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Eastern Bering Sea (Bristol Bay) Coastal Research on Bristol Bay Juvenile Salmon, July and September 1999

by

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Abstract

Eastern Bering Sea research cruises were conducted by the Auke Bay Laboratory Ocean Carrying Capacity program during July and September 1999 to study the early marine distribution, migration, and growth of juvenile Bristol Bay sockeye salmon. During July, most of the juvenile sockeye salmon were encountered northeastward of Port Moller and were distributed from nearshore to 74 km offshore. During September, most of the juvenile sockeye salmon were encountered southwestward of Port Moller to 111 km east of Unimak Pass and were distributed from nearshore environment to 111 km offshore and further (150 km offshore) along the 100 m shelf break. The expanded distribution of juvenile sockeye salmon encountered during September 1999 may have been the result of increased sea surface temperatures. During July 1999, juvenile sockeye salmon were only encountered when sea surface temperatures were 6 degrees C or more; sea surface temperatures in offshore waters during July were 4 to 5 degrees C. During September 1999, sea surface temperatures had warmed considerably; nearshore sea surface temperatures were 10 to 10.5 degrees C, while offshore surface water temperatures were 8.5 to 9.5 degrees C.

Increased sea surface temperatures may also have lead to rapid increase in growth. During July 1999, juvenile sockeye salmon lengths ranged from 80 to 105 mm near the coast to 105 to 115 mm off Port Moller. During September 1999, juvenile sockeye salmon lengths near the coast ranged from 105 to 140 mm, while lengths of juvenile sockeye salmon encountered at offshore locations ranged from 190 to 240 mm. Analyses of plankton, stomach contents, fresh water age, and scale growth data collected during both surveys will be done to shed additional light on the growth and migration characteristics of juvenile sockeye salmon from Bristol Bay.

Introduction

During 1997 and 1998, lower than expected returns of sockeye salmon to Bristol Bay prompted the State of Alaska and the U. S. Department of Commerce to declare the Bristol Bay region an economic disaster area. The cause of the disastrous returns of sockeye salmon to Bristol Bay is not fully understood, but may be related to changes in the marine environment. Fishery scientists generally agree that conditions in the ocean, particularly in the first few months after leaving freshwater, strongly influence interannual variability in salmon survival and growth (Parker 1962; Pearcy 1992). The assumption is that growth rates of juvenile salmon in the estuarine and nearshore marine environments are directly linked to their survival. Thus, years with favorable environmental conditions and increased growth rates of juvenile salmon may improve their early marine survival, and ultimately lead to increasing adult returns of salmon in the following years.

During July and September 1999, the Auke Bay Laboratory conducted surveys of juvenile salmon distribution, migration, and growth along the coastal waters of the eastern Bering Sea. The 1999 surveys were the first in a series of annual assessments to document variations in the biological characteristics (growth, migration, and distribution) of juvenile sockeye salmon leaving Bristol Bay. The primary goal of the annual assessments is to establish and verify the linkages between adult sockeye salmon survival and annual variations in biological characteristics of juvenile sockeye salmon.

Methods

Coastal surveys of the eastern Bering Sea were conducted during July 12 to 26 and September 2 to 12, 1999. The survey area was bounded to the west by Cape Cheerful (off of Unalaska Island) and to the east by the Egegik River in Bristol Bay (Figure 1). The cruise itineraries and participating scientists are listed in Tables 1 and 2, respectively. Transects sampled during the surveys were perpendicular to the coast and generally 55 to 110 km apart. Sampling at each transect began near the coast then continued offshore with stations every 18.5 km to at least 110 km or further if large catches of juvenile sockeye salmon occurred at offshore stations.

Both surveys were conducted aboard the contracted fishing vessel (F/V) *Great Pacific*. The vessel is a 38-m stern trawler with a main engine of 1450 horsepower and a cruising speed of 10 kts. Fish samples were collected using a midwater rope trawl, which is 198 m long, has hexagonal mesh in wings and body, and has a 1.2-cm mesh liner in the codend. The rope trawl was towed at 4 to 5 kts, at or near surface, and had a typical spread of 52 m horizontally and 18 m vertically. All tows lasted 30 minutes and covered 2.8 to 4.6 km. Most sampling was done during daylight hours; during the July 1999 survey, one nearshore station at Strogonof Point was repeated 6 times (once every 4 hours for a 24 hour period) to document variability in catch between trawl hauls and possible differences in catch between day and night.

Salmon and other fishes were sorted by species and counted. Standard biological measurements including fork length, body weight, and sex as well as scale samples from the preferred area (to document age and growth) were taken from subsamples of all salmon species. Juvenile chum and sockeye salmon were frozen whole at –60°C for genetic analyses. During the July 1999 cruise, we caught several hundred immature chum salmon west of Port Moller. One of the objectives of the Ocean Carrying Capacity program is to document distribution and migration of hatchery salmon whose otoliths were thermally marked during incubation. Therefore, we saved otolith and scale samples from immature chum salmon to identify hatchery origin and to document growth. All other fish species were counted and stomach contents as well as biological measurements including length and body weight were taken from subsamples of each species and stomach contents frozen for later laboratory analyses.

Oceanographic data were also collected at each trawl station immediately prior to each trawl haul. Depth profiles of salinity and temperature from surface to near bottom depths at each trawl station were collected using a Sea-Bird SBE 19 Seacat profiler. During July, plankton samples were collected at each trawl station using 60- and 20-cm diameter bongo samplers fitted with 333- and 153 μm mesh nets, respectively. The smaller bongo was attached to the towing wire 1 m above the large frame. During September, plankton samples were collected at each trawl station using 60-cm diameter bongo samplers fitted with 505- and 333 μm mesh nets, respectively. Double oblique tows were made from near surface to approximately 10 m from the bottom; estimated depth of bongo tow was calculated either by wire angle and length of wire out or by a time, depth recorder. Volume of water filtered by each net was estimated by flow meters. Plankton samples were preserved in 5% buffered Formalin. Plankton samples will be processed during the coming year at the Polish Plankton Sorting and Identification Center according to protocols developed by the Recruitment Processes Team (RACE Division) of the AFSC.

Results

July

During the July 12 – 26 survey, 10 transects were sampled and 64 trawl stations were completed beginning at Cape Cheerful off of Unalaska Island and ending near Cape Greig, east of Ugashik River (Figure 2). A total of 3,145 salmon representing 5 species (*Oncorhynchus* spp.) were captured (Table 3). The vast majority of salmon caught were juvenile salmon including sockeye (*O. nerka*; 72%), coho (*O. kisutch*; 9%) and chinook salmon (*O. tschawytcsha*; <1%). No juvenile chum (*O. keta*) or pink (*O. gorbuscha*) salmon were captured during the survey. Immature and maturing salmon occurred less frequently; immature chum, sockeye, and chinook salmon comprised 10%, <1%, and <1% of the catch, respectively. Maturing sockeye and chinook salmon also comprised less than 1% of the catch each, while maturing pink and chum salmon comprised 2% and 4%, respectively. Other species captured during the survey are listed in Table 4.

