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FISHERIES RESEARCH INSTITUTE
School of Fisheries
University of Washington
Seattle, WA 98195

ALASKA SALMON RESEARCH

D. E. Rogers, Principal Investigator
with B. Rogers, Fishery Biologist; and
G. Blair and D. Helton, Graduate Students

ANNUAL REPORT

to

Pacific Seafood Processor Association

Approved

Submitted 3 March 1989 Robert C. Francis
Director

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ALASKA SALMON RESEARCH

Introduction

The Fisheries Research Institute was established in 1946 with the financial support of the major Alaskan salmon processors to 1) investigate the causes of the declines in production that had occurred in most of the stocks since the 1930s, 2) work with the government agency (Bureau of Commercial Fisheries) to increase our knowledge of the biology of salmon and the effects of the fisheries, and 3) assist salmon processors by providing a second opinion on matters of salmon fisheries management. These objectives are still valid today; however, with the return to high levels of production in most fisheries our primary objectives are now to determine how to maintain that production and how to harvest/process salmon most efficiently, e.g. accurate forecasts and in-season fishing time distributed throughout the run.

We currently have salmon research projects in Bristol Bay, Southeast Alaska, Chignik, and a study of the high seas distribution of salmon stocks. In recent years we have also worked at Kodiak, the Alaska Peninsula, and on the Yukon River stocks. All of these projects have been carried out in cooperation with the Alaska Department of Fish and Game or the National Marine Fisheries Service (high seas) and we have cooperative research projects with salmon biologists from Japan and the U.S.S.R.

This report will focus on our Bristol Bay and Southeast projects with emphasis on forecasting (Port Moller) and escapement policies to maximize production, both present and in the future.

Bristol Bay

Forecasting

Forecasts of the 1989 Bristol Bay sockeye runs were provided to Bristol Bay processors in December, 1988 and they are presented in Table 1 with the forecasts and actual runs for the past four years. The FRI forecasts (D. E. Rogers) are based on the same sources as the ADF&G forecasts but FRI has often used different methods of analysis. The forecasts were reasonably accurate in 1985 and 1986 especially in regards to the magnitude of the catch; however, in 1987 the run was larger than expected and in 1988 it was smaller. In both years, the Port Moller test fishery provided an accurate forecast of the run just prior to the mid-point and this was especially useful for management of the 1987 Kvichak run. Although the test fishery performed well in 1987 and 1988, this was often not the case in past years because the ratio of index catch to numbers of fish in the run varied from year to year (Table 2). We examined some factors that may have caused this variation in the past so that we might maintain a high degree of accuracy in the forecasts.

Port Moller Test Fishery

An offshore test fishery for Bristol Bay sockeye and chum salmon has been conducted out of Port Moller since 1967 to estimate abundance, age composition and run timing before the fish reach the fishing districts within Bristol Bay. The test fishery is conducted from early June to the first week of July and can provide the fishing industry and ADF&G with run characteristics about one week prior to their arrival in the fishing districts. The fishery was originally operated by ADF&G, but after the 1985 season when there was a change in the gill net mesh size and material and a somewhat inaccurate forecast, they dropped the program. The unusually late run in 1986 that came without warning (no Port Moller program) caused some serious disruption in the Bristol Bay fishery and this prompted the industry to finance the program in 1987.

Table 1. Pre-season Bristol Bay sockeye salmon forecasts and the actual runs (millions).

YEAR	Forecast/Run	Kvichak	Naknek	Egegik	Ugashik	Nushagak	Total Run	Catch
1985	FRI	12.2	5.3	5.8	4.4	4.3	33.0	18.2
	ADFG	12.2	4.9	6.6	5.6	4.3	35.0	20.3
	Japan CPUE						38.0	
	Actual Run	13.4	3.7	8.6	7.4	3.0	36.6	23.5
1986	FRI	9.2	4.5	5.9	6.7	4.8	32.1	19.4
	ADFG	4.5	3.2	5.4	4.9	3.8	22.5	13.3
	Japan CPUE						31.7	
	Actual Run	2.0	3.9	6.2	5.9	4.9	23.7	15.8
1987	FRI	2.8	2.0	5.8	3.1	5.1	19.5	12.4
	ADFG	2.7	2.1	4.9	3.1	3.3	16.8	9.3
	Japan CPUE						17.0	
	Actual Run	9.6	2.4	6.7	2.8	5.1	27.3	16.0
1988	FRI	12.3	3.1	6.2	3.1	5.0	30.6	20.8
	ADFG	9.3	2.5	5.6	3.2	5.6	26.5	16.8
	Japan CPUE						18.5	
	Actual Run	6.8	1.8	8.0	2.2	3.2	23.4	14.0
1989	FRI	20.4	3.6	6.7	3.0	3.4	38.0	25.4
	ADFG	12.5	3.1	5.6	3.6	3.1	28.9	16.2
	Japan CPUE						26.9	
	Actual Run							

Table 2. Bristol Bay runs and sockeye per Port Moller index catch.

Year	Inshore Run (millions)	Cummulative P. M. Index	Fish per Index (thousands)
1968	8.0	301	27
1969	19.0	603	32
1970	39.4	823	48
1971	15.8	680	23
1972	5.4	98	55
1973	2.4	340	7
1974	11.0		
1975	24.2	1289	19
1976	11.5	689	17
1977	9.7	782	12
1978	19.9	447	45
1979	39.9	1034	39
1980	62.5	527	118
1981	34.5	1052	33
1982	22.2	759	29
1983	45.9	645	71
1984	41.1	633	65
1985	36.6	1804	20
1986	23.7		
1987	27.3	1215	22
1988	23.4	803	29

Methods The test fishery relies on the fact that sockeye and chum salmon returning to Bristol Bay spawning grounds from North Pacific feeding areas are usually concentrated in a relatively narrow band as they travel along the north side of the Alaska Peninsula. The bulk of the adult salmon generally stay between 20 and 50 miles offshore (30 to 60 miles off Port Moller), while the seaward migrants (smolts) are concentrated within 20 miles of the coast. ADF&G established 12 fishing stations along a transect line between Port Moller and Cape Newenham (Fig. 1). Ten stations were regularly fished for the abundance index, 5 on one day and 5 on the next. This design provided good onshore-offshore distribution at the expense of effort in the usual center of abundance (30 to 60 miles or stations 2 to 8). Since 1987, we have regularly fished stations 2, 4, 6, and 8 with a repeat of the last station each fishable day. Stations 1 and 10 are fished only if it is apparent that the onshore-offshore distribution is unusual.

For the past two years, the test fishing vessel has been the F/V Nettie H., a 70 ft combination crabber, longliner and salmon tender that is equipped with a hydraulic reel. Test fishing was conducted in most weather conditions. The main limitation in fishing in rough weather is the strength of the hydraulic reel and the tension on the net as it is being retrieved. During the 1988 season there were 5 days when fishing was impossible.

A 200 fathom long, 60 mesh deep, 5 inch stretched-mesh gill net is used. The web is multistrand monofilament (center core). Prior to 1985, the test fishery used 5.25 inch stretched-mesh with multifilament nylon (cable lay) webbing. These gear types are not equivalent in fishing efficiency, so comparisons between catches made prior to 1985 with those made since are difficult.

The net is set so that it runs north and south, roughly at right angle to the salmon's migratory path. It is fished for about one hour and usually during daylight Because it takes more time to haul in the net when there is a large catch, the following formula is used to estimate and standardize fishing time:

Fishing time= net time in water + (time to set and haul)/2

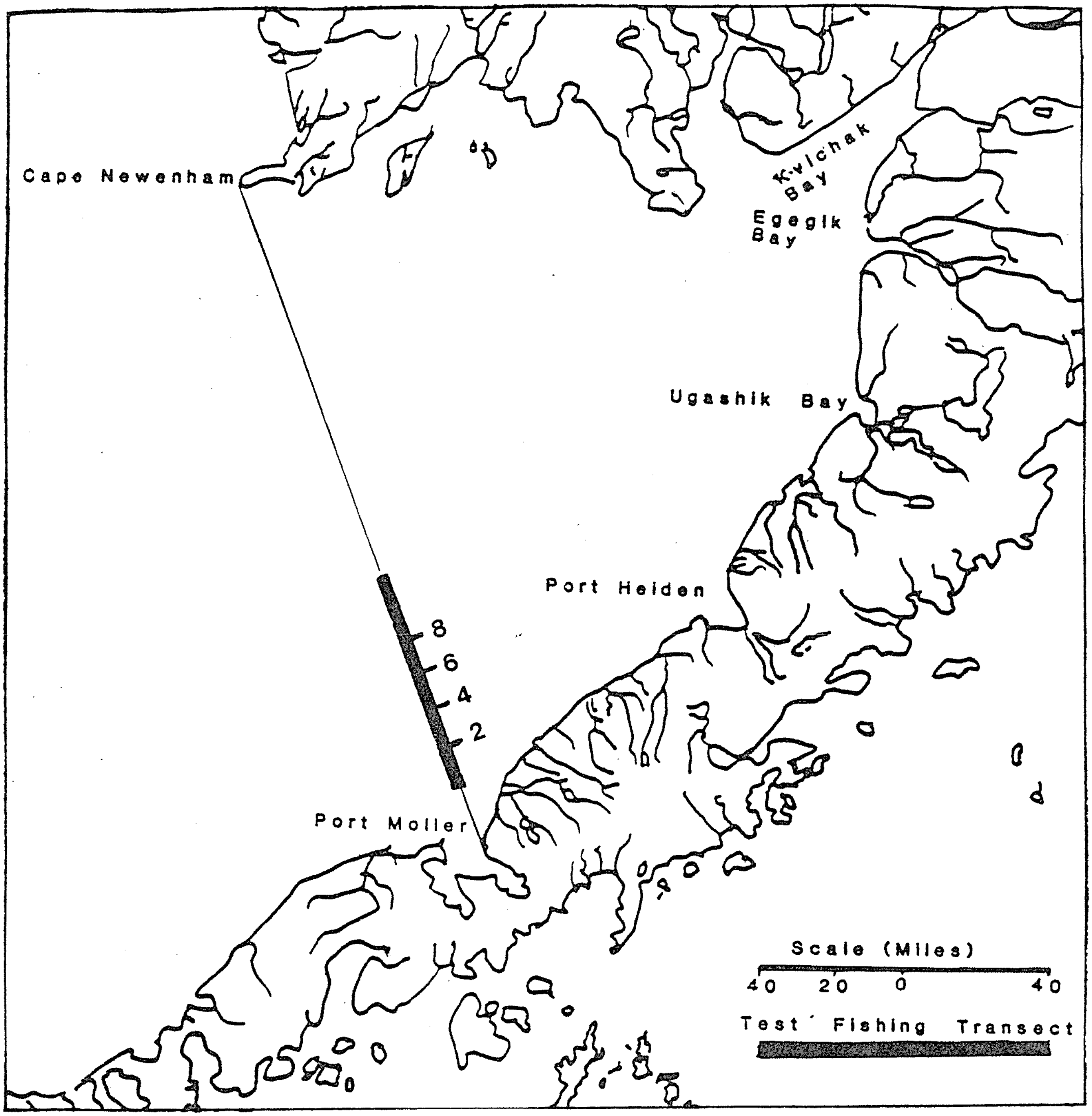


Fig. 1. Location of the Port Moller test fishery.

