass, fish depths continued to increase slightly with increasing bottom depths. Few pollock were encountered where bottom depths exceeded 1,000 m.

The abundance estimate for pollock in the Bogoslof area was 239 million fish weighing 0.240 million metric tons (Tables 5, 6, 7; Fig. 6). This was the highest abundance in terms of numbers of fish estimated since the 1999 Bogoslof EIT survey. The size composition was bimodal (Figs. 7 and 8) with major modes at 46 and 60 cm FL. The average fork length for the population was 49.7 cm, shorter than the 51 to 56 cm FL that have characterized the Bogoslof spawning pollock population since 1992 (Fig. 6). Based on the 1D analysis, the relative estimation error of the abundance estimate was 11.8% (Table 5).

DISCUSSION

In the 2006 Bogoslof EIT survey, a 38% increase over 2005 pollock numbers was observed for fish less than 50 cm FL. Most of the increased abundance was observed between 43 and 49 cm FL. Although age-at-length results for the 2006 EIT survey are not yet available, age data from previous years suggest that fish 43-49 cm FL were about 5-6 years old (Fig. 10; Honkalehto et al. 2005). This large increase is likely from incoming 6-year-olds of the 2000 year class, which was a relatively strong year class on the Bering Sea shelf (Ianelli et al. 2005). For the Bogoslof EIT survey time series, peak recruitment for dominant year classes has typically occurred at age 6 to 7. This would imply that peak 2000 year-class recruitment either occurred in 2006 or will occur in 2007.

In the 2000-2003 surveys, the Umnak stratum accounted for a relatively small portion (i.e., $\leq$ 26%) of the CBS Convention Specific Area biomass. In 2005, its contribution increased to 34%, and in 2006, 58% of the biomass was observed in the Umnak region. It is interesting to note that of the younger female pollock (< 55 cm FL) present in each of the two areas in 2006, 66% in Umnak were spawning or had already spawned – compared with only 11% in Samalga Pass (Fig. 9). Smaller pollock were present in Umnak – perhaps representing a year class not present in Samalga Pass. Even so, of those lengths common to both areas, a much higher proportion of females were either spawning or spent in Umnak.

At different stages in the Bogoslof EIT time series, the survey area and transect spacing have been modified to reflect changes in abundance and geographic distribution. Transect spacing of recent surveys (e.g., 2002, 2003, and 2005) was 5 nmi. In an effort to more efficiently sample the CBS Convention Specific Area in 2006, transect spacing was reduced to 3 nmi and the northern extent of transects was shortened from what it was in the previous three survey years. This resulted in more transect coverage of the spawning aggregations. The abundance estimate's relative estimation error was the lowest since the EIT survey in 2001, suggesting that the change in survey design has improved the quality of the abundance estimates.

Fewer Pacific ocean perch were encountered in the 2006 survey than in 2005. This along with randomization of the starting transect location, and reduction of transect spacing from 5 nmi to 3 nmi in 2006, supports the suggestion that the 2005 survey likely encountered a particular topographic feature or localized area where POP aggregated

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SCIENTIFIC PERSONNEL

Name	Nationality	Position	Organization
Taina Honkalehto	USA	Chief Scientist	AFSC
Denise McKelvey	USA	Fishery Biologist	AFSC
Scott Furnish	USA	Computer Specialist	AFSC
Tyler Yasenak	USA	Fishery Biologist	AFSC
William Floering	USA	Fishery Biologist	AFSC
Robert Self	USA	Fishery Biologist	AFSC
Sandi Neidetcher	USA	Fishery Biologist	AFSC
Seok-Gwan Choi	Korea	Fishery Biologist	NFRDI

AFSC - Alaska Fisheries Science Center, Seattle, WA

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

Table 1.--Simrad ER60 38 kHz acoustic system description and settings during the winter 2006 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	13-Feb Three Saint's Bay, Alaska	4-Mar Captain's Bay, Alaska	22-Mar Uganik 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)	26.43	26.43	26.46	26.46
Sa correction (dB)	-0.57	-0.57	-0.60	-0.56
3 dB beamwidth (deg)				
Along:	7.05	7.03	6.96	6.97
Athwart:	7.02	7.01	7.01	6.98
Angle offset (deg)				
Along:	0.03	0.02	0.04	0.01
Athwart:	0.02	0.03	0.02	0.03
Post-processing S_v threshold (dB):	-70	--	--	--
Standard sphere TS (dB)	--	-42.14	-42.14	-42.14
Sphere range from transducer (m):	--	24.78	21.52	18.95
Absorption coefficient (dB/m):	0.009931	0.009889	0.009942	0.009806
Sound velocity (m/s)	1467.0	1461.5	1460.8	1457.9
Water temp at transducer (^{o}C):	--	3.4	3.3	2.9

Note: Gain and Beam pattern 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 2.--Trawl station and catch data summary from the winter 2006 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		
												Pollock		Other
					Latitude (N)	Longitude (W)	Footrope	Bottom	Gear depth[2]	Surface[3]		(kg)	Number	(kg)
1	AWT	5-Mar	17:19	18.5	53 53.91	167 12.98	426	678	4.0	3.6	301	357	468	19
2	AWT	6-Mar	5:38	2.0	53 35.69	167 38.31	374	775	4.2	4.1	302	540	732	4
3	AWT	6-Mar	7:14	10.1	53 37.25	167 38.31	566	945	3.5	4.1	303	1,261	1,724	33
4	AWT	6-Mar	11:37	5.3	53 35.03	167 43.27	368	906	4.0	4.1	304	242	249	13
5	AWT	6-Mar	14:41	9.0	53 36.87	167 48.44	382	456	4.0	4.1	305	647	589	3
6	AWT	7-Mar	15:21	23.1	53 21.81	168 53.93	414	860	3.7	3.9	306	40	32	8
7	AWT	7-Mar	20:59	22.8	53 12.57	168 58.70	385	843	3.9	4.1	307	246	206	9
8	AWT	7-Mar	23:22	5.0	53 12.19	168 58.61	477	844	3.5	4.1	308	2,381	2,300	5
9	AWT	8-Mar	22:12	6.0	53 08.72	169 03.74	427	594	3.8	4.0	309	1,016	798	7
10	AWT	9-Mar	0:49	1.2	53 04.51	169 08.93	438	742	3.8	4.3	310	8,750	7,345	-
11	AWT	9-Mar	3:20	4.0	53 04.18	169 12.55	646	981	3.4	4.1	311	1,015	1,146	11
12	AWT	9-Mar	6:08	5.5	52 59.29	169 13.90	405	652	3.6	4.0	312	1,208	638	2
13	AWT	9-Mar	10:49	11.2	52 59.12	169 21.03	411	645	3.6	3.9	313	449	258	2
14	AWT	9-Mar	12:38	15.2	52 58.66	169 24.73	404	566	3.8	3.9	314	997	509	2

[1]Gear type: AWT = Aleutian wing trawl

[2]Average Sea-Bird Electronics (SBE) temperature measured at the trawl headrope depth (about 29 m above the footrope) while fishing.

