SOUTHEAST ALASKA PINK AND CHUM SALMON INVESTIGATIONS, 1988-89

Final Report for the Period July 1 1988 to June 30, 1989

By

Karl Hofmeister
and
James R. Dangel

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AUTHOR

Karl Hofmeister is the Project Leader for Pink and Chum Salmon Research for the Alaska Department of Fish and Game, Division of Commercial Fisheries, P.O. Box 20, Douglas, Ak 99824.

James R. Dangel is an Assistant Project Leader for Pink and Chum Salmon Research for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 304 Lake Street Room 103, Sitka, Ak 99835.

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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 from July 1, 1988 through June 30, 1989. The 1988 pink salmon (*Oncorhynchus gorbuscha*) returns to both northern and southern Southeast Alaska came in below the lower end of the preseason forecast range. The estimated return to southern Southeast Alaska totaled 13.3 million with a 9.2 million harvest and an escapement index of 4.1 million. The estimated return to northern Southeast Alaska totaled 4.8 million with a harvest of 2.1 million and an escapement of 2.7 million. The 1989 forecast for southern Southeast is 19.6 million with a range of 11.8 to 32.9 million. The 1989 forecast for northern Southeast is 10.5 million with a range of 7.3 to 13.7 million (Geiger and Savikko 1989).

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 ($r^2 = .81$, $n = 11$).

Sex ratios in the seine catch were as high as 70% males early in the season and as low as 30% males late in the season. In most years the sex ratio reached 50% males during the same week that the cumulative catch reached 50%.

INTRODUCTION

The Southeast Alaska pink salmon forecast research project was initiated in 1963. This report describes project activities during the period July 1, 1988 through June 30, 1989. The general scope of this project involves collection, analyses, and reporting of data useful for making preseason forecasts, determining in-season run strength, 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 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 spawner (R/S). These include: the average daily temperature over the November through February time period following spawning (the colder the lower the survival); coldest 14 day moving average of minimum daily temperature over this same time period (again the colder the lower the survival); 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); and the lowest 30-day total precipitation over the spawning period (July 15 through September 30)(lower the precipitation the poorer the survival). The environmental parameters used in each year were chosen base 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. Average air temperature during the year of out-migration is the parameter which exhibits the highest correlation with return in northern 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.

The monitoring of pink salmon sex ratios was initiated in 1981 after it became apparent during a fecundity study that the sex ratio of pink salmon in the seine catch was skewed strongly to males early in the season and strongly to females late in the season. The study was undertaken because it was felt that conservative management policies of restricting fishing time until significant escapements were observed may be resulting in the majority of the harvest occurring on the segment of the pink salmon population which is heavily weighted toward females. The consequential predominance of males in the escapement would be the exact opposite of what is required for maximum production (Pain 1974). This sex composition data is also of value in in-season assessments of run timing and run strength.

This report describes the 1988 return, presents the 1989 pink salmon forecast, and summarizes the data collected during the Early Marine program in the spring of 1989. Pink salmon sex ratio data which has been collected since 1981 is also included in this report. Specific project objectives include:

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, distribution, 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.

3. Measure changes in selected environmental parameters and determine the relationship between these parameters and pink and chum fry migration timing, abundance, size, and the subsequent abundance of returning adults.

4. Evaluation of the usefulness of sex ratio data for in-season assessment of run timing and run strength and post-season evaluation of management actions.

PINK SALMON FORECASTS

Methods

Multiple linear regression analysis using escapement and combinations of environmental data was used to make the 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 proportion of streams surveyed. The adjustment is made by estimating the total number of anadromous streams within each district and multiplying the number of streams not surveyed within any one year by the average peak escapement of all streams within the district with a peak escapement count under 10,000. All large streams of over 10,000 spawners are surveyed every year. The majority of escapement counts are made by management biologists during routine aerial surveys for fishery opening decisions. Weir counts and foot stream surveys are also included. 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 and 1988 were not included in the regression because the escapement indices were outside the range of previous years and were considered outliers. These two years were included, nevertheless, in calculation of the 80% confidence level. Variables used in the regression analysis include: brood year escapement index, average minimum daily winter air temperature (November 1 through February 28), and the lowest total 50-day precipitation over the spawning period (July 15 through September 30). All 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, 1989 was the second year the forecast was prepared without the benefit of the pre-emergent fry index and again a number of approaches were tried, but none were considered reliable. The escapement index in northern Southeast Alaska is poorly correlated with return and, therefore, is not a good predictor variable. The model that was used for the 1989 prediction included escapement indices weighted by the average size of the parent adults and the average air temperature during the year of out-migration. Air temperatures were obtained from five N.O.A.A. recording stations throughout northern Southeast Alaska (Haines, Juneau, Sitka, Gustavus, and Little Port Walter).
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 1988 was only 13.3 million fish (Table 1) which was 30.8 million below the forecast midpoint of 44.1 million (Hofmeister et al. 1988). Sex ratio data indicated that the run timing was average to slightly later than average (see sex ratio section), and consequently, more harvesting was allowed than would have been the case if the weakness of the run had been accurately forecasted. The escapement index in 1988 of 4.1 million (Table 2) was the lowest achieved since 1974 and was only 68% of the established goal of 6.0 million. Of even more concern is that the distribution of the escapement was poor; streams in Districts 101 through 103 received 80% of their established escapement goals while streams in Districts 105 through 108 received only 35% of their goal levels. Escapement indices were below goal levels in all districts (Figure 2). The northern Southeast Alaska return of 4.8 million (Table 1) was .4 million below the lower end of the forecast range of 5.2 to 10.6 million. The escapement index of 2.7 million was the lowest achieved since 1974 (Table 3). Escapement indices were below goal levels in all districts (Figure 3).

