Attachment 5

Information submitted to the Scientific and Technical Committee

by the United States Party

for the 7th Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea

Moscow, 16-19 September 2002

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Contents

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Section I

Table 1. United States Pollock Catches in metric tons, 1993-2002

Year	E. Bering Sea	Aleutians	Bogoslof	Gulf of Alaska
1993	1,198,790	54,074	885	108,066
1994	1,197,224	53,224	556	110,890
1995	1,169,614	60,184	264	73,248
1996	1,102,579	26,597	389	37,106
1997	1,036,789	24,721	163	89,893
1998	1,058,288	22,053	8	123,805
1999	889,561	965	1	93,422
2000	1,019,067	1,174	29	23,643
2001	1,247,305	788	61	70,485
(Up to August 1) 2002	792,309	887	5	71,877
(Remainder of 2002)	544,191	13	90	18,944

Note: (Data from http://www.fakr.noaa.gov/sustainablefisheries/catchstats.htm)

Table 2. Historical catch of pollock from the Bering Sea, in metric tons, 1977-2002

Year	Western Bering Sea	Donut Hole	Navarin Region	Bogoslof	Aleutian Region	Eastern Bering Sea	Total Bering Sea
1977	265000				7625	978370	1,250,995
1978	417000				6282	979431	1,402,713
1979	546,000				9,504	935,714	1,491,218
1980	825,000				58,156	958,280	1,841,436
1981	1,133,000				55,516	973,502	2,162,018
1982	976,000				57,978	955,964	1,989,942
1983	1,006,000				59,026	981,450	2,046,476
1984	755,000	181,200	503,000		81,834	1,092,055	2,613,089
1985	662,000	363,400	488,000		58,730	1,139,676	2,711,806
1986	867,000	1,039,800	570,000		46,641	1,141,993	3,665,434
1987	812,000	1,326,300	463,000	377,436	28,720	859,416	3,866,872
1988	1,327,000	1,395,900	852,000	87,813	30,000	1,228,721	4,921,434
1989	1,029,000	1,447,600	684,000	36,073	15,531	1,229,600	4,441,804
1990	814,000	917,400	232,000	151,672	79,025	1,455,193	3,649,290
1991	504,000	293,400	178,000	264,760	78,649	1,217,301	2,536,110
1992	597,000	10,000	315,000	160	48,745	1,164,440	2,135,345
1993	677,000	1,957	389,000	885	54,074	1,198,790	2,321,706
1994		NA	288,900	556	53,224	1,197,224	1,539,904
1995		Trace	427,300	264	60,184	1,169,614	1,657,362
1996		Trace	753,000	389	26,597	1,102,579	1,882,565
1997		Trace	735,000	163	24,721	1,036,789	1,796,673
1998		Trace	719,000	8	22,053	1,058,288	1,799,349
1999		Trace	639,000	1	965	889,561	1,529,527
2000		Trace	377,000	29	1,174	1,019,067	1,397,270
2001		Trace	400,000	61	788	1,247,305	1,648,154
2002*		Trace		5	887	792,309	793,201
Remain 02				90	13	544191	

* U.S. data for 2002 is through August 1, 2002

Sources of Data

U.S. Data, 1979-1992 from Pollock stock assessment document at 7th Annual Conference
1993-2002 data from web site: www.fakr.noaa.gov
Navarin Data, 1994-2001 (from Russian pollock stock assessment document presented by the Russian Party at the 6th annual conference in Poland)
Navarin Data, 1984-1993 (from The Aleutian Basin Pollock Stock in 2001 written by TINRO and presented at 6th annual conference)
Western Bering Sea data from Balykin (1996)

Table 3 Bering Sea "donut hole" pollock catches (in metric tons) and catch per unit effort (in t/hour, t/day, or t/trawl) by country by quarter, 1985-1993.

		CHINA[1] T	CHINA[1] T/HR	JAPAN[2] T	JAPAN[2] T/HR	KOREA[3] T	KOREA[3] T/HR	POLAND[2] T	POLAND[2] T/HR	USSR/FSU[4] T	USSR/FSU[4] T/TRAWL	TOTAL[5] T
1985	Q1	?		136.315	?	68.841	6.6	30.392	6.23			235.548
	Q2	?		8.429	?	11.789	6.7	67.472	7.50			87.690
	Q3	?		2.549	?	0	-	94	3.36			2.643
	Q4	?		16.213	?	1.814	11.7	17.916	9.82			35.943
	TOT	1.600		163.506	4.8	82.444	6.6	115.874	7.39			363.424
1986	Q1	?		381.012	7.7	79.758	6.86	72.396	7.26	?	?	533.166
	Q2	?		76.000	6.7	11.394	4.80	49.435	7.31	?	?	136.829
	Q3	?		6.514	2.2	0	0.00	345	3.03	?	?	6.859
	Q4	?		242.095	12.4	64.566	11.91	41.073	6.47	?	?	347.734
	TOT	3.200		705.621	8.5	155.718	8.02	163.249	7.00	12.000	?	1.039.788
1987	Q1	0	0	345.917	8.0	60.729	9.07	86.968	6.80	?	?	493.614
	Q2	0	0	80.103	4.5	16.753	5.38	86.142	5.66	?	?	182.998
	Q3	34	0.88	905	0.9	26.176	3.58	16.157	6.00	?	?	43.272
	Q4	16.495	4.61	376.625	11.2	138.212	8.75	41.051	4.07	?	?	572.383
	TOT	16.529	4.57	803.550	8.4	241.870	7.35	230.318	5.64	34.000	?	1.326.267
1988	Q1	849	1.83	126.089	4.4	17.524	3.66	58.929	2.85	?	?	203.391
	Q2	0	0	85.880	4.4	32.233	4.13	102.646	5.72	?	?	220.759
	Q3	343	1.75	34.262	5.8	60.546	3.70	54.106	4.90	?	?	149.257
	Q4	17.227	3.76	503.751	9.1	158.296	6.43	83.033	4.39	?	?	762.307
	TOT	18.419	3.51	749.982	6.8	268.599	5.01	298.714	4.38	61.000	?	1.396.714
1989	Q1	1.138	1.43	110.289	3.7	24.882	2.92	41.047	3.42	?	?	177.356
	Q2	0	0	138.490	10.8	134.209	5.20	105.481	6.15	?	?	378.180
	Q3	16.991	2.95	34.658	5.3	91.625	3.16	44.660	3.72	?	?	187.934
	Q4	13.010	2.85	371.472	6.3	91.580	3.61	77.382	4.82	?	?	553.444
	TOT	31.139	2.80	654.909	6.0	342.296	3.86	268.570	4.51	150.700	34.3	1.447.614
1990	Q1	3.207	1.51	74.267	2.3	15.454	1.65	17.331	2.08	?	?	110.259
	Q2	4.093	2.66	165.488	4.4	120.534	2.94	102.176	3.52	?	?	392.291
	Q3	13.997	2.03	50.744	4.2	75.462	2.53	55.976	2.63	?	?	196.179
	Q4	6.529	1.73	126.521	2.4	32.821	1.48	47.971	2.50	?	?	213.842
	TOT	27.826	1.94	417.020	3.1	244.271	2.39	223.454	2.87	4.800	22.9	917.371
1991	Q1	132		12.880	.6	3.913	0.5	1.714	0.82	270	9.6$^{T/D}$	18.909
	Q2	4.978	.8	71.766	3.0	35.770	1.6	38.072	1.90	3.201	23.4$^{T/D}$	153.787
	Q3	10.540	1.1	33.203	2.6	29.196	1.3	15.073	1.66	0	0	88.012
	Q4	1.003	.9	22.601	1.3	9.080	0.4	7	0.08	0	0	32.691
	TOT	16.653	1.0	140.450	1.8	77.959	1.0	54.866	1.76	3.471	18.5$^{T/D}$	293.399
1992	Q1	408	14.9$^{T/D}$	0	.	0	.	0	.	0?	.?	409
	Q2	3.565	17.4$^{T/D}$	2.695	1.2	4.018	0.8	0	.	0?	.?	10.137
	Q3	0	.	-	.-	35	0.5	0	.	-	.-	35
	Q4	0	.	-	.-	0	.-	0	.	-	.-	-
	TOT	3.973	17.1	2.695	1.2	4.053	0.8	0	.-	0	.-	10.581
1993	Q1	-	.-	-	.-	-	.-	-	.-	-	.-	-
	Q2	-	.-	66	0.6	232	0.5	595	0.76	-	.-	-
	Q3	-	.-	30	0.3	244	0.3	-	.-	-	.-	-
	Q4	-	.-	3	.-	-	.-	-	.-	-	.-	-
	TOT	-	.-	99	0.4	476	0.4	595	0.76	-	.-	-

*preliminary data 1-Data provided by China. 2-Data provided at the 1991 and 1992 Seattle pollock workshops. 3-Compiled from data provided by Korea at 1990 Khabarovsk symposium and at 1991 and 1992 Seattle workshops; cpue data was interpolated from a graph presented at the 1990 Khabarovsk symposium. 4-Data presented at US-USSR bilateral meetings. from 1991 and 1992 Seattle pollock workshops and from 1991 Washington DC meeting. 5-Quarterly totals may not sum to the yearly total if a quarterly breakdown was not available. Updated through October 31, 1995

Additional notes on Korean data: CPUE data in t/day are as follows

1991 Q1	10.0	1992 Q1	-	1993 Q1	-
1991 Q2	25.0	1992 Q2	12.5	1993 Q2	5.5
1991 Q3	1.3	1992 Q3	7.0	1993 Q3	5.2
1991 Q4	0.4	1992 Q4	-	1993 Q4	-

Additional notes on data from Poland: CPUE data in t/day are as follows

1985 Q1	49.75	1986 Q1	49.24	1987 Q1	43.47	1988 Q1	24.52
1985 Q2	56.05	1986 Q2	49.73	1987 Q2	51.02	1988 Q2	56.21
1985 Q3	47.00	1986 Q3	20.31	1987 Q3	68.50	1988 Q3	55.49
1985 Q4	58.90	1986 Q4	43.90	1987 Q4	41.86	1988 Q4	51.33
Annual	54.50	Annual	47.70	Annual	47.00	Annual	43.80

1989 Q1	27.38	1990 Q1	18.40	1991 Q1	6.40	1992 Q1	-
1989 Q2	59.01	1990 Q2	40.30	1991 Q2	19.50	1992 Q2	-
1989 Q3	39.88	1990 Q3	31.30	1991 Q3	18.30	1992 Q3	-
1989 Q4	41.76	1990 Q4	20.90	1991 Q4	0.60	1992 Q4	-
Annual	42.94	Annual	29.50	Annual	18.00	Annual	-

1993 Q3 12.90

Notes About Fisheries Management of Pollock Resources
in the U.S. EEZ in the Bering Sea-Aleutians Region, Year 2002
excerpted from
Eastern Bering Sea Walleye Pollock Stock Assessment
by
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Gary Walters, and Neal Williamson
Alaska Fisheries Science Center
National Marine Fisheries Service
11/20/01

Summary of Catch quotas for Year 2002

Bogoslof Area – No directed fishery for pollock since 1998, bycatch limit for 2002= 100 mt
Aleutians Region – No directed fishery for pollock since 1999, bycatch limit for 2002 = 1,000 mt
Eastern Bering Sea – Catch quota for 2002 = 1,485,000 mt

Fisheries Management Issues

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the NPFMC have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA). These have been designed to reduce the possibility of of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the eastern Bering Sea (EBS) led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which *could* lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here we examine the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

Additional pollock fishery exclusion zones around sea lion rookery or haulout sites,
Phased-in reductions in the seasonal proportions of TAC from critical habitat, and
Additional seasonal TAC releases to disperse the fishery in time.

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the north Pacific ocean managed by the NPFMC: the Aleutian Islands (1,001,780 square km inside the EEZ), the eastern Bering Sea (968,600 square km), and the Gulf of Alaska (1,156,100 square km). The marine portion of Steller sea lion critical habitat in Alaska west of 150°W encompasses 386,770 square km of ocean surface, or 12% of the fishery management regions.

Prior to 1999, a total of 84,100 square km, or 22% of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 square km or 13% of critical habitat). The remainder was largely management area 518 (35,180 square km, or 9% of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central Bering Sea pollock.

In 1999, an additional 83,080 square km (21%) of critical habitat in the Aleutian Islands was closed to pollock fishing along with 43,170 square km (11%) around sea lion haulouts in the GOA and eastern Bering Sea. Consequently, a total of 210,350 square km (54%) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea foraging area.

The Bering Sea/Aleutian Islands pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher processor sector (allocated 36% of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry. Reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire Aleutian Islands region to pollock fishing and by phased-in reductions in the proportions of seasonal TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 mt of pollock was caught in the Aleutian Island regions, with over 17,000 mt caught in AI critical habitat. Since that time directed fishery removals of pollock have been prohibited.

On the eastern Bering Sea shelf, both the catches of pollock and the proportion of the total catch caught in critical habitat have been reduced significantly since 1998 as a result of the management measures (though the drop in the latter half of 2000 was due to closures from an injunction):

Year	Months	Catch Outside SCA	Total Catch	Percent Inside SCA
1998	Jan-Jun	70,786	384,899 82%	
	Jun-Dec	247,691	403,068	39%
	Jan-Dec	318,477	787,967	60%
1999	Jan-Jun	154,963	338,801	54%
	Jun-Dec	360,117	467,776	23%
	Jan-Dec	515,080	806,577	36%
2000	Jan-Jun	240,801	375,285	36%
	Jun-Dec	550,109	571,903	4%
	Jan-Dec	790,910	947,188	16%
2001	Jan-Jun	343,458	474,545	28%
	Jun-Dec	367,686	641,660	43%
	Jan-Dec	711,144	1,116,205	36%

Note: Pollock catches as reported by at-sea observers only, 2001 data are preliminary.

An additional goal for minimizing the potential for impacting the sea lion population is to disperse the fishery throughout more of the pollock range on the eastern Bering Sea shelf. This was apparent in the first half of 2001 with more fishing distributed northwest of the SCA and around the Pribolof Islands (Fig.

1.2). However, in the second-half of 2001 the fishery was more concentrated than usual within the SCA (Fig. 1.5). This is in sharp contrast to the same period in 2000 when this area was closed for much of the season.

Seasonal TAC releases were intended to disperse the fishery throughout more of the year. Prior to the increased sea lion conservation measures, the fishery was concentrated in 2 seasons, each approximately 6 weeks in length in January-February, and September-October; 94% of the pollock fishery occurred during these four months, with 45% in January-February and 49% in September-October. In 1999, the measures dispersed the early fishery into March (which reduced the percentage taken in February) and the later fishery into August, but very little into the April-July period. One way of examining the seasonal aspect of the 2000 fishery is to plot the raw observer sampling effort by month (Fig. 1.7). This is roughly proportional to total catch by the pollock fishery and shows that significant removals occurred in 7 months of the year.

Also relevant to current management measures are examinations of historical patterns of pollock fishing. For this we compiled foreign observer data by month for each year and computed the geographic center of where the removals occurred. Results show that the fishing patterns in the 1980s were quite different than in the 1990s. There appears to be much greater separation between fishing in the early and later seasons within a year during the 1990s while during the 1980s, there appears to be very similar centers of catch distributions in both early and late seasons (Fig. 1.8). This could be partly due to differences in observer coverage and changes to pelagic gear during the 1990s.

TABLE 4—2002 ACCEPTABLE BIOLOGICAL CATCH (ABC), TOTAL ALLOWABLE CATCH (TAC), INITIAL TAC (ITAC), CDQ RESERVE ALLOCATION, AND OVERFISHING LEVELS OF GROUNDFISH IN THE BERING SEA AND ALEUTIAN ISLANDS AREA (BSAI)[1]

[All amounts are in metric tons]

Species	Area	Overfishing level	ABC	TAC	ITAC[2]	CDQ reserve[3]
Pollock[4]	Bering Sea (BS)	3,530,000	2,110,000	1,485,000	1,283,040	148,500
	Aleutian Islands (AI)	31,700	23,800	1,000	900	100
	Bogoslof District	46,400	4,310	100	90	10
Pacific cod	BSAI	294,000	223,000	200,000	170,000	15,000
Sablefish[5]	BS	2,900	1,930	1,930	821	265
	AI	3,850	2,550	2,550	541	431
Atka mackerel	BSAI	82,300	49,000	49,000	41,650	3,675
	Western AI		19,700	19,700	16,745	1,478
	Central AI		23,800	23,800	20,230	1,785
	Eastern AI/BS		5,500	5,500	4,675	413
Yellowfin sole	BSAI	136,000	115,000	86,000	73,100	6,450
Rock sole	BSAI	268,000	225,000	54,000	45,900	4,050
Greenland turbot	BSAI	36,500	8,100	8,000	6,800	600
	BS		5,427	5,360	4,556	402
	AI		2,673	2,640	2,244	198
Arrowtooth flounder	BSAI	137,000	113,000	16,000	13,600	1,200
Flathead sole	BSAI	101,000	82,600	25,000	21,250	1,875
Other flatfish[6]	BSAI	21,800	18,100	3,000	2,550	225
Alaska plaice	BSAI	172,000	143,000	12,000	10,200	900
Pacific ocean perch	BSAI	17,500	14,800	14,800	12,580	1,111
	BS		2,620	2,620	2,227	197
	AI Total		12,180	12,180	10,353	914
	Western AI		5,660	5,660	4,811	425
	Central AI		3,060	3,060	2,601	230
	Eastern AI		3,460	3,460	2,941	260
Northern rockfish[7]	BSAI	9,020	6,760	6,760	5,746	
	BS			19	16	(7)
	AI			6,741	5,730	506
Shortraker/Rougheye[7]	BSAI	1,369	1,028	1,028	874	
	BS			116	99	(7)
	AI			912	775	68
Other rockfish[8]	BS	482	361	361	307	27
	AI	901	676	676	575	51
Squid	BSAI	2,620	1,970	1,970	1,675	
Other species[9]	BSAI	78,900	39,100	30,825	26,201	2,312
Total		4,974,242	3,184,085	2,000,000	1,717,399	187,504

[1] Amounts are in metric tons. These amounts apply to the entire Bering Sea (BS) and Aleutian Islands (AI) management area unless otherwise specified. With the exception of pollock, and for the purpose of these specifications, the Bering Sea subarea includes the Bogoslof District.

[2] Except for pollock, squid, and the portion of the sablefish TAC allocated to hook-and-line or pot gear, 15 percent of each TAC is put into a reserve. The ITAC for each species is the remainder of the TAC after the subtraction of the reserve.

[3] Except for pollock and the hook-and-line or pot gear allocation of sablefish, one half of the amount of the TACs placed in reserve, or 7.5 percent of the TACs, is designated as a CDQ reserve for use by CDQ participants (see § 679.31).

[4] The American Fisheries Act (AFA) requires that 10 percent of the annual pollock TAC be allocated as a directed fishing allowance for the CDQ sector. NMFS then subtracts 4 percent of the remainder as an incidental catch allowance of pollock, which is not apportioned by season or area. The remainder is further allocated by sector as follows: inshore, 50 percent; catcher/processor, 40 percent; and motherships, 10 percent. NMFS, under regulations at § 679.24(b)(4), prohibits nonpelagic trawl gear to engage in directed fishing for non-CDQ pollock in the BSAI.

[5] The ITAC for sablefish reflected in Table 3 is for trawl gear only. Regulations at § 679.20(b)(1) do not provide for the establishment of an ITAC for the hook-and-line or pot gear allocation for sablefish. Twenty percent of the sablefish TAC allocated to hook-and-line gear or pot gear and 7.5 percent of the sablefish TAC allocated to trawl gear is reserved for use by CDQ participants (see § 679.31(c)).

[6] "Other flatfish" includes all flatfish species, except for Pacific halibut (a prohibited species), flathead sole, Greenland turbot, rock sole, yellowfin sole, arrowtooth flounder, and Alaska Plaice.

[7] The CDQ reserves for shortraker, rougheye, and northern rockfish will continue to be managed as the "other red rockfish" complex for the BS. For 2002 the CDQ reserve for the "other red rockfish" complex is 10 mt.

[8] "Other rockfish" includes all *Sebastes* and *Sebastolobus* species except for Pacific ocean perch, northern, shortraker, and rougheye rockfish.

[9] "Other species" includes sculpins, sharks, skates and octopus. Forage fish, as defined at § 679.2, are not included in the "other species" category.

TABLE 5.—2002 ABCS, TACS, AND OVERFISHING LEVELS OF GROUNDFISH FOR THE WESTERN/CENTRAL/WEST YAKUTAT (W/C/WYK), WESTERN (W), CENTRAL (C), EASTERN (E) REGULATORY AREAS, AND IN THE WEST YAKUTAT (WYK), SOUTHEAST OUTSIDE (SEO), AND GULF-WIDE (GW) DISTRICTS OF THE GULF OF ALASKA

[Values are in metric tons]

Species	Area [1]	ABC	TAC	Overfishing
Pollock [2].				
Shumagin	(610)	17,730	17,730	
Chirikof	(620)	23,045	23,045	
Kodiak	(630)	9,850	9,850	
WYK	(640)	1,165	1,165	
Subtotal	W/C/WYK	51,790	51,790	75,480
SEO	(650)	6,460	6,460	8,610
Total		58,250	58,250	84,090
Pacific cod [3].				
	W	22,465	16,849	
	C	31,680	24,790	
	E	3,455	2,591	
Total		57,600	44,230	77,100
Flatfish (deep-water) [4]	W	180	180	
	C	2,220	2,220	
	WYK	1,330	1,330	
	SEO	1,150	1,150	
Total		4,880	4,880	6,430
Rex sole [4]	W	1,280	1,280	
	C	5,540	5,540	
	WYK	1,600	1,600	
	SEO	1,050	1,050	
Total		9,470	9,470	12,320
Flathead sole	W	9,000	2,000	
	C	11,410	5,000	
	WYK	1,590	1,590	
	SEO	690	690	
Total		22,690	9,280	29,530
Flatfish (shallow-water) [5]	W	23,550	4,500	
	C	23,080	13,000	
	WYK	1,180	1,180	
	SEO	1,740	1,740	
Total		49,550	20,420	61,810
Arrowtooth flounder	W	16,960	8,000	
	C	106,580	25,000	
	WYK	17,150	2,500	
	SEO	5,570	2,500	
Total		146,260	38,000	171,060
Sablefish [6]	W	2,240	2,240	
	C	5,430	5,430	
	WYK	1,940	1,940	
	SEO	3,210	3,210	
Subtotal	E	5,150	5,150	
Total		12,820	12,820	19,350
Pacific ocean perch [7]	W	2,610	2,610	3,110
	C	8,220	8,220	9,760

	WYK	780	780	
	SEO	1,580	1,580	
Subtotal	E			2,800
Total		13,190	13,190	15,670
Short raker/rougheye [8]	W	220	220	
	C	840	840	
	E	560	560	
Total		1,620	1,620	2,340
Other rockfish [9,10]	W	90	90	
	C	550	550	
	WYK	260	150	
	SEO	4,140	200	
Total		5,040	990	6,610
Northern Rockfish [10,12]	W	810	600	
	C	4,170	4,170	
	E	N/A	N/A	
Total		4,980	4,980	5,910
Pelagic shelf rockfish [13]	W	510	510	
	C	3,480	3,480	
	WYK	640	640	
	SEO	860	860	
Total		5,490	5,490	8,220
Thornyhead rockfish	W	360	360	
	C	840	840	
	E	790	790	
Total		1,990	1,990	2,330
Demersal shelf rockfish [11]	SEO	350	350	480
Atka mackerel	GW	600	600	6,200
Other species [14]	GW	[15] N/A	11,330	N/A
Total [16]		394,780	237,890	509,450

[1] Regulatory areas and districts are defined at § 679.2.

[2] Pollock is apportioned in the Western/Central Regulatory areas among three statistical areas. During the A and B seasons the apportionment is based on the relative distribution of pollock biomass at 23 percent, 68 percent, and 9 percent in Statistical Areas 610, 620, and 630 respectively. During the C and D seasons pollock is apportioned based on the relative distribution of pollock biomass at 47 percent, 23 percent, and 30 percent in Statistical Areas 610, 620, and 630 respectively. These seasonal apportionments are shown in Table 21. In the West Yakutat and the Southeast Outside Districts of the Eastern Regulatory Area the annual pollock TAC is not divided into seasonal allowances.

[3] The annual Pacific cod TAC is apportioned 60 percent to an A season and 40 percent to a B season in the Western and Central Regulatory Areas of the GOA. Pacific cod is allocated 90 percent for processing by the inshore component and 10 percent for processing by the offshore component. Seasonal apportionments and component allocations of TAC are shown in Table 22.

[4] "Deep water flatfish" means Dover sole, Greenland turbot, and deepsea sole.

[5] "Shallow water flatfish" means flatfish not including "deep water flatfish," flathead sole, rex sole, or arrowtooth flounder.

[6] Sablefish is allocated to trawl and hook-and-line gears (Table 20).

[7] "Pacific ocean perch" means *Sebastes alutus.*

[8] "Shortraker/rougheye rockfish" means *Sebastes borealis* (shortraker) and *S. aleutianus* (rougheye).

[9] "Other rockfish" in the Western and Central Regulatory Areas and in the West Yakutat District means slope rockfish and demersal shelf rockfish. The category "other rockfish" in the Southeast Outside District means Slope rockfish.

[10] "Slope rockfish" means *Sebastes aurora* (aurora), *S. melanostomus* (blackgill), *S. paucispinis* (bocaccio), S. *goodei* (chilipepper), *S. crameri* (darkblotch), *S. elongatus* (greenstriped), *S. variegatus* (harlequin), *S. wilsoni* (pygmy), *S. babcocki* (redbanded), S. *proriger* (redstripe), *S. zacentrus* (sharpchin), *S. jordani* (shortbelly), *S. brevispinis* (silvergrey), S. *diploproa* (splitnose), *S. saxicola* (stripetail), *S. miniatus* (vermilion), and S. *reedi* (yellowmouth). In the Eastern GOA only, "slope rockfish" also includes northern rockfish, *S. polyspinous.*

[11] "Demersal shelf rockfish" means *Sebastes pinniger* (canary), *S. nebulosus* (china), *S. caurinus* (copper), *S. maliger* (quillback), *S. helvomaculatus* (rosethorn), *S. nigrocinctus* (tiger), and *S. ruberrimus* (yelloweye).

[12] "Northern rockfish" means *Sebastes polyspinis.*

[13] "Pelagic shelf rockfish" means *Sebastes ciliatus* (dusky), *S. entomelas* (widow), and *S. flavidus* (yellowtail).

[14] "Other species" means sculpins, sharks, skates, squid, and octopus. The TAC for "other species" equals 5 percent of the TACs of assessed target species.

[15] N/A means not applicable.

[16] The total ABC is the sum of the ABCs for assessed target species.

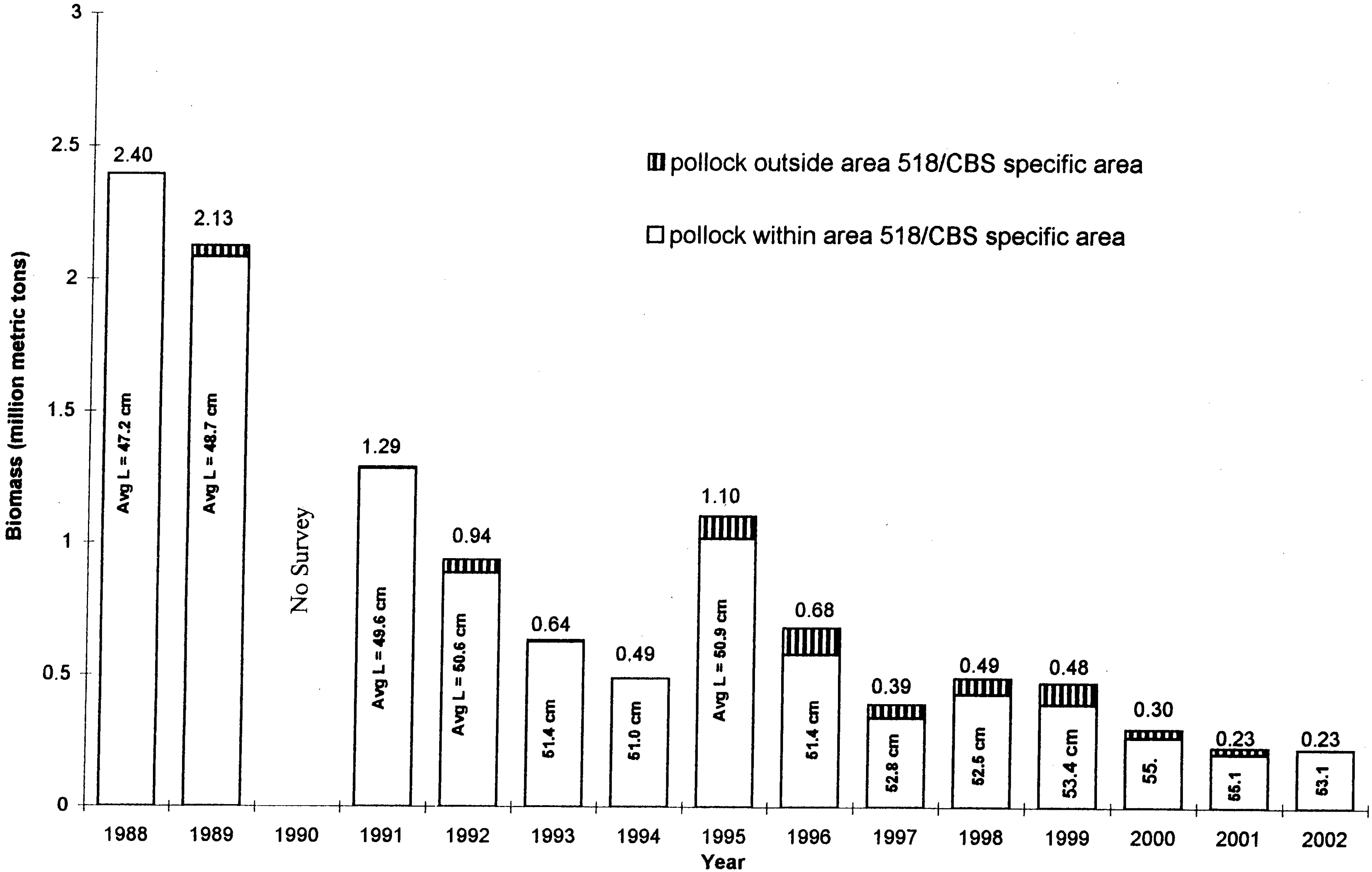


Figure 13. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2002. The U.S. conducted all but the 1999 survey, which was conducted by Japan. Total estimated pollock biomass for each survey year is indicated on top of each bar.

Web Site Information

Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea

Information on Records of the Annual Conferences can be found at:

http://www.fakr.noaa.gov/international/default.htm

The following records are currently in the Website:

2001 (6^{th} Annual Meeting at Gdynia, Poland)
2000 (5^{th} Annual Meeting at Shanghai, China)
1999 (4^{th} Annual Meeting at Pusan, Republic of Korea)
1998 (3^{rd} Annual Meeting at Tokyo, Japan)

Suggestions:

1. Develop a web site for the Convention.
2. Designate custodian for maintenance of website.
3. Web page should contain information like:
   - Short description of the Convention
   - Text of the Convention
   - Organization
   - Events and Meetings
   - Records of Meetings and other Publications
   - Statistics
   - Delegations List
   - Contact Persons

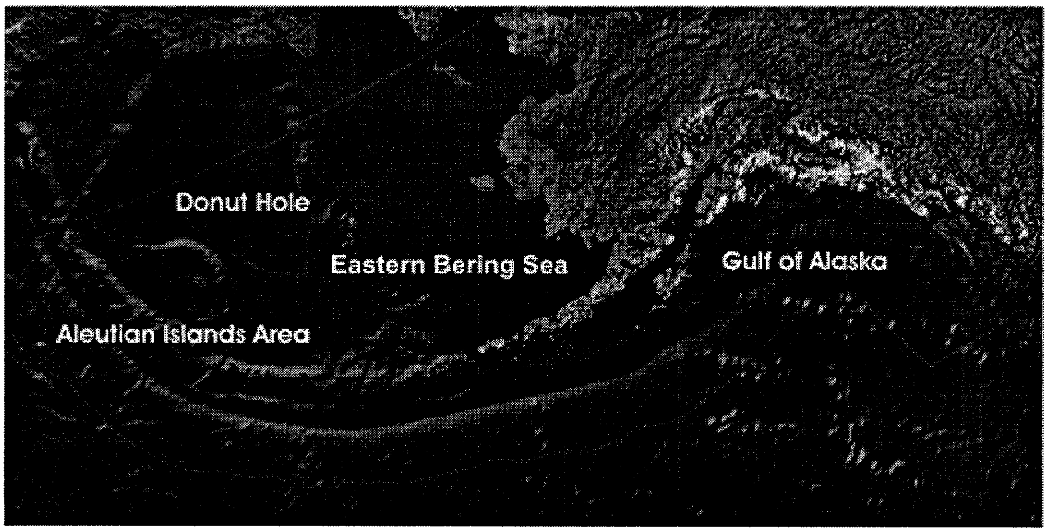
Example web page: http://161.55.80.213/refm/donut_hole.htm

Alaska Fisheries Science Center
NATIONAL MARINE FISHERIES SERVICE

Central Bering Sea or "Donut Hole"

The Donut Hole is located between U.S. and Russian 200 mile Exclusive Economic Zone (EEZ). The Donut Hole lies within international waters and encompasses approximately 48,000 square miles of surface area and makes up 19 percent of the Aleutian Basin or 10 percent of the entire Bering Sea area.

The Alaska Fisheries Science Center's Resource Ecology and Fisheries Management (REFM) Division conducts research and data collection to support management of Northeast Pacific and eastern Bering Sea fish and crab resources. Part of this responsibility includes scientific and technical coordination on the Convention on the Conservation and Management of Pollock Resources Central Bering Sea signed in 1994.



REFM Home
Programs
Status of stocks
Observer program
Ecosystem research
Socioeconomics
Age and growth

Other Research and Information on the Central Bering Sea

Related Data

Survey Reports

*Echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) on the southeastern Bering Sea shelf and in the Aleutian Basin near Bogoslof Island in February and March, 2001 (by Taina Honkalehto, Paul Walline, Denise McKelvey, and Neal Williamson)

Reported Catch (Excel Data Sheets)

Pollock catches by Poland, 1985-1991

Pollock catches by Korea, 1994-1991

Geographical coordinates of statistical blocks for reporting catch data

Physical Oceanography

The physical oceanography of the Bering Sea (Phyllis J. Stabeno, James D. Schumacher, and Kiyotaka Ohtani)

Convention Reports

* Report of the 6th Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (2001)

* Report of the 5th Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (2000)

* Report of the 4th Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (1999)

* Report of the 3rd Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (1998)

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Section II

Report – Results of the echo integration-trawl survey of walleye pollock conducted on the southeastern Bering Sea shelf and in the southeastern Aleutian Basin near Bogoslof Island in February and March 2002 (by Taina Honkalehto, Neal Williamson, Dale Hanson, Denise McKelvey, and Steve de Blois, 8/21/2002)

Results of the echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) conducted on the southeastern Bering Sea shelf and in the southeastern Aleutian Basin near Bogoslof Island in February and March 2002

by Taina Honkalehto, Neal Williamson, Dale Hanson, Denise McKelvey, and Steve de Blois

INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) conduct research surveys of Bering Sea walleye pollock (*Theragra chalcogramma*) to estimate pollock distribution and abundance. Results presented in this report are from the echo integration-trawl (EIT) survey carried out between 18 February and 11 March 2002 on the southeastern Bering Sea shelf and in the southeastern Aleutian Basin near Bogoslof Island (the Bogoslof Island area). The primary objective of the Bering Sea shelf portion of the survey was to assess the abundance and distribution of pollock inhabiting the Steller sea lion Conservation Area (SCA) east of 168°W. The primary objective of the Bogoslof portion was to assess the abundance and distribution of pre-spawning pollock in the southeastern Aleutian Basin. The biomass estimate for pollock inside the North Pacific Fishery Management Council's (NPFMC) Statistical Reporting Area 518 (Area 518; the same as the Central Bering Sea (CBS) Convention Specific Area[1]) obtained during this survey provides an index of abundance for Aleutian Basin pollock. The Japan Fisheries Agency also conducted an EIT survey of pollock in the southeastern Aleutian Basin between 9 February and 5 March 2002. This survey was conducted aboard the *R/V Kaiyo Maru* in cooperation with the U.S. in order to estimate distribution and abundance of pre-spawning pollock. In addition to surveying

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[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."

the Bogoslof Island area, they surveyed basin and slope waters north of the Aleutian Island chain west of 170°W to about 176°W. Prior to the start of the U.S. survey in February, the two vessels conducted an intership calibration to compare acoustic systems. Intership calibration results will be presented in a different report. This report summarizes the U.S. EIT survey results on observed pollock distribution and biological composition, and provides abundance estimates. It also summarizes oceanographic observations and acoustic system calibration results.

METHODS

Itinerary

18 Feb	Embark scientists in Dutch Harbor, AK; calibration of acoustic systems in Captains Bay.
19-20 Feb	Intership calibration of the NOAA ship *Miller Freeman* with Japan Fisheries Agency *R/V Kaiyo Maru* in the Islands of Four Mountains area (Samalga Pass).
20 Feb-1 Mar	Transit to Bering Sea shelf. Retrieval of 2 temperature sensor moorings in Bristol Bay. EIT survey of the southeastern Bering Sea shelf (transects 98-114).
1 Mar	Exchange scientists and obtain fuel in Dutch Harbor.
1-10 Mar	EIT survey of the southeastern Bering Sea shelf (transects 115-122) and southeastern Aleutian Basin (transects 199-220). Acoustic system calibration in Captains Bay.
11 Mar	Inport Dutch Harbor.

Acoustic Equipment

Acoustic data were collected with a Simrad[2] EK500 quantitative echo sounding system (Bodholt et al. 1989, Bodholt and Solli 1992) on the NOAA ship *Miller Freeman*, a 66-m (216-foot) stern trawler equipped for fisheries and oceanographic research. Two split-beam transducers (38 kHz and 120 kHz frequencies) were mounted on the bottom of the vessel's retractable centerboard

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

extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Echo integration data sampled with a horizontal resolution of about 9 m and a vertical resolution of 0.5 to 2.0 m and target strength data were collected simultaneously at both frequencies. The depth limit of acoustic data collection was 1000 m. Scientists scrutinized these data using Simrad BI500 echo integration and target strength data analysis software (Foote et al. 1991, Simrad 1993) aided by digital echograms to partition the acoustic information into pollock, non-pollock fish, myctophid scattering layer, and undifferentiated invertebrate/fish mixture, and stored them in a relational database. Results presented here are based on the 38-kHz data. Acoustic data were also collected at 38 kHz and 120 kHz with a new acoustic system (Simrad EK60 quantitative echosounding system and Sonardata Echolog) run in parallel to the EK500 acoustic system for testing. Comparison of the performance of the EK500 and EK60 38 and 120 kHz transceivers was facilitated by the use of a custom-designed multiplexer. The multiplexer generated master trigger pulses and switched transducers between transceivers on an alternate ping basis; this device also ensured that the 38 and 120 kHz transceivers were properly synchronized. For each frequency (38 or 120 kHz), the transducer was connected by the multiplexer to one transceiver for a complete trigger-transmit-receive cycle and was then connected to the other transceiver for the next trigger-transmit-receive cycle. The multiplexer ping interval was adjustable between 1 and 3 seconds, therefore the ping interval for one transceiver could be varied between 2 and 6 seconds.

Trawl Gear

Midwater and bottom trawl nets were used to sample observed echosign. Midwater and near-bottom echosign was sampled using an Aleutian Wing 30/26 Trawl (AWT). This trawl was constructed with full-mesh nylon wings with polyethylene 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 3.2-cm (1.25-in) codend liner. The AWT was fished with 82.3 m (270 ft) of 1.9-cm (0.75-in) diameter (8x19 wire) non-rotational dandylines. On the shelf, the AWT was fished with 113.6-kg (250-lb) or 226.8-kg (500-lb) tom weights on each side; in the basin, 340.2-kg

(750-lb) tom weights were used. The bottom trawl was used in the Bering Sea shelf area to sample echosign on or near bottom, and on a few occasions, to sample echosign observed in the upper 50 m (due to difficulty deploying the AWT in water shallower than about 60 m). The polyethylene Nor'eastern high-opening bottom trawl (PNE) was equipped with roller gear and was constructed with stretch mesh sizes that ranged from 13 cm (5 in) in the forward portion of the net to 89 mm (3.5 in) in the codend. It was fitted with a nylon codend liner with a mesh size of 32 mm (1.25 in). The 27.2-m (89.1-ft) headrope had 21 floats [30-cm (12-in) diameter]. A 24.7-m (81-ft) chain fishing line was attached to the 24.9-m (81.6-ft) footrope which was constructed of 1-cm (0.4-in) 6 x 19 wire rope wrapped with polypropylene rope. The 24.2-m (79.5-ft) roller gear was constructed with 36-cm (14-in) rubber bobbins spaced 1.5 to 2.1 m (5 to 7 ft) apart. A solid string of 10-cm (4-in) rubber disks separated the bobbins in the center section of the roller gear. Two 5.9-m (19.5-ft) wire rope extensions with 10-cm (4-in) and 20-cm (8-in) rubber disks were used to span the two lower flying wing sections and were attached to the roller gear. The roller gear was attached to the fishing line using chain toggles [2.9 kg (6.5 lb.) each] which comprised five links and one ring. The trawl was rigged with triple 54.9-m (180-ft) galvanized wire rope dandylines. Both nets were fished with 5-m^2 Fishbuster trawl doors [1,247 kg (2,750 lb) each].

The vertical net opening and headrope depth were monitored during all hauls using a WESMAR third wire or a Furuno acoustic link netsounder system attached to the trawl headrope. Net opening varied depending on the trawl type and tom weights. For bottom trawl hauls, the net opening ranged from 5 to 9 m and averaged 7 m. For midwater trawl hauls that were fished with 113.6-kg (250-lb) tom weights, the net opening ranged from 16 to 21 m and averaged 18 m. When the midwater trawl was fished with the 226.8-kg (500-lb) tom weights, the net opening ranged from 21 to 28 m and averaged 23 m. In the Bogoslof Island area, where the midwater trawl was fished with 340.2-kg (750 lb) tom weights, the net opening ranged from 20 to 29 m and averaged 26 m.

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 and mooring locations. 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

Survey design differed slightly between the two areas covered during this cruise. The Bering Sea shelf survey began on 23 February 2002 north of the Alaskan Peninsula at about 162° 30'W longitude and proceeded west across the shelf to about 168°W, ending on 4 March. The 25 north-south transects were spaced 8 nmi apart and covered a 12,784 nmi^2 area. The Bogoslof Island area survey began 5 March 2002 north of Unalaska Island at about 167°W, and proceeded west towards the Islands of Four Mountains near 170°W, concluding on 8 March. The 22 north-south transects were spaced 5 nmi apart and covered a 2,903 nmi^2 area (Fig. 1).

Echo integration and trawl data were collected 24 hours a day. Acoustic system settings used during the collection (Table 1) were based on results from acoustic system calibrations and on experience from prior winter Bering Sea shelf surveys. Trawl hauls were conducted to identify echosign and to provide biological samples. Average trawling speed for both nets was approximately 3 kts. Standard catch sorting and biological sampling procedures were used to provide weight and number by species for each haul (MACE Sampling Manual)[3]. Pollock were sampled to determine sex, fork length, body weight, maturity, and ovary weight of selected females. For age determinations, pollock otoliths were collected and stored in a 50% ethanol-water solution. An electronic motion-compensating scale was used to weigh individual pollock specimens. Fork lengths were measured to the nearest cm (i.e., a fish measuring between 49.5

[3] Midwater Assessment and Conservation Engineering (MACE) Sampling Manual. 2001. Unpublished document. Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115.

cm and 50.5 cm was recorded as 50 cm) and recorded with a Polycorder measuring device (a hand-held computer connected to a bar coded length reader, Sigler 1994) and downloaded into a desktop computer. Maturity was determined by visual inspection and categorized as immature, developing, pre-spawning, spawning, or post-spawning. Additional samples of pollock tissue, stomach contents, ovaries, and gametes were collected for ongoing research by AFSC scientists. Whole fish were retained for a calorimetric prey study and for Observer Program training specimens.

Pollock target strength data collections were made when conditions were suitable (i.e., low fish density, single species aggregations, unimodal size distribution, and calm seas). Repeated passes were made over fish aggregations at speeds of less than 3 kts. Biological data were obtained from trawl hauls made in conjunction with the acoustic data collection using the methods described above.

Standard sphere acoustic system calibrations were made prior to the Bering Sea shelf survey and at the end of the Bogoslof Island area survey to measure acoustic system performance for both the echosounders at each frequency. During calibrations, the *Miller Freeman* was anchored at bow and stern. Weather, sea state conditions, and acoustic system settings were recorded. Two copper calibration spheres, 23 mm (120-kHz sphere, TS = -40.3 dB) and 60 mm (38-kHz sphere, TS = -33.6 dB) diameters, were suspended at about 25 m and 30 m, respectively, below the centerboard-mounted transducers. 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, TS data were collected on a grid of angle coordinates, and beam shape was estimated (Foote et al. 1987).

U.S./Japan Acoustic Systems Comparison

An intership calibration of acoustic systems between the NOAA ship *Miller Freeman* and the Japan Fisheries Agency *R/V Kaiyo Maru* was conducted 19 to 20 February in the Islands of Four Mountains area (Fig 1). Intership calibration results will be presented in a subsequent document.

Data Analysis

The abundance of pollock was estimated by combining echo integration and trawl data. Echo integration data collected between 14 m from the surface (5 m below the centerboard-mounted transducer) and 0.5 m off the bottom were scrutinized for pollock stored in a database. Pollock length data from 37 hauls were aggregated into 10 analytical strata based on echosign type, geographic proximity of hauls, and similarity in size composition data. Average pollock backscattering strength along each 0.5 nmi of transect was multiplied by transect width to estimate area backscattering for transect segments. Area backscattering segments were summed to compute total pollock area backscattering for each analytical stratum. These echo integration values 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. Two length-weight relationships observed from trawl data were applied to estimate pollock biomass for each length category, one for pollock on the eastern shelf and one for the Bogoslof Island area. Age data for winter 2002 were not available when this analysis was completed. However, age data from the winter 2001 EIT survey were available, and age-specific numbers and biomass were estimated for that year using age-length keys developed from the trawl data.

In the Bogoslof Island area, pre-spawning pollock aggregations are often densely packed and vertically and/or horizontally stratified by sex. Therefore it is sometimes difficult to obtain a random sample of lengths from these aggregations to estimate population size composition. At ages older than about 5 years, female pollock have longer lengths at age than male pollock, thus the sex composition of the trawl hauls directly affects the estimates of population size composition. Although we caught more females than males in the Bogoslof area, we assumed that the sex ratio in the spawning aggregations we sampled was 50:50, and estimated population size composition under this assumption.

Numbers and biomass at length were estimated for pollock between 14 m from the surface and 0.5 m from the bottom for the entire area surveyed. This area was divided into two regions, the eastern shelf, and the Bogoslof area. Estimates were also made for the CBS specific area and the SCA. Estimates for the CBS specific area were the same as for the Bogoslof area minus the number of pollock estimated from a small area outside the CBS border. Estimates for the SCA were made by adding the shelf area and Bogoslof area abundance estimates and removing abundances estimated for transect area outside the SCA borders.

