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Results of the March 2003 Echo Integration-trawl Survey of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Southeastern Aleutian Basin Near Bogoslof Island, Cruise MF2003-04

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Results of the March 2003 Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Southeastern Aleutian Basin Near Bogoslof Island, Cruise MF2003-04

by Denise McKelvey and Neal Williamson

August 2003

INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering Program of the Alaska Fisheries Science Center (AFSC) have conducted echo integration-trawl (EIT) surveys in the southeastern Aleutian Basin near Bogoslof Island to estimate midwater pollock (*Theragra chalcogramma*) distribution and abundance annually since 1988, with the exception of 1990. The biomass estimate for pollock within the Central Bering Sea (CBS) Convention Specific Area[1] obtained during these surveys provide an index of abundance for the Aleutian Basin pollock stock (Honkalehto and Williamson, 1995). The results presented here are from the echo integration-trawl (EIT) survey carried out 8-14 March 2003 aboard the NOAA ship *Miller Freeman*, Cruise MF2003-04.

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

METHODS

Itinerary

7 Mar	Embark scientists in Dutch Harbor, AK.
8 Mar	Calibration of acoustic system in Captains Bay, AK.
9-13 Mar	EIT survey of the southeastern Aleutian Basin, near Bogoslof Island.
13-14 Mar	Survey operations suspended due to bad weather.
14-15 Mar	Transit to Shelikof Strait, AK.

Acoustic Equipment

Acoustic data were collected with Simrad EK500[2] and Simrad EK60 quantitative echo-sounding systems (Simrad, 2001; Bodholt et al. 1989, Bodholt and Solli 1992) on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Three split-beam transducers (38 kHz, 120 kHz, and 200 kHz) were mounted on the bottom of the vessel's retractable centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Simrad EK 500 data (38 and 120 kHz) and Simrad EK60 data (200 kHz) were logged with SonarData EchoLog 500. The 38 kHz data were analyzed using SonarData Echoview (V 2.25.109) PC-based post-processing software. Echo integration and target-strength (TS) data were collected simultaneously at all frequencies. Results presented here are based on the 38 kHz data.

Trawl Gear

Midwater and near-bottom 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

[2] Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

32-mm (1.25-in) codend liner. The AWT was fished with 82.3 m (270 ft) of 1.9-cm (0.75-in) diameter (8 ×19 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 24 to 37 m, and averaged 30 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 calibration sites. Sea surface temperature, salinity, and other environmental data were collected using the *Miller Freeman's* Scientific Computing System (SCS). Ocean current profile data were obtained using the vessel's centerboard-mounted acoustic Doppler current profiler system operating continuously in water-profiling mode.

Survey Design

The Bogoslof Island area echo integration-trawl survey began 9 March 2003 north of Unalaska Island at about 167°W longitude, and proceeded west towards the Islands of Four Mountains near 170°W, concluding on 13 March. The 22 north-south parallel transects were spaced 5 nautical miles (nmi) apart and covered a 2,993 nmi^2 area (Fig. 1), within the CBS Specific Area. Average transecting speed was about 11 knots. Echo integration data were collected 24 hours a day between 14 m from the surface (5 m below the centerboard-mounted transducer) 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 were based on results from acoustic system calibrations and on experience from prior surveys (Table 1A). Trawl hauls were conducted to identify echosign, and to provide biological samples for the primary goals of the survey and for additional research projects (e.g., fecundity studies, parasite studies). 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 (i.e., a fish measuring between 49.5 cm and 50.5 cm was recorded as

50 cm). 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. All data were recorded electronically using the Fisheries Scientific Computing System (FSCS) and stored in a relational database. Samples of pollock tissue, ovaries, and gametes were collected for ongoing research by AFSC scientists. Whole fish were retained for training fisheries observers.

Standard sphere acoustic system calibrations were made prior to the Bogoslof Island area survey to measure acoustic system performance for the EK500 at 38 and 120 kHz, and for the EK60 at 200 kHz. During calibrations, the *Miller Freeman* was anchored at bow and stern. Weather, sea state conditions, and acoustic system settings were recorded. Three calibration spheres were suspended below the centerboard-mounted transducers. Two were copper calibration spheres of 23 mm (120-kHz sphere, TS = -40.3 dB) and 60 mm (38-kHz sphere, TS = -33.6 dB) diameter, and the third was a tungsten carbide sphere of 38.1 mm (200-kHz sphere, TS = -39.5 dB) diameter. After each sphere was centered on the acoustic axis, split-beam target-strength and echo integration data were collected to determine acoustic system gain parameters. The average on-axis target strength and on-axis integration values were measured and recorded. Transducer beam characteristics were measured using a Simrad software program (EKLOBES). Each sphere was pulled through its corresponding transducer beam, target-strength data were collected on a grid of angle coordinates, and beam pattern was estimated (Foote et al. 1987).

Data Analysis

The abundance of pollock was estimated by combining echo integration and trawl data. Echosign identified as pollock was stored in a database. Pollock length data from 5 hauls were aggregated into three analytical strata based on echosign type, geographic proximity of hauls, and similarity in size composition data. Average pollock volume backscattering strength along each 0.5 nmi of transect was multiplied by transect width to estimate area backscattering strength for transect segments. Area backscattering segments were summed to compute total pollock area backscattering for each analytical

stratum. Stratum totals were then summed and scaled using a previously derived relationship between target strength and fish length (TS = 20 Log FL - 66; Traynor 1996) and the length composition data, resulting in an estimate of numbers of pollock by size. A length-weight relationship observed from trawl data was applied to estimate pollock biomass for each length category. Age data for winter 2003 were not available when this analysis was completed.

In the Bogoslof Island area, pre-spawning pollock aggregations are often densely packed and vertically and/or horizontally stratified by sex. Therefore it is not always possible to obtain an unbiased sample of lengths from these aggregations to estimate population size composition. 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, we assumed that the sex ratio that we sampled was 50:50 and estimated abundance under this assumption.

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 1B). The EK500 38-kHz and 120 kHz collection systems showed no significant differences in gain parameters or transducer beam pattern characteristics before and after the Bogoslof Island area survey.

Oceanographic Conditions

Temperature profiles from the basin region at three sites (Table 2) indicated well-mixed water columns with little variation in temperature between the surface and deeper waters. Temperatures in the upper 500 m of the water column ranged from 3.6° to 5.1°C and averaged 4.4°C.

Biological Sampling

Biological data and specimens were collected from 5 trawl hauls (Tables 2 and 3; Fig. 1). Poor weather conditions precluded additional trawl sampling. Walleye pollock dominated the trawl catches by weight (97.9%; Table 4). Lanternfish (Myctophidae) and Pacific ocean perch (*Sebastes alutus*) each contributed about 1% of the total catch by weight.

