UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
Resource Assessment and Conservation Engineering Division
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May 20, 1996

PRELIMINARY CRUISE RESULTS

NOAA SHIP *MILLER* FREEMAN, CRUISE NO. 96-02

VARIANCE ESTIMATION STUDY OF ECHO INTEGRATION-TRAWL SURVEY DATA IN THE SHUMAGIN ISLANDS AREA

CRUISE PERIOD, AREA, AND SCHEDULE

Scientists from the Alaska Fisheries Science Center (AFSC) conducted a series of replicate echo integration-trawl (EIT) surveys of walleye pollock (Theragra *chalcogramma*) as part of a variance estimation study aboard the NOAA ship Miller Freeman during February 15-25, 1996. The cruise began and ended in Dutch Harbor, Alaska. The survey covered an area north of the Shumagin Islands that included Stepovak Bay, Unga Strait, and the Shumagin Gully.

The itinerary for the Miller Freeman was as follows (dates are local):

Feb 15	Embark scientists in Dutch Harbor, Alaska
Feb 15-16	Transit to Shumagin Islands area; en route conduct sphere calibration in Belkofski Bay
Feb 17-24	Conduct variance estimation study
Feb 24	Transit to Dutch Harbor
Feb 25	Disembark scientific personnel; end of cruise

OBJECTIVES

Principal objectives of the cruise were to collect echo integration and midwater-trawl data to:

1. determine the distridution, biomass, and biological composition of pollock in the survey area;

2. evaluate one- and two-dimensional geostatistical approaches to variance estimation; and

3. investigate diel changes in abundance and distribution of pollock.

Secondary objectives were to:

1. collect pollock target strength data for scaling echo integration data to estimates of absolute abundance;

2. calibrate two centerboard-mounted acoustic systems using standard sphere techniques;

3. collect and preserve whole stomachs from pollock, Pacific cod (*Gadus* macrocephalus), arrowtooth flounder (Atheresthes stomias), and all species of shark other than spiny dogfish (*Squalus* acanthius) for food habits studies (contact: Patricia Livingston, AFSC);

4. collect mature pollock ovaries to assess interannual variations in fecundity (contact: Bern Megrey, AFSC);

5. spawn mature pollock and culture fertilized eggs for laboratory experiments on larval growth rates and metabolism (contact: Kevin Bailey, AFSC);

6. collect adult pollock for food habits reference samples for the National Marine Mammal Laboratory (NMML) (contact: Kathryn Chumbley, AFSC);

7. collect micronekton samples with fine-mesh nets attached to trawl gear (contact: Jay Orr, AFSC);

8. collect physical oceanographic data including temperature and salinity profiles at selected sites, plus continuously monitor sea surface parameters (e.g., temperature, salinity, light level, and productivity); and

9. Collect water current profiles using the vessel's acoustic Doppler current profiler (ADCP) system (contact: Ned Cokelet, Pacific Marine Environmental Laboratory).

VESSEL? ACOUSTIC EQUIPMENT? AND TRAWL GEAR

The survey was conducted on board the NOAA ship Miller Freeman, a 66-m (216-foot) stern trawler equipped for fisheries and

oceanographic research. Two Simrad[1] split-beam transducers, one operating at 38 kHz and the other at 120 kHz, were mounted on the bottom of the vessel's centerboard. With the centerboard fully extended, the transducers were 9 m below the water surface. System electronics were housed in a portable laboratory mounted on the vessel's weather deck. Acoustic data were collected at both frequencies with a quantitative echo sounding system (Simrad EK500). Data from the Simrad EK500 echo sounder/receiver were stored and processed using Simrad BI500 echo integration and target strength data analysis software on a SUN workstation.

Midwater echosign was sampled using an Aleutian wing 30/26 trawl (AWT). The AWT is a full-mesh wing trawl constructed of nylon except for 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 non-rotational dandylines, 453.6-kg (1,000-lb) tom weights on each side, and 5-m^2 (53.8-ft^2) "Fishbuster" doors [1,247.4 kg (2,750 lb)]. Trawl depth and vertical and horizontal openings were monitored with a WesMar third-wire system attached to the headrope of the trawl. Additionally, one or two small-mesh nets, each 6.1 m (20 ft) long with a 10.8-m^2 opening and 0.5-cm mesh, were attached to several locations along the AWT to try to sample micronekton and macrozooplankton near the path of the trawl.

Tow depth profiles for all trawls were obtained by attaching a microBT (small, retrievable temperature profiler) to the net. Water temperature and salinity profile data were collected at calibration sites with a Seabird CTD system. Sea surface oceanographic data and environmental data were collected using the Miller *Freeman*'s Scientific collection System (SCS). Ocean current profile data were provided by the vessel's centerboard-mounted ADCP system.

SURVEY METHODS

The variance estimation study in the Shumagin Islands area consisted of eight independent surveys, a time replicate experiment, and a set of eight orthogonal transects (Table 1). The starting point of each survey was selected at random. The first three replicate surveys, with parallel transects oriented east-west and spaced two nmi apart, covered Stepovak Bay south to Korovin Island (Fig. 1, "A"). Acoustic data from these surveys indicated that most of the biomass was concentrated in two

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

regions--an eastern subarea and a western subarea. At this point, the original experimental design was modified to make the most efficient use of remaining vessel time. Two replicate surveys were conducted in the eastern subarea with parallel transects oriented roughly east-west and spaced one nmi apart (Fig. 1, "B"). Likewise, two replicate surveys were conducted in the western subarea with parallel transects oriented roughly north-south and spaced one nmi apart (Fig. 1, "C"). An abbreviated survey of the western end of the Shumagin Gulley (Fig. 1, "D") was conducted upon completion of the replicate survey work.

The time replicate experiment consisted of repeated sampling along two transects -- one in the eastern subarea and one in the western subarea (Fig. 2, dashed lines). Each transect was replicated eight times. Measurements were made over a 22-hour period between replicate surveys 2 and 3.

A set of transects orthogonal to the transect direction of the first three replicate surveys was collected thoughout the study period (Fig. 2, solid lines). A total of eight orthogonal transects ranging in length from 5-11 nmi form this data set. All but one of these orthogonal transects were conducted at night.

Favorable weather conditions permitted an average vessel speed of between 10 and 12 knots while running transects. Both acoustic systems (38 kHz and 120 kHz) collected echo integration data and split-beam target strength data concurrently. Echo integration data from the 38-kHz system will be used to provide estimates of pollock abundance. There are no plans at this time to analyze data from the 120-kHz system.

Collection of target strength data required suitable conditions (e.g., low fish density, monospecific aggregation, unimodal size distribution, and calm seas) and involved passing repeatedly (at speeds of less than 4 kts) over an aggregation of pollock, then collecting biological data from hauls conducted just after collection of acoustic data. These target strength data will be interpreted along with historical target strength information, and then used to scale echo integration values from the 38 kHz transducer to provide estimates of pollock density (numbers/m^2).

Midwater trawl hauls were made at selected locations (Fig. 3) to identify echosign and to provide biological samples. Average trawling speed was about 3 knots. The vertical net opening for the Aleutian wing trawl averaged 31 m and ranged from 20 to 36 m. Standard catch sorting and biological sampling procedures were used to provide weight and number by species for each haul. Pollock were further sampled to determine sex, fork length (FL), body weight, age, maturity, and mature ovary weight. An electronic scale was used to determine all weights taken from

individual pollock specimens. Fork lengths of adult and juvenile pollock were measured to the nearest cm and recorded with a Polycorder measuring device (a combination of bar code reader and hand-held computer), then downloaded into a personal computer. During past EIT surveys, maturities had been determined by visual inspection of gonads based on a five-stage scale: immature, developing, pre-spawning (mature), spawning, and post-spawning (spent). In winter 1996 EIT surveys, maturities were determined by visual inspection using a new eight-stage scale that attempts to better describe spawning stages and provide similar maturity data among participating nations. The eight-stage scale can be expressed in terms of the five-stage scale as follows: immature, developing 1 and 2, pre-spawning 1 and 2, spawning, and post-spawning 1 and 2. Pollock stomachs, mature ovaries, and Pacific cod stomachs were preserved in a 10% formalin solution. Pollock for the NMML study were frozen whole. Midwater catches from the fine-mesh net(s) attached to the AWT were processed by weighing the non-gelatinous portion, preserving it in 10% formalin, then weighing and discarding the gelatinous portion.