[3]SBE temperature measured at 1 m.

Table 3.--Numbers of biological samples and measurements collected during the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul No.	Pollock					Whole fish	Seabird observations	Myctophid lengths
	Lengths	Weights and maturities	Otoliths	Ovary weights	Ovary samples			
1	381	121	52	32	-	-	x	-
2	340	68	42	6	3	x	x	-
3	251	67	40	2	1	-	x	50
4	206	42	42	7	2	-	x	-
5	319	86	42	18	1	-	x	-
6	32	32	32	26	-	-	-	-
7	206	43	43	28	-	-	x	-
8	287	82	48	46	10	-	x	-
9	322	81	45	42	5	-	x	-
10	280	83	49	42	5	-	x	-
11	333	77	40	15	-	-	x	-
12	228	53	43	25	4	-	x	-
13	258	44	28	24	3	-	x	-
14	238	84	47	54	-	-	x	-
Totals	3,681	963	593	367	34	1 site	13 sites	50

Table 4.--Catch by species from 14 midwater trawl hauls during the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Species name	Scientific name	Weight (kg)	Percent by weight	Number
walleye pollock	*Theragra chalcogramma*	19,149.0	99.4	16,994
lanternfish unidentified	Myctophidae (family)	31.9	0.2	1,308
longnose lancetfish	*Alepisaurus ferox*	15.5	0.1	2
jellyfish unidentified	Scyphozoa (class)	14.5	0.1	38
squid unidentified	Teuthoidea (order)	14.3	0.1	107
Chinook salmon	*Oncorhynchus tshawytscha*	10.1	0.1	11
Greenland turbot	*Reinhardtius hippoglossoides*	8.4	<0.1	1
Pacific ocean perch	*Sebastes alutus*	5.3	<0.1	5
smooth lumpsucker	*Aptocyclus ventricosus*	5.0	<0.1	4
grenadier unidentified	Macrouridae (family)	3.3	<0.1	1
lamprey unidentified	Petromyzontidae (family)	3.3	<0.1	9
northern lampfish	*Stenobrachius leucopsarus*	2.4	<0.1	209
northern smoothtongue	*Leuroglossus schmidti*	0.9	<0.1	160
arrowtooth flounder	*Atheresthes stomias*	0.6	<0.1	2
emarginate snailfish	*Careproctus furcellus*	0.6	<0.1	1
California headlight lampfish	*Diaphus theta*	0.3	<0.1	25
hatchetfish	Sternoptychidae (family)	0.3	<0.1	10
shrimp unidentified	Decapoda (order)	0.2	<0.1	75
twoline eelpout	*Bothrocara brunneum*	0.2	<0.1	1
Pacific viperfish	*Chauliodus macouni*	0.1	<0.1	2
Total		19,265.98		18,965

Table 5.--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 2006.

	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	0.227	2,903	12.2	0.227	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

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

Table 6.--Continued.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
53	48	85	--	122	106	73	49	81	52	26	35	17	13	7	6	4	--	7	5
54	19	50	--	63	67	66	43	88	53	31	41	21	16	8	7	3	--	7	5
55	12	13	--	40	41	50	37	81	48	28	38	33	21	12	9	5	--	8	3
56	4	5	--	17	27	29	26	69	40	24	35	38	20	13	12	7	--	6	6
57	3	8	--	8	13	14	17	58	37	22	30	33	24	17	13	7	--	7	5
58	1	1	--	4	6	9	10	47	28	17	27	36	23	15	14	10	--	6	7
59	0	0	--	1	5	3	6	31	19	13	18	23	16	13	12	9	--	8	5
60	0	0	--	1	1	1	3	17	12	12	13	15	13	11	12	13	--	7	7
61	2	0	--	1	<1	1	2	7	6	6	8	18	10	9	8	9	--	9	5
62	0	0	--	<1	<1	<1	1	4	2	3	5	13	7	6	6	7	--	7	5
63	0	0	--	0	0	0	<1	2	1	1	3	4	4	4	4	5	--	7	4
64	0	0	--	0	1	<1	0	1	<1	1	1	3	2	3	3	5	--	5	2
65	0	0	--	<1	0	0	0	<1	<1	<1	1	1	1	1	1	3	--	4	2
66	0	0	--	0	0	0	0	<1	0	<1	1	<1	<1	1	1	1	--	2	2
67	0	0	--	0	0	0	0	0	0	0	0	1	<1	<1	<1	1	--	2	1
68	0	0	--	0	0	0	0	1	0	0	<1	0	<1	<1	<1	<1	--	1	1
69	0	0	--	0	0	0	0	0	0	0	0	0	0	<1	0	<1	--	<1	<1
70	0	0	--	0	0	0	0	0	0	0	0	0	0	<1	<1	0	--	<1	<1
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	<1
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	<1	0
Total	3,236	2,687	--	1,419	975	613	478	1,081	666	337	435	416	229	171	181	134	--	225	239

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 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
10	0	0	--	0	0	0	0	<1	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
12	0	0	--	0	0	0	0	5	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
14	0	0	--	0	0	0	0	1	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
16	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
18	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
20	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
22	0	0	--	13	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	38	0	--	0	0
24	0	0	--	61	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
26	0	0	--	26	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
28	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
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	7	0	--	0	0
31	0	0	--	0	37	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
33	0	0	--	0	48	0	0	0	0	0	0	0	0	0	9	2	--	0	0
34	0	0	--	0	0	0	0	53	35	0	29	0	0	0	48	2	--	0	0
35	0	0	--	0	0	0	0	93	0	29	0	0	0	0	73	0	--	0	0
36	0	0	--	0	68	0	0	42	96	18	32	0	0	0	204	0	--	0	0
37	3,199	846	--	115	0	0	0	113	109	84	92	0	0	0	456	16	--	39	0
38	2,304	0	--	768	84	260	0	435	465	173	395	0	0	19	508	6	--	323	29
39	6,365	1,461	--	1,843	0	634	202	1,697	562	507	1,250	258	168	149	823	7	--	942	145
40	10,573	1,116	--	2,801	451	1,776	1,190	5,510	1,857	634	3,208	1,242	195	315	1,716	80	--	3,143	869
41	12,697	1,532	--	7,940	1,235	2,276	2,855	9,777	3,637	851	4,484	5,598	575	403	1,919	170	--	5,257	2,326