The sockeye and chum index catches are then computed individually as the number of fish caught per hour per 100 fathoms of net (usually about one-half of the actual catch). The sum of the four index catches at stations 2, 4, 6, and 8 is the daily index and the cumulative daily indices through selected dates are calculated to forecast the run. Index values for missed stations or days are estimated by the average for the two days before and the two days after the missing index. The length of each sockeye is measured (mid eye to tail fork), sexed and a scale sample is taken for ageing (done by ADF&G in King Salmon). At each fishing station, surface water temperature, air temperature, wind velocity and direction, and tide stage are recorded.

Results. A preliminary analysis of the catch data shows no obvious flaws in the experimental design. Analysis of variance failed to detect any significant differences in catches associated with wind conditions ($P< 0.508$), tide stage ($P< 0.578$), nor time of day ($P< 0.687$). The age composition of sockeye salmon sampled off Port Moller is similar to the composition in the total run to Bristol Bay, and has been more accurate than pre-season forecasts of age composition. In the past three test seasons, the age composition has been within three percentage points of the inshore age composition. Also the sex ratio of sockeye caught by the test fishery and in the Bristol Bay run are not significantly different-- close to 50:50. In contrast, lengths of sockeye caught off Port Moller and in the commercial fishery show significant differences. Over an 18 year period, the average length of sockeye captured off Port Moller has been consistently larger (0.37 inch on average) than reported in the Bristol Bay fishery. Despite the size difference, the test fishery has accurately reflected the year to year variation in the average sizes of the inshore fish.

The test fishery run timing curves, cumulative daily indices, provide a measure of the run size and timing. In the past three test seasons, the Port Moller catches have reflected the Bristol Bay runs in relative timing and magnitude (Figs. 2-4). In 1988, however, the fish appeared to move somewhat faster into the Bay than in 1985 and 1987 perhaps because water temperatures were a little warmer. In addition, the 1988 catches were somewhat lower relative to the size of the run, i.e., the number of sockeye per index was

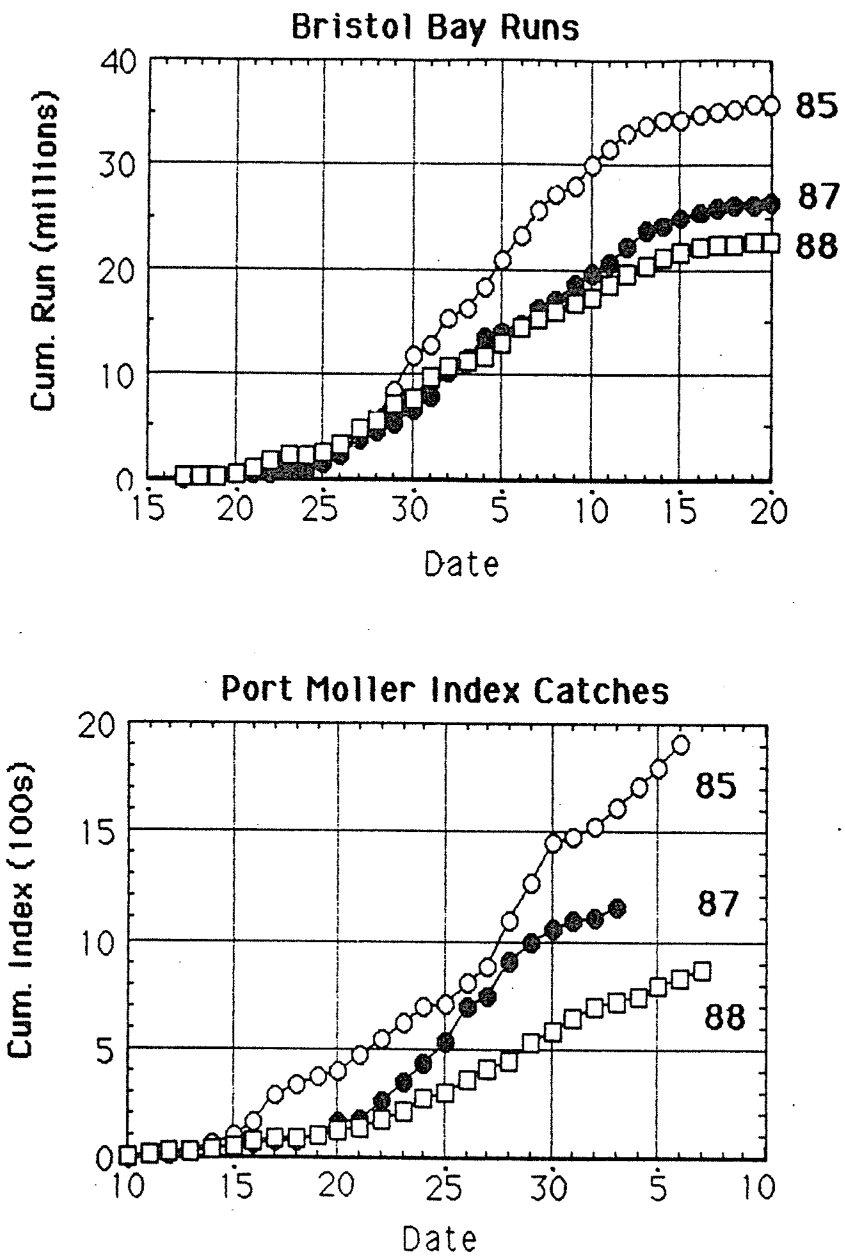


Fig. 2. Cumulative daily sockeye indices (sum of index catches for stations 2,4,6, and 8) for 1985, 1987-88 (bottom) and the cumulative daily runs in Bristol Bay fishing districts as calculated post-season by lagged escapements (top).

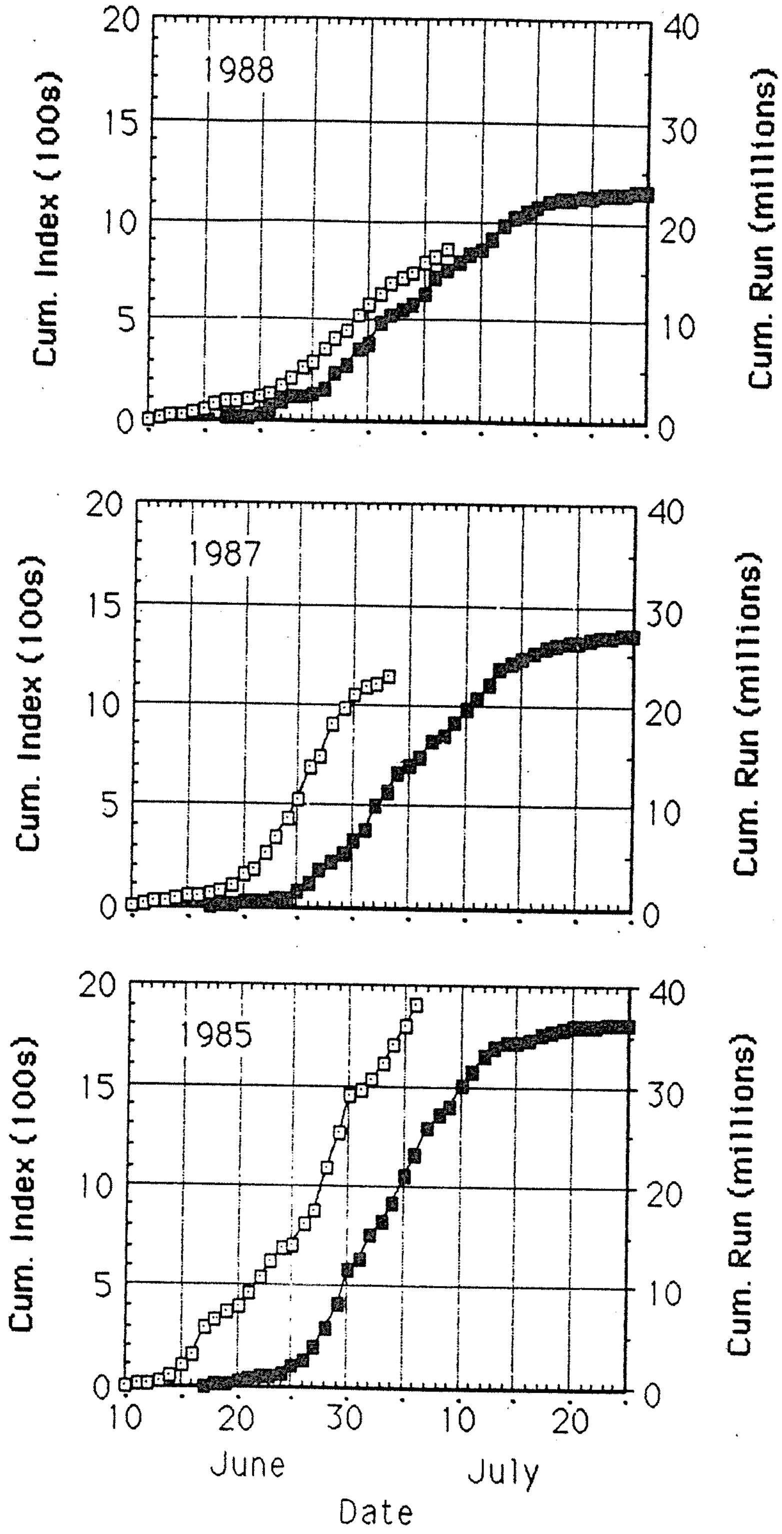


Fig. 3. Cumulative daily sockeye index catches at Port Moller and the cumulative daily Bristol Bay runs in the fishing districts (calculated post-season) by date for 1985, 1987, and 1988.

