SOUTHEAST ALASKA PINK AND CHUM SALMON INVESTIGATIONS, 1989-90

Final Report for the Period July 1, 1989 to June 30, 1990

By

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ABSTRACT

Forecast data collection, preparation, and analysis continued to the be primary activity of the Pink and Chum Salmon Investigations Project during the period July 1, 1989 through June 30, 1990. The 1989 pink salmon (*Oncorhynchus gorbuscha*) returns to both northern and southern Southeast Alaska were above the upper end of the preseason forecast range. The return to southern Southeast Alaska was 54.5 million with a 45.8 million harvest and an escapement index of 8.7 million. The return to northern Southeast Alaska totaled 18.2 million with a harvest of 13.6 million and an escapement index of 4.5 million. The 1990 forecast for southern Southeast Alaska is 13.1 million, with a range of 8.5 to 20.1 million. The 1990 forecast for northern Southeast is 6.8 million, with a range of 3.5 to 13.2 million (Geiger and Savikko 1990).

Early marine studies continued in Tenakee Inlet and in southern Southeast Alaska. A high correlation between total pink survival (return per index spawner) and fry lengths in May was documented.

INTRODUCTION

The Southeast Alaska pink salmon forecast research project was initiated in 1963. This report describes project activities during the period July 1, 1989 through June 30, 1990. The general scope of this project involves collection, analysis, and reporting of data useful for making preseason forecasts and evaluating escapement goals.

The primary objective of the forecast research project is to improve sampling and analytical techniques and to collect background data to provide accurate annual preseason estimates of pink salmon returns to northern and southern Southeast Alaska. Annual pink salmon forecasts are of importance to the fishing industry, both fishermen and processors, for operational planning, and to fisheries managers for regulatory decision making.

Pink salmon returns to Southeast Alaska have been forecast with variable success since 1967. The forecast was initially based on fry abundance in the gravel just prior to out-migration, as measured by pre-emergent pumping. In 1965 pre-emergent fry sampling was initiated on selected streams region wide. In 1970 the program was expanded to include 12 new sample areas in seven new streams. In 1984, the entire southern area pre-emergent program was deleted as a result of budget reductions and, in 1986, the entire northern area pre-emergent sampling program was deleted, also as a result of budget reductions.

Forecasts made since the elimination of the pre-emergent programs have been based on escapement estimates, fry size during their early marine residence, and environmental parameters thought to be reflecting freshwater and/or early marine survival. In southern Southeast Alaska numerous environmental parameters have been found which exhibit a correlation with survival as measured by return per index spawner (R/S). These include: the average daily temperature over the November through February time period following spawning (the colder it is, the lower the survival); coldest 14 day moving average of minimum daily temperature over this same time period (again the colder it is, the lower the survival); and the last day of the coldest 14 day temperature noted above (early season cold spells result in lower survival than equally cold periods later in the winter). The environmental parameters used in each year were chosen based on which provided the highest overall correlation coefficient when combined with escapement in a linear regression to predict return. In northern Southeast Alaska the correlation between the above parameters and the return is much lower than in southern Southeast Alaska.

One of the weaknesses of the current regression forecast method is that, because of lack of sufficient data, marine survival is assumed to be constant from year to year. We know, however, that it is not constant and can vary greatly. Early marine fry studies were initiated in 1976 in the hope of collecting data which would prove useful in estimating survival during the first few months of the salmon's marine life stage.

Budgetary constraints resulted in eliminating the southern Southeast Alaska study in 1979 and 1980 and in reducing the sampling effort in the northern study area in 1986.

This report describes the 1989 return, presents the 1990 pink salmon forecast, and summarizes the data collected during the Early Marine program in the spring of 1989. Specific project objectives were to:

1. Continue adding to a historical database to be used for developing techniques for reliable forecasts of the pink salmon returns to the benefit of the resource, fishermen, processors, and fisheries managers.

2. Measure abundance, and growth of pink and chum salmon fry in marine nursery areas in Tenakee Inlet and selected streams in the Ketchikan area and relate this data to abundance of returning adults.

PINK SALMON FORECASTS

Methods

Multiple linear regression analysis using escapement indices, air temperature, and fry size as independent variables were used to make the 1990 forecasts. Returns to the southern and northern areas of Southeast Alaska are forecasted separately. Prior adult tagging studies (Verhoeven 1952, Hoffman et al. 1983) have shown little overlap in migration routes for returns to these two areas and production appears to vary independently. While there are differences in the odd and even year returns, all years were included in the forecast model because there has not been a pronounced odd-even-year cycle in southern Southeast Alaska since 1970 and there has never been an odd-even-year cycle in northern Southeast Alaska (Figure 1). The southern area encompasses Districts 101 to 108 and the northern area encompasses Districts 109 to 116.

Escapement estimates for northern and southern Southeast Alaska are obtained by summing the individual district escapement indices in each area. The district escapement indices are calculated by summing the highest escapement count made on each stream surveyed in the district and adjusting for the number of streams not surveyed within that district. The number of streams in each district is defined as the number of streams for which an escapement count is available at least once during the 1960 through 1989 time period. The number of streams not surveyed in each district is multiplied by the average escapement count to all streams within that district with a peak escapement count of under 10,000 pinks. Escapement index estimates for each district are recalculated for all years each year to insure that the expansion factor used to correct for unsurveyed streams is consistent between years. The majority of escapement counts are made by management biologists during routine aerial surveys for fishery opening decisions. Weir counts are not included in the calculation since the data is only available from a few years and the counts represent a total escapement rather than index count. No attempt is made to convert the escapement index to a total escapement estimate and, consequently, escapement indices are less than total escapements (Dangel and Jones 1988).

The southern Southeast Alaska forecast is based on 20 years of data (1967 through 1986). Return years 1987, 1988, and 1989 were not included in the regression because of reasons explained in the results section. These three years were included, nevertheless, in calculation of the 80% confidence level. Variables used in the regression analysis include: brood year escapement index, and the average minimum daily winter air temperature (November 1 through February 28). Environmental data are averages of recordings from five N.O.A.A. recording stations throughout southern Southeast Alaska (Annette, Beaver Falls, Ketchikan, Petersburg, and Wrangell).

In northern Southeast Alaska, 1990 was the third year the forecast was prepared without the benefit of the pre-emergent fry index. The model used for the 1990 prediction was multiple linear regression analysis with brood year escapement index and fry length as independent variables. Because comparable fry length data is available only from 1981 to present, the number of years included in the regression had to be reduced to 8 (return years 1982 through 1989).

Confidence ranges are made for the return forecasts by comparing actual returns with hindcasts made for each year included in the determination of parameters on the multiple regression model. A constant was chosen such that by subtracting and adding it to the natural log of the hindcast, ranges were determined for each year that, in 80% of the cases, included the natural log of the return estimated for that year. This constant is then applied to the natural log of the forecasted return and the anti logs are taken to produce an 80% confidence range.

Results and Discussion

The pink salmon return to southern Southeast Alaska in 1989 was 54.5 million fish (Table 1) which was 35.3 million above the forecast midpoint of 19.6 million (Hofmeister and Dangel 1989). The escapement index in 1989 of 8.7 million (Table 2) was the fifth highest achieved since statehood. In addition, the escapement was well distributed, with all districts except 105 exceeding goal levels (Figure 2). The northern Southeast Alaska return of 18.2 million (Table 1) was 4.5 million above the upper end of the forecast range of 7.3 to 13.7 million. The escapement index of 4.6 million was the fourth highest achieved since statehood (Table 3). Escapement goals were met or exceeded in districts 109 through 112. Escapement levels in districts 113 and 114 were below desired levels (Figure 3).

Southern Southeast Alaska 1989 Forecast Evaluation

This was the third consecutive year in which the return to southern Southeast Alaska came in well outside the forecast range. The returns in 1987 and 1988 were both overestimated, while the return in 1989 was underestimated. An extensive search for environmental variables to account for the large errors in recent years was unsuccessful. Because the prediction made in 1989 was influenced by the large errors in 1987 and 1988, they will be included in this evaluation. The error in 1987 may have been the result of density independent mortality, resulting from one of the coldest winters of the study period, and the highest brood year escapement index achieved to that date (Table 1 and Figure 4). The mortality caused by the cold winter of 1985-1986 may not have been entirely represented by temperature alone, since an extreme cold spell struck earlier in the year than normal (Figure 4). Many of the pinks would still have been in the egg stage at that time, thus unable to move further down in the gravel to escape freezing conditions. This theory is supported by the fact that a positive correlation exists between date of the coldest 14 day period of the winter, recorded as the number of days after November 1st, and survival as measured by return per index spawner.

While density independent mortality caused by the extreme winter conditions of 1985-1986 may explain the large error in 1987, they can not explain the poor survival experienced by pinks returning in 1988. One theory which can not be evaluated due to a lack of appropriate data, such as a pre-emergent index, is that the large number of dead eggs in the gravel after the 1985-1986 die-off fouled the substrate for the following year. A second possible explanation for the poor survival of pinks returning in 1988 is exceptionally high ocean mortality. There is no data available to evaluate this possibility either. It is mentioned only because of the numerous news reports in 1987 and 1988 dealing with the increased interception of North American salmon by the high seas drift gill net fishery.

It is also possible that the poor returns of 1987 and 1988 were the result of overescapement. This theory has the advantage of a single cause for both 1987 and 1988. Figure 5 is a graph of the spawner recruit relationship for southern Southeast. An estimate of the total escapement was made by multiplying the escapement index by 2.5. The expansion factor of 2.5 was selected because a study by Jones and Dangel in 1988 found that aerial observers are able to count approximately 40% of the fish in a creek, and most of the escapement estimates in southern Southeast are aerial surveys. The graph shows a relatively strong relationship (r^2=.68) between brood year escapement index and return, at least through 22 million. The extreme drop in return magnitude after the brood year escapement index reached 31 million is not indicative of typical salmon populations. One would first expect to see a leveling off followed by a drop in return magnitude as the optimum escapement was reached and then exceeded. It will, however, take additional data points with escapement magnitudes above 22 million and below 31 million to determine if the poor returns in 1987 and 1988 were the result of overescapement.

While no variables have been found to account for the poor returns in 1987 and 1988,'a new variable has been found which results in a reasonably accurate prediction for 1989. That variable is the sum of the previous two brood year escapements. There are two possible mechanisms for the relationship: one, maintaining high escapement levels insures that marginally productive streams receive adequate escapement levels; and two, maintaining high spawning populations result in increased redd building activity which may clean fines from the gravel to the extent that the substrate is cleaner for future spawning populations. Figures 6 and 7 show the results of including the new variable in the prediction model. Figure 6 shows the results of a multiple linear regression with only the escapement index and winter temperatures as independent variables. For reasons explained above, return years 1987 and 1988 were left out of the regression analysis, but their hindcasts are included in the graph to show the extreme errors which occur in those years using both the two and three variable models. The average error per year (sign ignored) excluding 1987 and 1988 is 6.4 million in the two variable model (Figure 6) and 5.4 million in the three parameter model (Figure 7). The major difference in the two models is that by including the two previous brood years into the regression the error in predicting the 1989 return drops from an underestimate of 25.5 million (Figure 6) to an underestimate of only 5.5 million (Figure 7). Figure 8 shows the results of including return years 1987 and 1988 into the three parameter regression analysis. The hindcasts are improved for 1987 and 1988 but large errors now occur in 1985 and 1986. Including 1987 and 1988 into the regression analysis drops the r^2 value from .80 to .60.

The influence of non-brood year escapements on pink salmon returns to southern Southeast was further evaluated in Figures 9 and 10. Both figures are the result of linear regression analysis with a single independent variable, and include return years 1966 through 1989 with 1987 and 1988 omitted from analysis. Figure 9 uses brood year escapement as the independent variable, and has an r^2 value of .64. Figure 10 uses the sum of the escapements 2,3, and 4 years prior to the return and has an r^2 value of .78. Figure 10 suggests that the returns to southern Southeast are being influenced by the escapement levels of recent years. This is further supported by the fact that an r^2 value of .60 is obtained when predicting the return to southern Southeast by using the sum of escapements 3,4, and 6 years prior to the return. In other words, the sum of three non brood year escapements provides predictions just as accurate as those obtained by using brood year escapement as an independent variable.

Northern Southeast Alaska 1989 Forecast Evaluation

The 1989 return forecast to northern Southeast Alaska was 10.5 million. The actual return came in at 18.2 million, which was 4.5 million above the upper end of the forecast range (7.3 to 13.7 million). The forecast for 1989 was the second made without the benefit of the pre-emergent fry index. Unlike southern

Southeast, no strong relationships have been found between escapement indices or winter temperatures and the return to northern Southeast. A strong relationship (r^2 = .72, n = 10) has been found between return to northern Southeast and the size of fry collected during the early marine program in Tenakee Inlet. While this relationship was noted in last year's annual report, the limited number of years for which data was available resulted in a decision against using the relationship for the 1989 prediction. If the fry size data had been used, a more accurate return prediction of 20.1 million (Table 4) would have been obtained. Fry data will be used as a variable in the 1990 prediction.