PRELIMINARY RESULTS

Standard sphere calibrations

Four standard sphere calibrations were conducted before, during, and after the cruise. Both the 38-kHz and 120-kHz acoustic systems were calibrated each time. Calibration results for the 38-kHz system are presented in Table 2. For the calibrations, the *Miller Freeman* was anchored fore and aft in 72-102 m of water. Acoustic properties of two copper spheres suspended below the transducer were measured. split-beam target strength and echo integration data collected with the Simrad EK500 system described acoustic system gain parameters and transducer beam pattern characteristics. No significant differences in gain parameters or transducer beam pattern characteristics for the 38-kHz system were observed among any of the four calibrations.

EIT surveys

Trackline mileage (including transit and mileage for haul operations) totaled approximately 2,079 nmi. Pollock densities observed during the first three replicate surveys were consistently low in the northern portion of Stepovak Bay and consistently high just east of Renshaw Point (Fig. 4). In contrast, densities changed markedly east of Korovin Island. The first replicate survey detected low concentrations of pollock in this area, then the next two replicate surveys detected much higher concentrations. Replicate surveys 4-7 continued to observe high concentrations of pollock east of Renshaw Point and east of Korovin Island (Figs. 5 and 6). Distribution of pollock densities observed while running orthogonal transects (Fig. 7)

was consistent with observations made during the seven replicate surveys. Low pollock densities were detected during the abbreviated survey of Shumagin Gully (Fig. 6). Representative day and night time replicate transects are presented in Figure 8. Average density observed along the transect in the western subarea remained relatively constant throughout the time replicate experiment. However, in the eastern subarea, average density underwent a dramatic reduction at night. For both subareas, the variation from one density output to the next along the transect was much less at night than in the day.

Biological data were collected and specimen and tissue samples were preserved from six Aleutian wing trawl hauls. Trawl station and catch data are summarized in Table 3. Oceanographic data were collected from two CTD casts (Table 4) and six microBT casts (Table 5).

Pollock was the most abundant fish species captured (Table 6), accounting for greater than 98% of catch composition by weight. Types of biological data and numbers of samples and measurements collected from pollock and Pacific cod are listed in Table 7. Pollock captured in trawls ranged in length from 12 cm to 66 cm. Raw length measurements were summed into an unweighted length frequency distribution (Fig. 9). Male pollock averaged 49.6 *cm* long; females averaged 51.7 cm. Sex ratios were markedly different between the three trawls conducted north of Korovin Island (Fig. 3) and the three done east of the island. Of 896 pollock sexed in hauls 1-3, 94.3% were male. (In haul 3, all sexed pollock were male.) In hauls 4-6, sex ratios were more balanced (1,040 pollock sexed, 48.0% male).

Maturity compositions for both sexes of pollock are shown in Fig. 10. Of 584 males sampled, 47% were in a pre-spawning condition, 13% were spawning, and 39% were in a post-spawning condition. Of 272 females, 60%, 7%, and 30% were in pre-spawning, spawning, and post-spawning conditions, respectively. The mean gonado-somatic index (GSI: gonad weight/total body weight) for mature, pre-spawning pollock females was 0.19 (Fig. 11). Maturity composition and mean GSI from pollock caught in hauls 1-3 did not differ from those caught in hauls 4-6.

Target strength data collection

Target strength data were collected and hauls were made on the early morning (local time) of February 17 (haul 1) and February 24 (haul 6). Although haul 1 was 95.6% pollock by number, haul 6 was 61.5% pollock, 35.6% eulachon, and 2.2% Pacific cod by number. Adult pollock in haul 1 averaged about 50 cm and ranged from 43 to 59 cm long. Adult pollock from haul 6 were similar, averaging 51 cm and ranging from 43 cm to 63 cm. For the two hauls, a total of five juvenile pollock (<25 cm) were caught along with the adults.

SCIENTIFIC PERSONNEL

Name	Sex/ Nationality	Position	Organization
Neal Williamson	M/USA	Chief Scientist	AFSC
Daniel Twohig	M/USA	Instrument Chief	AFSC
Steve de Blois	M/USA	Fish. Biologist	AFSC
Mike Guttormsen	M/USA	Fish. Biologist	AFSC
Taina Honkalehto	F/USA	Fish. Biologist	AFSC
Vladimir Vologdin	M/Russia	Acoustician	TINRO

AFSC - Alaska Fisheries Science Center, Seattle, WA
TINRO - Pacific Research Institute of Fisheries and Oceanography Vladivostok, Russia

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Table 1. Summary of surveys conducted during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02. Times are GMT. Sunrise was approximately 1800, sunset 0400.

	Start Date	Start Time	End Date	End Time	Duration (hr:min)	Diel Period (Day/Night)	Direction	Area
replicate surveys								
1	17 Feb	1901	18 Feb	1223	17:22	D - N	south	A
2	18 Feb	1907	19 Feb	1439	19:32	D - N	north	A
3	20 Feb	1856	21 Feb	1629	21:33	D - N	south	A
4	21 Feb	1758	22 Feb	0835	15:37	D - N	south	B
5	22 Feb	0945	22 Feb	1714	07:29	N	west	C
6	22 Feb	2050	23 Feb	0449	07:59	D	east	C
7	23 Feb	0500	23 Feb	1852	13:52	N	south	B
Shumagin Gully survey								
8	24 Feb	0315	24 Feb	0714	03:59	D - N	east	D
time replicates								
901.1	19 Feb	1815	19 Feb	1934	01:19	D	west	B
901.2	19 Feb	1957	19 Feb	2104	01:07	D	west	C
902.2	19 Feb	2107	19 Feb	2209	01:02	D	east	C
902.1	19 Feb	2229	19 Feb	2338	01:09	D	east	B
903.1	19 Feb	2343	20 Feb	0110	01:27	D	west	B
903.2	20 Feb	0133	20 Feb	0242	01:09	D	west	C
904.2	20 Feb	0247	20 Feb	0348	01:01	D	east	C
904.1	20 Feb	0407	20 Feb	0522	01:15	N	east	B
905.1	20 Feb	0527	20 Feb	0650	01:23	N	west	B
905.2	20 Feb	0711	20 Feb	0817	01:06	N	west	C
906.2	20 Feb	0822	20 Feb	0923	01:01	N	east	C
906.1	20 Feb	0943	20 Feb	1054	01:11	N	east	B
907.1	20 Feb	1059	20 Feb	1212	01:13	N	west	B
907.2	20 Feb	1234	20 Feb	1335	01:01	N	west	C
908.2	20 Feb	1339	20 Feb	1439	01:00	N	east	C
908.1	20 Feb	1500	20 Feb	1618	01:18	N	east	B
orthogonals								
150	17 Feb	1122	17 Feb	1205	00:43	N	north	C
152	17 Feb	1806	17 Feb	1833	00:27	D	north	A
155	18 Feb	1249	18 Feb	1312	00:23	N	north	C
250	19 Feb	1455	19 Feb	1523	00:28	N	south	A
251	19 Feb	1526	19 Feb	1602	00:36	N	south	A
252	19 Feb	1610	19 Feb	1707	00:57	N	south	B
350	21 Feb	1643	21 Feb	1737	00:54	N	south	A
450	22 Feb	0847	22 Feb	0912	00:25	N	north	B

Table 2. Summary of 38-kHz sphere calibrations conducted before, during, and after the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

Date	Location	Water Temp (deg. C)		Sphere Range from Transducer (m)	Gain (db)		3-db Beam Width (deg.)	Angle Offset	
		at Transducer*	at Sphere		TS	SV		Along	Athwart
4 Feb	Port Susan, WA	7.4	9.6	27.3	27.2	27.1	6.72	-0.11	-0.08
16 Feb	Belkofski Bay, AK	2.2	2.3	26.9	27.2	27.0	6.74	-0.09	-0.05
8 Mar	Nateekin Bay, AK	3.6	3.6	27.3	27.2	27.1	6.72	-0.10	-0.06
27 Mar	Malina Bay, AK	3.7	3.8	27.4	27.2	27.2	6.73	-0.10	-0.07
Feb-Mar	system settings during surveys	--	--	--	27.3	27.1	7.20""	-0.09	-0.02

* The transducer is located approximately 9 m below the water surface.

** 3-dB beamwidth setting differs from 3-dB beamwidths measured during calibrations because a new measurement algorithm was used during calibrations, not because of physical changes in the transducer.