Relative estimation errors for the acoustic data were derived using a 1-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 were used for computation of error because they account for the observed spatial structure. The method was applied separately to the shelf and Bogoslof Island areas because transect spacing differed (8 and 5 nmi, respectively). These errors quantify only transect sampling variability. Other sources of error (e.g., target strength, trawl sampling, error associated with ageing) 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 EK500 38-kHz frequency collection system (used for data analysis) showed no significant differences in gain parameters or transducer beam pattern characteristics in either of the Captains Bay, AK calibrations before and after the Bering Sea shelf and Bogoslof Island area survey. Calibration results for the EK500 120-kHz system indicated that there were some changes in gain parameters and beam pattern characteristics during the winter field season. Calibration results from the EK60 acoustic system will be reported elsewhere.

Target Strength

Two pollock target strength collections were made on the Bering Sea shelf. The first collection occurred during the day on 28 February and the second collection occurred on 10 March. Results will be reported elsewhere.

Oceanographic Data

Oceanographic data were collected from trawl-mounted SBE 39s at 38 sites (Table 2), CTDs at 4 sites, and continuous surface thermosalinograph readings. In the southeastern shelf region surveyed, bottom depths ranged between about 40 to 50 m in the east and along the Alaskan peninsula, deepening gradually to 200 m in the west at the shelf break. Water temperature varied with depth and location. The upper 50 m of the water column was well mixed and usually colder than the deeper layers. Temperatures varied between 0.9° and 3.5°C and averaged 2.3°C(Fig. 2). Between 50 and 100 m the water column was more stratified with temperatures increasing rapidly with depth, to greater than 4.5°C in some areas. Temperatures between 50 and 100 m ranged from 0.9 to 4.7°C and averaged 3.1°C. Water deeper than 100 m ranged from 3.2 to 4.4°C and averaged about 3.9°C. In contrast, temperature profiles from the basin region 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 2.8 to 3.9°C and averaged 3.5°C.

Surface temperatures ranged from -0.9° to 3.8°C. The coldest surface temperatures (colder than 0°C) were observed on the shelf at the beginning of the survey (east of transect 101), near the Alaskan Peninsula (Fig. 3). Surface temperatures progressively warmed from east to west. The warmest waters (greater than about 3.5°C) occurred near the Aleutian chain in basin waters west of about 167° W.

Biological sampling

Biological data and specimens were collected from 38 trawl hauls, 27 using the midwater trawl and 11 using the bottom trawl (Table 2, Fig. 1). All bottom trawl hauls were conducted on the southeastern Bering Sea shelf; 4 were hard on bottom and 7 were with the bottom trawl slightly off bottom or in midwater. Length frequency data were collected from more than 12,000 pollock specimens (Table 3) for scaling the acoustic data to produce population estimates. Biological data and specimens for other research projects (fecundity studies, trophic investigations, pollock early life history studies, etc.) were also collected at many of the trawl haul locations (Table 4). On the Bering Sea shelf and in the Bogoslof Island area, pollock dominated the midwater trawl catches in both weight and numbers (Tables 5 and 6). Jellyfish and rock sole (*Lepidopsetta* sp.) were next most abundant on the shelf, and together accounted for about 6% of midwater catches by weight. In the Bogoslof area, lanternfish (Myctophidae) and Pacific lamprey (*Lampetra tridentata*) were the next most abundant in midwater catches by weight, but comprised only 0.2% of the total catch. Pollock accounted for more than 95% of bottom trawl hauls catches on the shelf by weight, with Pacific cod (*Gadus macrocephalus*) and rock sole together accounting for about 3.1% (Table 7).

Bering Sea Shelf

Twenty seven trawl hauls were conducted in the southeastern shelf area (hauls 1 to 26, and 38: Fig. 1). Pollock fork lengths ranged from 18 to 66 cm. Modal lengths decreased from 49 cm in the east along the Aleutian Island chain to 23 cm in the western part of the shelf survey area (Fig. 4). Catch sex ratios for all hauls and fish sizes ranged from 23 to 78% male (Fig. 5). Among pollock larger than 29 cm fork length (approximately age 3 and older), 66% of the females and 51% of the males were pre-spawning (Fig. 6a). Twenty seven percent of females and 23% of males were developing. One percent of females and about 20% of males were actively spawning. For pollock 29 cm and smaller (approximately ages 1 and 2, sexes combined), 13% were immature and 87% were developing. Female pollock were estimated to be 50% mature at 41 cm (Fig. 6c). The mean gonadosomatic index (GSI) for pre-spawning females on the shelf was 0.12 (Fig. 7a). GSI was higher between 162° and 164°W and also between 166° and 168°W than in the middle portion of the shelf survey area (Fig. 7c). As GSI appears to be related to length (Fig. 7a) the differences may be partly due to slight differences in mean length. The regression of total body weight to length for sexes combined used in population analysis was $W=0.004 * FL^{3.1498}$ where FL is fork length and W is weight (Fig. 8a).

Pollock were observed on all transects (Fig. 9a). They were most abundant north of the Alaska peninsula and Aleutian Island chain between Amak Island and the west edge of Unimak Pass (transects 101-111, see Fig. 1). The highest pollock concentrations were observed on or near-bottom in waters adjacent to Amak Island at about the 50-60 m isobath, and north of the center of Unimak Island between about the 95 and 110 m isobaths. Pollock were usually off-bottom and not as densely aggregated at night as during the day. South of 55°N and west of 165°W (just north of Unimak Pass) pollock aggregations were more pelagic. West of Akutan Island, pollock were observed near bottom on the slope in deeper water (between the 200 and 500 m isobaths) close to the Aleutian Island chain. Pollock were present in very low densities or absent between about 166°W and 167°W except for one patch of juveniles (mostly age 2) observed between the north ends of transects 115 and 116. Between 167 and 168°W, along the 200-m isobath and inshore to 150 m, pollock occasionally formed isolated 1 to 2 nmi long patches of dense pelagic schools consisting mainly of 2-year-old juveniles. In 2002 (Fig. 9a) the easternmost transects had lower densities of fish than the easternmost transects in the 2001 survey (Fig. 9b), and transects north of the center of Unimak Island had higher densities in 2002 than in 2001.

The abundance estimate for pollock on the Bering Sea shelf between 14 m below the surface and 0.5 m off bottom is 2.329 billion fish (1.355 million metric tons (t)) (Table 8, Fig.10). The relative estimation error of the shelf biomass based on the 1D geostatistical analysis is 6.2%. Twenty two percent of the estimated number of pollock (3% of the total biomass) were smaller than 30 cm (the smallest was 18 cm), and of those, the average fork length was 23.1 cm. Eleven percent by numbers were 30 to 40 cm (6% of the biomass) with an average length of 35.9 cm. Pollock greater than 40 cm comprised 67% by numbers (91% of the biomass) with an average length of 47.7 cm.

Age data from the winter 2001 southeastern Bering Sea shelf survey show that the average length at age for fish older than age 4 was slightly greater for females than males on the shelf (Fig. 11). Population estimates by age for eastern Bering Sea shelf pollock indicate that in 2001 the 1996 and 1995 year classes made up about 30% and 24% of the population by numbers, respectively. The 2000 year class was next most numerous, at about 18% of the population (Fig. 12).

Bogoslof Area

In the Bogoslof area, the fork lengths of pollock sampled in trawl hauls (haul numbers 27 to 37) ranged from 23 to 70 cm. Length compositions were bimodal; 47 to 52 cm modes were dominant in the region at the northeast corner of Umnak Island (Fig. 4), while 56 to 60 cm modes were dominant in the Islands of Four Mountains area. In one trawl haul sample of an aggregation north of the center of Unalaska Island (transect 200, haul 27), pollock had a narrow length range (30 to 46 cm) and a mode of 40 cm. Catch sex ratios ranged from 13 to 69% male (Fig. 5). Eighty-four percent of the female and 40% of the male pollock were in pre-spawning condition (Fig. 6b). Most developing stage pollock were observed in haul 27 on transect 200. Three percent of females and about 46% of males were actively spawning. The average gonadosomatic index (GSI) for pre-spawning females was 0.18 (Fig. 7b), comparable to Bogoslof in winters 2000 and 2001 (0.17 in both of those years), indicating that survey timing was similar in relation to peak spawning. The average Bogoslof GSI was higher than the average shelf GSI (Fig. 7c), suggesting that spawning was more spread out in time, or occurred later on the Bering Sea shelf, or both. The regression equation of total body weight to length for sexes combined used in population analysis for Bogoslof was $W=0.007 * FL^{3.0458}$ where FL is fork length and W is weight (Fig. 8b).

The spatial distribution of pollock in the Bogoslof/Aleutian Basin area (Fig. 9a) was similar to that observed in 2001 (Fig. 9b). Pollock were concentrated along the north slopes of the Aleutian Island chain, either at the northeast end of Umnak Island, or between the west end of Umnak and the Islands of Four Mountains, just north of Samalga Pass. In 2002 more pollock were observed in the Umnak Island aggregation than in 2001.

The abundance estimate for pollock in the Bogoslof area between 14 m below the surface and 1,000 m is 181 million fish (0.227 million t) (Table 8, Fig. 10). The relative estimation error of the Bogoslof pollock biomass estimate based on the 1D analysis is 12.2%. The abundance estimates and relative estimation error for pollock inside the CBS Specific Area/Area 518 are the same as for the total area. Thirty-six percent of the pollock by numbers (21% of the biomass) were 50 cm or smaller in length, and of those, the average fork length was 44.9 cm. The smallest pollock were 23 cm in length. The remaining 64% of the estimated pollock numbers (79% of the biomass) were larger than 50 cm, and of those, the average fork length was 57.7 cm. The largest pollock observed was 70 cm in length.

The abundance estimate for the SCA is 2.497 billion pollock (1.574 million t) (Table 8). The relative estimation error of the SCA pollock biomass estimate based on the 1D analysis is 5.7%. The population estimate for the entire area surveyed on the southeastern shelf and Bogoslof area combined is 2.510 billion pollock (1.582 million t). The relative estimation error of the pollock biomass estimate for the entire area surveyed based on the 1D analysis is 5.6%.

Age composition data from the winter 2001 Bogoslof Island area survey show that average length at age was higher for females than males at all ages (Fig. 11). Population estimates by age indicate that the 1989 year class was dominant, comprising about 18% of the population in numbers, the 1990 year class was next most important, comprising about 10% in numbers, and the 1992 and 1996 year classes each contributed about 8% of the population by numbers (Fig. 12).

DISCUSSION

The 2002 southeastern Bering Sea shelf survey was the third winter EIT pollock survey in a series that began in 2000. The survey designs for the 2001 and 2002 winter surveys were similar although two transects were added east of the eastern edge of the SCA in 2002. Few pollock were observed east of the eastern border of the SCA in 2002, in contrast to 2001 when they were concentrated on the eastern border of the SCA (Fig. 9). Although the modal lengths of adult pollock sampled in the SCA in 2001 and 2002 were similar (46 cm), the underlying length compositions were different. In 2002 more smaller and younger fish were present. Pollock from a size class of two-year-old juvenile fish were present in 2002 near the 200-m isobath in the northwestern part of the SCA. They were observed as one year olds in 2001. No pollock of one-year-old sizes were observed in 2002, and relatively few adults were observed in the northwest part of the SCA in either year compared to numbers of adults in the eastern part of the SCA north of Unimak Island. Maturity composition was similar for both sexes between years. However, the length at 50% maturity for females was estimated to be 41 cm in 2002 while it was estimated at 43 cm in 2001. This was due to the presence of greater numbers of pollock in the 30 to 40 cm length range in 2002 than in 2001, and to the proportion of mature fish. In winter 2002, estimated pollock abundance on the eastern shelf (1.355 million t) was higher than in 2001 (0.825 million t)(Table 8).

In the second part of the winter 2002 EIT survey, pollock in the Bogoslof Island area were surveyed for the 13th time in 14 years. Pre-spawning pollock aggregate in this area in February and March each year (Honkalehto and Williamson 1995, 1996), and spawn between the end of February and mid-March. During the earliest survey years (1989-92), Bogoslof pre-spawning pollock occupied a large area of the southeast Aleutian basin extending from east of Bogoslof Island westward to the Islands of Four Mountains and Samalga Pass, with highest concentrations surrounding Bogoslof Island. At that time they were subject to a large commercial fishing effort. Fishing in this region was terminated in 1992.

In 2002, as in recent years (2000 and 2001), pollock were highly concentrated in Samalga Pass (74% of biomass in 2002, 76% in 2001, and 72% in 2000), and were otherwise sparsely distributed within the Bogoslof area. There has been little change in population biomass since prior to 2000 (Table 8). However, Bogoslof population estimates from EIT surveys indicate that biomass is decreasing with time (Fig. 13). There has been little recruitment to the spawning population since the 1989 year class began appearing in about 1994 (Tables 9, 10, 11, and 12, Figs.14 and 15). Estimated numbers at age of dominant Bogoslof year classes (Figs. 15 and 16) showed that the 1989 year class became the main component of the population at age 5, replacing the 16-year-old 1978 year class in 1994. The 1992 year class first became important in the population at age 6 in 1998, but appeared to peak in numbers in 1999. There was evidence of increased numbers of the 1996 year class in 2001 (Fig. 15).

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Table 1. Results from standard sphere acoustic system calibrations conducted before, during, and after the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area.

Date	Location	Frequency (kHz)	Water Temp (°C) at Transducer[1]	Water Temp (°C) at Sphere	Sphere Range from Transducer (m)	TS Gain[2] (dB)	S_v Gain[2] (dB)	3-dB Beam Width (deg) Along	3-dB Beam Width (deg) Athwart	Angle Offset (deg) Along	Angle Offset (deg) Athwart
17-Jan	Port Susan, WA	38	9.3	9.3	32.1	25.6	25.4	6.92	6.83	-0.10	0.01
		120	9.3	9.3	27.3	27.1	27.6	6.67	6.50	-0.19	0.09
10-Feb	Sanborn Harbor, AK	38	2.5	3.1	-	-	-	6.90	6.78	-0.10	-0.02
		120	2.5	3.1	-	-	-	6.76	6.71	-0.26	0.19
18-Feb	Captains Bay, AK	38	1.8	3.7	28.2	26.1	25.8	6.90	6.79	-0.11	-0.01
		120	-	-	-	-	-	-	-	-	-
10-Mar	Captains Bay, AK	38	3.2	3.2	29.1	26.1	25.6	6.94	6.82	-0.10	0.00
		120	3.2	3.2	23.6	26.0	26.2	7.01	6.93	0.14	0.04
25-Mar	Ugak Bay, AK	38	3.3	3.4	26.6	26.0	25.6	6.94	6.79	-0.09	0.01
		120	3.3	3.4	-	-	-	6.86	6.84	-0.08	0.09
Feb 18-Mar 10	System settings during surveys	38	-	-	-	26.0	25.7	6.90	6.80	-0.08	0.03
		120	-	-	-	27.1	27.1	6.70	6.70	-0.23	-0.14

S_v threshold used for post-processing = -69 dB

[1]The transducer was located approximately 9 m below the water surface.

[2]Gain terms are defined in MacLennan et al. (2002).

Note: 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 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area.

Haul No.	Gear Type[1]	Date	Time (GMT)	Duration (minutes)	Start Position Latitude (N)		Start Position Longitude (W)		Depth (m) Footrope	Depth (m) Bottom	Temp. (deg. C) Gear[2]	Temp. (deg. C) Surface	SBE 39 Profiler No.	Pollock Catch (kg)	Pollock Catch number	Other Catch (kg)
1	PNE	22-Feb	4:38	24	55	33.76	163	12.34	59	64	1.3	1.1	301	1,341.0	1,466	424.6
2	AWT	23-Feb	7:50	10	55	53.46	162	24.69	62	65	1.7	1.7	306	469.3	526	32.9
3	PNE	23-Feb	21:46	10	55	34.09	163	7.13	61	61	0.9	1.1	307	801.6	916	65.1
4	AWT	24-Feb	4:48	17	55	33.30	163	20.89	52	70	2.3	1.9	308	810.7	925	169.3
5	PNE	24-Feb	10:22	11	55	24.52	163	35.13	37	70	2.0	1.9	309	713.1	842	57.7
6	PNE	24-Feb	14:33	11	55	53.62	163	35.60	84	92	2.8	2.5	310	208.2	282	51.5
7	PNE	24-Feb	20:43	8	55	14.40	163	49.13	57	58	2.1	2.3	311	1,312.9	1,407	2.1
8	PNE	25-Feb	2:20	5	55	33.43	164	3.47	97	97	3.8	2.6	312	8,804.1	12,567	275.9
9	AWT	25-Feb	8:14	3	55	57.03	164	18.53	75	92	2.0	2.2	313	536.4	2,262	13.1
10	PNE	25-Feb	14:08	46	55	7.05	164	17.41	50	62	2.2	1.8	314	345.4	520	17.8
11	PNE	25-Feb	19:21	12	55	18.78	164	31.36	94	103	4.2	2.5	315	924.9	1,168	12.8
12	AWT	26-Feb	2:58	40	55	39.81	164	47.06	91	99	2.8	2.2	316	1,405.7	2,241	316.3
13	AWT	26-Feb	15:32	9	55	19.04	164	59.08	94	111	2.3	2.5	317	1,050.2	2,666	10.3
14	PNE	27-Feb	1:13	8	55	32.93	165	14.04	112	112	4.4	2.4	318	2,500.6	3,803	64.4
15	AWT	27-Feb	9:15	20	54	26.98	165	9.92	115	140	3.1	2.8	319	1,051.8	1,349	9.2
16	AWT	27-Feb	15:36	15	54	48.30	165	25.79	148	175	4.2	2.7	320	521.7	1,149	0.4
17	PNE	27-Feb	23:15	6	55	55.64	165	30.06	102	102	4.7	2.1	321	6,855.7	13,797	414.3
18	AWT	28-Feb	6:53	20	55	10.88	165	41.32	113	122	3.2	2.6	322	404.3	656	8.9
19	PNE	28-Feb	13:48	30	54	37.89	165	38.91	332	338	3.9	2.7	323	231.5	316	20.4
20	AWT	1-Mar	9:41	26	54	14.13	166	4.50	264	367	3.3	2.9	324	1,240.6	1,606	30.8
21	AWT	2-Mar	9:06	19	55	30.62	166	33.23	102	133	3.5	2.4	325	291.3	2,756	6.1
22	AWT	3-Mar	10:36	12	55	2.01	167	4.31	148	158	4.1	2.7	326	215.0	2,547	1.0
23	AWT	3-Mar	12:18	14	54	59.20	167	4.51	75	PNE	2.8	2.7	327	754.6	8,852	1.6
24	AWT	3-Mar	20:00	15	55	1.10	167	18.18	140	209	4.0	2.6	328	422.9	4,943	2.4
25	AWT	4-Mar	3:03	43	55	8.01	167	32.64	138	198	3.5	3.1	329	18.0	212	2.2

Table 2. continued

Haul No.	Gear Type[1]	Date	Time (GMT)	Duration (minutes)	Start Position Latitude (N)		Longitude (W)		Depth (m) Footrope	Bottom	Temp. (deg. C) Gear[2]	Surface	SBE 39 Profiler No.	Pollock Catch (kg)	number	Other Catch (kg)
26	AWT	4-Mar	13:29	8	55	29.23	168	3.88	111	151	3.0	2.4	330	286.4	2,910	0.3
27	AWT	5-Mar	6:08	13	53	55.77	167	10.18	404	541	3.8	3.6	331	3,623.7	7,667	34.2
28	AWT	5-Mar	18:37	43	53	40.70	167	37.51	440	822	3.8	3.5	332	226.9	185	20.3
29	AWT	5-Mar	23:08	9	53	35.57	167	44.32	495	719	3.7	3.4	333	860.8	773	25.7
30	AWT	7-Mar	19:04	14	53	1.66	169	15.32	435	965	3.4	3.5	334	331.6	209	1.0
31	AWT	8-Mar	8:16	12	53	7.51	169	25.47	469	898	3.6	3.6	335	1,527.1	1,104	3.9
32	AWT	8-Mar	11:31	4	53	5.17	169	25.03	419	854	3.5	3.5	336	611.9	427	0.1
33	AWT	9-Mar	1:51	10	53	8.51	169	19.67	502	1273	3.6	3.7	337	2,699.6	2,175	0.4
34	AWT	9-Mar	5:16	14	53	5.07	169	15.52	439	973	3.5	3.7	338	291.5	179	2.2
35	AWT	9-Mar	7:37	3	53	5.20	169	10.48	441	859	3.5	3.7	339	3,822.2	2,213	1.8
36	AWT	9-Mar	14:38	5	53	8.85	169	7.43	477	1,075	3.5	3.7	340	237.3	184	1.2
37	AWT	9-Mar	17:20	10	53	8.86	169	5.58	474	966	3.5	3.7	341	6,780.5	4,236	0.7
38	AWT	10-Mar	10:42	21	54	56.95	167	4.50	113	196	3.1	3.3	--	23.0	50	1.1

[1] Gear type: AWT = Aleutian wing trawl, PNE = Poly Nor'eastern bottom trawl

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

Table 3. Numbers of walleye pollock biological samples and measurements collected during the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area.

Haul	Lengths	Maturity	Otoliths	Fish weights	Ovary weights
1	326	78	57	78	24
2	332	62	62	62	40
3	310	80	80	80	42
4	338	59	56	59	14
5	302	55	55	55	26
6	282	60	60	60	32
7	389	64	62	64	24
8	305	51	51	51	24
9	389	104	104	104	0
10	366	57	57	57	36
11	407	60	60	60	26
12	390	63	63	63	18
13	445	74	74	74	11
14	363	45	45	45	18
15	344	43	41	43	13
16	401	58	58	58	10
17	439	46	46	46	15
18	338	41	41	41	17
19	316	49	49	49	19
20	354	52	52	52	31
21	288	68	68	68	2
22	234	48	20	48	0
23	238	62	32	62	0
24	332	135	84	135	17
25	212	0	0	0	0
26	340	143	111	143	15
27	368	87	78	87	2
28	185	82	82	82	46
29	366	78	78	78	24
30	209	84	84	84	46
31	389	87	87	87	28
32	343	84	84	84	38
33	345	113	113	113	38
34	179	85	85	85	64
35	379	103	103	103	88
36	184	101	101	101	0
37	329	100	100	100	50
38	50	49	0	50	0
Totals	12,106	2,710	2,483	2,711	898

Table 4. Numbers of biological samples collected for fisheries research projects at the AFSC during the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area.

	Pollock				Whole Fish Collections	
Haul	Ovaries[1]	Stomachs[2]	Gametes[3,4]	fin clips[5]	A[4,6]	B[4,7]
1	9	-	-	-	X	X
2	11	4	-	-	-	X
3	6	10	-	-	X	X
4	3	15	-	-	-	X
5	3	15	-	-	-	X
6	7	2	-	-	-	-
7	2	15	-	-	-	-
8	2	15	-	-	-	X
9	-	15	-	-	-	X
10	-	15	-	100	X	-
11	1	18	-	-	X	-
12	-	15	-	-	X	X
13	1	9	-	-	X	-
14	-	-	-	-	X	X
15	1	3	-	-	X	X
16	-	15	-	-	-	X
17	1	15	-	-	-	X
18	-	8	-	-	-	-
19	4	-	-	-	-	-
20	6	-	-	-	-	X
21	-	15	-	-	-	X
22	-	15	-	-	-	-
23	-	-	-	-	-	X
24	-	1	-	-	-	X
25	-	-	-	-	-	-
26	-	5	-	-	-	-
27	-	-	-	-	-	X
28	12	-	-	-	-	-
29	11	1	-	-	-	X
30	26	-	X	84	-	-
31	1	-	-	-	-	-
32	2	1	-	16	-	-
33	3	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	X	-	-	-
36	-	-	-	-	-	X
37	1	-	-	-	-	-
Totals	112	227	2 sites	200	8 sites	19 sites

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

[2] Pollock stomach content collections for trophic investigations (P. Livingston)

[3] Pollock gametes propagated for early life history investigations (S. Porter)

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

[5] Pollock genetic samples collected for stock identification work (M. Canino)

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

[7] Whole fish collected for calorimetric investigations (L. Logerwell)

Table 5. Catch by species from 22 midwater trawl hauls (includes 15 Aleutian wing trawls and 7 Poly nor'eastern bottom trawls fished in midwater habitats) during the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf.

Species Name	Scientific Name	Weight (kg)	Percent by Weight	Numbers
walleye pollock	*Theragra chalcogramma*	14,555.9	92.4	41,601
jellyfish	Scyphozoa (class)	849.6	5.4	--
rock sole sp.	*Lepidopsetta* sp.	120.4	0.8	529
Pacific cod	*Gadus macrocephalus*	68.9	0.4	35
yellowfin sole	*Limanda aspera*	60.3	0.4	246
Pacific ocean perch	*Sebastes alutus*	24.0	0.2	21
smooth lumpsucker	*Aptocyclus ventricosus*	23.5	0.1	12
flathead sole	*Hippoglossoides elassodon*	13.0	0.1	31
arrowtooth flounder	*Atheresthes stomias*	10.4	0.1	24
starfish	Asteroidea (class)	5.3	< 0.1	49
Pacific lamprey	*Lampetra tridentata*	4.1	< 0.1	10
yellow Irish lord	*Hemilepidotus jordani*	2.5	< 0.1	9
coho salmon	*Oncorhynchus kisutch*	2.4	< 0.1	1
starry flounder	*Platichthys stellatus*	1.0	< 0.1	2
sea anemone	Actiniaria (order)	0.9	< 0.1	2
horsehair crab	*Erimacrus isenbeckii*	0.9	< 0.1	2
Pacific halibut	*Hippoglossus stenolepis*	0.8	< 0.1	3
squid unidentified	Teuthoidea	0.7	< 0.1	20
Pacific herring	*Clupea pallasi*	0.5	< 0.1	4
Alaska plaice	*Pleuronectes quadrituberculatus*	0.5	< 0.1	1
pandalid shrimp unidentified	Pandalidae	0.5	< 0.1	7
sponge hermit crab	*Pagurus brandti*	0.4	< 0.1	3
eulachon	*Thaleichthys pacificus*	0.3	< 0.1	12
hermit crab unidentified	Paguridae	0.2	< 0.1	3
chinook salmon	*Oncorhynchus tshawytscha*	0.2	< 0.1	1
Pacific sandfish	*Trichodon trichodon*	0.1	< 0.1	1
sturgeon poacher	*Podothecus acipenserinus*	0.1	< 0.1	1
snail	Gastropoda (class)	0.1	< 0.1	1
lanternfish unidentified	Myctophidae	0.1	< 0.1	4
Pacific sand lance	*Ammodytes hexapterus*	< 0.1	< 0.1	2
Totals		15,747.5		42,637

Table 6. Catch by species from 11 Aleutian wing trawl hauls conducted during the winter 2002 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*	21,013.1	99.6	19,352
lanternfish	Myctophidae	18.2	0.1	1,769
Pacific lamprey	*Lampetra tridentata*	11.5	0.1	20
squid unidentified	Teuthoidea	10.8	0.1	109
Pacific sleeper shark	*Somniosus pacificus*	9.9	< 0.1	1
longnose lancetfish	*Alepisaurus ferox*	9.6	< 0.1	1
Bathyscaphoid squid unidentified	Cranchiidae	7.6	< 0.1	2
chinook salmon	*Oncorhynchus tshawytscha*	5.6	< 0.1	4
Pacific ocean perch	*Sebastes alutus*	4.7	< 0.1	4
northern smoothtongue	*Leuroglossus schmidti*	3.5	< 0.1	513
magistrate armhook squid	*Berryteuthis magister*	2.6	< 0.1	11
jellyfish	Scyphozoa (class)	2.3	< 0.1	2
smooth lumpsucker	*Aptocyclus ventricosus*	2.0	< 0.1	2
California headlightfish	*Diaphus theta*	1.4	< 0.1	54
emarginate snailfish	*Careproctus furcellus*	0.7	< 0.1	1
salps	Thaliacea (class)	0.3	< 0.1	28
longfin dragonfish	*Tactostoma macropus*	0.2	< 0.1	10
shrimp unidentified	Decapoda	0.2	< 0.1	92
slender barracudina	*Lestidiops ringens*	0.2	< 0.1	6
eulachon	*Thaleichthys pacificus*	0.2	< 0.1	2
Atka mackerel	*Pleurogrammus*	0.1	< 0.1	1
fish unidentified	Teleostei	0.1	< 0.1	1
Pacific viperfish	*Chauliodus macouni*	< 0.1	< 0.1	1
blackmouth eelpout	*Lycodapus fierasfer*	< 0.1	< 0.1	1
Totals		21,104.6		21,987

Table 7. Catch by species from 4 Poly nor'eastern bottom trawl hauls conducted during the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf.

Species Name	Scientific Name	Weight (kg)	Percent by weight	Numbers
walleye pollock	*Theragra chalcogramma*	18,962.0	95.9	31,083
Pacific cod	*Gadus macrocephalus*	415.4	2.1	192
rock sole sp.	*Lepidopsetta* sp.	189.6	1.0	666
sablefish	*Anoplopoma fimbria*	85.3	0.4	85
flathead sole	*Hippoglossoides elassodon*	59.0	0.3	191
jellyfish	Scyphozoa (class)	33.6	0.2	--
Pacific halibut	*Hippoglossus stenolepis*	16.8	0.1	28
arrowtooth flounder	*Atheresthes stomias*	12.3	0.1	37
yellowfin sole	*Limanda aspera*	2.6	< 0.1	12
red king crab	*Paralithodes camtschaticus*	2.5	< 0.1	1
rex sole	*Glyptocephalus zachirus*	1.3	< 0.1	1
yellow Irish lord	*Hemilepidotus jordani*	0.9	< 0.1	1
starfish	Asteroidea (class)	0.5	< 0.1	11
Totals		19,781.7		32,308

Table 8. Estimates of walleye pollock biomass by survey area and management area from February-March echo integration-trawl surveys on the southeastern Bering Sea shelf and in the Bogoslof Island area between 1988-2002.

Shelf Survey Area				**Steller sea lion Conservation Area (SCA)**[1]	
Year	**Biomass (million t)**	**Area**	**Relative estimation error (%)**	**Biomass (million t)**	**Relative estimation error (%)**
2000	0.816	4,956	13.2	1.117	11.0
2001	0.825	11,612	8.1	0.968	7.1
2002	1.355	12,784	6.2	1.574	5.7

Bogoslof Survey Area				**Central Bering Sea Specific Area/Area 518**	
Year	**Biomass (million t)**	**Area**	**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

1 SCA includes CBS Specific area/ Area 518

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

Table 9. Continued.

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

Table 10. Estimates of biomass at length (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
10	0	0	--	0	0	0	0	<1	0	0	0	0	0	0	0
11	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0
12	0	0	--	0	0	0	0	5	0	0	0	0	0	0	0
13	0	0	--	0	0	0	0	2	0	0	0	0	0	0	0
14	0	0	--	0	0	0	0	1	0	0	0	0	0	0	0
15	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
17	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
19	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
21	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
23	0	0	--	70	0	0	0	0	0	0	0	0	0	0	38
24	0	0	--	61	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
26	0	0	--	26	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
28	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
30	0	0	--	0	0	0	0	0	0	0	0	0	0	0	7
31	0	0	--	0	37	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
33	0	0	--	0	48	0	0	0	0	0	0	0	0	0	9
34	0	0	--	0	0	0	0	53	35	0	29	0	0	0	48
35	0	0	--	0	0	0	0	93	0	29	0	0	0	0	73
36	0	0	--	0	68	0	0	42	96	18	32	0	0	0	204
37	3,199	846	--	115	0	0	0	113	109	84	92	0	0	0	456
38	2,304	0	--	768	84	260	0	435	465	173	395	0	0	19	508
39	6,365	1,461	--	1,843	0	634	202	1,697	562	507	1,250	258	168	149	823
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
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

Table 10. Continued

Length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2,002
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
62	0	0	--	780	600	372	1,826	7,951	3,578	6,439	9,748	15,120	12,972	11,334	12,296
63	0	0	--	0	0	0	200	3,978	2,835	2,999	6,344	5,181	7,033	7,722	8,207
64	0	0	--	0	1,363	415	0	1,074	863	1,489	1,777	3,198	4,277	5,489	5,719
65	0	0	--	938	0	0	0	495	578	1,096	1,156	1,833	1,660	2,730	2,463
66	0	0	--	0	0	0	0	163	0	329	1,251	403	534	1,132	1,515
67	0	0	--	0	0	0	0	0	0	0	0	863	520	715	583
68	0	0	--	0	0	0	0	2,570	0	0	276	0	403	426	777
69	0	0	--	0	0	0	0	0	0	0	0	0	0	55	0
70	0	0	--	0	0	0	0	0	0	0	0	0	0	100	61
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

Table 11. Estimates of population at age (million fish) 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	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 12. Estimates of biomass at age (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	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

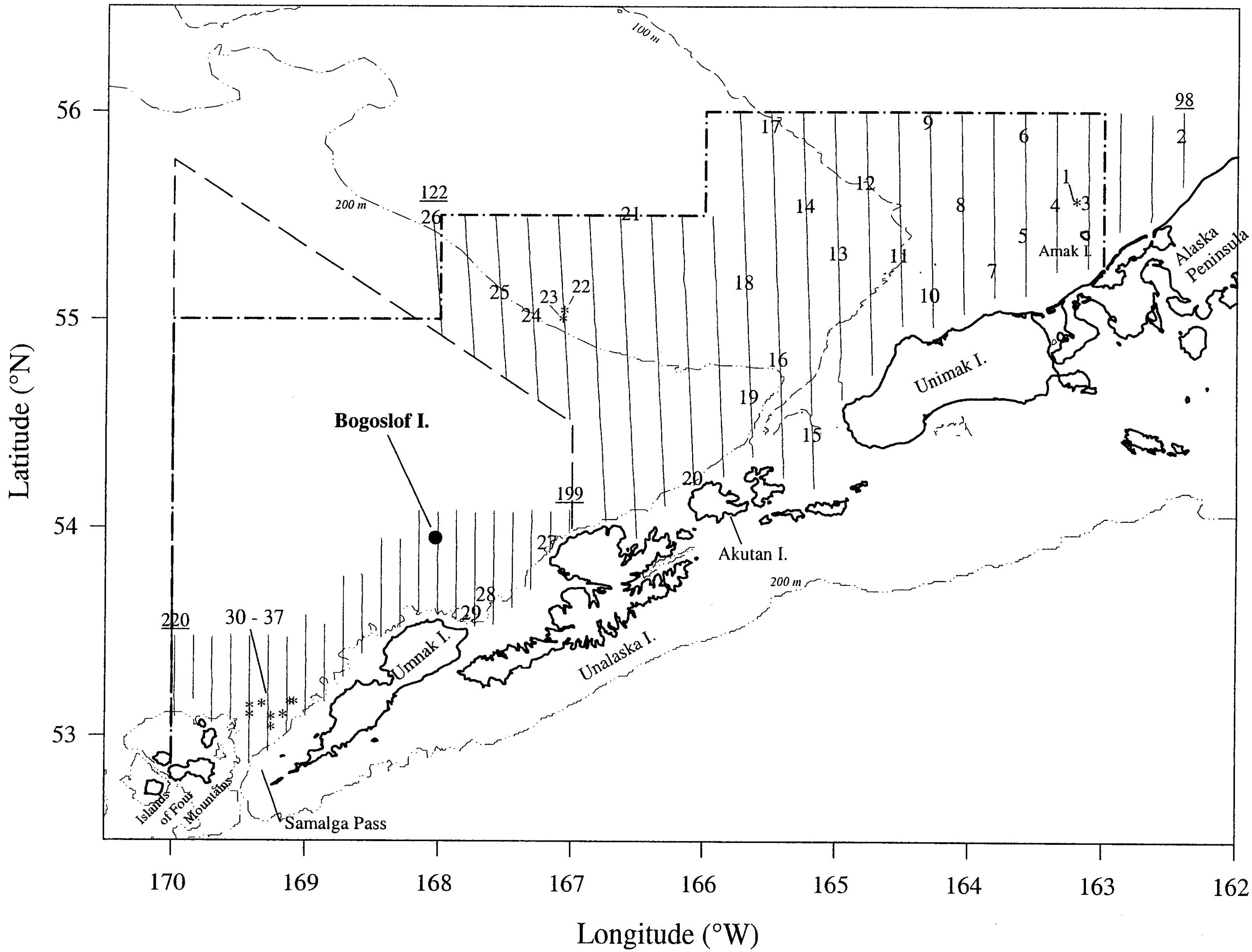


Figure 1. Trackline and haul locations from the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area. Hauls close together are indicated with asterisks and numbers. Transect numbers are underlined. Dash-dotted line indicates boundary of the Steller sea lion Conservation Area (SCA), and long-dashed line outlines NPFMC Area 518/Central Bering Sea specific area.

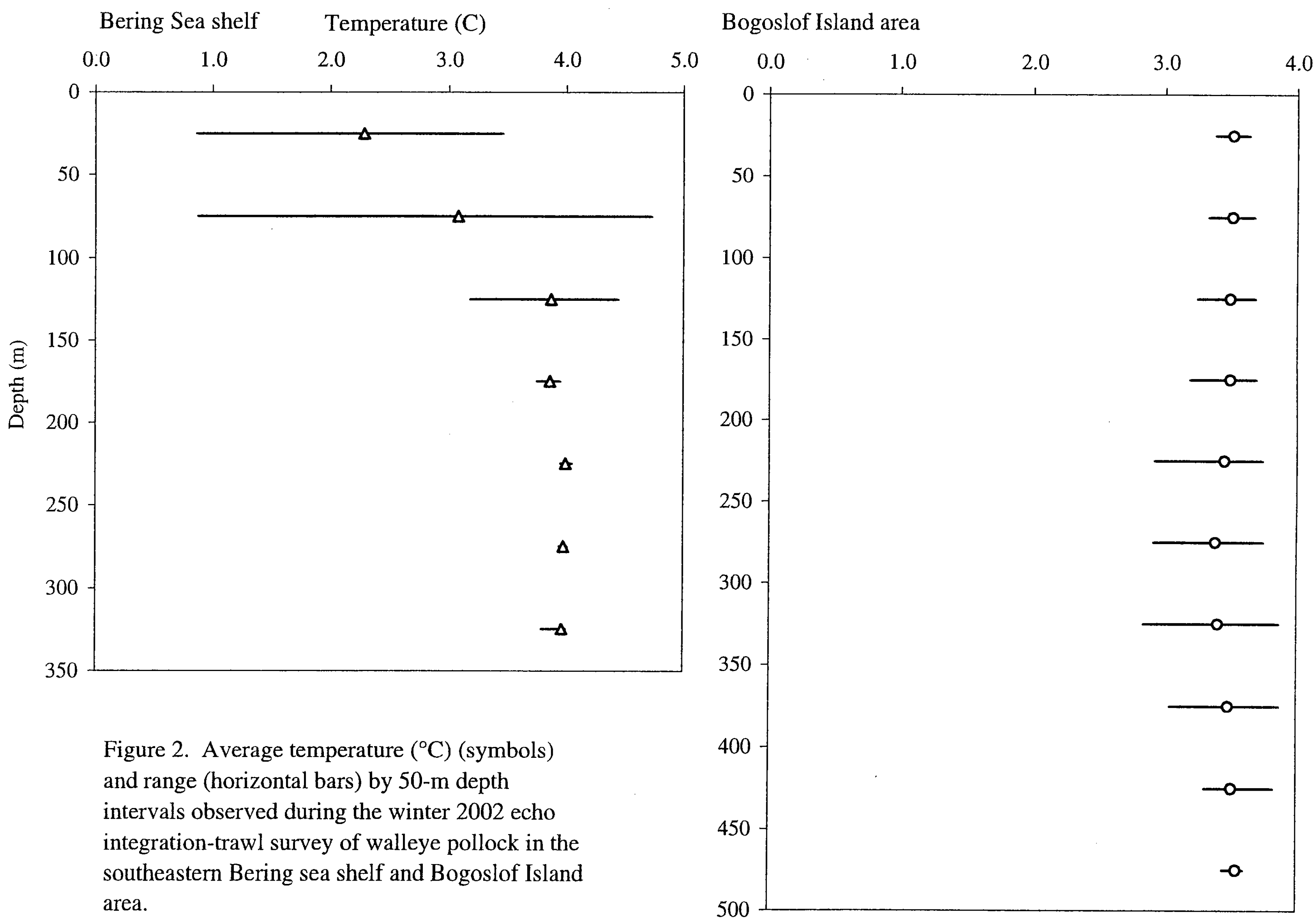


Figure 2. Average temperature (°C) (symbols) and range (horizontal bars) by 50-m depth intervals observed during the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering sea shelf and Bogoslof Island area.

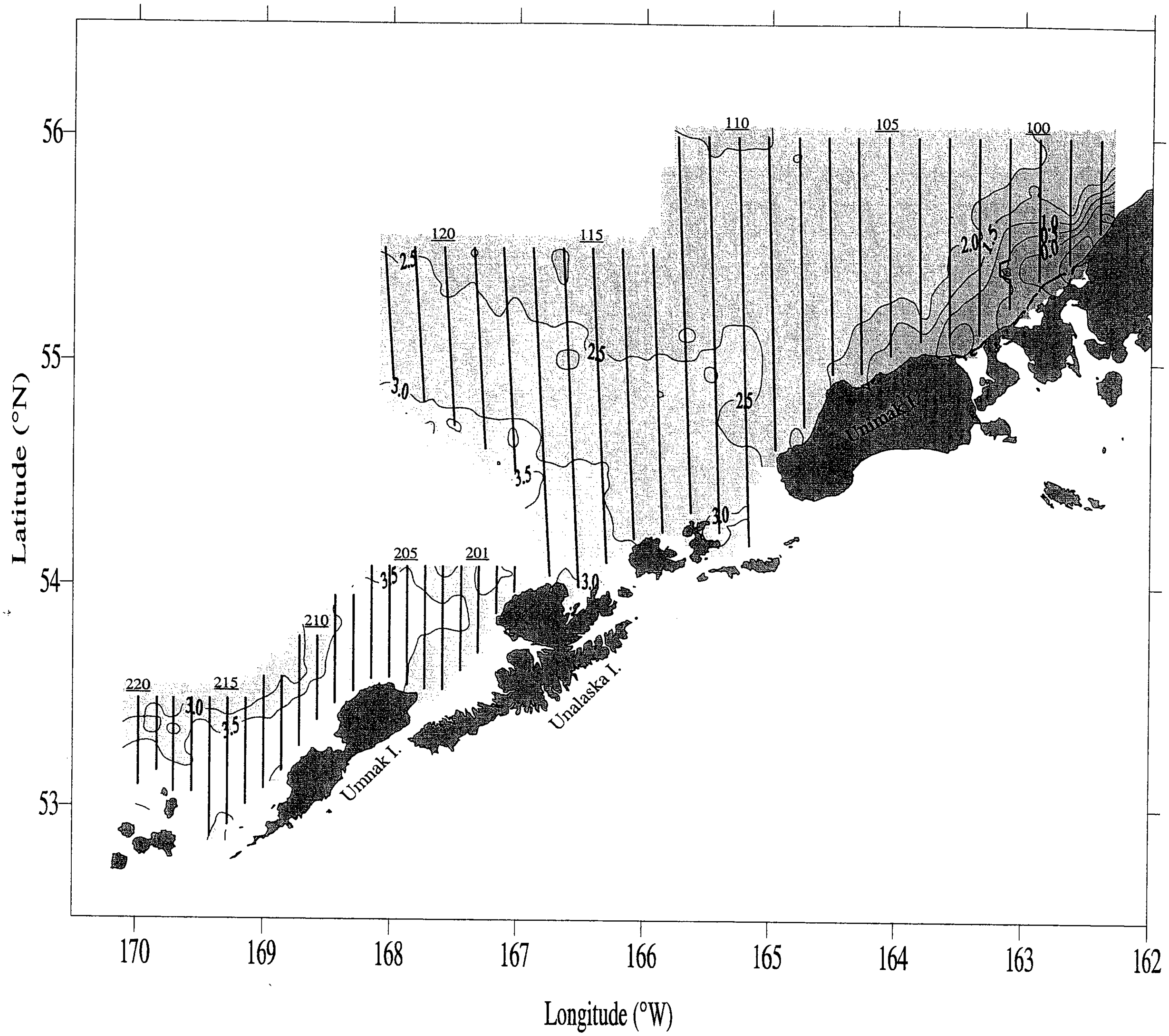


Figure 3. Transect lines with surface temperature contours (in °C) during the winter 2002 echo integration-trawl survey of the southeast Bering Sea shelf and Bogoslof Island area. Transect numbers are underlined.

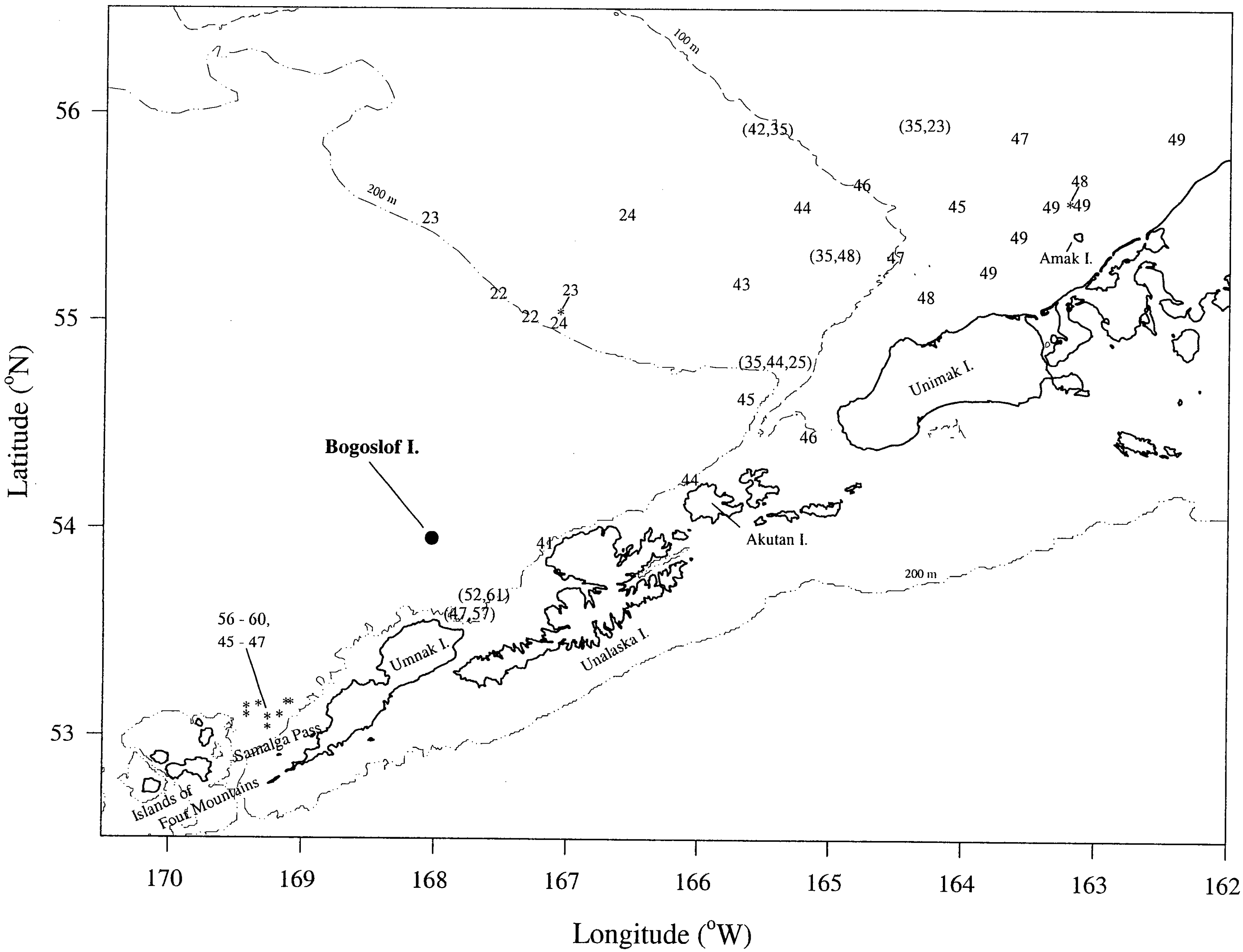


Figure 4. Haul locations with pollock modal lengths (cm) from the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area. Hauls with more than one mode have modes listed in parentheses in order of importance. Hauls west of Umnak Island in Samalga Pass are labeled with asterisks and dominant mode ranges.