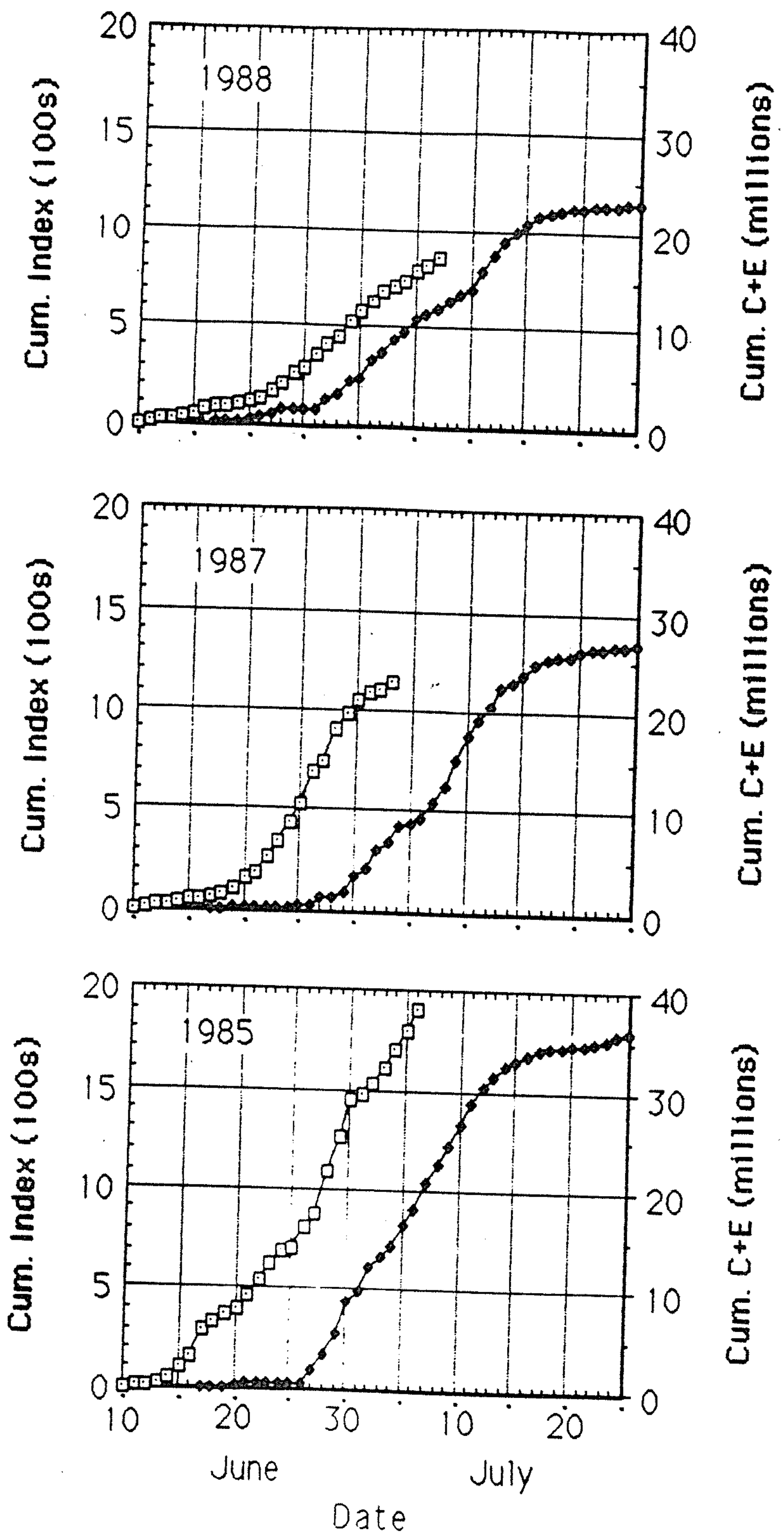


Fig. 4. Cumulative daily sockeye index catches at Port Moller and the cumulative daily catch plus escapement (at towers) in Bristol Bay by date for 1985, 1987, and 1988.

higher. For the 1988 forecast we applied the average of the ratios of run to index in 1985 and 1987 to the 1988 index and this provided forecasts of 15 million on June 25 and 30, and a final forecast of 17 million (0.021 x 803) on July 5 (Table 3).

Table 4 gives the Bristol Bay sockeye catches through June 25, 30 and July 5 with the projected final 1988 catches if the fishing pattern was typical of past years. For example, in past years 7.5% of the Egegik catch was made through June 25, and since the catch in 1988 was 1.2 million at that time, the final catch was projected to be 16 million. Although Egegik was the worst case, obviously, projections this early in the run can be way off the mark. However, by July 5 it was apparent that the run would be greater than the 17 million forecasted by the Port Moller index. Nearly that many could be expected in the Naknek/Kvichak and Egegik districts alone from catches and escapements in those districts, which through July 4 (the usual mid-point in the run) totalled 8.1 million. A forecast totaling 22 million (12 million catch) was issued on July 6 that combined the information from Port Moller and the inshore run. As of July 5 with a catch of about 7 million for all districts, the final projected catch was 15 million or close to the final catch of 14 million.

The early arrival of fish at Egegik along with considerable fishing effort led to early season expectations of a catch at least as large or larger than the pre-season forecasts of 17 to 21 million. The cumulative Bristol Bay catch and escapement in 1988 was ahead of 1985 through June 28 and the 1985 run and catch totalled 37 and 24 million (Fig. 5). Although the picture changed after June 29, the 1988 catch and escapement still was ahead of 1987 until July 9 and did not accurately reflect the final size of the run until nearly July 15.

Test Fishing Recommendations. Changes made to the Port Moller test fishery should be done cautiously and without sacrificing the existing design. Prior to 1988, it appeared that the catches made in the June fishery in the Shumagins/South Unimak fishery could provide a "free" and accurate forecast of the Bristol Bay run; however, in 1988 the information from that fishery was conflicting and largely useless. The current experimental design at Port Moller seems to work well and any change that changes gear efficiency

Table 3. Ratios of final Bristol Bay run to Port Moller index catches through three dates.

Year	Run (millions)	Through 25-Jun P.M. Index	Through 25-Jun Run per Index	Through 30-Jun P.M. Index	Through 30-Jun Run per Index	Through 5-Jul P.M. Index	Through 5-Jul Run per Index
1985	36.6	714	0.051	1446	0.025	1804	0.020
1987	27.3	540	0.051	1065	0.026	1215	0.022
1988	23.4	296	0.079	593	0.039	803	0.029

Table 4. The 1988 Bristol Bay catches (millions) and projected final catches estimated from average percentages made through selected dates in the past ten years.

District	Through 25-Jun Actual Catch	Through 25-Jun Projected Final	Through 30-Jun Actual Catch	Through 30-Jun Projected Final	Through 5-Jul Actual Catch	Through 5-Jul Projected Final	Final Catch	Final Run	6-Jul Port Moller Run Forecast
Naknek/Kvichak	0.3	9.5	0.6	3.2	1.8	4.1	3.6	8.8	8.0
Egegik	1.2	16.0	2.6	9.1	4.0	7.9	6.4	8.0	8.0
Nushagak	0.1	2.5	0.3	1.4	1.0	2.0	1.7	3.2	3.5
Ugashik	0.1	3.5	0.1	0.8	0.1	0.4	1.5	2.2	1.5
Togiak	0.1	- -	0.1	- -	0.2	0.6	0.8	1.2	1.0
TOTAL	1.8	31.5	3.7	14.5	7.1	15.0	14.0	23.4	22.0

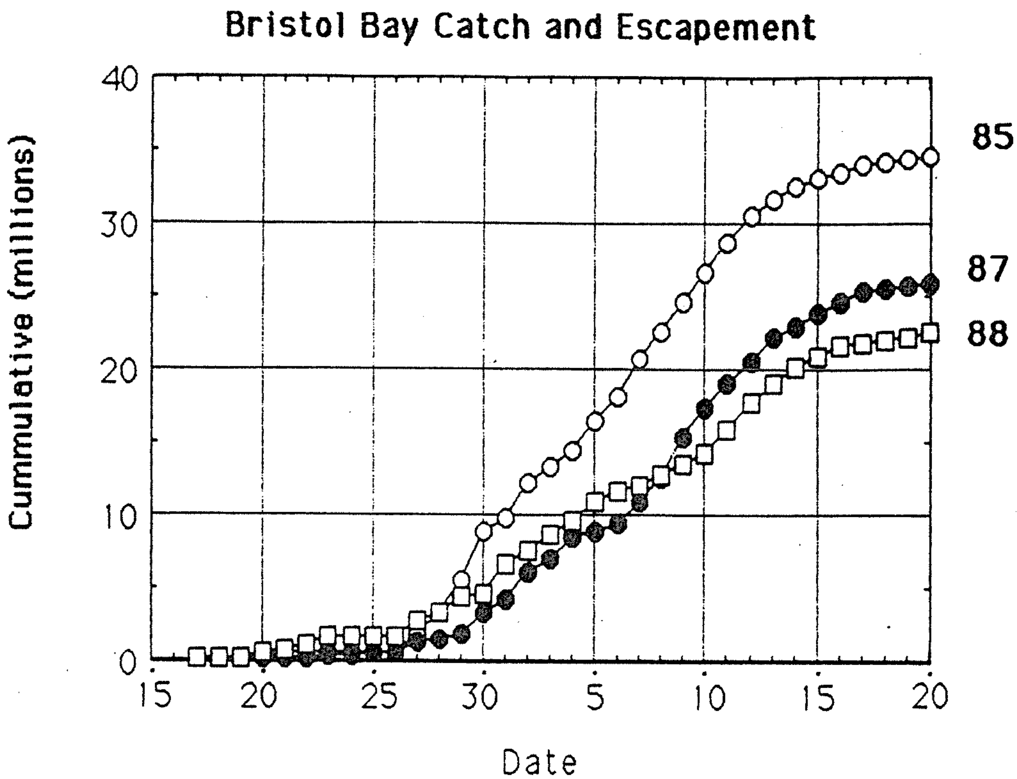


Fig. 5. Cumulative daily sockeye catch plus escapement (at towers): 1985, 1987-88.

makes it difficult to relate previous seasons research. The development of a multi-year data base is essential to maintaining accuracy in the forecasts; however, some modifications in the sampling design have been proposed and are under consideration.

1. Increased fishing time per station when catches are low.

Early season sample sizes are small and quite variable, e.g. for lengths and ages. Increased fishing time would provide a larger sample size and help make early predictions of age composition and perhaps abundance, more accurate. As the catches increased after about June 20, the fishing time could be back to an hour per set.

2. Change the sampling routine.

The present sampling method tries to repeat one station daily, usually station 2 or 8. These stations generally produce smaller catches than the middle stations. A better use of fishing time may be to fish an extra station each day (station 0 or 10) or repeat one of the middle stations.