Southern Southeast Alaska 1990 Forecast

The 1990 pink salmon forecast is 13.1 million, with an 80% confidence range of 8.5 to 20.1. As explained in the 1989 forecast review section, the forecast model which works reasonable well between 1966 and 1986 results in three consecutive poor predictions in 1987 ,1988, and 1989. Consequently, the 1990 forecast should be viewed with more than the normal degree of skepticism.

The 1988 escapement index of 4.1 million was the lowest achieved in the last 12 years. Winter temperatures were very close to average (29.1°F compared to a 23 year average of 28.6°F). The only environmental parameter found which was outside of the range of study period experience (1967 to 1989) was precipitation. A major storm which moved through Southeast in November resulted in more rain over a two day period than any other storm since N.O.A.A. record keeping was initiated in 1947. The total mortality resulting from this flood can not be measured; however, pre-emergent pumping conducted by the F.R.E.D. Division on a McDonald Lake stream indicated that at least that stream had a major mortality caused by eggs being washed out of the gravel. Another concern was that the number of fry observed during the 1989 early marine program was well below that observed in 1988. This decline was especially apparent on the west coast of Prince of Wales Island. However, abundance was greater than that observed in 1986 when beach seines had to be doubled in length in order to obtain adequate fry samples for the condition index program. A final concern is that the escapement distribution in 1988 was very poor. Districts 101 through 104 had escapement indices only slightly below goals, while districts 105 though 108 were all well below goal levels. Consequently, no pink salmon directed seine harvesting should be expected in districts 105 through 107 in 1990.

If the three outlier years (1987 through 1989) are not omitted from the regression the mid point of the prediction would be 19.0 million. However, the average error per year, disregarding sign, in hindcasting for the 1967 through 1986 time period raises from 4.7 to 7.2 when the three outlier years are included. Consequently, the 1990 prediction was made without return years 1987 through 1989.

Northern Southeast Alaska 1990 Forecast

The return forecast for northern Southeast Alaska is 6.8 million, with a 80% confidence range of 3.5 to 13.2 million. This is the first year that fry length data from the Tenakee Inlet early marine program is being utilized for predictions. The correlation between fry length or weight during the May 16th through May 31 time period and apparent survival as measured by return per index spawner was noted in earlier years but not included in the official prediction because of the relatively small data base. We now have nine years of comparative data, and the correlation continues to remain strong (r= .91, 7 degrees of freedom). Because early marine fry data is being utilized, the number of years incorporated into the regression formula had to be reduced to eight (return years 1982 through 1989), as comparative fry data is only available back to 1981.

The above prediction was published in the 1990 state wide salmon forecast publication (Geiger 1990). Since that time, additional work has been completed on Tenakee Inlet fry. Fry collected during 1979 and 1980 were entered into a computer file which allows for extending the prediction data base back to 1980. In addition, the fry length weight data from all years was edited, and fry with unrealistic length to weight ratios were deleted from the data files. The updated results are given in the following section.

EARLY MARINE SURVIVAL STUDIES

Tenakee Inlet

Methods

Monitoring of Tenakee Inlet pink and chum fry abundance continued in 1989. Fyke netting for fry abundance estimates from the Kadashan River, which drains into Tenakee Inlet, was not conducted in 1989, because budgetary constraints had resulted in that portion of the program being dropped in 1986.

Fry abundance in Tenakee Inlet was monitored once each week, weather permitting, by conducting visual surveys along the shoreline at Cannery Point (Figure 11). Fry were counted by one person wearing polarized sun glasses and standing in the bow of a 4 m skiff. The skiff was piloted along the shoreline in water as shallow as possible, at speeds less than 6 knots, and numbers and locations of fry were recorded directly on maps at the time of observation. Fry samples for weight and length analysis were collected with a beach seine. The seine measured 38.5 m long by 1.8 m deep and had a uniform rectangular mesh of 3.2 x 6.4 mm. Fry samples collected for length-weight analysis were preserved in a 10% buffered (sodium borate) formalin solution.

Results and Discussion

The number of pink salmon observed at Cannery Point, by statistical week, by year is shown in Table 5. The counts obtained during statistical weeks 17 and 18 in 1989 were the highest ever recorded for those weeks. The count in statistical week 20 of 745,000 was the third highest count ever obtained at Cannery Point.

Pink salmon fry in Tenakee Inlet increased from an average length and weight of 33.4 mm and 263.9 mg,respectively, on May 2, to 41.3 mm and 608 mg on May 31, for an average growth rate of 0.26 mm per day in length, and 11.5 mg per day in weight. In comparison, last year's fry grew at a rate of 0.44 mm and 23.3 mg per day. The length and weight of fry collected from Tenakee Inlet during the May 1 through May 15, and May 16 through May 31 time period is presented in Table 6.

No useful relationships have been found between the number of fry counted during the early marine program and the subsequent pink salmon return. There is, however, a strong relationship between fry size and return. Figure 12 shows the results of predicting pink salmon returns to northern Southeast utilizing linear regression analysis with the weight of pink salmon collected during the May 15 through May 31 time period as the independent variable. The relationship results in an r^2 value of .74. Utilizing fry length or weight as an independent variable in the regression makes little difference since the two are correlated with an r^2 value of .95.

Although there is no correlation between the brood year escapement index and the subsequent return to northern Southeast (r^2 = .01), including the brood year escapement index into the regression analysis with fry size does explain a significant (p = .104) additional amount of variability.

Ketchikan Area

Methods

Early marine survival studies in the Ketchikan area continued for the twelfth year in 1989. Studies conducted from 1976 through 1978 were centered in Cholmondeley Sound (Jones et al. 1986). The program was reinitiated in 1981 with the study area expanded to include Moria Sound, Boca De Quadra, and Smeaton Bay. Since 1981, the emphasis of the study has been to obtain fry samples from marine nursery areas in the hope of finding a relationship between fry size or condition and early marine survival for use in improving forecasts. Moria Sound was dropped from the early marine program in 1986 due to budgetary constraints.

The timing and abundance of out-migrant fry from Sunny (stream no. 120-40-87), Nigelius (stream no. 101-45-94), and Spit (stream no. 101-45-75) Creeks were monitored from April 19 through May 30 using a 0.45 m by 0.9 m fyke net placed to sample a column of water 0.45 meters wide. In order to compare relative out-migration magnitude at Sunny Creek between years, all graphs were standardized by assuming an out-migration of zero on March 3 and June 23. The standardization was required because beginning and ending fyke netting dates often did not include the entire out-migration period. Because the number of sample days varied greatly between years, the index of relative abundance was obtained by calculating the area under the out-migration curve rather than by summing the catches.

The marine fry collection technique was changed in 1986 from evening dip netting to daylight beach seining. The change was made after comparison of fry collected by beach seine and dip net indicated that dip netting was a size selective capture technique compared to beach seining. The beach seine was 38 m long by 1.8 m deep with a uniform mesh of 3.2 by 6.4 mm. No method has been found to correct for the different collection techniques. Fry samples collected for length and weight analysis from both fresh water and marine areas were preserved in a 10% buffered (sodium borate) formalin solution. The fry were measured and weighed approximately six months after collection.

Estimating fry abundance along premeasured transects was added to the study in 1986. Those areas which were known to be important nursery areas were selected as transect locations (Figure 13). Fry numbers were estimated by a person wearing polarized sunglasses, standing in the bow of a 5.2 m skiff while it traveled at idle speed along the shoreline.

Results and Discussion

The maximum daily fyke net catch of pink salmon in Sunny Creek in 1989 occurred on May 15 (Figure 14). The calculated date of 50% out-migration occurred on May 12. The calculated pink out-migration index of 28,374 was the lowest index achieved since 1984. The indices from 1985 to 1989 can not be compared directly to indices obtained prior to 1985 because a fish ladder was installed in 1984 which opened up additional spawning areas. Fyke net catches from Nigelius and Spit Creeks, along with stream temperatures, are listed in Table 7. The outmigration from Nigelius creek in 1989 was the largest of the study period. Four of the nine daily catches in 1989 were higher than the largest catch from the previous three years. The peak daily catch from Spit creek was 4,924 on April 24. This was also the largest daily catch of the four year study.

Pink salmon fry abundance estimates by study area are listed in Table 8. A review of the information suggests that there were far more fry in most transects in 1987 than in 1988. The relative magnitudes of the returns in 1988 (13 million) and 1989 (51 million) suggest the opposite. While differences in high seas survival between the two years may explain part of the discrepancy, it is not likely that it varied to the extent required to account for the large difference in return magnitudes. Two main problems which restrict the reliability of visual abundance estimates however, are the inability of different observers to accurately estimate the number of fry in large schools, and the frequency of poor weather which restricts visibility.

The relationship between fry size and survival, as measured by return per index spawner, is strong for the northern Southeast Alaska return, but is not present for the southern Southeast Alaska return. The only parameter collected during the Early Marine Survival Studies Program in southern Southeast Alaska which exhibited a correlation with return was the date of 50% out-migration from Sunny Creek (Figure 14). The relationship between the southern Southeast escapement index, the date of 50% outmigration, and, the subsuquent adult return from the beginning of the study in 1976 through 1986 resulted in an r^2 value of .87. Inclusion of the last three return years (1987,1988, and 1989) drops the r^2 value to .14.

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Table 1. Southern and northern Southeast Alaska harvest and escapement in thousands, and return per spawner, 1960-89.

	Southern Southeastern				Northern Southeastern			
	Harvest	Escapement	Return	RTN/SP	Harvest	Escapement	Return	RTN/SP
1960	1,542	2,023	3,565		1,428	1,326	2,753	
1961	3,873	2,491	6,364		8,697	2,237	10,934	
1962	11,007	3,952	14,960	7.39	548	1,365	1,913	1.44
1963	5,145	3,758	8,903	3.57	13,914	2,828	16,742	7.48
1964	11,258	4,434	15,693	3.97	7,279	2,107	9,385	6.87
1965	5,710	3,189	8,899	2.37	5,154	2,212	7,366	2.60
1966	15,649	4,804	20,453	4.61	4,786	2,682	7,467	3.54
1967	642	1,669	2,311	0.72	2,425	1,673	4,098	1.85
1968	15,201	4,889	20,090	4.18	9,865	3,210	13,075	4.88
1969	1,198	2,070	3,268	1.96	3,594	2,142	5,736	3.43
1970	5,412	4,166	9,578	1.96	5,239	2,700	7,939	2.47
1971	6,250	4,823	11,073	5.35	3,011	2,958	5,969	2.79
1972	9,153	4,080	13,233	3.18	3,240	2,832	6,072	2.25
1973	4,555	3,395	7,951	1.65	1,875	2,363	4,239	1.43
1974	4,221	3,696	7,917	1.94	656	1,945	2,602	0.92
1975	3,330	4,778	8,108	2.39	615	1,558	2,173	0.92
1976	5,157	5,249	10,406	2.82	137	1,434	1,571	0.81
1977	11,242	6,175	17,417	3.65	2,506	4,163	6,669	4.28
1978	18,425	5,455	23,880	4.55	2,773	3,177	5,950	4.15
1979	6,992	4,820	11,812	1.91	3,813	5,083	8,896	2.14
1980	12,907	6,293	19,200	3.52	1,425	2,652	4,077	1.28
1981	13,468	6,015	19,483	4.04	5,334	4,054	9,388	1.85
1982	12,917	6,057	18,974	3.01	11,293	4,364	15,657	5.90
1983	31,421	8,807	40,228	6.69	6,044	4,780	10,824	2.67
1984	19,637	9,108	28,745	4.75	4,992	3,902	8,894	2.04
1985	30,612	12,345	42,957	4.88	21,098	9,010	30,108	6.30
1986	44,480	13,848	58,325	6.40	1,174	2,941	4,115	1.05
1987	4,473	5,427	9,900	0.80	4,820	4,368	9,188	1.02
1988	9,200	4,068	13,268	0.96	2,100	2,700	4,800	1.63
1989	45,762	8,752	54,514	9.68	13,638	4,556	18,194	4.06

Table 2. Southern Southeast Alaska pink salmon escapement by district and year in thousands of fish.