Length measurements were collected from about 1,800 pollock specimens (Table 3, Fig 2) for scaling the acoustic data and computing size-specific population estimates. Pollock sampled in trawl hauls ranged from 33 to 69 cm FL. Length compositions varied over the region surveyed and were grouped into three strata (Fig. 3). Pollock lengths from hauls 1 and 2 were unimodal with the mode at 48-49 cm FL; they were combined to represent the Umnak Pass region, stratum 1. Pollock lengths from haul 3 were more evenly dispersed between 44 and 67 cm FL and were considered to represent the Umnak Island region, stratum 2. Length compositions from hauls 4 and 5 were bimodal with modes at about 48-50 and 59-60 cm. These hauls were combined to represent the Samalga Pass region, stratum 3. Trawl catch sex ratios ranged from 12% to 92% male.

Maturity stage data, length-weight data, and otoliths were collected from 346 pollock specimens. The unweighted maturity composition showed that 81% percent of the female and 25% of the male pollock were in pre-spawning condition (Fig. 4a). Seven percent of the females and about 63% of the males were actively spawning. The average gonado-somatic index (GSI: ovary weight/body weight) for pre-spawning mature female pollock was 0.17 (Fig. 4b), which was similar to the average GSI observed during recent years . This suggests that the survey's timing was similar to previous years in relation to peak spawning. The regression equation of total body weight to length for sexes combined was $W = 0.003 \times FL^{3.2238}$, where FL is fork length (cm) and W is weight (g) (Fig. 4c).

Pollock Distribution and Abundance

The spatial distribution of pollock in the survey area was similar to that observed in recent years. Pollock were primarily concentrated just north of Samalga Pass about 300-400 m below the surface, with lesser concentrations along the shelf break at the northeast end of Umnak Island (Fig. 1).

The abundance estimate for pollock in the Bogoslof area between 14 m below the surface and 1,000 m was estimated at 0.134 billion fish weighing 0.198 million metric tons (Table 5, Fig. 5). The size composition was bimodal; 38% of the pollock by numbers (25% of the biomass) were 54 cm or smaller in length, and of those, the average fork length was 48.9 cm. The remaining 62% of the estimated pollock numbers (75% of the biomass) were larger than 54 cm, and of those, the average fork length was 59.9 cm. Based on the 1D analysis, the relative estimation error of the Bogoslof pollock biomass estimate is 21.5%. The abundance estimates and relative estimation error for pollock inside the CBS Specific Area are the same as for the total area (Table 5).

DISCUSSION

In 2003, as in recent years, pollock were highly concentrated in Samalga Pass (84% of biomass in 2003, 74% in 2002, 76% in 2001), and were otherwise sparsely distributed within the Bogoslof area. Poor weather conditions towards the end of the survey limited trawl sampling to only two hauls in the Samalga Pass region. Length composition data are used to scale acoustic data to total abundance and then, combined with age data, to partition total abundance into year class. If the size composition in the Samalga Pass area was biased due to inadequate sampling, the effect on total abundance would be relatively small because the target strength-to-length relationship changes little over the observed size range of approximately 45-65 cm. However, resultant biases in estimates of size-at-age compositions might be of concern. The bimodal length composition of 48-50 and 59-60 cm observed this year, was consistent with the bimodal length composition observed in this region during the 2002 survey (i.e., 45-47 cm, 56-60 cm) (Fig. 6).

There has been little change in population biomass since 2000 (Table 5, Fig. 7) and little recruitment to the spawning population since the 1992 year class first appeared as 6-year olds in 1998 (Fig. 8). Even though age data from the 2002 and 2003 surveys are not yet available, a comparison of the abundance of small fish (e.g., smaller than 50 cm FL) estimated from this year's survey results with the abundance of small fish estimated from previous survey results suggests that the incoming 1996 year class is not strong (Table 6).

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SCIENTIFIC PERSONNEL

Name	Gender/Nationality	Position	Organization
Neal Williamson	M/USA	Chief Scientist	MACE
Denise McKelvey	F/USA	Fishery Biologist	MACE
Paul Walline	M/USA	Fishery Biologist	MACE
Scott Furnish	M/USA	Computer Spec.	MACE
William Floering	M/USA	Fishery Biologist	MACE
Tyler Yasenak	M/USA	Fishery Biologist	MACE
Kresimir Williams	M/USA	Fishery Biologist	MACE
Robert Self	M/USA	Fishery Biologist	MACE
Annette Brown	F/USA	Fishery Biologist	FOCI
Jason Conner	M/USA	Fishery Biologist	GF-STAT

MACE - Midwater Assessment and Conservation Engineering Program, RACE, AFSC, Seattle, WA

FOCI - Fisheries Oceanography Coordinated Investigations, RACE, AFSC, Seattle, WA

GF-STAT - Groundfish, Survey Technology Applications Team, RACE, AFSC, Seattle, WA

Table 1. Acoustic system description and settings during the winter 2003 echo integration-trawl survey of walleye pollock in the Bogoslof Island area (A) and results from standard sphere acoustic system calibrations conducted before, during, and after the survey (B).

	(A)		(B)					
	8-14 Mar System Setting		6-Feb, Alitak Bay, AK		8-Mar, Captains Bay, AK		30-Mar, Sea Otter Bay, AK	
Echosounder:	Simrad EK 500		Simrad EK 500		Simrad EK 500		Simrad EK 500	
Transducer:	ES38B	ES120-7C	ES38B	ES120-7C	ES38B	ES120-7C	ES38B	ES120-7C
Frequency (kHz):	38	120	38	120	38	120	38	120
Transducer depth (m):	9.15	9.15						
Absorption coefficient (dB/km):	10	29						
Pulse length (ms):	1.0 (medium)	0.3 (medium)						
Band width (kHz):	3.8 (Wide)	1.2 (narrow)						
Transmitted power (W):	2000	1000						
Angle sensitivity:	21.9	21.9						
2-Way beam angle (dB):	-20.7	-20.7						
TS transducer gain (dB):	25.9	26.5	25.9	26.8	25.8	26.7	25.8	26.7
Sv transducer gain (dB):	25.6	26.7	25.8	27.0	25.5	26.8	25.5	26.7
3 dB beamwidth (deg)								
Along:	6.90	6.80	--	--	6.98	6.85	6.96	6.85
Athwart:	6.80	6.80	--	--	6.87	6.68	6.85	6.81
Angle offset (deg)								
Along:	-0.08	-0.06	--	--	-0.10	-0.24	-0.11	-0.24
Athwart:	0.03	0.07	--	--	-0.02	0.11	-0.01	0.07
Range (m):	1000	250	--	--	--	--	--	--
Post-processing Sv threshold (dB):	-70	--	--	--	--	--	--	--
Sphere range from transducer (m):	--	--	25.5	20.0	36.3	27.5	33.3	23.1
Water temp (°C):								
at transducer:	--	--	3.0	3.0	4.6	4.6	5.4	5.4
at sphere:	--	--	3.0	3.0	4.9	4.9	5.4	5.4

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

Table 2. Trawl station and catch data summary from the winter 2003 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul	Gear		Time	Duration	Start Position		Depth (m)		Temp. (C)		Profiler	Catch Pollock		Catch Other
No.	Type[1]	Date	(GMT)	(minutes)	Latitude (N)	Longitude (W)	Footrope	Bottom	Gear[2]	Surface	No.	(kg)	Number	(kg)
1	AWT	9-Mar	18:24	36	53 42.48	167 27.90	304	-	3.9	3.8	301	244.4	295	51.6
2	AWT	10-Mar	4:30	20	53 33.48	167 45.78	521	640	3.6	4.4	302	1,249.7	1,364	67.8
3	AWT	10-Mar	19:32	11	53 37.08	168 09.12	240	639	4.8	4.7	303	862.8	628	4.8
4	AWT	13-Mar	5:08	3	53 02.28	169 08.16	301	416	-	3.2	-	2,214.5	1,194	1.5
5	AWT	13-Mar	7:56	4	53 03.42	169 09.36	380	602	-	3.7	-	1,376.2	1,033	0.3

[1]Gear type: AWT = Aleutian Wing Trawl

[2]Gear temperature was measured at the trawl headrope depth.