3. Increased length of the net.

A longer net would help increase sample sizes and could be used experimentally with different mesh sizes. The addition of 50 fathoms of a larger mesh, and 50 fathoms of a smaller mesh may provide a more representative sample of the sizes of fish and perhaps a better measure of abundance.

4. Standardized collection of oceanographic data.

The recording of weather and sea conditions has been done with limited and crude resources. A recording thermometer and an anemometer would help standardize data collection. The collection of additional oceanographic data including plankton samples, water temperature profiles, and water transparency should also be considered.

5. Stock identification by scale analysis.

With increased sample sizes, it may be possible to identify the major stock origins through scale pattern analysis and thus estimate the strengths of the specific runs, e.g. Nushagak, Kvichak, Egegik. The practicality of this is dependant on ADF&G staff, available time and sample size. The process of stock separation via scale analysis may be to slow to be of value during the season.

6. An additional test fishery.

A test fishery closer in to Bristol Bay using a conventional gillnetter may provide a later, but more accurate estimate of run timing and abundance than that provided by the Port Moller test fishery.

Of these modifications, only the first two and part of the fourth will likely be implemented in 1989. The others all require some additional cost and require further consideration.

Lake Research

During the summer of 1988, we continued our long-term monitoring of spawning distribution, growth and abundance of fry, and the physical and biological environment for the sockeye salmon of the Wood River (Nushagak) and Kvichak lake systems. Most of our annual observations in the Wood River Lakes extend over more than 30 years and constitute the longest continuous biological and environmental record on any salmon stock in Alaska. In 1988, we also completed the field work on a study of the variation in body size and shape of sockeye salmon spawners in relation to the physical conditions of the spawning grounds in the Wood River and Kvichak systems. In general, fish spawning in small shallow streams are very small and narrow bodied, those in deeper rivers are larger and deeper, whereas beach spawners (in the lakes) are very deep bodied. We still need to determine whether these differences exist to any extent as the fish pass through the fishery, i.e. before they mature. Finally, in 1988 we counted the sockeye escapement into the Newhalen River/Lake Clark system of the Kvichak. Although Lake Clark makes up only about 10% of the surface area of the Kvichak lake system (Lake Iliamna 90%), in recent years it has commonly received 20-30% of the system escapement. We believe that the distribution of the escapement between the two lakes needs to be considered in escapement policy for the system, and to determine this policy we need a multi-year data base.

Newhalen River Escapement. The annual escapements of sockeye salmon to the Kvichak lake system are estimated from expanded 10-min counts on each bank of the river at Igiugig (outlet of Lake Iliamna) by ADF&G. The relationship between the escapement and the returns (catch plus escapement) 4-6 years later, has formed the basis for the escapement goals and thus has largely determined the catches from the annual Kvichak runs. This approach to management assumes that the annual escapements are uniformly or randomly distributed among the many spawning grounds. In the mid-1970s, our spawning ground surveys indicated that a greater proportion of the Kvichak escapement was going to the Lake Clark/Newhalen River than was the case in prior years and the areas for spawning and rearing of fry were rather limited there.

We began in 1979 to estimate the annual escapements up the Newhalen River by counting from the river banks near the mouth of the river. Then from 1980 to 1985 we also counted at a point 22 miles up-river that produced more accurate counts, but at more cost and less value for possible use in in-season management. The escapement estimated near the mouth of the river (about two days travel time from Igiugig) is made by expanding 20-min counts on one bank, for each of 10 daylight hours, to a daily count for both banks. We count when and where the visibility is best and assume that the fish utilize both banks equally (which was the case up-river) and that their migratory rate does not change at night. We can then compare the daily counts at Newhalen with the Igiugig counts to estimate the travel time between the two places, and by lagging the Newhalen counts back to Igiugig the appropriate number of days, we can calculate the daily proportions of the cumulative Kvichak run that was going up the Newhalen River.

The cumulative daily escapements for the two rivers timed to the Kvichak are given in Table 5 for 1983-1988 (no Newhalen count for 1987), and the daily ratios of Newhalen to Kvichak cumulative escapement are shown in Figure 6. The first day of the escapement each year was defined as the first day that the Kvichak escapement totalled about 100,000. The ratios were often variable for the first few days and then tended to increase after about 16 days. This late increase is caused by milling fish that swim up-river along the bank of the Newhalen and are counted, then drift down- river in the middle where they are usually not seen. This results in an over-estimate of the late escapement. To overcome this problem, we have used the average proportion of Newhalen count to Kvichak count for day 5 to 16 and the seasons total Kvichak escapement to estimate the Newhalen/Lake Clark escapement.

In 1988, we estimated that nearly 60% of the Kvichak escapement of 4.1 million ended up in the Newhalen River/Lake Clark system, and since the estimate of the Newhalen River spawners was about 0.3 million, then about 2.1 million or 51% of the escapement ended up in Lake Clark which has about 9% of the lake system surface area (Table 6). This is likely to result in very poor growth of the fry there , migration at age 2, and a return mostly in 1993 to Lake Clark rather than to Lake Iliamna. There was also a large escapement into Lake Clark in 1984 and most of the production from that year should return in 1989.

Table 5. Cumulative daily escapements in the Kvichak and Newhalen Rivers, 1983-1988 (in 1,000's). Newhalen escapements estimated from expanded counts lagged back 3 days for 1986 and 2 days for other years.

	1983		1984		1985		1986		1987		1988	
Date	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen	Kvichak	Newhalen.	Kvichak	Newhalen
25-Jun			17	10							1	
26			86	34							4	5
27	3	2	121	42	1						75	85
28	142	142	133	75	113	14					264	128
29	521	220	804	258	362	38					313	140
30	943	280	1821	389	631	67					328	187
1-Jul	1366	358	2600	635	979	110			30		364	244
2	1683	458	3116	913	1216	192	1		537		778	456
3	1779	523	3630	1185	1337	278	8	3	1118		1193	632
4	1865	577	4320	1385	1601	350	75	7	1547		1598	676
5	1965	614	5113	1652	1907	451	212	8	1703		1901	784
6	2012	635	5968	1899	2330	480	268	16	1782		2079	1076
7	2054	651	6787	2232	2738	538	278	24	1867		2189	1313
8	2210	685	7581	2474	3137	754	280	30	2636		2232	1505
9	2559	713	8437	2669	3833	874	310	51	3659		2272	1629
10	2654	749	8992	2887	4625	1138	442	72	4526		2389	1721
11	2686	834	9222	3060	5327	1311	539	98	5137		2775	1868
12	2735	891	9358		5800	1373	680	189	5404		3473	2106
13	2790	933	9748		6067	1445	854	250	5654		3753	2372
14	2853	948	10032		6366		987	320	5773		3840	2657
15	3195	1121	10111		6586		1080	359	5878		3948	2848
16	3417	1219	10172		6674		1012	382	5946		3990	2976
17	3447	1261	10270		6706		1110	391	5971		4020	3094
18	3487	1301	10360		6856		1115	397	5986		4046	3203
19	3539	1345	10430		6976		1119	406	6000		4057	3313
20	3558	1386	10455		7051		1122	410	6013		4062	3435
21	3564	1418	10467		7116		1130	420	6032		4065	
22	3568	1472	10476		7171		1154	428	6055		4065	
23	3569	1490	10485		7201		1169	441	6063			
24		1500	10490		7211		1174	450	6066			
25		1540	10491				1177	454				

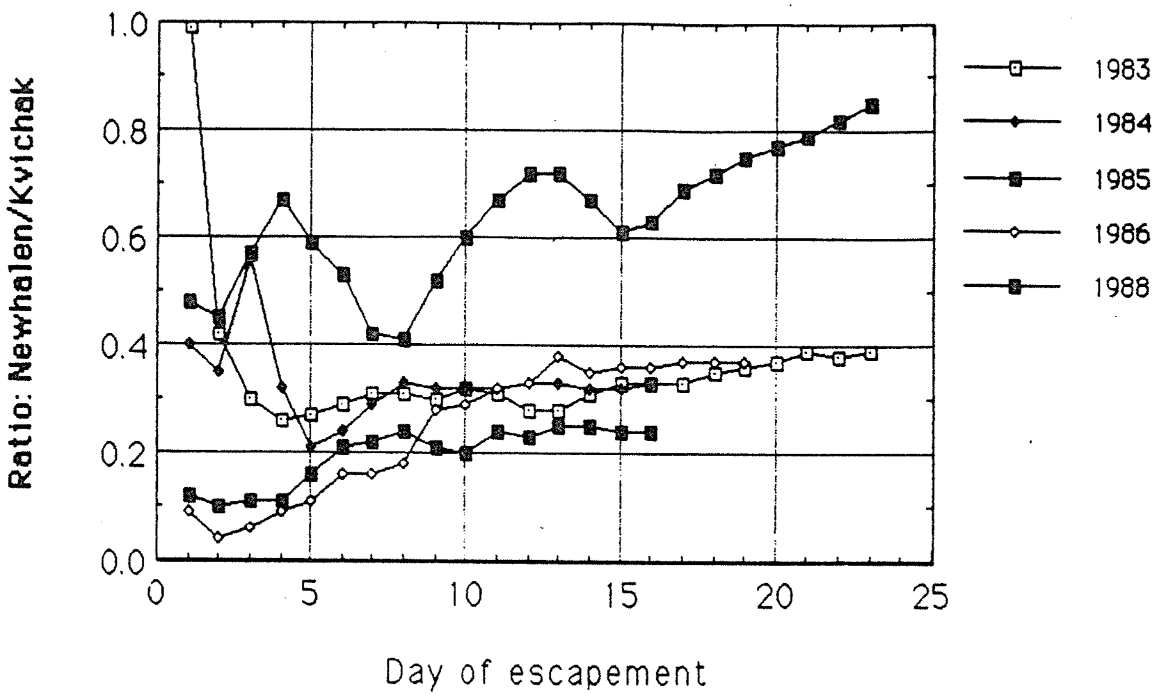


Fig. 6. Daily ratios between the cumulative Newhalen escapement (lagged back) and the cumulative Kvichak escapement, 1983-86 and 1988.

Table 6. The Kvichak lake system escapements and the percentages going to the Newhalen River and Lake Clark. Newhalen River spawners estimated by two times the aerial survey estimate.