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

Table 3. Summary of Aleutian wing trawl stations and catch data from the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

Haul		Time	Start Position		Depth (m)		Temp. (deg. C)		Pollock Catch		Other Catch	
No.	Date	(GMT)	Latitude (N)	Longitude (W)	Gear	Bottom	Gear	Surface	kg	number	kg	number
1	17 Feb	1547-1550	55 32.72	160 12.72	102	170	3.7	3.3	58.9	66	0.3	3
2	18 Feb	1425-1437	55 34.59	160 14.24	156	189	4.8	3.2	6,799.5	5,687	3.5	62
3	22 Feb	1859-1903	55 34.15	160 18.74	168	189	4.8	3.0	8,901.5	10,093	170.5	185
4	23 Feb	2022-2025	55 23.96	159 58.96	113	142	4.1	3.3	16,847.6	16,429	386.4	56
5	24 Feb	0104-0105	55 25.68	160 00.58	112	126	3.8	3.3	4,004.9	3,763	77.1	15
6	24 Feb	1022-1052	55 25.50	159 44.19	109	153	3.4	3.5	161.7	166	38.9	104

Table 4. Summary of CTD casts conducted during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

Cast	Event	Date	Time (GMT)	Position		Depth		Location
				Latitude (N)	Longitude (W)	CTD cast	Bottom	
1	sphere cal	4 Feb	2213	48 09.15	122 24.67	47	81	Port Susan, WA
2	sphere cal	17 Feb	0103	55 07.34	162 10.42	58	72	Belkofski Bay, AK

Table 5. Summary of MBT casts conducted during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

Drop	Haul	Date	Time (GMT)	Position		Depth (m)	
				Latitude (N)	Longitude (W)	MBT Cast	Bottom
1	1	17 Feb	1422-1618	55 32.72	160 12.72	74	170
2	2	18 Feb	1358-1508	55 34.59	160 14.24	131	189
3	3	22 Feb	1840-1921	55 34.15	160 18.74	134	189
4A.	4	23 Feb	2011-2043	55 23.96	159 58.96	80	142
4B	5	24 Feb	0052-0120	55 25.68	160 00.58	78	126
5	6	24 Feb	0958-1107	55 25.50	159 44.19	77	153

Table 6. Summary of catch by species in 6 Aleutian wing trawls during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

Common Name	Scientific Name	Weight (kg)	Percent	Numbers
Walleye Pollock	***Theragra chalcogramma***	36,774.1	98.2	36,204
Pacific Cod	***Gadus macrocephalus***	665.6	1.8	91
Eulachon	***Thaleichthys pacificus***	10.5	<0.1	331
Rock Sole	***Pleuronectes bilineatus***	0.5	<0.1	3
Scissortail Sculpin	***Triglops forficatus***	0.1	<0.1	1
Totals		37,450.8	100.0	36,630

Table 7. Summary of biological samples and measurements collected during the winter 1996 variance estimation study of EIT survey data in the Shumagin islands area, MF96-02.

Haul	Length	Maturity	Otoliths	Fish Weight	Ovary Weight	Pollock Stomachs	Pacific Cod Stomachs	Fecundity Samples'	NMML Pollock
1	66	66	66	66	4	20	--	1	--
2	268	150	150	150	4	20	--	4	--
3	298	168	168	168	--	7	--	--	30
4	297	150	150	150	44	20	2	12	--
5	270	157	157	157	74	20	4	6	--
6	166	165	166	166	31	--	3	1	--
Totals	1,365	856	857	857	157	87	9	24	30

Note -- Length includes samples from random length frequency only

* Fecundity samples include weights of liver, ovary, and whole body without stomach contents, plus otolith samples, maturity, and sex determination.

NMML = National Marine Mammal Laboratory

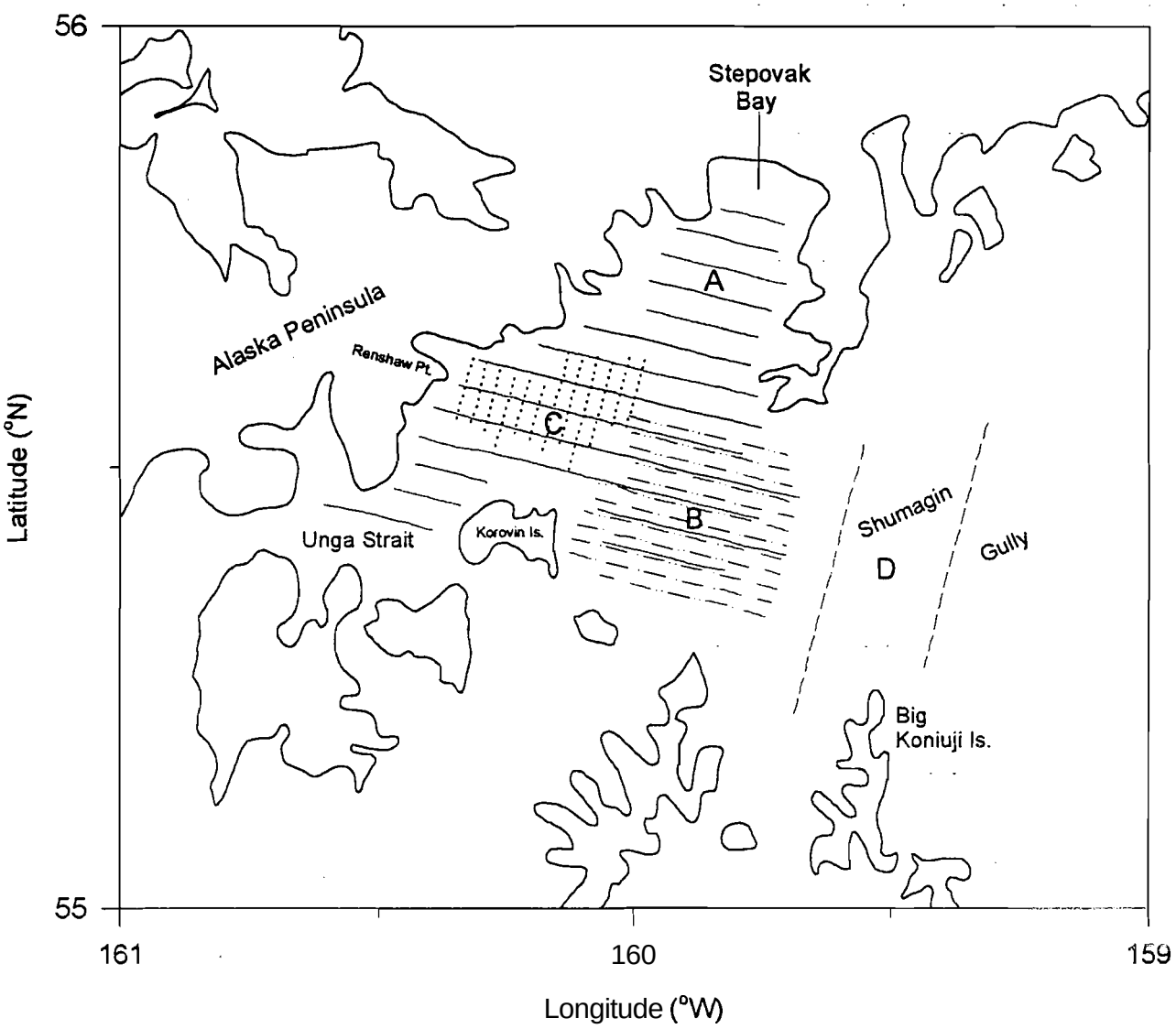


Figure 1. Representative tracklines used during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02. " A through "D" represent different areas covered by replicate surveys 1-7 and survey 8.