Table 3. Numbers of biological samples and measurements collected during the winter 2003 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Haul No.	Lengths	Fish Weights, Otoliths, Maturity	Ovary Weight	Ovary Collection[1]	Vitellogenin Study[2]	Muscle Tissue Collection[3]	Gamete Collection[4,5]	Whole Fish Collections[4,6]
1	295	70	28	11	5	25	-	X
2	338	67	8	2	10	11	X	-
3	314	70	54	1	11	20	-	-
4	393	67	39	9	6	10	-	-
5	464	72	34	5	5	4	-	-
Totals	1,804	346	163	28	37	70	1 site	1 site

[1] Pollock ovaries sampled for a fecundity study (B. Megrey)

[2] Pollock ovaries and serum sampled for a reproductive hormone study (B. Megrey)

[3] Pollock muscle collections taken for parasite studies (F. Morado)

[4] "X" indicates a collection was made, but numbers were not specified.

[5] Pollock gametes propagated for early life history investigations (A. Brown)

[6] Whole fish retained for identification training (S. Corey)

Table 4. Catch by species from 5 midwater trawl hauls during the winter 2003 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

Species Name	Scientific Name	Weight (kg)	Percent by weight	Numbers
walleye pollock	*Theragra chalcogramma*	5,947.6	97.9	4,514
lanternfish unidentified	Myctophidae	55.7	0.9	5,098*
Pacific ocean perch	*Sebastes alutus*	45.1	0.7	62
squid unidentified	Teuthoidea (order)	7.6	0.1	35
smooth lumpsucker	*Aptocyclus ventricosus*	6.4	0.1	2
chinook salmon	*Oncorhynchus tshawytscha*	4.0	0.1	2
Pacific lamprey	*Lampetra tridentata*	3.5	0.1	9
capelin	*Mallotus villosus*	2.3	< 0.1	-
arrowtooth flounder	*Atheresthes stomias*	1.0	< 0.1	1
hatchetfish unidentified	Sternoptychidae	0.3	< 0.1	6
shrimp unidentified	Decapoda (order)	0.1	< 0.1	65*
jellyfish unidentified	Scyphozoa (class)	< 0.1	< 0.1	1
northern smoothtongue	*Leuroglossus schmidti*	< 0.1	< 0.1	5
Totals		6,073.6		9,800

** lantern fish and shrimp numbers for one haul were estimated by using the average weight of each from other hauls in the area.

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 2003.

	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

Table 6. Numbers-at-length estimates (millions) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No survey was conducted in 1990. The 1999 survey was conducted by the Japan Fisheries Agency.

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

Table 6. Continued.

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

Table 7. Biomass-at-length estimates (metric tons) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No survey was conducted in 1990. The 1999 survey was conducted by the Japan Fisheries Agency.

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
10	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0	0
11	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0	0
12	0	0	--	0	0	0	0	5	0	0	0	0	0	0	0	0
13	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0	0
14	0	0	--	0	0	0	0	1	0	0	0	0	0	0	0	0
15	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
17	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
19	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
21	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
23	0	0	--	70	0	0	0	0	0	0	0	0	0	0	38	0
24	0	0	--	61	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
26	0	0	--	26	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
28	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
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	7	0
31	0	0	--	0	37	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
33	0	0	--	0	48	0	0	0	0	0	0	0	0	0	9	2
34	0	0	--	0	0	0	0	53	35	0	29	0	0	0	48	2
35	0	0	--	0	0	0	0	93	0	29	0	0	0	0	73	0
36	0	0	--	0	68	0	0	42	96	18	32	0	0	0	204	0
37	3,199	846	--	115	0	0	0	113	109	84	92	0	0	0	456	16
38	2,304	0	--	768	84	260	0	435	465	173	395	0	0	19	508	6
39	6,365	1,461	--	1,843	0	634	202	1,697	562	507	1,250	258	168	149	823	7
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
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

Table 7. Continued

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
65	0	0	--	938	0	0	0	495	578	1,096	1,156	1,833	1,660	2,730	2,463	7,281
66	0	0	--	0	0	0	0	163	0	329	1,251	403	534	1,132	1,515	3,582
67	0	0	--	0	0	0	0	0	0	0	0	863	520	715	583	1,954
68	0	0	--	0	0	0	0	2,570	0	0	276	0	403	426	777	746
69	0	0	--	0	0	0	0	0	0	0	0	0	0	55	0	391
70	0	0	--	0	0	0	0	0	0	0	0	0	0	100	61	0
Totals	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

Table 8. Numbers-at-age estimates (millions) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No survey was conducted in 1990. The 1999 survey was conducted by the Japan Fisheries Agency. Age data are not yet available for 2002 and 2003.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
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
2	0	0	--	4	0	0	0	0	0	0	0	0	0	0
3	0	0	--	0	1	1	0	2	0	0	0	0	0	0
4	0	6	--	2	2	33	21	6	<1	<1	<1	2	1	1
5	28	15	--	12	27	17	86	75	6	4	11	5	6	14
6	327	58	--	46	54	44	26	278	96	16	61	29	4	12
7	247	363	--	213	97	46	38	105	187	55	34	77	14	10
8	164	147	--	93	74	48	36	68	85	88	70	34	30	10
9	350	194	--	160	71	42	36	80	40	38	77	50	16	14
10	1,201	91	--	44	55	28	17	53	37	28	32	75	28	12
11	288	1,105	--	92	57	51	27	54	24	16	25	29	45	18
12	287	222	--	60	33	25	23	19	24	16	21	27	21	31
13	202	223	--	373	34	27	13	59	12	13	19	25	16	13
14	89	82	--	119	142	42	9	32	36	7	18	16	11	7
15	27	90	--	41	164	92	45	12	18	13	9	12	11	9
16	17	30	--	38	59	47	36	31	4	5	15	10	9	8
17	7	60	--	29	8	25	28	103	16	4	5	8	3	5
18	3	0	--	32	15	11	16	60	35	12	8	6	6	1
19	0	0	--	56	22	11	4	18	26	12	10	3	3	3
20	0	0	--	4	42	11	4	5	12	7	15	4	2	1
21	0	0	--	2	13	10	8	5	3	2	4	3	1	0
22	0	0	--	0	3	1	2	6	2	1	1	2	1	0
23	0	0	--	0	1	1	2	6	1	<1	0	<1	0	<1
24	0	0	--	0	0	0	1	2	0	1	0	0	<1	<1
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0
Totals	3,236	2,687	--	1,419	975	613	478	1,081	666	336	435	416	229	171