Year	Kvichak System Escapement (millions)	Newhalen/Lake Clark Escapement (millions)	Percent of Kvichak (%)	Newhalen River Spawners (millions)
1979	11.22	9.00	80	0.56
1980	22.51	7.50	33	2.64
1981	1.75	0.26	15	0.03
1982	1.14	0.34	30	0.13
1983	3.57	1.08	30	0.41
1984	10.49	3.20	31	0.67
1985	7.21	1.62	22	0.15
1986	1.18	0.29	25	0.01
1987	6.07	- - -	- -	1.46
1988	4.06	2.41	59	0.29

Kvichak Spawning Distribution. We began aerial and ground surveys of the sockeye salmon spawning grounds in the Kvichak system in the 1950s; however, many of the major beach spawning areas were not surveyed until 1961, after some "large" concentrations of carcasses were discovered on several beach spawning areas in 1960. The relative runs to the four main types of spawning ground in the Kvichak system are shown in Fig. 7. These "runs" are the sum of the counts for the spawning grounds surveyed (not all places are included) times the ratio of Kvichak system run to Kvichak system escapement.

The pattern of the runs to the various spawning grounds in the Kvichak suggests that the historical (1950s to mid-1970s) cyclical runs to the Kvichak were largely caused by a very cyclical pattern in the abundance of beach spawners, especially the Island spawners. The recent changes in the cycle, successive large runs, appears to be mainly caused by an increase in river spawners, which includes the Newhalen River and the Tazimina River in lower Lake Clark. The island beaches have relatively few spawners except in years ending in 0 or 5 and have been receiving decreasing numbers in those years. These changes in the pattern of the Kvichak runs and their distributions on the spawning grounds need to be followed and considered in establishing annual escapement goals for the system.

Sockeye Fry in Iliamna Lake. We have sampled the sockeye salmon fry in the Kvichak lake system each year since 1962 (1961 brood year) by townetting at night in late-August to early-September. Only the upper end of Lake Iliamna, where most spawning and fry are concentrated, is routinely sampled, and we have not routinely sampled the fry in Six-mile Lake (upper end of the Newhalen River) of the Lake Clark system, where fry from the Tazimina River are likely to be concentrated. The geometric means of the catches provide a measure of relative density (number per 5 min tow) and the mean lengths of the fry are adjusted each year, based on their daily growth rate, to September 1 (Table 7).

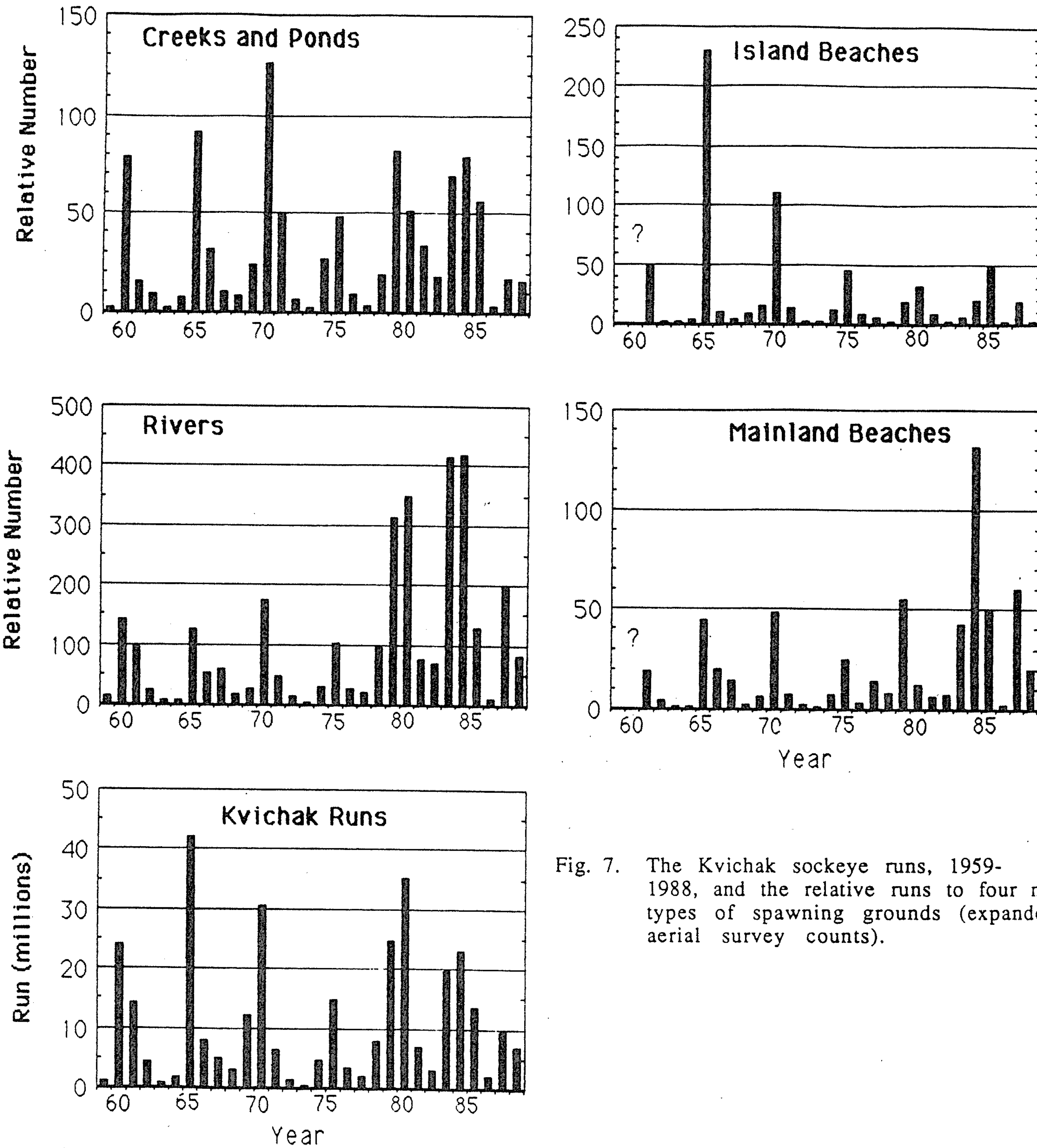
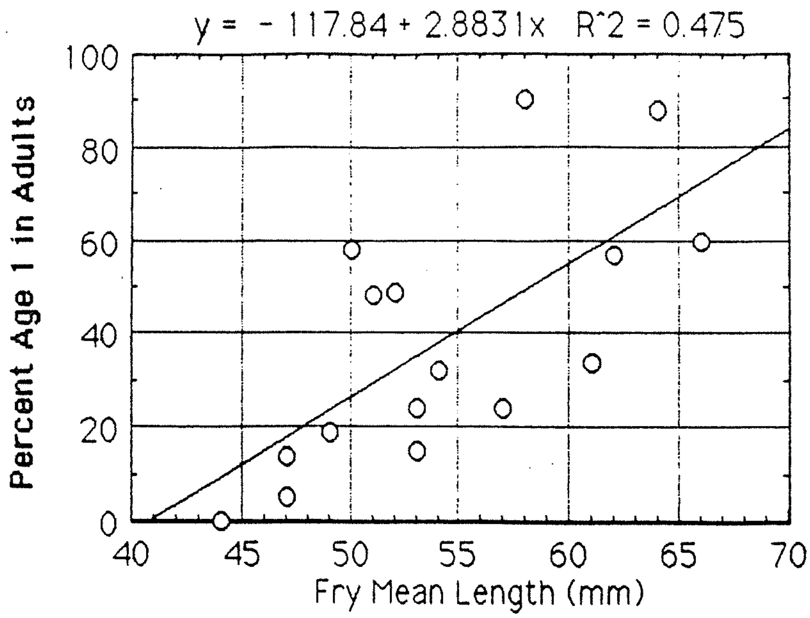
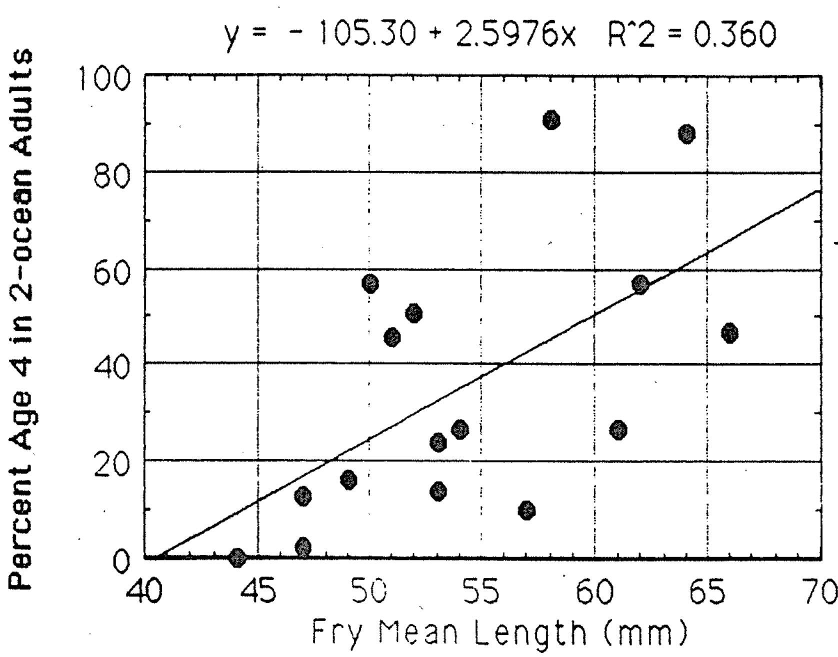


Fig. 7. The Kvichak sockeye runs, 1959-1988, and the relative runs to four main types of spawning grounds (expanded aerial survey counts).

Table 7. Mean tow net catches and lengths (mm) of sockeye fry in Lakes Iliamna and Clark.

Brood Year	Kvichak Escapement (millions)	Lake Iliamna Mean Catch	Lake Iliamna Mean Length	Lake Clark Mean Catch	Lake Clark Mean Length
61	3.7	90	53	13	50
62	2.6	12	45	54	50
63	0.3	5	54	3	50
64	1.0	7	62	2	50
65	24.3	170	53	23	52
66	3.8	67	57	15	47
67	3.2	78	62	47	59
68	2.6	43	62	9	50
69	8.4	386	61	11	55
70	13.9	127	44	20	38
71	2.4	4	50	15	41
72	1.0	3	58	17	48
73	0.2	2	71	12	57
74	4.4	491	54	80	55
75	13.1	252	49	105	49
76	2.0	16	53	--	--
77	1.3	11	61	--	--
78	4.1	339	62	65	56
79	11.2	282	53	60	48
80	22.5	134	61	26	59
81	1.8	37	52	58	46
82	1.1	9	68	18	57
83	3.6	242	64	40	56
84	10.5	147	46	84	51
85	7.2	63	54	16	49
86	1.2	10	60	--	--
87	6.1	79	63	11	52





Brood Year	Escape.	Mean Length
84	10.5	46
85	7.2	54
86	1.2	60
87	6.1	63

Fig. 8. Relationships between the freshwater age of adult sockeye in the Kvichak returns by brood year (1961-1983) and the mean lengths of the fish as fry in Lake Iliamna on 1 September; percentages in 2-ocean returns (bottom) and percentages in the total returns (top).