	District							SSE
	101	102	103	105	106	107	108	Total
1960	597.3	209.7	735.5	106.5	78.9	241.2	0.0	2,023.1
1961	671.4	174.3	653.1	268.0	317.3	193.0	213.4	2,490.5
1962	1,199.2	302.3	1,015.3	349.6	550.6	391.7	143.7	3,952.4
1963	876.1	250.0	1,104.4	395.3	464.3	462.8	205.0	3,757.9
1964	1,259.5	499.6	1,125.1	488.6	585.2	380.3	96.1	4,434.4
1965	636.5	256.6	1,138.0	402.3	447.8	269.3	38.3	3,188.8
1966	1,430.0	509.7	1,363.1	499.4	591.3	410.3	0.0	4,803.8
1967	461.7	88.6	397.6	342.8	219.9	136.3	22.5	1,669.4
1968	1,832.8	524.3	1,173.7	528.9	356.2	385.2	88.2	4,889.3
1969	717.6	309.8	414.2	182.2	183.8	159.2	103.4	2,070.2
1970	1,509.0	252.5	1,462.9	231.3	297.8	319.0	93.4	4,165.9
1971	1,347.6	636.0	1,573.2	336.6	411.6	475.1	42.8	4,822.9
1972	1,640.2	318.8	900.4	303.1	244.3	426.7	246.1	4,079.6
1973	903.5	518.1	818.8	293.9	368.3	395.4	97.4	3,395.4
1974	1,278.3	464.8	1,149.1	230.0	216.3	274.7	83.0	3,696.2
1975	1,444.0	668.8	1,438.2	309.3	403.5	483.6	30.4	4,777.8
1976	1,495.4	619.6	1,539.3	173.8	708.2	694.1	18.1	5,248.5
1977	2,235.0	673.9	1,607.6	278.7	357.4	956.6	65.8	6,175.0
1978	2,108.3	541.1	1,709.7	308.1	304.9	447.4	35.6	5,455.1
1979	1,056.9	649.7	1,654.4	475.8	389.9	475.5	117.9	4,820.1
1980	2,314.5	630.1	2,704.1	157.8	166.3	283.4	37.0	6,293.2
1981	1,904.0	594.0	2,553.3	376.5	264.4	288.9	33.4	6,014.5
1982	2,257.3	558.7	2,050.4	272.6	370.0	464.1	83.4	6,056.5
1983	3,100.4	1,140.6	3,302.8	550.7	284.0	384.5	43.5	8,806.5
1984	3,760.4	937.1	3,322.9	277.8	369.6	415.3	24.4	9,107.5
1985	3,861.1	1,163.9	4,693.2	649.1	903.2	978.6	95.4	12,344.5
1986	4,518.8	1,388.1	5,792.9	678.8	899.8	571.5	44.7	13,894.6
1987	2,220.9	503.8	1,881.2	142.7	161.7	284.4	77.5	5,272.4
1988	1,466.3	549.7	1,402.6	133.9	222.3	251.0	42.5	4,068.3
1989	2,850.9	883.8	2,954.2	406.4	647.7	882.6	125.9	8,751.6
Goal	2,000.0	600.0	1,700.0	500.0	600.0	600.0		6,000.0

Table 3. Northern Southeast Alaska pink salmon escapement by district and year in thousands of fish.

Year	District 109	110	110	112	113	114	115	NSE Total
1960	103.8	228.9	260.2	173.3	430.8	108.9	19.9	1,325.8
1961	360.6	398.2	371.1	285.4	663.6	158.2	0.0	2,237.1
1962	388.8	307.1	215.1	145.4	252.4	56.1	0.3	1,365.2
1963	484.3	323.7	426.0	805.3	1,303.0	486.1	0.0	3,828.4
1964	681.5	466.2	289.6	424.6	104.7	140.0	0.0	2,106.6
1965	630.5	216.4	337.3	436.3	165.4	425.7	0.0	2,211.6
1966	659.7	431.2	455.4	620.3	420.9	94.0	0.0	2,681.5
1967	333.9	197.7	269.6	340.7	380.3	147.5	3.5	1,673.2
1968	694.0	967.7	458.6	580.0	298.2	164.6	47.2	3,210.3
1969	355.9	275.7	241.8	471.3	536.5	251.0	10.1	2,142.3
1970	469.1	529.5	443.5	684.0	348.5	171.5	54.2	2,700.3
1971	487.5	595.6	283.0	594.5	604.0	393.6	0.0	2,958.2
1972	430.0	727.2	606.2	558.2	316.7	194.0	0.0	2,832.3
1973	309.1	302.8	288.0	526.9	586.5	261.4	89.1	2,363.8
1974	292.0	290.9	444.6	358.9	427.1	132.3	0.0	1,945.8
1975	209.0	88.1	157.0	294.0	663.4	136.8	10.1	1,558.4
1976	230.9	192.5	103.4	267.9	502.8	136.4	0.0	1,433.9
1977	503.5	283.9	352.1	671.5	2,058.9	242.5	50.3	4,162.7
1978	463.7	428.0	205.5	1,005.5	867.4	206.7	0.1	3,176.9
1979	730.8	731.7	493.1	830.0	1,964.5	251.8	80.7	5,082.6
1980	428.7	415.3	283.3	639.2	608.7	243.6	33.5	2,652.3
1981	363.8	389.3	299.1	767.9	1,948.5	240.0	45.4	4,054.0
1982	764.1	614.9	731.2	844.8	1,155.9	203.5	49.6	4,364.0
1983	586.0	396.0	761.0	829.3	1,880.5	272.9	54.7	4,780.4
1984	695.5	443.5	466.5	483.9	1,577.2	205.4	30.0	3,902.0
1985	1,162.6	1,084.2	1,803.3	1,363.4	2,749.8	581.0	265.5	9,009.8
1986	739.8	287.8	215.1	780.6	737.4	179.3	0.7	2,940.7
1987	600.5	1,040.6	892.9	656.4	942.1	160.1	75.1	4,367.7
1988	624.6	469.1	326.0	641.8	576.4	195.3	59.1	2,892.3
1989	809.3	991.8	632.3	787.5	1,091.9	192.7	71.8	4,577.3
Goal	600.0	1,000.0	500.0	600.0	1,600.0	500.0		4,800.0

Table 4. Northern Southeast predictions using brood year escapement index and fry size as independent variables in a multiple linear regression (r^2 = .83).

Year of Return	Brood Year Esc. Index In Millions	Fry Weight In mg.	Return In Millions	Hindcast Return In Millions
1980	3.2	448	4.2	3.6
1981	5.2	578	9.4	12.0
1982	2.8	801	15.3	17.6
1983	4.1	447	10.5	4.9
1984	4.1	653	9.0	13.4
1985	4.5	911	29.6	24.7
1986	4.0	405	4.1	3.0
1987	8.4	434	10.1	10.9
1988	3.0	539	5.1	7.1
1989	4.5	799	18.2	20.1
1990	3.1	641		11.4

Table 5. Tenakee Inlet early marine fry surveys at Cannery Point in thousands.

	Statistical Week									
Year	15	16	17	18	19	20	21	22	23	24
1989			232	206	64	745	83	68		
1988					171	103	41	75	278	
1987			51	45	166	43	37	166	47	
1986				39	188	221	95	319	145	
1985				123	756	1,036	516	1		
1984		185	185		58		221	74		
1983	9	2	16	48	130	141	155	120		
1982			10	20	500	400	200	25	31	15
1981	2		7	42	81	8	8	13	8	2
1980	3		5	127	59	86	23			

Table 6. Average length and weight of pink salmon fry captured in Tenakee Inlet May 1 through May 15, and May 16 through May 31.

	May 1 through May 15			May 16 through May 31		
	Length MM	Weight MG	SAMPLE SIZE	Length MM	Weight MG	SAMPLE SIZE
1979	36.2	380	845	38.1	448	861
1980	35	327	1,028	40	578	1,042
1981	37.5	438	1,006	46	873	763
1982	36	362	893	38.2	447	1,059
1983	38.3	426	3,071	44	653	2,449
1984	38.5	409	656	47.7	911	2,740
1985	35.7	294	3,628	38.7	430	1,920
1986	34.3	294	3,710	38.3	450	1,211
1987	34.8	315	1,917	40.4	539	2,592
1988	36.5	392	3,224	44.7	799	2,782
1989	35.4	342	2,282	41.1	641	1,715

Table 7. Number of pink and chum salmon fry trapped by fyke nets in Nigelius and Spit Creeks in Carroll Inlet, with stream temperatures, 1986, 1987, 1988, and 1989.

	NIGELIUS								SPIT							
	1986		1987		1988		1989		1986		1987		1988		1989	
Date	Pink	Temp	Pink	Temp	Pink	Temp	Pink	Temp	Pink	Temp	Pink	Temp	Pink	Temp	Pink	Temp
25-Mar	-	-	-	-	107	3	-	-	-	-	-	-	7	3	-	-
28-Mar	-	-	-	-	214[a]	3	-	-	-	-	-	-	-	-	-	-
02-Apr	-	-	4,166[b]	5	-	-	-	-	-	-	1,941	5	-	-	-	-
10-Apr	-	-	-	-	-	-	-	-	-	-	4,373	4 [c]	-	-	-	-
12-Apr	-	-	-	-	845	3	-	-	-	-	-	-	470	4	-	-
13-Apr	-	-	-	-	987	3	-	-	-	-	-	-	851	4	-	-
19-Apr	-	-	-	-	867	3	448	2	-	-	-	-	1,022	5	-	-
20-Apr	-	-	-	-	529	3	-	-	-	-	-	-	485	5	-	-
21-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,803	4
22-Apr	-	-	1,010	5.5	-	-	-	-	-	-	3,010	4.2	-	-	-	-
23-Apr	-	-	1,874	5.5	-	-	-	-	-	-	2,720	3.3	-	-	-	-
24-Apr	-	-	-	-	-	-	4,413	4	-	-	-	-	-	-	4,924	6
26-Apr	-	-	-	-	438	4	1,340	4	-	-	-	-	764	4	3,610	5
30-Apr	-	-	342	7.5	-	-	-	-	-	-	3,068	8	-	-	-	-
01-May	-	-	312	8	-	-	3,822	4	-	-	1,838	9	-	-	2,291	7
02-May	1,961	6	-	-	-	-	11,903	4	1,208	6	-	-	-	-	2,304	7
03-May	2,210	7	-	-	-	-	-	-	2,590	8	-	-	-	-	-	-
05-May	-	-	94	7.8	-	-	-	-	-	-	575	7.5	-	-	-	-
06-May	-	-	80	7	-	-	-	-	-	-	219	6.8	-	-	-	-
07-May	-	-	-[d]	9	-	-	-	-	-	-	-	8	-	-	-	-
08-May	2,766	9	-	-	-	-	-	-	1,533	8	-	-	-	-	-	-
09-May	-	9.8	-	-	-	-	-	-	-	8	-	-	-	-	-	-
10-May	-	-	-	-	17	-	6,080	5	-	-	-	-	13	-	2,478	7
13-May	384	9	-	-	-	-	-	-	616	6.5	-	-	-	-	-	-
14-May	302	9.5	-	-	-	-	-	-	303[e]	7.5	-	-	-	-	-	-
15-May	-	-	-	-	-	-	19,227	6	-	-	-	-	-	-	-	7.5
16-May	-	-	-	-	-	-	-	-	-	-	14	6	-	-	-	-
19-May	-	-	0	9.5	-	-	-	-	48[f]	8.5	1	6.5	-	-	-	-
20-May	-	-	-	-	-	-	-	-	-	-	0	11.5	-	-	-	-
23-May	-	-	-	-	-	-	590	12	-	-	-	-	-	-	74	11.5
25-May	18	11	-	-	-	-	-	-	53	9	-	-	-	-	-	-
30-May	-	-	-	-	-	-	3	14.5	-	-	-	-	-	-	2	12

a/ Average count of a 4 day soak, 3/26-3/29.
b/ 2 Day set.
c/ No count because of a hole in the net.
d/ No count because of hole in net.
e/ Beaver in net.
f/ 5 Steelhead in net.

Table 8. Visual estimates of pink salmon abundance in early marine study areas of southern Southeast Alaska.