Table 9. Biomass-at-age estimates (metric tons) from February-March echo integration-trawl surveys of walleye pollock in the Bogoslof Island area. No survey was conducted in 1990. The 1999 survey was conducted by the Japan Fisheries Agency. Age data are not yet available for 2002 and 2003.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
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
2	0	0	--	170	0	0	0	0	0	0	0	0	0	0
3	0	0	--	0	162	284	0	681	0	0	0	0	0	0
4	0	2,184	--	715	782	18,809	13,028	3,411	322	87	78	1,809	324	437
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
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
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
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
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
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
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	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
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
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
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
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
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
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
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
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
21	0	0	--	1,341	15,240	10,167	8,866	5,433	4,023	1,885	5,376	3,574	1,566	0
22	0	0	--	0	3,186	1,329	2,011	7,728	1,974	947	1,078	2,668	1,810	0
23	0	0	--	0	1,287	598	2,323	6,696	661	419	0	514	0	493
24	0	0	--	0	0	0	860	2,758	0	888	0	0	526	493
25	0	0	--	0	0	0	0	0	0	0	0	0	0	0
Totals	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

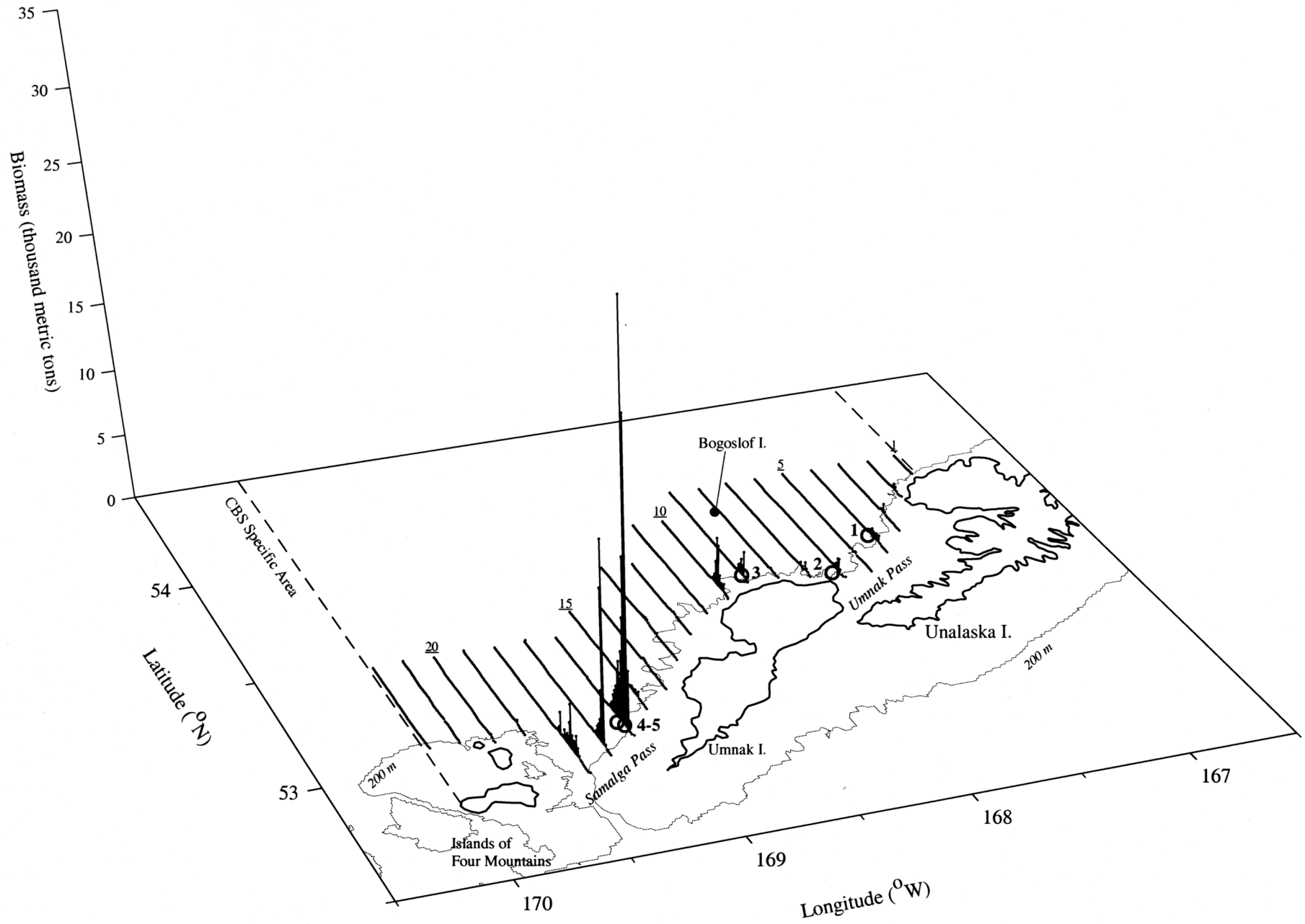


Figure 1. Trawl haul location (numbered circles) and biomass (1000 metric tons) attributed to pollock observed during the winter 2003 echo integration-trawl survey in the Bogoslof Island area. Transect numbers are underlined and the CBS Specific Area is indicated.