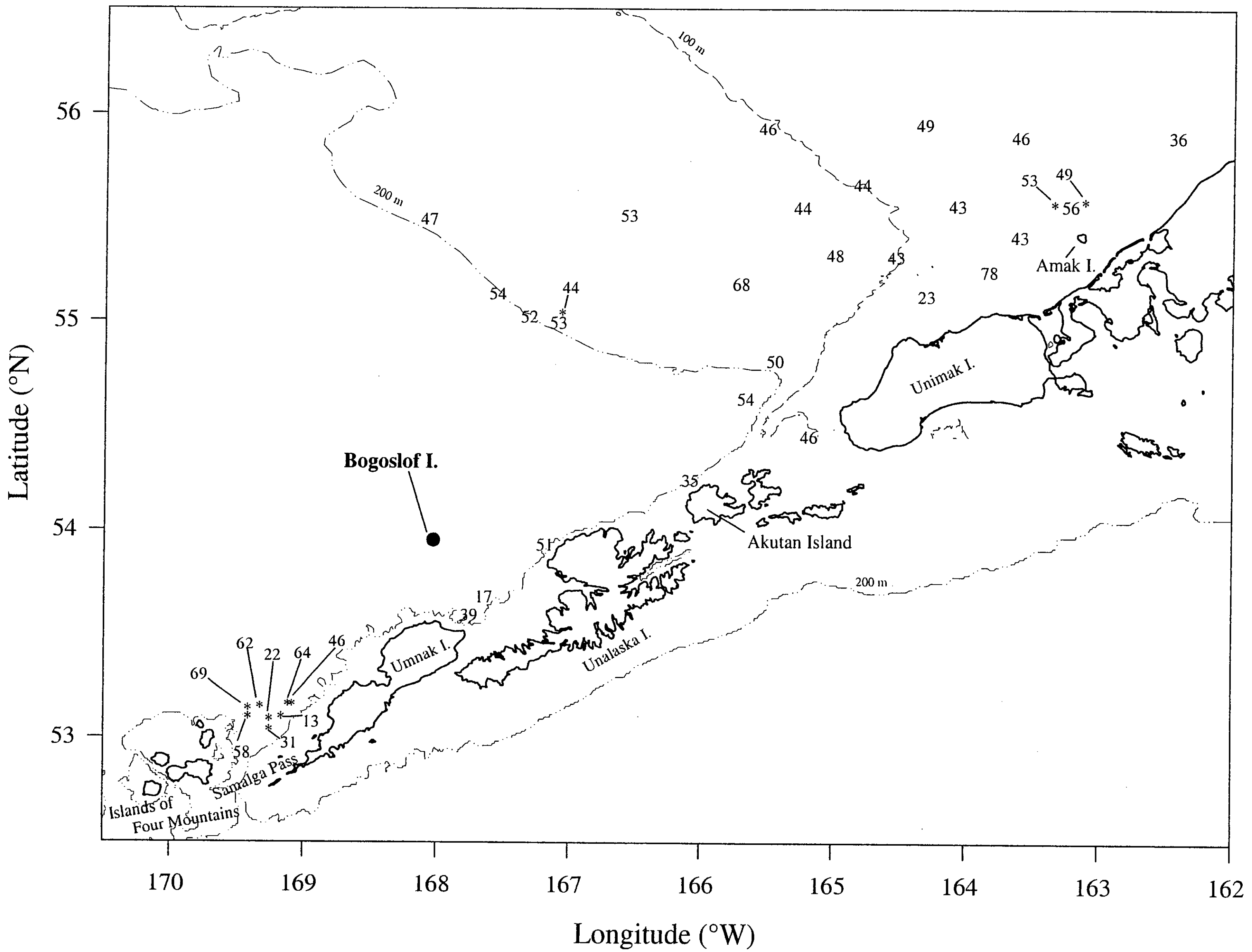
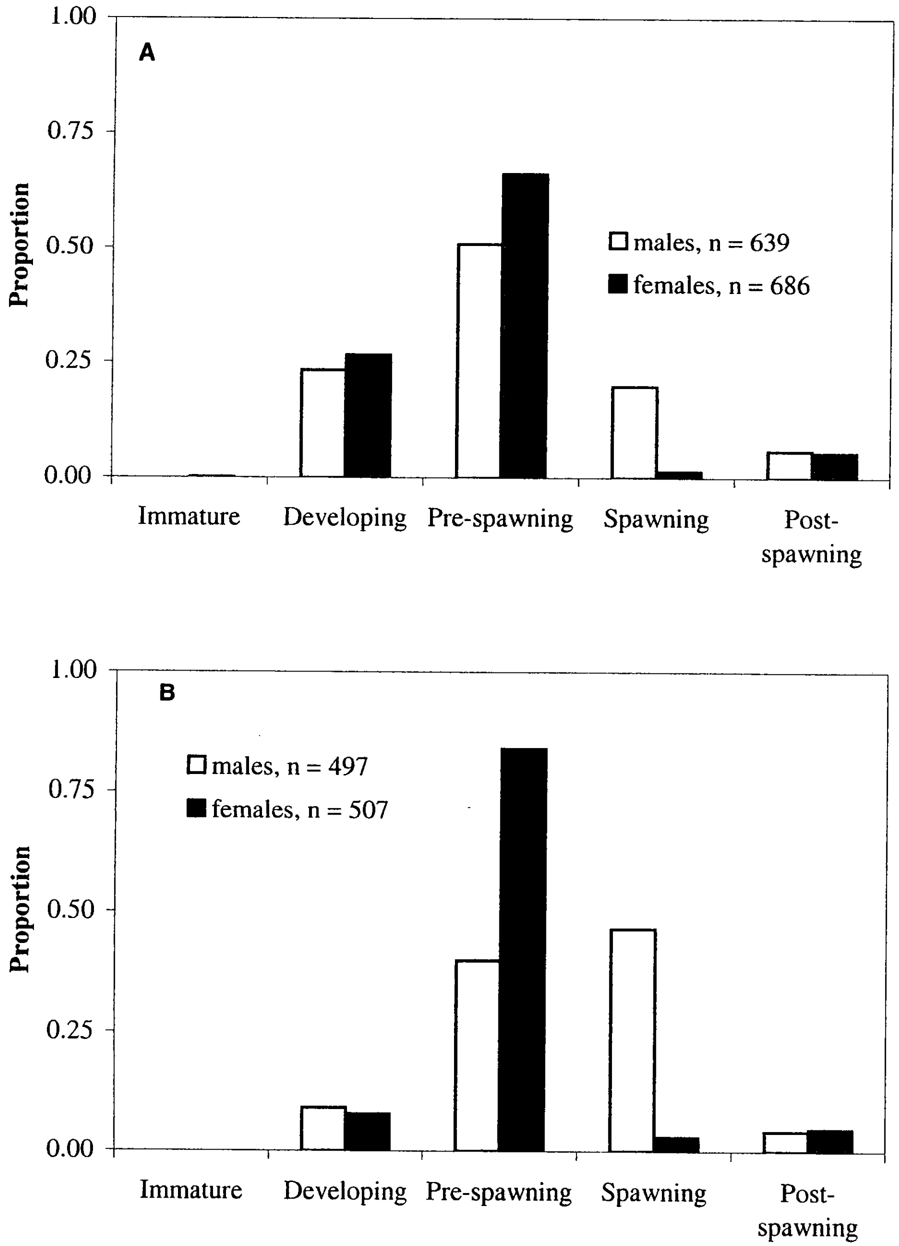


Figure 5. Haul locations with percent male pollock (N > 50) from the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area. Hauls close together are shown as asterisks with the percent male label adjacent to the haul location.



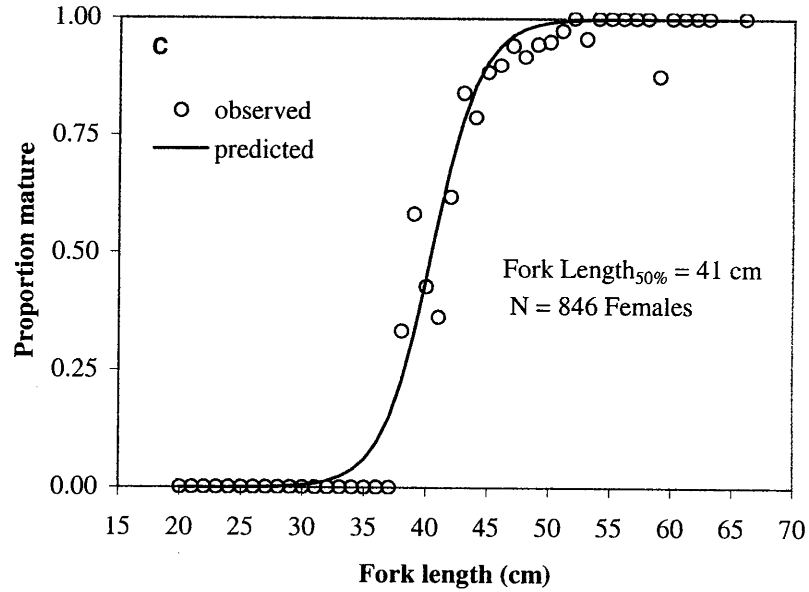


Figure 6. Pollock (>29 cm fork length) maturity stages observed during the winter 2002 echo integration-trawl survey of the southeastern Bering Sea shelf (A) and southeastern Aleutian Basin near Bogoslof Island (B). Fitted logistic function and proportion mature at each size class for female pollock observed in the southeastern Bering Sea shelf region (C). Fork length$_{50\%}$ is the predicted fork length of fish that are 50% mature.

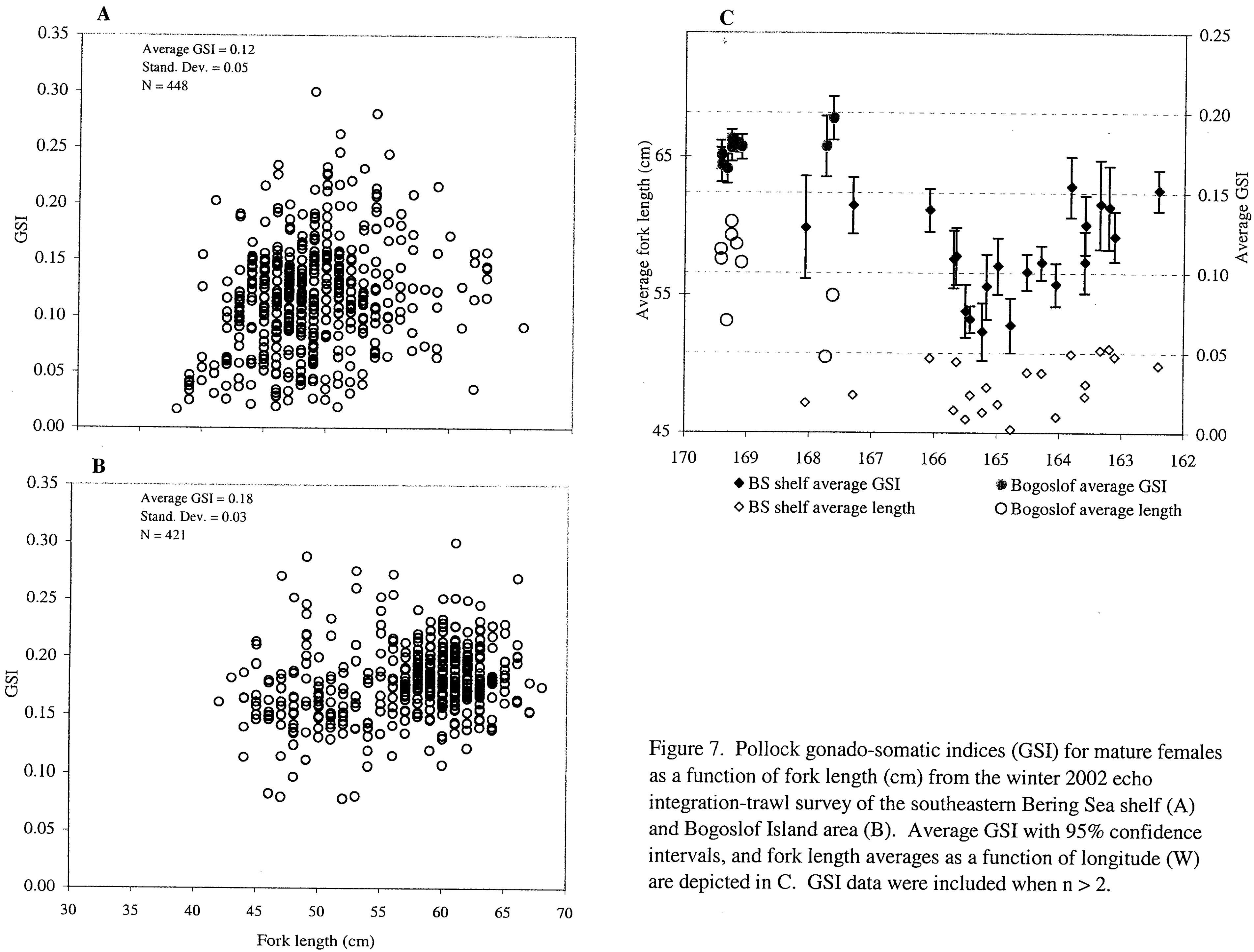


Figure 7. Pollock gonado-somatic indices (GSI) for mature females as a function of fork length (cm) from the winter 2002 echo integration-trawl survey of the southeastern Bering Sea shelf (A) and Bogoslof Island area (B). Average GSI with 95% confidence intervals, and fork length averages as a function of longitude (W) are depicted in C. GSI data were included when n > 2.

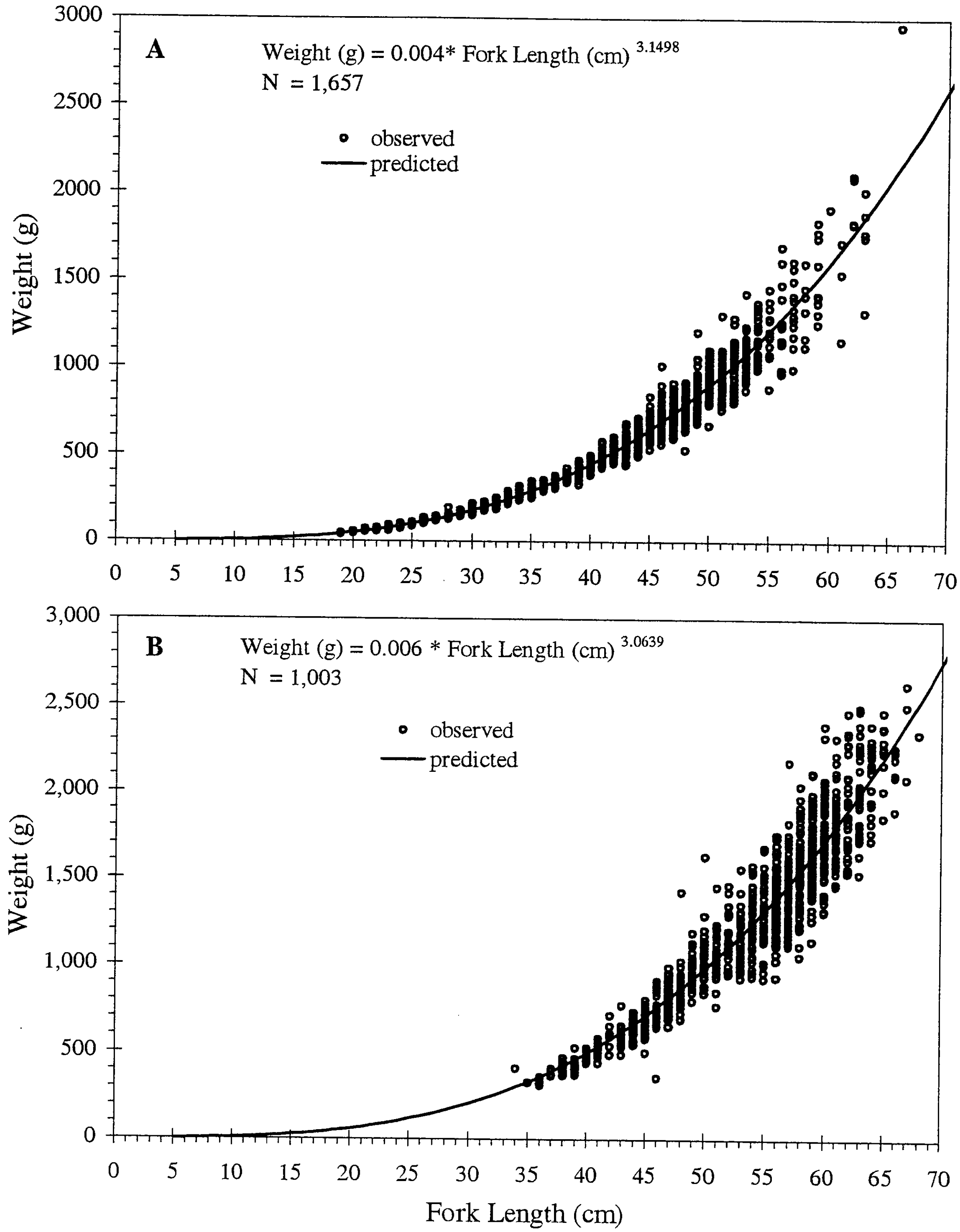


Figure 8. Pollock length-weight relationships (sexes combined) observed during the winter 2002 echo integration-trawl survey of the southeastern Bering Sea shelf (A) and Bogoslof Island region (B).

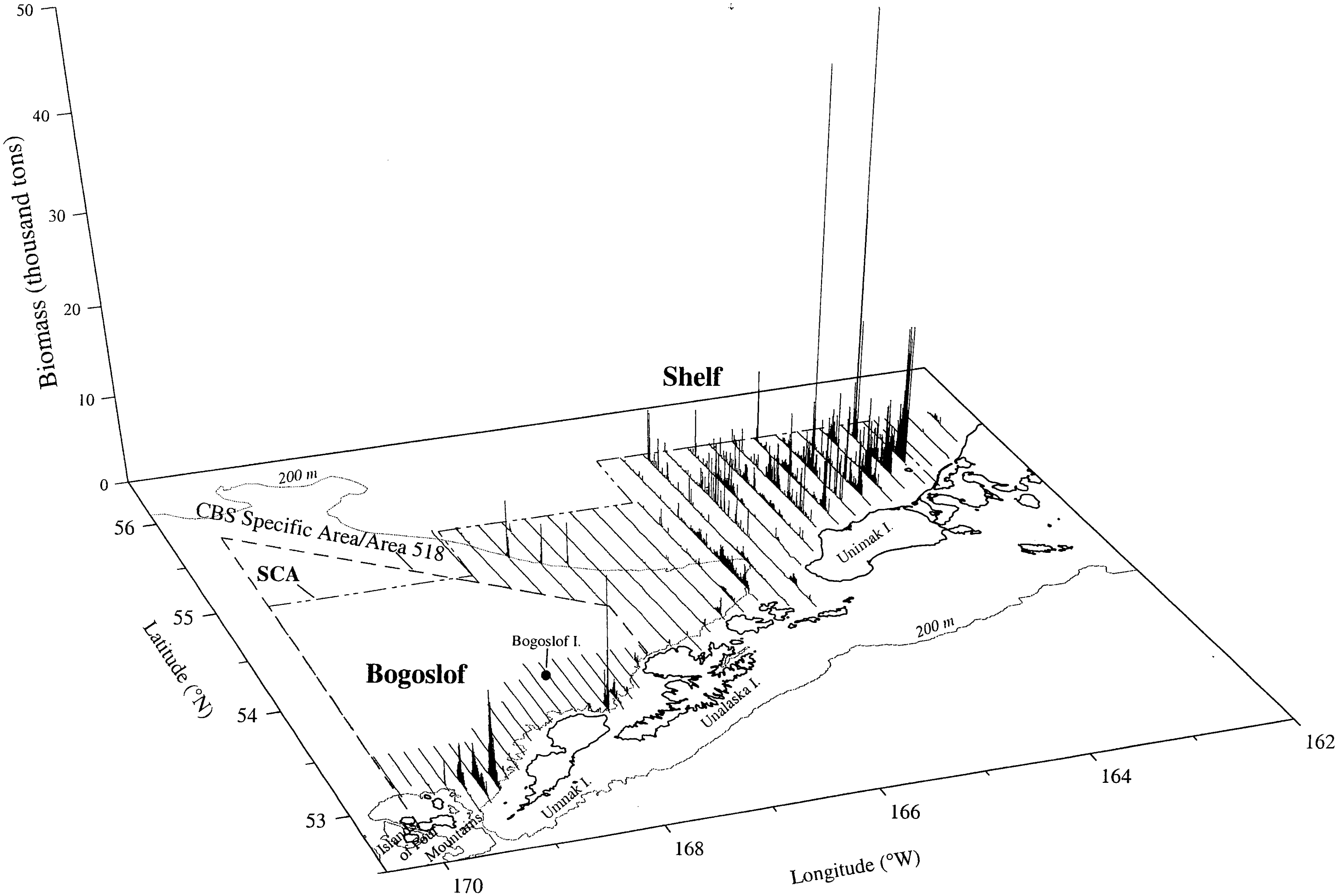


Figure 9a. Pollock biomass (1000 t) along tracklines from the winter 2002 echo integration-trawl survey of walleye pollock in the southeastern Bering Sea shelf and Bogoslof Island area. Steller sea lion Conservation Area (SCA) and CBS Specific Area/Area 518 are indicated.

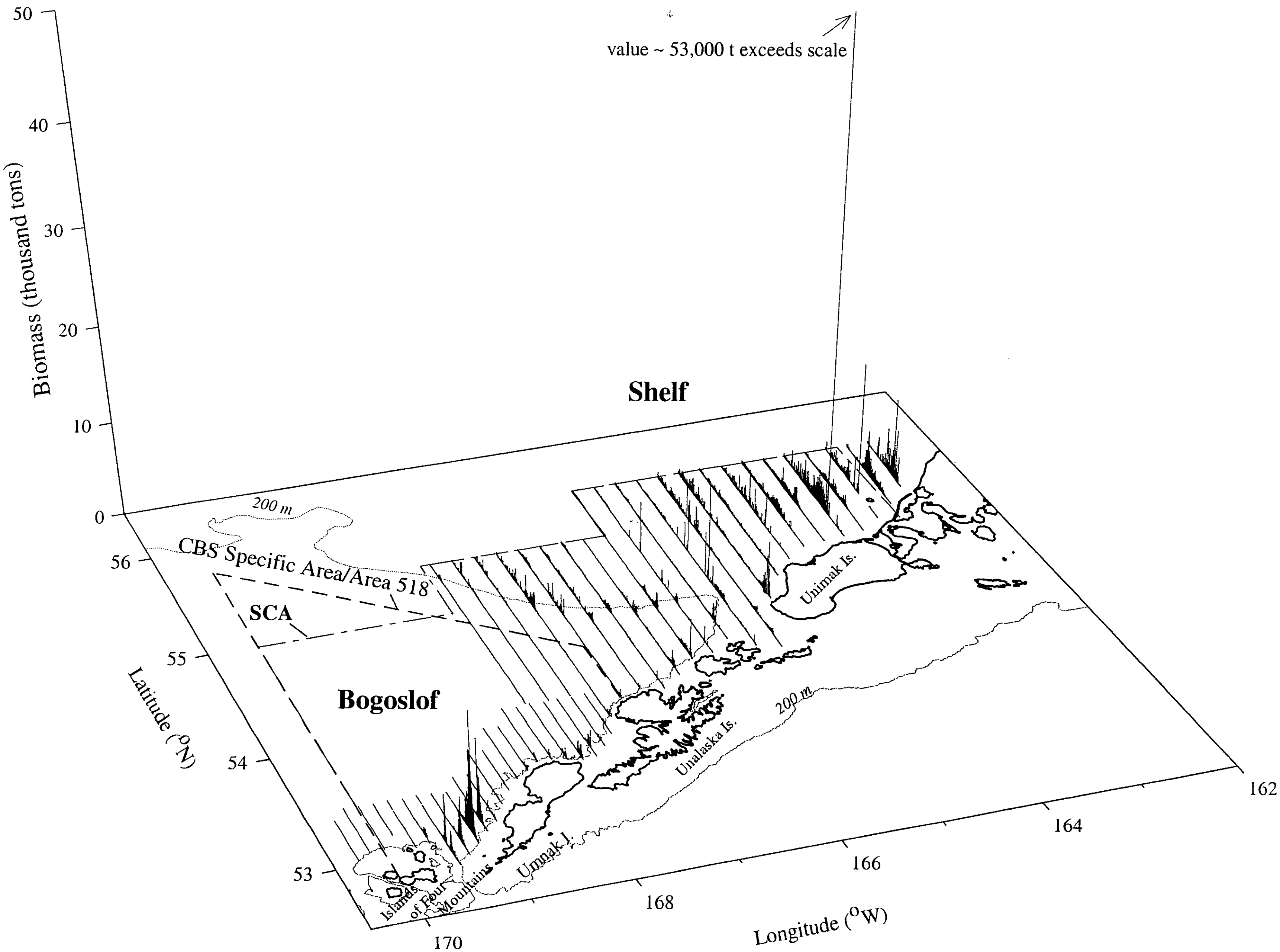


Figure 9b. Pollock biomass (1000 t) along tracklines from the winter 2001 echo integration-trawl survey of walleye pollock in the the southeastern Bering Sea shelf and Bogoslof Island area. Steller sea lion Conservation Area (SCA) and CBS Specific Area/Area 518 are indicated.

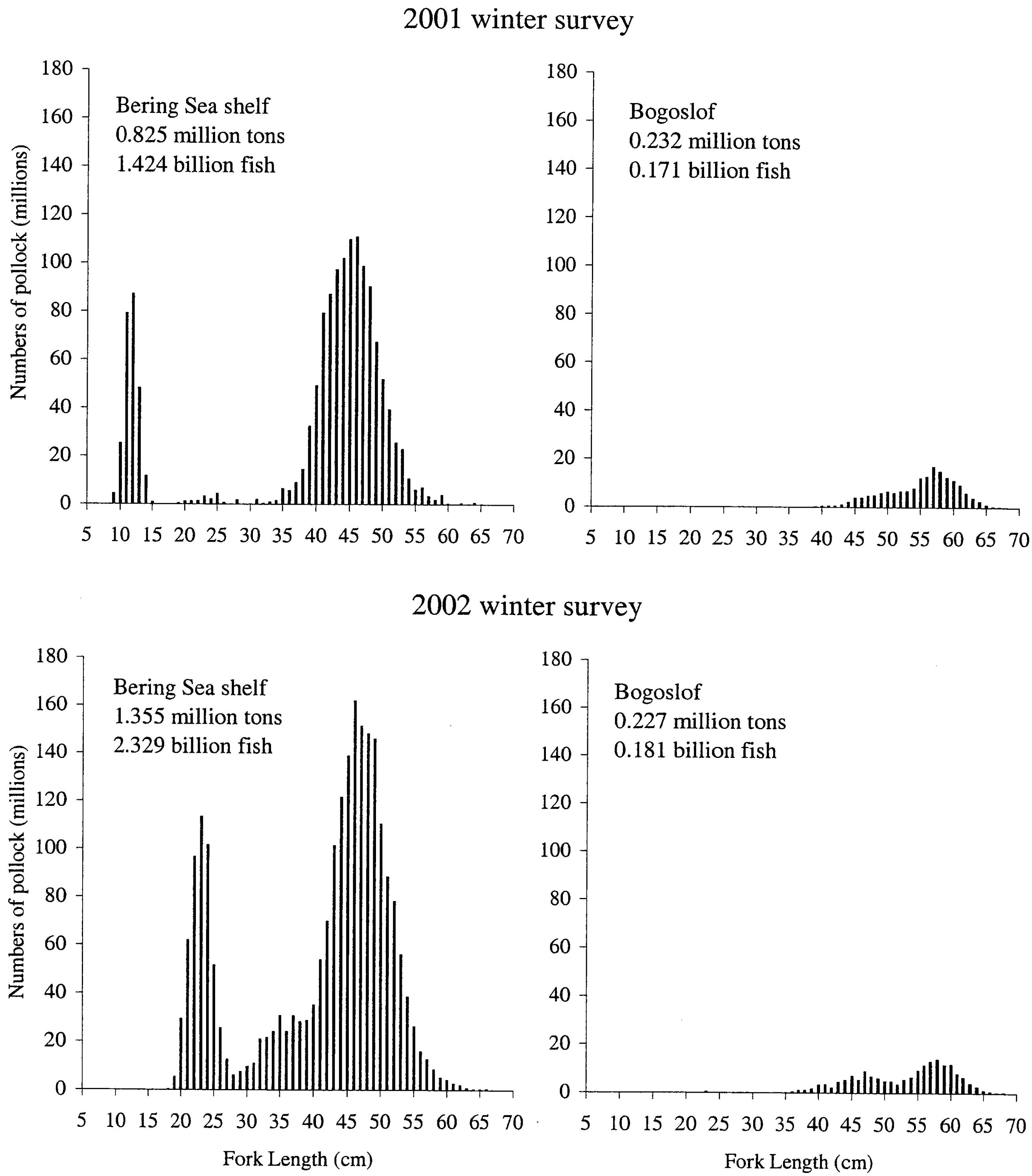


Figure 10. Population-at-length estimates from the winter 2001 (top) and winter 2002 (bottom) echo integration-trawl surveys of walleye pollock in the southeastern Bering Sea shelf (left) and Bogoslof Island area (right).

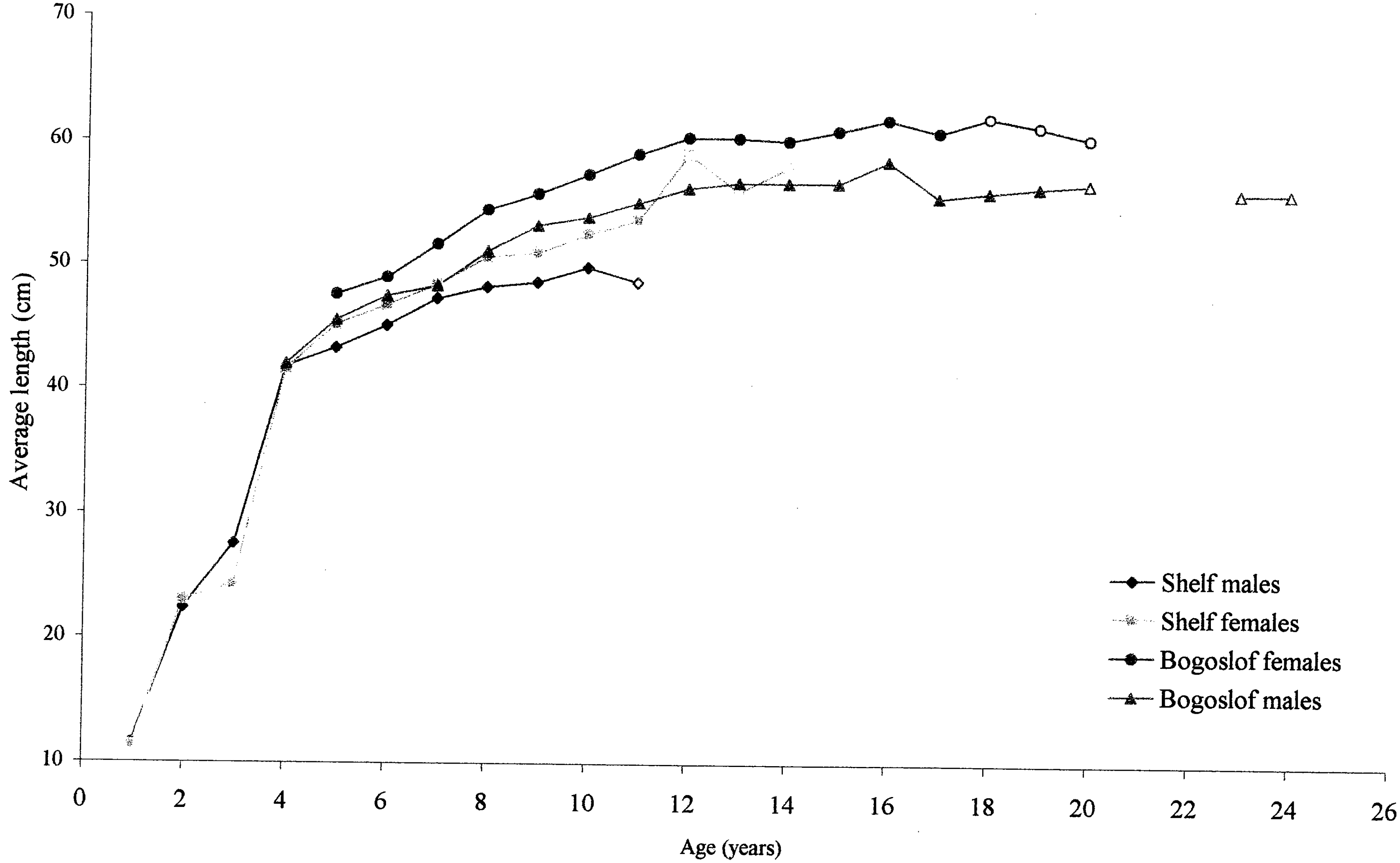


Figure 11. Average lengths at age for pollock from the winter 2001 echo integration-trawl survey of the Bering Sea shelf and Bogoslof Island area. Samples based on fewer than 5 individual pollock have hollow symbols.

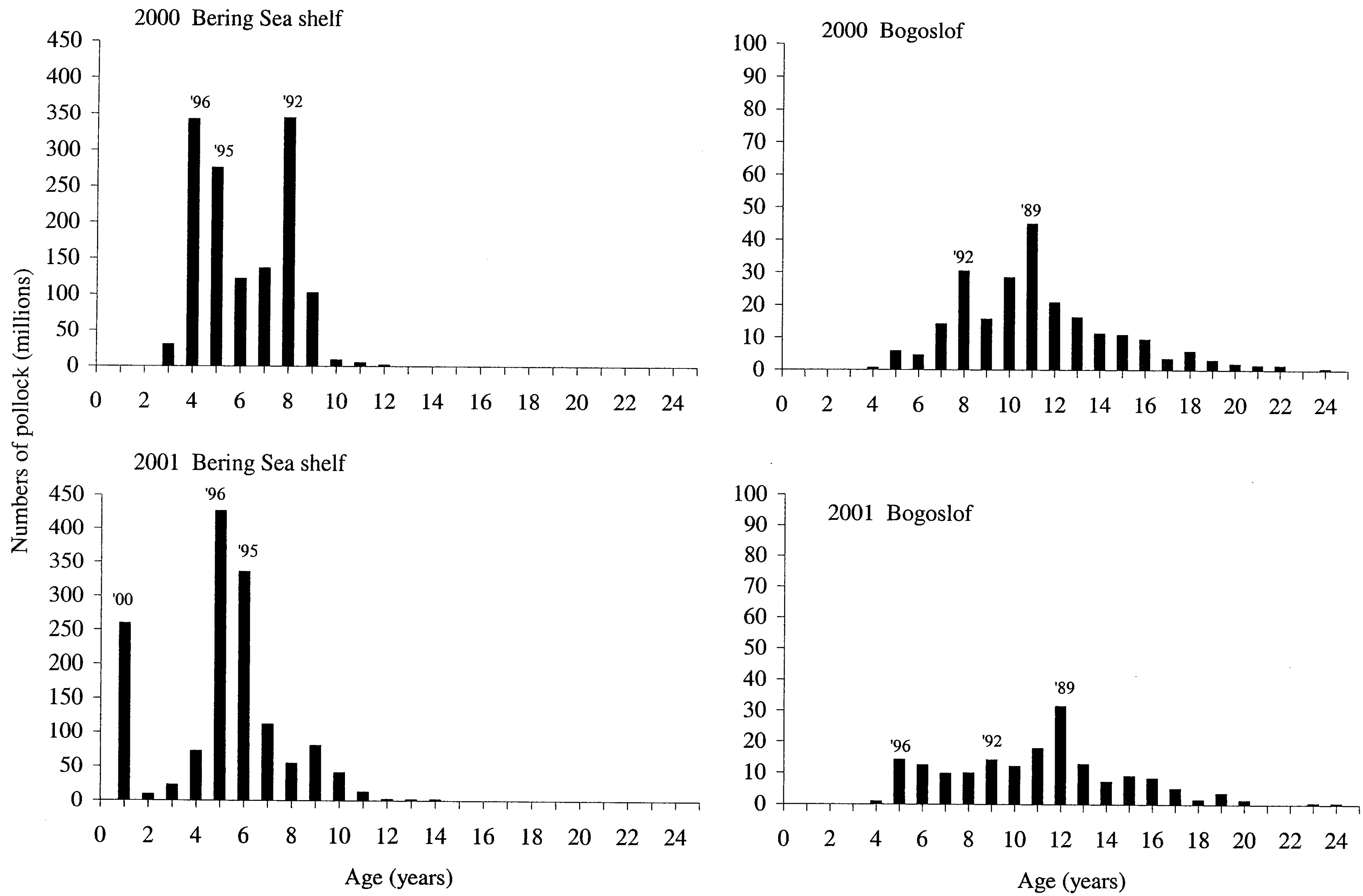


Figure 12. Population-at-age estimates from the winter 2000 (top) and 2001 (bottom) echo integration-trawl survey of walleye pollock on the southeastern Bering Sea shelf (left) and in the Bogoslof Island area (right). Major year classes are indicated. Note Y-axis scales differ.

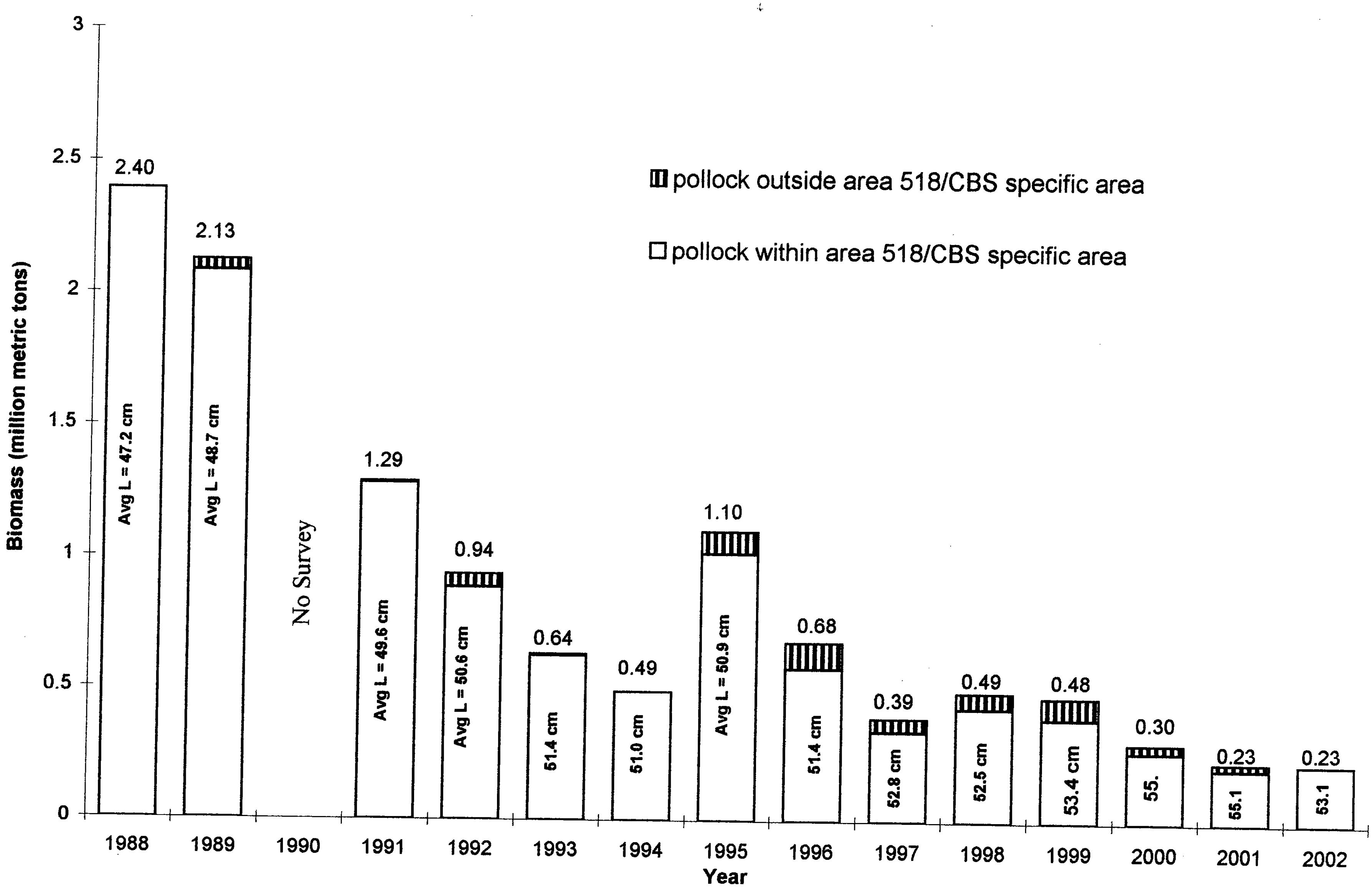


Figure 13. Biomass estimates and average fork lengths obtained during winter echo integration-trawl surveys for walleye pollock in the Bogoslof Island area, 1988-2002. The U.S. conducted all but the 1999 survey, which was conducted by Japan. Total estimated pollock biomass for each survey year is indicated on top of each bar.

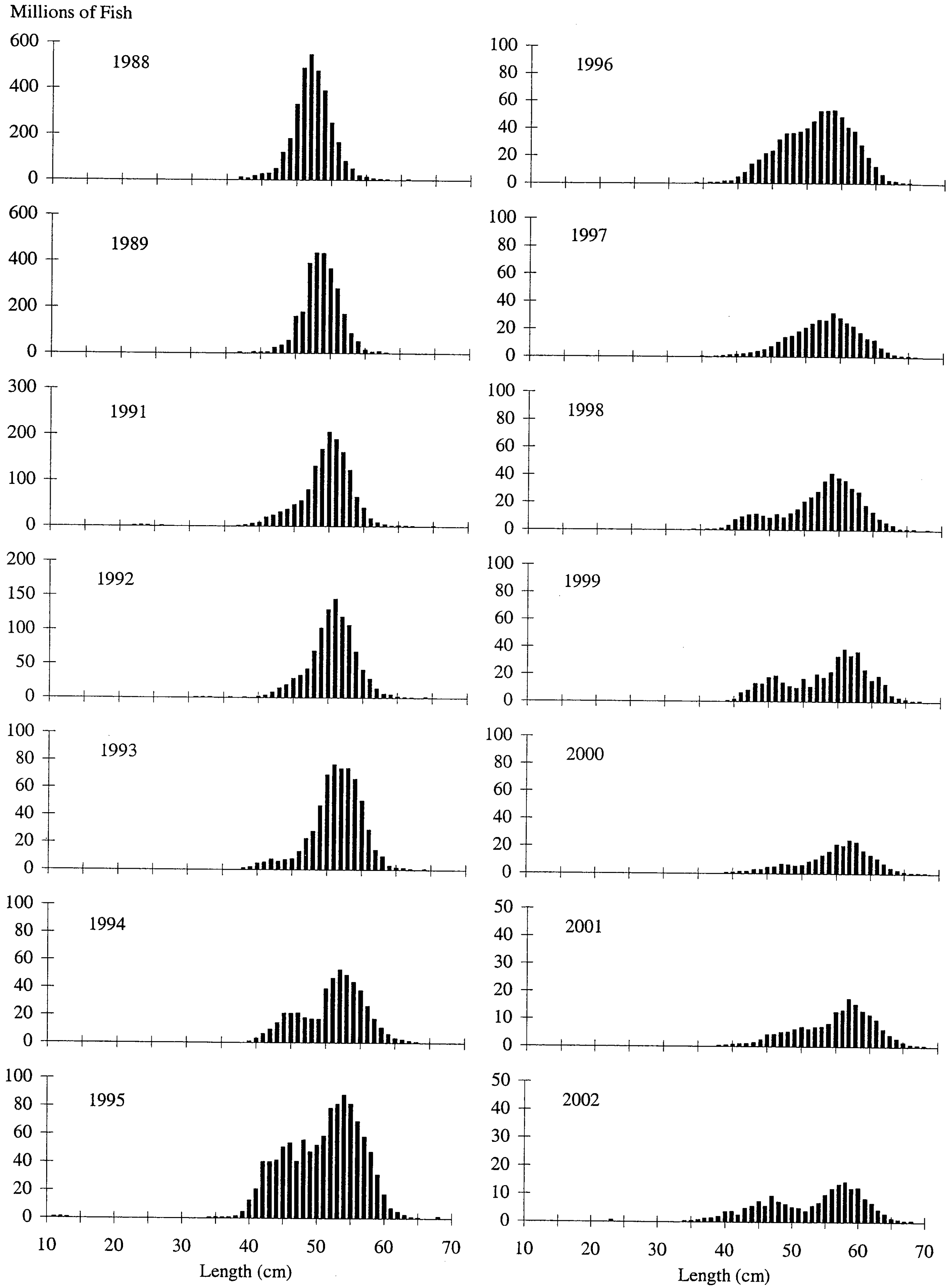
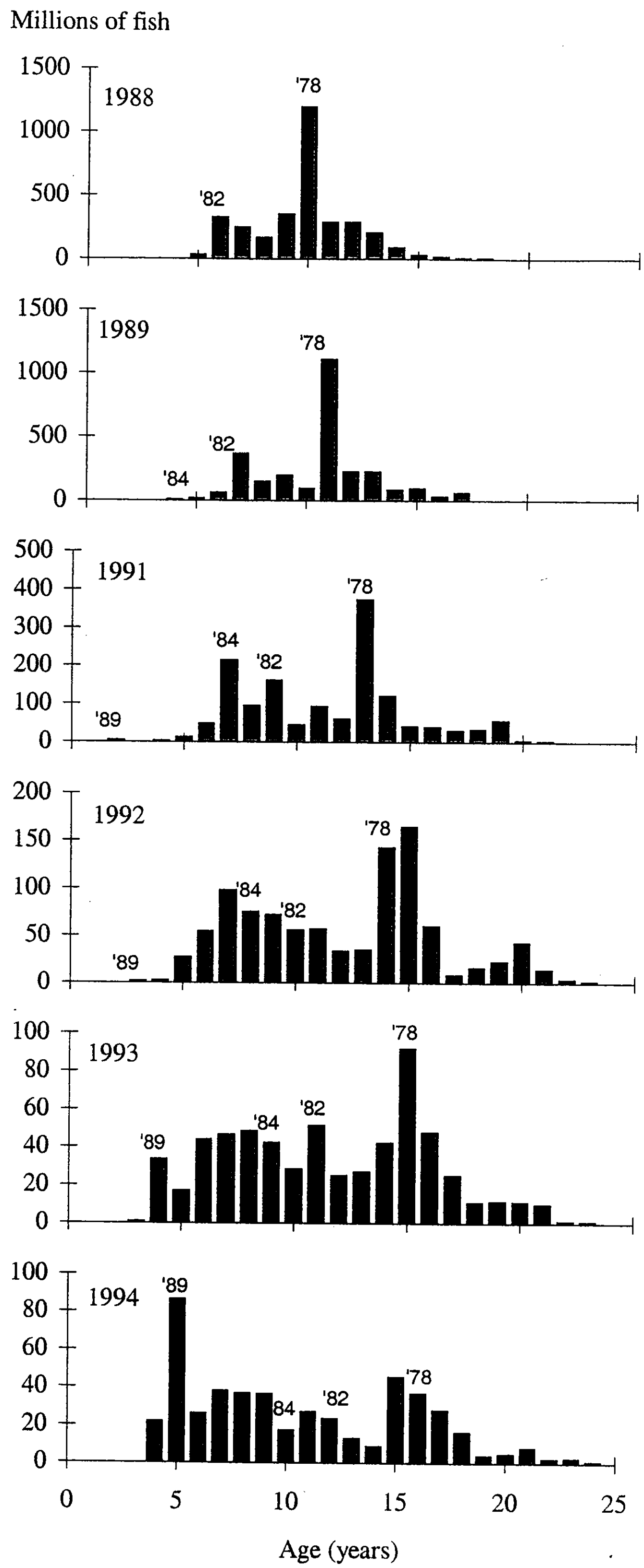


Figure 14. Population-at-length estimates from echo integration-trawl surveys of spawning pollock near Bogoslof Island in winter 1988-2001. The U.S. conducted all but the 1999 survey, which was conducted by Japan. There was no survey in 1990. Note y-axis scales differ.