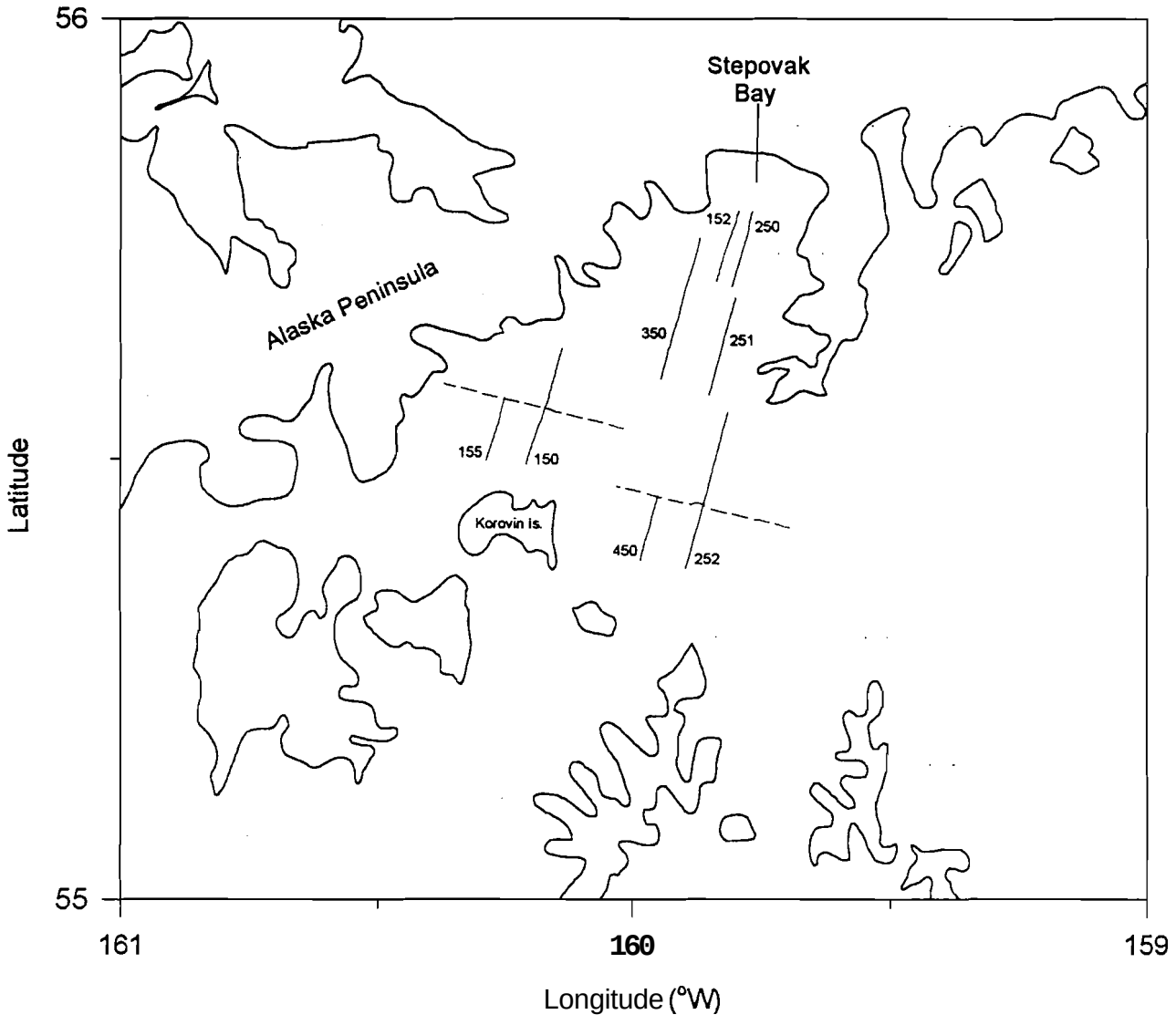


Figure 2. Time replicate transects (- - -) and orthogonal transects (——) used during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02. Orthogonal transect numbers are indicated.

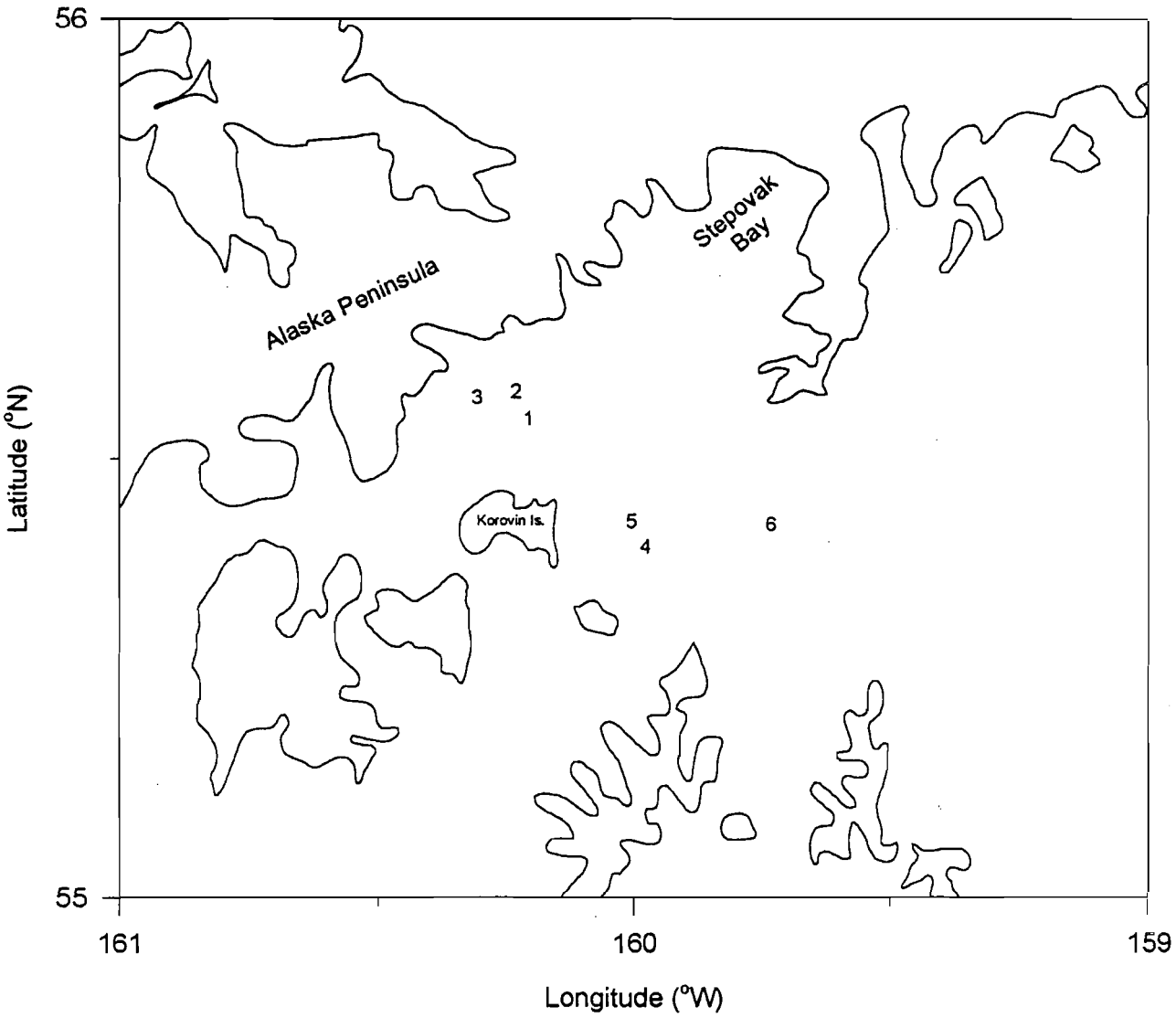
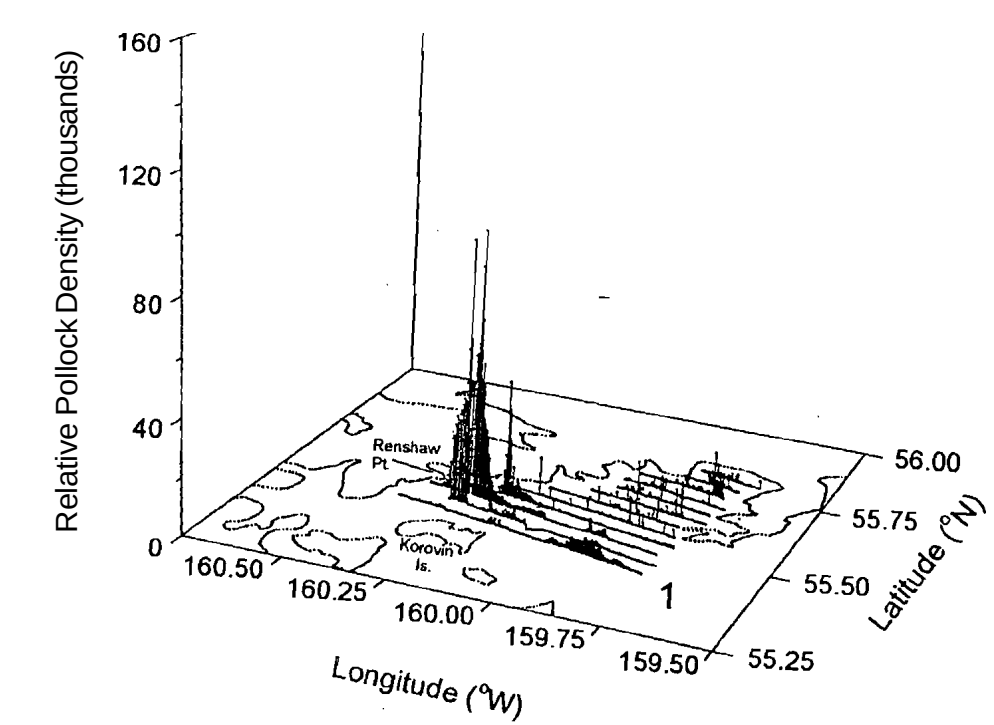
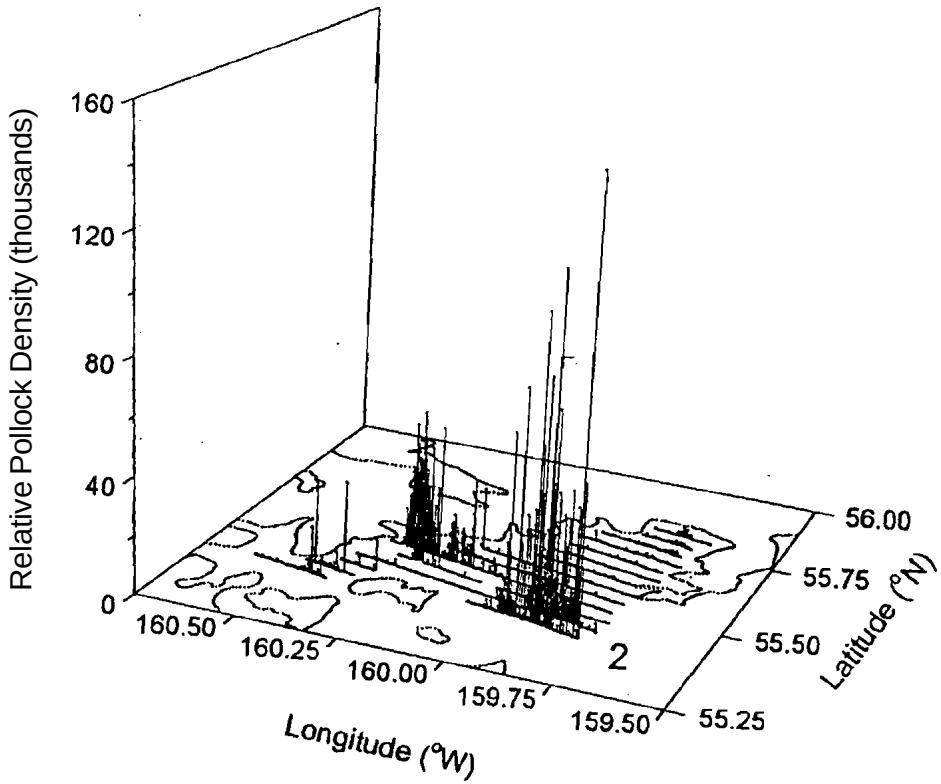