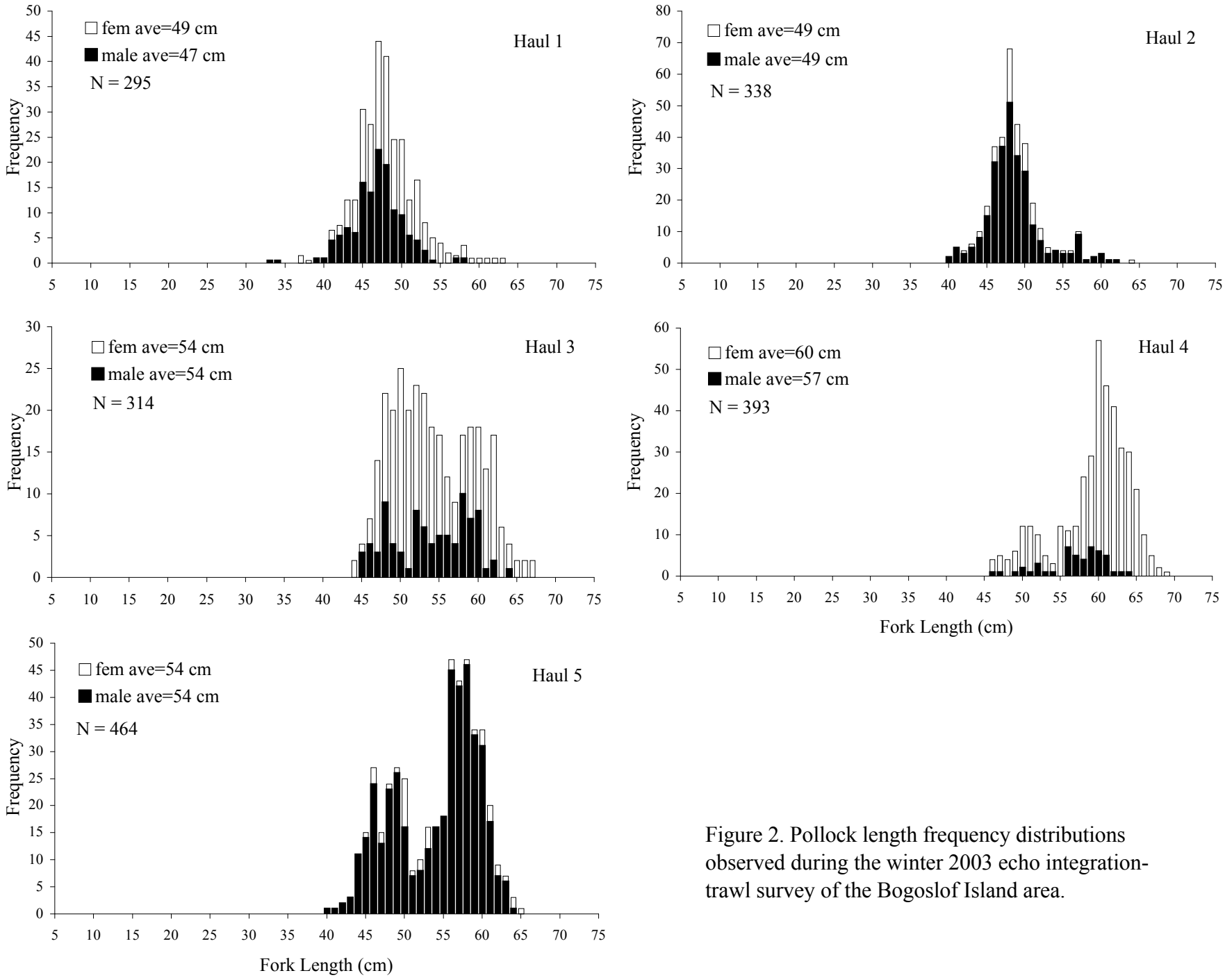


Figure 2. Pollock length frequency distributions observed during the winter 2003 echo integration-trawl survey of the Bogoslof Island area.

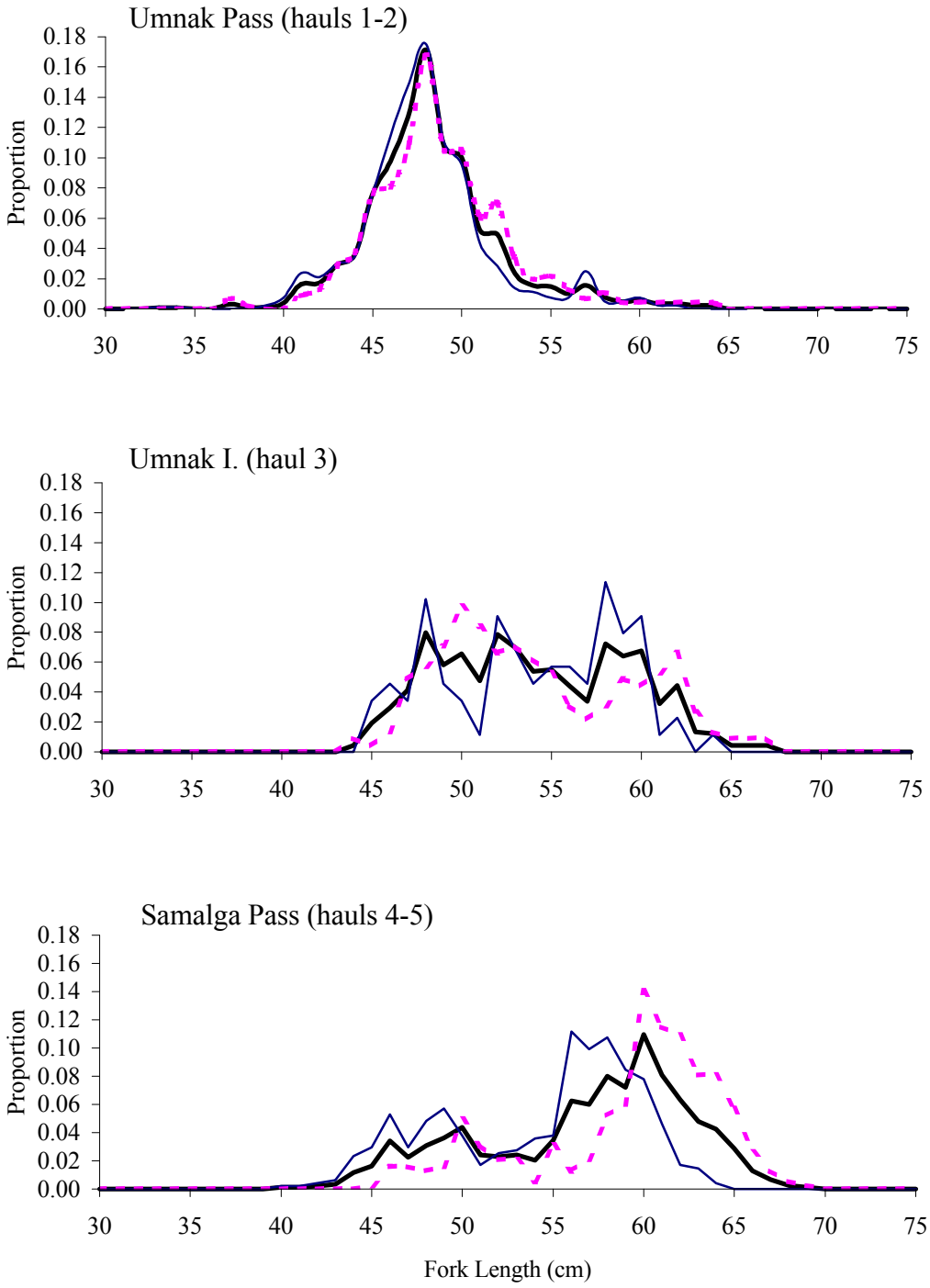
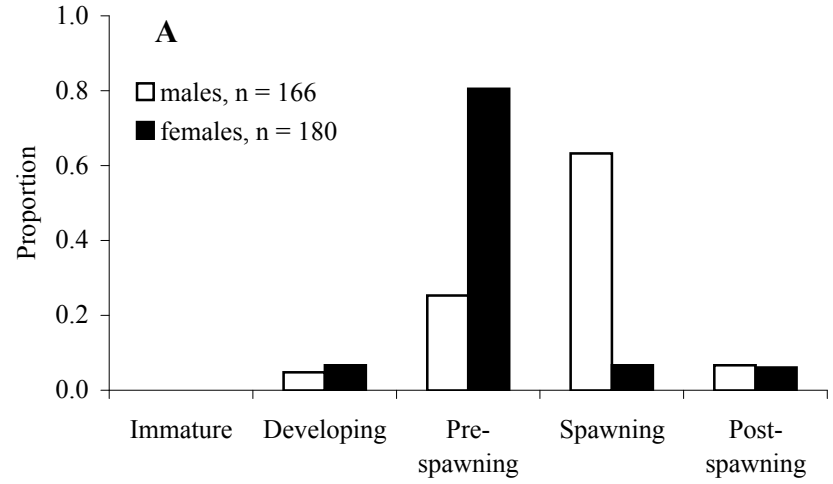
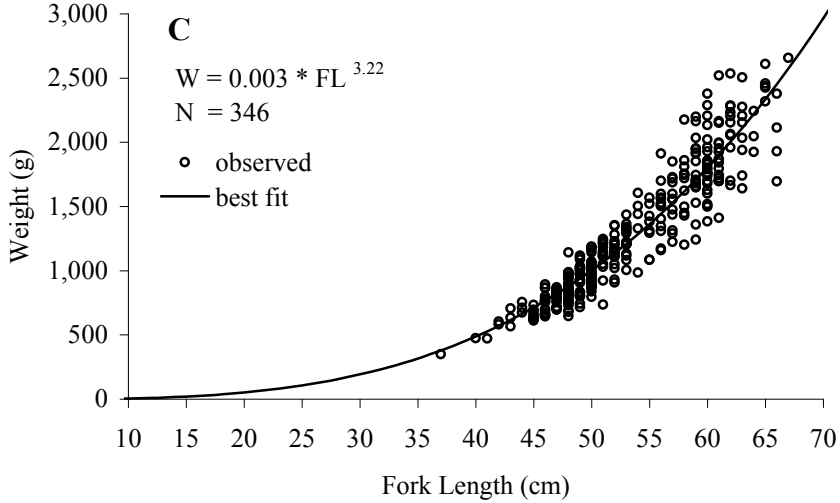