Southern Southeast Alaska 1988 Forecast Evaluation

This was the second consecutive year the pink salmon return to southern Southeast Alaska came in below the lower end of the forecast range. The actual return was only 36% of the return forecast in 1987 (27.2 predicted, 9.9 actual) and 30% of the return forecast in 1988 (44.1 predicted, 13.3 actual). At the time the 1988 forecast was made it was thought the large error in the 1987 forecast may have been the result of density independent mortality caused by the severe winter of 1985-1986. It was noted in the 1987 prediction publication (Eggers and Dean 1987) that winter conditions in 1985-1986 were the most severe over the 22 year study period (1967 through 1988) began and the brood year escapement index was 3 million fish higher than the previous high of the study period. Therefore, it was felt that the regression model may have put too much weight on escapements and not enough weight on winter temperatures. Failure of the 1988 return casts doubt on this theory. The brood year escapement index for 1988's return (1986) was a study period high of 13.9 million, and winter temperatures were the fourth highest of the 22 year study period. Consequently, the poor survival experienced by pink salmon returning in 1988 cannot be attributed to harsh winter conditions.

As of the writing of this report no explanation has been found for the large inaccuracies in the last two years predictions. Pink salmon predictions to Southeast Alaska are made under the assumption that high seas survival is constant, since only those variables associated with fresh water and early marine survival are used in the prediction model. No high seas environmental parameters have been found which exhibit a correlation with return. In most years, with the exception of 1983, 1987, and 1988, the assumption is probably justified since returns correlated reasonably well with predictions (Figure 4). The error in 1983 may be explained by the fact that pink salmon returning in that year were in the ocean during one of the strongest recorded *El Nino* events in history. While we still have no hard data to verify that high seas mortality was the cause of the large errors in 1987 and 1988, a search for inshore environmental variables (N.O.A.A. precipitation and temperature data) to account for the extremely poor survival was unsuccessful.

The poor survival in 1987 and 1988 may have been caused by over-escapement (Table 3). The escapement indices in 1985 and 1986, brood years for 1987 and 1988 returns, were over 3 million higher than the previous maximum index and the returns-per-index spawner in 1987 and 1988 were the second and third lowest of the study period (Table 1). If pink survival is density dependent at the egg to smolt stage, the poor survival experienced in 1987 and 1988 could be attributed to over-escapement of the parent stock. Neither the Ricker nor the Beverton-Holt models fit the escapement-return relationship well (Figure 5). Consequently, we cannot at this time determine if the poor returns in 1987 and 1988 were the result of overescapement and/or exceptionally high environmentally induced mortality. It will probably take additional years of returns from index escapements exceeding 8.0 million, along with refinements of the total return estimates, to adequately evaluate these relationships between spawner-return and accompanying environmental factors. Determining whether or not the optimum escapement has been exceeded is the most important question facing pink salmon research, because it is central to the Department fulfilling it's mandate of managing the pink salmon population to insure maximum sustained yield.

Northern Southeast Alaska 1988 Forecast Evaluation

The 1988 return forecast to northern Southeast Alaska was 7.9 million. The actual return came in at 4.8 million, which was 0.4 million below the lower end of the forecast range (5.2 to 10.6 million). The forecast for 1988 was the first made without the benefit of the pre-emergent fry index. At the time the 1988 forecast was made it was felt that the relatively warm winter and spring temperatures would offset the poor escapement in 1986. It is not clear at this time whether the error in northern Southeast's prediction was the result of overestimating the influence of mild winter and spring conditions on survival or if northern Southeast Alaskan pinks experienced an exceptionally poor high seas survival as suspected for the southern Southeast Alaskan population. The additional uncertainty in northern Southeast Alaska is due to the fact that the relationships between inshore environmental parameters, escapement index, and return is much weaker in northern southeast than southern Southeast Alaska.