Figure 3. Aleutian wing trawl haul locations during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.





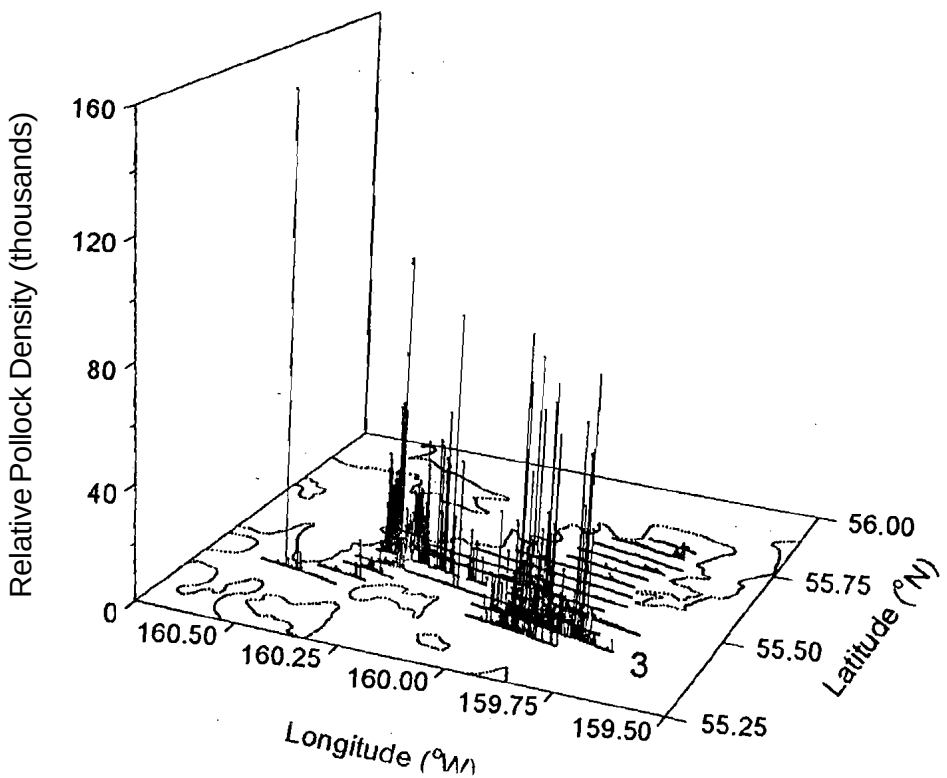


Figure 4. Relative pollock density along trackline from replicate surveys 1, 2, and 3 of the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