Cholmondeley Sound	Transect 1				Transect 2				Transect 3				Transect 4			
Date	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
08-Apr	-	14	-	-	-	3570	-	-	-	380	-	-	-	-	-	-
14-Apr	-	-	400	-	-	-	1100	-	-	-	4000	-	-	-	50	-
20-Apr	-	-	-	10	-	-	-	0	-	-	-	0	-	-	-	50
27-Apr	-	2000	-	-	-	22200	-	-	-	2100	-	-	-	14400	-	-
28-Apr	-	34900	-	300	-	41000	-	290	-	7740	-	150	-	24400	-	100
01-May	20	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-
04-May	-	-	5500	-	-	-	8600	-	-	-	2100	-	-	-	900	-
05-May	-	-	-	700	-	-	-	300	-	-	-	300	-	-	-	1700
07-May	2000	-	-	-	610	-	-	-	1360	-	-	-	490	-	-	-
09-May	-	9000	-	-	-	56000	-	-	-	15300	-	-	-	9800	-	-
11-May	-	-	8200	-	-	-	50100	-	-	-	11900	-	-	-	6000	-
12-May	-	-	-	300	-	-	-	200	-	-	-	1000	-	-	-	500
14-May	200	-	-	-	2600	-	-	-	150	-	-	-	1150	-	-	-
19-May	-	7700	-	-	-	3870	-	-	-	14700	-	-	-	15900	-	-
20-May	-	-	6900	1500	-	-	71800	960	-	-	-	6580	-	-	-	-
21-May	1500	-	-	7020	8800	-	-	1200	-	-	-	3500	19400	-	-	-
25-May	-	-	-	-	-	-	-	-	-	-	-	2900	-	-	-	1100
26-May	-	-	-	2700	-	-	-	16900	-	-	-	5400	-	-	-	4700
28-May	-	3760	-	-	-	6590	-	-	-	2110	-	-	-	9200	-	-
30-May	300	-	-	-	25000	-	-	-	1100	-	-	-	123000	-	-	-
09-Jun	2200	-	-	-	4600	-	-	-	5400	-	-	-	71500	-	-	-
10-Jun	1100	-	-	-	2800	-	-	-	6500	-	-	-	89600	-	-	-

Smeaton Bay	Transect 1				Transect 2				Transect 3				Transect 4			
Date	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
16-Apr	-	-	9100	-	-	-	50	-	-	-	600	-	-	-	2100	-
21-Apr	-	-	50	-	-	-	0	-	-	-	500	-	-	-	1500	-
22-Apr	-	6400	-	-	-	1000	-	-	-	2500	-	-	-	250000	-	-
23-Apr	-	0	-	-	-	200000	-	-	-	4000	-	-	-	3200	-	-
26-Apr	-	-	-	4890	-	-	-	8820	-	-	-	1740	-	-	-	3470
30-Apr	-	30	-	-	-	20	-	-	-	120	-	-	-	14400	-	-
02-May	-	-	-	-	30	-	-	-	100	-	-	-	20	-	-	-
03-May	-	-	-	7000	-	-	-	3300	-	-	-	3800	-	-	-	7800
06-May	-	-	600	-	-	-	900	-	-	-	10100	-	-	-	11950	-
07-May	-	9100	-	-	-	300	-	-	-	75	-	-	-	3400	-	-
08-May	30	-	-	-	1800	-	-	-	-	-	-	-	-	-	-	-
11-May	-	-	-	500	-	-	-	600	-	-	-	2800	-	-	-	14500
13-MAY	-	-	6300	-	-	-	900	-	-	-	600	-	-	-	20100	-
15-May	15	-	-	-	2700	-	-	-	400	-	-	-	11200	-	-	-
17-May	-	9100	-	0	-	-	-	0	-	-	-	9300	-	-	-	4800
18-May	-	9100	-	0	-	450	-	30	-	600	-	12700	-	11700	-	10500
24-May	-	-	-	1000	-	-	-	50	-	-	-	3200	-	-	-	18100
29-May	200	750	-	-	0	500	-	-	300	400	-	-	700	30700	-	-
04-Jun	94	-	-	-	3000	-	-	-	1300	-	-	-	2500	-	-	-

Boca de Quadra	Transect 1				Transect 2				Transect 3			
Date	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
15-Apr	-	-	900	-	-	-	100	-	-	-	100	-
21-Apr	-	-	0	-	-	-	100	-	-	-	100	-
23-Apr	-	2000	-	-	-	-	-	-	-	2000	-	-
27-Apr	-	-	-	-	-	-	-	3680	-	-	-	420

-Continued-

Table 8. (page 2 of 2.)

Boca de Quadra (Cont.)			Transect 1				Transect 2				Transect 3	
Date	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
30-Apr	-	1420	-	-	-	2630	-	-	-	-	-	-
04-May	-	-	-	-	-	-	-	2210	-	-	-	1930
05-May	-	-	0	-	-	-	850	-	-	-	950	-
07-May	-	5400	-	-	-	2400	-	-	-	-	-	-
09-May	600	-	-	-	-	-	-	-	-	-	-	-
11-May	-	-	-	-	-	-	-	700	-	-	-	5800
12-May	-	-	0	-	-	-	600	-	-	-	600	-
16-May	-	-	-	-	-	-	-	-	3	-	-	-
18-May	-	363000	-	-	-	22000	-	5450	-	-	-	6200
22-May	500	-	-	-	50	-	-	-	0	-	-	-
25-May	-	-	-	-	-	-	-	60	-	-	-	200
30-May	250	-	-	-	0	-	-	-	65	-	-	-
05-Jun	300	-	-	-	0	-	-	-	15	-	-	-

Carroll Inlet			Transect 1				Transect 2				Transect 3	
Date	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
02-Apr	-	-	-	-	-	20000	-	-	-	-	-	-
08-Apr	-	14	-	-	-	3570	-	-	-	380	-	-
10-Apr	-	-	-	-	-	-	-	-	-	0	-	-
17-Apr	-	230	-	-	-	2830	-	-	-	0	-	-
18-Apr	-	-	-	240	-	-	-	270	-	-	-	75
22-Apr	-	2870	-	150	-	5010	-	120	-	0	-	-
23-Apr	-	120	-	-	-	620	-	-	-	125	-	-
25-Apr	-	-	-	170	-	-	-	1800	-	-	-	630
29-Apr	-	860	-	-	-	-	-	-	-	-	-	-
30-Apr	-	3400	-	-	-	11300	-	-	-	40	-	-
01-May	-	-	-	600	-	-	-	4900	-	-	-	1400
03-May	0	-	-	-	150	-	-	-	25	-	-	-
05-May	-	3	-	-	-	43800	-	-	-	27	-	-
07-May	-	90	-	-	-	139000	-	-	-	5	-	-
08-May	500	-	-	-	50	-	-	-	2000	-	-	-
09-May	-	-	-	4700	-	-	-	700	-	-	-	2200
10-May	-	-	-	2400	-	-	-	3000	-	-	-	-
12-May	1100	-	-	-	4800	-	-	-	500	-	-	-
13-May	2300	-	-	-	4600	-	-	-	-	-	-	-
14-May	500	-	-	-	3000	-	-	-	3500	-	-	-
18-May	-	160	-	-	-	4300	-	-	260	-	-	-
19-May	-	1350	-	-	-	2500	-	-	-	5700	-	-
20-May	-	19400	-	-	-	1200	-	-	-	700	-	-
21-May	-	800	-	-	-	4300	-	-	-	370	-	-
22-May	-	6000	-	600	-	6200	-	3800	-	-	-	10
23-May	17400	-	-	-	700	-	-	4200	125	-	-	-
24-May	-	-	-	1900	-	-	-	2900	-	-	-	-
25-May	-	-	-	2400	-	-	-	-	-	-	-	-
28-May	240000	-	-	-	300	-	-	-	25	-	-	-
30-May	-	-	-	0	-	-	-	5	-	-	-	1
04-Jun	150	50	-	-	300	259	-	-	150	220	-	-
06-Jun	8	-	-	-	200	-	-	-	-	-	-	-
12-Jun	4800	-	-	-	6000	-	-	-	0	-	-	-
16-Jun	50	-	-	-	400	-	-	-	0	-	-	-

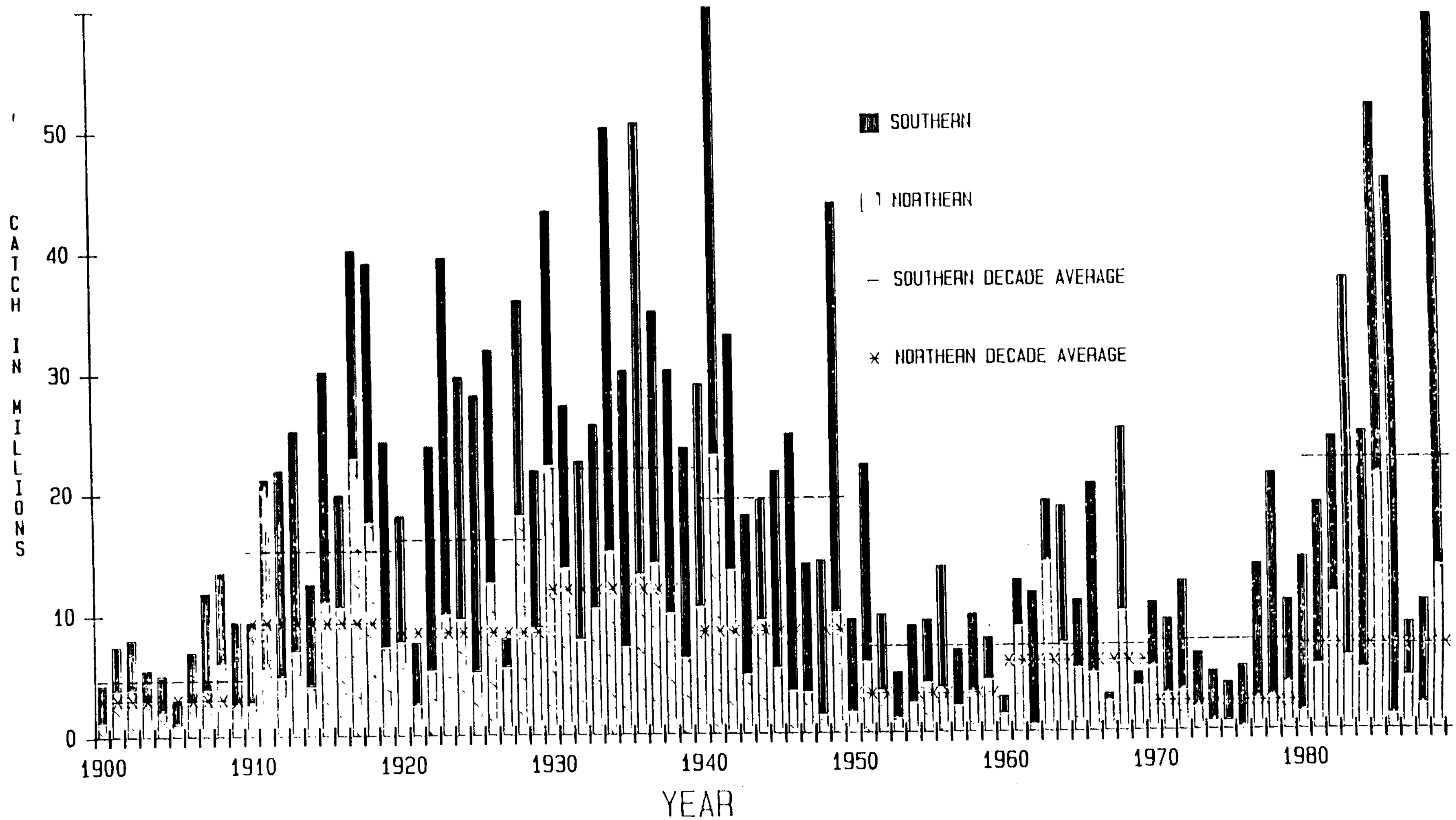

Figure 1. Northern and southern Southeast Alaska pink salmon harvests, 1892 through 1989, with decade averages.

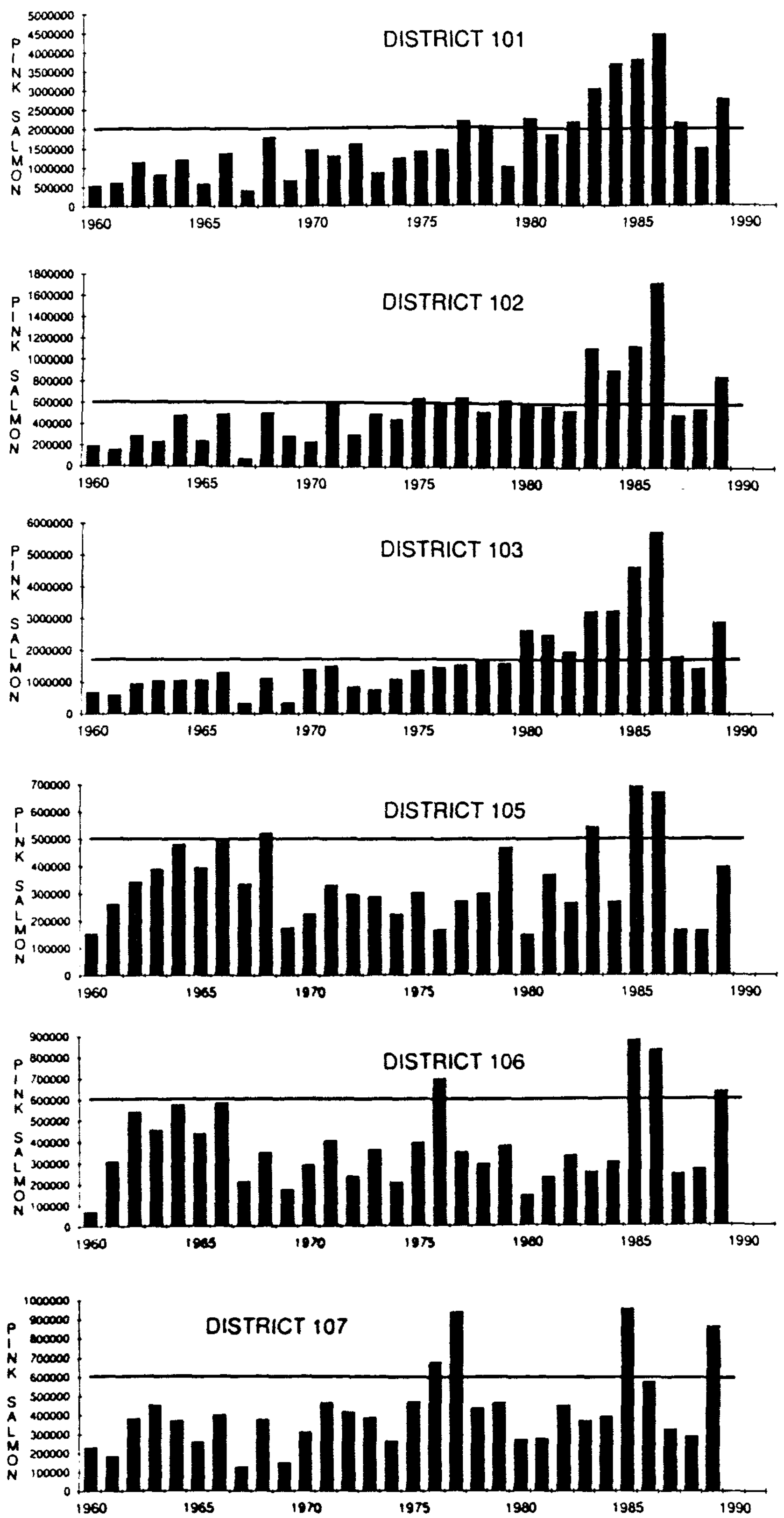

Figure 2. Southern Southeast Alaska pink salmon escapement index and escapement goals by district and year.