Juvenile sockeye salmon were mainly distributed north and east of Port Moller with the largest catch per unit effort (CPUE) east of Ugashik River near Cape Greig and the smallest CPUE at Cinder River (Figures 2 and 3). The largest concentrations of juvenile sockeye salmon were found nearshore (less than 18.5 km) for transects east of Port Heiden, whereas, juvenile sockeye salmon were distributed nearshore to as far as 74 km offshore for transects west of Port Heiden. Only one juvenile sockeye salmon was captured west of Port Moller at the nearshore station of Moffit Point. Average length of juvenile sockeye salmon varied with distance offshore. In general, juvenile sockeye salmon were smallest nearshore and increased in length with distance offshore (Table 5). The average length of all juvenile sockeye salmon subsampled during the survey was 106.1 mm (*n*=229; sd=22.6).

Sea surface temperatures varied with distance from shore and area. From Cape Cheerful to Cape Lieskof (west of Port Moller), sea surface temperature increased with distance offshore; whereas from Cape Seniavin to Cinder River (east of Port Moller) sea surface temperatures generally decreased with distance from shore (Table 6). Plankton samples collected during the survey will be analyzed in the upcoming year and the results will be used to document juvenile salmon distribution with respect to plankton abundance.

Repeat sampling at the Strogonof Point nearshore station indicated high variability between trawl hauls depending on time of day. Catch of juvenile sockeye salmon ranged from 3 to 25 during the first four trawl hauls which included one night time haul and 3 day time hauls (Figure 4). Catch of juvenile sockeye salmon increased dramatically for the last two trawl hauls, which included one day time haul (125 juvenile sockeye salmon) and on night time haul (159 juvenile sockeye salmon; Figure 4). The high variability in juvenile sockeye salmon catch may have been due to influx of salmon into the sampling area either by: 1) encountering new arrivals of salmon along during their seaward migration; or 2) the dramatic increase in offshore (east) winds; wind speed for the first 4 trawl hauls ranged from 5 to 15 knots, while wind speed for the last two trawl hauls ranged from 30 to 40 knots. The increased wind speed may have pushed juvenile sockeye salmon, located very nearshore and outside the trawl area, to more offshore locations.

September

During the September 2 – 12 survey, 7 transects were sampled and 42 trawl stations were completed beginning 55 km east of Cape Seniavin and ending near Cape Mordvinof (Figure 5). A total of 4,894 salmon representing 5 species were captured (Table 3). The largest component of the catch was juvenile salmon including sockeye (93%), chum (4%), coho (2%), pink (<1%), and chinook (<1%). Immature chum, sockeye, and chinook salmon comprised less than 1% of the catch each. Maturing pink, chum, sockeye, and coho salmon also comprised less than 1% of the catch each. Other species captured during the survey are listed in Table 4.

Juvenile sockeye salmon were distributed from Cape Krenitzin to 55.5 km east of Cape Seniavin (Figure 5). The largest concentrations of juvenile sockeye salmon were found west of Port Moller with the largest CPUE of juvenile sockeye salmon at Cape Krenitzin (Figure 6). No juvenile sockeye salmon were captured west of Cape Krenitzin. Juvenile sockeye salmon were distributed from nearshore areas to 110 km and beyond; the largest catch of juvenile sockeye salmon occurred at 130 km offshore of Cape Krenitzin. Average length of juvenile sockeye salmon increased with distance offshore and seaward along the migration path (Table 5). The average length of all juvenile sockeye salmon captured during the survey was 172.1 mm (n=732; sd=30.1).

Sea surface temperatures varied by distance offshore and location sampled. Sea surface temperatures were warmest at near-shore locations and coolest at offshore stations for transects sampled east of Port Moller. For transects west of Port Moller, sea surface temperature remained fairly uniform across the area surveyed. (Table 6).

Discussion

Juvenile sockeye salmon from all river systems entering Bristol Bay follow the same southwesterly seaward migration route along the coastal waters of the eastern Bering Sea (Straty 1974; Straty and Jaenicke 1980; and Straty 1981). The seasonal timing of this migration can be influenced by annual differences in environmental conditions, such as time of ice breakup on lakes and anomalously cold sea temperatures (Straty 1981). This was the first year the Ocean Carrying Capacity program conducted surveys in the eastern Bering Sea to examine effects of the environment on migration, distribution, and growth of Bristol Bay juvenile sockeye salmon. The 1999 summer and fall surveys were unique in that they occurred after a cold spring in the eastern Bering Sea, which was characterized by a delay in the breakup of lake-ice in sockeye salmon nursery lakes (personal communication, Drew Crawford, Alaska Department of Fish and Game, Anchorage) and anomalously cold sea temperatures. The cold spring may have delayed the seaward migration of juvenile sockeye salmon. For example, during July we caught only one juvenile sockeye salmon west of Port Moller; whereas, past studies of juvenile salmon migration in the eastern Bering Sea that occurred after relatively warm springs, indicated that large catches of juvenile sockeye salmon could occur west of Port Moller during this time period (Straty and Jaenicke 1980; Hartt and Dell 1986; Isakson et al. 1986).

The July and September 1999 surveys were designed to test for seasonal (summer and fall) differences in growth, distribution, and migration of juvenile salmon along the coastal waters of the eastern Bering Sea. During July, most of the juvenile sockeye salmon were encountered northeastward of Port Moller and were distributed from nearshore to 74 km offshore. During September, most of the juvenile sockeye salmon were encountered southwestward of Port Moller to 111 km east of Unimak Pass and were distributed from nearshore environment to 111 km offshore and further (150 km offshore) along the 100 m shelf break. This widespread occurrence of juvenile sockeye salmon in offshore waters differs from the historical model given by French et al. (1976), which indicates a coastal migration along the eastern Bering Sea (Figure 7). Future studies will be directed to study the extent of offshore migration during summer and fall.