Figure 3. Pollock proportion-at-length (sexes combined: bold line, males: medium line, females: dashed line) derived for strata 1-3 during the winter 2003 echo integration-trawl survey of the Bogoslof Island area.





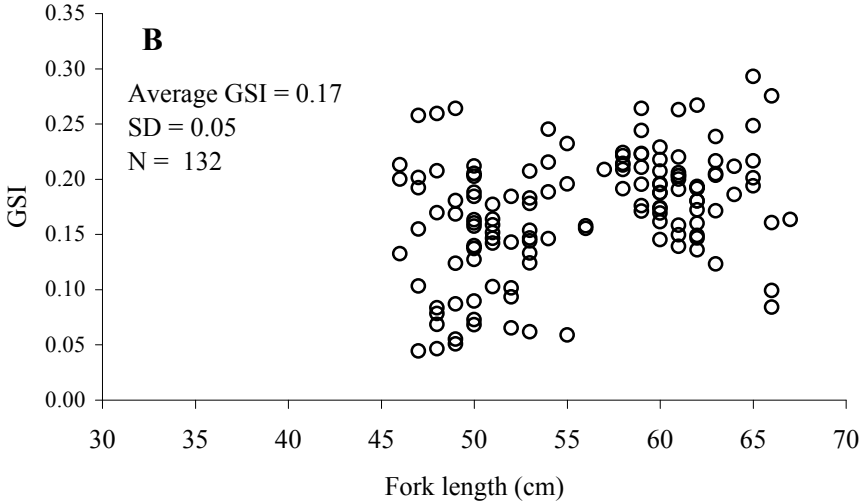


Figure 4. Pollock maturity stages (A), gonado-somatic index (GSI) for pre-spawning females as a function of fork length (cm) (B), and length-weight relationship (sexes combined) (C) observed during the winter 2003 echo integration-trawl survey of the Bogoslof Island area.