Table 7.--Continued

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
42	24,360	10,704	--	10,812	3,316	3,571	4,990	20,730	7,012	1,387	5,652	7,223	674	464	1,307	251	--	6,158	5,378
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	770	2,885	437	--	6,318	9,034
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	1,562	3,642	1,166	--	6,398	11,836
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	2,966	5,117	2,128	--	8,145	15,091
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	3,218	4,174	4,079	--	8,122	16,667
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	4,095	7,420	3,823	--	8,682	14,277
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	4,548	6,062	5,873	--	7,934	14,524
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	5,654	5,646	5,747	--	7,115	12,801
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	6,794	4,904	6,956	--	7,453	8,940
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	6,361	5,004	4,232	--	9,035	9,558
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	7,605	3,992	4,883	--	7,711	7,312
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	8,203	6,504	4,764	--	8,074	5,941
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	10,064	8,249	4,115	--	8,735	6,430
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	16,246	12,509	6,435	--	11,061	4,877
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	17,977	16,277	10,745	--	8,930	9,602
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	24,987	19,422	10,852	--	9,814	6,813
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	23,153	21,834	15,700	--	9,735	10,528
59	0	0	--	1,284	7,872	4,376	9,546	48,878	28,918	21,031	28,241	28,362	26,252	20,390	19,158	14,905	--	13,976	8,888
60	0	0	--	2,743	2,631	1,989	4,716	28,240	19,749	20,509	21,604	18,174	22,075	19,263	20,581	23,011	--	13,186	11,377
61	2,561	0	--	2,195	562	1,756	3,644	11,855	10,762	11,428	14,301	22,618	18,519	16,883	14,659	17,326	--	16,771	8,337
62	0	0	--	780	600	372	1,826	7,951	3,578	6,439	9,748	15,120	12,972	11,334	12,296	14,954	--	13,268	9,718
63	0	0	--	0	0	0	200	3,978	2,835	2,999	6,344	5,181	7,033	7,722	8,207	11,240	--	14,025	7,997
64	0	0	--	0	1,363	415	0	1,074	863	1,489	1,777	3,198	4,277	5,489	5,719	10,540	--	10,001	5,553
65	0	0	--	938	0	0	0	495	578	1,096	1,156	1,833	1,660	2,730	2,463	7,281	--	9,033	4,367
66	0	0	--	0	0	0	0	163	0	329	1,251	403	534	1,132	1,515	3,582	--	5,120	4,679
67	0	0	--	0	0	0	0	0	0	0	0	863	520	715	583	1,954	--	5,161	3,264
68	0	0	--	0	0	0	0	2,570	0	0	276	0	403	426	777	746	--	2,157	1,716
69	0	0	--	0	0	0	0	0	0	0	0	0	0	55	0	391	--	933	644
70	0	0	--	0	0	0	0	0	0	0	0	0	0	100	61	0	--	381	467
71	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	99	74
72	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	118	0
73	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0	0	--	109	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	231,795	226,548	198,403	--	253,459	240,059

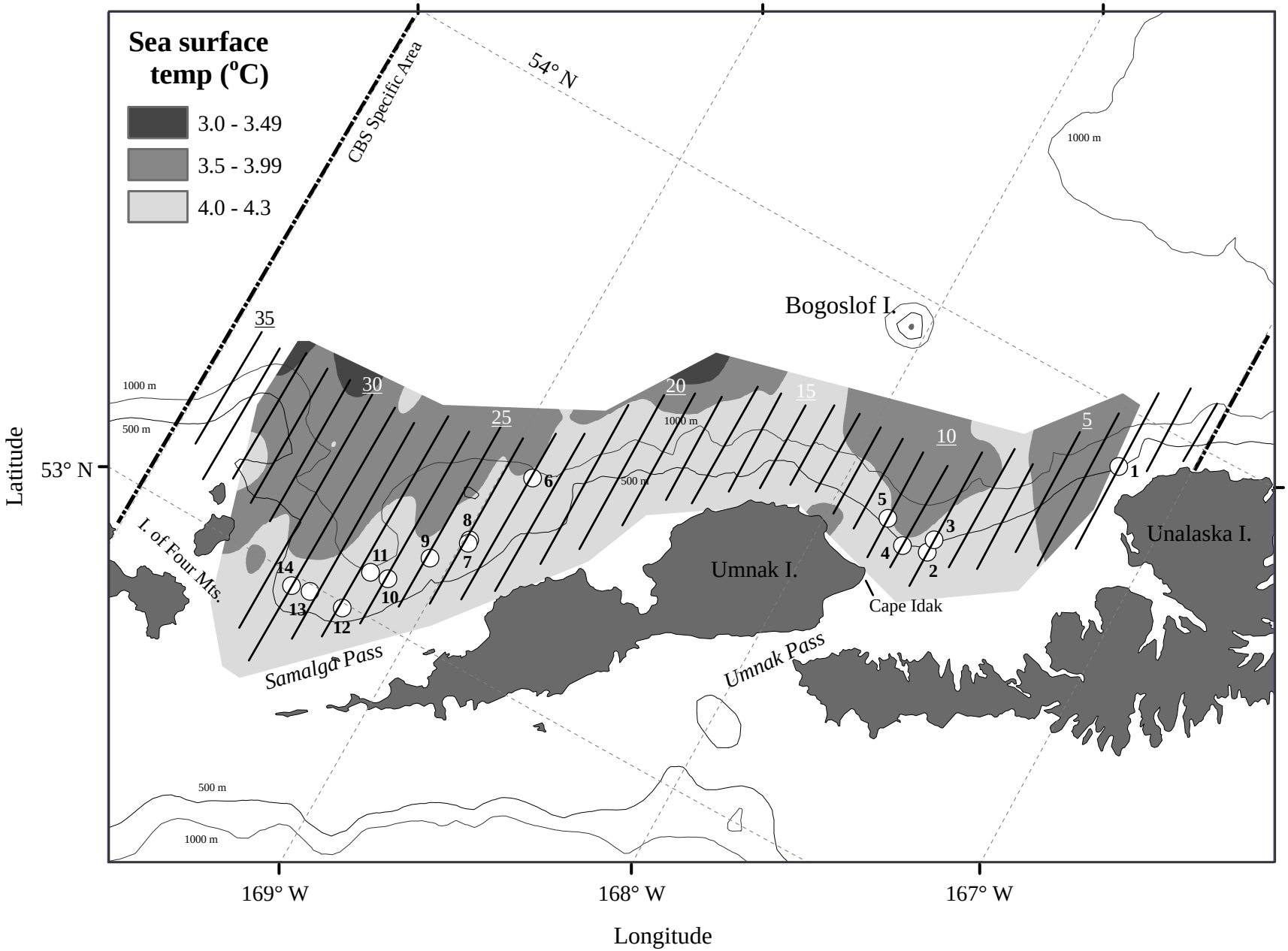

Figure 1.--Transects, haul locations, and sea surface temperature measured from the ship's sensor and recorded during the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Hauls are indicated by circles. Transect numbers are underlined. The dash-dotted line indicates the Central Bering Sea Specific Area.