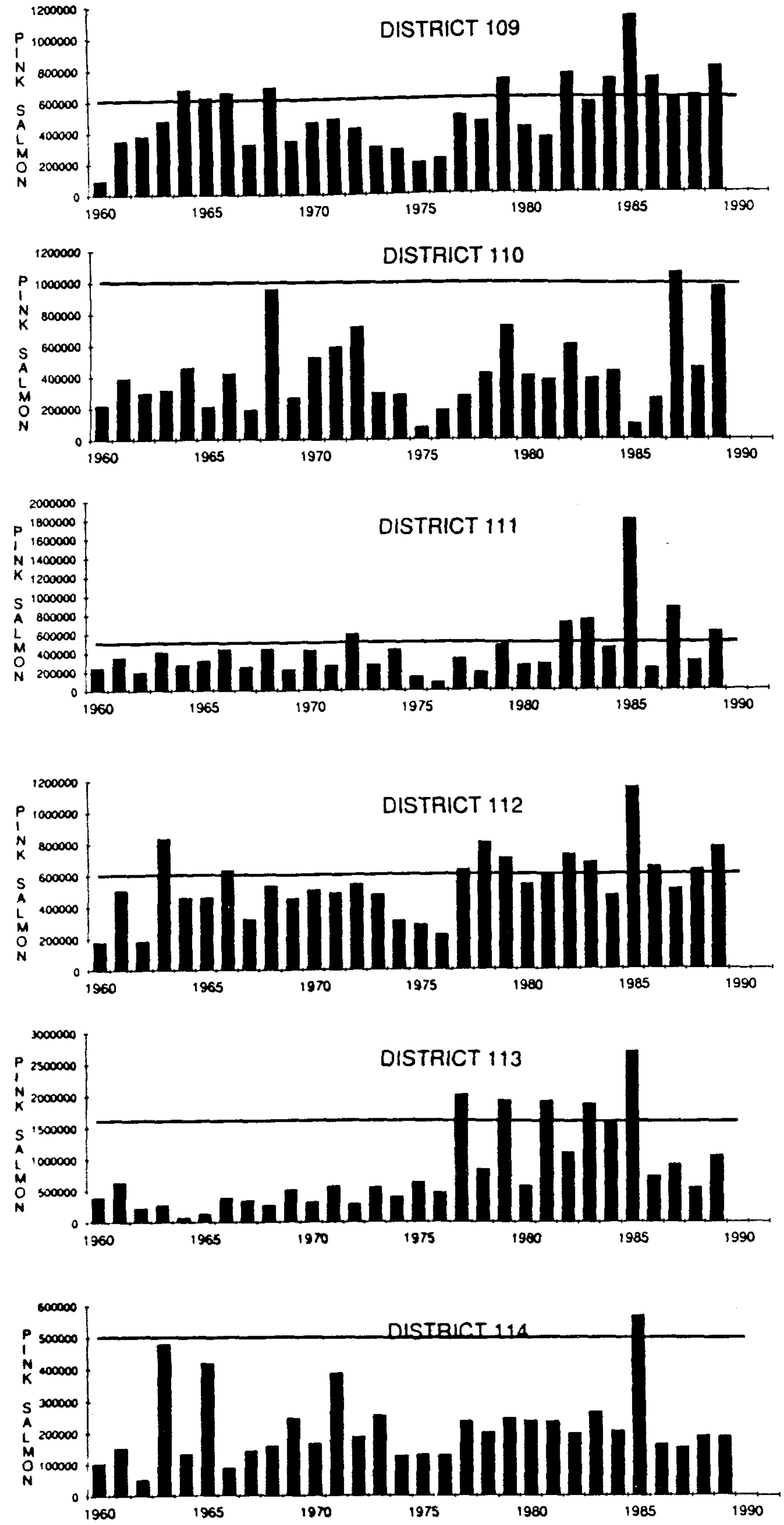

Figure 3. Northern Southeast Alaska pink salmon escapement index and escapement goals by district and year.

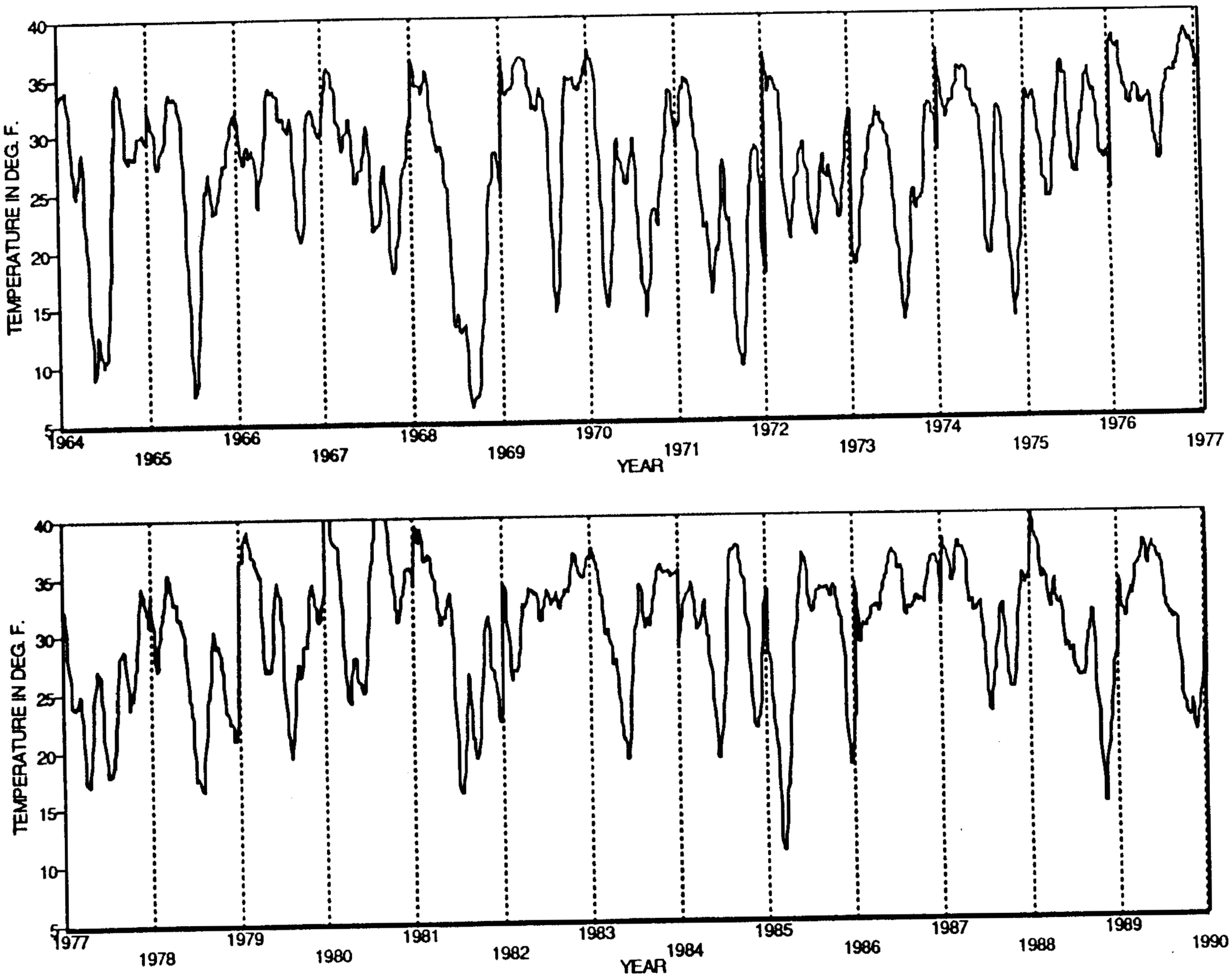

Figure 4. Fourteen-day moving average minimum air temperatures from Annette Island, Beaver Falls, Ketchikan, Petersburg, and Wrangell over the November 1 - February 28 time period (1964 -1990).

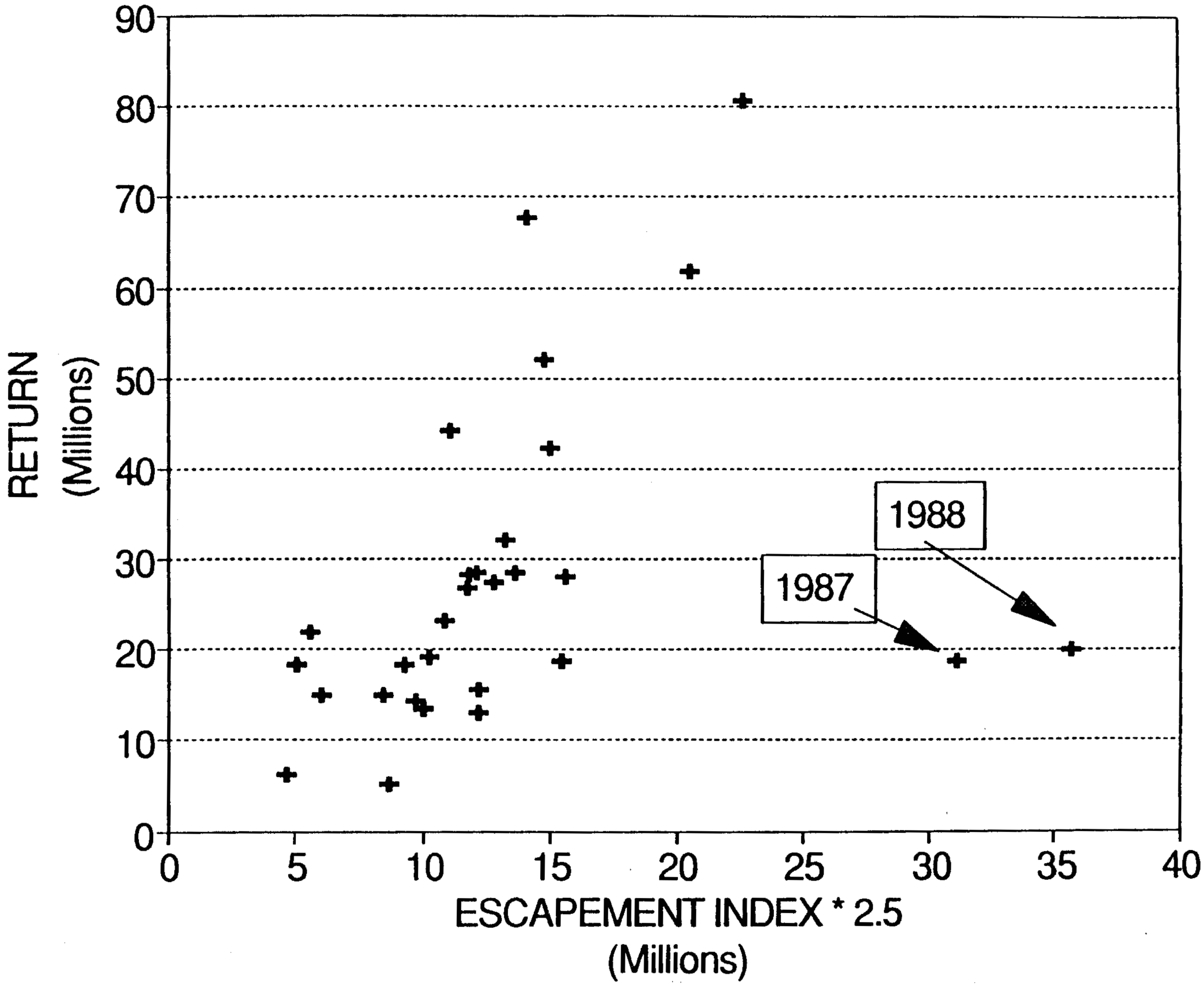

Figure 5. Spawner recruit relationship for pink salmon returning to southern Southeast Alaska.