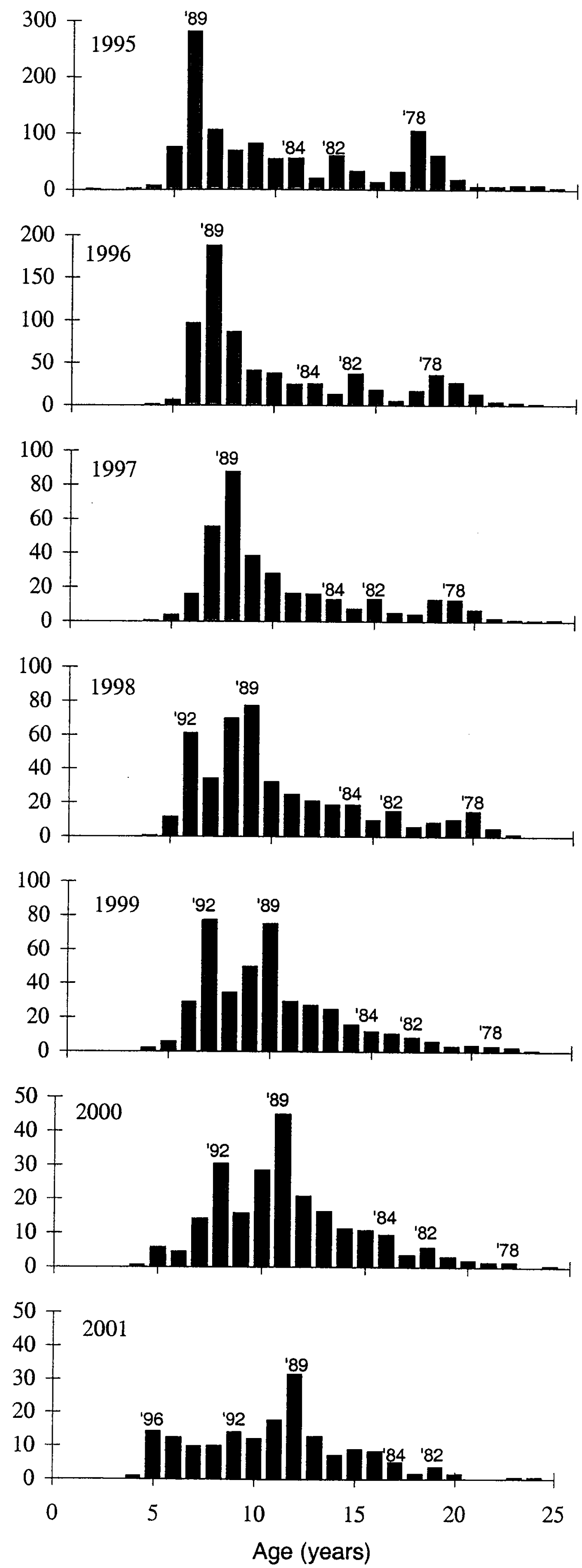


Figure 15. Population-at-age estimates obtained during echo integration-trawl surveys of walleye pollock near Bogoslof Island in winter 1988-2001. Major year classes are indicated. The U.S. conducted all but the 1999 survey, which was conducted by Japan. No survey was conducted in 1990. Ages are not yet available for 2002. Note y-axis scales differ.

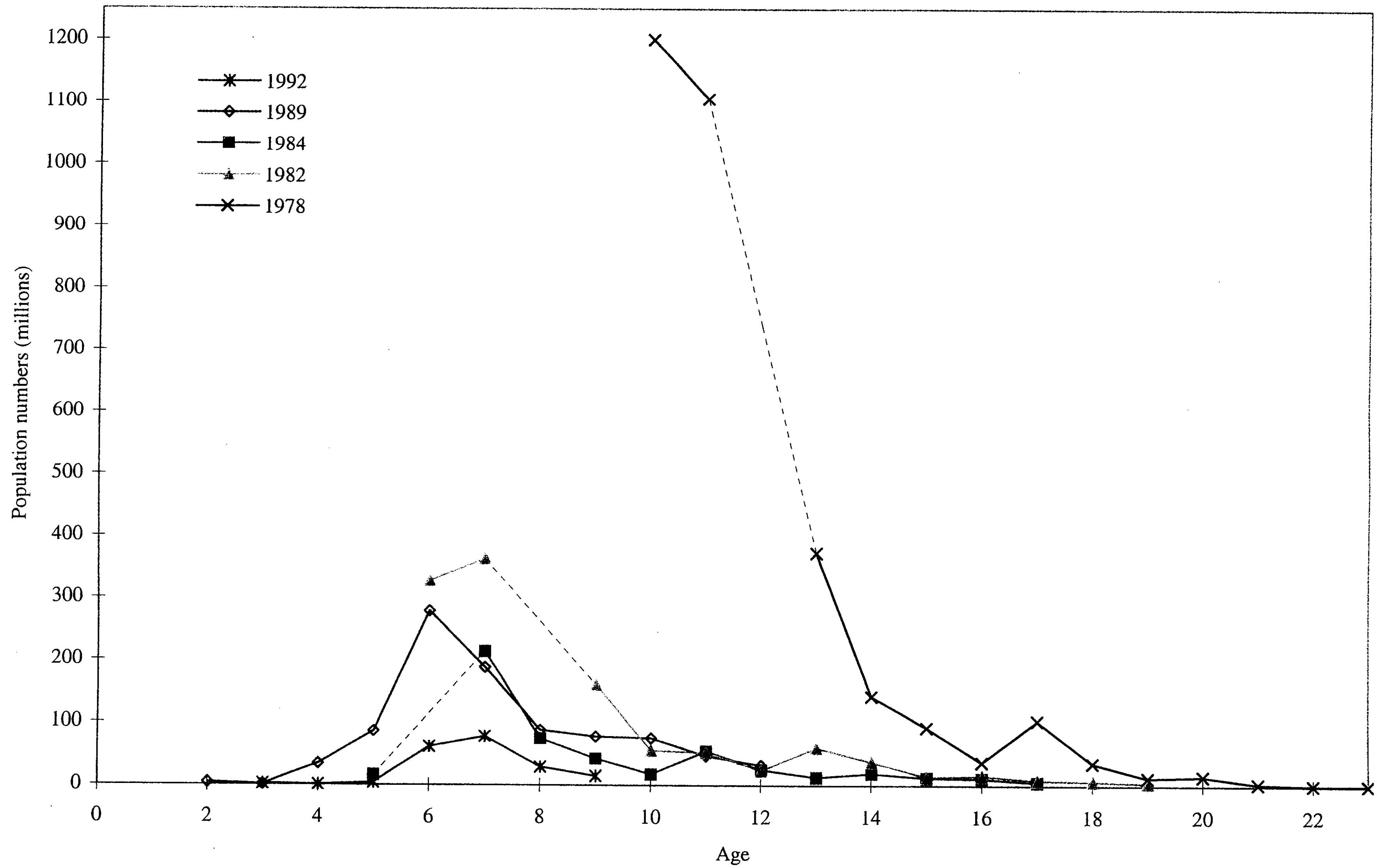


Figure 16. Estimated population numbers at age for dominant year classes observed in winter echo integration-trawl surveys of Bogoslof Island area spawning pollock. Data are from surveys conducted in 1988-2001. The U.S. conducted all but the 1999 survey, which was conducted by Japan. No survey was conducted in 1990 (dashed lines).

Section III

Report – Eastern Bering Sea walleye pollock stock assessment
(by James Ianelli, Troy Buckley, Taina Honkalehto, Gary Walters,
and Neal Williamson, 11/20/2001)

Eastern Bering Sea Walleye Pollock Stock Assessment

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National Marine Fisheries Service

11/20/01

Summary

The primary focus of this chapter is on the eastern Bering Sea region. The Aleutian Islands Region and Bogoslof Island area are treated separately in Sections 1.15 and 1.16 on pages 85 and 88, respectively.

Changes in the input data
The 2001 NMFS bottom-trawl survey estimates of population numbers-at-age were available for analysis in this assessment. In terms of biomass, the bottom-trawl survey estimate for 2001 is 4.14 million tons, down by 19.5% from the 2000 estimate of 5.14 million tons. This level of decline was expected given the estimated age-structure of the population relative to availability patterns of pollock to the bottom-trawl survey. For the echo-integration trawl (EIT) surveys we used an updated estimate of abundance-at-age from the 2000 summer survey and also used revised sample-size values for the time series of EIT abundance-at-age data that reflects the number of trawl-hauls.

The NMFS observer samples of pollock age and size composition were evaluated for the 2000 fishery and these data were included in the analyses. The estimates of average weight-at-age from the fishery were also revised. The total catch estimate was updated for 2000 and for 2001, we assumed that the catch is equal to the 2001 TAC (1,400,000 t). We also examined observer data for different fishing patterns with the implementation of recent management measures.

Changes in the assessment model
Minor changes to the assessment model were made relative to that used in Ianelli et al. (2000). These include adding an environmental effect (bottom temperatures) to survey catchability and developing alternative specifications for selectivity forms for the fisheries and surveys (following recommendations from the NPFMC's SSC).

Changes in the assessment results
Alternative stock assessment model configurations all indicated somewhat higher overall abundance levels than those estimated from last year's model. For example, the 2000 biomass level as estimated from this year's model is 12% higher than the estimate from last year's assessment model. This highlights that estimates from the assessment models are always highly uncertain (confidence bounds ranging from half to double the point estimates are not uncommon, particularly for stocks that are on or near an increasing trend).

Computations leading to the year 2002 maximum ABC alternatives based on the $F_{40\%}$ and F_{msy} are 2,269 and 2,108 thousand tons, respectively for the reference model (F_{msy} harvests based on the harmonic mean value). The lower value for the F_{msy} value this year reflects the level of uncertainty about stock size. The 2002 overfishing level (OFL) alternatives for the reference model are 2,833 and 3,531 thousand tons corresponding to $F_{35\%}$ and F_{msy} (arithmetic mean). These harvest level determinations fail to account for uncertainty in potential changes in harvest rates on the EBS stock outside of the US EEZ (particularly for pre-recruit age groups). Also, apparent continuing declines in Steller sea lion populations in adjacent areas continue to cause concern since pollock are an important prey item. Stock levels appear to be quite high for EBS pollock, but a large degree of uncertainty in the estimates remain. We therefore feel that quotas below these ABC levels would obviously be prudent. For example, a fixed catch of 1.4 million tons is projected to maintain the stock above the $B_{40\%}$ level of spawning stock biomass in the near term.

In the summer of 2000, NMFS conducted a bottom-trawl survey throughout the Aleutian Islands region. The estimate of on-bottom pollock in the Aleutians from this survey is 105,554 t. This gives **ABC** and **OFL values of 23,750 t** and **31,666 t,** respectively.

For the Bogoslof region, we followed the SSC recommendations and compute maximum permissible ABC and OFL based on Tier 5. This results in **34,800 t** and **46,400 t** for ABC and OFL, respectively. Further to the December 1999 SSC meeting minutes; we reduced the ABC relative to the target stock size (2 million tons). This gives a recommended 2002 ABC of **4,310 t** for the Bogoslof Island region.

1.1. Introduction

The stock structure of Bering Sea pollock (*Theragra chalcogramma*) is not well defined. In the U.S. portion of the Bering Sea pollock are considered to form three stocks for management purposes. These are: eastern Bering Sea which consists of pollock occurring on the eastern Bering Sea shelf from Unimak Pass and to the U.S.-Russia Convention line; Aleutian Islands Region which encompasses the Aleutian Islands shelf region from 170°W to the U.S.-Russia Convention line; and Central Bering Sea -Bogoslof Island pollock, which are thought be a mixture of pollock that migrate from the U.S. and Russian shelves to the Aleutian Basin around the time of maturity. In the Russian EEZ, pollock are considered to form two stocks, a western Bering Sea stock centered in the Gulf of Olyutorski, and a northern stock located along the Navarin shelf from 171°E to the U.S.- Russia Convention line. The northern stock is believed to be a mixture of eastern and western Bering Sea pollock with the former predominant. Currently, scientists at the AFSC are collaborating on a genetics study that will help clarify issues surrounding stock structure. In September 1999, scientists from countries belonging to the Central Bering Sea Convention convened a stock identification workshop in Yokohama, Japan, where they presented results of current research on pollock stock identification. This workshop addressed the current state-of-the-art techniques. A sampling protocol and exchange program between the countries was established. Problems were highlighted and efforts were made to keep management applications of stock-structure studies a high priority.

1.2. Catch history and fishery data

From 1954 to 1963, pollock were harvested at low levels in the Eastern Bering Sea and directed foreign fisheries began in 1964. Catches increased rapidly during the late 1960s and reached a peak in 1970-75 when catches ranged from 1.3 to 1.9 million t annually (Fig. 1.1). Following a peak catch of 1.9 million t in 1972, catches were reduced through bilateral agreements with Japan and the USSR.

Since the advent of the U.S. EEZ in 1977 the annual average eastern Bering Sea pollock catch has been 1.2 million t and has ranged from 0.9 million in 1987 to nearly 1.5 million t (including the Bogoslof Islands area catch; Fig. 1.1) in 1990 while stock biomass has ranged from a low of 4-5 million to highs of

10-12 million t. In 1980 United States vessels began fishing for pollock and by 1987 they were able to take 99% of the quota. Since 1988, only U.S. vessels have been operating in this fishery and by 1991, the current domestic observer program of this fishery was fully operational.

Foreign vessels began fishing in the mid-1980s in the international zone of the Bering Sea (commonly referred to as the "Donut Hole"). The Donut Hole is entirely contained in the deep water of the Aleutian Basin and is distinct from the customary areas of pollock fisheries, namely the continental shelves and slopes. Japanese scientists began reporting the presence of large quantities of pollock in the Aleutian Basin in the mid-to-late 1970's, but large scale fisheries did not occur until the mid-1980's. In 1984, the Donut Hole catch was only 181 thousand t (Fig. 1.1, Table 1.1). The catch grew rapidly and by 1987 the high seas catch exceeded the pollock catch within the U.S. Bering Sea EEZ. The extra-EEZ catch peaked in 1989 at 1.45 million t and has declined sharply since then. By 1991 the donut hole catch was 80% less than the peak catch, and data for 1992 and 1993 indicate very low catches (Table 1.1). A fishing moratorium was enacted in 1993 and only trace amounts of pollock have been harvested from the Aleutian Basin by resource assessment fisheries.

1.2.1. Fishery characteristics

The pattern of the fishery from 1995 to 1999 had been to have an "A-season" opening on January 20th with the season lasting about 1 month, depending on the catch rate. Historically, a second "B-season" opening has occurred on September 1st (though 1995 opened on Aug 15th). This has changed considerably over the past few years and management has focused on minimizing the possibility that the pollock fishery inhibits the recovery of the Steller sea lion population or adversely modifies their habitat. We discuss this in detail in the next section.

Since the closure of the Bogoslof management district (518) to directed pollock fishing in 1992, the "A-season" (January – March) pollock fishery on the eastern Bering Sea (EBS) shelf has been concentrated primarily north and west of Unimak Island (Ianelli *et al.* 1998). Depending on ice conditions and fish distribution, there has also been effort along the 100 m contour between Unimak Island and the Pribilof Islands. This pattern has gradually changed during the period 1999 - 2001 (Fig. 1.2). The total catch estimates by sex for the A-season compared to the fishery as a whole indicates that over time, the number of males and females has been fairly equal with a slight tendency to harvesting males more than females in recent years (Fig. 1.3). The length frequency information from the fishery shows that the size of pollock is generally larger than 40 cm but with some smaller fish caught during years when a strong year-class appeared (Fig. 1.4).

After 1992, the "B-season" (typically September – October) fishery has been conducted to a much greater extent west of 170°W than it had been prior to 1992 (Ianelli *et al.* 1998). This shift was due to the implementation of the CVOA (Catcher Vessel Operational Area) in 1992 and also the geographic distribution of pollock by size. The pattern in the past few years shows an increase in this trend (towards catching pollock west of 170°W) and decreasing amounts with the Sea lion conservation area (SCA) until this year. Large removals occurred within the SCA in the second half of 2001 compared to 1999 and 2000 (Fig. 1.5).

The length frequency information from the fishery reveals a marked progression of the large 1989 year-class growing over time and the appearance of the 1992 year-class in 1996-97 and subsequent 1996 year class in 1998-2001 (Fig. 1.6).

1.2.2. Fisheries Management

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the NPFMC have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA). These have been designed to reduce the possibility of of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the eastern Bering Sea (EBS) led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which *could* lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here we examine the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

- Additional pollock fishery exclusion zones around sea lion rookery or haulout sites,
- Phased-in reductions in the seasonal proportions of TAC that can be taken from critical habitat, and
- Additional seasonal TAC releases to disperse the fishery in time.

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the north Pacific ocean managed by the NPFMC: the Aleutian Islands (1,001,780 km^2 inside the EEZ), the eastern Bering Sea (968,600 km^2), and the Gulf of Alaska (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150°W encompasses 386,770 km^2 of ocean surface, or 12% of the fishery management regions.

Prior to 1999, a total of 84,100 km^2, or 22% of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 km^2 or 13% of critical habitat). The remainder was largely management area 518 (35,180 km^2, or 9% of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central Bering Sea pollock.

In 1999, an additional 83,080 km^2 (21%) of critical habitat in the Aleutian Islands was closed to pollock fishing along with 43,170 km^2 (11%) around sea lion haulouts in the GOA and eastern Bering Sea. Consequently, a total of 210,350 km^2 (54%) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea foraging area.

The Bering Sea/Aleutian Islands pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher processor sector (allocated 36% of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry.

Reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire Aleutian Islands region to pollock fishing and by phased-in reductions in the proportions of seasonal

TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 mt of pollock was caught in the Aleutian Island regions, with over 17,000 mt caught in AI critical habitat. Since that time directed fishery removals of pollock have been prohibited.

On the eastern Bering Sea shelf, both the catches of pollock and the proportion of the total catch caught in critical habitat have been reduced significantly since 1998 as a result of the management measures (though the drop in the latter half of 2000 was due to closures from an injunction):

Year	Months	Catch Outside SCA	Total Catch	Percent Inside SCA
1998	Jan-Jun	70,786	384,899	82%
	Jun-Dec	247,691	403,068	39%
	Jan-Dec	318,477	787,967	60%
1999	Jan-Jun	154,963	338,801	54%
	Jun-Dec	360,117	467,776	23%
	Jan-Dec	515,080	806,577	36%
2000	Jan-Jun	240,801	375,285	36%
	Jun-Dec	550,109	571,903	4%
	Jan-Dec	790,910	947,188	16%
2001	Jan-Jun	343,458	474,545	28%
	Jun-Dec	367,686	641,660	43%
	Jan-Dec	711,144	1,116,205	36%

Note: Pollock catches as reported by at-sea observers only, 2001 data are preliminary.

An additional goal for minimizing the potential for impacting the sea lion population is to disperse the fishery throughout more of the pollock range on the eastern Bering Sea shelf. This was apparent in the first half of 2001 with more fishing distributed northwest of the SCA and around the Pribolof Islands (Fig. 1.2). However, in the second-half of 2001 the fishery was more concentrated than usual within the SCA (Fig. 1.5). This is in sharp contrast to the same period in 2000 when this area was closed for much of the season.

Seasonal TAC releases were intended to disperse the fishery throughout more of the year. Prior to the increased sea lion conservation measures, the fishery was concentrated in 2 seasons, each approximately 6 weeks in length in January-February, and September-October; 94% of the pollock fishery occurred during these four months, with 45% in January-February and 49% in September-October. In 1999, the measures dispersed the early fishery into March (which reduced the percentage taken in February) and the later fishery into August, but very little into the April-July period. One way of examining the seasonal aspect of the 2000 fishery is to plot the raw observer sampling effort by month (Fig. 1.7). This is roughly proportional to total catch by the pollock fishery and shows that significant removals occurred in 7 months of the year.

Also relevant to current management measures are examinations of historical patterns of pollock fishing. For this we compiled foreign observer data by month for each year and computed the geographic center of where the removals occurred. Results show that the fishing patterns in the 1980s were quite different than in the 1990s. There appears to be much greater separation between fishing in the early and later seasons within a year during the 1990s while during the 1980s, there appears to be very similar centers of catch distributions in both early and late seasons (Fig. 1.8). This could be partly due to differences in observer coverage and changes to pelagic gear during the 1990s.

1.2.3. Catch data

Significant quantities of pollock are discarded and must be taken into account in estimation of population size and forecasts of yield. Observer length frequency observations indicated that discarded pollock include both large and small pollock. Since observers usually sample the catch prior to discarding, the size distribution of pollock sampled closely reflects that of the actual *total* catch. Discard data as compiled by the NMFS Alaska Regional Office have been included in estimates of total catch since 1990.

Pollock catch in the eastern Bering Sea and Aleutian Islands by area from observer estimates of retained and discarded catch, 1990-2000 are shown in Table 1.2. Since 1990 estimates of discarded pollock have ranged from a high of 11% of total pollock catch in 1991 to a low of 1.5% in 1998 (the 2000 value was 2%). These recent low values reflect the implementation of the Council's Improved Utilization and Improved Retention program. Variability in discard rates may also be due to the age-structure and relative abundance of the available population. For example, if the most abundant year-class in the population is below marketable size, these smaller fish may be caught incidentally. With the implementation of the AFA, the fleets have more time to pursue the sizes of fish they desire since they are guaranteed a fraction of the quota. In addition, several vessels have made gear modifications to avoid retention of smaller pollock. In all cases, the magnitude of discards is accounted for within the population assessment and for management (to ensure the TAC is not exceeded).

We estimate the catch-at-age composition using the methods described by Kimura (1989) and modified by Dorn (1992). Briefly, length-stratified age data are used to construct age-length keys for each stratum and sex. These keys are then applied to randomly sampled catch length frequency data. The stratum-specific age composition estimates are then weighted by the catch within each stratum to arrive at an overall age composition for each year. Data were collected through shore-side sampling and at-sea observers. The three strata for the EBS were: 1) INPFC area 51 from January - June; 2) INPFC area 51 from July - December; and 3) INPFC area 52 from January - December. This method was used to derive the age compositions from 1991-2000 (the period for which all the necessary information is readily available). Prior to 1991, we used the same catch - age composition estimates as presented in Wespestad *et al.* (1996). Recently, we examined stratifying the fisheries catch data by month and NMFS survey areas as opposed to the normal fishery seasons and INPFC areas. The results from this work are preliminary but compared favorably with the current estimates of catch-at-age.

The time series of the catch proportions-at-age suggests that in 1999 and 2000 a broad range of age groups were harvested with a continued strong showing of the 1992, 1995, and 1996 year classes (Fig. 1.9). We present these values (as used in the age-structured model) from 1979-2000 in Table 1.3. The 1999 and 2000 estimates of pollock catch-at-age data were collected using a new survey sampling strategy. Under the new scheme, more observers collect otoliths from a greater number of hauls (but far fewer specimens per haul). The objective of the new system was to improve geographic coverage while at the same time lowering the total number of otoliths collected (since a large number were not subsequently aged and arguably would not contribute further to the precision of catch-at-age estimates). The geographic coverage was significantly improved (Fig. 1.10) as was the precision when compared with earlier years (Fig. 1.11). The sampling effort for lengths was significantly decreased in 1999 and 2000, but the number of otoliths processed for age-determinations increased (Table 1.4). As part of a study to evaluate the effectiveness of the new sampling protocol, observers in 1999 also collected data using the "old" method. These samples have not been processed to date but should allow a more direct comparison between the old and new methods.

1.3. Resource surveys

This year, scientific research catches are reported to fulfill requirements of the Magnuson-Stevens Fisheries Conservation and Management Act. The following table documents annual research catches (1977 - 1999) from NMFS surveys in the Bering Sea and Aleutian Islands Region (tons):

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Bering Sea	15	94	458	139	466	682	508	208	435	163	174	467
Aleutian Is.				193		40	454			292		

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bering Sea	393	369	465	156	221	267	249	206	262	121	162	NA	NA
Aleutian Is.			51			48			36			NA	NA

Since these values represent extremely small fractions of the total removals (~0.02%), they are not explicitly added to the total removals by the fishery.

1.3.1. Bottom trawl surveys

Trawl surveys have been conducted annually by the AFSC to assess the abundance of crab and groundfish in the Eastern Bering Sea. Until 1975 the survey only covered a small portion of the pollock range. In 1975 and since 1979, the survey was expanded to encompass more of the EBS shelf occupied by pollock. The level of sampling for lengths and ages in the bottom-trawl survey is shown in Table 1.5.

Since 1983 the biomass estimates have been relatively high and showed an increasing trend through 1990 (Table 1.6). Between 1991 and 2001 the bottom trawl survey biomass estimate has ranged from 2.2 to 5.5 million t. The estimate for 2001 is 4.14 million tons, down 19.5% from the 2000 estimate of 5.14 million. In general, the survey indicates a relatively stable stock trend since 1982 with periods of 3-4 years of increases and decreases (Fig. 1.12). This variability is due to the effect of year-class variability evident from survey abundance-at-age estimates (Fig. 1.13). One characteristic of year class variability from survey data is that some strong year-classes appear in the surveys over several ages (e.g., the 1989 year class) while others appear at older ages (e.g., the 1992 year class). This suggests that the age-specific spatial distribution of pollock available to bottom-trawl gear is variable.

In 2001, pollock catch-rates were slightly higher than usual around St. Matthew Island with other pockets of high densities in the northwest region, west of the Pribolof Islands, and just northeast of Unimak Island (Fig. 1.14). The survey age composition information also provides insights on patterns in length-at-age. In particular, when converted to weights-at-age it appears that in recent years the average size (ages 4-8) is about 90% of the average since 1982. (Fig. 1.15). Since 1982, the pattern in size at age shows a regular periodic trend about every 10 years.

As in the past few assessments, we conducted an analysis on the total mortality of the 1974-1992 cohorts based solely on NMFS survey data. This simple approach involves regressing the log-abundance of age 6 and older pollock against age by cohort. We selected age 6 because younger pollock are still recruiting to the bottom trawl survey gear. A key assumption of this analysis is that all ages are equally available to the gear. The estimates of total mortality by cohort are difficult to interpret—here we take them as some form of average mortality over the life of the cohort (since we know that harvest rates varied from year to year). The values used in the regression are shown in Fig. 1.16. The estimates of mortality shows somewhat of an increasing trend for these cohorts with a mean total instantaneous value around 0.45 (except for the 1990-1992 cohorts; Fig. 1.17). The low values estimated from some year-classes, namely the 1990-1992 cohorts, could be due to the fact that there are fewer age-groups (6, 5, and 4, respectively) in the regressions. Alternatively, it may suggest some net immigration into the survey area or a period of lower natural mortality. In general, these values are consistent with the types of values obtained from within the assessment models for total mortality (though the model values tend to be somewhat higher, averaging about 0.5 for these cohorts).

Studies on the spatial abundance by area

Research on applying NMFS survey data to gain insights on the movement and distribution of pollock around the Bering Sea continues. Recently, survey catch rates have been compiled on an age-specific basis. This facilitates comparing catch rates by age over space and time. One application of such analyses is to examine the relative abundance inside and outside of management areas. For example, catch rates inside of the Sea lion conservation area shows the tendency for few young fish and relatively high old-fish catch rates compared to pollock outside of the SCA (Fig. 1.18). This gives some indication of how selectivity/availability of the age-structured population may change under different geographical management practices.

In addition to evaluating the overall geographic concentrations of pollock over time, these data were further broken down by length and ages. Compared to the average CPUE-weighted mean length distribution by area, the 2001 survey had bigger pollock in the shallow areas of Bristol Bay and around Nunivak Island and a swath of pollock 30-35 cm mean length in the middle shelf region (Fig. 1.19).

These mean-length patterns show that in general, smaller fish are more common in the northern areas with apparent movement towards the south and east as the pollock become larger. These patterns are also revealed when one computes the centers of abundance based on age-specific CPUE data. This is done by simply computing the CPUE-weighted average location for specific ages. Since bottom temperature has long been considered important in the distribution of pollock on the shelf, we pooled over years into three categories: cold (°C < 2), intermediate (2 ≤ °C < 3), and warm (°C ≥ 3) based on the mean bottom temperature (Fig. 1.20). The average locations for warm years are further on-shelf than for cold years (Fig. 1.21) indicating a broader dispersal onto the shelf in warmer years. The average locations for intermediate years were not depicted here, but were most similar to the cold years. The mean centers of distribution in both warm and cold years have very similar patterns with age. Younger fish are found to the north and northwestern regions and as they age, the centers of distribution move south and southeasterly. Similar evaluations (Buckley et al. In Prep.) show that among the strong year-classes, centers of distribution tend to be either "northwest" type or "southeast" type (Fig. 1.22). They show a number of possible factors contributing to these patterns including density dependence and early-life conditions.

Effect of temperature

This year we introduced use of the bottom temperature data collected during the NMFS summer bottom-trawl surveys. Since we have shown that temperature affects the distribution of pollock on the shelf, it seems likely that temperature may affect the availability of the stock to the survey. That is, temperature may affect the proportion of the stock that is within or outside of the standard survey area. We therefore evaluate this potential as an effect on the survey catchability in year *t* base on temperature T_t as:

$$q_t = \mu_q + \beta_q T_t$$

where μ_q is the mean catchability and β_q represents the slope parameter. The time series of temperature (Fig. 1.20) is used in Model 4 (which, for the model was normalized to have a mean value of zero).

1.3.2. Echo-integration trawl (EIT) surveys

Whereas bottom trawl surveys are conducted annually and assess pollock from the bottom to 3 m off bottom, EIT surveys have been conducted approximately triennially since 1979 to estimate pollock in midwater (Traynor and Nelson 1985). However, during the last decade 6 EIT summer surveys have been conducted in 1991, 1994, 1996, 1997, 1999 and 2000. The details and research results from these EIT surveys have been presented in detail in previous assessments (e.g., Ianelli et al. 2000; Honkalehto et al. In Prep.).

Proportions of pollock biomass estimated east vs. west of 170° W, and inside vs. outside the sea lion conservation area (SCA), are about the same for summer EIT surveys conducted from 1994 to 2000 (Table 1.7). The time series of estimated EIT survey proportions-at-age is presented in Fig. 1.23. The number of trawl-hauls, and sampling quantities for lengths and ages from the EIT survey are presented in Table 1.8. Otolith age-determinations from the 2000 EIT survey were completed in the last year and have been incorporated in this assessment. The difference from the numbers-at-age used in selected model configurations in Ianelli et al. (2000) is shown in Fig. 1.24.

In 2000 and 2001 NMFS conducted winter EIT surveys on the EBS shelf region in addition to the Bogoslof Island region. These added areas cover most of the SCA. Details of the 2001 research is presented in an Appendix report in this volume. One purpose of these studies is to assess the variability of pollock concentrated within this zone by season and over different years. Preliminary analyses piecing these data together with the main assessment model have provided some indication that the population tends to aggregate within the SCA in the winter. Unfortunately, the estimated "available" segment of the population (based on age compositions from 1991, 1995, 2000, and 2001 surveys) suggests that a broad range of ages are either within the shelf area but not fully vulnerable to the trawl or echo sign (e.g., the fish could be on the bottom and hence not counted in the echo-integration procedure); or outside of the area (Fig. 1.25). Unfortunately, the relative degree of vulnerability/availability is difficult to quantify. Presumably, younger fish tended to be outside of this region during the winter (since they are commonly found/caught during summer EIT surveys) while older bigger fish may be in the area but close to the bottom (as indicated from bottom trawl surveys).

1.4. Analytic approach

1.4.1. Model structure

The SAM analysis was first introduced in the 1996 SAFE (Ianelli 1996) and was compared with the cohort-analysis method that has been used extensively for pollock in past years. Since the cohort-analyses methods can be thought of as special cases of the SAM analysis (e.g., as shown in Ianelli 1997), we have not continued the use of VPA/cohort algorithms due to their limitations in dealing with many aspects of data in a statistical sense. The statistical age-structured approach has also been documented from analyses performed on simulated data for the Academy of Sciences National Research Council (Ianelli and Fournier 1998). Other changes from last year's analyses include:

- Investigations on the spatial distribution of pollock by age was pursued
- Based on spatial distribution results, an environmental time series (bottom temperatures) were added to the model as a potential effect on stock availability to bottom trawl survey gear
- The 2001 EBS bottom trawl survey estimate of population numbers-at-age was included.
- The 2000 EBS EIT survey estimate of population numbers-at-age were updated from the preliminary values used in last year's assessment.
- Investigations on alternative specifications for selectivity forms for the fisheries and surveys were pursued (following recommendations from the NPFMC's SSC).

The technical aspects of this model are presented in Section 1.14 and have been presented previously (Ianelli 1996, and Ianelli and Fournier 1998). Briefly, the model structure is developed following Fournier and Archibald's (1982) methods, with a number of similarities to Methot's extension (1990). We implemented the model using automatic differentiation software developed as a set of libraries under C++.

1.4.2. Parameters estimated independently

Natural Mortality and maturity at age

We assumed fixed natural mortality-at-age values based on studies of Wespestad and Terry (1984). These provide estimates of M=0.9, 0.45, and 0.3 for ages 1, 2, and 3+ respectively. These values have been used since 1982 in catch-age models and forecasts and appear to approximate the true rate of natural mortality for pollock. Recent studies on Gulf of Alaska pollock indicate that natural mortality may be considerably higher when predators are taken explicitly into account. This may also hold for the EBS region, however, the abundance of pollock is proportionately much higher than all other fish species compared to the Gulf of Alaska. This may explain why cannibalism is much more common in the EBS than in the Gulf. Note that to some degree, the role of cannibalism is modeled through the implementation of a Ricker (1975) stock-recruitment curve. This curve can take the form where having higher stock sizes may result in lower average recruitment levels.

Maturity at age was assumed the same as that given in Wespestad (1995) which dates back to Smith (1981). This was shown to be consistent with maturity observed in winter surveys in recent years. However, this research is continuing and will be an active study area to coincide with future winter surveys and observer data collections. These values are given here together with the baseline assumption of natural mortality-at-age:

Age	1	2	3	4	5	6	7	
M	0.900	0.450	0.300	0.300	0.300	0.300	0.300	
Prop. Mature	0.000	0.008	0.290	0.642	0.842	0.902	0.948	
Age	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
M	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Prop. Mature	0.964	0.970	1.000	1.000	1.000	1.000	1.000	1.000

Length and Weight at Age

Length, weight, and age data have been collected extensively for pollock. Samples of length-age and weight-length data within each stratum indicate growth differences by sex, area, and year-class. General patterns have been that pollock in the northwest area are slightly smaller at age than in the southeast. Since our estimates of harvests-at-age are stratified by area (and season), these differences are taken into account before analyses within the model. For the fishery, we use year (when available) and age-specific estimates of average weights-at-age as computed from the fishery age and length sampling programs. These values are shown in Table 1.9 and are important for converting model estimated catch-at-age (in numbers) to estimated total annual harvests (by weight). Since we do not assume a fishery catch-effort relationship explicitly, the fishing mortality rates depend largely on the total annual harvests by weight. For the bottom-trawl and EIT surveys, we tune the model to estimates of total numbers of fish.

1.4.3. Parameters estimated conditionally

For the reference model presented here, 723 parameters were estimated. These include vectors describing recruitment variability in the first year (as ages 2-15 in 1964) and the recruitment deviations (at age 1) from

1964-2001. Additionally, projected recruitment variability was also estimated (using the variance of past recruitments) for five years (2002-2006). The two-parameter stock-recruitment curve is included in addition to a term that allows the average recruitment before 1964 (that comprises the initial age composition in that year) to have a mean value different from subsequent years. Thus, 61 parameters comprise initial age composition and subsequent recruitment values.

Fishing mortality is parameterized to be semi-separable. That is, there is a year component and an age (selectivity) component. The age component is allowed to vary over time with changes allowed every three years. The age component is constrained such that its mean value will be equal to one, this means that it will not be confounded with the time component (see Section 1.14, Model details). In addition, we assume that the age-component parameters are constant for the last 4 age groups (ages 12-15). Therefore, the time component of fishing mortality numbers 38 parameters (estimable since we place low variance on the likelihood component on the total catch biomass) and the added age-time component of variability results in a 12x12 matrix of 144 parameters. This brings the total fishing mortality parameters to 192. Please note however, that in standard cohort analyses such as that of Pope (1972) the number of parameters for a similarly dimensioned problem would be 38x15 or 570 fishing mortality parameters. Of course in a VPA, these parameters are not estimated statistically, rather implicitly using an algorithm that assumes no errors in the total catch-at-age.

For the bottom trawl survey, a similar parameterization for the selectivity-at-age estimates includes an overall catchability coefficient, age and year specific deviations in the average availability-at-age which totals 215 parameters for these data. Similarly, for the EIT survey, which began in 1979, these parameters number 233. Estimates for changes in EIT selectivity sometimes occur for years when the survey was not conducted. This increases the number of parameters we estimate, but avoids problems associated with surveys occurring on irregularly spaced intervals. The idea of estimating these changes is to allow some continuity in unaccounted-for variability of fish available to our survey gear. That is, we expect things to change in this regard but our null hypothesis is that the survey operation is constant with respect to relative changes in age class availability.

Finally, 2 additional fishing mortality rates are estimated conditionally. These are the values corresponding to the $F_{40\%}$ and $F_{35\%}$ harvest rates. These rates satisfy the constraint that given selectivity-at-age vector (we used the mean selectivities based on model configuration), proportion-mature-at-age, natural mortality rate, and weight at age, there are unique values that correspond to the fishing mortality rates.

The likelihood components can thus be partitioned into the following groups:

- Total catch biomass (Log normal, σ=0.05)
- Bottom trawl survey variances (annual estimates of standard error, as represented in Fig. 1.12) and an assumed variance for the EIT survey abundance index, (i.e., Log normal, σ=0.2)
- Fishery and survey proportions-at-age estimates (Robust quasi-multinomial with effective sample sizes presented in Table 1.10). These values were selected based on comparisons of catch-at-age variance estimates obtained from the fishery stratified sampling scheme (Kimura 1989) with values obtained in earlier fits to the stock assessment model (Ianelli 1996, Table A1, Annex B).
- Selectivity constraints (penalties on age-age variability, time changes, and decreasing (with age) patterns)

1.5. Model evaluation

To examine model assumptions and data sensitivities, we evaluated several dozen different model configurations. For clarity, we present a limited number of these results. Some of these are in response to specific requests by the NPFMC family and others are intended to illustrate some properties of model behavior relative to the extensive surveys and fishery observations conducted by the AFSC for walleye pollock.

A list of the models presented includes:

Model 1 **Reference model,** future selectivity based on most recent (3-year) estimate (short-term selectivity estimate). This was the model configuration selected by the Council for ABC recommendations since 1998 with a slight modification to how we treat bottom-trawl survey selectivity (here as an asymptotic, time-varying logistic curve).

Model 2 As reference model but with bottom-trawl survey selectivities modeled as coefficients varying over time (and possibly decreasing with age).

Model 3 As reference model but with fishery selectivity allowed to change more frequently over time (SSC recommended sensitivity).

Model 4 As reference model but with bottom-trawl survey catchability including an environmental covariate (bottom temperature).

Model 5 As reference model, but with bottom-trawl survey catchability fixed at 1.0.

Model 6 As Model 5 but estimating natural mortality.

Model 7 As Reference Model, but disregarding the survey information.

These models can be summarized as follows:

Model	Description
1	Reference model
2	BTS selectivity as last year (2000 assessment)
3	Fishery selectivity allowed to vary more frequently
4	Bottom temperature a covariate with survey catchability
5	Bottom-trawl survey catchability fixed at 1.0.
6	Estimate natural mortality
7	Disregard all survey data

Our reference model can be characterized as one that includes a moderate number of stochastic processes. These are principally changes in age-specific availability over time for survey and fishery gears and recruitment variability. As specified, these processes involve a large number of parameters but capture a reasonable amount of the overall uncertainty. The slight change in reference model this year was to invoke a simplifying process on bottom-trawl survey catchability to have it be asymptotic yet retain the properties desired for the characteristics of this gear. Namely, that the function should allow for flexibility in selecting age 1 pollock. Additionally, time-varying shifts should be allowed. The new functional form of this selectivity is:

$$s_{t,a} = \left[1 + e^{-\alpha_t(a-\beta_t)}\right]^{-1}, \quad a > 1$$
$$s_{t,a} = \mu_s e^{\delta_t^{\mu}}, \qquad a = 1$$
$$\alpha_t = \bar{\alpha} e^{\delta_t^{\alpha}}$$
$$\beta_t = \bar{\beta} e^{\delta_t^{\beta}}$$

where the parameters of the selectivity function follow a random walk process as in Dorn et al. (2000):

$$\delta_t^{\mu} - \delta_{t+1}^{\mu} \sim N\left(0, \sigma_{\delta^{\mu}}^2\right)$$
$$\delta_t^{\alpha} - \delta_{t+1}^{\alpha} \sim N\left(0, \sigma_{\delta^{\alpha}}^2\right).$$
$$\delta_t^{\beta} - \delta_{t+1}^{\beta} \sim N\left(0, \sigma_{\delta^{\beta}}^2\right)$$

The parameters to be estimated in this part of the model are thus the $\bar{\alpha}, \bar{\beta}, \delta_t^{\mu}, \delta_t^{\alpha}$, and δ_t^{β} for t=1982, 1983,...2001. The variance terms for these parameters were specified to be 0.04.

Comparing this result with that used in the 2000 assessment (e.g., Model 2) gives an improved goodness of fit (i.e., a lower –ln(likelihood) function; Table 1.11). Also, the stock condition estimates from Model 1 are slightly less optimistic compared to Model 2 (Table 1.12). We prefer the new selectivity form for the bottom-trawl survey because asymptotic selectivity seems most appropriate for this gear type, particularly given that pollock tend to reside more on the bottom as they age.

As with last year, the stock-recruitment curve fitting for the Reference model (Model 1) is using only the period from 1978-2001. Also as with last year we ran models with many stock-recruitment alternatives (including: Beverton-Holt, constant recruitment, different assumptions about specified priors on steepness, length of time series used for estimating stock-recruitment relationship etc). Several of these alternative model specifications were presented in Ianelli et al. (2000) and all gave more optimistic scenarios than the Reference Model presented here.

In 2000, the Council's SSC requested that we examine alternatives where selectivity was allowed to vary more frequently over time. We first examined implementing a time-varying 4-parameter logistic function (with several alternative parameterizations). Our experience here was that the estimation became unstable. The reason we think this occurred was due to the fact that as the parameters for the selectivity function approached an ascending-asymptotic form, the parameters describing the descending limb of the selectivity function no-longer had correct derivatives. Since the 4-parameter logistic is a non-differentiable function problems can arise when derivatives are automatically computed (regardless if they are estimated by finite-difference methods). As a fall-back, we allowed the coefficients to vary every two years as in Model 3 and also in every year (though we chose not to present these results since they were very similar). Results from this configuration improved the fit to the data while other stock indicators were very similar to the reference case. Either Models 1 or 3 probably represents the uncertainty in the fishery age-specific selection process equally well.

Since there is some indication that the geographical distribution of pollock as observed by bottom-trawl survey gear shifts depending on temperature, we introduced mean bottom temperature as having an effect on survey catchability (Model 4). Results suggest that there is a slight negative relationship between bottom temperatures and survey catchability (slope -0.631, with standard error 0.363). The significance of this fit is moderate, given this standard error, and there is improvement in the overall fit (Table 1.11). Based on this relationship, survey catchability tends to be lower at warmer temperatures and slightly higher at colder temperatures (Fig. 1.26). In other words, in cold years pollock appear to be more available to the survey gear than in warm years. For contrast, in Model 5 we constrained survey catchability to be exactly equal to 1. This resulted in a worse fit to the data and a much higher biomass estimate.

Obtaining model estimates of survey catchability that are greater than 1.0 may seem counterintuitive, given that we expect the bottom-trawl gear to be missing pollock that are up in the water column and outside of the survey area. We note that there is a significant age-component to this catchability and that the estimates are likely an artifact of model mis-specification rather than due to the effects of "herding" or other survey mechanism. For example, factoring the age-effect (selectivity) of the survey gear and considering the average biomass of pollock age 5 and older, the survey catchability is slightly less than 1.0. Considering age 3 and older pollock biomass, the average catchability by the survey is about 0.70. This effect is because young pollock are less available to bottom-trawl survey gear.

In Model 6 we evaluated the ability of our model to estimate natural mortality (with survey catchability fixed at a value of 1.0). The parameterization was specified for age-3 and older as Me^{ρ} where the estimate was (from $M=0.3$): $\hat{\rho}$=0.095 with a standard error of 0.088 (and Me^{ρ}=0.33). This suggests that given the current model specification, alternative estimates of natural mortality are similar.

Finally, in Model 7 we examined the influence of our survey data on assessment model results. Disregarding both survey indices and age composition data sets (the data were still physically included in the model, but were downweighted in the –ln(likelihood) function to 1/100th of their original emphasis. This model yielded results surprisingly similar to Model 1, but with greater uncertainty.

In the past few years we've included an analysis using an ocean current circulation model to aid in the estimation of year-class strengths for forecasting. We failed to update this analysis this year but have found that its implementation had relatively little impact on values critical for harvest management regulations. The environmental effect did not appear to shift or influence the underlying stock-recruitment relationship that was estimated (although it did help explain part of the inter-annual variability). Some results from oceanic conditions dating back to 1960's are presented in Section 1.8 below.

Based on the examinations of the alternative models presented here (and also over those that were run but not presented) we feel that our Model 1 is appropriate and encompasses a wide range of uncertainties about the stock status.

1.5.1. A note about survey estimates and model results

Questions often arise about how biomass estimates from different surveys relate to model results since they are typically quite different. For example, the "total age-3+ biomass" estimates for 2001 are over 11 million tons compared to the bottom-trawl survey biomass estimate of slightly more than 4.1 million tons. Such a difference can be attributed to three main factors: **weight** (averaged by age), **time** (within a year), and **selectivity/availability**. In more detail:

Weight: The NMFS fishery observer program collects large amounts of pollock average-weight-at-age data. These are considered very reliable and include measurements of individual body length and weight along with age-determination structures. The averages we compute are actually the catch-weighted average over the entire year and do not represent estimates of average weight-at-age on January 1st. We could change this convention to reflect more precisely what the value is, but then comparisons would become difficult over different assessment years. Perhaps more importantly, the survey mean weights-at-age (as applied in deriving survey biomass estimates) are quite different from those observed in the fishery and can have large implications on the biomass estimates presented (Fig. 1.27).