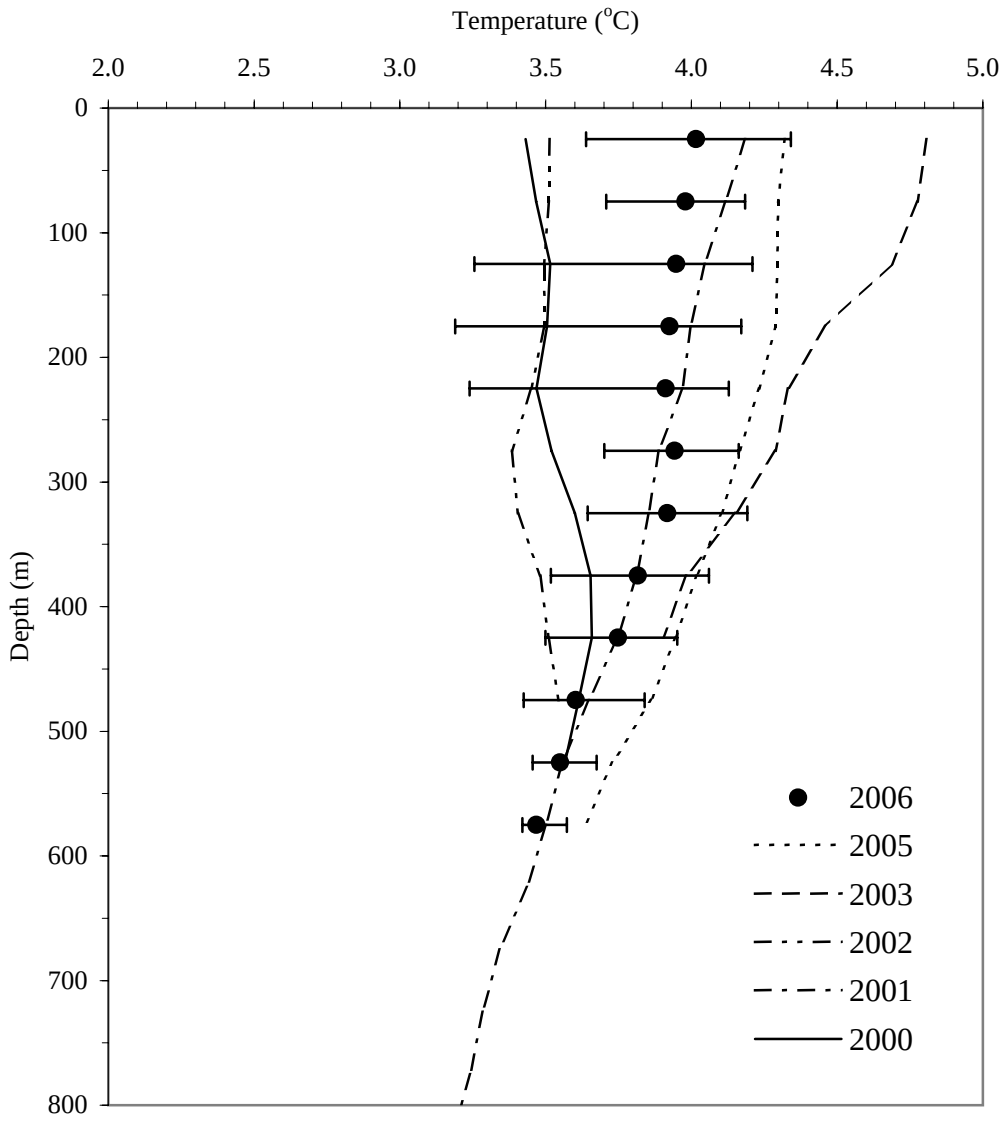

Figure 2.--Average temperature (°C) (symbols) by 50-m depth intervals observed during hauls from the winter 2000-2003, and 2005-2006 echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. The horizontal bars represent temperature range observed during the 2006 survey.
Note: Temperature data from the 2003 survey were collected from only three locations.