The expanded distribution of juvenile sockeye salmon encountered during September may have been the result of increased sea surface temperatures. During July, juvenile sockeye salmon were only encountered when sea surface temperatures were 6 degrees C or more; sea surface temperatures in offshore waters where juvenile sockeye salmon were encountered during July were often below 6 degrees C. During September, sea surface temperatures had warmed considerably; nearshore sea surface temperatures were 10 to 10.5 degrees C, while offshore surface water temperatures were 8.5 to 9.5 degrees C. Increased sea surface temperatures during between July and September 1999 may have also lead to rapid increase in growth. During July, juvenile sockeye salmon were generally small in size, with an average length of 106.1 mm. During September, juvenile sockeye salmon had grown significantly (t=30.6; $p<0.001$) with an average length of 172.1 mm.

Further analyses of plankton, stomach contents, fresh water age, and scale growth data collected during both surveys will be done to shed additional light on the growth and migration characteristics of juvenile sockeye salmon emigrating from Bristol Bay.

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Table 1. Cruise itineraries for the July 12 – 26 and September 2 – 12 juvenile salmon surveys in the coastal waters of the eastern Bering Sea.

Date	Location/Activity
July 1999	
12-July	Depart Dutch Harbor, run to Cape Cheerful and begin sampling
14-July	Begin sampling Cape Sarichef; enroute Cape Lapin
15-July	Begin sampling Cape Lapin; enroute Moffit Point
16-July	Begin sampling Moffit Point; enroute Cape Lieskof
17-July	Begin sampling Cape Lieskof; enroute Cape Seniavin
18-July	Begin sampling Cape Seniavin; enroute 55.5 km east of C. Seniavin
19-July	Begin sampling 55.5 km east of C. Seniavin; enroute Strogonof Point
20-July	Begin sampling Strogonof Point; enroute Cinder River
21-July	Begin sampling Cinder River; enroute Cape Greig
22-July	Begin sampling Cape Greig; enroute Strogonof Point
23-July	Begin sampling Strogonof Point (repeat sampling nearshore)
24-July	Underway enroute Dutch Harbor
25-July	Arrive Dutch Harbor, begin offloading samples and gear
26-July	Disembark scientists
September 1999	
2-September	Depart Dutch Harbor, enroute 55.5 km east of Cape Seniavin
3-September	enroute 55.5 km east of Cape Seniavin
4-September	Begin sampling 55.5 km east of Cape Seniavin; enroute C. Seniavin
5-September	Begin sampling Cape Seniavin; enroute Cape Rohznof
6-September	Begin sampling Cape Rohznof; enroute Cape Lieskof
7-September	Begin sampling Cape Lieskof; enroute Moffit Point
8-September	Begin sampling Moffit Point; enroute Cape Krenitzin
9-September	Begin sampling Cape Krenitzin; enroute Cape Mordvinof
10-September	Begin sampling Cape Mordvinof; enroute 92.5 km offshore C. Krenitzin
11-September	Begin sampling 92.5 km offshore Cape Krenitzin; enroute Dutch Harbor
12-September	Arrive Dutch Harbor; offload samples and gear; disembark scientists

Table 2. Participating scientists for the July 12 – 26 and September 2 – 12 juvenile salmon surveys in the coastal waters of the eastern Bering Sea.

Scientist	Agency
July 1999	
Edward V. Farley, Jr. (Chief Scientist)	Auke Bay Laboratory, AFSC, NMFS
James M. Murphy	Auke Bay Laboratory, AFSC, NMFS
Christine T. Baier	AFSC, NMFS
Milo D. Adkison	University of Alaska, Fairbanks
Vladimir I. Radchenko	Pacific Research Fisheries Center (TINRO)
September 1999	
Edward V. Farley, Jr. (Chief Scientist)	Auke Bay Laboratory, AFSC, NMFS
Richard E. Haight	Auke Bay Laboratory, AFSC, NMFS
Charles M. Guthrie, III.	Auke Bay Laboratory, AFSC, NMFS
Franklin R. Satterfield, IV	University of Alaska, Fairbanks

Table 3. Total number of stations by transect and total catch of juvenile (J), immature (I), and adult (A) salmon by species and transect during July and September, 1999. Dash (-) indicates no salmon caught. [* indicates repeated nearshore sampling.]

Transect	No.	Pink		Chum			Sockeye			Coho		Chinook		
	Stations	J	A	J	I	A	J	I	A	J	A	J	I	A
July 12 - 26, 1999														
Cape Cheerful	7	-	26	-	185	36	-	22	6	-	-	-	-	-
Cape Sarichef	6	-	34	-	112	6	-	8	-	-	-	-	-	-
Cape Lapin	6	-	6	-	14	15	-	-	4	1	2	-	-	-
Moffit Point	6	-	4	-	-	18	1	-	12	1	4	-	1	1
Cape Lieskof	6	-	1	-	-	19	-	-	4	-	-	4	3	1
Cape Seniavin	6	-	1	-	-	8	387	-	-	2	-	-	-	-
56 km east of C. Seniavin	6	-	-	-	-	2	345	-	-	-	1	-	-	-
Strogonof Point	4	-	2	-	-	2	347	-	13	9	1	-	2	-
Cinder River	6	-	1	-	-	2	38	-	-	6	-	-	-	-
Cape Greig	5	-	-	-	-	1	795	-	-	251	-	-	-	-
Strogonof Point *	6	-	1	-	-	8	346	-	4	19	-	-	-	-
Total	64	-	76	-	311	117	2,259	30	43	289	8	4	6	2
September 2 - 12, 1999														
56 km east of C. Seniavin	5	-	-	22	-	-	41	-	-	1		-	-	-
Cape Seniavin	6	-	-	31	-	-	14	-	-	29	1	-	1	-
Cape Rohznof	6	2	-	87	-	1	229	-	1	2	1	-	1	-
Cape Lieskof	6	3	-	27	3	5	859	-	-	6	1	-	-	-
Moffit Point	6	4	-	10	-	4	778	-	2	43	4	2	1	-
Cape Krenitzin	10	6	1	3	-	2	2,647	-	-	6	3	-	2	-
Cape Mordvinof	3	1	-	-	5	-	-	1		-	1	-	-	-
Total	42	16	1	180	8	12	4,568	1	3	87		2	5	0
Grand Total	106	16	77	180	319	129	6,827	31	46	376	8	6	11	2

Table 4. Total number of stations by transect and total catch of marine fishes and jelly fish (in pounds) by species and transect during July and September, 1999. Dash (-) indicates no fish caught. [* indicates repeated nearshore sampling.]