Time: By convention, we have always applied the estimated mean-weight-at-age observed from the fishery to *begin-year* numbers at age as estimated within the model. The effect of fishing and natural mortality can be substantial prior to when the survey occurs in mid-summer. When we model survey abundance, we account for this within-year mortality prior to fitting model predictions to the observed survey abundance data. This difference alone (using begin-year abundance versus mid-year) has a substantial impact on the presentation of age-3+ biomass estimates (even using the same average weight-at-age data; Fig. 1.28).

Selectivity: It has been understood for some time that the bottom-trawl surveys do not sample all ages within the pollock population equally well. For example, we know that age-2 pollock are relatively rare in the survey gear. This is presumably an availability problem (off bottom, outside of area, etc). For example, correcting for the age-specific availability of the bottom-trawl surveys, the abundance expands on average 6-fold. Relative to the stock assessment model results, this expansion suggests that the survey over-estimates the abundance relative to our model results (Fig. 1.29). This result is conditioned on the estimates of age-specific availability/selectivity. However, these are likely to be robust since the survey tends to track age classes quite well over time. Also note that for our main result presented below, we estimate the bottom-trawl survey catchability to be about 1.44 (indicating a conservative application).

1.6. Results

Several key results have been summarized in Tables 1.12 & 1.13. The difference in the current and projected age structure for Model 1 relative to the last year's assessment (2000) is shown in Fig. 1.30. This figure shows that the absolute numbers at age are estimated to be somewhat higher in the current assessment. The increases may be attributed to the increase in the 1999 and 2000 survey abundance estimates (the bottom trawl survey in these two years increased by 61% and then 44%) and positive signs from the 2000 fishery catch-at-age data. Also, the 2000 EIT age composition data (updated this year) includes higher estimates of the 1996 year-class. The 1992 year-class is estimated to be slightly higher than in the past, presumably due to the predominance of that year-class in the recent EBS bottom-trawl surveys and in the fishery (e.g., Fig. 1.35 below). The 1996 year class is still estimated to be quite strong and is slightly higher than last year's estimate. This is also true for the 1995 year class (which has grown in strength based on the bottom-trawl survey; e.g., Fig. 1.13).

The estimated Model 1 selectivity pattern changes over time to become slightly more dome-shaped during the 1990s (Fig. 1.31). This may have coincided with the move to pelagic-only trawl gear as larger (older) fish tend to be more bottom-oriented. Model 1 fits the fishery age-composition data quite well and strong year classes are clearly evident (Fig. 1.32). The fit to the early Japanese fishery CPUE data (Low and Ikeda, 1980) is consistent with the populations trends for this period (Fig. 1.33).

We specified that selectivity could vary slightly over time for both surveys. This was done to account for potential changes in fish distribution. For example, it seems reasonable to assume that the presence of 1-year-olds available to the bottom-trawl gear on the shelf might be variable, even when the abundance is the same (Fig. 1.34). The bottom trawl survey age composition data are somewhat inconsistent in 2000 and 2001. The abundance of the 1995 year class has apparently increased while the proportion of the 1996 year class in these years was lower than expected (Fig. 1.35). Since the 1996 year class is so important to the fishery in the near-term, this development requires close attention (even though the 1996 year class has consistently appeared strong in the EIT survey (see below) and is currently recruiting well into the fishery).

We also point out that the 1992 year class was not well observed by the bottom trawl survey as age 3, 4, and to some extent, 5-year old pollock.

The Model 1 fit and estimated selectivity for the EIT survey data show a dramatic change in selectivity pattern over time (Fig. 1.36). This may be due in part to changes in pollock distribution (as the overall densities changed and also to the fact that large numbers of 1 and 2-year old fish were apparent in the survey that year. Also, the number of hauls sampled has generally increased over time—presumably this affects the overall estimate of the age composition of pollock available to the survey. These patterns are also illustrated in the model fit to the EIT survey age composition data (Fig. 1.37). The proportions at age observed in the survey are generally consistent with what appeared later in the bottom-trawl survey and fishery. Estimated numbers-at-age for Model 1 are presented in Table 1.14 and estimated catch-at-age presented in Table 1.15.

Uncertainty computations are a central part of the analyses presented in this assessment. In the past year, development of Bayesian integration methods has continued. Often with highly non-linear models, the multidimensional shape of the posterior distribution can be highly curved and present problems when expressing approximations to marginal distributions (e.g., as we do here via the Delta-method propagation-of-errors to obtain variance estimates for management quantities of interest). To explore this property, we computed the joint distribution based on 1 million Monte-Carlo Markov Chain simulations drawn from the posterior distribution. The chain was thinned to reduce potential serial correlation to 5,000 parameter "draws" from the posterior distribution. Selected model parameters (Model 1) are plotted pair-wise to provide some indication of the shape of the posterior distribution. In general, the model given the available data appears to be quite well behaved (clusters of parameters do not appear to follow strange curved or skewed tear-drop shapes; Fig. 1.38). In terms of policy evaluation, we projected the model forward (for each "sample" from the posterior) with a fixed catch of 1.3 million tons. The probability that the current stock size is below the (uncertain) $B_{40\%}$ level is quite low. However, by 2003, the expectation is that the stock size will be close to the $B_{40\%}$ stock size level, then increase (with considerable uncertainty) to well above this level by 2006 (Fig. 1.39).

1.6.1. Abundance and exploitation trends

The eastern Bering Sea bottom trawl survey estimates exhibited an increasing trend during the 1980s, were relatively stable from 1991 to 1995, and decreased sharply in 1996 but rose slightly in 1997 and then substantially in 1999 and 2000. This may be due, in part, to age-related distribution changes within the pollock population. Results from combined bottom trawl and EIT surveys, which more fully sample the population, have shown that older pollock are more vulnerable to bottom trawls than younger pollock (e.g., Figs. 1.34 and 1.35).

Current "exploitable" biomass estimates (ages 3 and older) derived from the statistical catch-age model suggest that the abundance of eastern Bering Sea pollock remained at a fairly high level from 1982-88, with estimates ranging from 10 to 11.5 million t. Peak biomass occurred in 1985 and declined to about 5 million t by 1991. Since then, the stock has apparently increased, declined slightly then increased again and is currently estimated to be over 11 million tons[1].

Historically, biomass levels have increased from 1979 to the mid-1980's due to the strong 1978 and relatively strong 1982 and 1984 year-classes recruiting to the fishable population (Table 1.16, Fig. 1.40). From 1985-86 to 1991 the fishable stock declined as these above average year-classes decreased in abundance with age and were replaced by weaker year-classes. In 1992 an upturn in abundance began

[1] Please refer to section 1.5.1 for a discussion on the interpretation of age-3+ biomass estimates.

with the recruitment of a strong 1989 year-class and peaked around 1995. An increase in abundance is expected in future years as apparently above average 1996 year-class recruits to the exploitable population. Retrospectively, compared with last year's assessment the recent estimates of age 3+ pollock biomass are somewhat lower in the current assessment during the 1980s and higher in recent years (Table 1.16). Again, this may be attributed to the increasing trends from both the EIT and bottom trawl survey estimates for 1999. Overall, compared with seven past assessments, the retrospective pattern shows a steady increase in estimates of stock size during the late 1990s (Fig. 1.41).

The abundance and exploitation pattern estimated from Model 1 shows that the spawning exploitation rate (SER, defined as the percent removal of spawning-aged females in any given year) has averaged about 18% in the past 10 years (Fig. 1.42). This compares to an overall average SER of 22.5% (1964 – 2000). The observed variation in pollock abundance is primarily due to natural variation in the survival of individual year-classes. These values of SER are relatively low compared to the estimates at the MSY level (~30%).

1.6.2. Recruitment

Recruitment of pollock is highly variable and difficult to predict. It is becoming clear that there is a great deal of variation in the distribution of pre-recruit pollock, both in depth and geographic area. To some extent, our approach takes this into account since age 1 fish are included in our model and data from both the EIT and bottom trawl survey are used. In earlier assessments (prior to 1998), the primary measure of pollock recruitment has been the relative abundance of age 1 pollock (or pollock smaller than 20 cm when age data are unavailable) in the annual eastern Bering Sea bottom-trawl survey. Also, bottom-trawl survey estimates of age 1 recruitment, when regressed against age 3 pollock estimates from catch-age models, indicate a linear relationship. This had been used to project age 3 numbers in population forecasts. Our method does not require external regressions since the necessary accounting is done explicitly, within a standard age-structured model. The key advantage in our approach is that the observation and process errors are maintained and their effect can be evaluated.

It appears that the annual bottom trawl survey does not fully cover the distribution of age 1 pollock. This is especially evident for the 1989 year-class that the survey found to be slightly below average, but upon recruitment to the fishery, was a very strong year-class. It appears that a significant amount of this year-class was distributed in the Russian EEZ—beyond the standard survey area—or unavailable to bottom trawl gear (perhaps in mid-water). In 1996, Russian scientists reported the 1995 year-class to be strong, but it appeared to be below average in the U.S. survey. However, in the 1997 EIT survey the 1995 year-class was abundant adjacent to the Russian EEZ.

The coefficient of variation or "CV" (reflecting uncertainty) on the strength of the 1996 year-class is about 25% for Model 1 (down from 39% last year). The 1996 year-class appears to be moderately strong. However, the 95% confidence bounds for the 1996 year-class are only slightly above mean recruitment for all years since 1964 (Fig. 1.43). Adding the effect of the surface currents on recruitment success appears to be a plausible mechanism but it does not reduce the degree of uncertainty in the magnitude of the 1996 year-class. This is due to the fact that we now have 7 direct observations of this year class from survey data: the EIT survey conducted in 1997, 1999, and 2000 and the bottom trawl surveys in 1997, 1998, 1999, and 2000 (though 2- and 3-year olds are less available to bottom-trawl survey gear).

1.7. Projections and harvest alternatives

1.7.1. Amendment 56 Reference Points

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (F_{ABC}) may be less than this maximum permissible level, but not greater. Estimates of reference points related to maximum sustainable yield (MSY) are currently available. However, the extent of their reliability is questionable. We therefore present both reference points for pollock in the BSAI to retain the option for classification in either Tier 1 or Tier 3 of Amendment 56. These Tiers require reference point estimates for biomass level determinations. For our analyses, we selected the following values from Model 1 results computed based on recruitment from post-1976 spawning events:

$B_{100\%}$ = **6,525** t female spawning biomass[2]

$B_{40\%}$ = **2,610** t female spawning biomass

$B_{35\%}$ = **2,300** t female spawning biomass

B_{msy} = **2,143** t female spawning biomass

1.7.2. Specification of OFL and Maximum Permissible ABC

For Model 1, the year 2000 spawning biomass is estimated to be 3,186 thousand tons (at the time of spawning, assuming the stock is fished at F_{msy}). This is well above the B_{msy} value of 2,143. Under Amendment 56, Tier 1a, the harmonic mean value is considered a risk-averse policy provided reliable estimates of F_{msy} and its pdf are available. The harmonic mean value for F_{msy} computations is somewhat different from the procedure outlined in Tier 1 of Amendment 56. Here the harmonic mean is computed from the estimated pdf for the year 2002 yield under F_{msy} rather than first finding the harmonic mean of F_{msy} and applying its value to the maximum likelihood estimate for the year 2002 stock size. The method we use results in somewhat lower ABC values since uncertainty in both the F_{msy} value and future stock size are both considered.

Corresponding values under Tier 3 are 2,964 thousand tons for year 2001 spawning values (under $F_{40\%}$ policy). This is well above the $B_{40\%}$ value of 2,610. The OFL's and maximum permissible ABC values by both methods are thus:

	OFL	Max ABC
Tier 1a	**3,531 thousand t**	**2,108 thousand t**
Tier 3a	**2,833 thousand t**	**2,269 thousand t**

1.7.3. ABC Recommendation

Currently, the biomass of eastern Bering Sea pollock appears to be quite high and decreasing. The total begin-year age-3+ biomass in 2002 is projected to be about 9.8 million t. The estimated female spawning biomass projected to the time of spawning in the year 2002 is about **2,964** thousand tons, well above of the

[2] Note that another theoretical "unfished spawning biomass level" (based on stock-recruitment relationship $\tilde{B}_0$) is somewhat lower (5,861 t).

$B_{40\%}$ level of **2,610** thousand tons and well above the $B_{35\%}$ and the value estimated for B_{msy} (**2,300** and **2,143** respectively; Fig. 1.44).

For the year 2002, maximum permissible ABC alternatives based on the $F_{40\%}$ and harmonic-mean F_{msy} are 2,269 and 2,108 thousand tons, respectively for the reference model (F_{msy} harvests based on the harmonic mean value) as shown in Table 1.13 for Model 1. However, subsequent recruitment has been below average (though is highly uncertain). Hence, short-term projections (shown below) predict that the spawning stock is likely to drop below the $B_{40\%}$ and B_{msy} levels. While we feel there is nothing intrinsically wrong with having the population drop below it's optimal level (since under perfect management, it is expected to be below the target exactly half of the time), choosing a harvest level that reduces this likelihood might 1) provide stability to the fishery; 2) provide added conservation given the current Steller sea lion population declines; and 3) provide added conservation due to unknown stock removals in Russian waters. We therefore consider it prudent to recommend a harvest level lower than the maximum permissible values. As an example, under constant catch scenarios of 1.4 and 1.3 million tons, the stock is expected to remain well above the $B_{40\%}$ level (Fig. 1.45).

1.7.4. Standard Harvest Scenarios and Projection Methodology

This year, a standard set of projections is required for each stock managed under Tiers 1, 2, or 3, of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2001 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2001 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2001. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2002, are as follow (A "*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2002 recommended in the assessment to the *max* F_{ABC} for 2002. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 1997-2001 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above one-half of its MSY level in 2004 and above its MSY level in 2014 under this scenario, then the stock is not overfished.)

Scenario 7: In 2002 and 2003, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2014 under this scenario, then the stock is not approaching an overfished condition.)

1.7.5. Projections and status determination

For the purposes of these projections, we present results based on selecting the $F_{40\%}$ harvest rate as the max F_{ABC} value and use $F_{35\%}$ as a proxy for F_{msy}. Scenarios 1 through 7 were projected 14 years from 2001 (Table 1.17). Under Scenario 1, the expected spawning biomass will decrease to slightly below $B_{35\%}$ then increase to above $B_{40\%}$ by the year 2007 (Fig. 1.44). Under this scenario, the yields are expected to vary between 1.0 – 1.8 million tons. If the highly conservative catch levels (estimated from the last 5 years) are to continue, then the stock is not projected to drop below $B_{40\%}$ at any time in the future (Fig. 1.46).

Any stock that is below its MSST is defined to be overfished. Any stock that is expected to fall below its MSST in the next two years is defined to be approaching an overfished condition. Harvest scenarios 6 and 7 are used in these determinations as follows:

Is the stock overfished? This depends on the stock's estimated spawning biomass in 2002:

a) If spawning biomass for 2002 is estimated to be below ½ $B_{35\%}$ the stock is below its MSST.

b) If spawning biomass for 2002 is estimated to be above $B_{35\%}$, the stock is above its MSST.

c) If spawning biomass for 2002 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest scenario 6 (Table 1.17). If the mean spawning biomass for 2012 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an overfished condition? This is determined by referring to harvest Scenario 7:

a) If the mean spawning biomass for 2004 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.

b) If the mean spawning biomass for 2004 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c) If the mean spawning biomass for 2004 is above ½ $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2014. If the mean spawning biomass for 2014 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

For scenarios 6 and 7, we conclude that pollock is not below MSST for the year 2002, nor is it expected to be approaching an overfished condition based on Scenario 7.

1.8. Other considerations

1.8.1. Ecosystem concerns

In general, a number of key issues for ecosystem conservation and management can be highlighted. These include:

- Preventing overfishing;
- Avoiding habitat degradation;
- Minimizing incidental bycatch (via multi-species analyses of technical interactions);
- Controlling the level of discards; and
- Considering multi-species trophic interactions relative to harvest policies.

For the case of pollock in the EBS, the NPFMC and NMFS continue to manage the fishery on the basis of these issues in addition to the single-species harvest approach. The prevention of overfishing is clearly set out as a main guideline for management. Habitat degradation has been minimized in the pollock fishery by converting the industry to pelagic-gear only. Bycatch in the pollock fleet is closely monitored by the NMFS observer program and managed on that basis. Discarding rates have been greatly reduced in this fishery and multi-species interactions is an ongoing research project within NMFS with extensive food-habit studies and simulation analyses to evaluate a number "what if" scenarios with multi-species interactions.

A large body of research on changes in the physical environment is ongoing at the Alaska Fisheries Science Center in collaboration with oceanographers at a number of institutions. Within the Center, we pursued application of the OSCURS model (Ingraham and Miyahara 1988) to describe changes in the Bering Sea that may have affected early-life conditions of pollock. The OSCURS model represents a drift-simulator that uses sea-level pressure data to predict surface current movements. The observed pressure data are used to derive winds and obtain measures of drift from arbitrary locations in the ocean. Arsenev (1967) presented drift patterns for the Bering Sea based on limited drift observations from Soviet research vessels during the 1960s. Direct observation of drift has been shown to be consistent with the magnitude and type of pattern expected based on simulations from the OSCURS model (e.g., Ingraham and Miyahara 1988). To enhance the description of Arsenev, we conducted OSCURS model runs from each month over a grid of points throughout the Eastern Bering sea from 1960-2000. Computing the monthly average over these years a "climatology" of surface currents indicates strong seasonal shifts (Fig. 1.47). The degree to which these seasonal patterns affect pollock abundance distribution and survival is an ongoing research project at the AFSC in collaboration with other climate and oceanographic research groups (e.g., the South East Bering Sea Carrying Capacity work). In addition to describing the general patterns of surface currents within the Bering Sea, these analyses provide the ability to scrutinize the degree of inter-annual variability in surface advection patterns. For example, examining the current patterns for April in different years gives some indication of the kind of inter-annual variability in current patterns (Fig. 1.48). Given alternative hypotheses on the importance of different spawning distributions (e.g., Hinckley 1987) these patterns provide insight on factors that may lead to high survival levels for eggs and larvae. For example, advection in the months subsequent to peak spawning (e.g., April) may provide a good indication of movement of eggs and larvae into prime nursery areas. To date, implementation of an advection model within the stock assessment model has had relative little impact on values critical for harvest management regulations.

1.8.2. Fishing fleet dynamics

It has become common knowledge that several (most) vessels fishing for pollock have made gear modifications designed to reduce the take of under-sized fish. This may change the effective selectivity of the gear in a predictable way. While our approach allows for changes in selectivity, further analyses on this effect may be warranted. Other substantial changes are occurring with the implementation of the RPA's and the American Fisheries Act (AFA). These have reduced the "race for fish" that was common in years before 1999. The impact of the AFA reduces bycatch and improves recovery percentages. In addition, the ability to avoid small fish will be enhanced since the fishery occurs over longer periods with lower daily harvest rates.

1.9. Summary

Summary results are given in Table 1.18.

1.10. Acknowledgements

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1.12. Tables

Table 1.1 Catch from the eastern Bering Sea by area, the Aleutian Islands, the Donut Hole, and the Bogoslof Island area, 1979-2001. (2001 values set equal to TAC). The southeast area refers to the EBS region east of 170W; the Northwest is west of 170W.

	Eastern Bering Sea			Aleutians	Donut Hole	Bogoslof I.
Year	Southeast	Northwest	Total			
1979	368,848	566,866	935,714	9,504		
1980	437,253	521,027	958,280	58,156		
1981	714,584	258,918	973,502	55,516		
1982	713,912	242,052	955,964	57,978		
1983	687,504	293,946	981,450	59,026		
1984	442,733	649,322	1,092,055	81,834	181,200	
1985	604,465	535,211	1,139,676	58,730	363,400	
1986	594,997	546,996	1,141,993	46,641	1,039,800	
1987	529,461	329,955	859,416	28,720	1,326,300	377,436
1988	931,812	296,909	1,228,721	30,000	1,395,900	87,813
1989	904,201	325,399	1,229,600	15,531	1,447,600	36,073
1990	640,511	814,682	1,455,193	79,025	917,400	151,672
1991	712,206	505,095	1,217,301	78,649	293,400	264,760
1992	663,457	500,983	1,164,440	48,745	10,000	160
1993	1,095,314	231,287	1,326,601	57,132	1,957	886
1994	1,183,360	180,098	1,363,458	58,637	NA	566
1995	1,170,828	91,939	1,262,766	64,429	trace	264
1996	1,086,840	105,938	1,192,778	29,062	trace	387
1997	820,050	304,543	1,124,593	25,940	trace	168
1998	965,766	135,399	1,101,165	23,822	trace	136
1999	814,622	177,378	988,674	965	trace	29
2000	839,175	293,532	1,132,707	1,244	NA	28
2001	NA	NA	1,400,000	800	NA	29

1979-1989 data are from Pacfin.

1990-1999 data are from NMFS Alaska Regional Office, includes discards.

2001 catch assuming full EBS TAC will be taken.

Table 1.2. Estimated retained, discarded, and percent discarded of total catch in the Aleutians, Northwest and Southeastern Bering Sea, 1990-2000. Source: NMFS Blend database.

Area	Year	Catch Retained	Discard	Total	Discard Percentage
Southeast (51)		582,660	57,851	640,511	
Northwest (52)		764,369	50,313	814,682	
Aleutians		69,682	9,343	79,025	
Total	1990	1,416,711	117,507	1,534,218	7.7%
Southeast (51)		614,889	97,317	712,206	
Northwest (52)		458,610	46,485	505,095	
Aleutians		73,608	5,041	78,649	
Bogoslof		245,467	19,293	264,760	
Total	1991	1,318,966	163,095	1,482,061	11.0%
Southeast (51)		600,861	62,596	663,457	
Northwest (52)		445,811	55,172	500,983	
Aleutians		45,246	3,498	48,745	
Total	1992	1,091,919	121,266	1,213,185	10.0%
Southeast (51)		1,011,020	84,294	1,095,314	
Northwest (52)		205,495	25,792	231,287	
Aleutians		55,399	1,733	57,132	
Total	1993	1,271,914	111819	1,383,732	8.1%
Southeast (51)		1,091,547	91,813	1,183,360	
Northwest (52)		164,020	16,078	180,098	
Aleutians		57,325	1,311	58,637	
Total	1994	1,312,892	109,202	1,422,094	7.7%
Southeast (51)		1,083,381	87,447	1,183,360	
Northwest (52)		82,226	9,713	91,939	
Aleutians		63,047	1,382	64,429	
Total	1995	1,228,654	98,542	1,339,728	7.4%
Southeast (51)		1,015,473	71,367	1,086,840	
Northwest (52)		101,100	4,838	105,938	
Aleutians		28,067	994	29,062	
Total	1996	1,145,133	77,206	1,222,339	6.3%
Southeast (51)		749,007	71,043	820,050	
Northwest (52)		281,986	22,557	304,543	
Aleutians		25,323	617	25,940	
Total	1997	1,056,316	94,217	1,150,533	8.2%
Southeast (51)		950,631	15,135	965,767	
Northwest (52)		133,818	1,581	135,399	
Aleutians		23,657	164	23,822	
Total	1998	1,108,106	16,881	1,124,987	1.5%
Southeast (51)		756,047	27,100	783,148	
Northwest (52)		204,785	1,912	206,697	
Aleutians		529	480	1,010	
Total	1999	961,362	29,492	990,855	3.0%
Southeast (51)		819,497	19,677	839,175	
Northwest (52)		291,590	1,941	293,532	
Aleutians		455	790	1,244	
Total	2000	1,111,543	22,408	1,133,951	2.0%

Table 1.3. Eastern Bering Sea walleye pollock catch by age in numbers (millions), 1979-2000.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
1979	101.4	543.2	720.0	420.2	392.6	215.5	56.3	25.7	35.9	27.5	17.6	7.9	3.0	0.5	2,567.3
1980	9.8	462.4	823.3	443.5	252.2	211.0	83.7	37.6	21.8	23.9	25.5	15.9	7.7	2.5	2,420.7
1981	0.6	72.2	1012.9	638.0	227.0	102.9	51.7	29.6	16.1	9.4	7.5	4.6	1.5	0.6	2,174.6
1982	4.8	25.3	161.4	1172.4	422.4	103.7	36.0	36.0	21.5	9.1	5.4	3.2	1.9	0.7	2,003.7
1983	5.1	118.6	157.8	313.0	817.0	218.3	41.4	24.7	19.8	11.1	7.6	4.9	3.5	1.7	1,744.5
1984	2.1	45.8	88.6	430.8	491.9	654.3	133.9	35.6	25.1	15.7	7.1	2.5	2.9	1.7	1,938.0
1985	2.7	55.3	382.2	122.1	366.7	322.3	444.3	112.8	36.7	25.9	24.9	10.7	9.4	4.0	1,919.9
1986	3.1	86.0	92.3	748.5	214.1	378.1	221.9	214.2	59.7	15.2	3.3	2.6	0.3	1.2	2,040.4
1987	0.0	19.9	112.2	78.0	415.8	139.6	123.2	91.2	248.6	54.4	38.9	21.6	29.1	6.1	1,378.5
1988	0.0	10.7	455.2	422.8	252.8	545.9	225.4	105.2	39.3	97.1	18.3	10.2	3.8	5.5	2,192.2
1989	0.0	4.8	55.3	149.5	452.6	167.3	574.1	96.6	104.1	32.5	129.5	10.9	4.0	2.6	1,783.8
1990	1.3	33.2	57.3	220.7	201.8	480.3	129.9	370.4	66.1	102.5	9.1	60.4	8.5	4.7	1,746.2
1991	1.0	60.9	40.7	85.4	141.5	156.9	396.4	51.6	217.1	22.1	114.7	15.2	74.4	60.9	1,438.8
1992	0.0	79.0	721.7	143.5	98.1	125.0	145.4	276.8	109.3	165.4	59.4	50.2	14.2	91.0	2,079.0
1993	0.1	9.2	275.0	1144.5	103.0	64.3	62.2	53.5	84.9	21.8	34.5	12.6	13.1	26.5	1,905.2
1994	0.3	31.5	59.8	383.4	1109.5	180.5	54.9	21.0	13.5	20.1	9.1	10.7	7.6	15.7	1,917.5
1995	0.0	0.3	75.3	146.6	398.4	764.7	131.8	34.9	10.9	6.0	15.3	4.4	7.1	11.3	1,606.9
1996	0.0	9.5	19.7	43.8	144.9	350.7	486.3	190.4	32.9	14.8	8.9	8.8	4.1	11.3	1,326.1
1997	0.1	65.4	33.2	107.1	470.6	290.8	255.9	198.9	62.9	14.2	6.5	5.1	3.1	14.8	1,528.8
1998	0.0	36.3	86.7	72.3	160.8	704.0	203.6	128.6	107.6	29.1	5.7	6.3	3.0	7.4	1,551.5
1999	0.1	7.5	296.5	219.5	105.0	154.8	475.9	131.4	57.3	33.1	3.9	2.1	0.4	2.5	1,490.0
2000	0.0	15.7	82.1	427.2	345.8	106.2	168.5	353.3	86.8	29.1	22.8	5.7	1.5	1.5	1,646.3

Table 1.4. Numbers of fishery samples used for lengths (measured) and age determinations (aged) by sex and strata, 1991-2000, of pollock as sampled by the NMFS observer program.

	Strata	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Measured males	Aleutians	34,023	33,585	33,052	28,465	21,993	12,336	10,477	6,906	75	70
	Northwest	126,023	110,487	38,524	28,169	17,909	22,290	58,307	32,185	16,629	43,897
	SE A Season	198,835	150,554	122,436	138,338	127,876	148,706	123,385	134,743	35,702	62,300
	SE B Season	102,225	134,371	143,420	153,336	175,524	193,832	114,826	205,309	38,208	62,855
Total		461,106	428,997	337,432	348,308	343,302	377,164	306,995	351,326	92,613	169,122
Measured females	Aleutians	14,620	19,079	21,055	16,125	16,475	8,792	9,056	5,368	60	114
	Northwest	124,934	114,778	39,985	28,185	19,282	22,144	51,358	39,576	19,019	42,162
	SE A Season	184,351	142,016	112,602	146,918	124,000	140,868	102,530	108,645	31,791	55,800
	SE B Season	90,056	136,626	135,661	146,540	150,632	149,583	105,999	174,729	35,019	40,233
Total		413,961	412,499	309,303	337,768	310,389	321,387	268,943	295,104	85,889	138,309
Aged males	Aleutians	22	110	81	157	73	86	15	142	0	0
	Northwest	320	179	147	132	123	0	326	216	312	269
	SE A Season	373	454	451	200	297	470	431	588	533	660
	SE B Season	248	317	475	571	415	442	284	307	728	833
Total		963	1,060	1,154	1,060	908	998	1,056	1,098	1,573	1,762
Aged females	Aleutians	23	121	82	151	105	77	15	166	0	0
	Northwest	340	178	153	142	131	0	326	236	312	313
	SE A Season	385	458	478	201	313	451	434	652	485	616
	SE B Season	233	332	458	574	392	434	312	308	725	574
Total		981	1,089	1,171	1,068	941	962	1,087	1,192	1,522	1,504

Table 1.5. Sampling effort of pollock in the EBS based on the NMFS bottom trawl survey 1982-2001.

Year	Number of Hauls	Lengths	Aged
1982	329	40,001	1,611
1983	354	78,033	1,931
1984	355	40,530	1,806
1985	353	48,642	1,913
1986	354	41,101	1,344
1987	342	40,144	1,607
1988	353	40,408	1,173
1989	353	38,926	1,227
1990	352	34,814	1,257
1991	351	43,406	1,083
1992	336	34,024	1,263
1993	355	43,278	1,385
1994	355	38,901	1,141
1995	356	25,673	1,156
1996	355	40,789	1,387
1997	356	35,536	1,193
1998	355	37,673	1,261
1999	353	32,532	1,385
2000	352	41,762	1,545
2001	355	47,335	1,641

Table 1.6. Biomass (age 1+) of eastern Bering Sea walleye pollock as estimated by surveys 1979-2000(millions of tons).

Year	Bottom trawl survey (t)	EIT Survey (t)	EIT Percent age 3+	Total[3] (t)	Near bottom biomass
1979	3.20	7.46	(22%)	10.66	30%
1980	1.00				
1981	2.30				
1982	2.86	4.90	(95%)	7.76	46%
1983	6.24				
1984	4.89				
1985	4.63	4.80	(97%)	9.43	54%
1986	4.90				
1987	5.11				
1988	7.11	4.68	(97%)	11.79	63%
1989	5.93				
1990	7.13				
1991	5.11	1.45	N/A	6.56	79%
1992	4.37				
1993	5.52				
1994	4.98	2.89	(85%)	7.87	64%
1995	5.41				
1996	3.20	2.31	(97%)	5.51	60%
1997	3.03	2.59	(70%)	5.62	54%
1998	2.21				
1999	3.57	3.29[4]	(95%)	6.86	52%
2000	5.14	3.05		8.19	63%
2001	4.14				

[3] Although the two survey estimates are added in this table, the stock assessment model treats them as separate, independent indices (survey "*q*'s" are estimated).

[4] This figure excludes the zone near the "horseshoe" area of the EBS (southeast) not usually surveyed, the value including this area was 3.35 million tons.

Table 1.7. Distribution of pollock between areas from summer echo integration-trawl surveys on the Bering Sea shelf, 1994-2000. Data are estimated pollock biomass from 14 m below the surface down to 3 m off bottom. Error bounds only quantify acoustic sampling variability.

	Dates	Area (nmi)^2	SCA	Biomass (million mt) (percent) E170-SCA	W170	Total Biomass (million mt)	95% Confidence Bounds
1994	Jul 9-Aug 19	78,251	0.312	0.399	2.18	2.89	NA
			(11%)	(14%)	(75%)		
1996	Jul 20-Aug 30	93,810	0.215	0.269	1.83	2.31	2.15-2.48
			(9%)	(12%)	(79%)		
1997	Jul 17-Sept 4	102,770	0.246	0.527	1.82	2.59	2.42-2.76
			(10%)	(20%)	(70%)		
1999	Jun 7-Aug 5*	103,670	0.299	0.579	2.41	3.29	2.95-3.62
			(9%)	(18%)	(73%)		
2000	Jun 7- Aug 2*	106,140	0.393	0.498	2.16	3.05	2.88-3.22
			(13%)	(16%)	(71%)		

* Note four weeks earlier than previous years' surveys

SCA = Sea lion Conservation Area
E170 - SCA = East of 170 W minus SCA
W170 = West of 170 W

Table 1.8. Number of hauls and sample sizes for EBS pollock collected by the EIT surveys.

Year	Stratum	No. Hauls	No. lengths	No. otoliths collected	No. aged
1979	**Total**	25	7,722	NA	2,610
1982	**Total**	48	8,687	NA	2,741
	Midwater, east of St Paul	13	1,725		783
	Midwater, west of St Paul	31	6,689		1,958
	Bottom	4	273		0
1985	**Total** (Legs1 &2)	73	19,872	NA	2,739
1988	**Total**	25	6,619	1,519	1,471
1991	**Total**	62	16,343	2,065	1,663
1994	**Total**	77	21,506	4,973	1,770
	East of 170 W				612
	West of 170 W				1,158
1996	**Total**	57	16,910	1,950	1,926
	East of 170 W				815
	West of 170 W				1,111
1997	**Total**	86	30,535	3,635	2,285
	East of 170 W				936
	West of 170 W				1,349
1999	**Total**	122	42,364	4,946	2,446
	East of 170 W	45	13,842	1,945	946
	West of 170 W	77	28,522	3,001	1,500
2000	**Total**	128	43,729	3,459	2,253
	East of 170 W	32	7,721	850	850
	West of 170 W	96	36,008	2,609	1,403

Table 1.9. Fishery annual average weights-at-age (kg) as estimated from NMFS observer data. These values are used in the model for computing the predicted fishery catch (in weight) and for computing biomass levels for EBS pollock. NOTE: 2001 weight-at-age is treated as the three-year average of values from 1998-2000.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1964-90	0.007	0.170	0.303	0.447	0.589	0.722	0.840	0.942	1.029	1.102	1.163	1.212	1.253	1.286	1.312
1991	0.007	0.170	0.277	0.471	0.603	0.722	0.837	0.877	0.996	1.109	1.127	1.194	1.207	1.256	1.244
1992	0.007	0.170	0.387	0.454	0.615	0.660	0.745	0.898	0.960	1.151	1.174	1.203	1.132	1.184	1.304
1993	0.007	0.170	0.492	0.611	0.657	0.770	0.934	1.078	1.187	1.238	1.385	1.512	1.632	1.587	1.465
1994	0.007	0.170	0.398	0.628	0.716	0.731	0.709	0.995	1.287	1.228	1.197	1.329	1.308	1.282	1.282
1995	0.007	0.170	0.389	0.505	0.733	0.841	0.854	1.000	1.235	1.314	1.375	1.488	1.402	1.336	1.491
1996	0.007	0.170	0.332	0.448	0.717	0.817	0.964	0.966	1.059	1.142	1.371	1.452	1.487	1.679	1.460
1997	0.007	0.170	0.325	0.468	0.554	0.745	0.890	1.071	1.084	1.236	1.332	1.421	1.570	1.451	1.418
1998	0.007	0.170	0.362	0.574	0.629	0.636	0.778	1.046	1.173	1.242	1.236	1.337	1.443	1.487	1.709
1999	0.007	0.170	0.412	0.492	0.655	0.697	0.750	0.960	1.081	1.347	1.275	1.404	1.500	1.539	1.529
2000	0.007	0.170	0.380	0.501	0.626	0.779	0.773	0.822	1.020	1.046	1.311	1.387	1.504	1.492	1.552
2001	0.007	0.170	0.384	0.522	0.637	0.704	0.767	0.943	1.092	1.212	1.274	1.376	1.482	1.506	1.597

Table 1.10. Pollock sample sizes assumed for the age-composition data likelihoods from the fishery, bottom-trawl survey, and EIT surveys, 1964-2001.

Year	Fishery		Year	Fishery	BTS	EIT
1964	10		1979	50		25
1965	10		1980	50		
1966	10		1981	50		
1967	10		1982	50	100	48
1968	10		1983	50	100	
1969	10		1984	50	100	
1970	10		1985	50	100	73
1971	10		1986	50	100	
1972	10		1987	50	100	
1973	10		1988	50	100	25
1974	10		1989	50	100	
1975	10		1990	50	100	
1976	10		1991	200	100	62
1977	10		1992	200	100	
1978	50		1993	200	100	
			1994	200	100	77
			1995	200	100	
			1996	200	100	57
			1997	200	100	86
			1998	200	100	
			1999	200	100	122
			2000	200	100	128
			2001		100	

Table 1.11. Results comparing fits Models 1-7. Effective N (sample size) computations are as presented in McAllister and Ianelli (1997). Note: Model 7 total –ln(likelihood) value is not comparable with others (since survey data are disregarded in the model fitting). See text for additional model descriptions.

Fits to data sources	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Total –ln(likelihood)	**-1217.27**	**-1209.07**	**-1230.62**	**-1220.33**	**-1214.45**	**-1216.67**	**-1132.27**
Age Composition data							
Effective N Fishery	200	207	200	199	198	197	201
Effective N Bottom trawl survey	219	202	221	227	227	223	NA
Effective N Hydro acoustic survey	117	116	114	118	117	119	NA
Survey abundance estimates, RMSE*							
Trawl Survey	0.20	0.25	0.19	0.18	0.23	0.22	0.70
EIT survey	0.33	0.32	0.34	0.32	0.34	0.33	0.57
Recruitment Residuals							
Due to Stock	0.24	0.24	0.25	0.24	0.24	0.24	0.24
Residual RMSE	0.39	0.40	0.37	0.40	0.40	0.41	0.39
Total	0.64	0.64	0.62	0.64	0.64	0.65	0.64

*RMSE = $\sqrt{\frac{\sum \ln\left(obs/pred\right)^2}{n}}$

Table 1.12. Results reflecting the stock condition for Models 1-7. Values in parentheses are coefficients of variation (CV's) of values immediately above. See text for model descriptions.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Biomass							
Year 2002 spawning biomass[5]	2,964	3,265	2,894	3,266	3,561	3,921	2,452
Year 2002 spawning biomass[6]	3,186	3,486	3,071	3,541	3,776	4,233	2,612
(CV)	(21%)	(17%)	(22%)	(21%)	(19%)	(19%)	(27%)
2001 spawning biomass	3,790	4,130	3,613	4,229	4,488	5,216	3,033
B_{msy}	2,143	2,306	2,215	2,130	2,395	2,404	2,052
(CV)	(31%)	(31%)	(32%)	(30%)	(30%)	(26%)	(32%)
$B_{40\%}$	2,610	2,745	2,618	2,647	2,829	2,842	2,461
(CV)	(19%)	(19%)	(19%)	(19%)	(18%)	(18%)	(19%)
Percent of B_{msy} spawning biomass	138%	142%	131%	153%	149%	163%	119%
Percent of $B_{40\%}$ spawning biomass	122%	127%	117%	134%	133%	149%	106%
2001 Age 3+ Biomass	11,680	12,695	11,153	12,815	13,501	15,899	9,683
Ratio B_{2001}/B_{2000} (3+ biomass)	93%	94%	95%	98%	96%	97%	93%
Recruitment	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Steepness parameter (h)	0.65	0.64	0.65	0.65	0.64	0.64	0.64
Avg Recruitment (all yrs)	22,629	23,497	22,638	22,963	24,154	27,843	21,844
(CV)	63%	65%	62%	64%	64%	67%	62%
Avg. Recruitment (since 1978)	25,246	26,440	25,219	25,727	27,366	32,287	23,837
(CV since 1978)	67%	68%	65%	68%	67%	68%	67%
1996 year-class	50,253	54,643	44,004	56,736	56,320	71,667	41,179
(CV 1996 year-class)	(21%)	(17%)	(22%)	(20%)	(21%)	(23%)	(24%)
Natural Mortality (age 3 and older)	0.300	0.300	0.300	0.300	0.300	0.330	0.300

Table 1.13. Results relating to yield for Models 1-7. See text for model descriptions.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
2002 Har. Mean F_{msy} yield	2,108	2,297	1,898	2,467	2,352	3,178	1,419
2002 F_{msy} yield	3,531	3,765	3,175	4,090	3,912	5,256	2,735
(CV)	(49%)	(48%)	(49%)	(48%)	(49%)	(48%)	(56%)
Year 2002 $F_{40\%}$ Yield	2,269	2,507	2,117	2,578	2,658	3,620	1,808
Year 2002 $F_{35\%}$ Yield	2,833	3,135	2,621	3,232	3,300	4,502	2,277
MSY (long-term expectation)	1,958	2,027	1,979	1,973	2,087	2,342	1,798
Average F(over ages 1-15)							
F_{msy}	0.67	0.63	0.59	0.73	0.55	0.74	0.74
(CV)	(129%)	(131%)	(126%)	(132%)	(124%)	(135%)	(138%)
$F_{40\%}$	0.377	0.367	0.351	0.392	0.333	0.442	0.429
Full-selection equivalent F's							
F_{msy}	1.234	1.223	0.979	1.355	1.052	1.423	1.343
$F_{40\%}$	0.690	0.717	0.583	0.730	0.639	0.849	0.781
$F_{35\%}$	0.913	0.953	0.760	0.975	0.838	1.136	1.047

[5] At time of spawning, fishing at F_{msy}

[6] At time of spawning, fishing at $F_{40\%}$

Table 1.14 Estimates of numbers at age for the EBS pollock stock under Model 1 (millions).

Year	1	2	3	4	5	6	7	8	9	10+
1964	4,917	3,846	2,194	527	221	346	141	58	32	197
1965	20,392	1,995	2,421	1,534	323	133	213	89	38	153
1966	14,470	8,275	1,257	1,695	945	196	83	136	58	128
1967	27,793	5,871	5,190	864	1,068	599	127	54	90	124
1968	25,684	11,258	3,635	3,369	479	598	349	75	33	132
1969	26,610	10,405	6,976	2,368	1,882	271	351	209	46	102
1970	21,230	10,760	6,384	4,372	1,393	1,113	163	211	125	86
1971	9,855	8,573	6,541	3,843	2,434	780	639	93	120	117
1972	11,324	3,971	5,127	3,668	1,940	1,239	410	334	48	120
1973	27,720	4,564	2,274	2,647	1,717	924	604	203	166	85
1974	21,201	11,142	2,531	1,054	1,080	716	398	264	89	112
1975	17,612	8,499	5,988	1,055	376	395	273	154	104	80
1976	13,304	7,105	4,927	2,676	400	147	162	114	66	80
1977	14,503	5,375	4,199	2,441	1,163	179	68	76	55	70
1978	27,861	5,867	3,227	2,259	1,183	576	91	35	40	66
1979	62,884	11,294	3,568	1,826	1,103	542	268	43	17	51
1980	25,878	25,496	6,889	2,055	916	521	260	130	21	33
1981	29,348	10,499	15,717	4,211	1,130	481	277	139	70	29
1982	15,715	11,919	6,624	10,858	2,530	601	246	144	73	52
1983	52,131	6,385	7,553	4,707	7,100	1,538	356	147	87	76
1984	12,458	21,184	4,052	5,417	3,165	4,511	959	224	93	103
1985	34,188	5,062	13,448	2,915	3,701	2,034	2,771	581	139	119
1986	12,553	13,893	3,214	9,679	1,993	2,381	1,252	1,683	360	156
1987	7,352	5,101	8,821	2,316	6,638	1,289	1,476	766	1,051	318
1988	4,377	2,988	3,243	6,409	1,625	4,514	852	943	491	880
1989	9,159	1,779	1,898	2,337	4,398	1,067	2,843	512	569	833
1990	52,355	3,722	1,129	1,365	1,596	2,864	665	1,684	304	840
1991	24,354	21,279	2,363	806	917	957	1,629	350	913	624
1992	18,296	9,898	13,499	1,677	534	535	526	821	182	796
1993	46,450	7,435	6,272	9,495	1,086	296	276	244	396	479
1994	12,034	18,881	4,729	4,560	6,140	592	134	135	128	489
1995	9,852	4,892	12,016	3,454	3,046	3,598	302	73	76	371
1996	25,453	4,005	3,115	8,804	2,361	1,882	1,996	175	44	283
1997	50,253	10,346	2,547	2,275	6,225	1,589	1,102	1,038	94	187
1998	16,482	20,428	6,581	1,861	1,609	4,192	932	575	559	159
1999	16,233	6,700	12,996	4,812	1,320	1,091	2,499	498	317	404
2000	14,994	6,598	4,261	9,414	3,389	880	688	1,454	280	429
2001	21,180	6,095	4,195	3,077	6,580	2,224	542	386	785	410
Median	19,344	7,270	4,495	2,662	1,602	830	377	206	93	130
Average	22,591	9,037	5,568	3,650	2,255	1,273	708	391	215	257

Table 1.15. Estimated catch-at-age of EBS pollock for Model 1 (millions).

	1	2	3	4	5	6	7	8	9	10+
1964	6	39	107	79	36	51	18	6	3	16
1965	26	20	115	223	51	19	26	9	4	12
1966	20	109	78	220	119	21	8	13	5	11
1967	67	137	557	189	226	111	22	9	13	18
1968	61	256	381	720	99	108	58	12	5	18
1969	95	317	932	423	330	44	58	35	8	20
1970	94	405	1,039	946	296	218	32	43	25	20
1971	58	430	1,382	1,067	664	197	164	24	31	34
1972	66	327	1,355	1,180	606	369	120	96	14	33
1973	209	481	745	1,043	658	339	217	72	58	29
1974	195	1,419	970	481	480	305	166	109	37	45
1975	90	625	2,078	452	155	155	103	57	38	29
1976	54	419	1,424	968	139	48	51	36	20	24
1977	47	254	1,002	737	337	49	18	20	14	17
1978	54	219	662	672	395	187	29	11	13	20
1979	115	395	691	515	349	167	81	13	5	15
1980	36	683	1,046	461	232	128	63	31	5	8
1981	20	89	917	691	278	130	72	35	17	7
1982	6	60	234	1,104	394	104	41	23	12	8
1983	17	25	208	377	877	211	47	19	11	10
1984	4	76	101	365	364	668	151	32	14	17
1985	11	18	331	195	422	299	433	82	20	20
1986	4	47	76	622	219	337	189	230	51	25
1987	1	12	147	106	471	121	177	90	121	36
1988	1	10	76	409	160	587	140	152	77	136
1989	3	6	48	159	461	147	495	87	95	138
1990	11	14	36	110	264	578	167	394	74	188
1991	6	87	86	73	169	215	453	91	246	156
1992	5	49	590	183	117	142	171	250	58	233
1993	8	15	100	1,045	250	100	82	63	91	96
1994	2	29	58	389	1,116	161	32	27	23	78
1995	1	6	114	230	438	786	57	12	11	46
1996	3	8	38	347	188	343	518	42	10	54
1997	6	20	31	89	491	287	284	247	22	35
1998	2	37	74	68	118	711	226	128	122	29
1999	2	14	249	205	114	141	467	104	60	64
2000	2	15	94	460	335	129	145	344	60	75
2001	4	17	108	176	756	377	132	105	192	83

Table 1.16. Estimates of begin-year age 3 and older biomass (thousands of tons) and coefficients of variation (CV) for Model 1 (current assessment) compared to estimates from the 2000-1997 assessments for EBS pollock. NOTE: see Section 1.5.1 for a discussion on the interpretation of age-3+ biomass estimates.