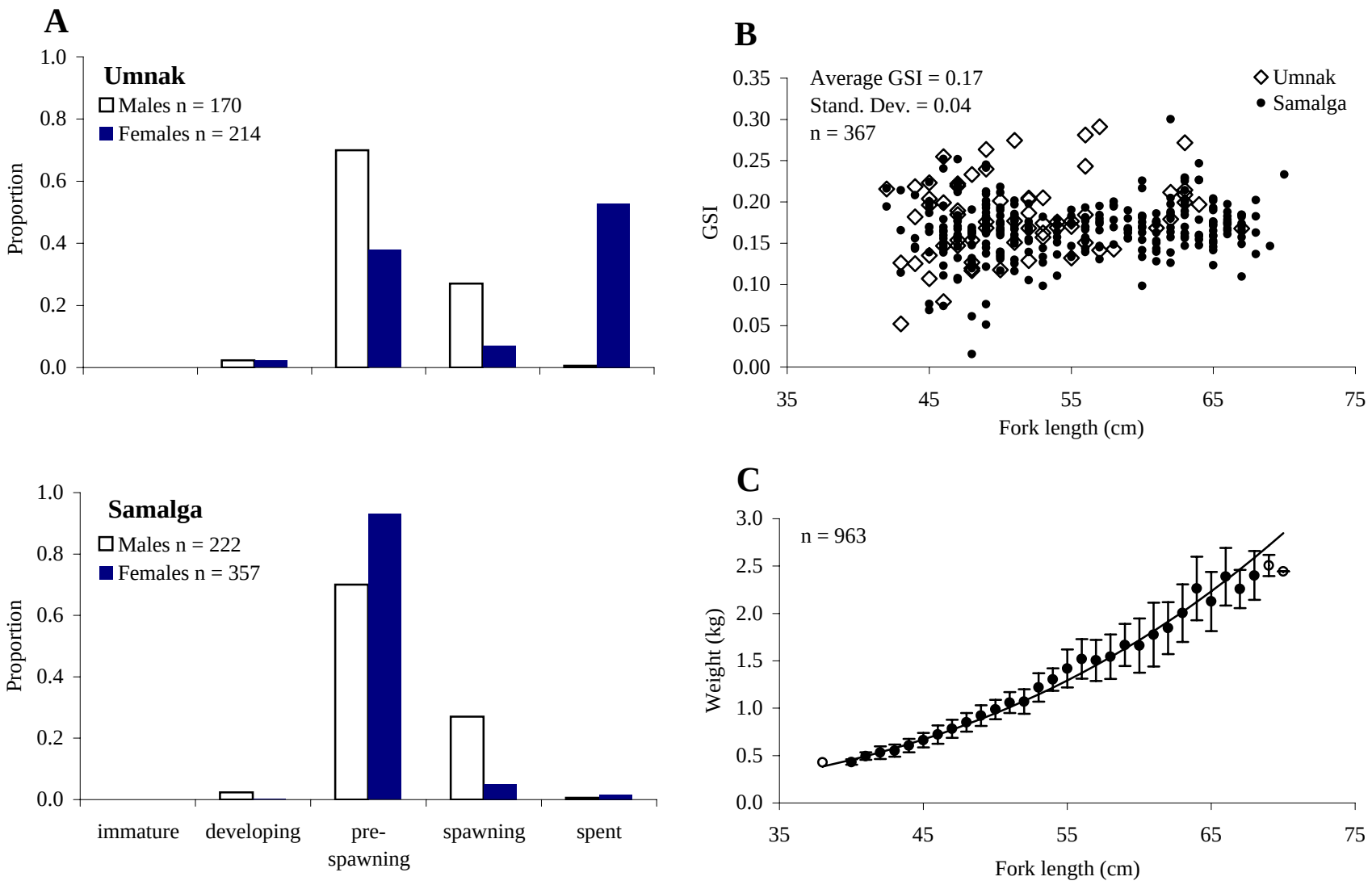

Figure 3.--Pollock maturity stages for length strata 1 and 2 (A), gonado-somatic index (GSI) for pre-spawning females as a function of fork length (cm) (B), and observed mean weight-at-length with a fitted regression line (sexes combined; hollow circles indicate fewer than five fish were measured) (C) observed during the winter 2006 echo integration-trawl survey of the Bogoslof Island area. Vertical bars indicate +/- one standard deviation.

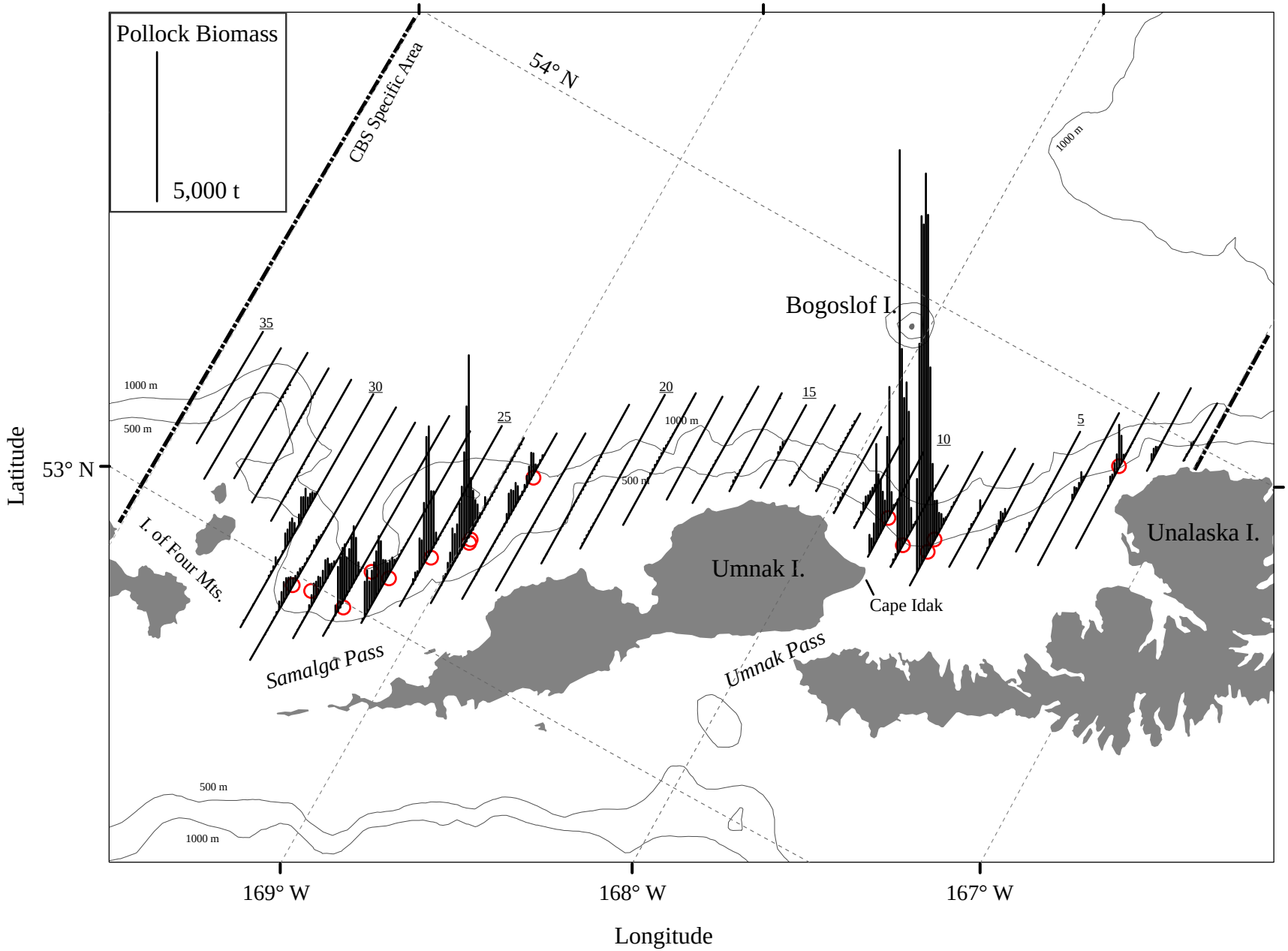

Figure 4.--Pollock biomass in metric tons (t) (vertical lines) and trawl hauls (circles) along tracklines from the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. The Central Bering Sea Convention area is indicated by a dash-dotted line.