Transect	No. Stations	Jelly Fish (lbs)	Juvenile pollock	Adult pollock	Yellow fin sole	Rock sole	Starry flounder	Sand-lance	Capelin	Herring	Sand-fish	Rainbow smelt
July 12 - 26, 1999												
Cape Cheerful	7	500	1	358	-	-	-	100	-	1,032	0	-
Cape Sarichef	6	-	20	17	-	-	-	-	-	39	63	-
Cape Lapin	6	2,600	-	10	5	-	1	1,020	10	5,627	70	-
Moffit Point	6	31,900	2,050	29	54	-	4	2,000	-	2	663	4
Cape Lieskof	6	35,800	350	14	45	-	2	6,000	-	4	243	3
Cape Seniavin	6	3,000	-	4	1,311	29	35	16	1	262	225	1
56 km east of C. Seniavin	6	700	-	3	721	54	-	296	14	74	196	-
Strogonof Point	4	370	-	1	139	33	56	144	122	11	90	-
Cinder River	6	60	17	45	3,209	11	7	1,890	220	307	50	-
Cape Greig	5	-	14	5	347	91	17	5,300	-	471	66	13
Strogonof Point *	6	100	203	-	1,658	93	259	8,000	1	1,141	482	2,201
Total	64	75,030	2,655	486	7,489	311	381	24,766	368	8,970	2,148	2,222
September 2 - 12, 1999												
56 km east of C. Seniavin	5	4,300	9,000	2	27	2	1	102	-	12	71	1
Cape Seniavin	6	22,000	24,500	1	71	1	-	102	10	1,147	373	78
Cape Rohznof	6	8,900	20,000	3	40	-	-	-	105	559	515	-
Cape Lieskof	6	7,400	9,500	-	2	-	1	-	-	2,317	52	-
Moffit Point	6	11,530	19,500	-	2	-	1	-	-	2,362	92	14
Cape Krenitzin	10	5,070	17,700	2	1	-	3	1	-	375	418	-
Cape Mordvinof	3	6,020	-	1	-	-	-	-	-	-	1,000	-
Total	42	65,220	100,200	9	143	3	6	205	115	6,772	2,521	93
Grand Total	106	140,250	102,855	495	7,632	314	387	24,971	483	15,742	4,669	2,315

Table 5. Number of juvenile sockeye salmon subsampled for length (mm), average length, and standard deviation of length by transect and station during July and September, 1999. Dash (-) indicates no fish caught. [# indicates no sampling at station.]

Transect	Nearshore			18.5 km			37 km			55.5 km			74 km			92.5 km		
	n	Ave	SD	*n*	Ave	SD	*n*	Ave	SD	*n*	Ave	SD	*n*	Ave	SD	*n*	Ave	SD
July 12 - 26, 1999																		
Cape Cheerful	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Cape Sarichef	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Cape Lapin	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Moffit Point	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Cape Lieskof	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Cape Seniavin	*	*	*	20	112	13.3	-	-	-	-	-	-		-	-	-	-	-
56 km east of C. Seniavin	20	91	5.3	20	94	6.5	-	-	-	20	129	14	19	147	6.3	-	-	-
Strogonof Point	20	101	16.1	14	93	7.9	-	-	-	-	-	-	-	-	-	-	-	-
Cinder River	13	90	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cape Greig	20	86	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September 2 - 12, 1999																		
56 km east of C. Seniavin	-	-	-	-	-	-	-	-	-	9	126	12	-	-	-	-	-	-
Cape Seniavin	-	-	-	-	-	-	10	124	8.9	-	-	-	-	-	-	-	-	-
Cape Rohznof	*	*	*	6	127	6.6	8	133	12	5	140	7.2	36	155	10.2	11	168	9.2
Cape Lieskof	50	135	6.1	50	150	16	50	150	16	28	176	16	11	187	12.5	10	188	13.6
Moffit Point	5	138	10	50	152	9.9	50	171	17	50	184	16	10	185	15.9	-	-	-
Cape Krenitzin	20	150	8.9	9	165	8.3	3	168	23	50	185	15	50	186	20.0	50	207	15.5
Cape Mordvinof	-	-	-	-	-	-	*	*	*	-	-	-	*	*	*	*	*	*

Table 6. Total number of juvenile sockeye salmon caught (*n*), temperature (°c), and salinity (o/oo) by station during July and September, 1999. Dash (-) indicates no fish caught. [* indicates no sampling done at station.]

Transect	Nearshore			18.5 km			37 km			55.5 km			74 km			92.5 km		
	n	T	S	*n*	T	S	*n*	T	S	*n*	T	S	*n*	T	S	*n*	T	S
July 12 - 26, 1999																		
Cape Cheerful	-	5.5	32.5	-	6.2	32.8	-	7.2	32.9	-	7.0	32.8		6.8	33.0	-	6.9	32.5
Cape Sarichef	-	6.0	*	-	6.2	32.1	-	5.8	32.1	-	6.8	32.4		6.8	32.7	-	7.0	32.5
Cape Lapin	-	6.6	31.7	-	6.0	32.1	-	6.4	32.1	-	6.3	32.0		6.0	32.2	-	7.2	32.0
Moffit Point	-	7.2	31.5	-	7.3	32.0	-	8.2	31.8	-	8.4	32.0		8.9	31.9	-	9.0	32.1
Cape Lieskof	-	7.2	31.5	-	8.2	31.7	-	9.1	31.8	-	9.1	31.7		9.2	31.8	-	9.3	32.0
Cape Seniavin	16	7.5	30.9	103	8.0	31.6	-	5.3	31.8	-	5.0	31.5	*	*	31.5	*	*	*
56 km east of C. Seniavin	57	6.6	31.3	25	5.6	30.9	2	5.6	31.8	128	6.5	32.5	19	6.3	31.2	-	4.9	31.6
Strogonof Point	332	8.7	30.4	14	6.1	31.1	-	4.6	31.4	-	3.9	31.3	*	*	*	*	*	*
Cinder River	13	8.4	30.6	3	6.9	30.8	-	5.6	30.9	*	*	*	*	*	*	-	5.6	29.3
Cape Greig	788	8.6	28.4	-	7.1	29.1	-	8.6	26.1	-	9.0	25.9	4	9.3	27.4	*	*	*
September 2 - 12, 1999																		
56 km east of C. Seniavin	3	10.5	31.2	9	9.6	31.4	2	7.5	31.7	-	6.5	31.5	-	7.4	31.2	*	*	*
Cape Seniavin	4	10.7	31.1	3	9.6	31.6	25	9.6	31.7	4	9.6	31.7	4	9.1	31.6	1	8.1	31.5
Cape Rohznof	*	*	*	8	9.5	31.7	31	9.4	32.3	7	9.3	31.9	139	9.5	31.8	42	9.6	31.8
Cape Lieskof	207	9.6	31.6	155	9.4	31.9	163	9.9	31.9	144	9.8	31.9	124	9.4	31.9	66	9.3	31.8
Moffit Point	5	9.3	31.6	201	8.8	32.0	185	9.4	32.0	220	9.9	32.2	111	10.0	32.0	56	9.6	32.1
Cape Krenitzin	23	9.1	31.6	52	8.6	31.9	21	8.6	32.1	341	9.6	32.0	205	8.8	32.1	178	8.5	32.1
Cape Mordvinof	-	8.0	31.9	-	7.7	*	*	*	*	-	8.4	*	*	*	*	*	*	*