Age 3+ Biomass	Current Assessment	CV	2000 Assessment	CV	1999 Assessment	CV	1998 Assessment	CV	1997 Assessment	CV
1964	1,726	46%	751	35%	917	41%	1,037	30%		
1965	2,196	40%	976	36%	976	32%	1,227	26%		
1966	2,251	41%	1,001	39%	919	31%	1,096	28%		
1967	3,420	33%	1,957	34%	1,858	24%	2,095	22%		
1968	3,876	34%	2,312	36%	2,312	27%	2,510	23%		
1969	5,137	32%	3,379	29%	3,579	22%	3,810	19%		
1970	6,079	30%	3,998	25%	4,479	19%	5,083	15%		
1971	6,580	28%	4,372	21%	5,161	16%	5,813	12%		
1972	6,078	27%	3,984	19%	4,896	15%	5,648	11%		
1973	4,520	32%	2,873	26%	3,357	20%	3,922	14%		
1974	3,193	39%	1,648	41%	1,952	28%	2,342	19%		
1975	3,366	26%	2,536	23%	2,683	18%	3,014	13%		
1976	3,434	22%	2,694	17%	2,748	16%	3,008	13%		
1977	3,444	20%	2,701	13%	2,716	14%	2,894	13%		
1978	3,327	19%	2,608	14%	2,668	15%	2,867	13%	3,244	19%
1979	3,280	19%	2,640	16%	2,720	16%	2,933	15%	3,183	21%
1980	4,322	16%	3,723	15%	3,888	16%	4,294	14%	4,618	19%
1981	8,127	14%	7,834	12%	8,064	13%	8,569	12%	9,190	16%
1982	9,261	13%	9,021	13%	9,229	13%	9,778	12%	10,524	17%
1983	10,298	13%	9,958	12%	10,153	12%	10,705	12%	11,555	16%
1984	10,000	13%	9,518	13%	9,685	12%	10,179	12%	11,028	17%
1985	12,181	11%	11,182	10%	11,370	10%	11,919	11%	12,853	15%
1986	11,381	11%	10,277	10%	10,440	10%	10,913	11%	11,796	16%
1987	11,951	10%	10,636	9%	10,769	9%	11,116	10%	11,952	15%
1988	11,159	10%	9,910	8%	9,991	9%	10,274	10%	11,020	15%
1989	9,394	10%	8,251	9%	8,305	9%	8,546	10%	9,210	16%
1990	7,393	11%	6,473	10%	6,497	10%	6,659	12%	7,240	18%
1991	5,582	12%	4,859	11%	4,842	11%	5,180	13%	5,690	20%
1992	8,898	10%	7,920	9%	7,800	10%	8,294	13%	9,465	21%
1993	11,503	10%	10,233	10%	9,873	10%	10,279	16%	12,086	25%
1994	10,590	11%	9,285	10%	8,622	12%	8,917	18%	10,626	29%
1995	12,617	13%	10,267	12%	8,817	15%	8,680	22%	9,998	32%
1996	10,752	14%	8,556	14%	7,147	17%	6,811	26%	8,142	36%
1997	8,984	16%	7,057	17%	5,710	22%	5,307	31%	6,631	42%
1998	9,335	20%	7,448	22%	5,961	28%	5,133	39%	5,133	39%
1999	12,593	28%	10,772	30%	7,513	36%				
2000	11,680	33%	10,490	34%						
2001	11,145	39%								

Table 1.17 Projections of Model 1 spawning biomass (thousands of tons) for EBS pollock for the 7 scenarios. The values for $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are **6,525**; **2,610**; and **2,300** t, respectively.

Sp.Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	3,790	3,790	3,790	3,790	3,790	3,790	3,790
2002	3,186	3,186	3,337	3,345	3,497	3,092	3,186
2003	2,525	2,525	3,031	3,062	3,711	2,285	2,525
2004	2,353	2,353	2,991	3,035	4,118	2,126	2,304
2005	2,461	2,461	3,111	3,159	4,566	2,249	2,304
2006	2,620	2,620	3,288	3,332	4,981	2,397	2,414
2007	2,721	2,721	3,425	3,465	5,302	2,477	2,481
2008	2,751	2,751	3,503	3,542	5,571	2,487	2,488
2009	2,741	2,741	3,533	3,573	5,786	2,465	2,465
2010	2,738	2,738	3,557	3,599	5,970	2,460	2,460
2011	2,753	2,753	3,588	3,632	6,141	2,475	2,475
2012	2,776	2,776	3,620	3,666	6,279	2,497	2,497
2013	2,778	2,778	3,630	3,677	6,376	2,496	2,496
2014	2,760	2,760	3,618	3,667	6,433	2,477	2,477
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	0.203	0.203	0.203	0.203	0.203	0.203	0.203
2002	0.377	0.377	0.188	0.179	0.000	0.499	0.377
2003	0.361	0.361	0.188	0.179	0.000	0.430	0.361
2004	0.330	0.330	0.188	0.179	0.000	0.396	0.429
2005	0.328	0.328	0.184	0.179	0.000	0.404	0.412
2006	0.331	0.331	0.182	0.179	0.000	0.414	0.416
2007	0.336	0.336	0.182	0.179	0.000	0.422	0.422
2008	0.338	0.338	0.182	0.179	0.000	0.423	0.424
2009	0.339	0.339	0.183	0.179	0.000	0.423	0.423
2010	0.339	0.339	0.183	0.179	0.000	0.423	0.423
2011	0.339	0.339	0.183	0.179	0.000	0.423	0.423
2012	0.340	0.340	0.184	0.179	0.000	0.424	0.424
2013	0.340	0.340	0.184	0.179	0.000	0.424	0.424
2014	0.339	0.339	0.183	0.179	0.000	0.423	0.423
Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	1,400	1,400	1,400	1,400	1,400	1,400	1,400
2002	2,269	2,269	1,248	1,190	0	2,833	2,269
2003	1,765	1,765	1,206	1,161	0	1,823	1,765
2004	1,376	1,376	1,127	1,095	0	1,407	1,703
2005	1,306	1,306	1,049	1,041	0	1,395	1,482
2006	1,385	1,385	1,063	1,057	0	1,515	1,540
2007	1,488	1,488	1,125	1,112	0	1,624	1,629
2008	1,550	1,550	1,188	1,171	0	1,671	1,671
2009	1,569	1,569	1,225	1,207	0	1,673	1,673
2010	1,568	1,568	1,241	1,222	0	1,663	1,662
2011	1,567	1,567	1,249	1,229	0	1,663	1,663
2012	1,575	1,575	1,256	1,235	0	1,678	1,678
2013	1,580	1,580	1,260	1,240	0	1,679	1,679

Table 1.18. Summary results for Model 1, EBS pollock. Tonnage units are thousands of metric tons.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M	0.900	0.450	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Prop.F. Mature	0.000	0.004	0.145	0.321	0.421	0.451	0.474	0.482	0.485	0.500	0.500	0.500	0.500	0.500	0.500
Fish. Selectivity	0.0014	0.0168	0.1487	0.3362	0.6997	1.0692	1.6062	1.8309	1.6238	1.3514	1.2631	1.2631	1.2631	1.2631	1.2631

	Model 1
2002 Spawning biomass	**3,186** t
B_{msy}	**2,143** t
$B_{40\%}$	**2,610** t
$B_{35\%}$	**2,300** t
Yield Considerations	
Year 2002 Harmonic Mean F_{msy} Yield	**2,108** t
Year 2002 Yield F40% (adjusted)	**2,269** t
Full Selection F's	
F_{msy}	**1.234**
$F_{40\%}$	**0.690**
$F_{35\%}$	**0.913**

1.13. Figures

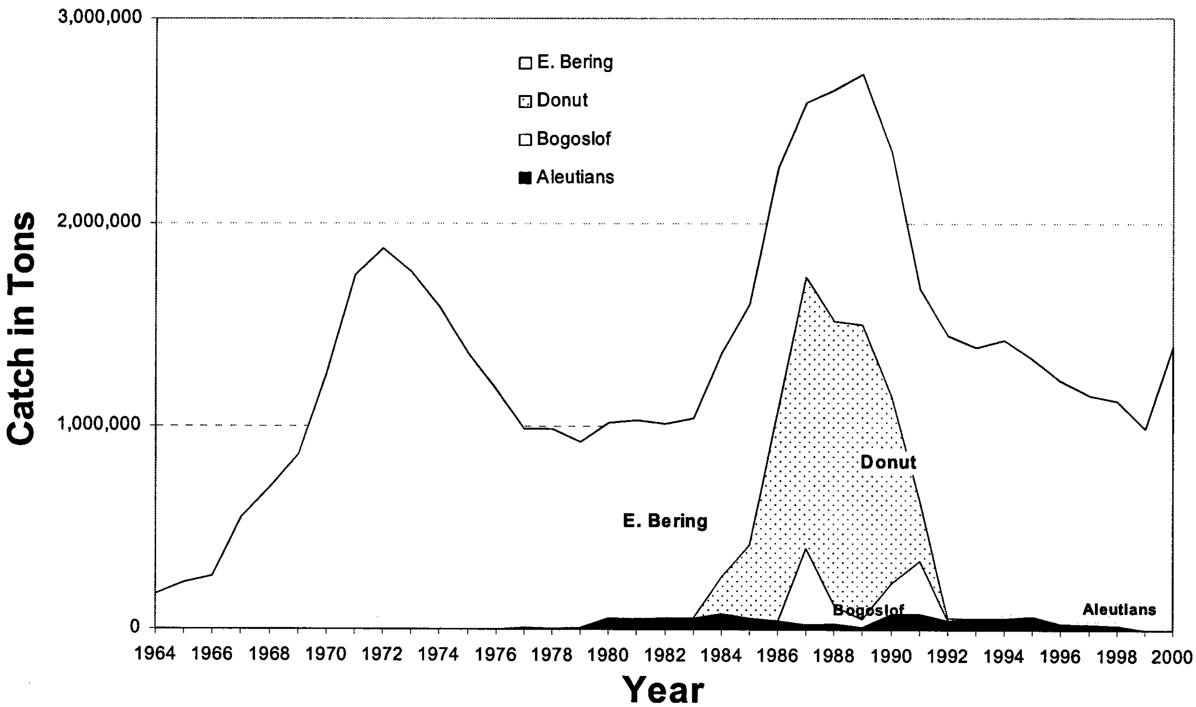


Figure 1.1. Walleye pollock catch in the eastern Bering Sea, Aleutian Islands, Bogoslof Island, and Donut Hole, 1964-2000.

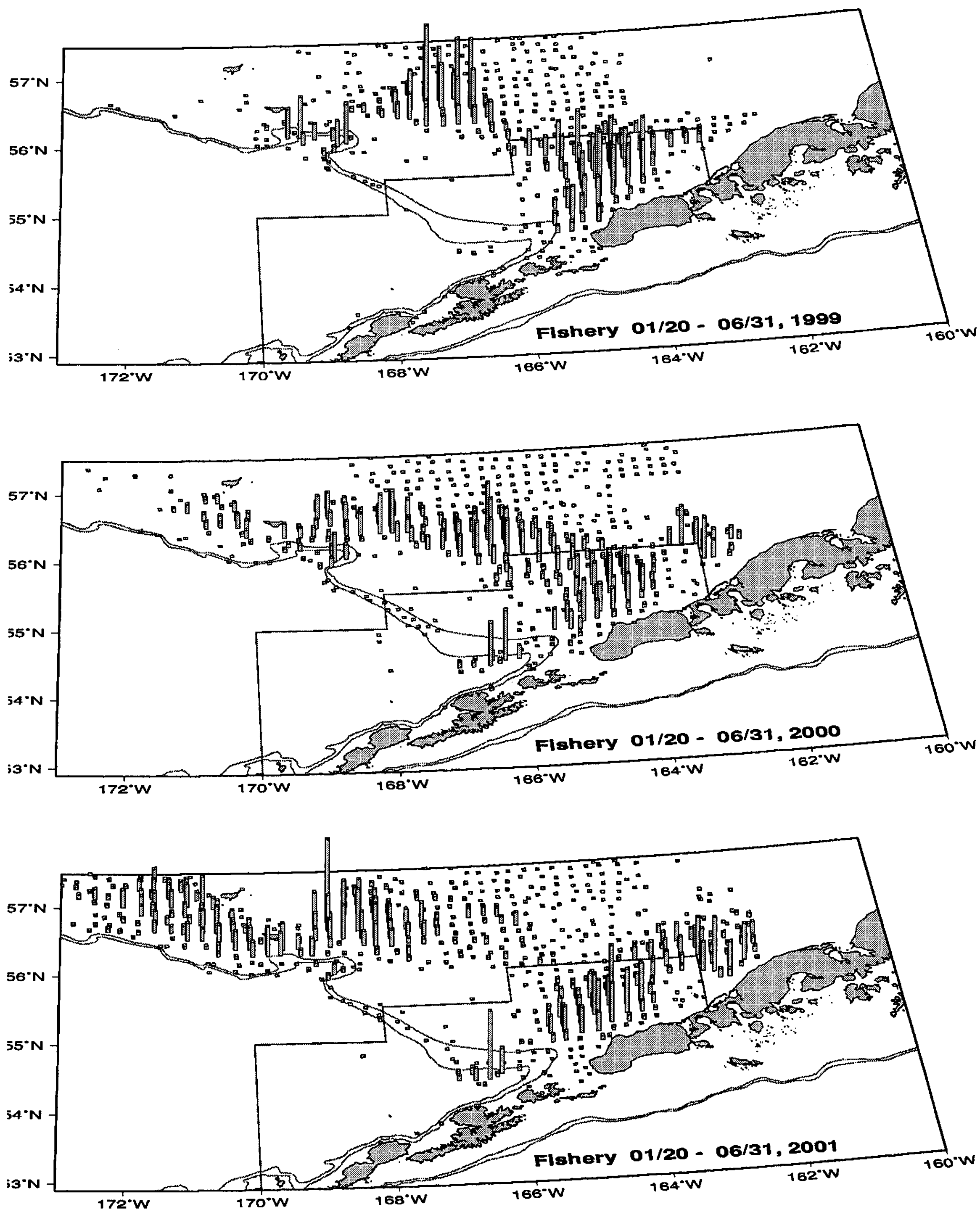


Figure 1.2. Concentrations of the pollock fishery 1999-2001, January - June on the EBS shelf. Line delineates SCA (sea lion conservation area). The column height represents relative removal on the same scale in all years.

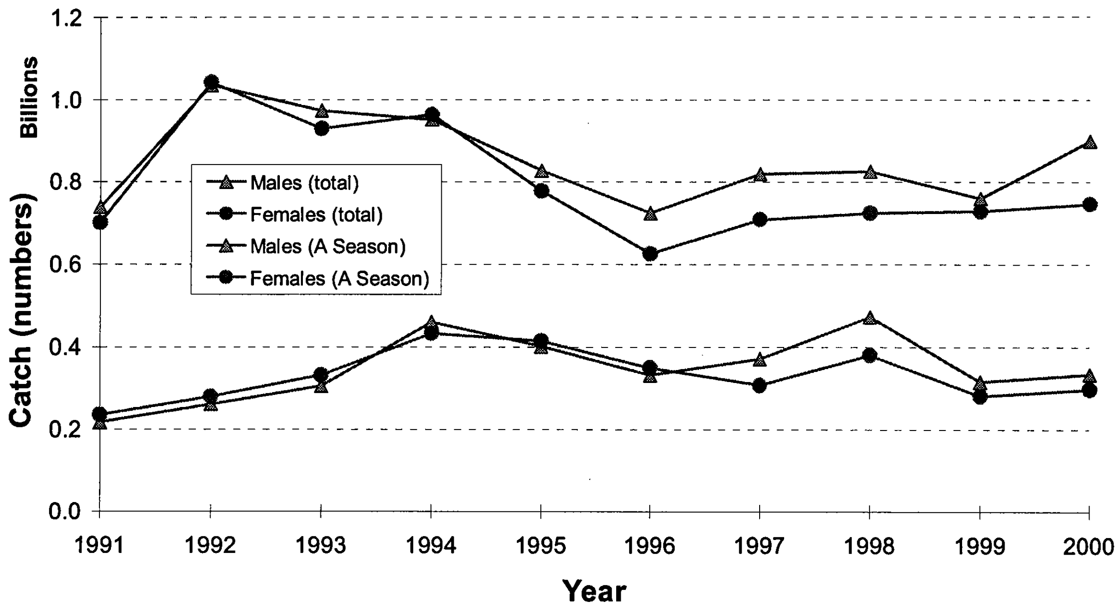


Figure 1.3. Estimate of EBS pollock catch numbers by sex for the "A season" and for the entire fishery, 1991-2000.

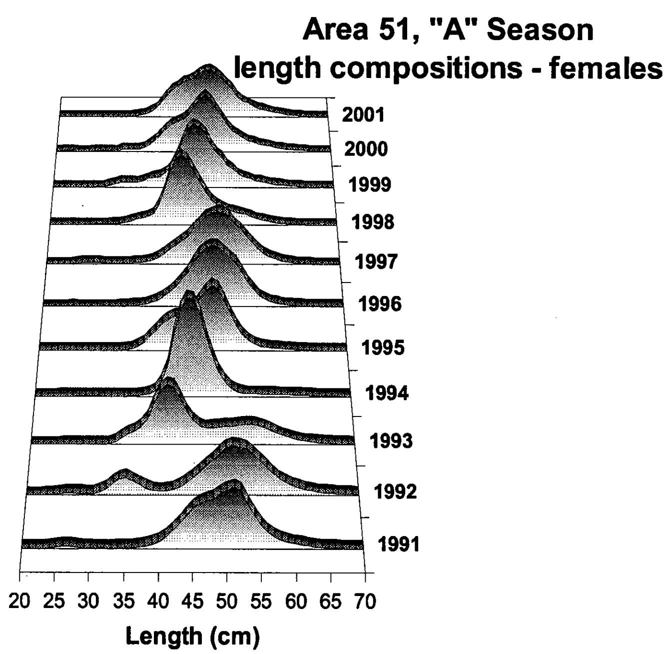


Figure 1.4. Fishery length frequency for the "A season" EBS pollock, 1991-2001. Data for 2001 are preliminary.

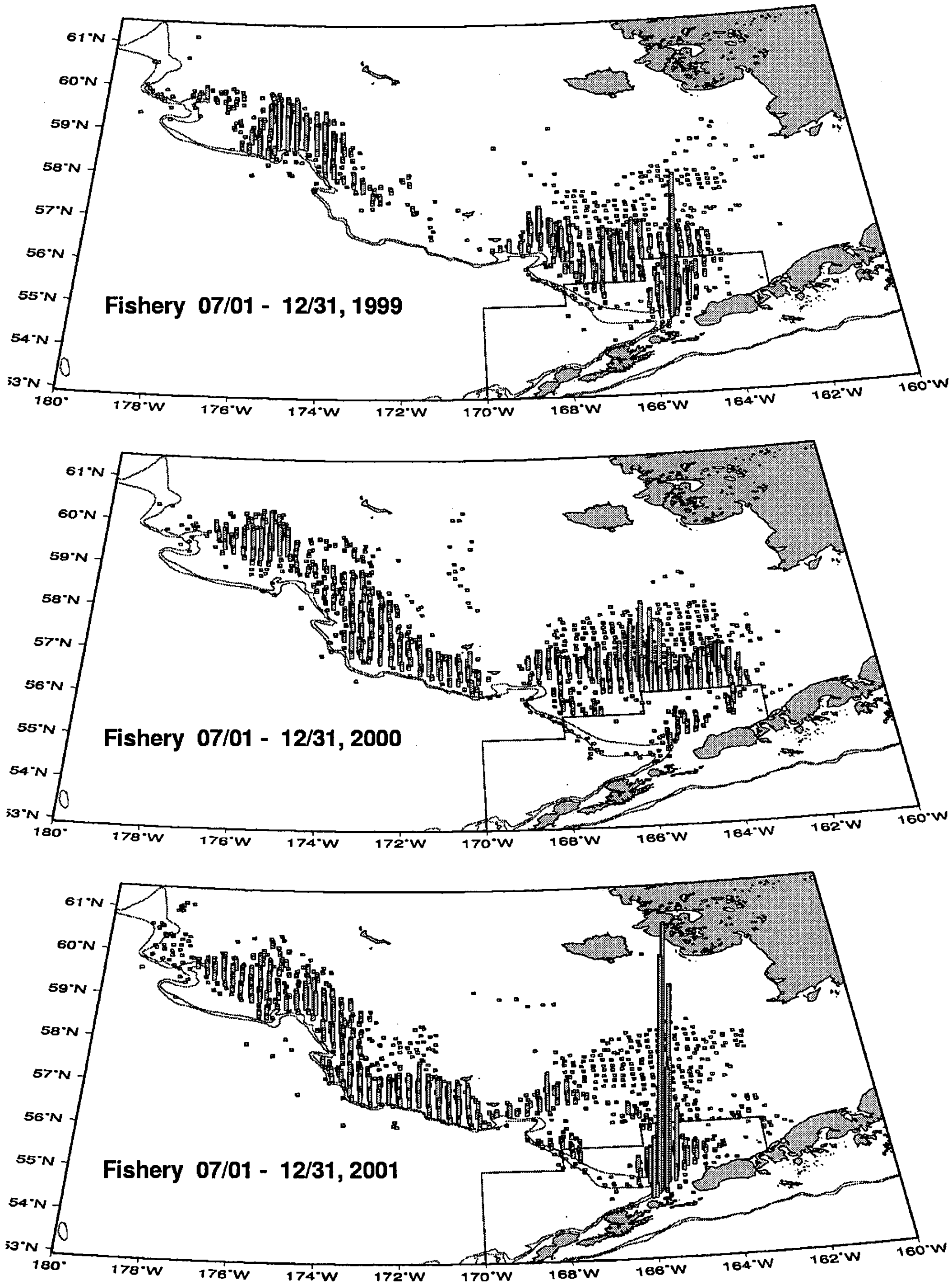


Figure 1.5. Concentrations of the pollock fishery 1999-2001, July – December on the EBS shelf. Line delineates SCA (sea lion conservation area). The density represents relative removal on the same scale over all years.

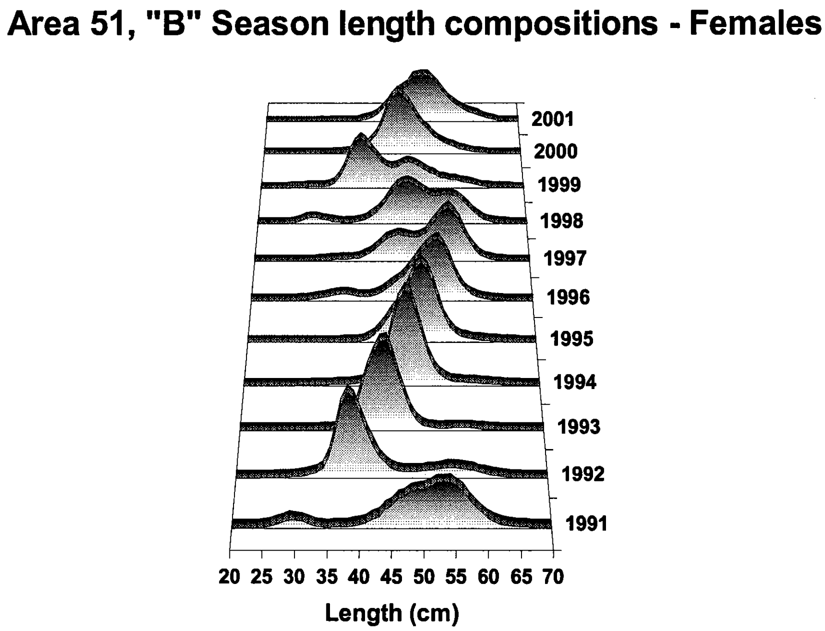


Figure 1.6. Length frequency of EBS pollock observed in period June-December for 1991-2001. Data for 2001 are preliminary.

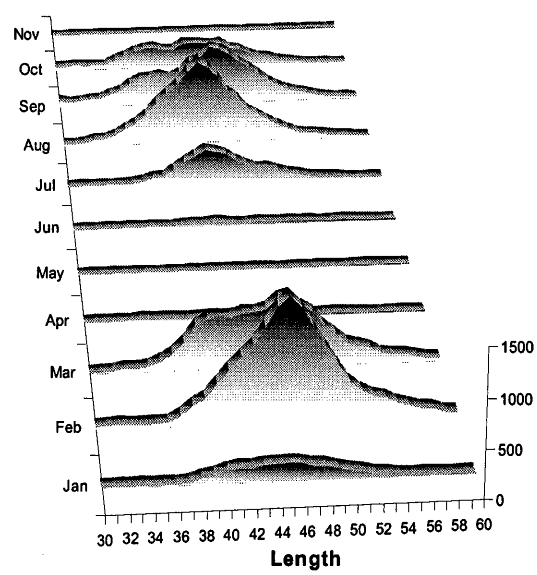
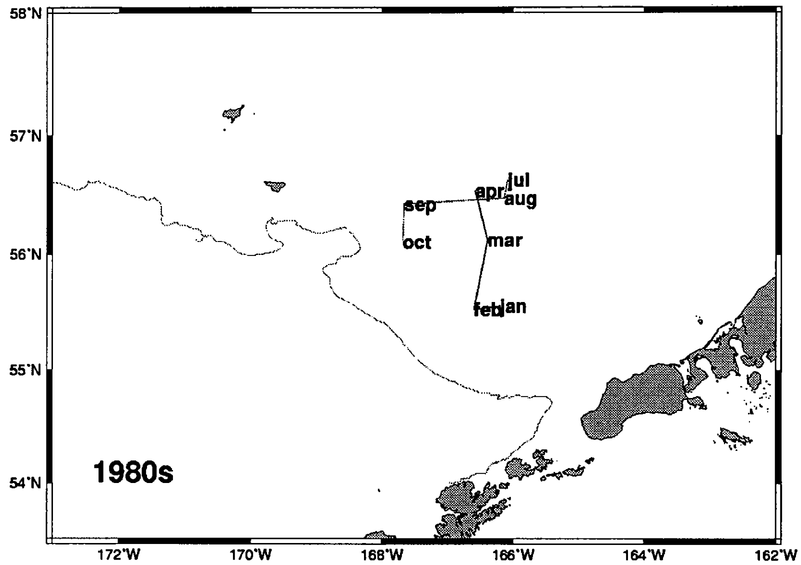


Figure 1.7. Fishery catch-at-length by month approximated by raw observer length-frequency values for the 2000 EBS pollock fishery.



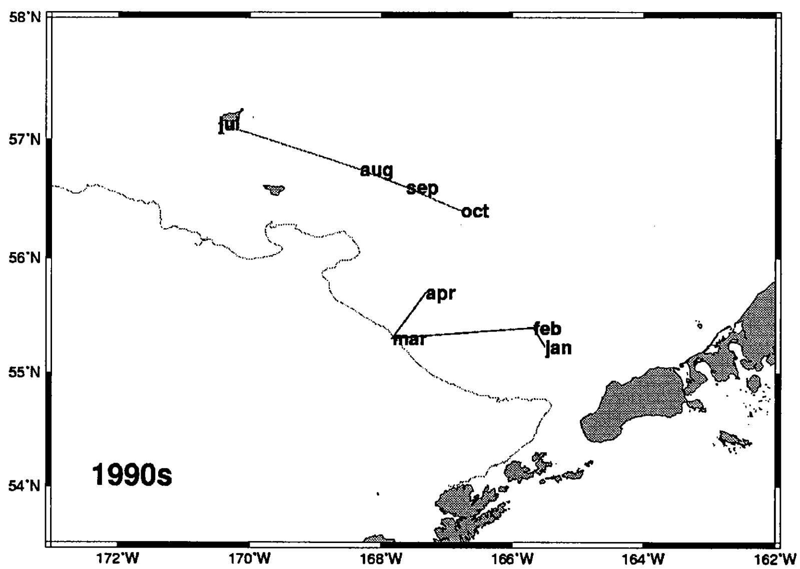


Figure 1.8. Average centers of monthly pollock catch-distribution based on NMFS observer data during the 1980s (top) and the 1990s (bottom).

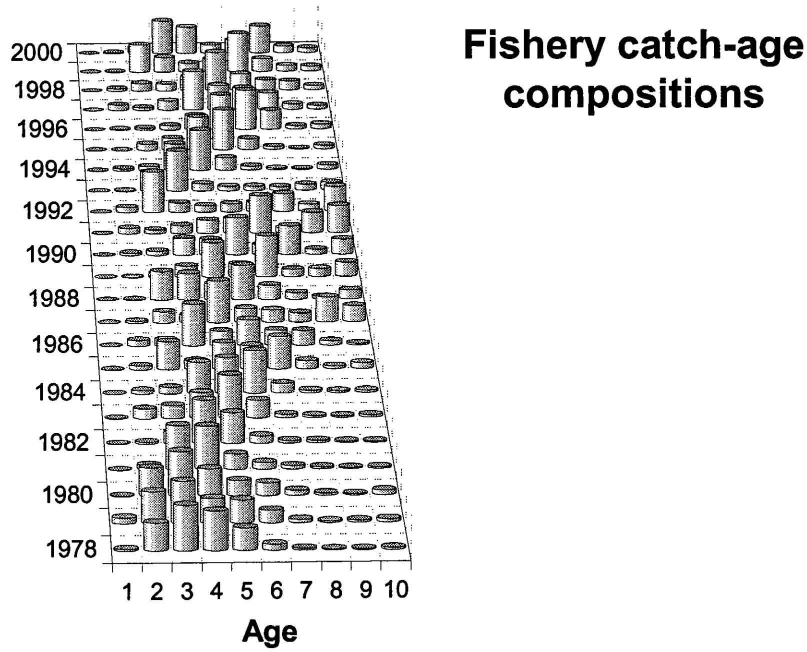


Figure 1.9. EBS walleye pollock fishery catch-at-age data (proportions). Age 10 represents age 10 and older pollock.

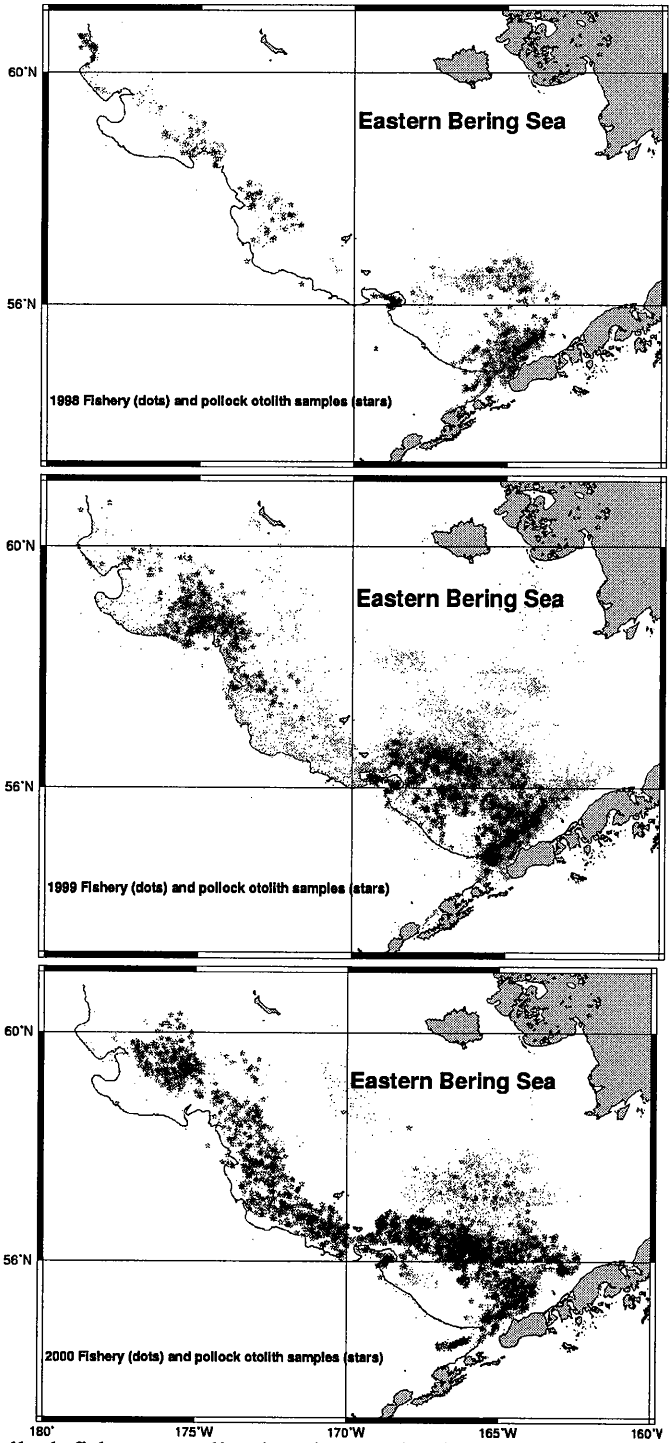


Figure 1.10. EBS pollock fishery sampling locations under the old sampling protocol (1998, top) and under the new protocol (1999, 2000; middle and bottom panels). Points represent haul locations and stars represent hauls were otolith samples were collected.

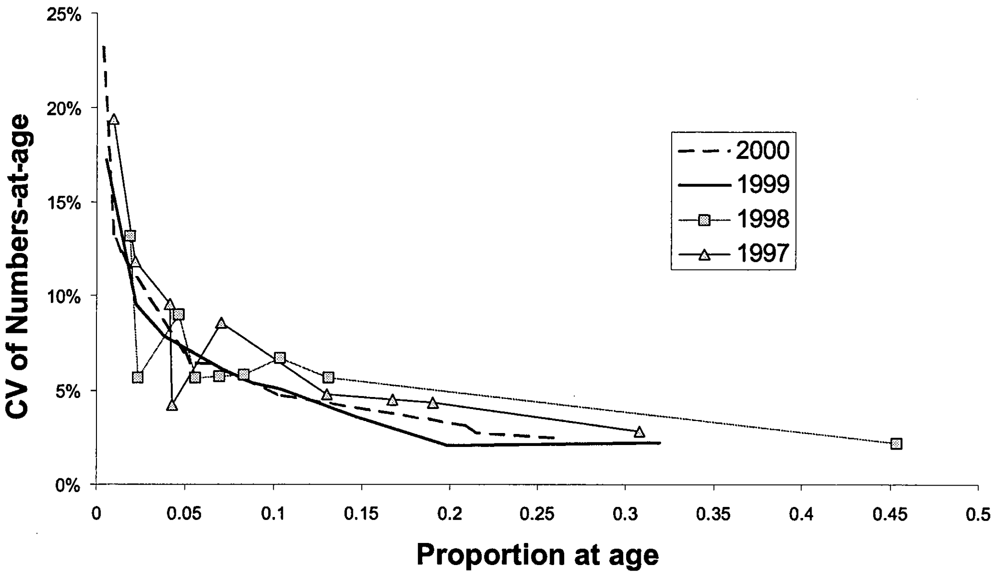


Figure 1.11. Estimated coefficients of variation in catch numbers-at-age from the EBS walleye pollock fishery relative to the proportion of catch numbers-at-age. In 2000 and 1999 the new observer sampling methods are compared with the old sampling protocol of 1997 and 1998.

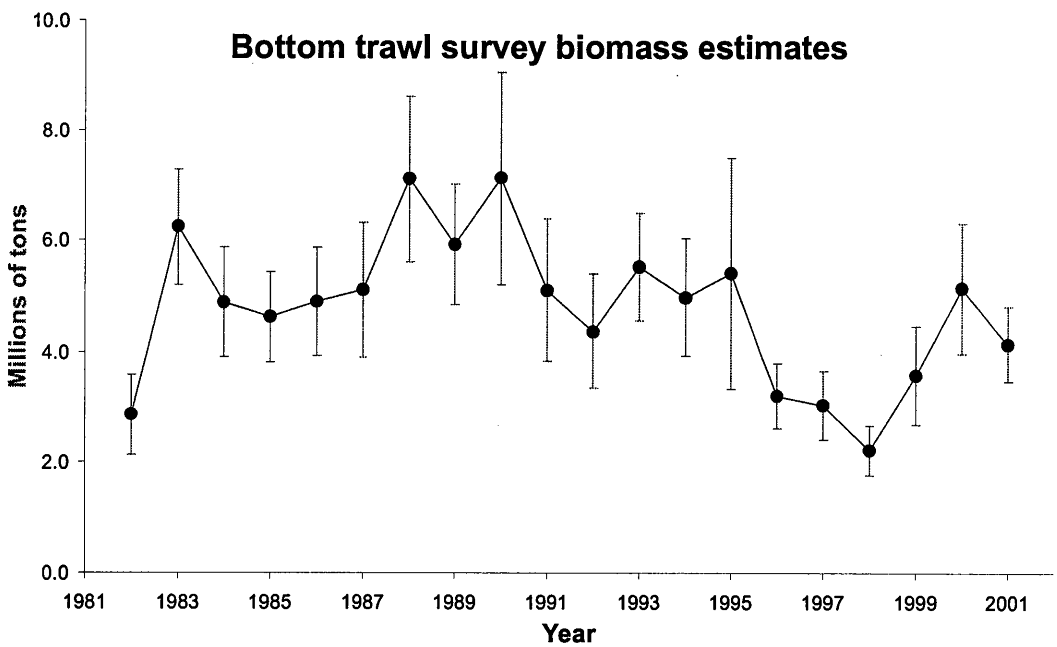


Figure 1.12. Bottom-trawl survey biomass estimates with 95% confidence bounds (based on sampling error) for EBS walleye pollock, 1982-2001.

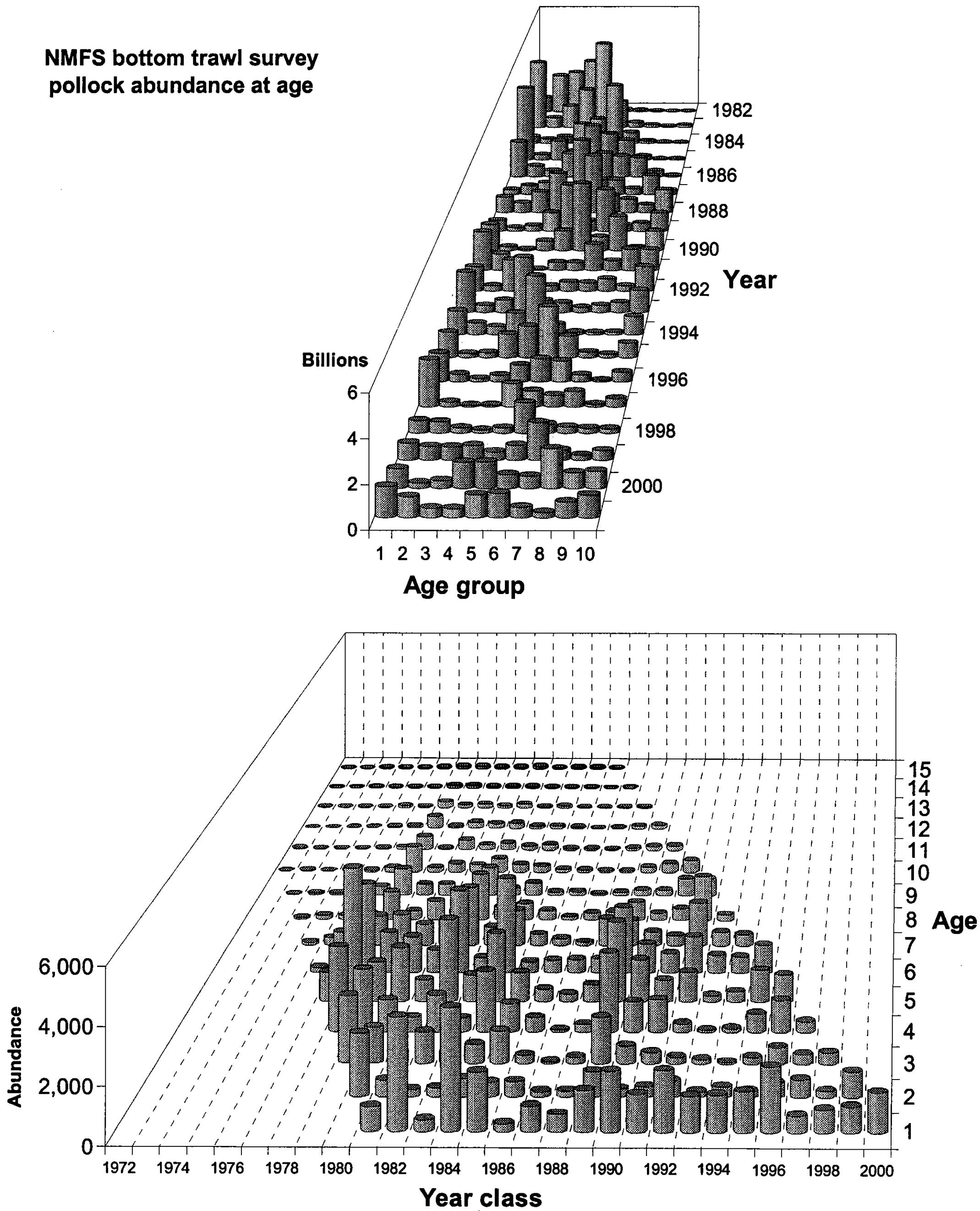


Figure 1.13. Abundance levels by age and year plotted over time (top) and by individual cohorts (year-classes) as estimated directly from the NMFS bottom-trawl surveys.

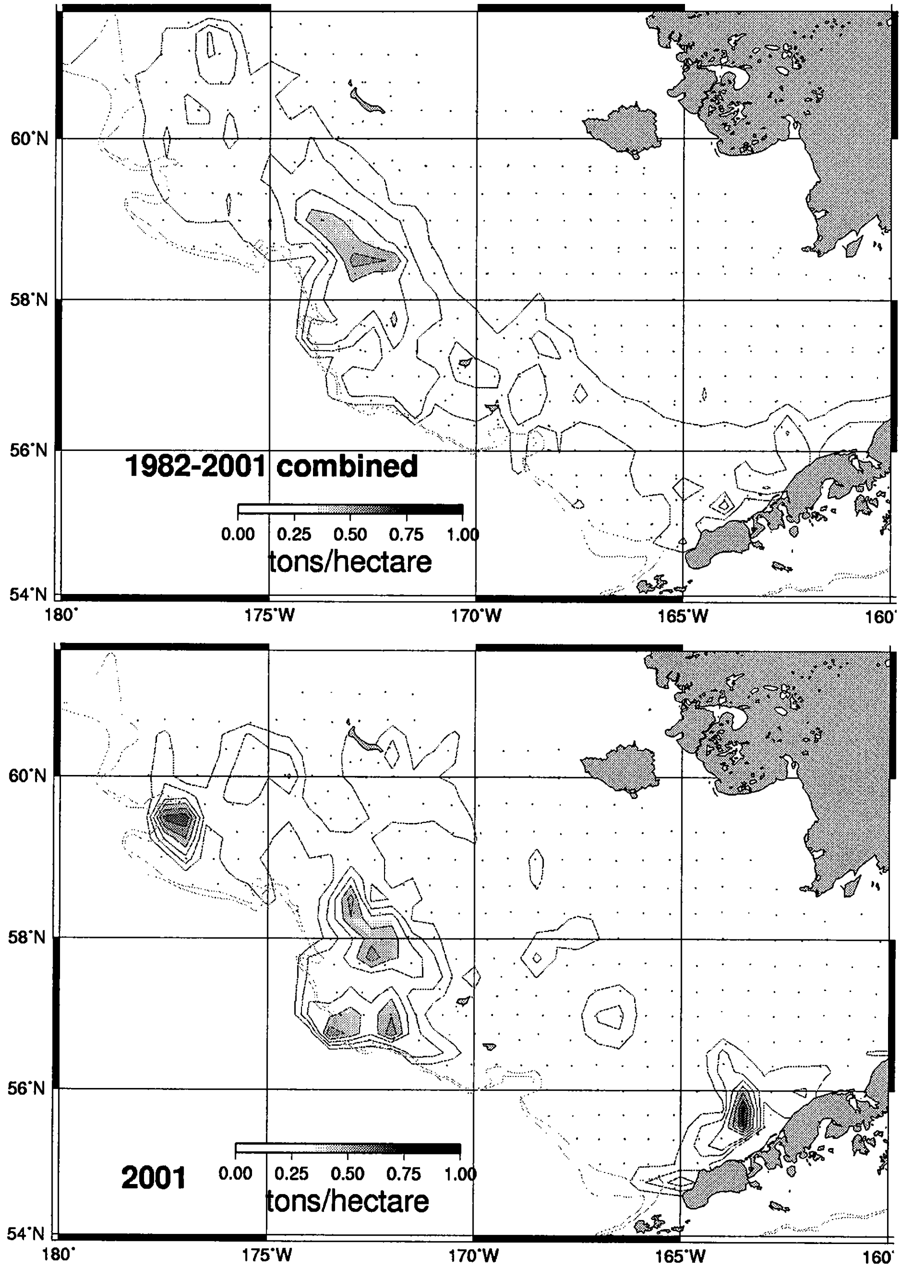


Figure 1.14. Maps showing the average walleye pollock catch-per-unit effort (1982-2001) compared to that observed during the 2001 NMFS EBS shelf bottom-trawl survey (bottom). Note that the average distribution plot contains CPUE values from the northwest portion that is not part of the "standard" survey area.

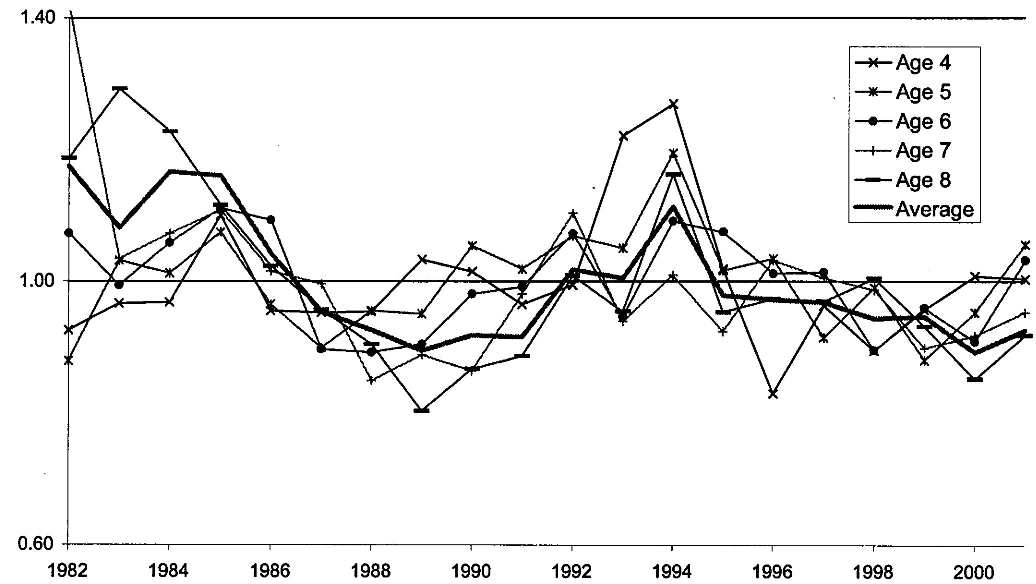


Figure 1.15. Trends in pollock average weights-at-age based on NMFS bottom trawl survey estimates, 1982-2001. Values are shown relative to their mean within each age or age group. Note that the length-weight relationship used here is constant, hence the differences are how average lengths-at-age vary over time in terms of weight.