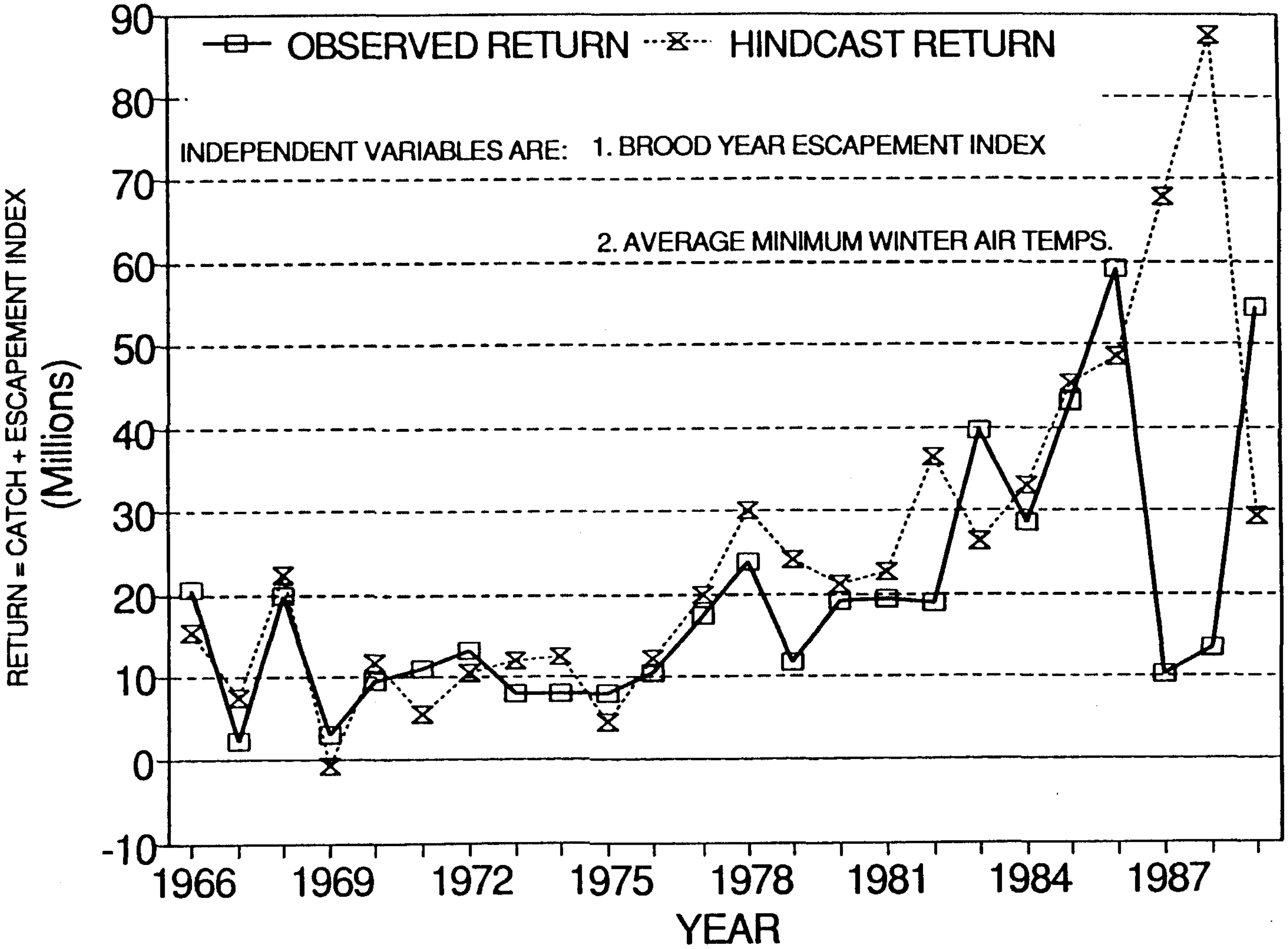

Figure 6. Multiple linear regression analysis with return years 1987 and 1988 omitted from regression analysis (two independent variables).

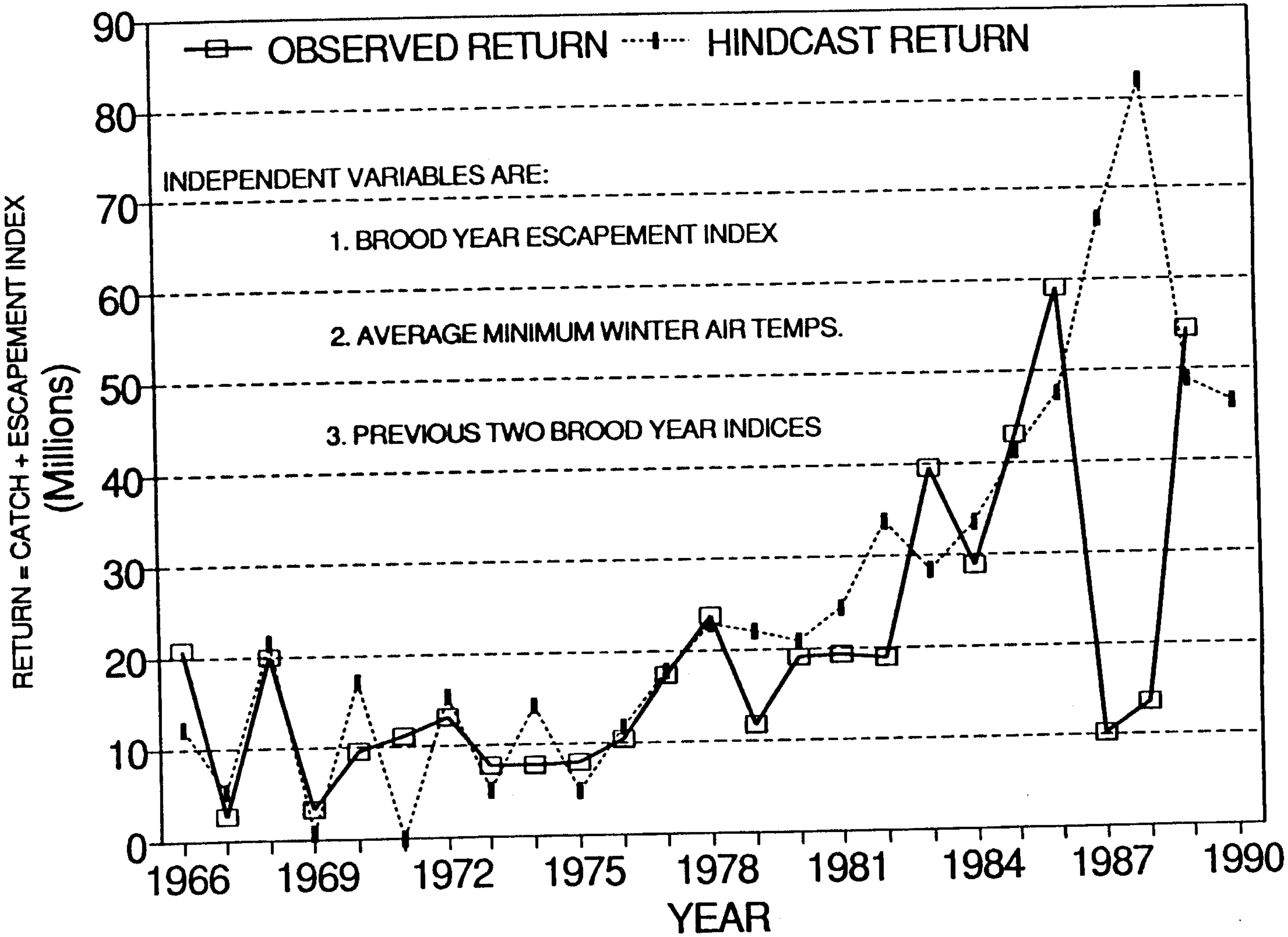

Figure 7. Multiple linear regression analysis with return years 1987 and 1988 omitted from regression analysis (three independent variables).

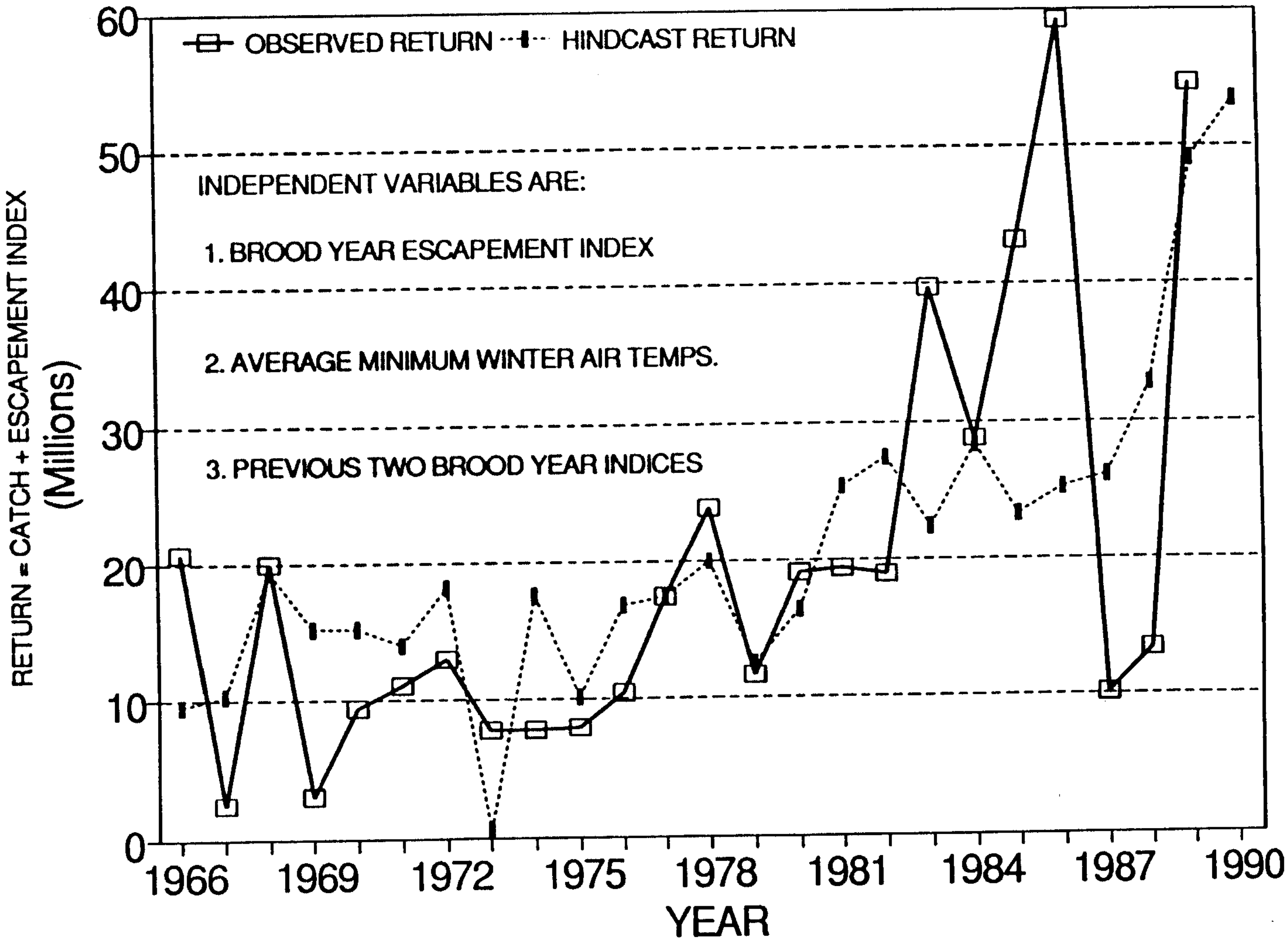

Figure 8. Multiple linear regression analysis with all years included in analysis (1966 - 1989).