The sockeye fry are usually smaller in Lake Clark than in Lake Iliamna because temperatures are usually colder and there is a shorter ice-free period. We suspect that many of the fry from the lower part of Lake Clark descend the Newhalen River and rear for part of their freshwater life in the middle and lower parts of Lake Iliamna. In both lakes, the annual growth of the fry is correlated with water temperatures which are greatly influenced by the spring weather. Cold temperatures usually result in small fry (40-50 mm) which then spend two years in the lake before migrating to sea and tend to return as adults five years after their parents. Warm temperature usually result in large fry (over 60 mm) which tend to go to sea after one year and tend to return four years after their parents.

The tow net sampling has been most useful in predicting the main age at return, from the larger escapements in the Kvichak, three years in advance (Fig. 8). For example, the fry from the 1984 brood year averaged only 46mm in 1985. Based on the relationship between length and the percentage of adults returning with a freshwater age of 1, only about 15% of the production of 2-ocean fish should have returned in 1988. The return of that age group in 1988 was 2.8 million, thus we should expect the remaining 85% (19 million) to return in 1989. The majority of the production from the 1985 escapement (7.2 million) should return in 1990 (5 years later), whereas the majority of the production from the 1987 escapement (6.1 million) should return in 1991 (4 years later). Therefore we may have three successive years with relatively large runs even though one year (1986) had a very small escapement.

<u>Wood River Lakes Research.</u> The Bristol Bay research program of FRI began with spawning surveys in the Wood River Lakes in 1946 to determine where, when and how many sockeye salmon spawned there. These surveys have continued to the present. A permanent camp was established on Lake Aleknagik (near the lake system outlet) in 1949 and that year the first of several important environmental measurements was made -- the date of spring ice breakup. Over the next 15 years several other annual measurements were added, so that we now have a good basis for measuring the environmental affects on sockeye growth and survival in the freshwater phases of their life (juveniles and spawning adults).

Ice breakup occurred five days earlier than average in 1988, and with above average sunlight (solar radiation) during June, water temperatures were above average through July (Table 8). There was an early and strong bloom of phytoplankton (as measured by chlorophyll content in June) that was followed by above average densities of zooplankton (the primary food of sockeye fry) during July and August. As a result of the early breakup, warm temperatures and abundant food, the sockeye fry in Lake Aleknagik experienced above average growth during the summer (they continue to grow through October) and nearly all of them will probably go to sea in 1989 at an average length of 85mm. The lake level was higher than normal during June and July but dropped to typical levels during the spawning period of August and September. Extremes in water level, either very high (fish spawn in places that will be dry or frozen in winter) or very low (spawners are too concentrated and are also more vulnerable to predators) are probably detrimental to successful spawning.

The spawner distribution of the 1988 escapement to the Wood River Lakes was about as expected from the distribution of the parent spawners in 1983 for the 3-ocean fish which are mostly river spawners, and in 1984 for the 2-ocean fish which are mostly beach spawners (Fig. 9). The sockeye that spawn in the smaller creeks of the system tend to be smaller 2-ocean fish, whereas those spawning in larger and deeper streams tend to be the larger 3-ocean fish. The spawning grounds containing a high percentage of 2-ocean fish (most beaches and many small creeks) exhibit a significant 4-year cycle of low abundance. This can be seen in Figure 9 by marking every fourth year beginning with 1953 and the 1989 run is in this low-year cycle.

The upper lakes of the Wood River system, which contain about 90% beach spawners, show this cycle quite clearly (Fig. 10). These lakes (Beverley and Kulik) make up about one-third of the surface area in the lake system, but in 1989 they are unlikely to make up more than 10% of the run and probably less. Therefore the usual escapement goal for the Wood River system of one million, which is based on a uniform distribution to the spawning grounds, should be lowered to match the spawning and rearing areas of Lakes Aleknagik and Nerka, about 600,000-700,000. The next large run to the upper lakes of the Wood River system will probably not come until 1991, i.e. four years after the large run in 1987 (Fig. 10).

Table 8. Summary of 1988 measurements in Lake Aleknagik (Wood River Lakes).

Measurement and years measured	Dates	1988	Past years Average	Range
1. Date of ice breakup 1949-		27-May	1-Jun	14 May, 16-Jun
2. Water temperature, 0-20m (C) 1958-	25-Jun	7.6	5.7	3.7, 9.2
	14-Jul	9.7	8.4	5.7, 12.0
	3-Aug	11.8	10.7	7.7, 14.0
	1-Sep	11.3	11.1	9.3, 13.0
3. Water transparency Secchi depth (m) 1962-	25-Jun	6.5	8.4	5.5, 10.5
	14-Jul	9.2	8.4	5.0, 10.9
	3-Aug	8.7	9.5	6.3, 11.9
	1-Sep	10.0	9.5	5.8, 12.1
4. Average daily solar radiation (gm/cal/cm) 1964-	June 16-30	458	427	283, 572
	July 1-15	309	405	284, 543
	July 16-31	339	358	192, 485
	Aug. 1-15	270	311	203, 386
	Aug. 16-31	181	260	165, 420
	Sept. 1-15	184	216	114, 300
5. Lake level (cm) 1952-	June 1-15	180	138	84, 222
	June 16-30	182	149	102, 218
	July 1-15	151	130	75, 191
	July 16-31	121	105	54, 172
	Aug. 1-15	89	84	34, 173
	Aug. 16-31	86	80	30, 184
	Sept. 1-15	95	80	29, 131
6. Chlorophyll "a", 0-20m (mg/m2) 1963-	25-Jun	40	27	10, 45
	14-Jul	24	27	10, 43
	3-Aug	23	21	6, 36
	1-Sep	22	22	12, 37
7. Zooplankton volume (ml/m2) 1967-	25-Jun	67	52	20, 168
	14-Jul	102	82	45, 161
	3-Aug	151	117	67, 226
	1-Sep	72	63	26, 107
8. Mean length of sockeye fry (mm) 1958-	1-Sep	59.1	56.5	43.2, 64.8

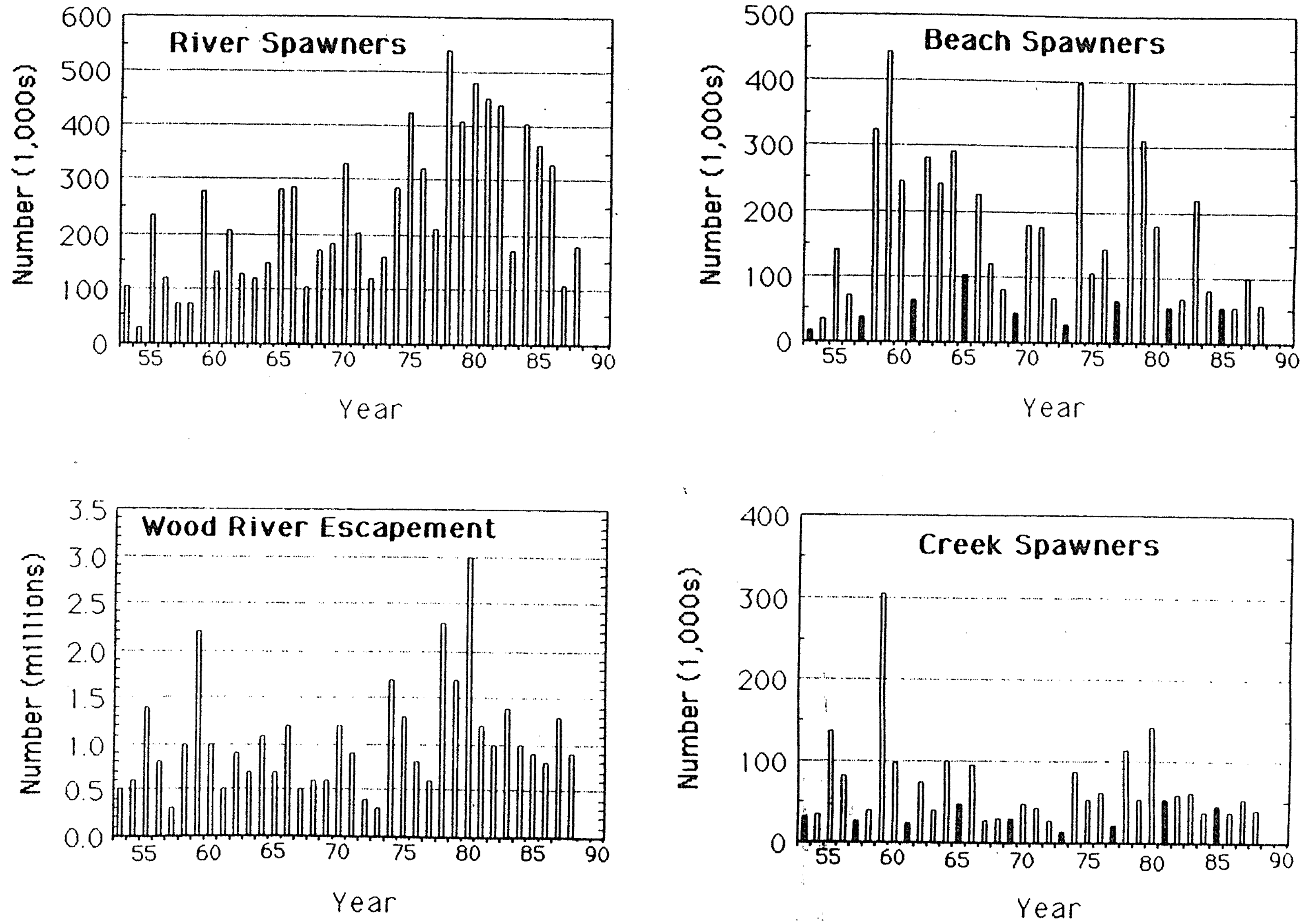


Fig. 9. Annual sockeye salmon escapements to the Wood River lake system, 1953-1988, and the numbers of spawners estimated by aerial surveys on three types of spawning ground.