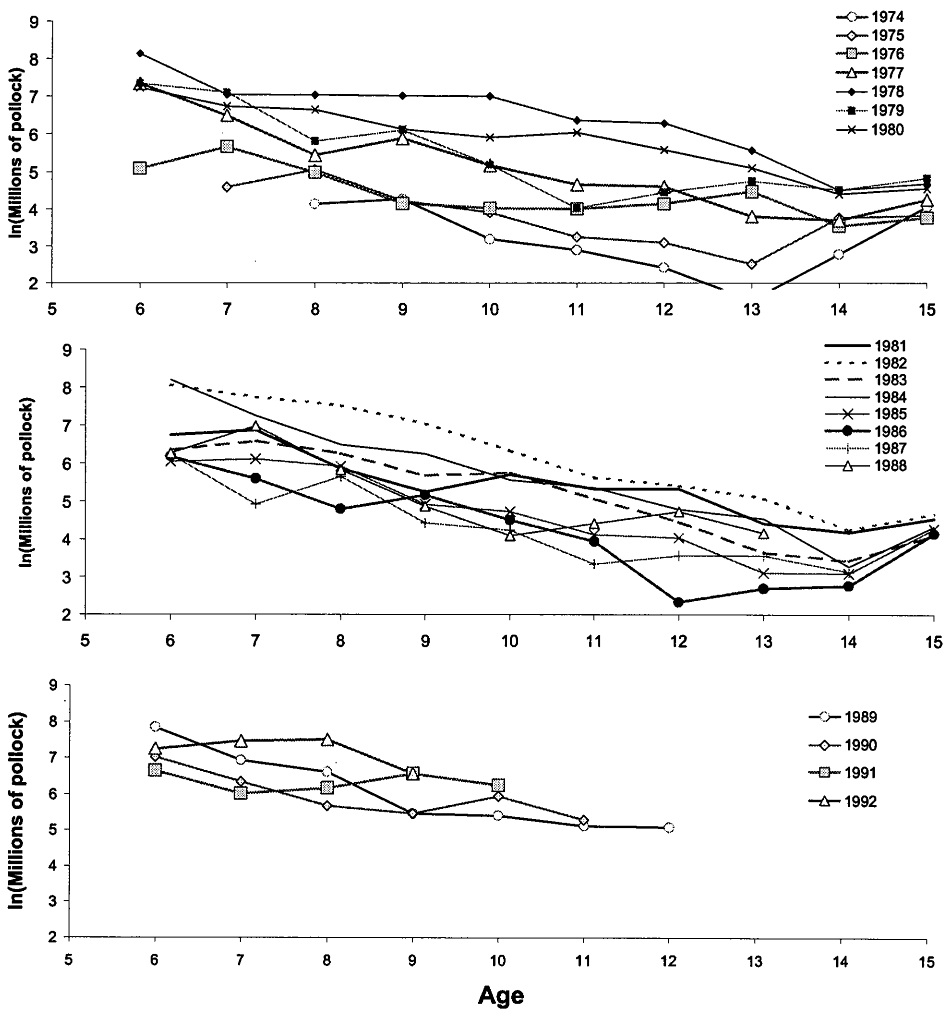


Figure 1.16. Log-abundance levels of individual EBS pollock cohorts (year-classes) as estimated directly from the NMFS bottom-trawl surveys. Estimates at age 15 were omitted since they represent age 15 and older pollock.

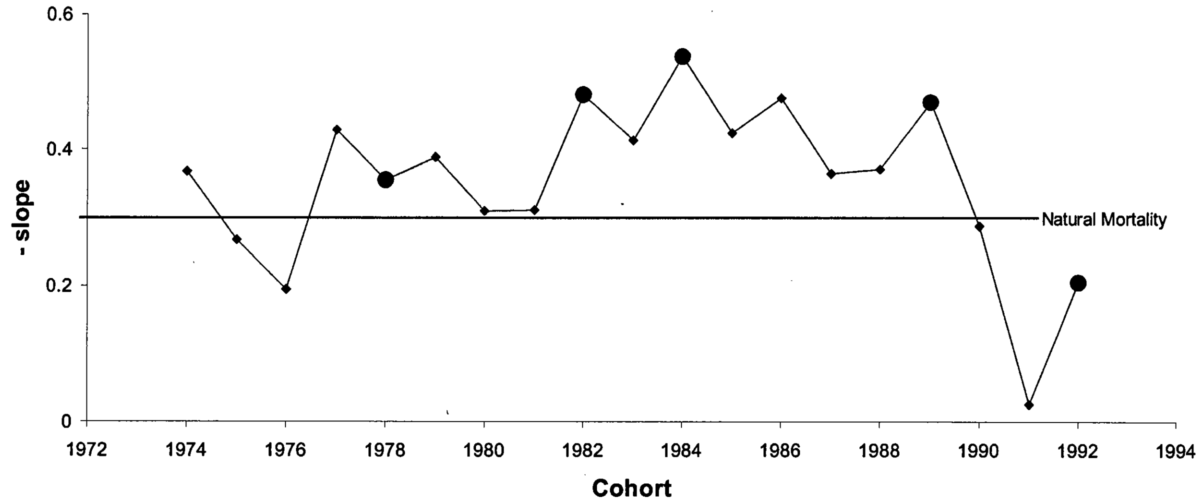


Figure 1.17. Negative slope estimates (as a proxy for total instantaneous mortality, Z) for 1974-1992 EBS pollock cohorts based on log-abundance levels as estimated directly from the NMFS bottom-trawl surveys. The assumed natural mortality rate for ages 3+ is shown as the single horizontal line. Year-classes greater than average are indicated by the larger filled circles.

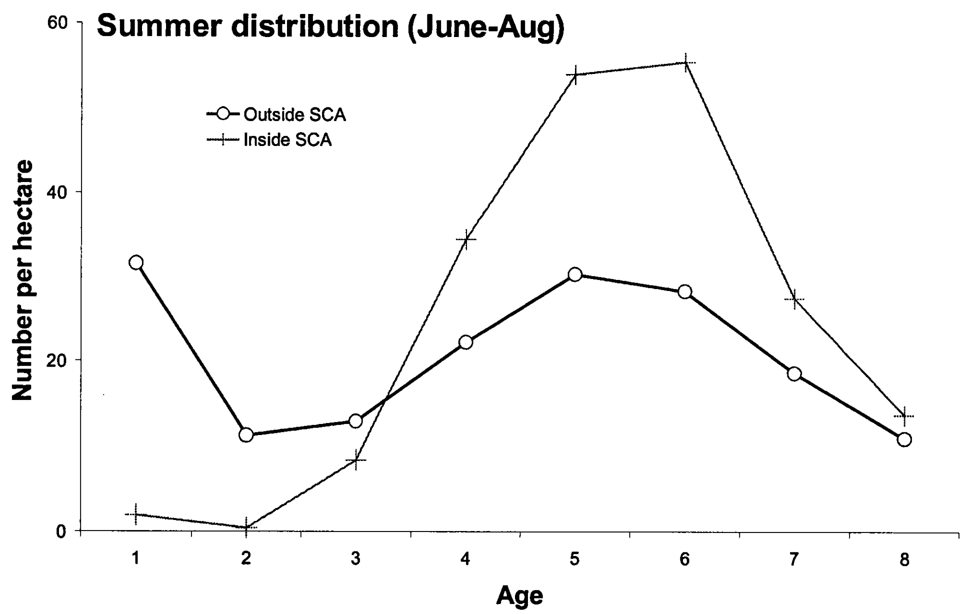


Figure 1.18. EBS pollock mean number per hectare by age based on tow-by-tow age-specific CPUE analyses of the NMFS bottom-trawl survey, 1982-1999.

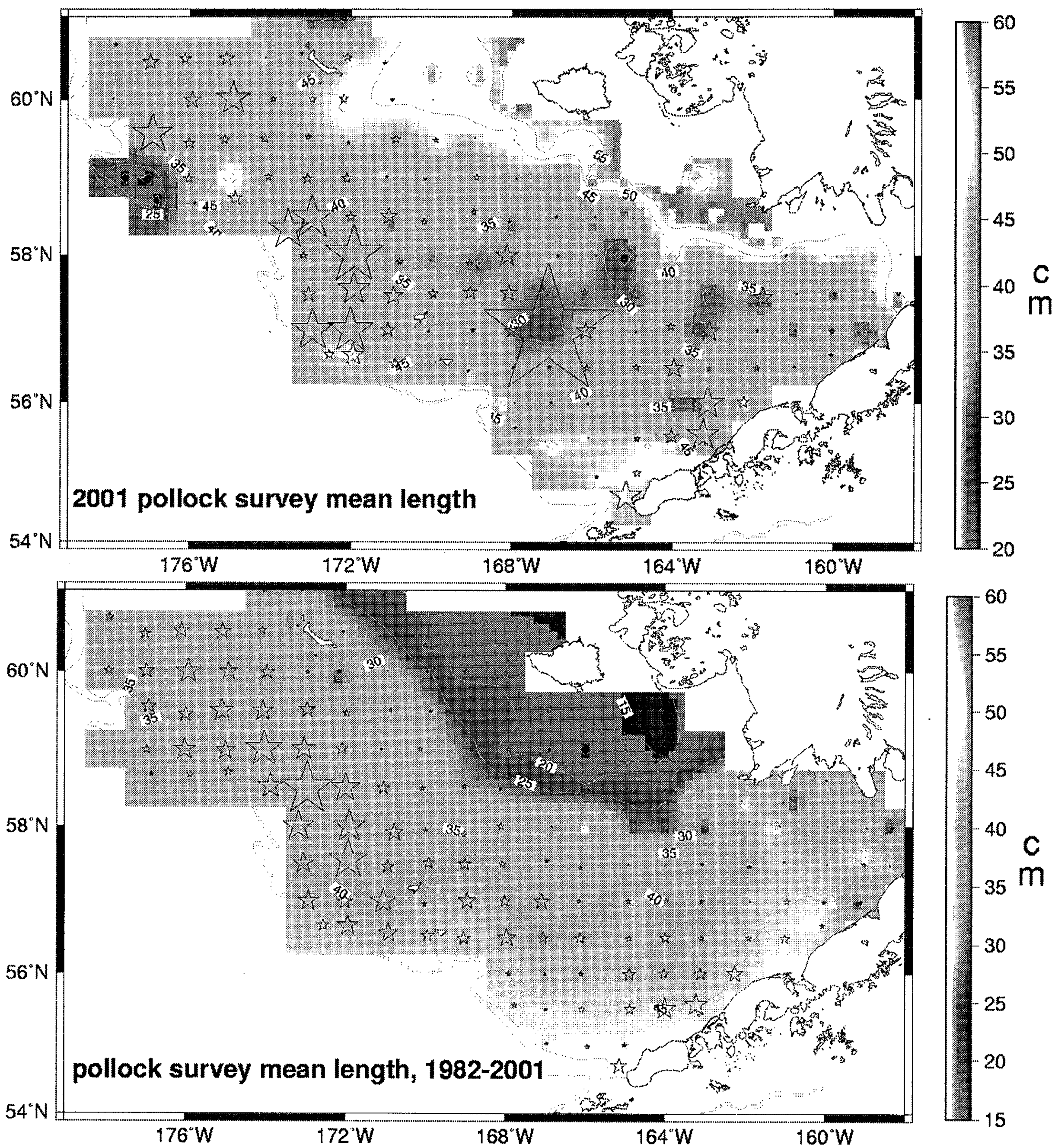


Figure 1.19. Average length distribution based on NMFS bottom trawl survey estimates for 2001 and averaged over 1982-2001. Average lengths are weighted by CPUE (catch (numbers) per unit effort). The size of the stars are proportional to the CPUE.

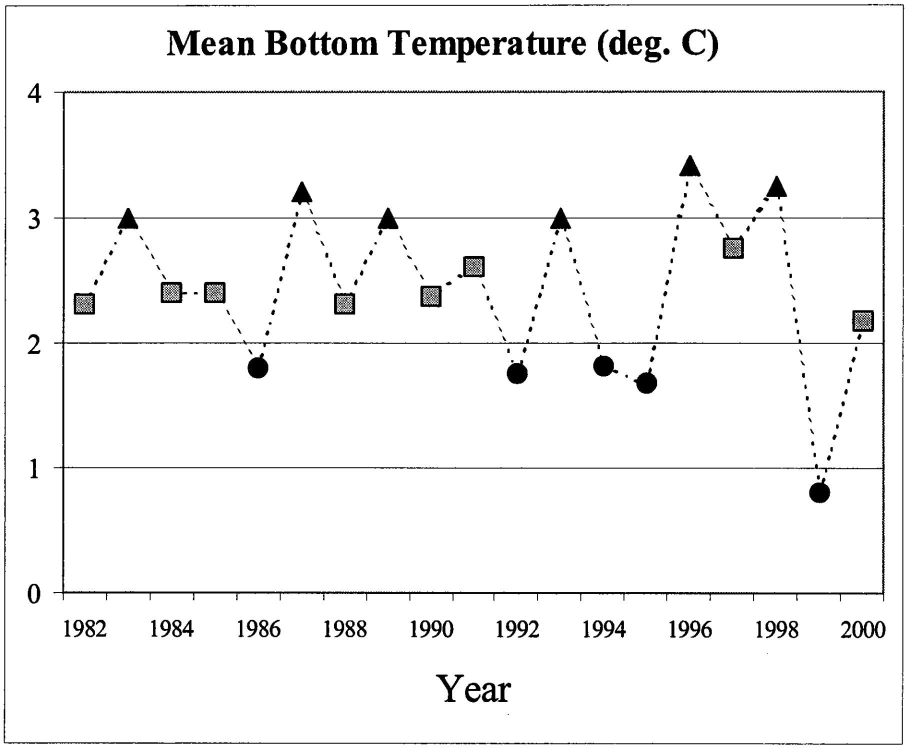


Figure 1.20. Mean summer bottom temperatures used to model bottom trawl survey pollock catchability, 1982-2000. Triangles represent years classified as "warm", squares as "intermediate," and circles as "cold" temperature years. (Note: these were normalized to have mean zero for use in the model).

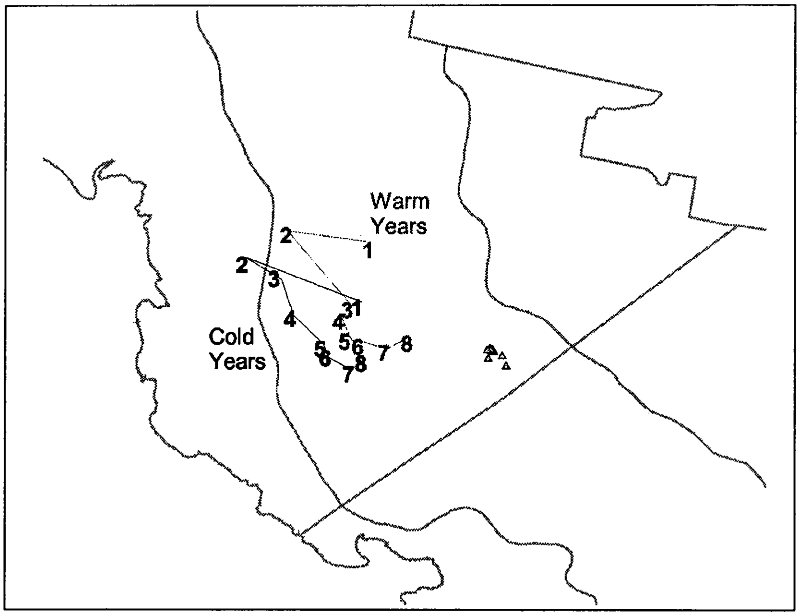


Figure 1.21. EBS pollock weighted (by number) average location by ages 1-8, 1982-2000. Lower-left line represents the average from "cold" years while the upper right line represents average location during "warm" years. Triangles represent the centers of survey operations in each year.

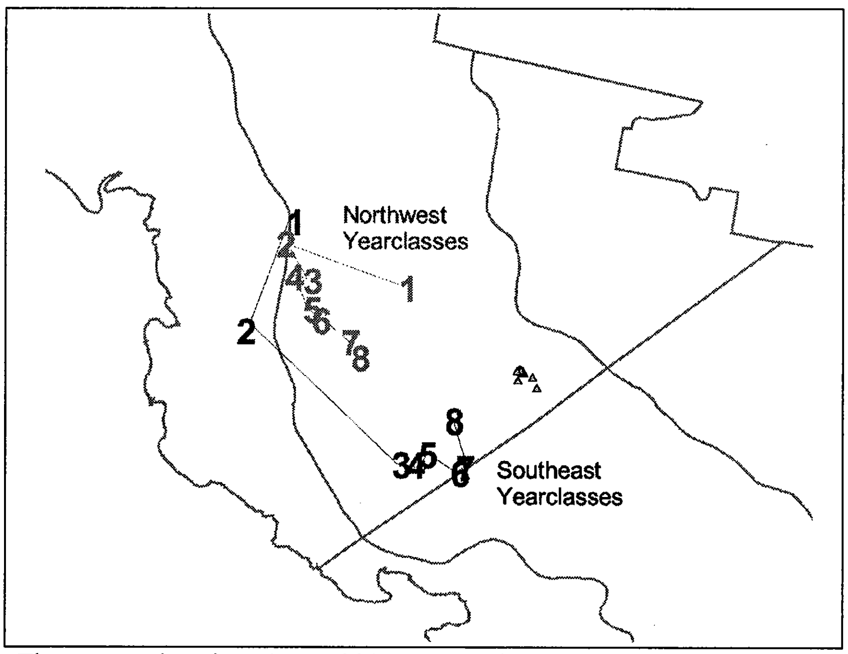


Figure 1.22. The average locations (centroids), ages 1-8 for pollock year-classes that remain concentrated in the NW area of the EBS shelf and those that shift southeastward as they age. Triangles represent the centers of survey operations in each year.

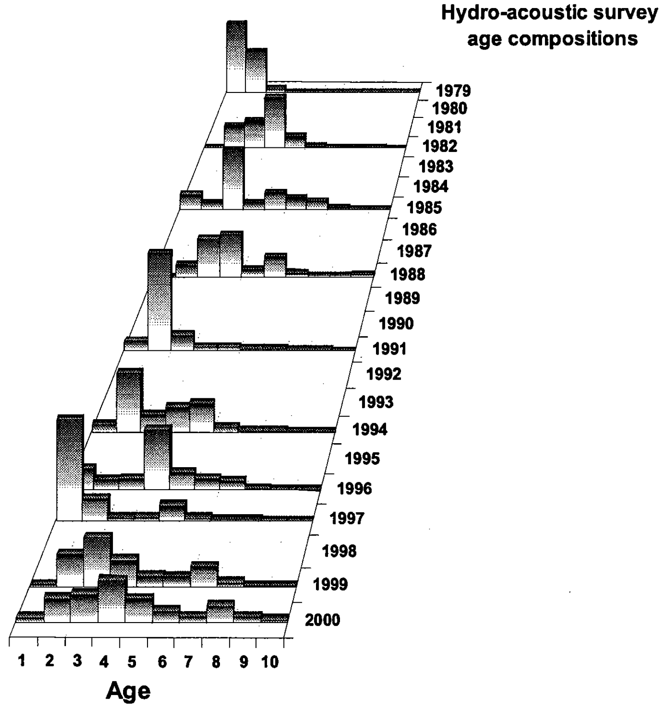


Figure 1.23. Time series of estimated proportions at age for EBS walleye pollock from the EIT surveys, 1979-2000.

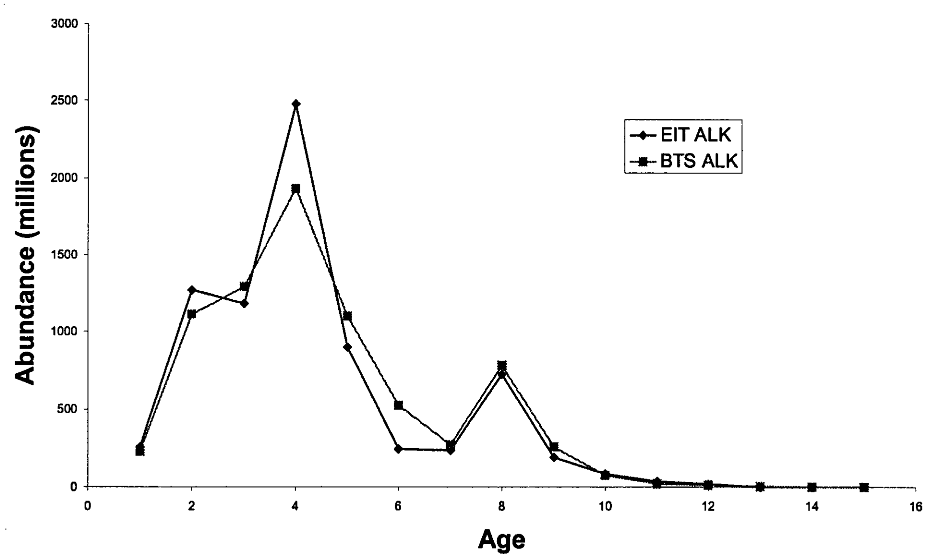


Figure 1.24. Comparison of the 2000 EIT estimates of pollock numbers-at-age based on the bottom-trawl survey age-length key (used in last year's assessment) with the final estimates based on using the age-length keys developed from the 2000 EIT survey.

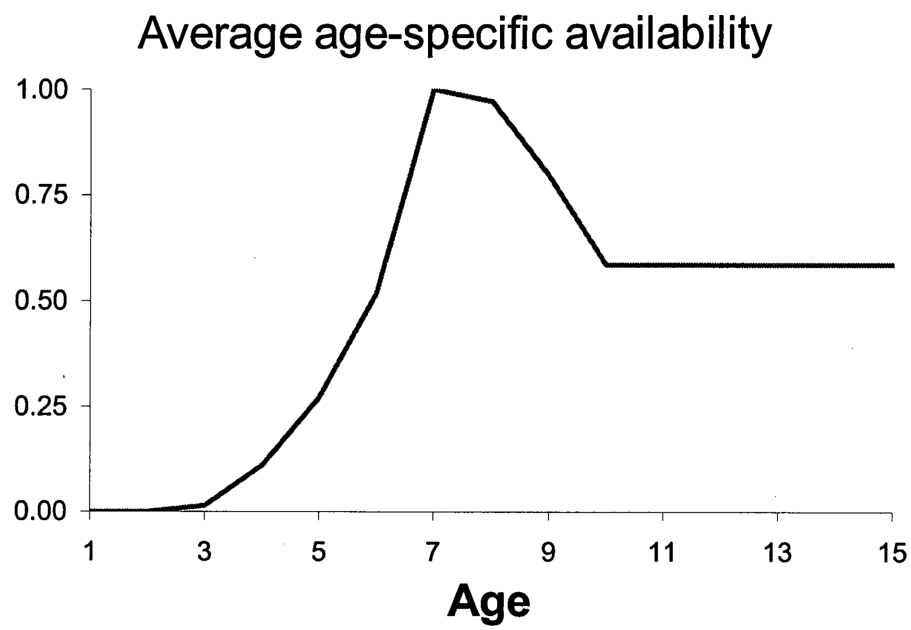


Figure 1.25. Availability/vulnerability estimates for the winter EIT shelf surveys relative to population estimates. Survey years include 2001, 2000, 1995 and 1991.

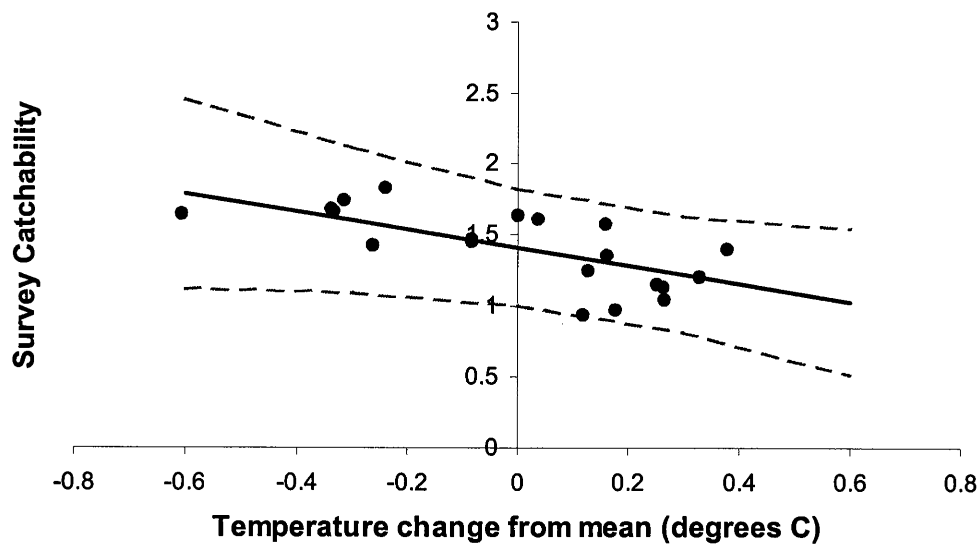


Figure 1.26. Estimated relationship between pollock bottom-trawl survey catchability and bottom temperature (normalized to have a mean value of 0) as under Model 4. Residuals relative to survey estimates area shown as points.

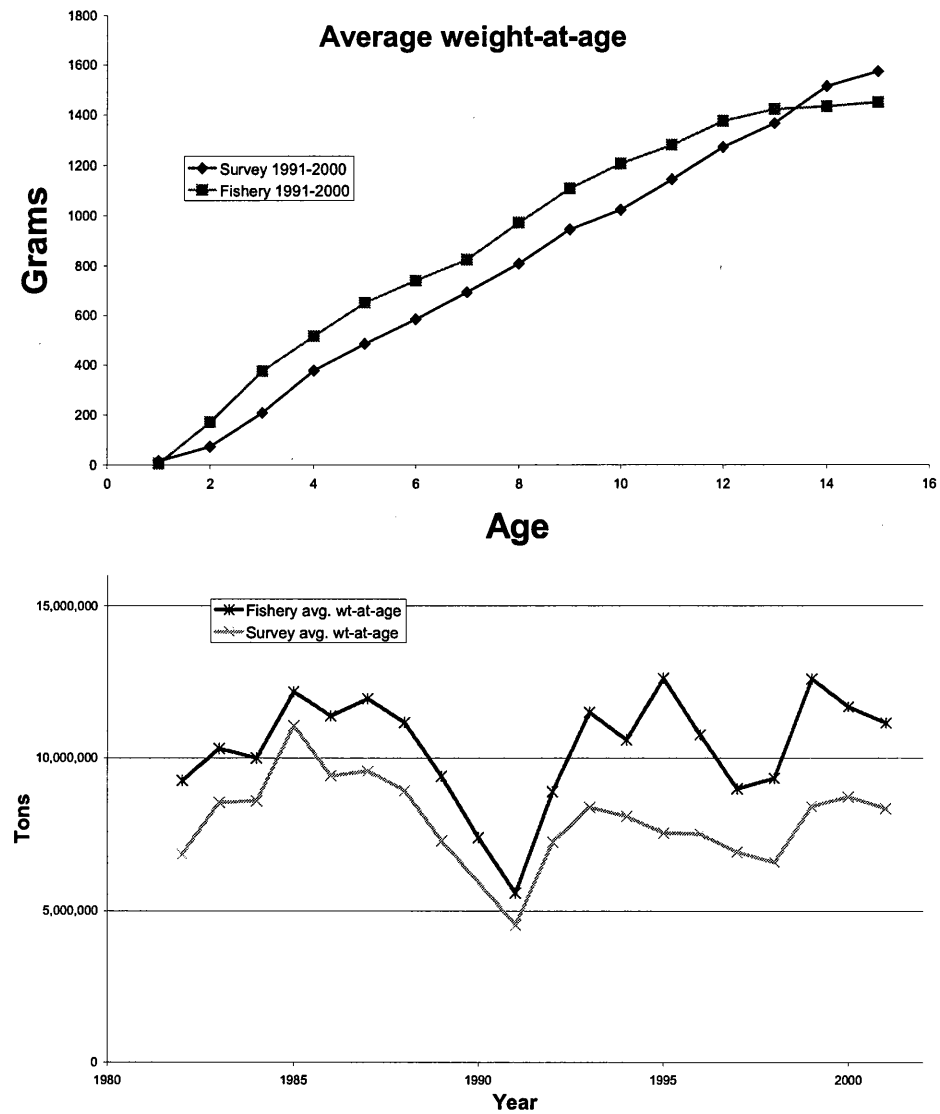


Figure 1.27. Mean EBS pollock weights-at-age as observed from NMFS bottom-trawl survey and from the EBS fishery (top panel), and the effect on estimated age-3+ biomass values (bottom panel), 1991-2000.

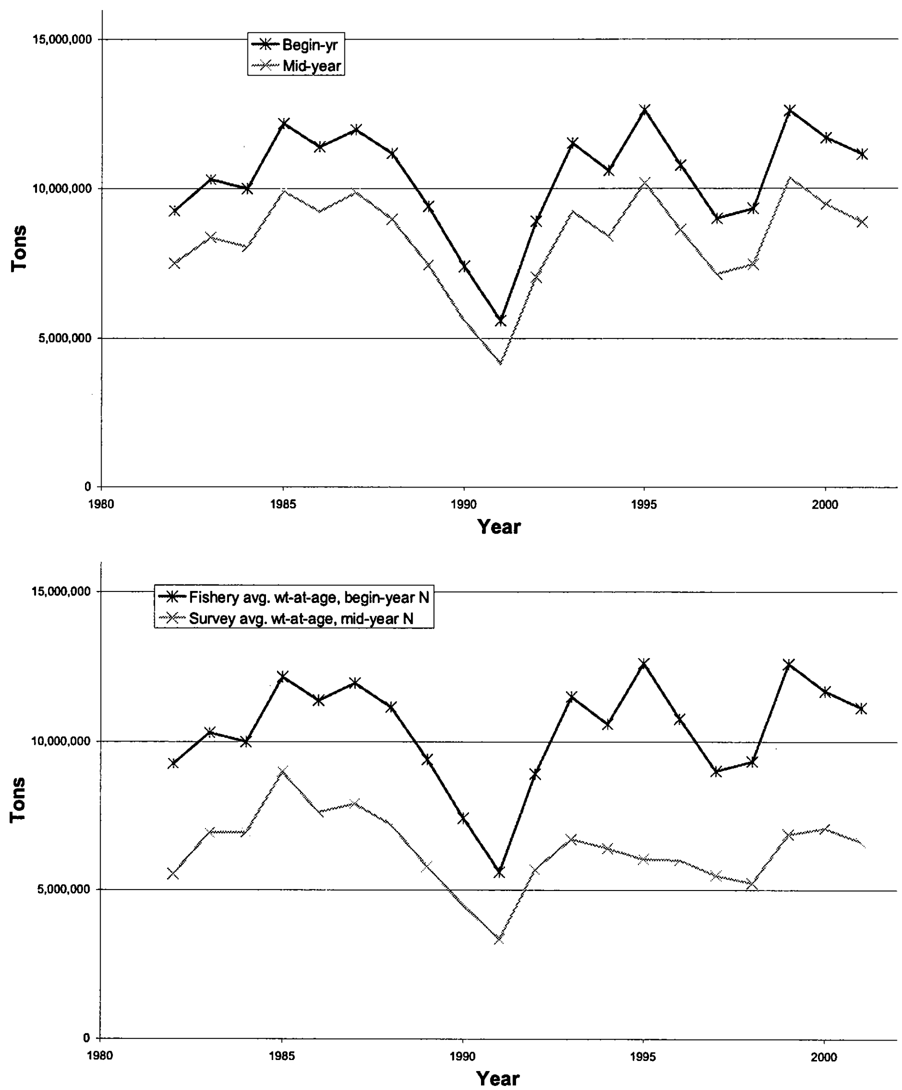


Figure 1.28. Age 3+ EBS pollock biomass computed using mean fishery-weights-at-age with begin-year numbers-at-age and mid-year numbers-at-age (top panel) and again but with mid-year numbers at age part using bottom-trawl survey average weights-at-age (bottom panel).

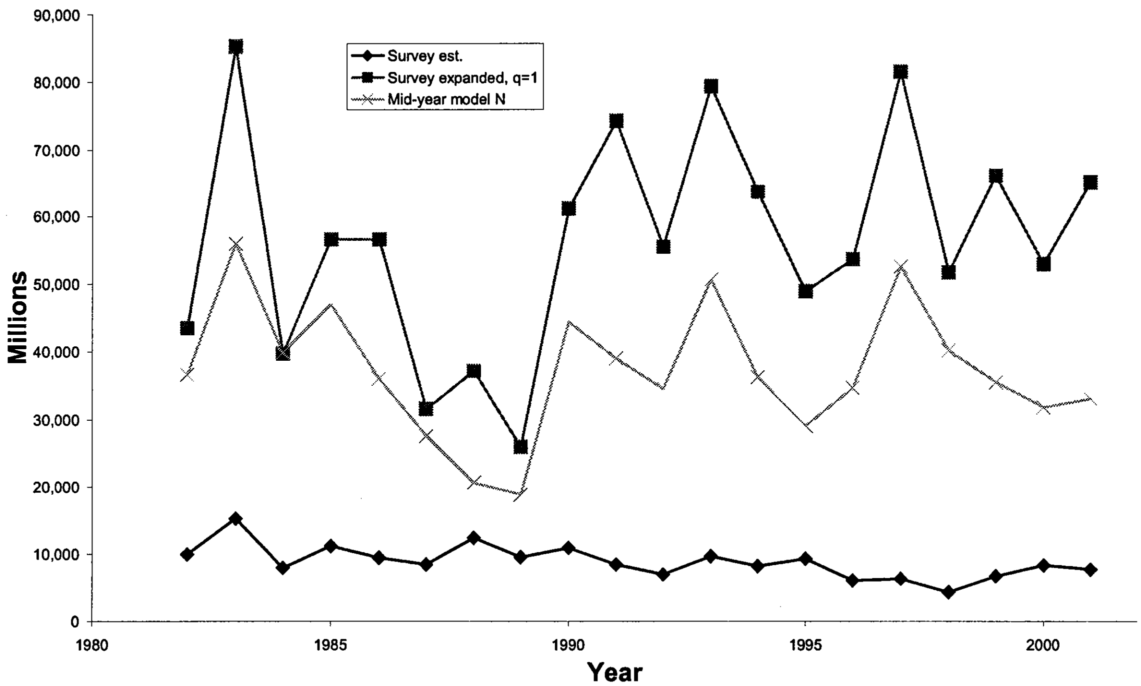


Figure 1.29. EBS pollock abundance as estimated by the bottom-trawl survey, as expanded by the age-specific availability, and as predicted by the stock assessment model.

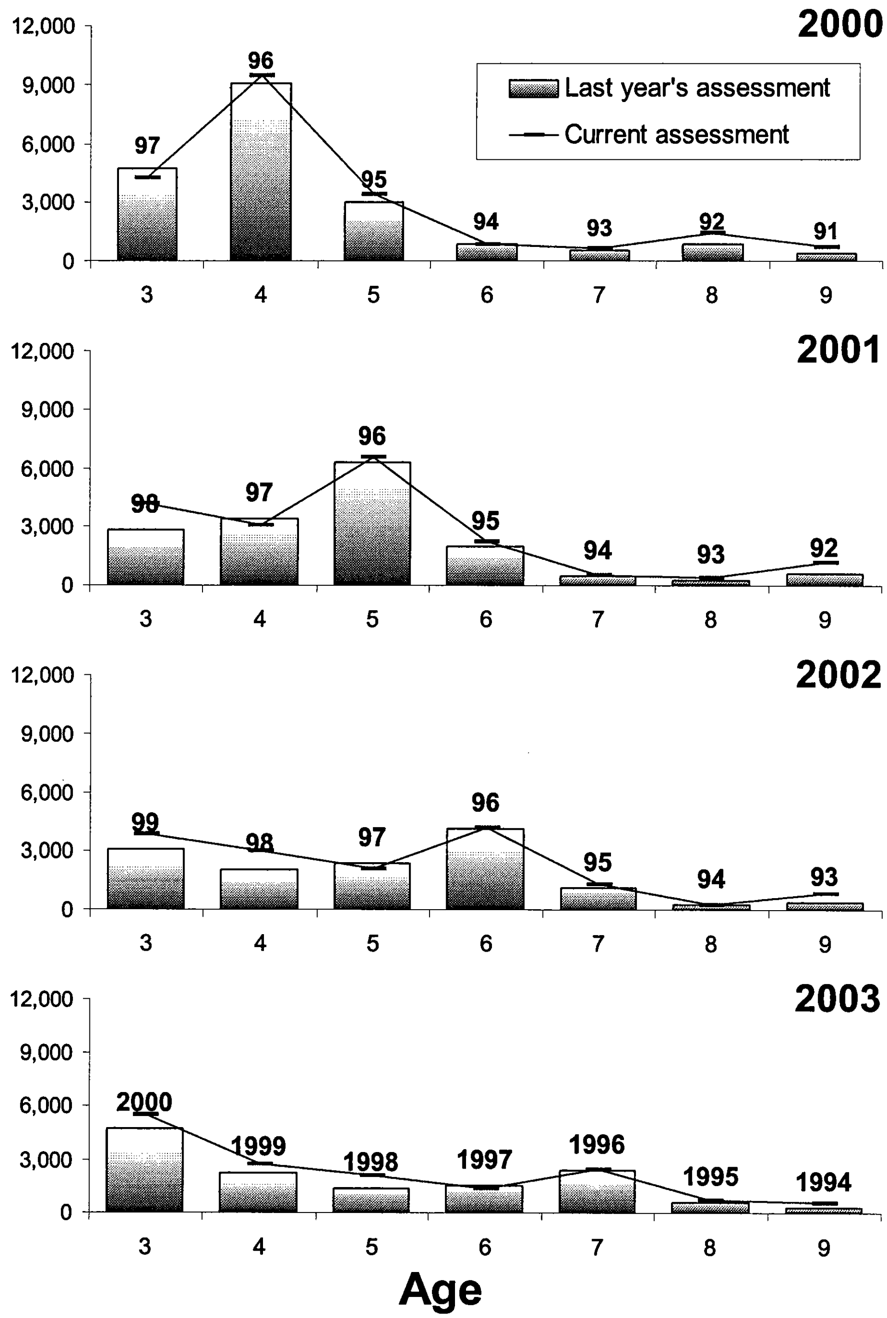


Figure 1.30. Projected EBS walleye pollock Model 1 population numbers at age compared with those presented in the last assessment (Model 1 from Ianelli *et al.*2000). Note that the "age 9" category represents all pollock age 9 and older.

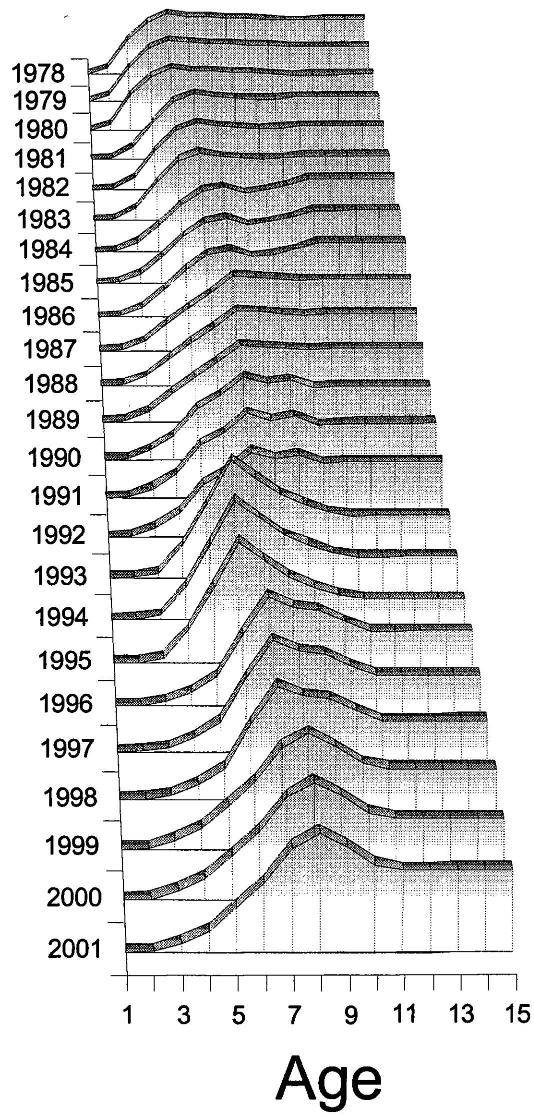


Figure 1.31. Selectivity at age estimates for the EBS walleye pollock fishery, 1978-2001 estimated for Model 1.

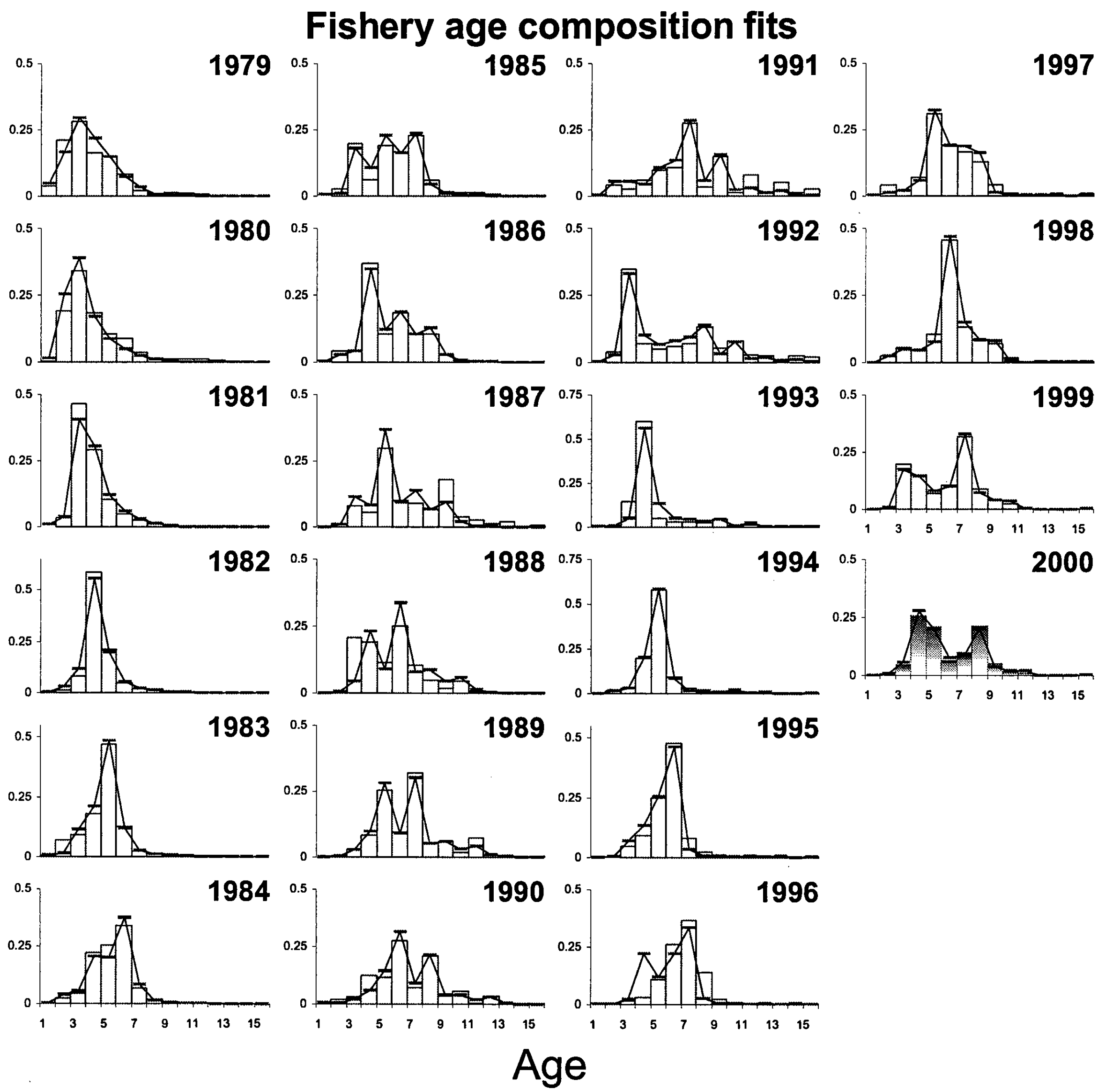


Figure 1.32. Model 1 fit to the EBS walleye pollock fishery age composition estimates (1979-2000). Lines represent model predictions while the vertical columns represent the data. Data new to this assessment are shaded.

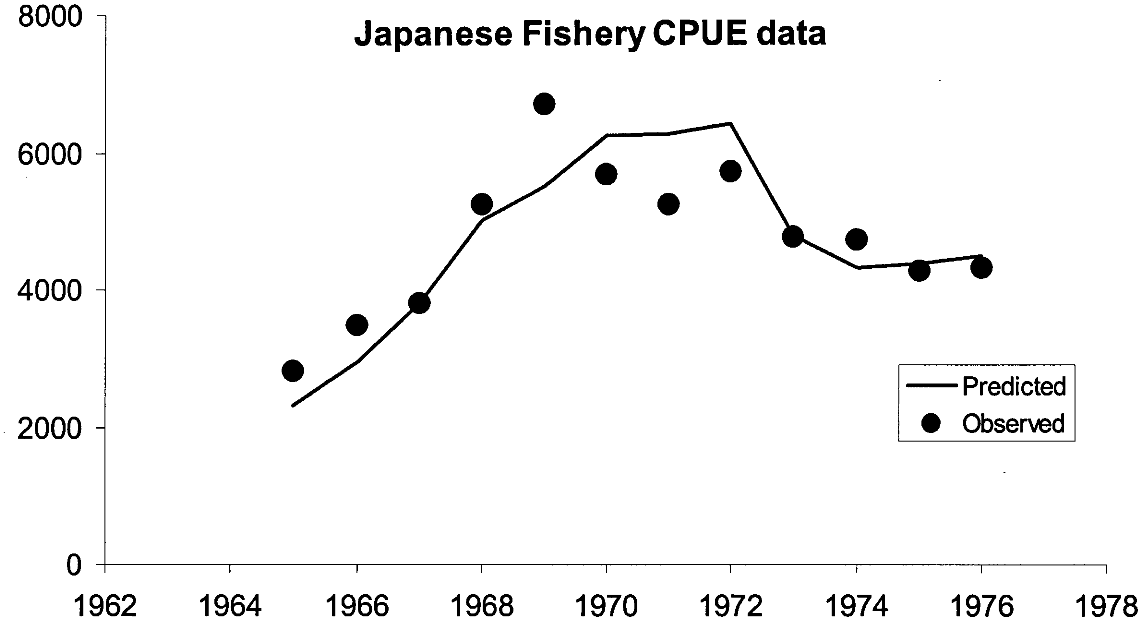


Figure 1.33. Model 1 fit to the EBS walleye pollock fishery CPUE data from Low and Ikeda (1980).