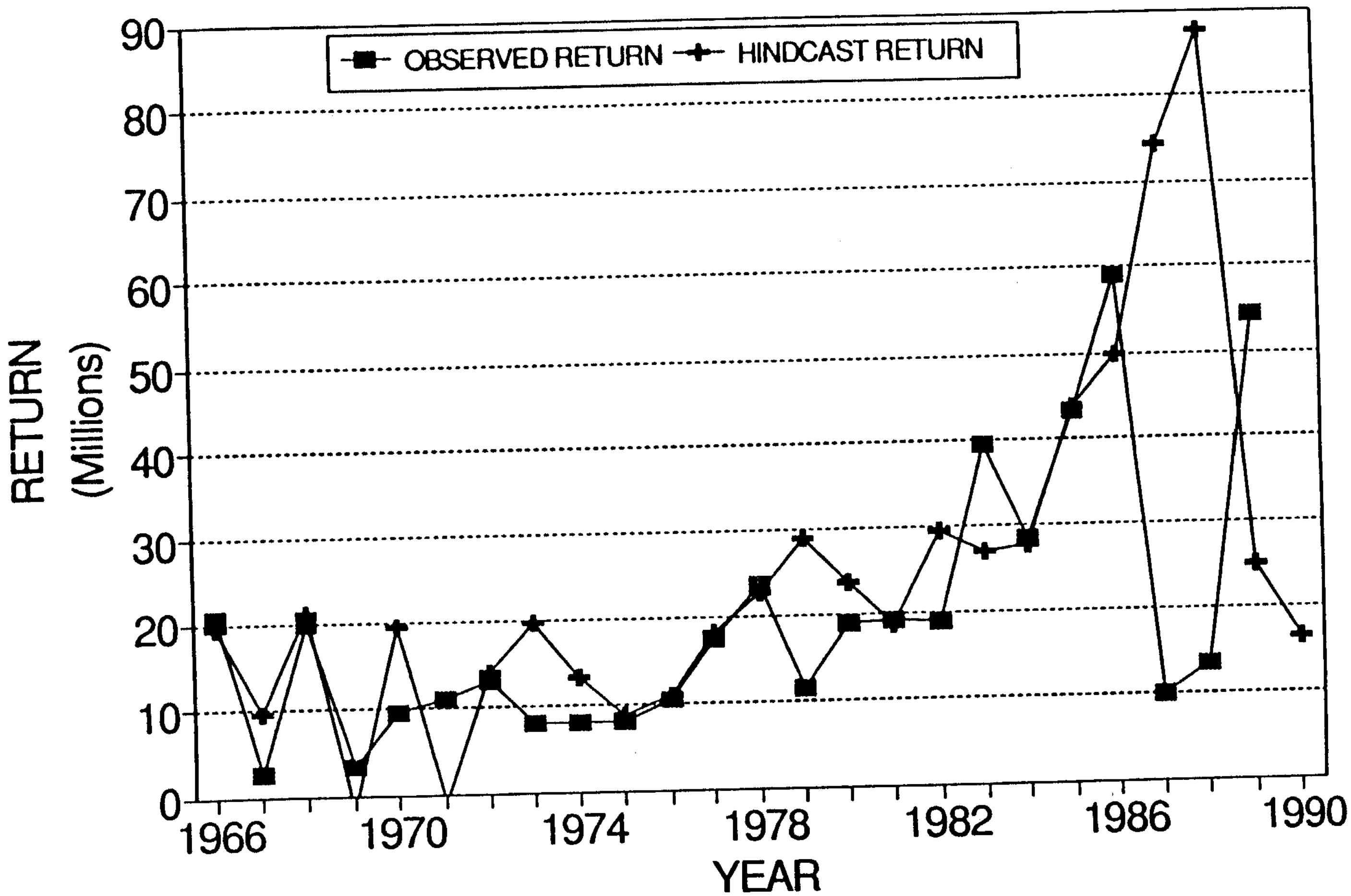

Figure 9. Linear regression analysis with brood year escapement index as the independent variable.

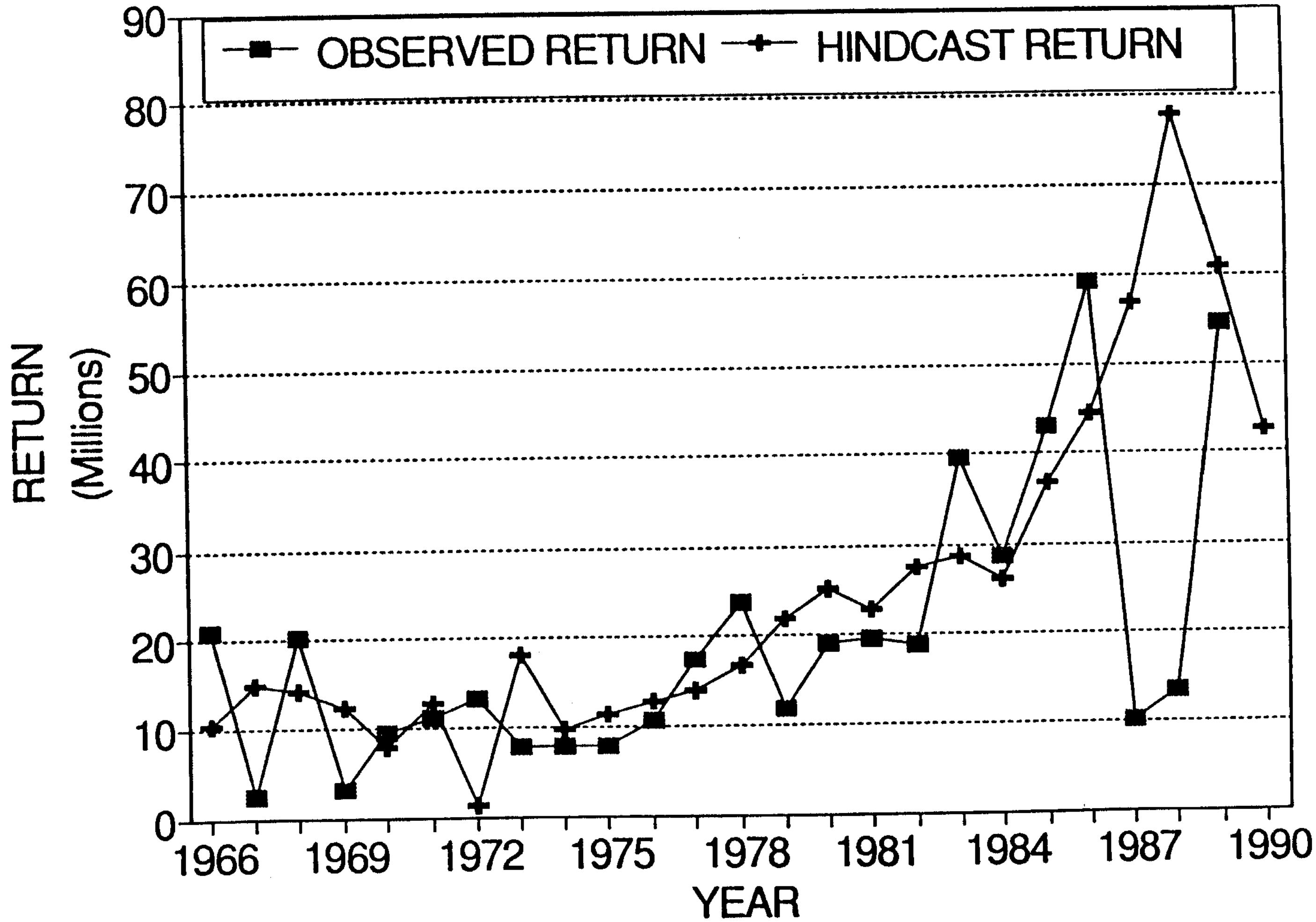

Figure 10. Linear regression analysis with the sum of escapement indices 2, 3, and 4 years prior to return as the single independent variable.

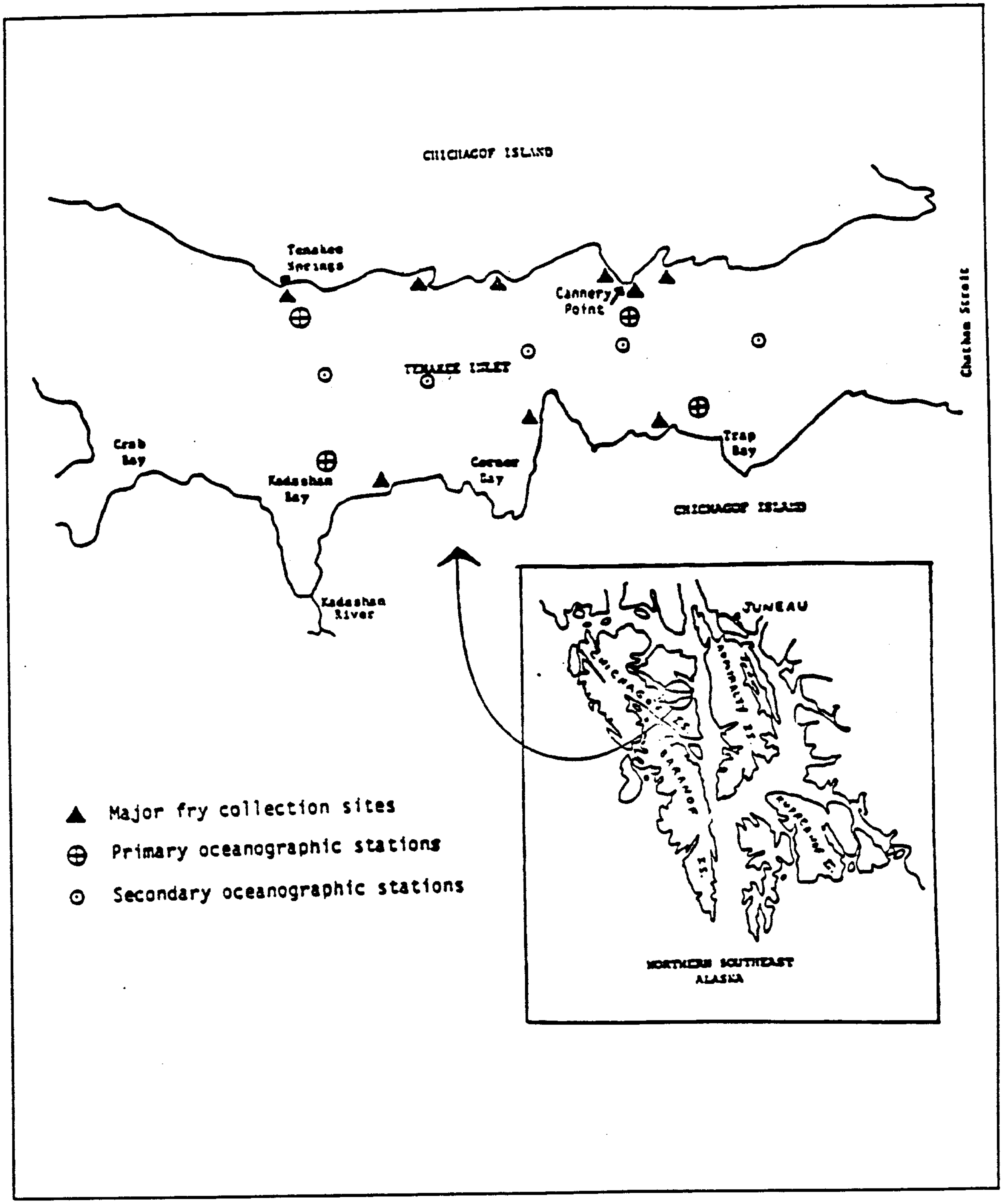

Figure 11. Major fry collection sites, primary and secondary oceanographic stations, and the location of Cannery Point in Tenakee Inlet.

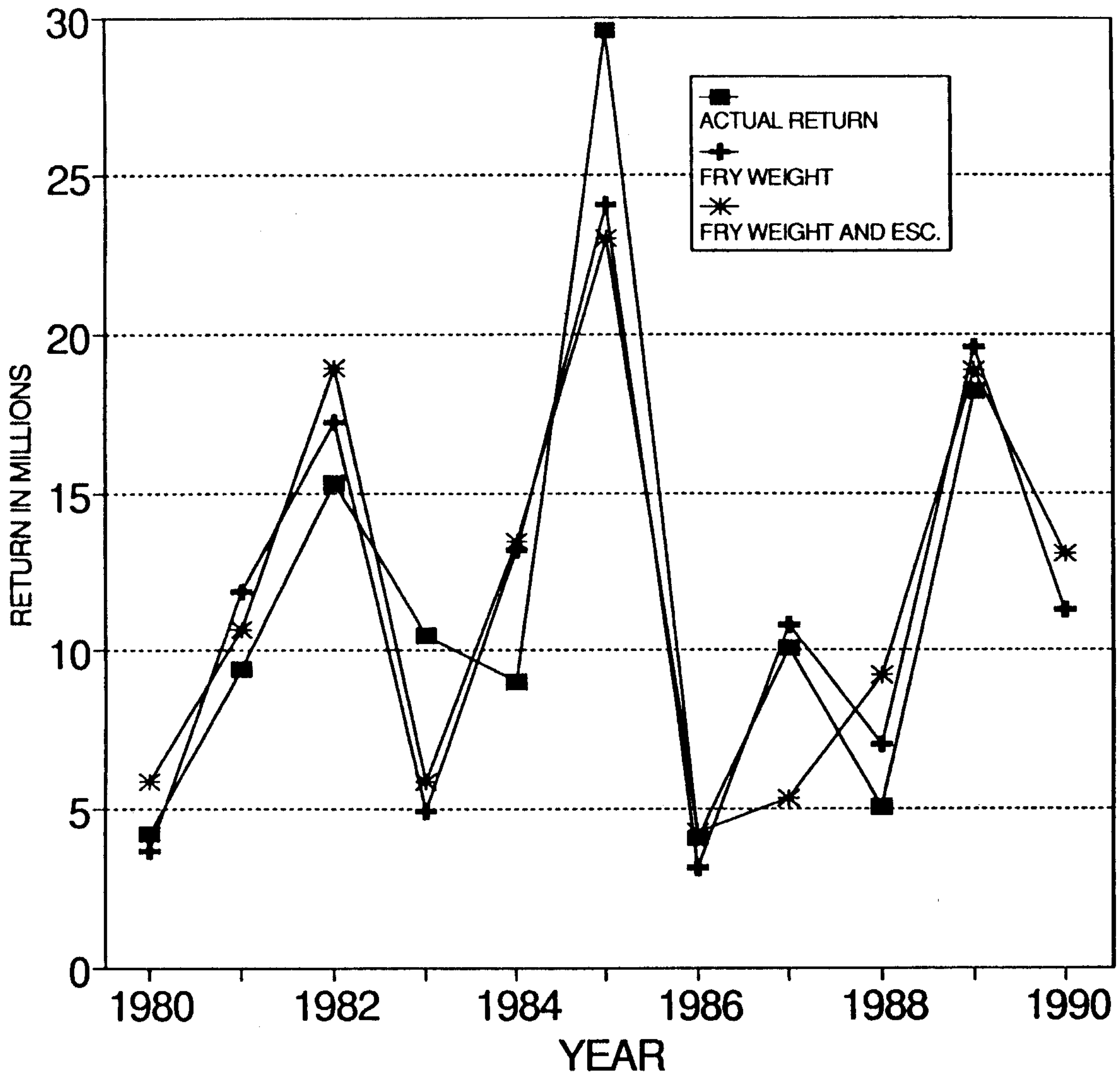

Figure 12. Northern Southeast Alaska return predictions using fry size and fry size plus the escapement index as independent variables.