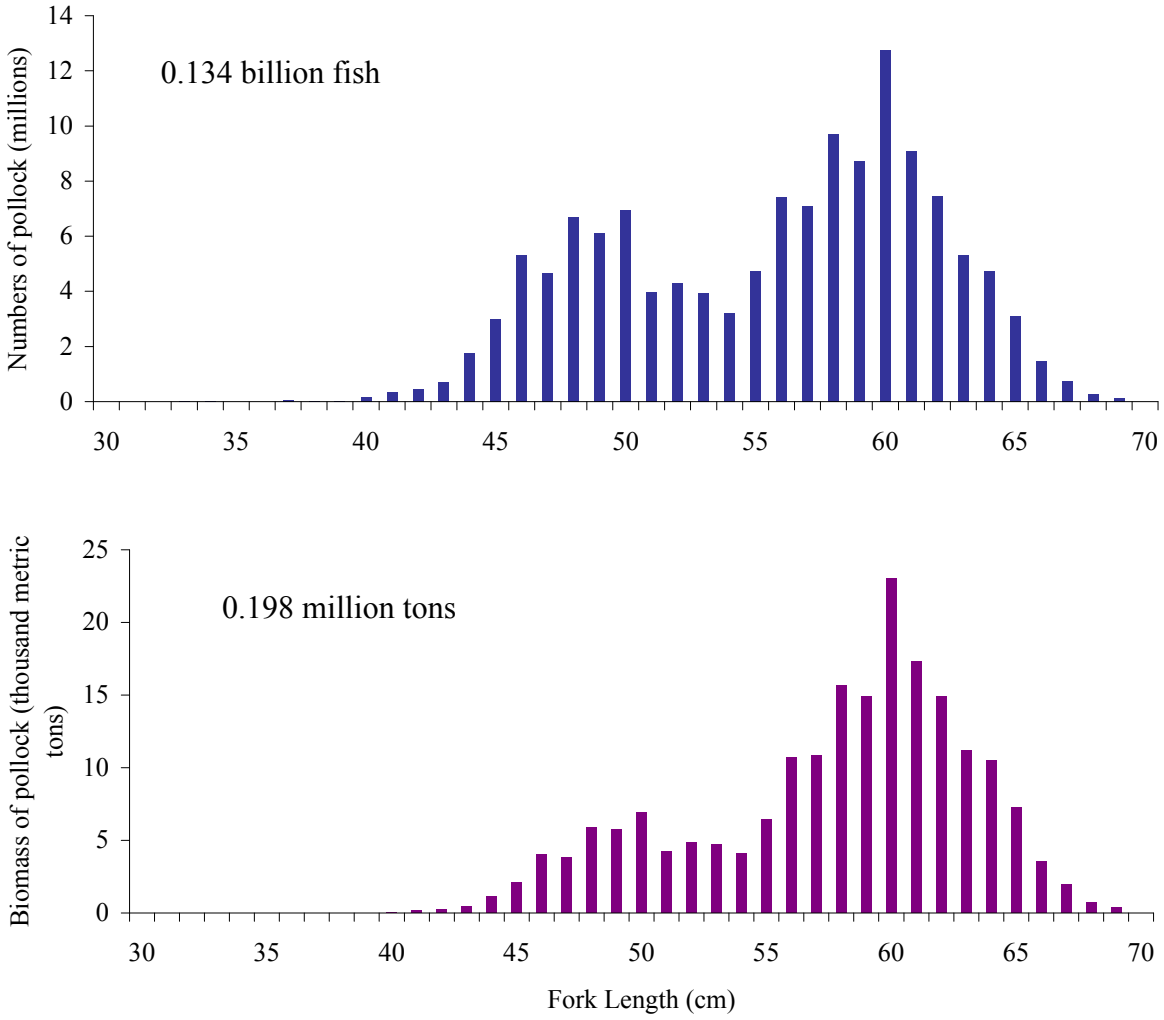


Figure 5. Population-at-length (top) and biomass-at-length (bottom) estimates from the winter 2003 echo integration-trawl survey of walleye pollock in the Bogoslof Island area.

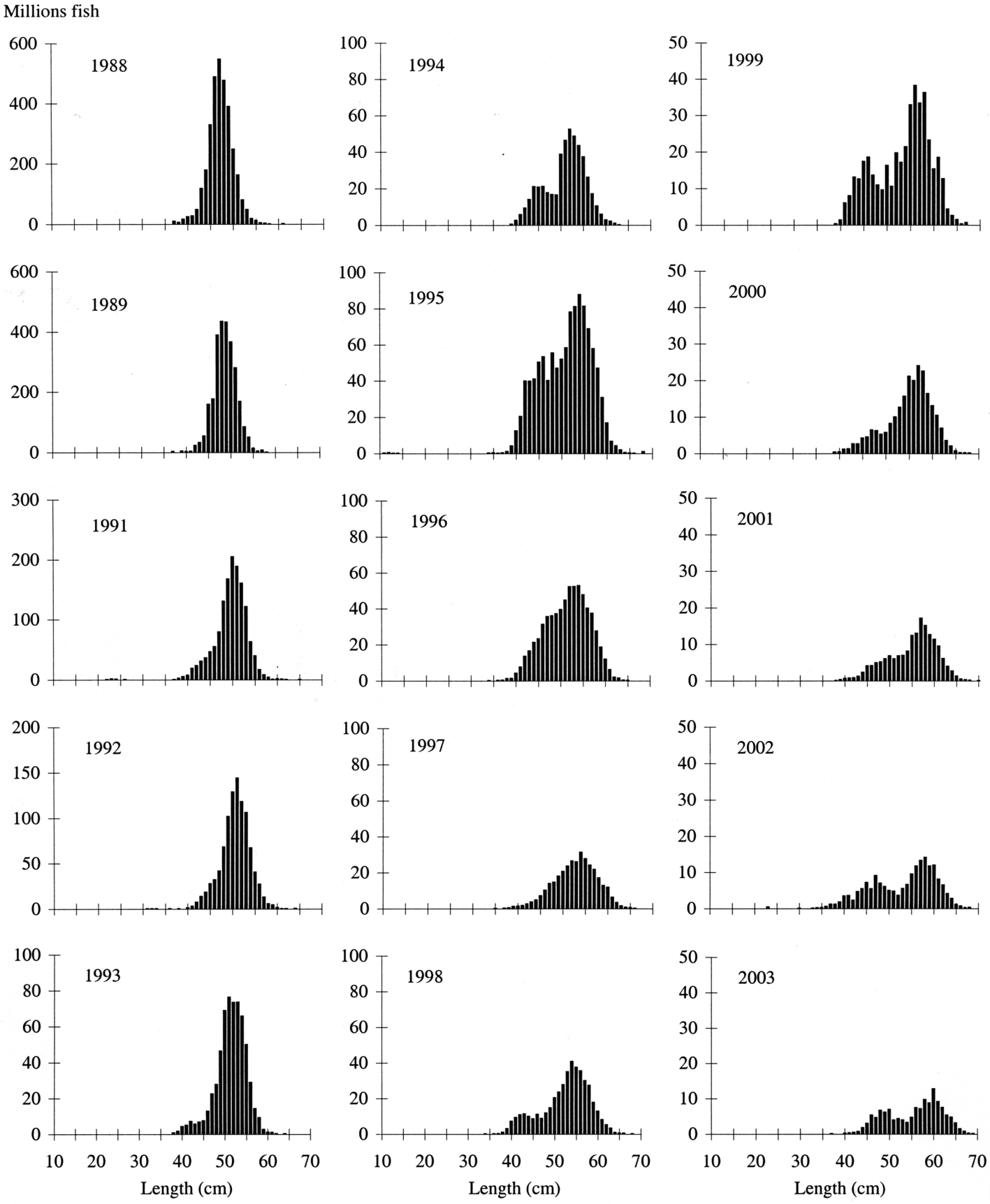


Figure 6. Numbers-at-length estimates (millions) from echo integration-trawl surveys of spawning pollock near Bogoslof Island in winter 1988-2003. The United States conducted all but the 1999 survey, which was conducted by Japan. There was no survey in 1990. Note y-axis scales differ.