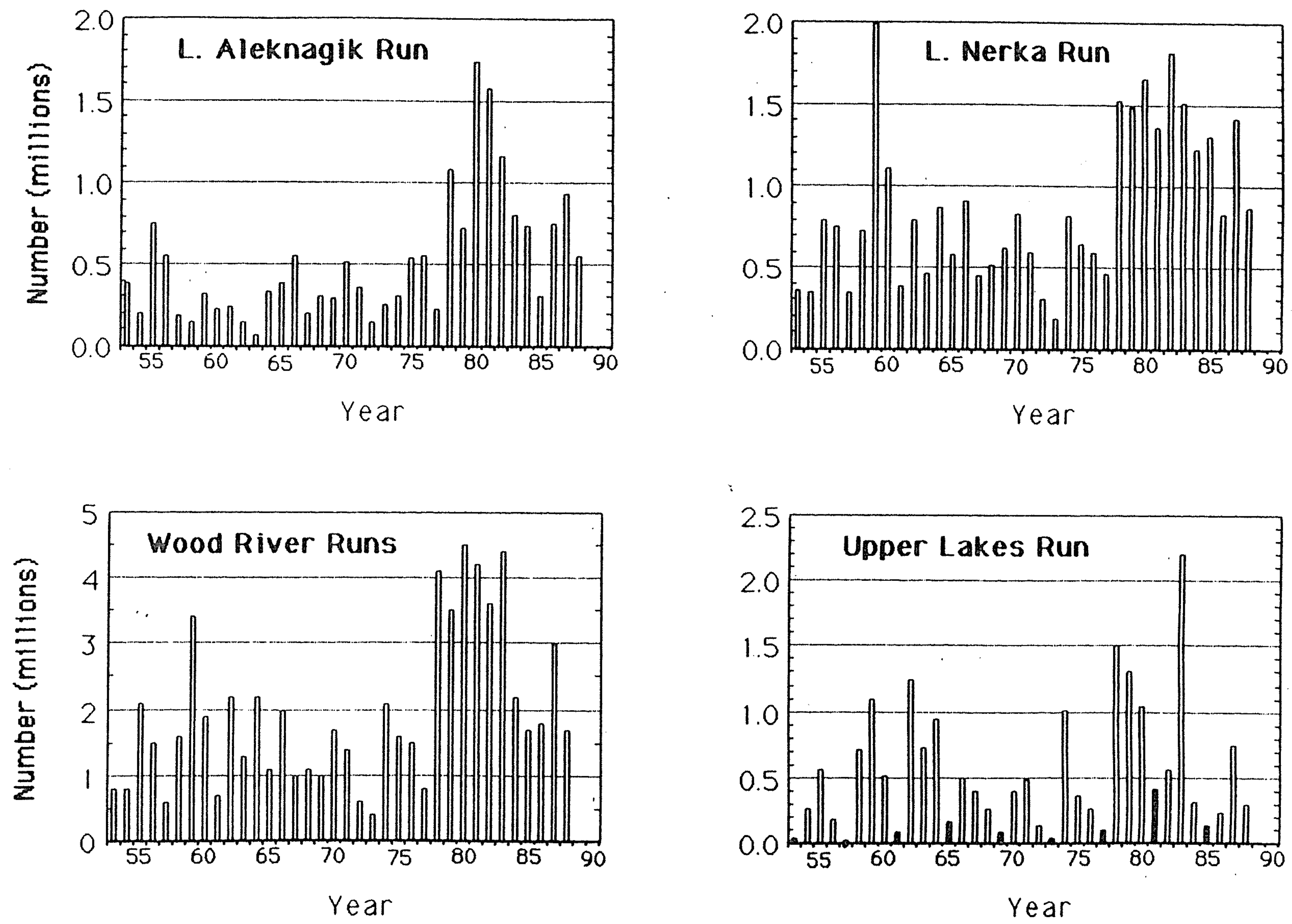


Fig. 10. Annual sockeye salmon runs to the Wood River lake system, 1953-1988, and the estimated runs to the three major parts of the system; Lake Aleknagik (20% of area), Lake Nerka (48% of area) and the upper lakes--Beverley and Kulik (32% of area).

Southeastern

Our recent research program in southeastern Alaska has been mostly carried out by O. A. Mathisen at the University of Alaska- Juneau. The emphasis has been on in-season forecasting of the pink runs in northern Southeast Alaska (Icy Straits). A separate report covering their 1988 work will be forthcoming.

The pink salmon catches in Southeast Alaska declined in the early 1950s, just as catches of all species and in nearly all other areas of Alaska did following the high production of the 1920s-1940s (Fig. 11). It appeared that, just as the catches in western and central Alaska had increased in the late 1970s, the catches in southeastern were going to increase to former levels in the early 1980s; however, catches dropped sharply in northern Southeast in 1986 and in southern Southeast in 1987. The decline in the southern region was unexpected since ADF&G had forecast large catches for both 1987 and 1988 (Table 9).

The annual runs (catch plus estimated escapement) have averaged larger and been more variable in the southern region than in the northern region since escapement estimates began in 1960 (Fig. 12). Since the late 1970s, the even year runs have been stronger in the southern region while the odd year runs have been stronger in the northern region; however, in both regions and for both brood lines in the southern region, the recent declines in catches and runs have followed from very large escapements, i.e. more than double the average (Fig. 13). It appears to be time to shift our research effort to the southern region.

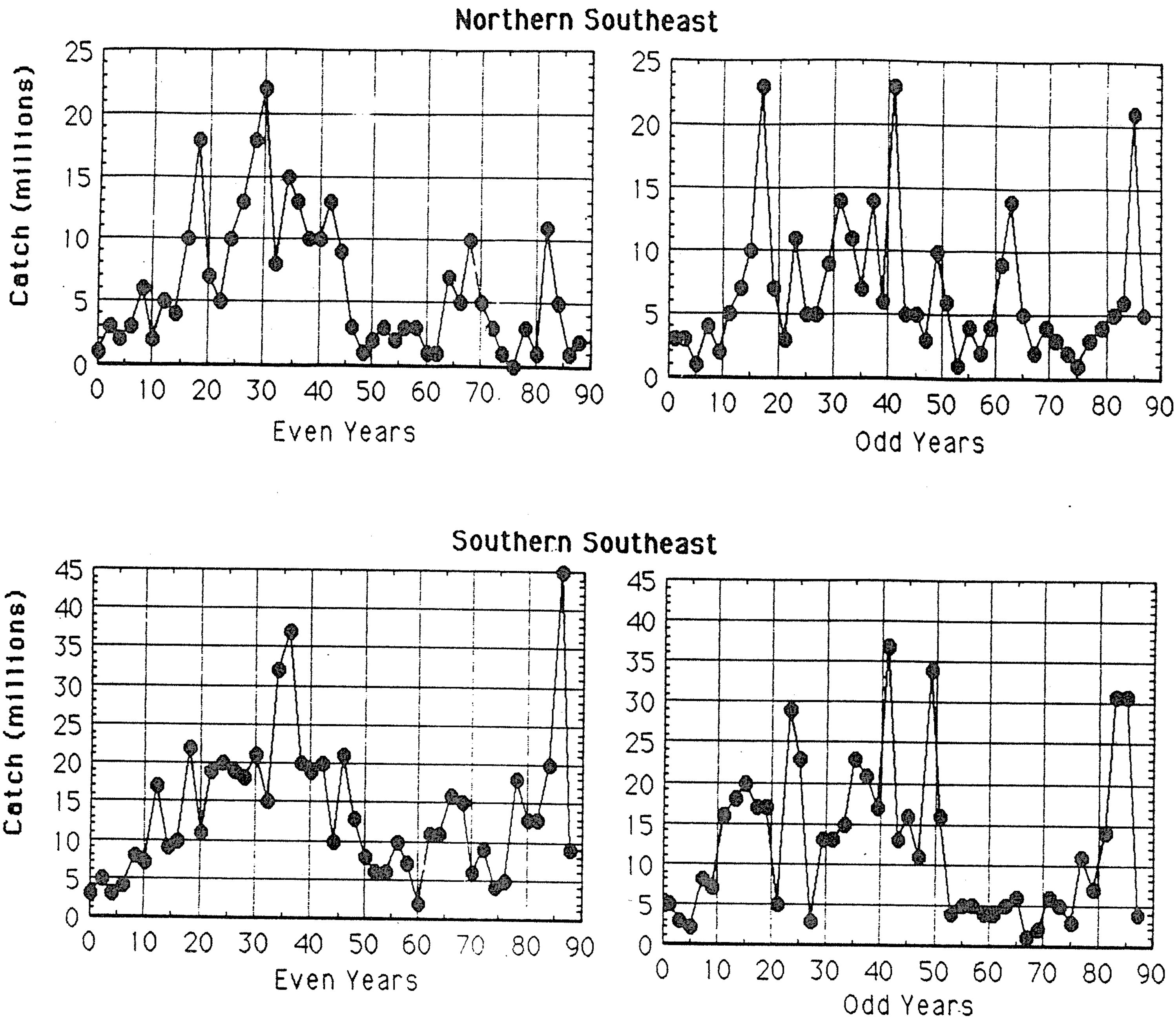


Fig. 11. Annual pink salmon catches in southeastern Alaska, by region and brood line,1900-1988.

Table 9. Southeastern pink salmon runs and the pre-season forecasts of the catches (millions).

Year	NORTHERN SOUTHEAST				SOUTHERN SOUTHEAST			
	Run	Escapement	Catch	Forecasted Catch	Run	Escapement	Catch	Forecasted Catch
1978	6.0	3.2	2.8	2	23.9	5.5	18.4	16
1979	8.9	5.1	3.8	5	11.8	4.8	7.0	9
1980	4.1	2.7	1.4	1	19.2	6.3	12.9	4
1981	9.4	4.1	5.3	2	19.5	6.0	13.5	9
1982	16.7	4.4	11.3	4	19.0	6.1	12.9	22
1983	10.8	4.8	6.0	1	40.2	8.8	31.4	12
1984	8.9	3.9	5.0	10	28.7	9.1	19.6	20
1985	30.1	9.0	21.1	7	43.0	12.3	30.6	25
1986	4.1	2.9	1.2	6	58.4	13.9	44.5	32
1987	9.3	4.2	5.1	5	9.9	5.5	4.4	21
1988	4.8	2.7	2.1	3	13.1	4.1	9.1	38
1989			?	7			?	14