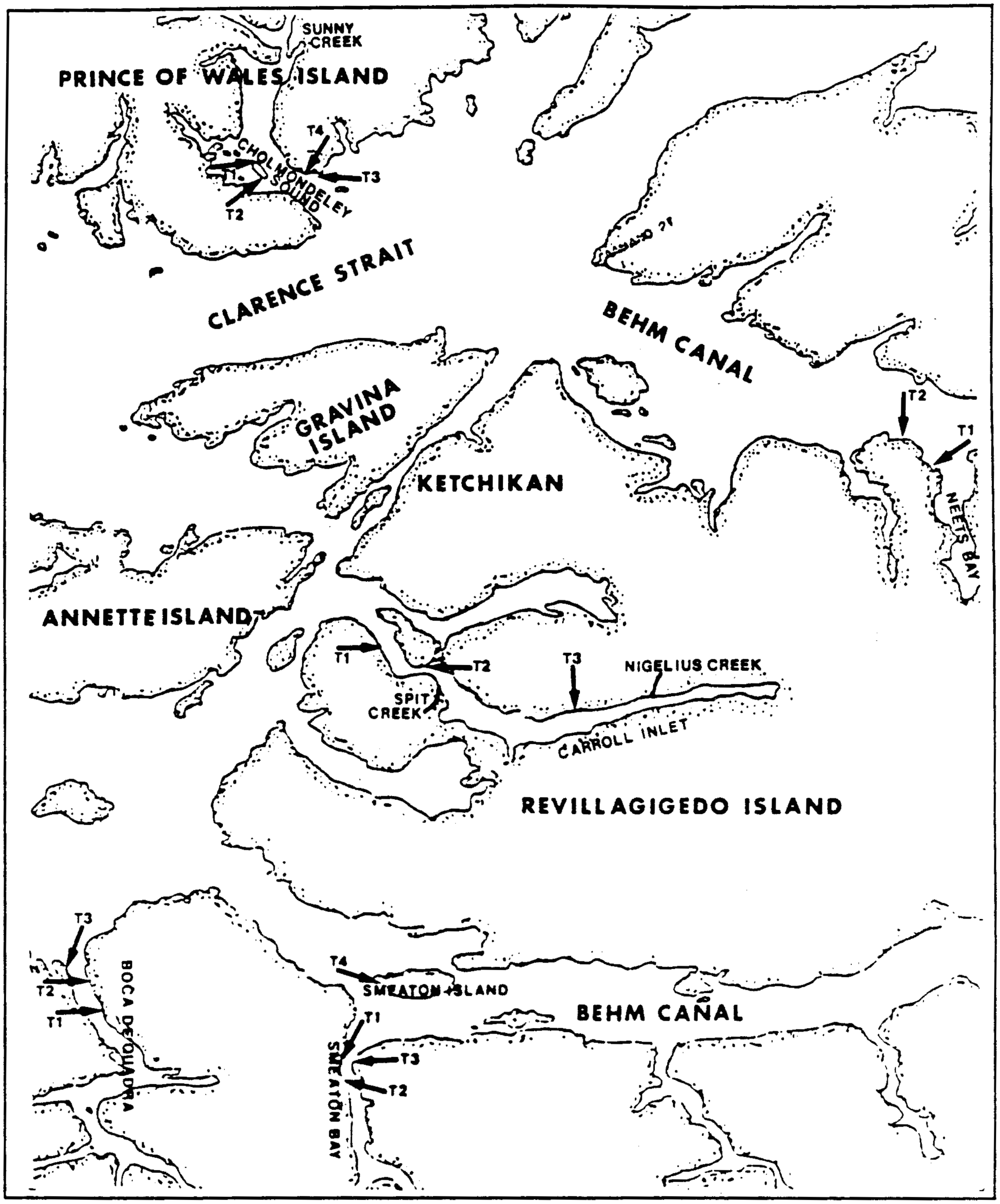

Figure 13. Early marine study area and transect locations in southern Southeast Alaska (east coast of Prince of Wales Island).

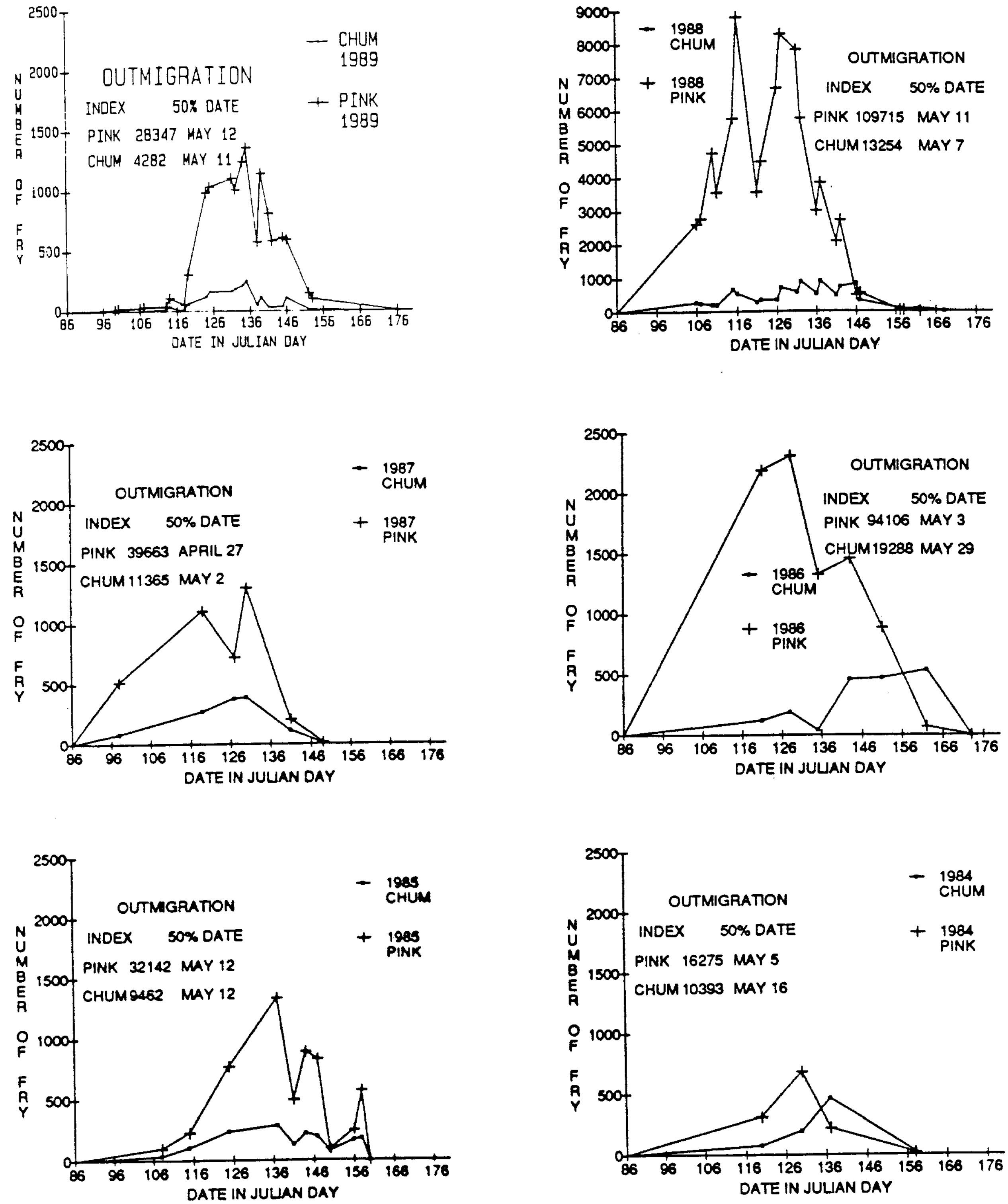

Figure 14. Pink and chum salmon outmigrations from Sunny Creek, 1976-1989.

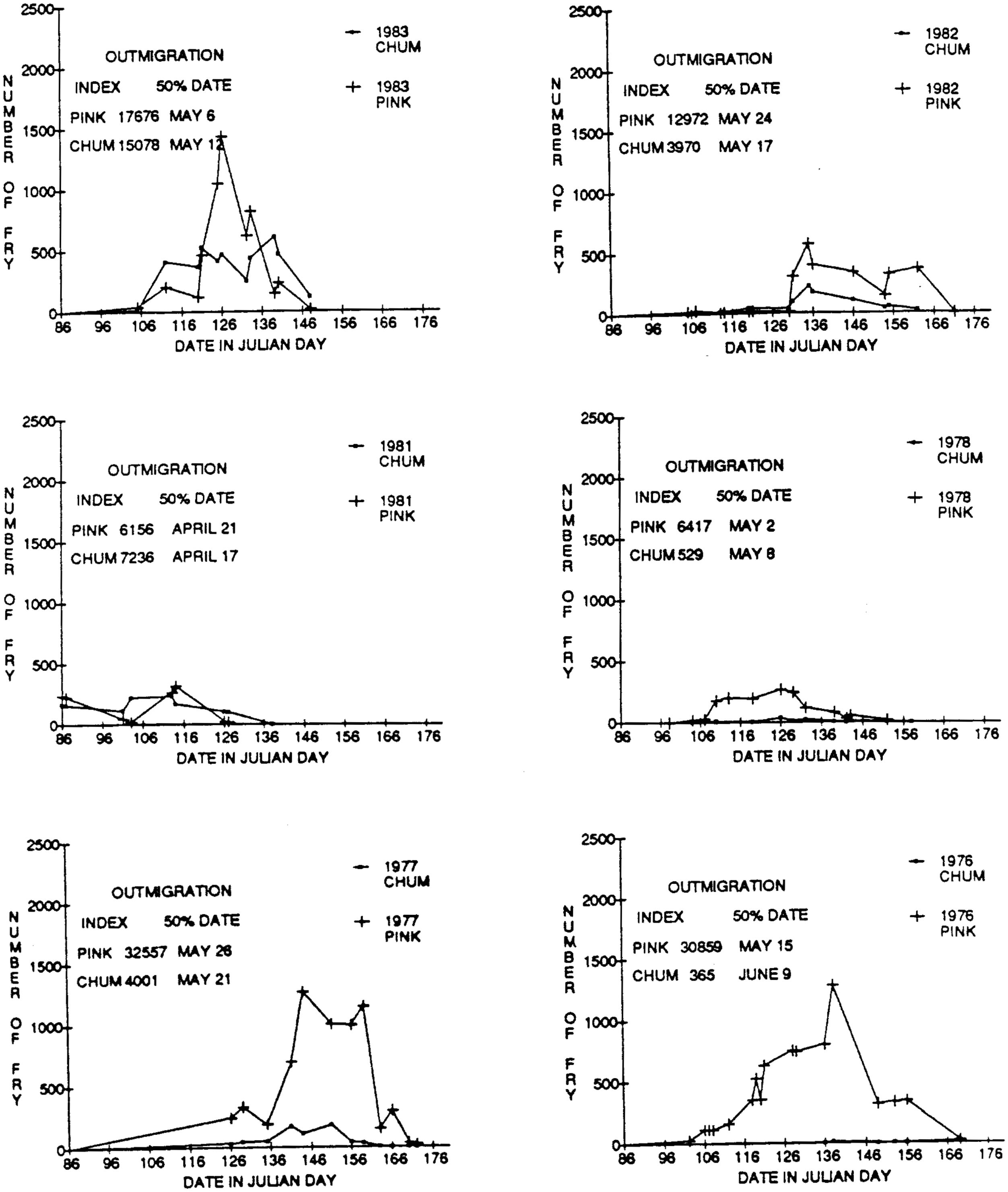

Figure 14. (page 2 of 2.)