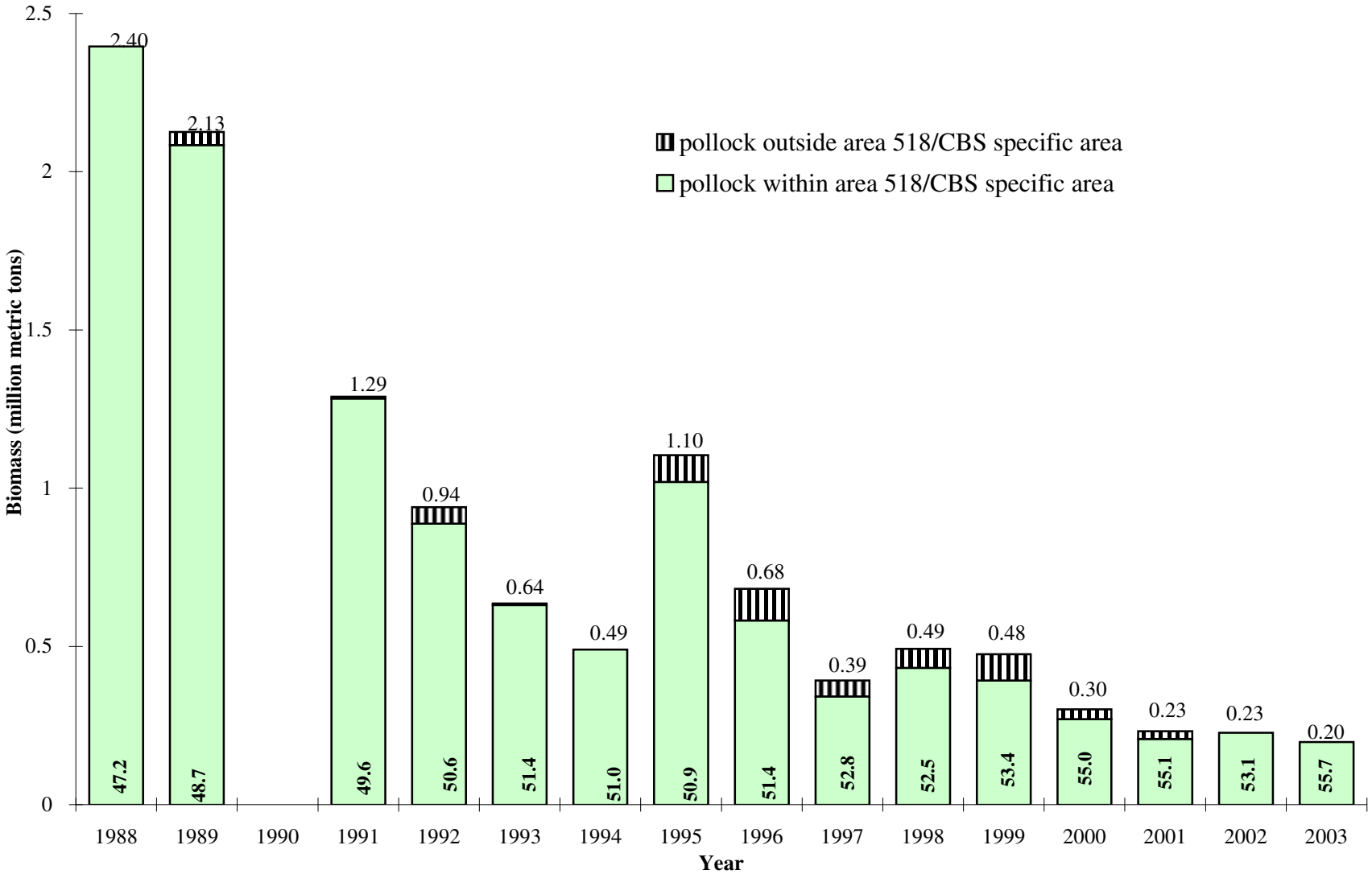


Figure 7. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2003. The U.S. conducted all but the 1999 survey, which was conducted by Japan. There was no survey in 1990. Total pollock biomass for each survey year is indicated on top of each bar and average fork length (cm) is indicated inside each bar.

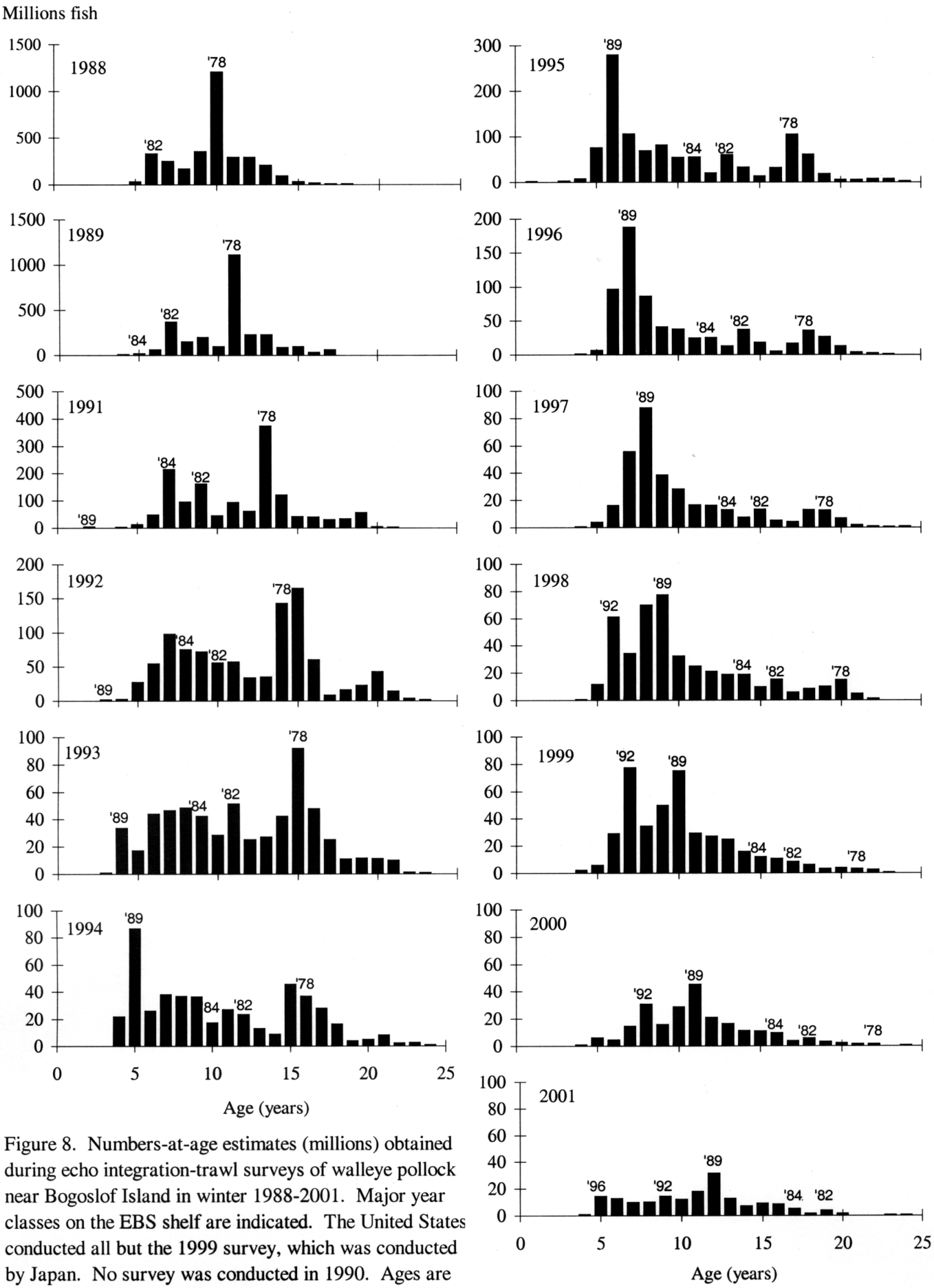


Figure 8. Numbers-at-age estimates (millions) obtained during echo integration-trawl surveys of walleye pollock near Bogoslof Island in winter 1988-2001. Major year classes on the EBS shelf are indicated. The United States conducted all but the 1999 survey, which was conducted by Japan. No survey was conducted in 1990. Ages are not yet available for 2002 and 2003. Note y-axis scales differ.