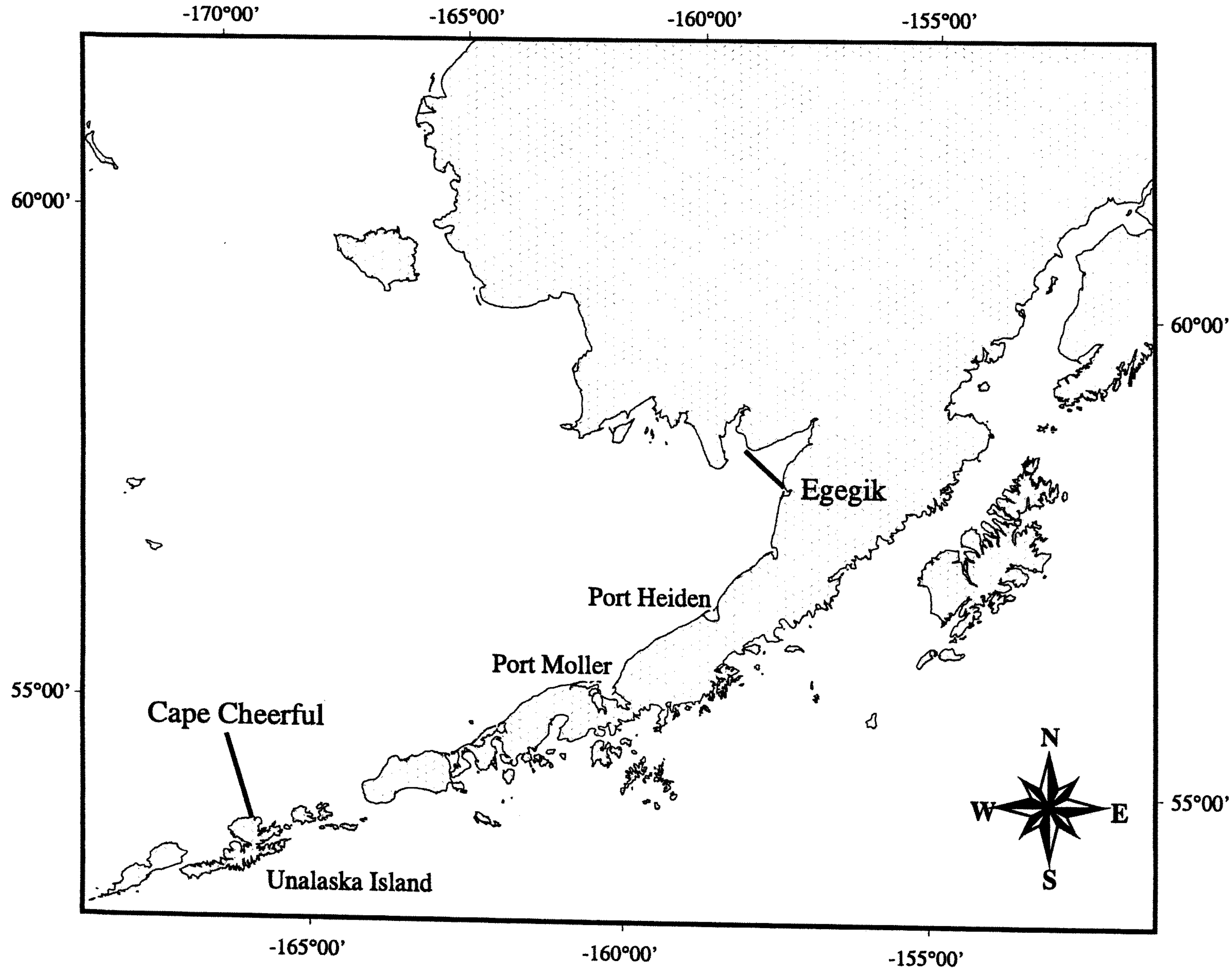

Figure 1. Area surveyed by Auke Bay Laboratory, Ocean Carring Capacity program (coastal waters - Cape Cheerful to Egegik) during July and September 1999.