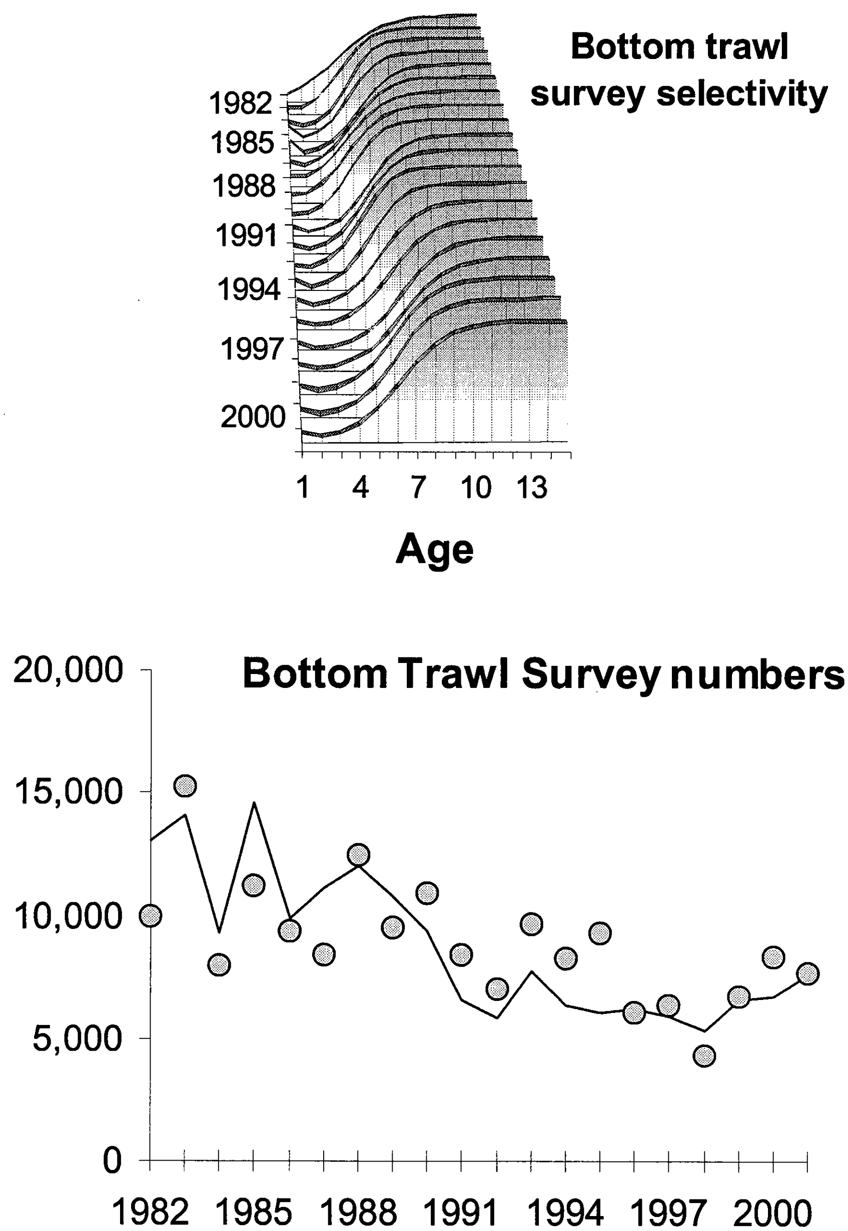


Figure 1.34. Estimates of bottom-trawl survey numbers (lower panel) and selectivity-at-age (with maximum value equal to 1.0) over time (upper panel) for EBS walleye pollock, Model 1.

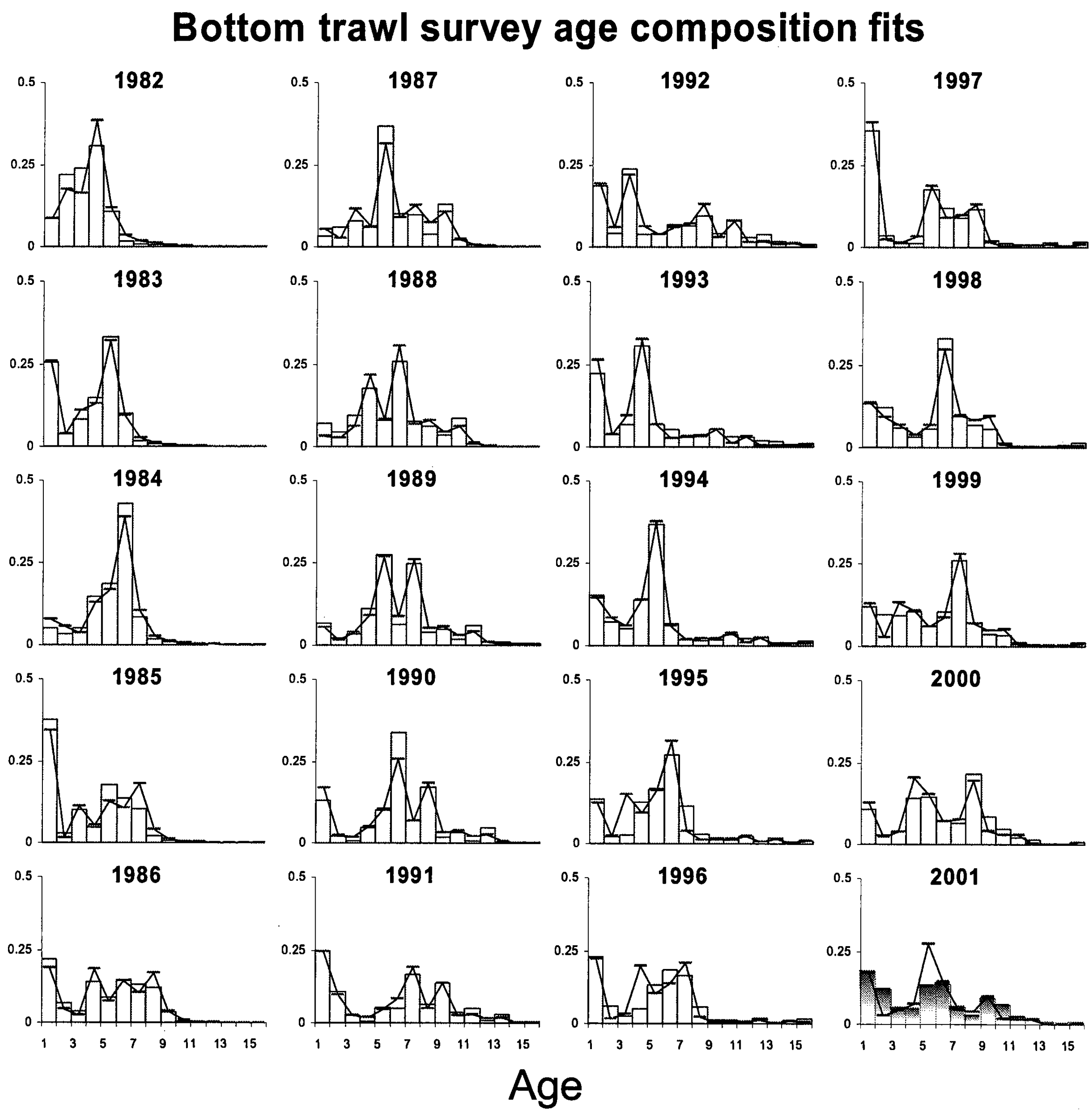


Figure 1.35. Model 1 fit to the bottom trawl survey age composition data (proportions) for EBS walleye pollock. Lines represent model predictions while the vertical columns represent the data. Data new to this assessment are shaded (2001).

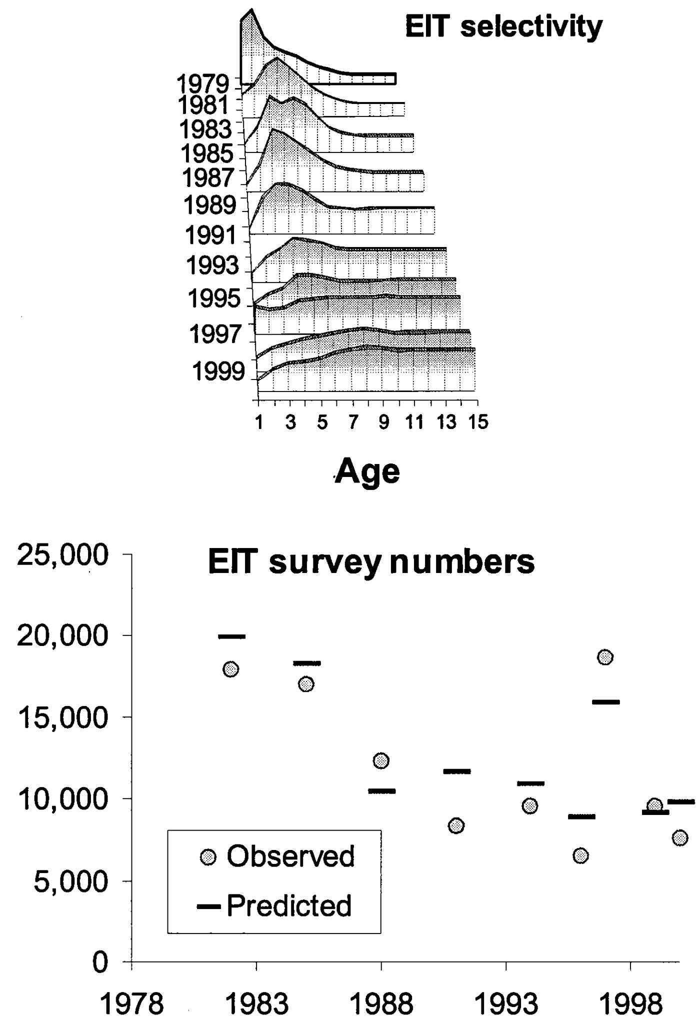


Figure 1.36. Model 1 estimates of EIT survey numbers (lower panel) and selectivity-at-age (with mean value equal to 1.0) over time (upper panel) for EBS walleye pollock. Note that the 1979 value (observed=115,424; predicted=49,326) are not plotted.

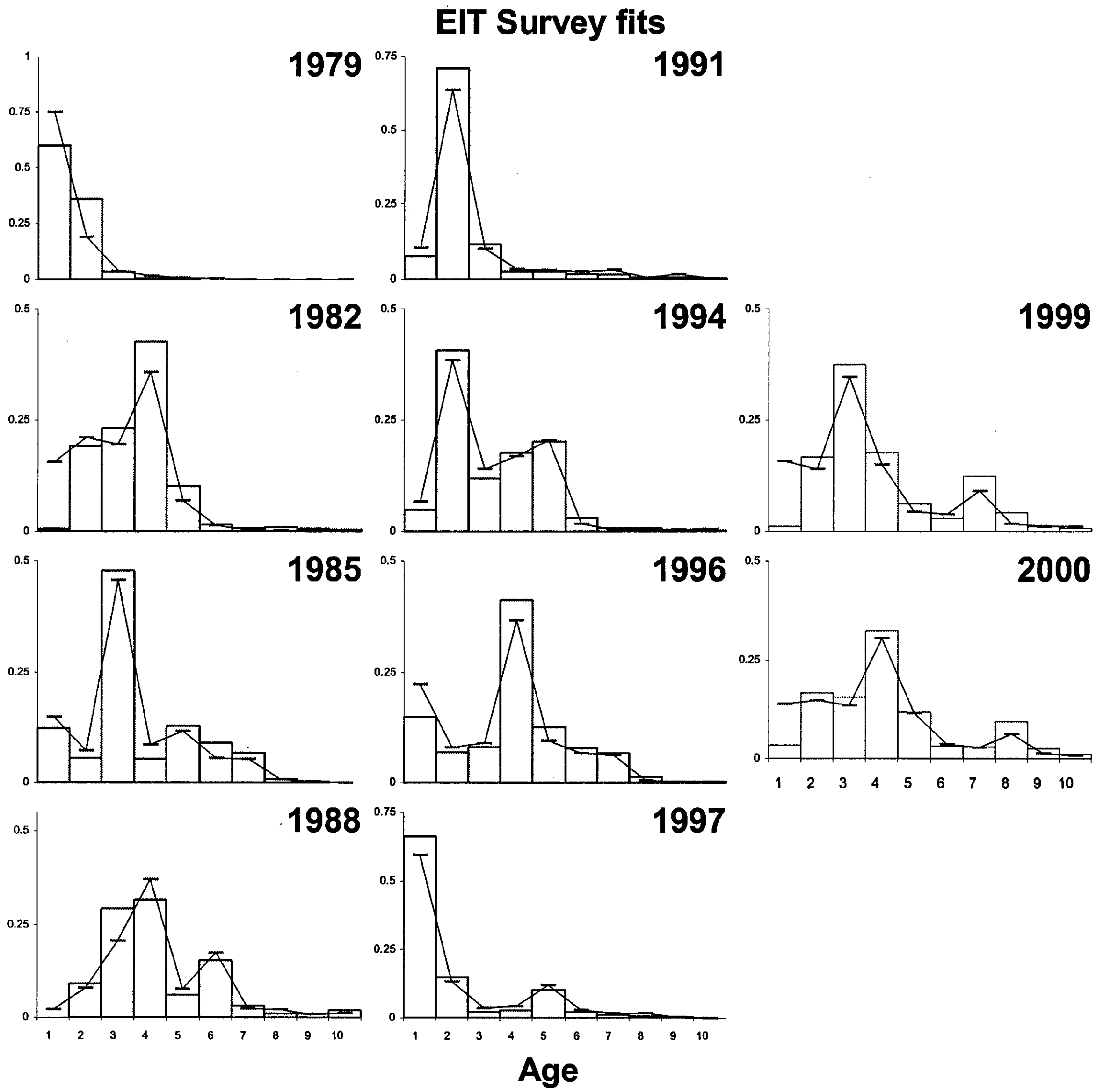


Figure 1.37. Model 1 fit to the EIT survey EBS walleye pollock age composition data (proportions). Lines represent model predictions while the vertical columns represent the data.

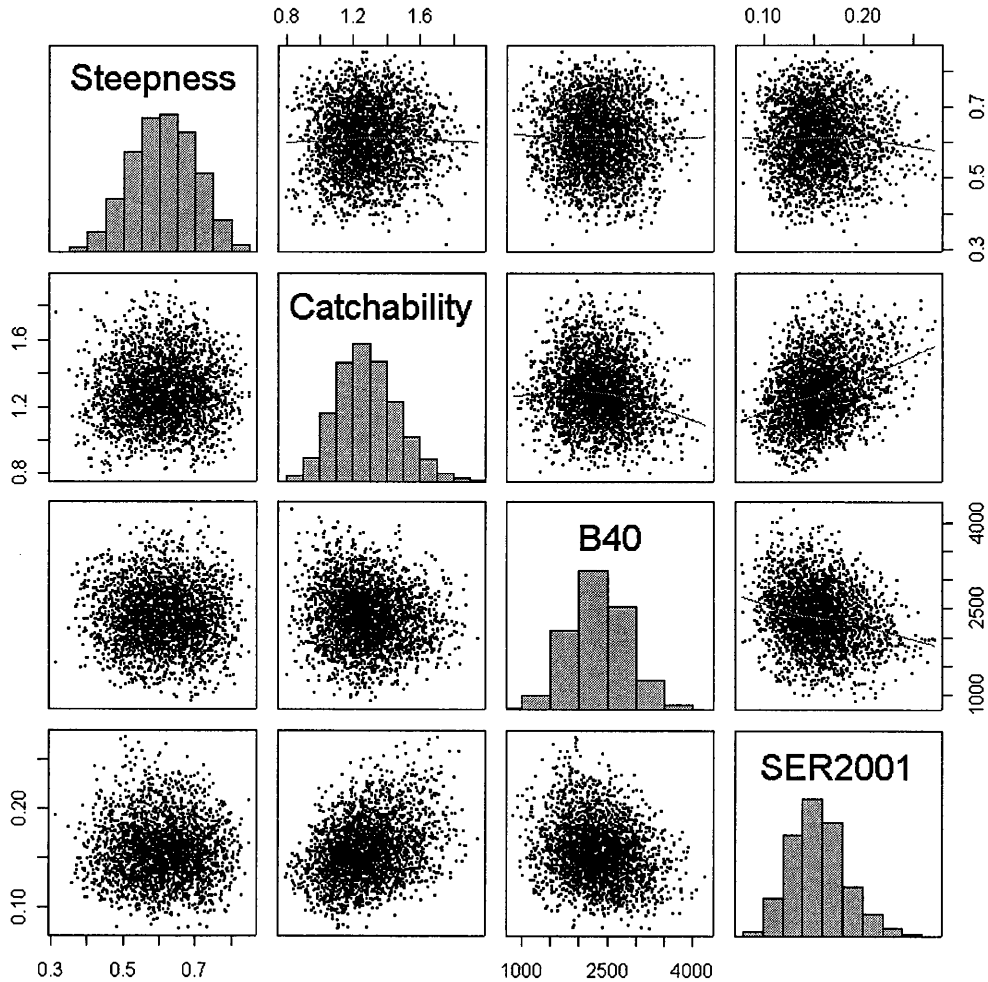


Figure 1.38. Pair-wise marginal plots of selected parameters of the joint posterior distribution based on a thinned MCMC chain used for integration.

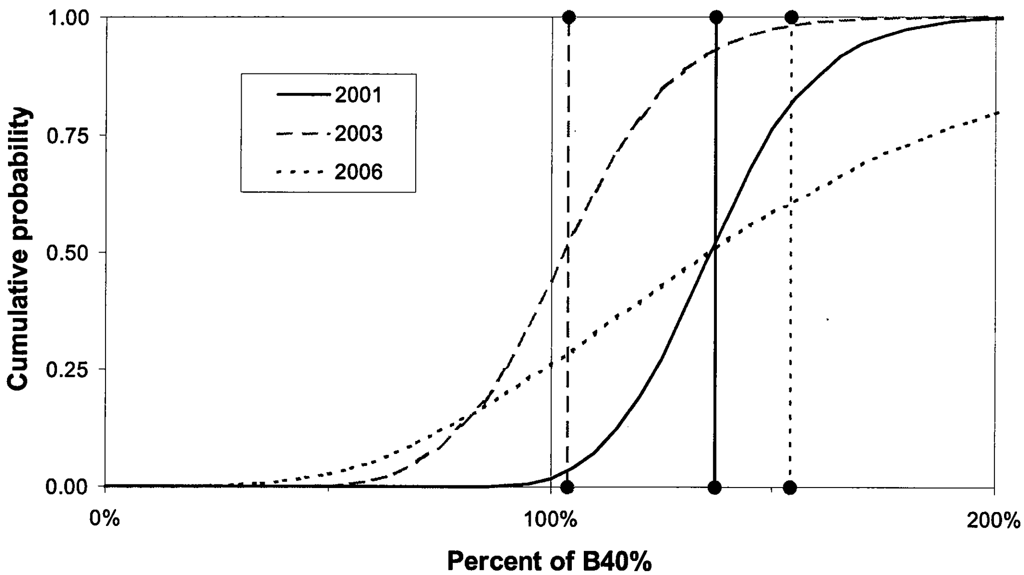


Figure 1.39. Cumulative probability that projected female spawning biomass levels will drop below $B_{40\%}$ based on a fixed constant catch levels of 1.3 million tons. Marginal distributions the full joint posterior distribution based on a thinned MCMC chain used for integration. Corresponding expected values (means) are shown by the vertical lines terminated with closed circles.

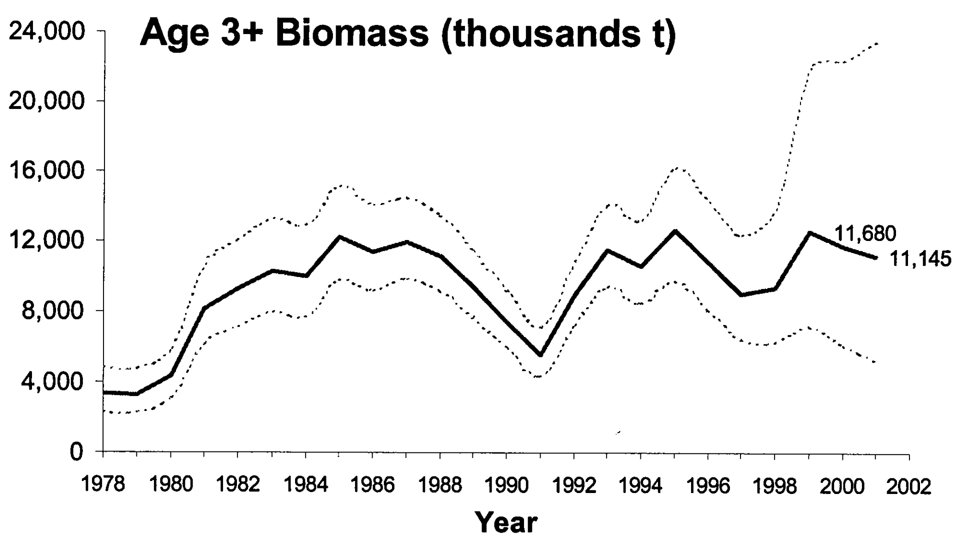


Figure 1.40. Estimated age 3+ EBS walleye pollock biomass under Model 1, 1978-2001. Approximate upper and lower 95% confidence limits are shown by dashed lines. Note: average fishery weights-at-age are applied to begin-year numbers-at-age to compute these values.

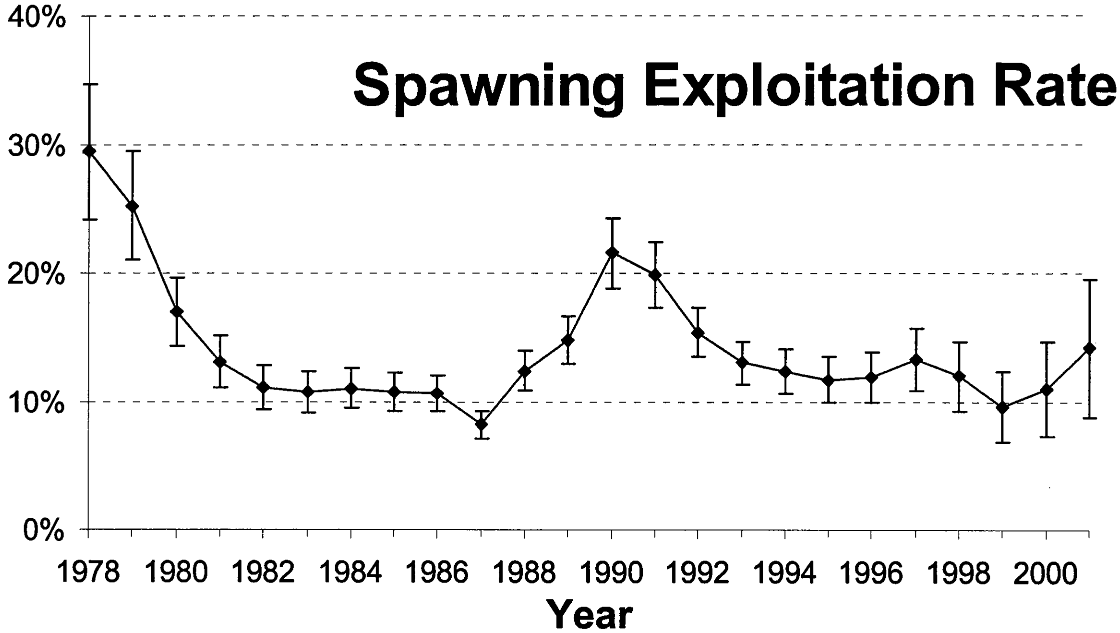


Figure 1.41. Estimated spawning exploitation rate (computed as the percent removals of spawning females each year) for EBS walleye pollock, Model 1. Error bars represent two standard deviations from the estimate.

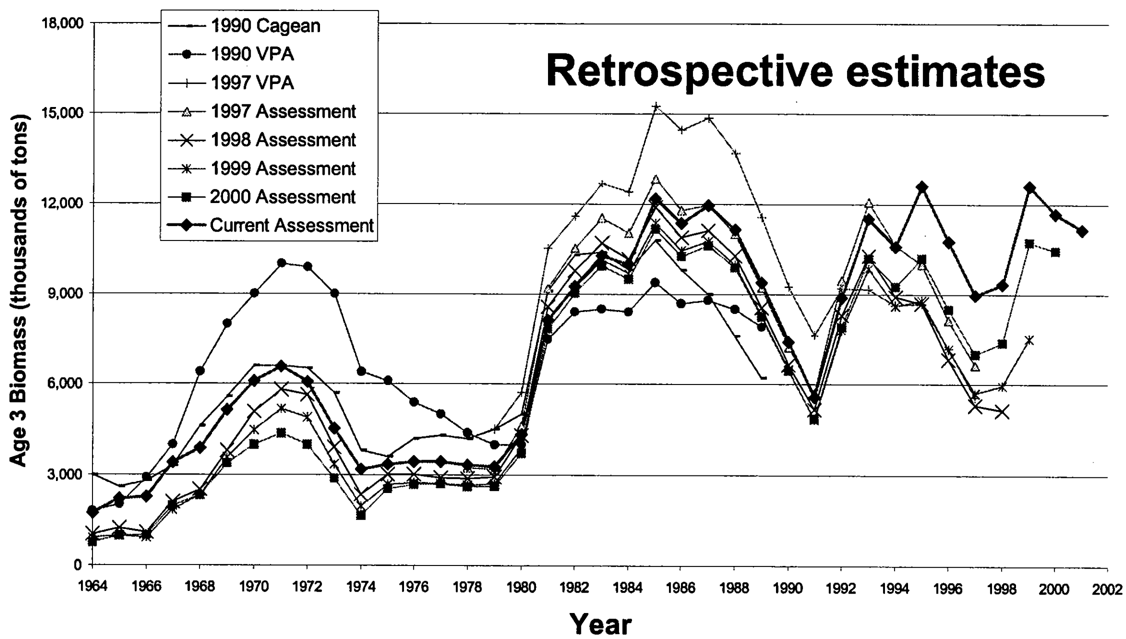


Figure 1.42. Comparison of the current assessment results with past assessments of begin-year EBS age-3+ pollock biomass.

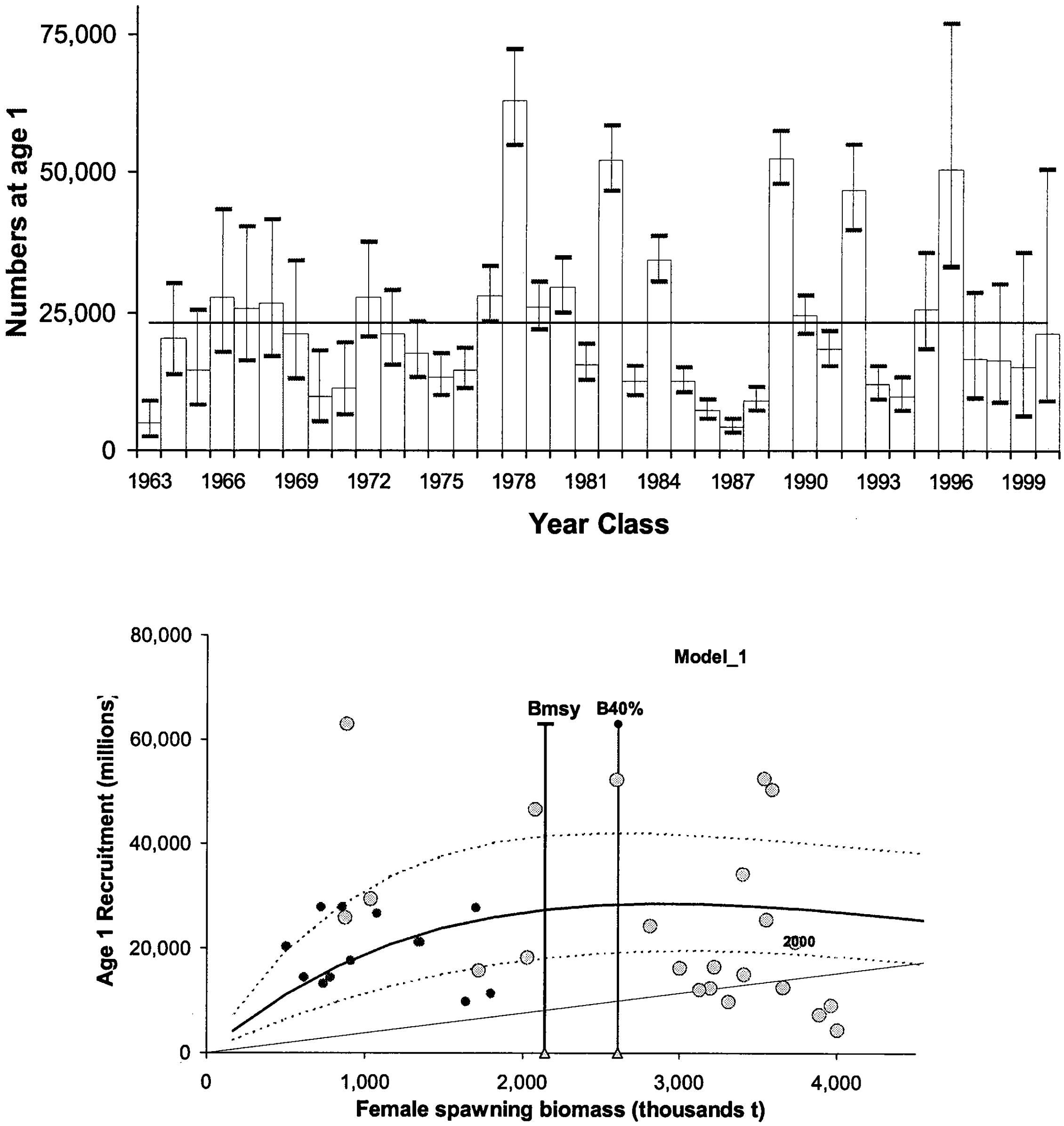


Figure 1.43. Year-class strengths by year (as age-1 recruits, upper panel) and relative to female spawning biomass (thousands of tons, lower panel) for EBS walleye pollock, Model 1. Solid line in upper panel represents the mean recruitment for all years since 1964. Vertical lines in lower panel indicate B_{msy} and $B_{40\%}$ level, curve represents fitted stock-recruitment relationship with diagonal representing the replacement lines with no fishing. Dashed lines represent lower and upper 95% confidence limits about the curve.

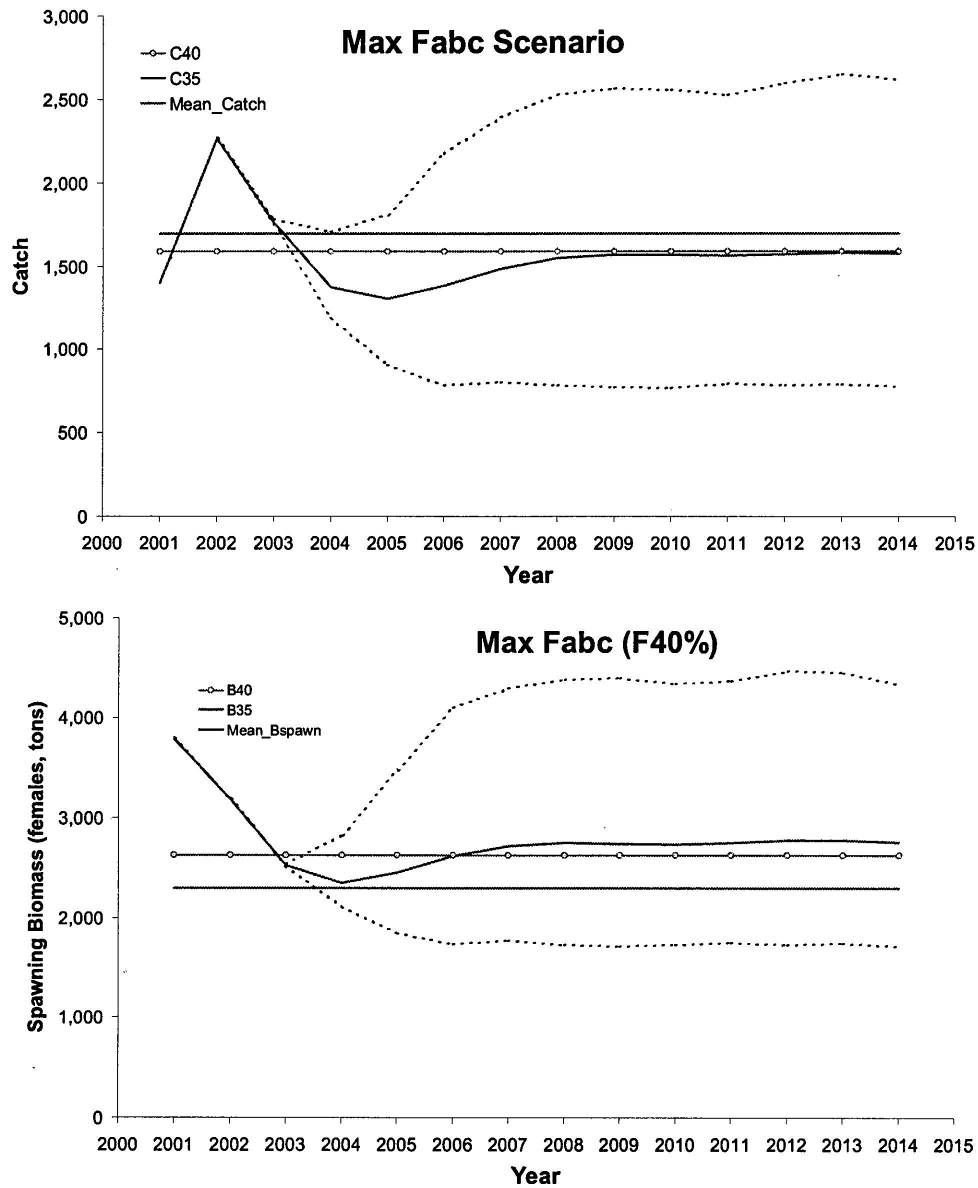


Figure 1.44. Projected EBS walleye pollock **yield** (top) and **Female spawning biomass** (bottom) relative to the long-term expected values under $F_{35\%}$ and $F_{40\%}$ (horizontal lines) for Model 1. $B_{40\%}$ is computed from average recruitment from 1978-2001. Future harvest rates follow the guidelines specified under Scenario 1, max F_{ABC} assuming $F_{ABC} = F_{40\%}$.

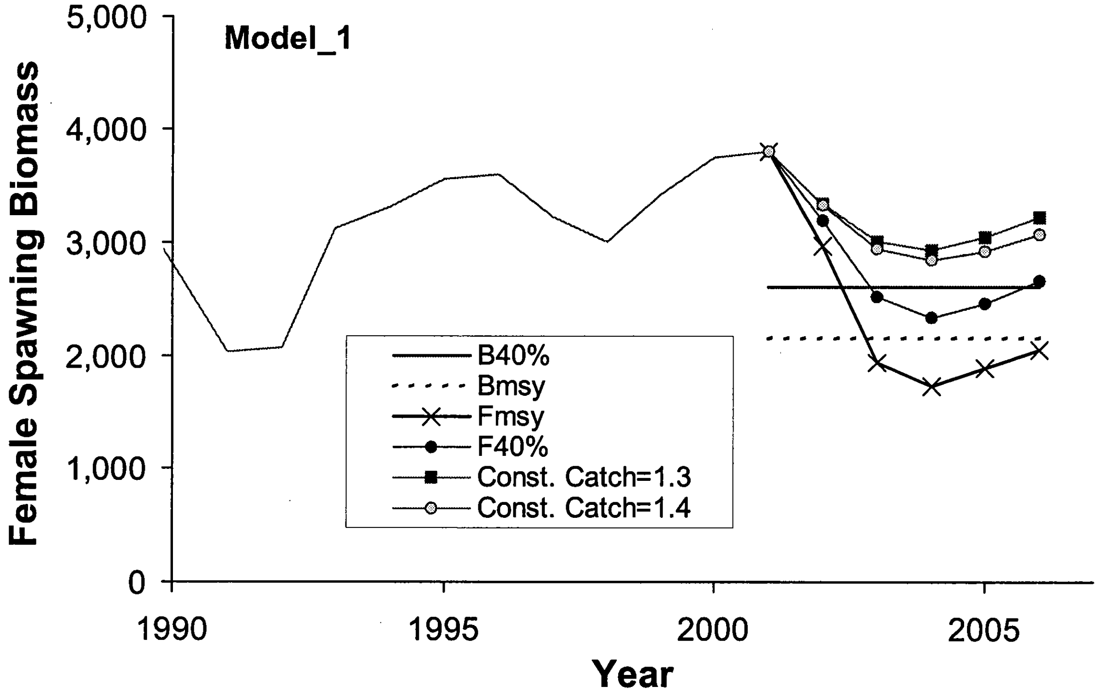
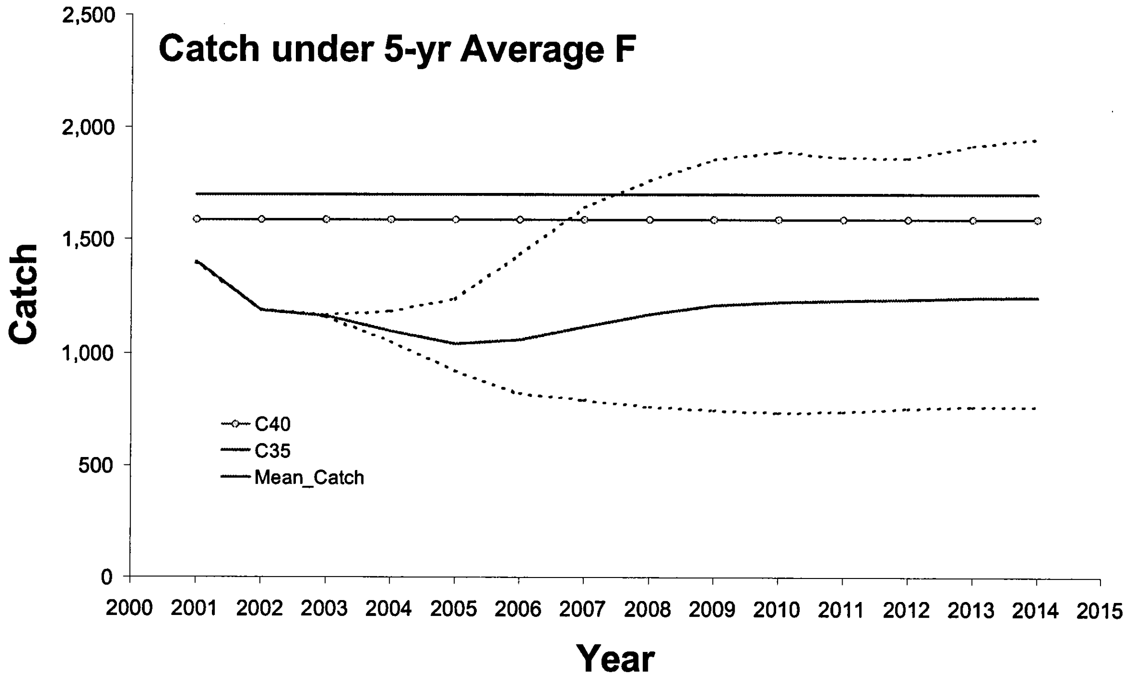


Figure 1.45. EBS walleye pollock female spawning biomass abundance trends, 1990-2006 as estimated by Model 1 and projections to 2006 at different catch strategies. Note that the F_{msy} catch levels are unadjusted. Horizontal solid and dashed lines represent the B_{msy}, and $B_{40\%}$ levels, respectively.



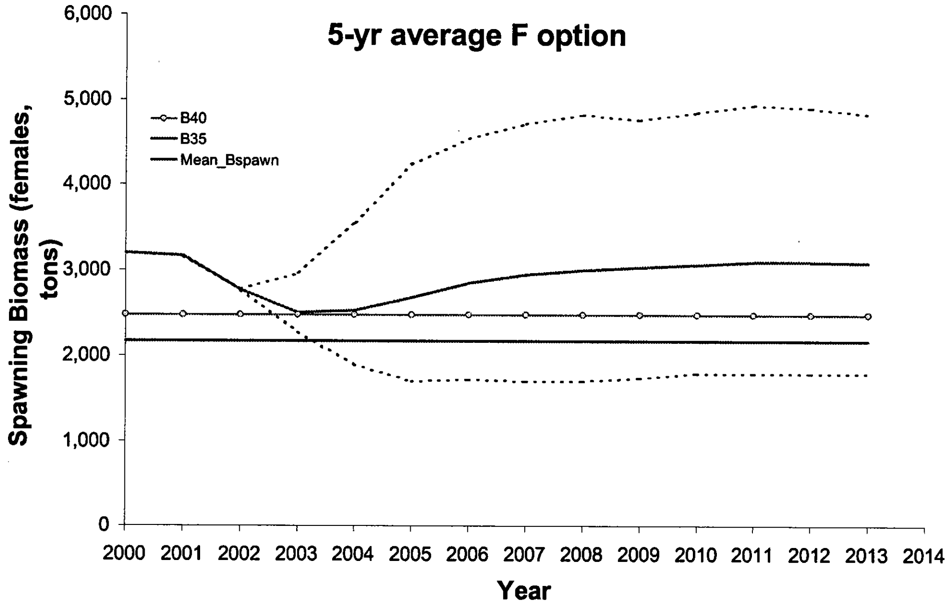


Figure 1.46. Projected EBS walleye pollock yield (top) and spawning biomass (bottom) under F equal to the mean value from 1997-2001 relative to the long-term expected values under $F_{35\%}$ and $F_{40\%}$ (horizontal lines) for Model 1.

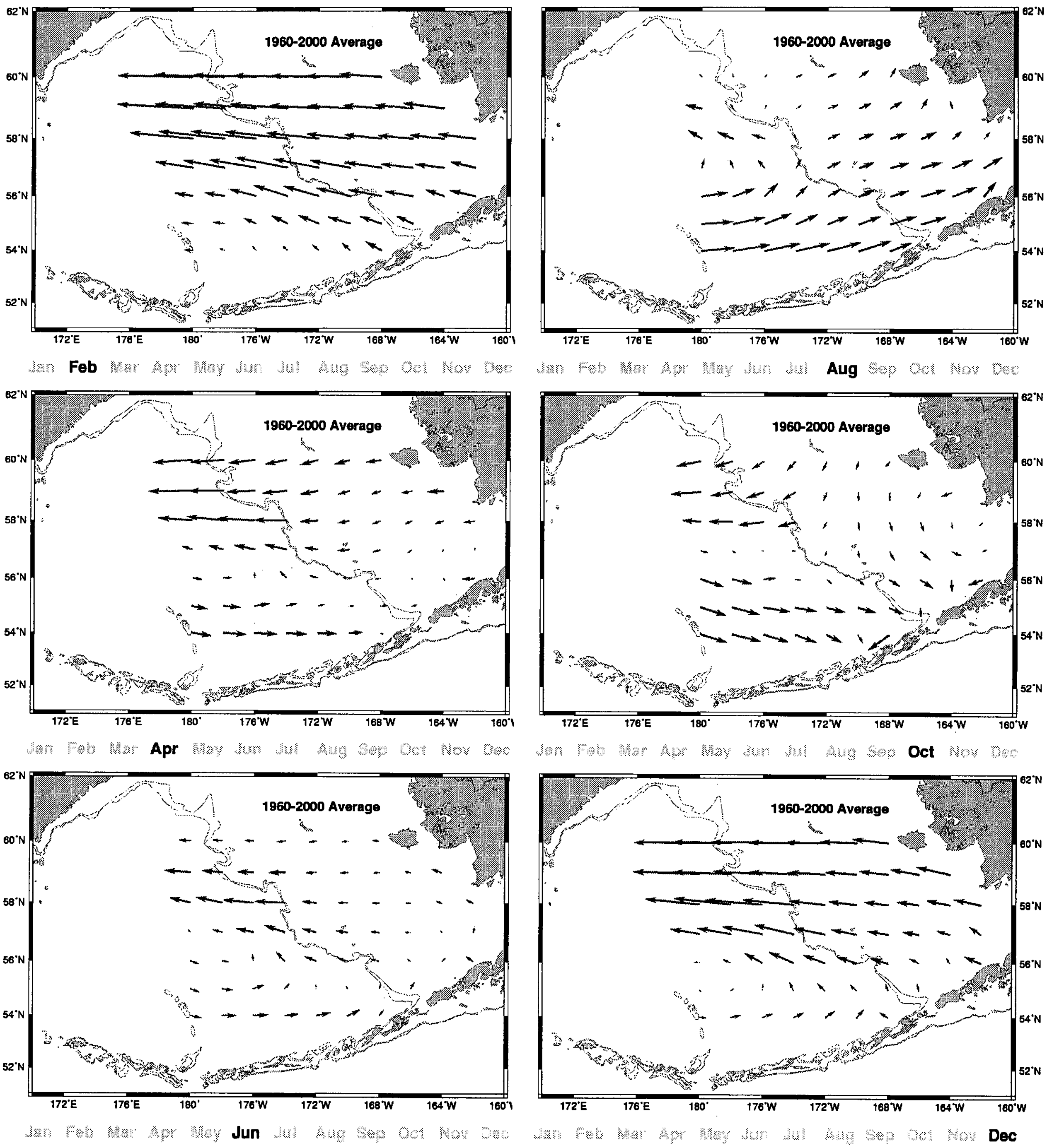


Figure 1.47. Average surface currents based on the OSCURS model, 1960-2000 for February, April, June, August, October and December.

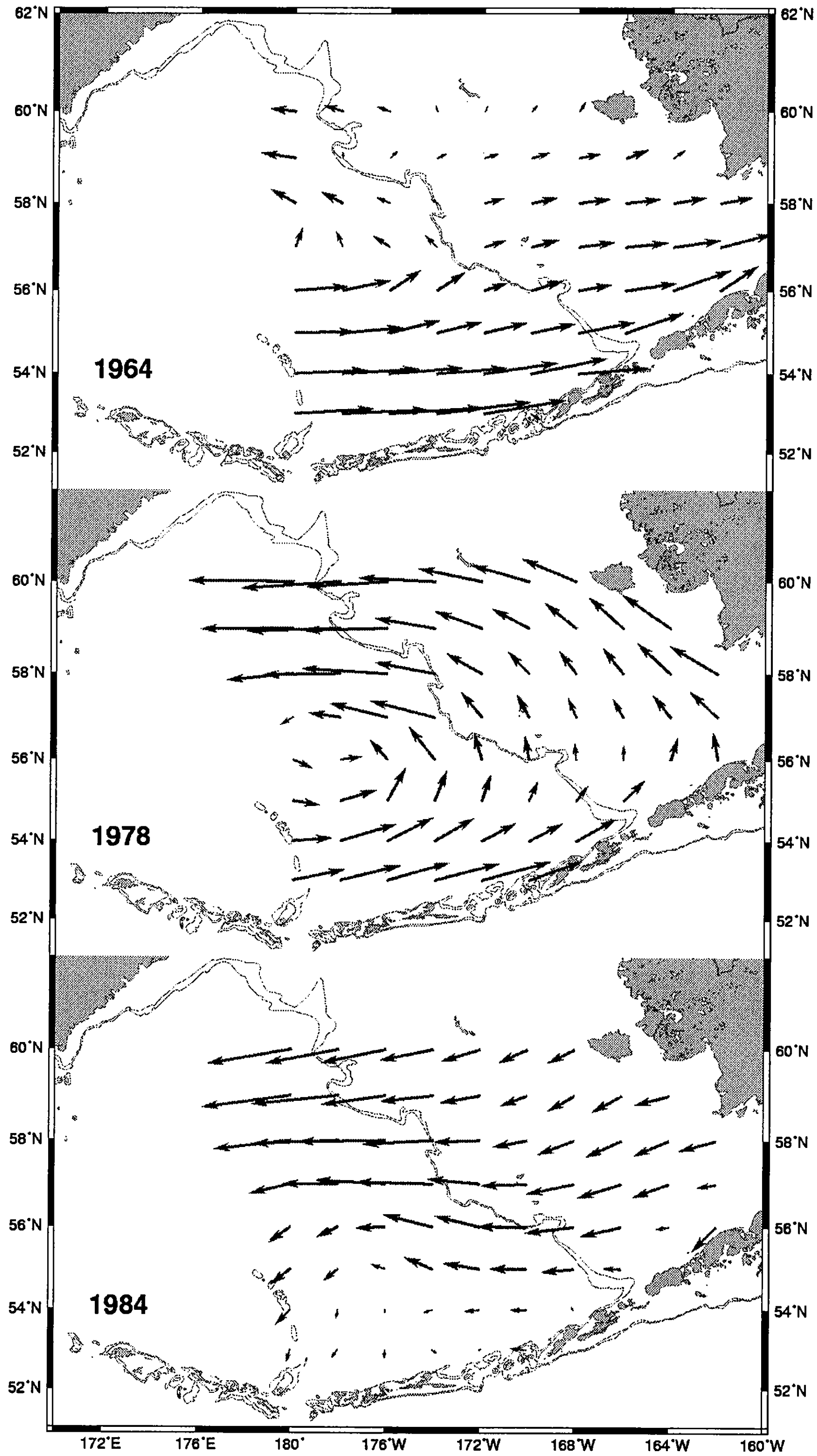


Figure 1.48. Average surface currents for **April** based on the OSCURS model in 1964, 1978, and 1984.