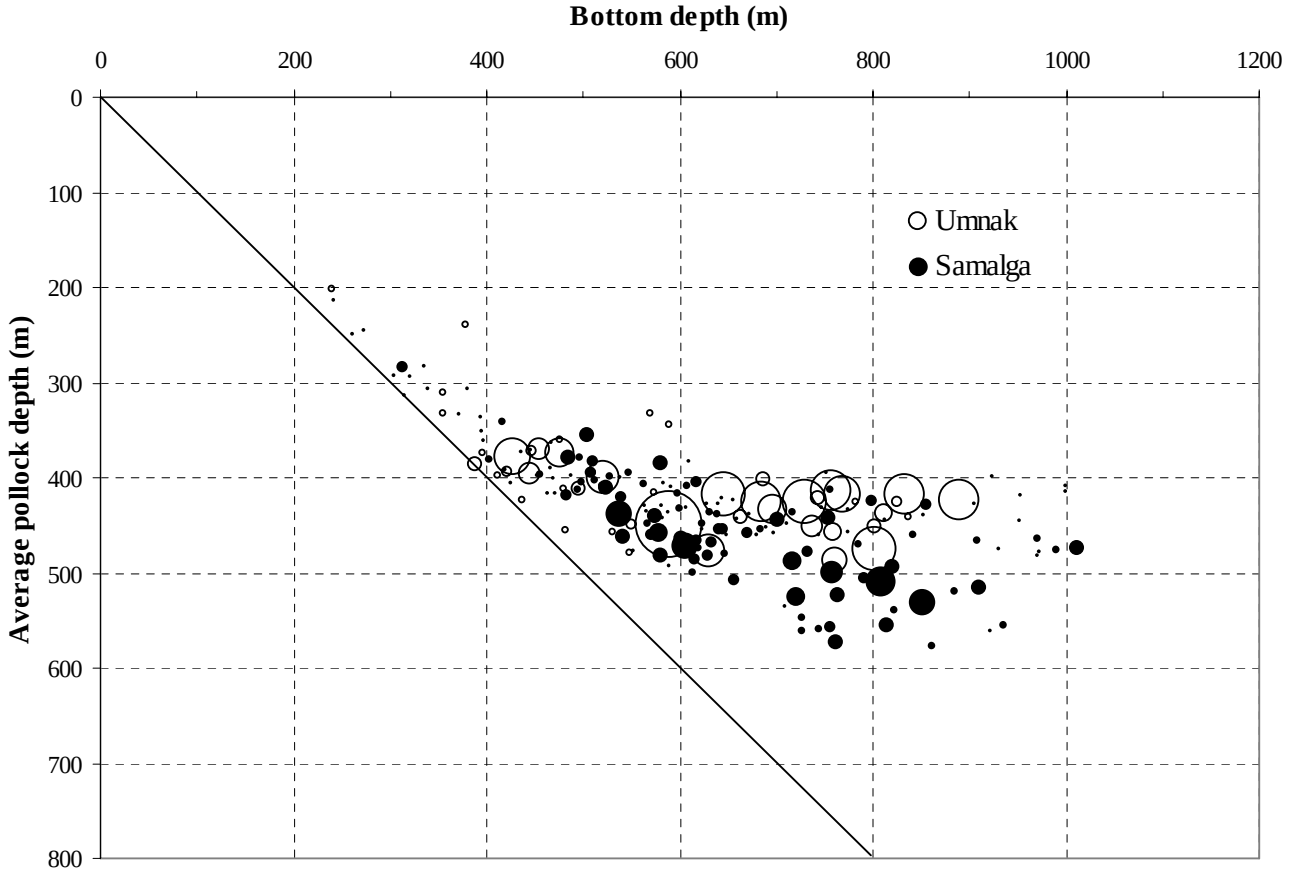

Figure 5.--Average pollock depth (weighted by biomass) versus bottom depth (m), per 0.5 nmi sailed distance for the Umnak and Samalga regions during the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Bubble size was scaled to the maximum biomass/0.5 nmi interval in the Umnak region (26,833.9 t). The diagonal line indicates where the average pollock depth equals bottom depth.