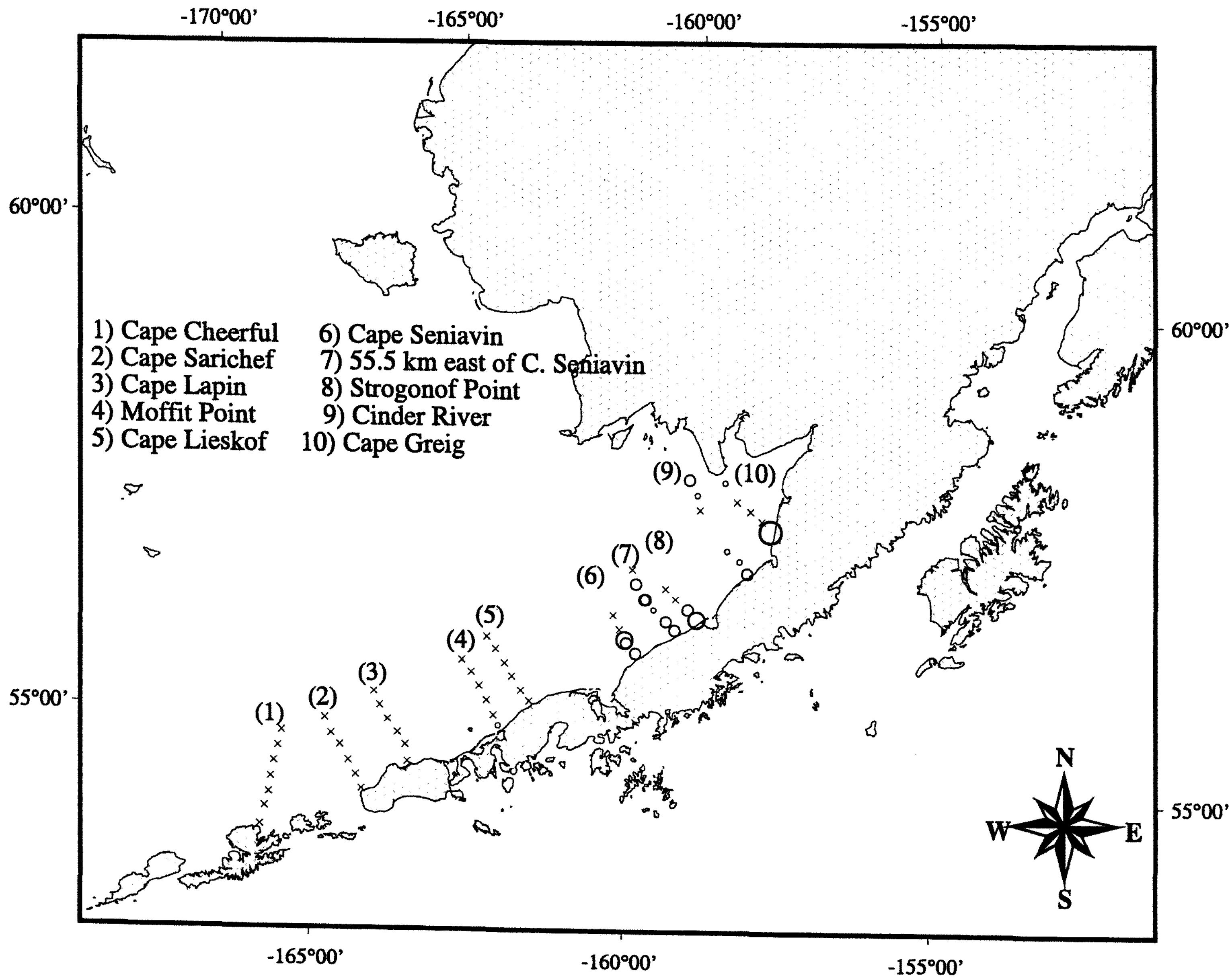

Figure 2. Transects sampled by the F/V GREAT PACIFIC during July 1999. Circles indicate location and range in catch of juvenile sockeye salmon (smallest circle = 1 - 10; next larger = 11 - 200; next larger = 201 - 500; largest circle = 501 - 800; x indicates a trawl station where no juvenile sockeye salmon were caught).

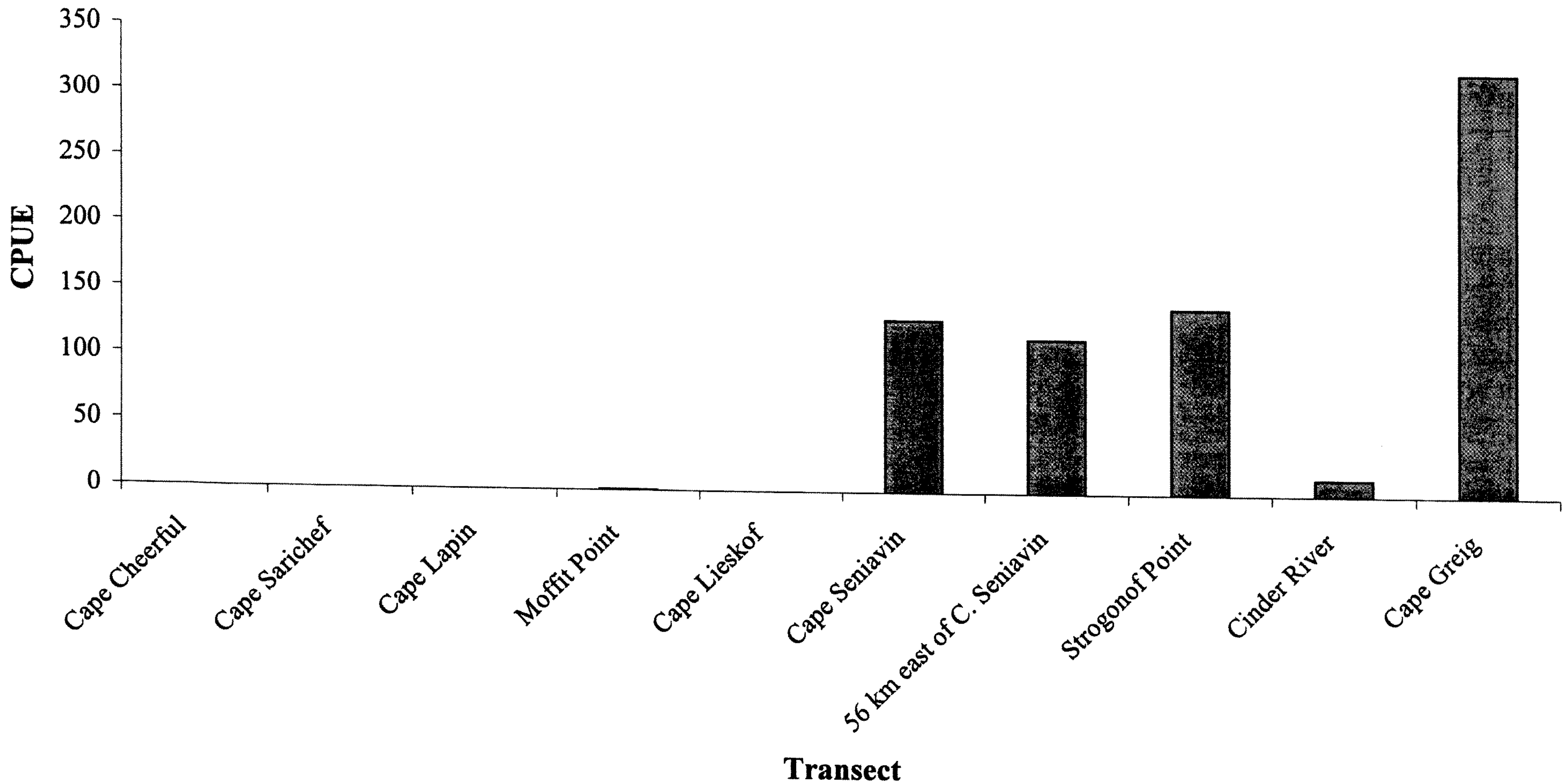

Figure 3. Catch per unit effor (CPUE) for juvenile sockeye salmon caught during July 1999.