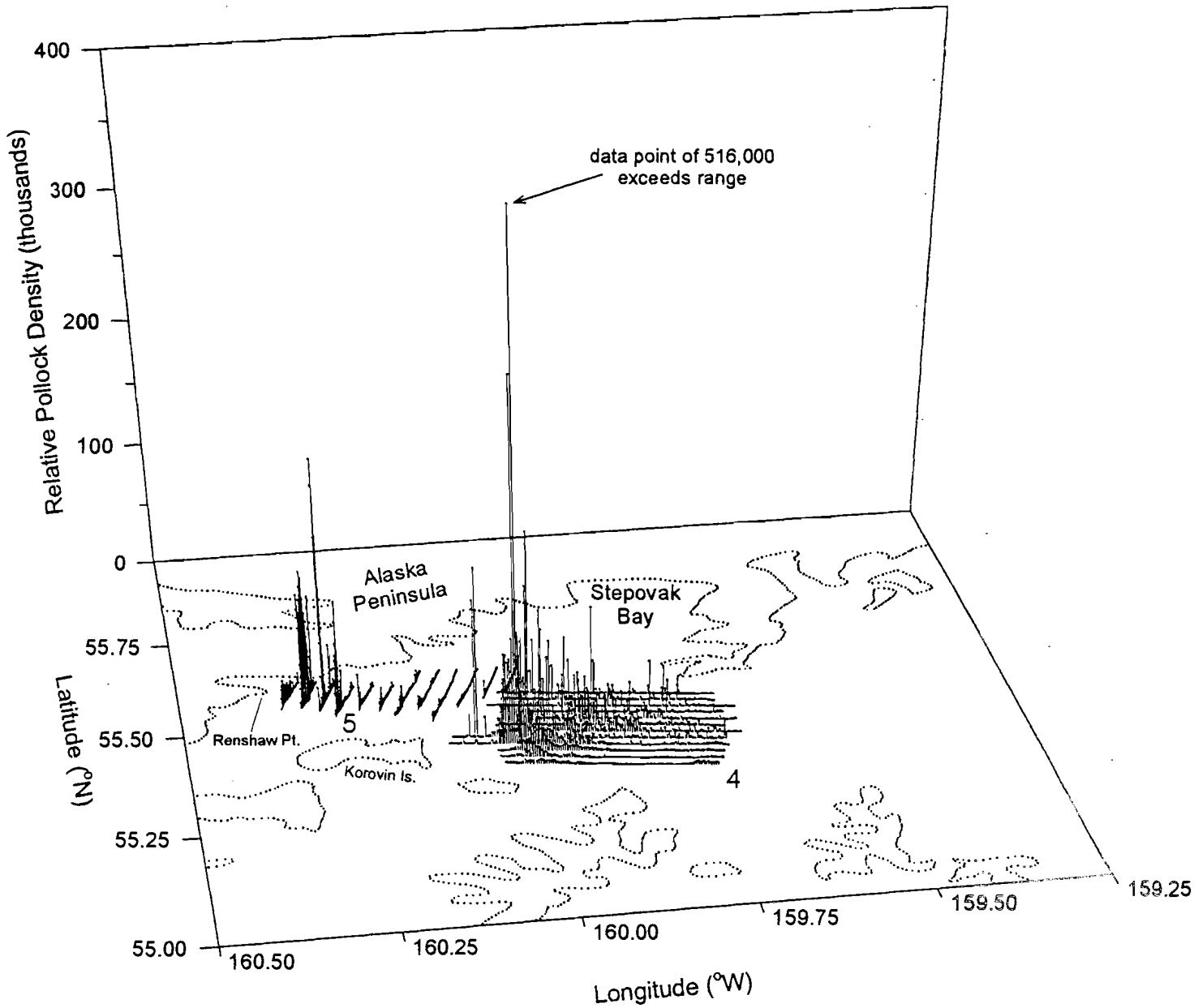


Figure 5. Relative pollock density along trackline from replicate surveys 4 and 5 of the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

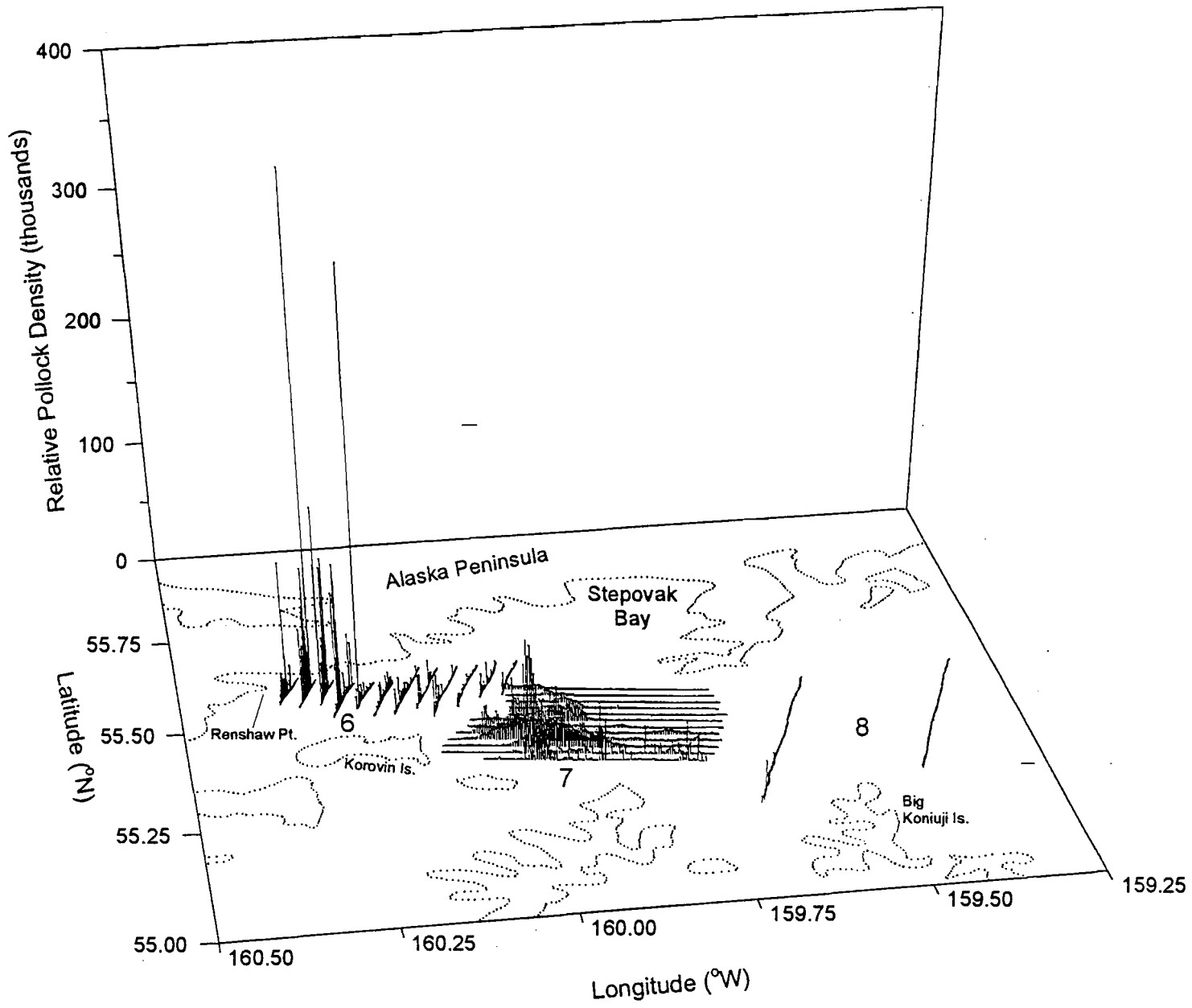


Figure 6. Relative pollock density along trackline from replicate surveys 6 and 7, and survey 8 of the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

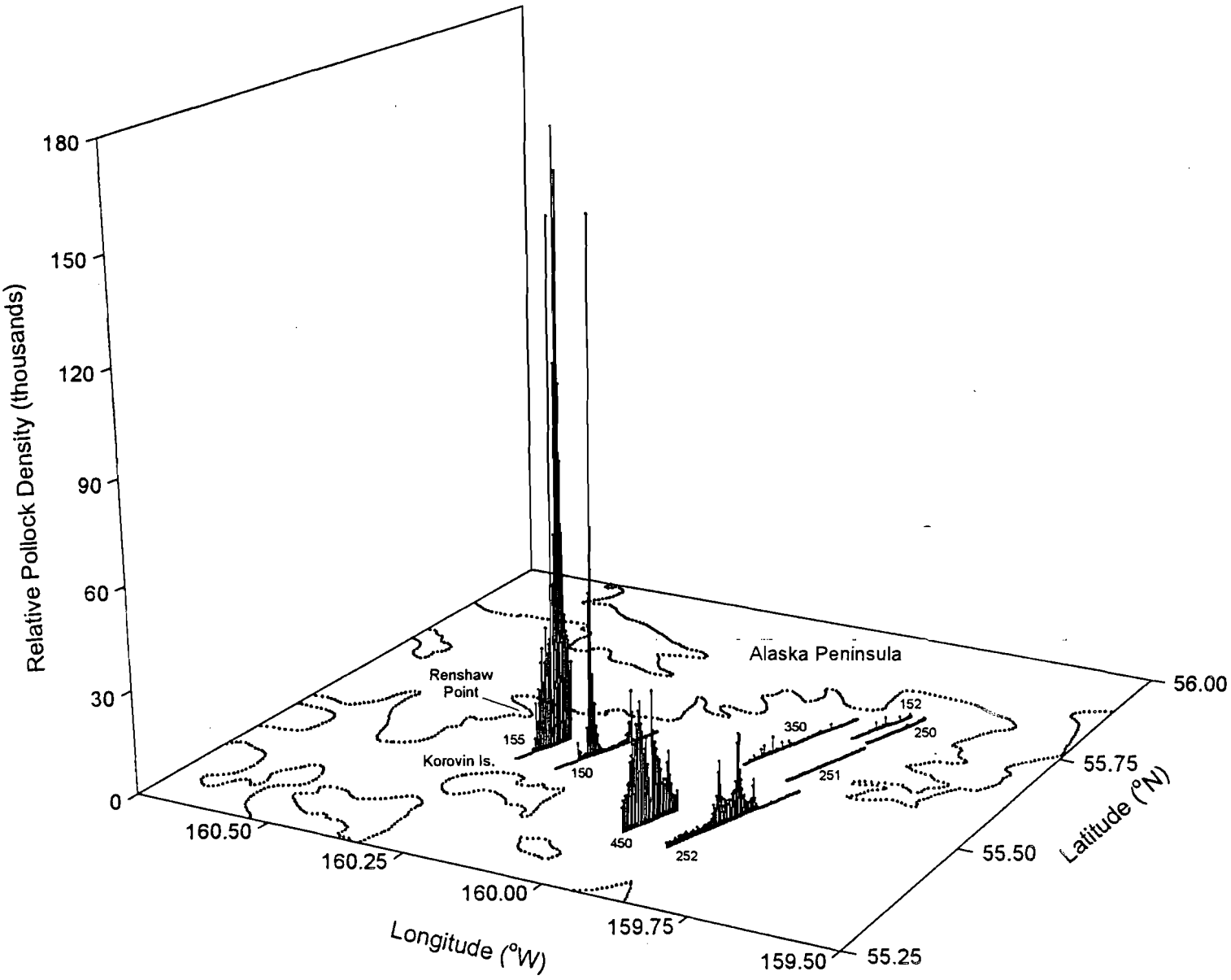


Figure 7. Relative pollock density along orthogonal transects during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02. Transect numbers are indicated.