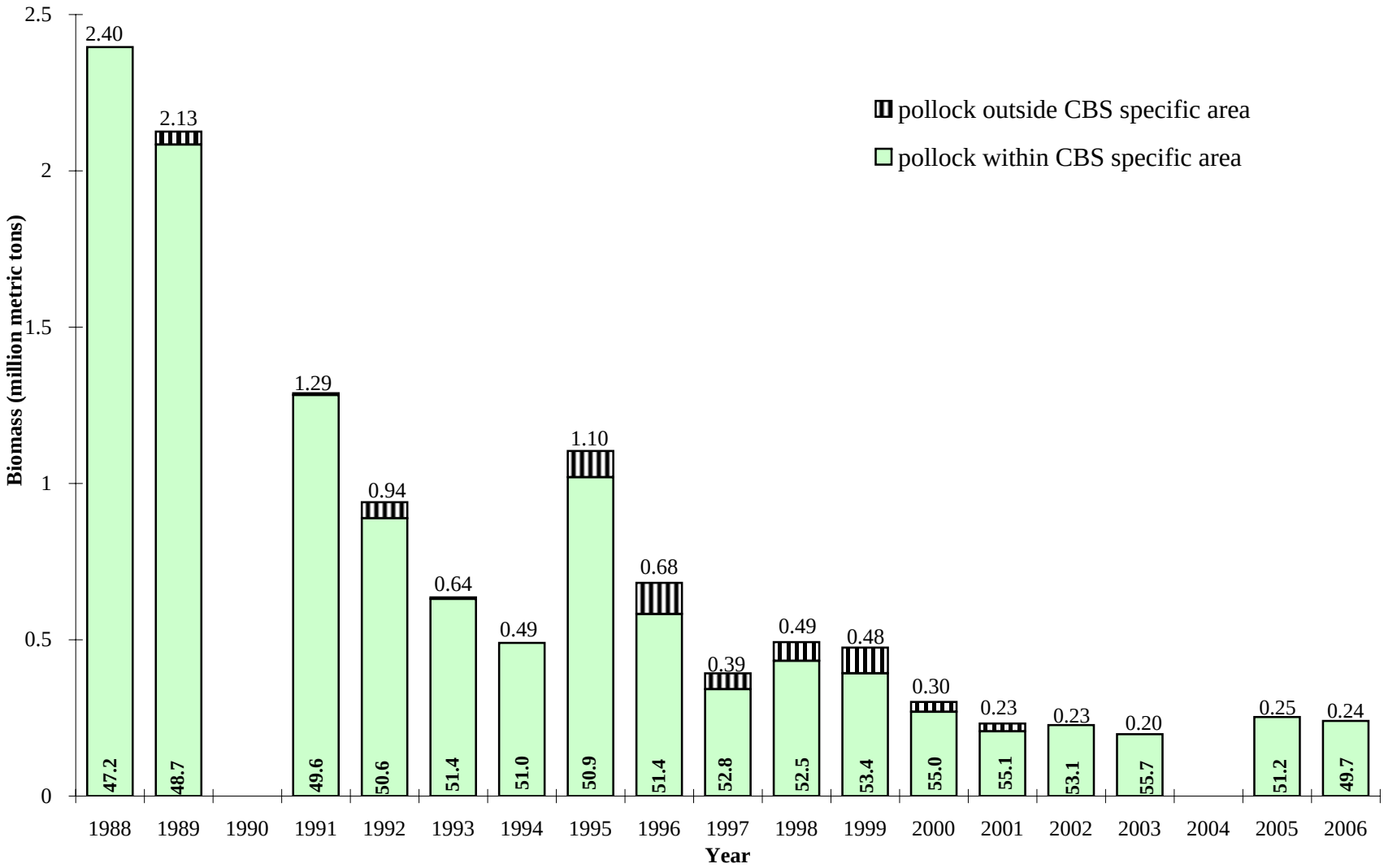

Figure 6.--Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2006. The United States conducted all but the 1999 survey, which was conducted by Japan. There were no surveys in 1990 or 2004. Total pollock biomass for each survey year is indicated on top of each bar and average fork length (cm) is indicated inside each bar.

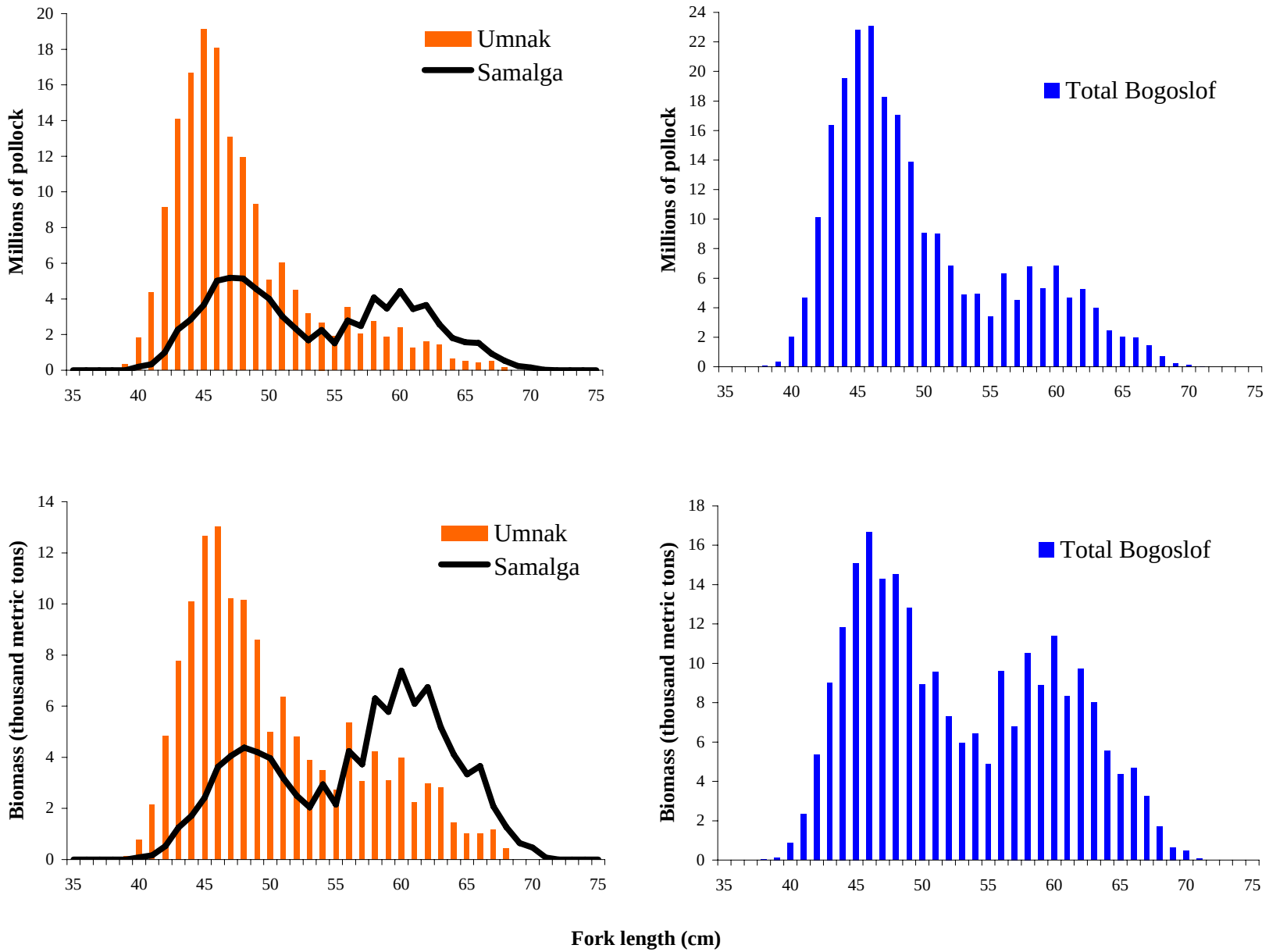

Figure 7.--Population at length (top) and biomass at length (bottom) estimates from the winter 2006 echo integration-trawl survey of walleye pollock in the Bogoslof Island area. Note Y-axis differences.