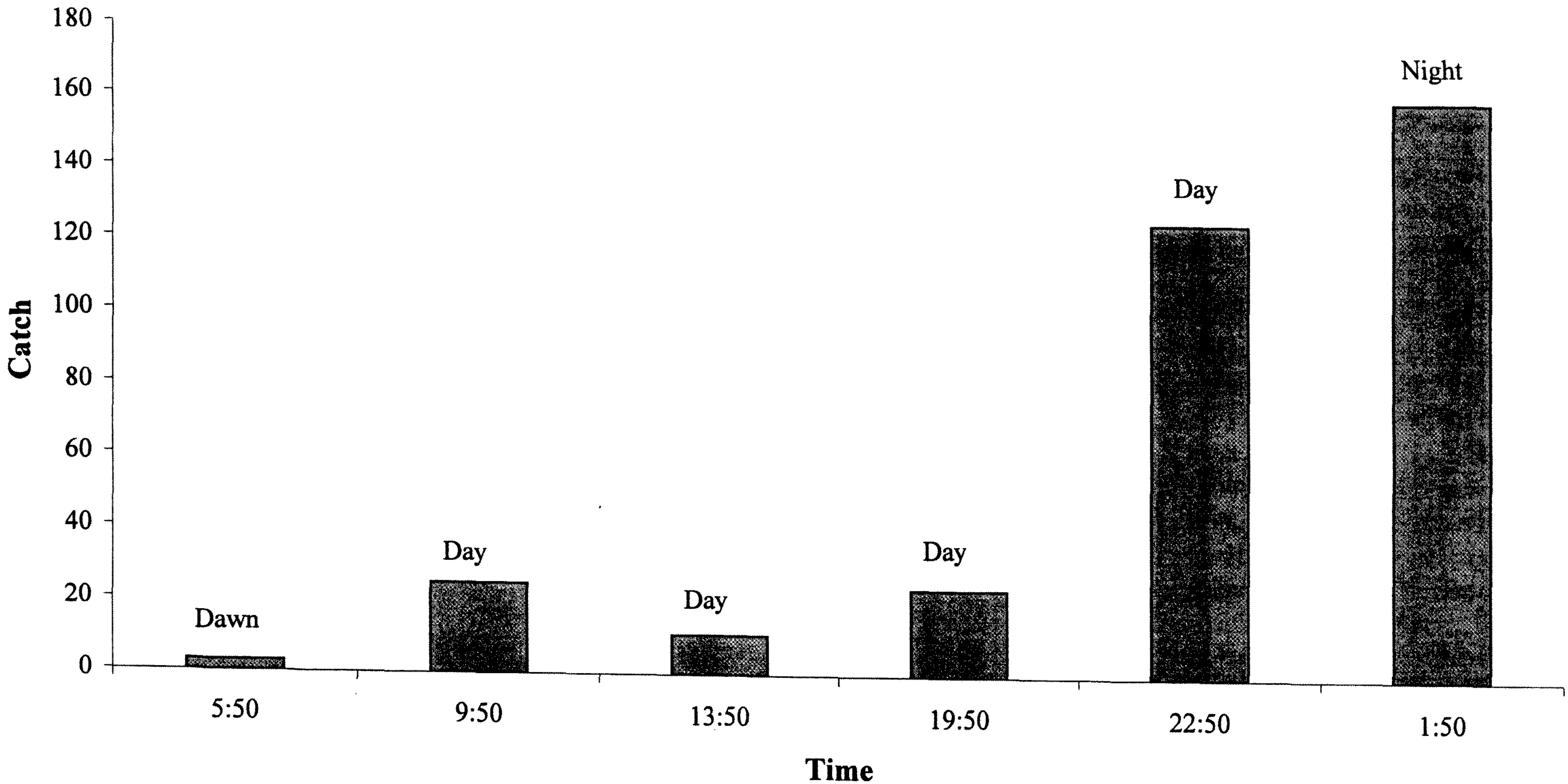

Figure 4. Catch of juvenile sockeye salmon at Strogonof Point at four hour intervals for a 24 hour period during July 1999.

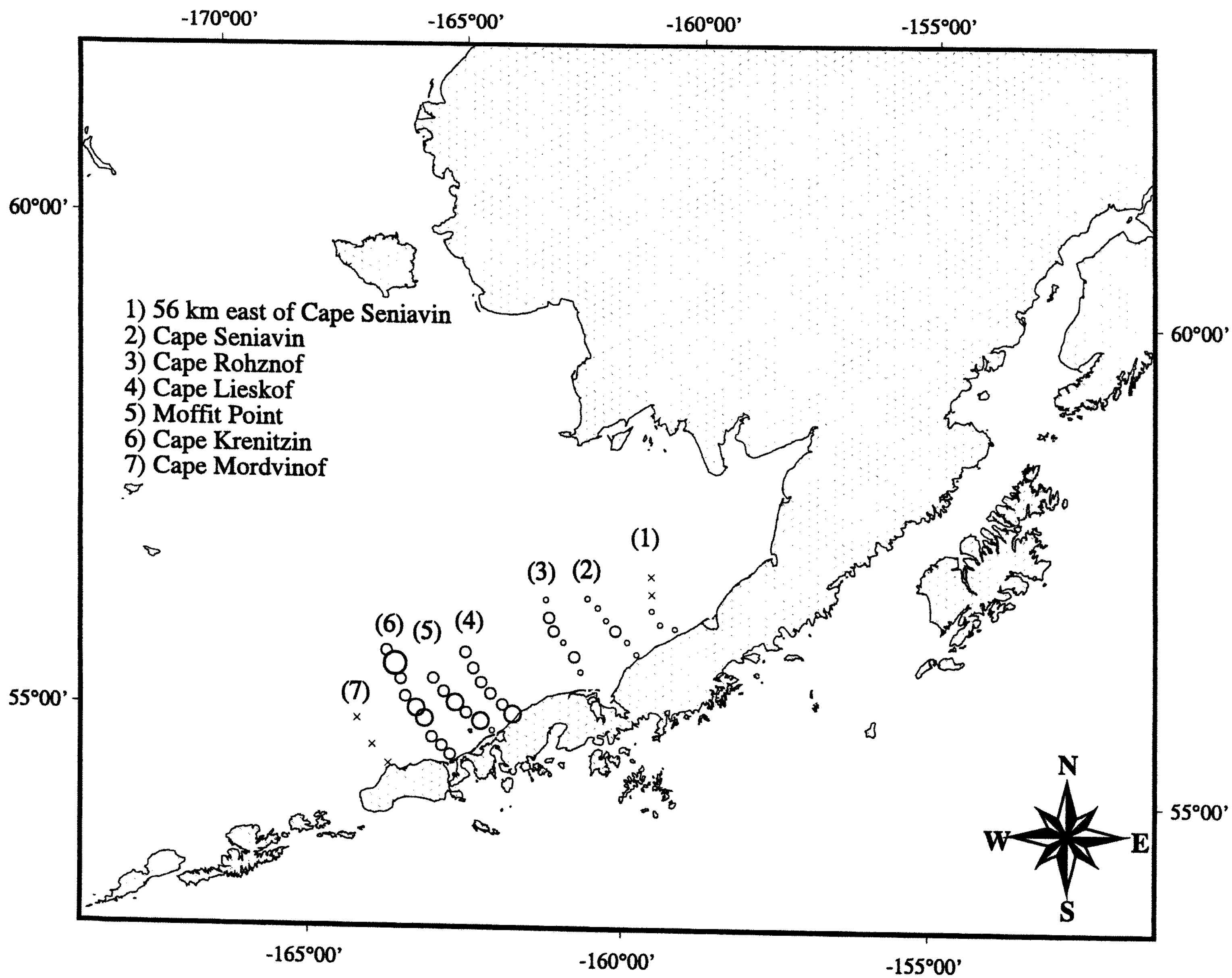

Figure 5. Transects sampled by the F/V GREAT PACIFIC during September 1999. Circles indicate location and range in catch of juvenile sockeye salmon (smallest circle = 1 - 10; next larger = 11 - 200; next larger = 201 - 500; largest circle = 501 - 1000; x indicates a trawl station where no juvenile sockeye salmon were caught).