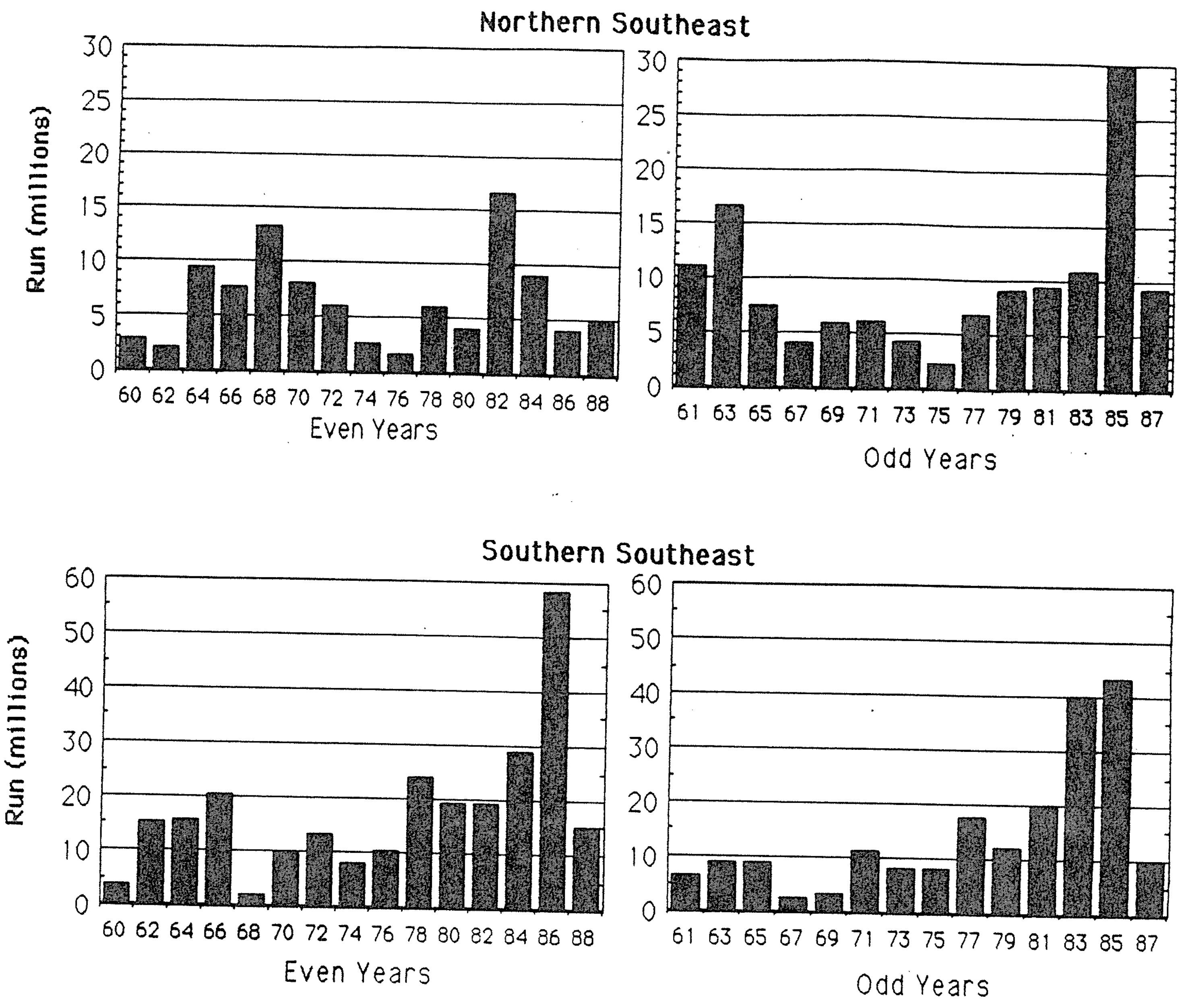


Fig. 12. The estimated annual runs (catch plus escapement) of pink salmon to southeastern Alaska by region and brood line, 1960-1988.

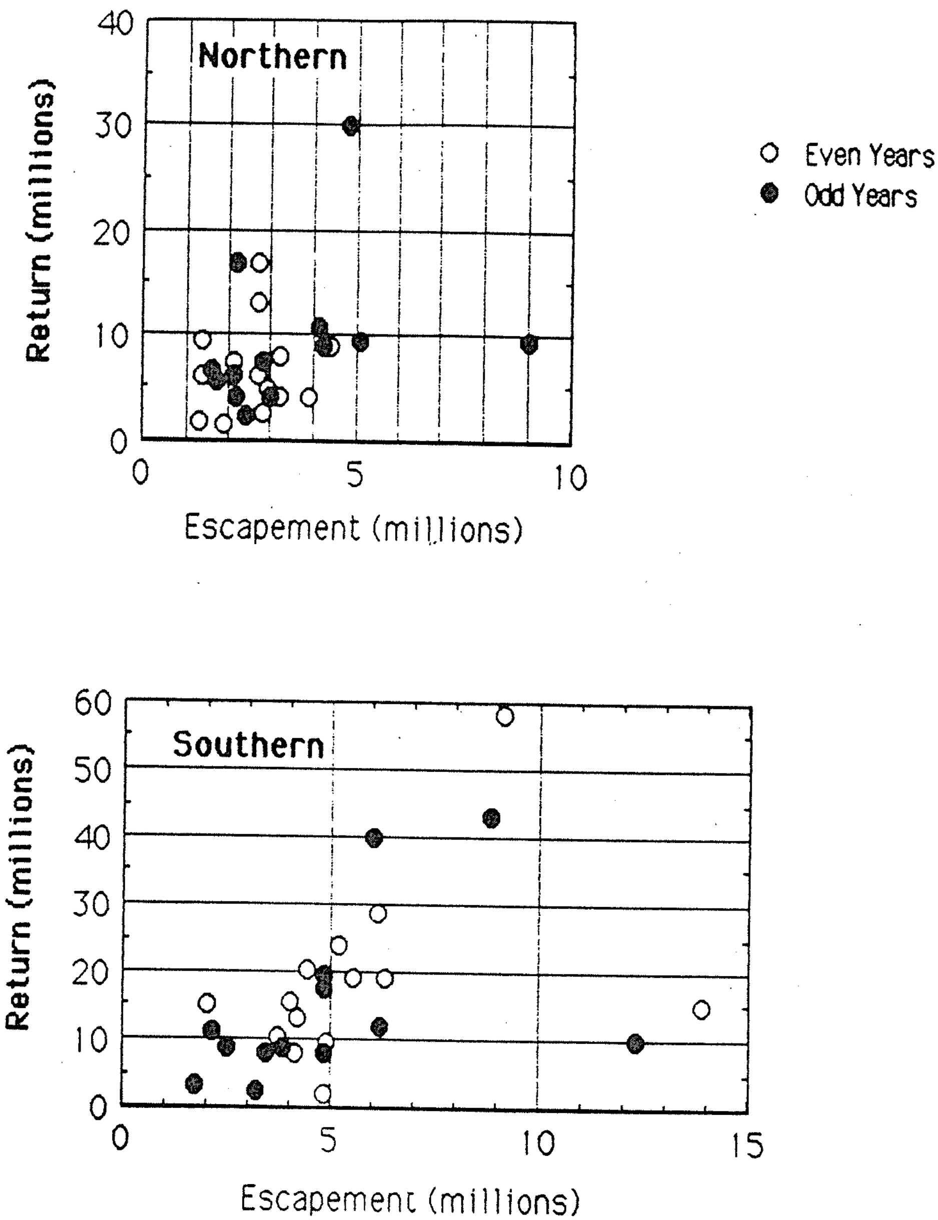


Fig. 13. Plots of returns (catch plus escapement) on escapements (2 years earlier) for pink salmon stocks in southeastern Alaska.

Proposed Research in 1989

Bristol Bay

We plan to maintain our long-term field program in the Wood River and Kvichak lake systems which includes monitoring of the physical and biological environment for juvenile sockeye salmon and adult spawners. We will continue our annual measurements of sockeye fry growth and relative fry abundance by beach seine and tow net sampling. The distribution and ages of adult spawners on the spawning grounds by ground and aerial surveys in cooperation with the Alaska Department of Fish and Game will continue to be obtained. We will also conduct the Newhalen River/Lake Clark adult enumeration and provide ADF&G with daily estimates of escapements during early July.

The Port Moller test fishery will be conducted as in 1987 and 1988 (June 11 to about July 4), however we plan to install a Panafax at our Lake Aleknagik camp (near Dillingham) in 1989 and provide processors with nearly daily reports on the progress of the test fishery with regard to the catches and the age composition of the inbound sockeye beginning about June 21. Also about that date we should be able to determine whether the run timing is likely to be early, average or late. Preliminary forecasts of the final run will be issued about June 25 and June 30 with a final forecast about July 5. All of the above assumes normal spring weather and timing of the runs.

We will continue to examine escapement goals for the Bristol Bay systems (especially the Kvichak) and maintain our working relationship with ADF&G. In addition, a forecast of the 1990 run will be provided to processors in the fall as a second opinion to the ADF&G forecast.

In January, 1989 we obtained funding ($122,900) from the Sea Grant program at the University for a two-year study of the historical growth of Nushagak sockeye salmon. The study will utilize our salmon scale collection that dates back to the early 1900s and the relationship between measurements of distances on scales between annuli and the lengths of the fish. We hope to determine whether there have been long-term changes in salmon growth that correspond to changes in their abundance or weather (temperature). Our salmon industry funding through P.S.P.A. was used for necessary matching funds to obtain these Federal funds.

Southeastern

We plan to shift the emphasis of the southeast research to the southern region where there is a need for both pre-season and in-season (test fishery) forecasts with some useful degree of accuracy. However, the troll test fishery in Icy Straits is planned for 1989. We have had some discussion with ADF&G and they are eager to work with us to develop a test-fish program with a useful lead time for management as well as processors. We plan to design the program in 1989 for implementation in 1990. In addition we will work on developing a useful pre-season forecast of pink salmon runs or catches from the existing data base. This work can be done with funds presently on hand so no funding is requested for 1989-1990.

BUDGET 1 April 1989 - 31 March 1990

Salaries	
Fish. Biol. III, 6 mos @ 100%	$15,600
Fish. Biol. II, 12 mos @ 50%	$11,800
Research Assistant, 9 mos @ 50%, 3 mos @ 100%	$12,150
Summer temporaries, 7 for 2.5 mos @ 100%	$21,500
TOTAL DIRECT SALARIES	$61,050
Employee Benefits	
Biologists, 24%: Research Assistant, 1%; Summer,8%	$8,418
Supplies and Services	$26,000
Travel and air charter	$20,000
Graduate student operating fees	$2,850
Equipment	
Outboard motor ($3,000), Panafax ($2,400)	$5,400
Subcontract to Peninsula Salmon	
Vessel and facilities at Port Moller, AK	$75,000
TOTAL DIRECT COSTS	$198,718
Indirect Costs	
29% of TDC excluding equipment and subcontract	$34,312
TOTAL PROPOSED BUDGET	$233,030
D. E. Rogers salary for 6 mos incl. benefits	$37,000
TOTAL	$270,030