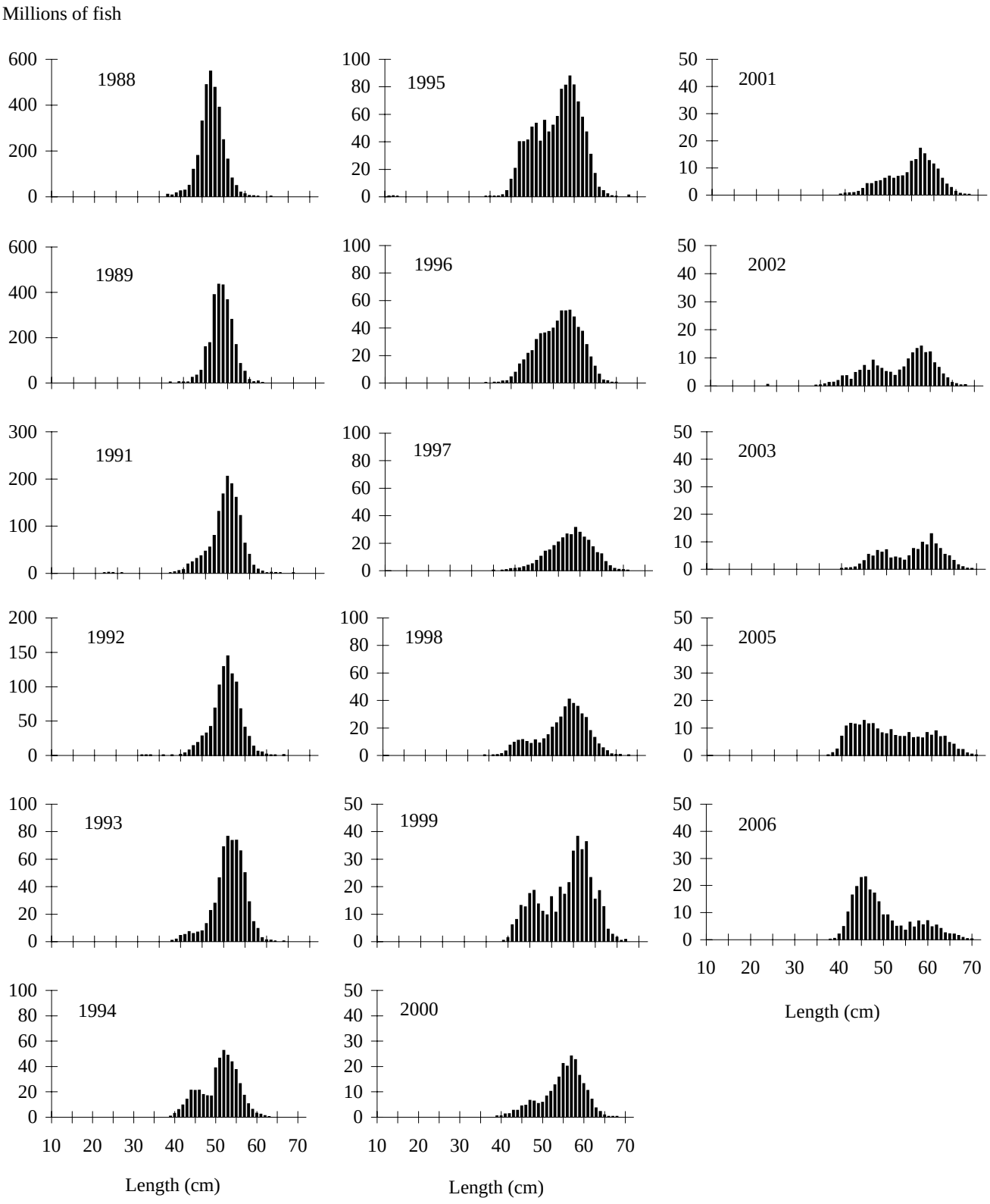

Figure 8.--Numbers-at-length estimates (millions) from winter echo integration-trawl surveys of spawning pollock near Bogoslof Island. The United States conducted all but the 1999 survey, which was conducted by Japan. There were no surveys in 1990 or 2004. Note Y-axis scales differ.

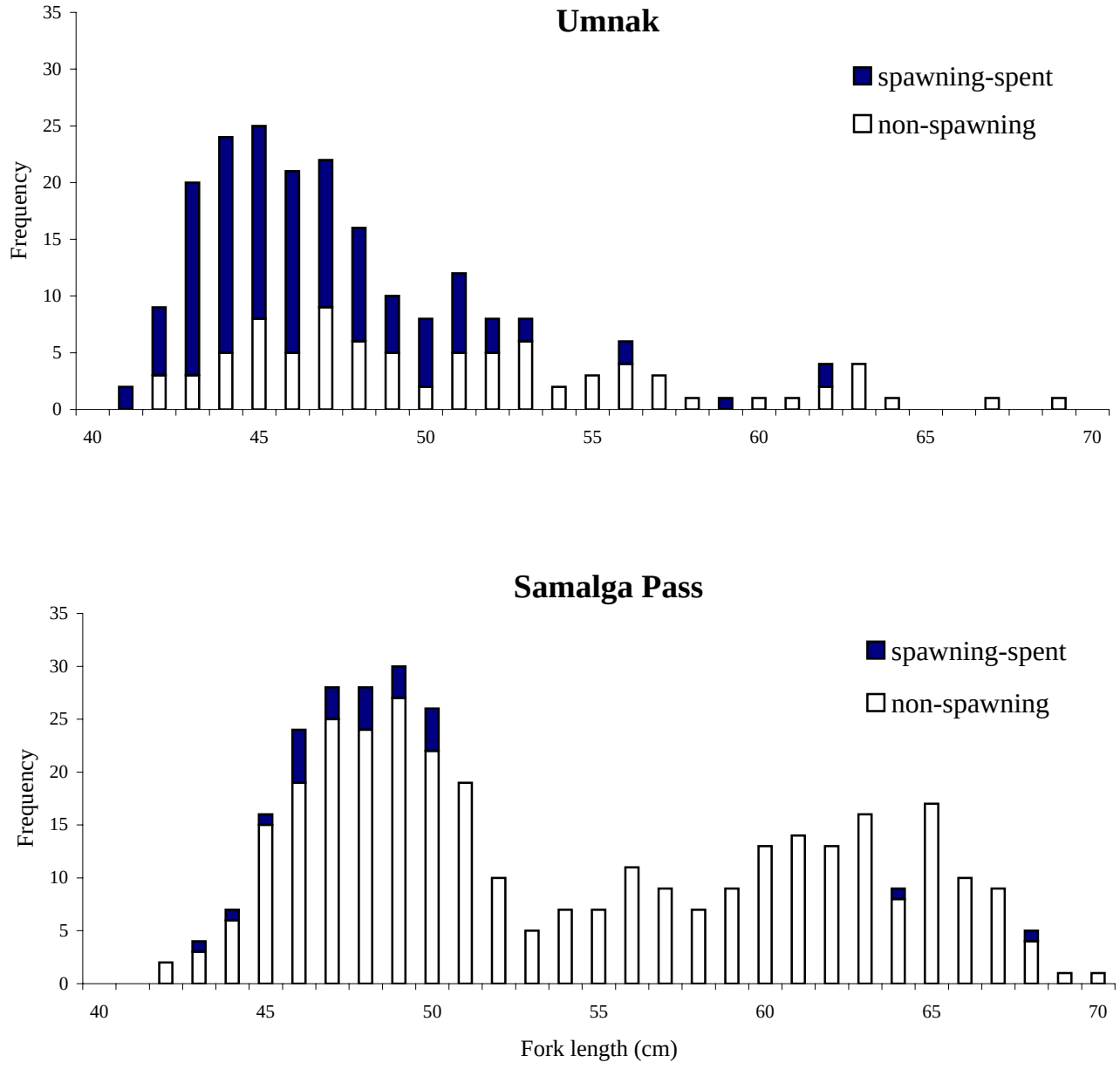

Figure 9.--Unweighted female pollock maturity at length for non-spawning and spawning-spent maturity stages observed in the Umnak and Samalga Pass regions during the winter 2006 echo integration-trawl survey of the Bogoslof Island area.