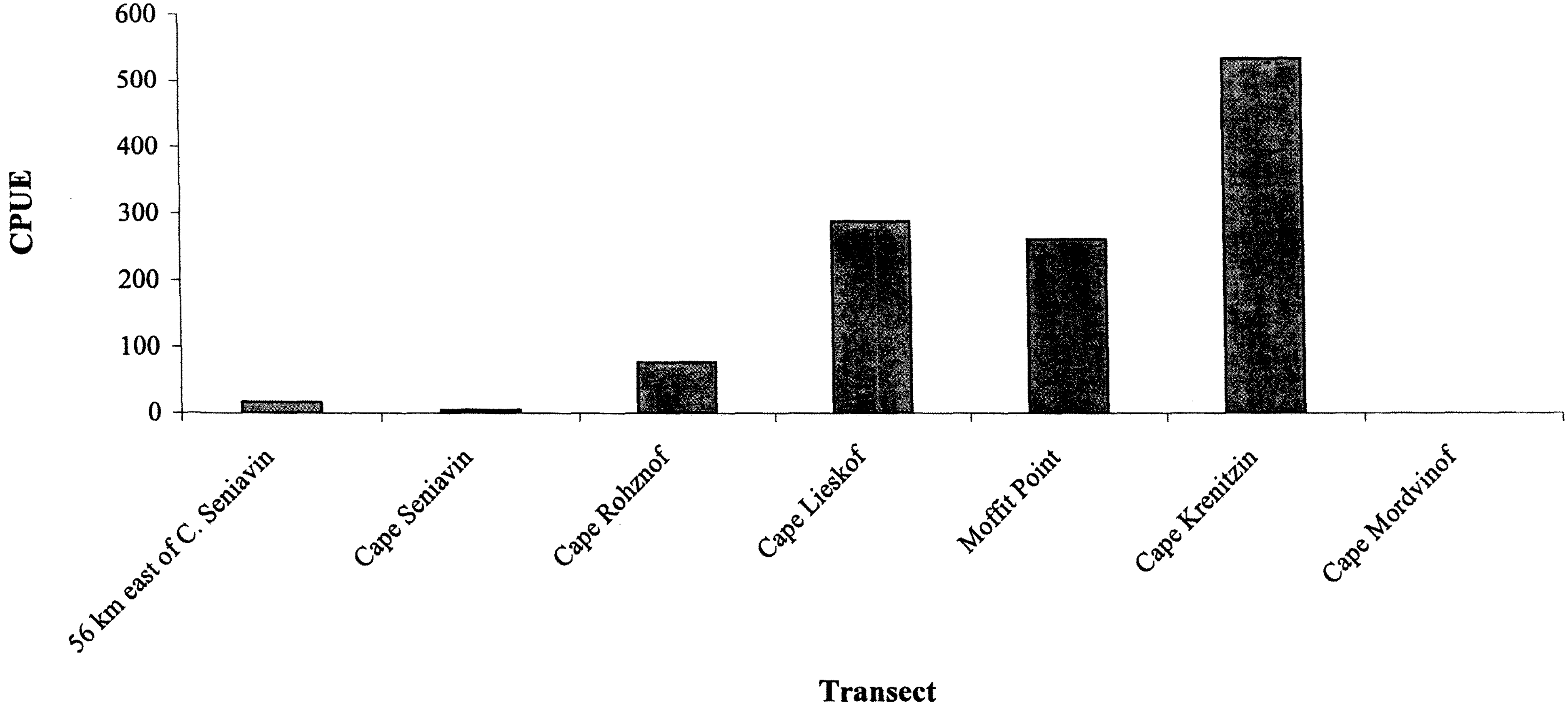

Figure 6. Catch per unit effor (CPUE) for juvenile sockeye salmon caught during September 1999.

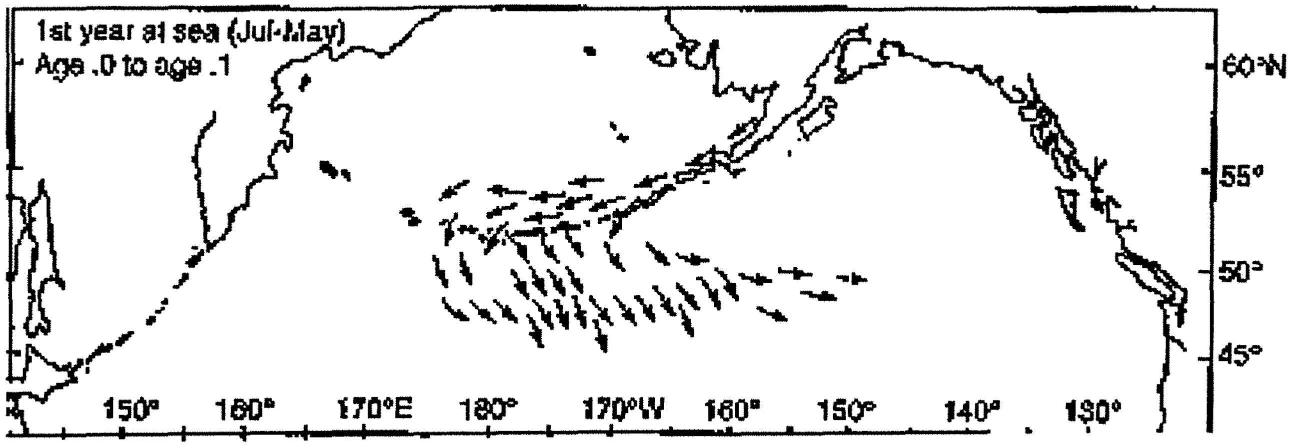

Figure 7. Model of migration of western Alaska sockeye salmon (Adapted from French et al. 1976)