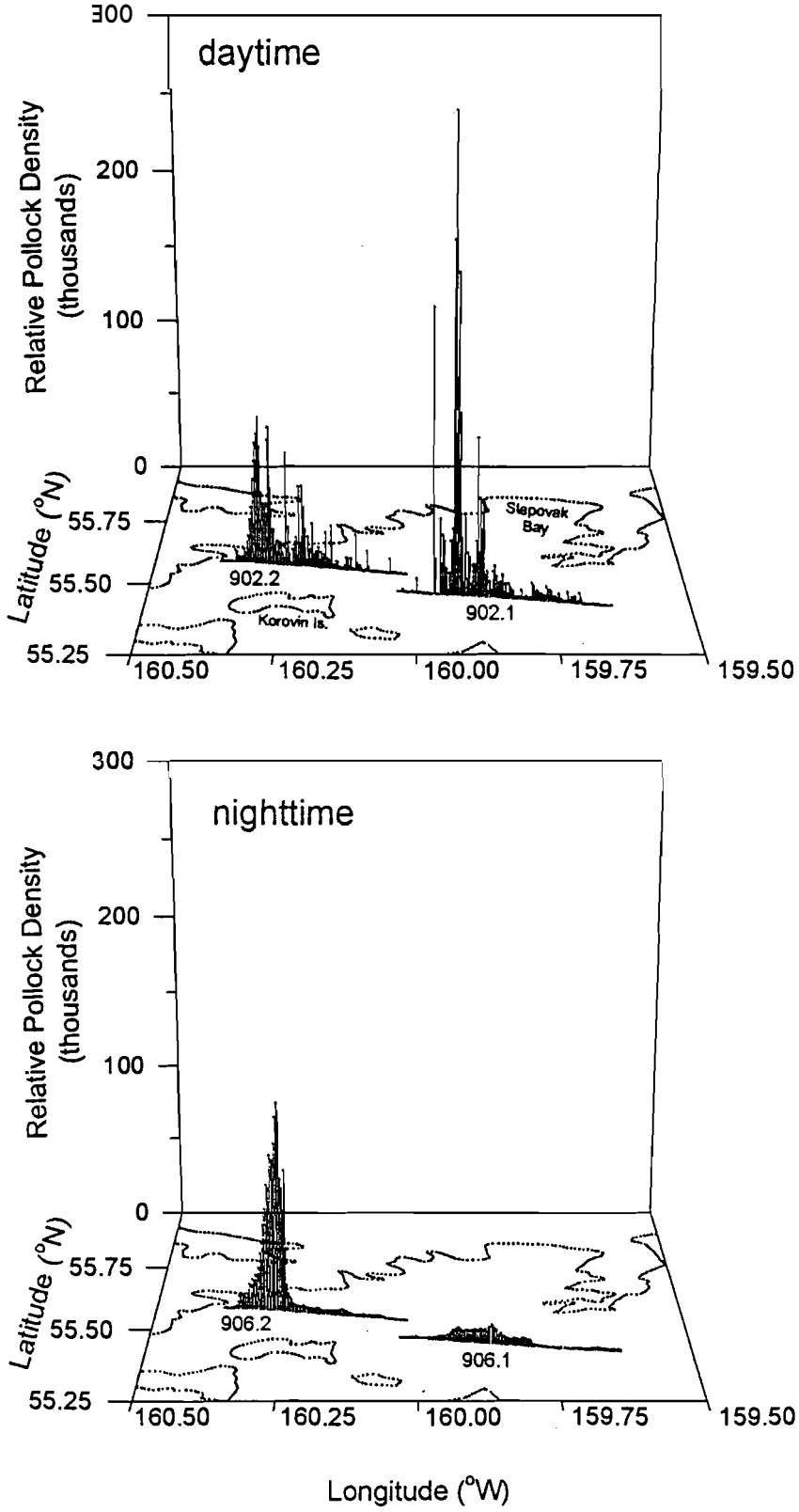


Figure 8. Relative pollock density along trackline from time replicate transects 902.1, 902.2, 906.1, and 906.2 during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

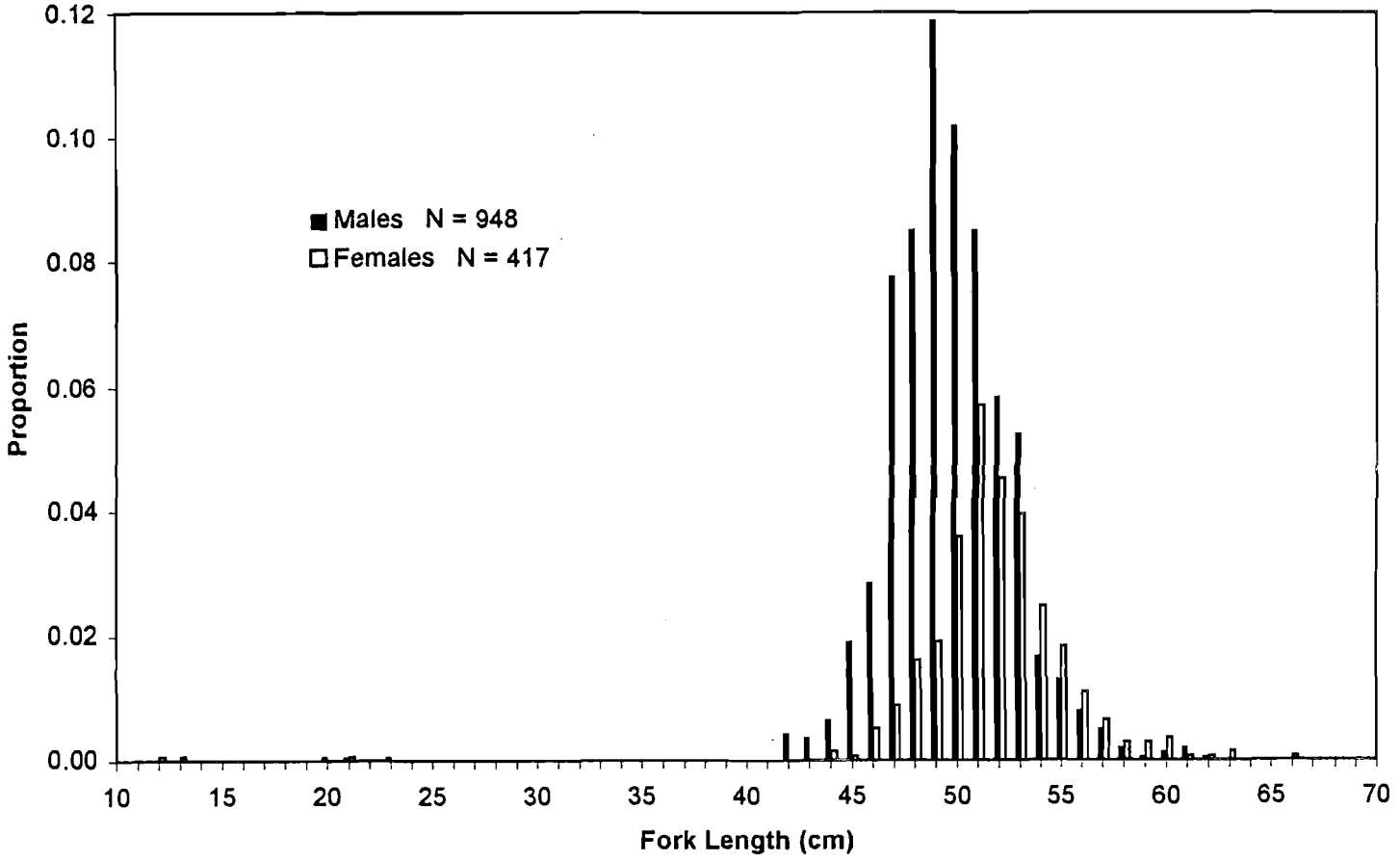


Figure 9. Pollock size composition from 6 Aleutian wing trawl hauls made during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02. N is the total number of males and females measured.

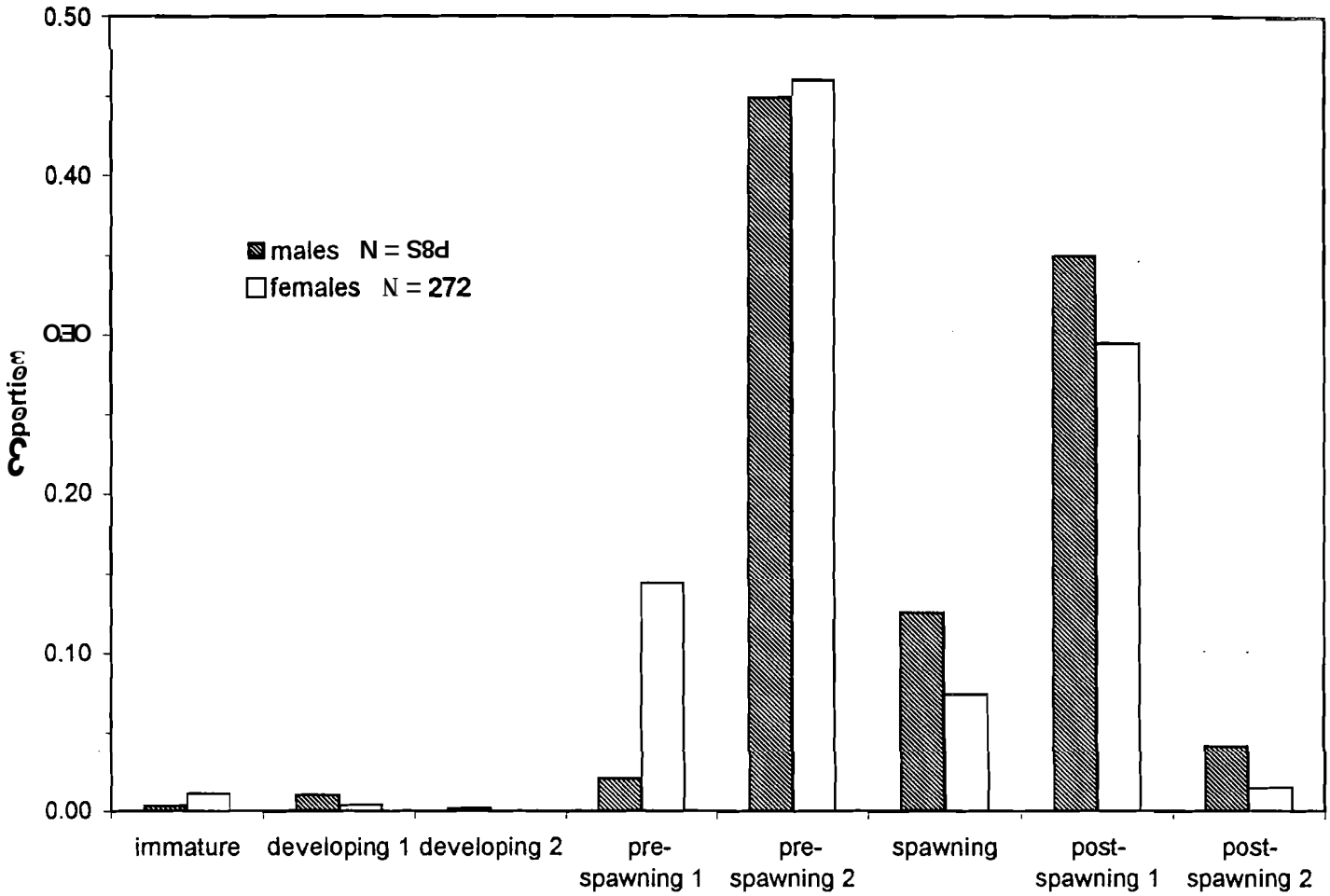


Figure 10. Maturity compositions of male and female pollock from the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.

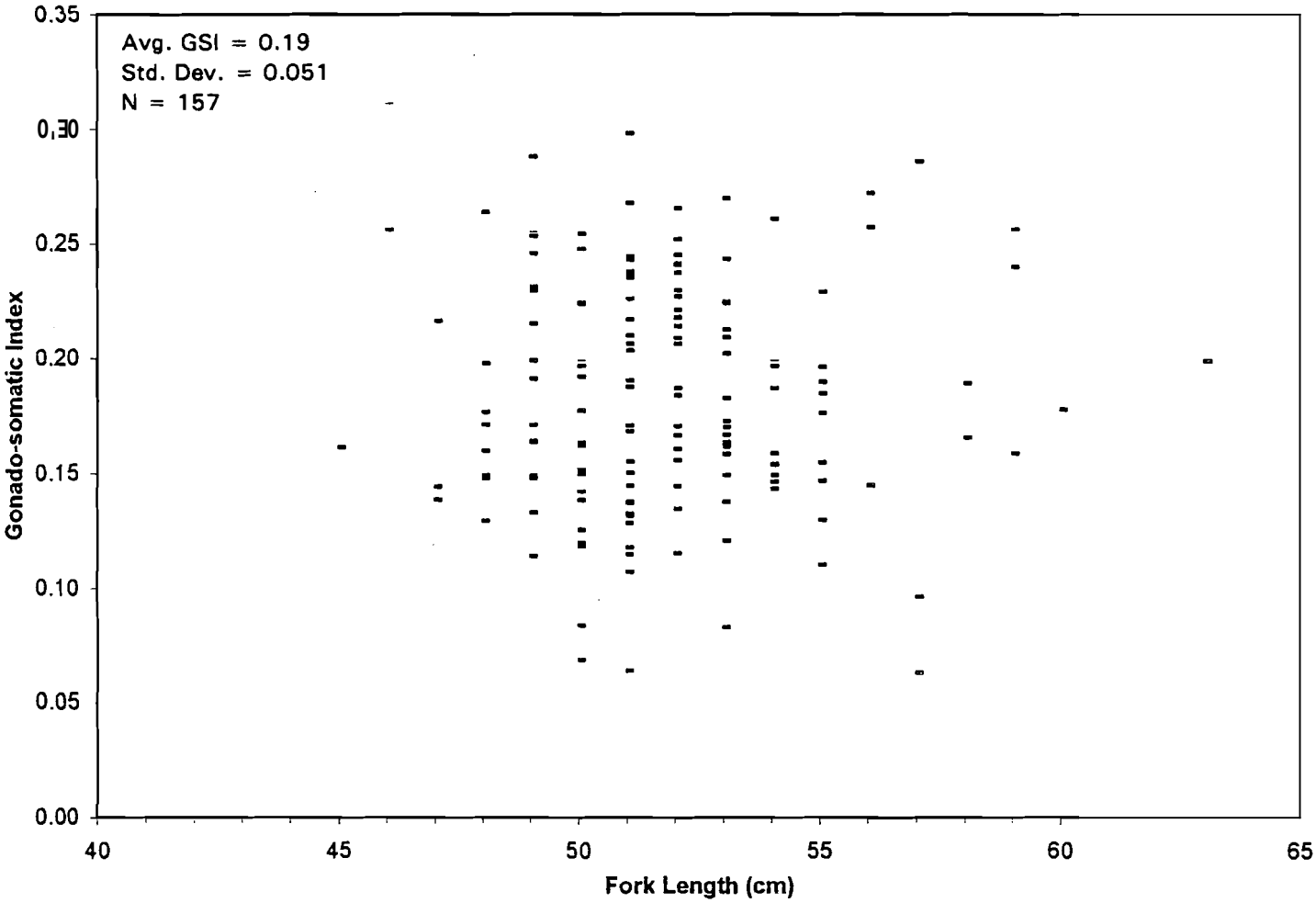


Figure 11. Pollock gonado-somatic indices plotted as a function of length for mature (pre-spawning) females from 6 trawls during the winter 1996 variance estimation study of EIT survey data in the Shumagin Islands area, MF96-02.