A strong relationship (r^2 = .90) has ben found between pink salmon returns and the two parameters, brood year escapement index and average size of fry collected during the Tenakee Inlet Early Marine program. Using data from return years 1978 through 1987, a forecast of 6.5 million fish (Table 4) was obtained for 1988. Which is closer to the actual return of 4.8 million than the pre season forecast of 7.9 that was based on brood year escapement and air temperatures data. The decision against using average fry length for estimating the return for 1988 was based on the fact that only 10 years of comparable data was available and on an intuitive belief that estimating survival to an area as large as northern Southeast Alaska based on size of fry in only one estuary is risky.

Southern Southeast Alaska 1989 Forecast

The 1989 pink salmon forecast is 19.8 million, with an 80% confidence range of 11.8 to 32.9. These numbers should be viewed with more than the normal degree of skepticism, considering that the last two forecasts were both extreme overestimates of the actual return (Figure 4) and reasons for the overestimates have not been found. If the conditions responsible for the poor survival over the previous two years are still occurring, the 1989 prediction will again be an overestimation of the actual return. If the 1987 and 1988 data had been included in determining parameters for the forecast model, the forecast would have been 11.3 instead of 19.8 million.

The 1987 escapement index of 5.6 million was the lowest achieved in the last 7 years and less than half of that which was achieved over the previous two years (Table 2). Winter temperatures were well above average, but a drought probably caused some increased mortality. The severity of the drought, as measured by a 50-day moving average precipitation over the spawning period, was equal to the most severe of the 20 year study period. However, the drought started late in the season with the lowest water levels occurring during the third week of September. This late timing may have reduced the drought's negative impacts because of shorter days and a lower sun angle during the latter part of September. Prespawn die-offs were noted in a few streams, especially those in which a large portion of the watershed had been logged. The number of streams affected and the severity of the die-offs in the affected streams did not, however, appear as severe as the 1977 and 1979 droughts.

Northern Southeast Alaska 1989 Forecast

The return forecast for northern Southeast Alaska is 10.5 million, with a 80% confidence range of 7.3 to 13.7 million. Returns to the northern districts are expected to be good in all districts except District 114, which had a relatively poor parent year escapement. Overall parent year escapements in the rest of the northern areas were good, with an overall total of 4.4 million pink salmon (Table 2).

Escapements in the parent year (1987) were well distributed through most of the northern areas. Escapements to Districts 110 and 111 were near all time high levels, while Districts 109 and 112 were at or slightly below goal levels. Harvestable surpluses are expected in all four districts. The District 113 parent year escapement was well below the established goal but should produce a respectable harvest with the good overwinter and spring environmental conditions that were experienced.

If fry length data had been used for the 1989 forecast a return of 11.2 million would be predicted. While the extremely strong correlation between Tenakee Inlet fry length, escapements, and return to northern Southeast Alaska exists for 1976 through 1988 data (r^2 = .90, n = 11), it was decided to wait one more year to ensure that the relationship is not the result of coincidence.

EARLY MARINE SURVIVAL STUDIES

Tenakee Inlet

Methods

Monitoring of Tenakee Inlet pink and chum fry populations and physical parameters was continued in 1988. Pink and chum salmon fry migrating from the Kadashan River, which drains into Tenakee Inlet, were not sampled in 1988, because budgetary constraints resulted in that portion of the program being dropped in 1986.

Fry abundance in Tenakee Inlet was monitored at least once each week by conducting visual surveys along the same transects which have been used in previous years (Jones et al. 1982). Transect locations within Tenakee Inlet included Cannery point, Trap Bay, Corner Bay, and the Tenakee Boat Harbor (Figure 6). 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, 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 form both fresh water and marine areas were preserved in a 10% buffered (sodium borate) formalin solution.

Tenakee Inlet water temperatures, salinity, and clarity were monitored at least once per week form April 22 through June 2 at the primary and secondary oceanographic stations shown in Figure 6. Temperatures and salinity were measured with a Yellow Springs Instrument Model 33. Recordings were taken at 1 m intervals from the surface down to 10 meters. Water clarity was measured with a 20 cm diameter secchi disc.

Results and Discussion

The maximum number of pink salmon fry observed in a day in Tenakee Inlet at Cannery Point in 1988 was 278,000 (Table 5), which was higher than the 1987 maximum count of 165,000, but considerably less than the 1986 maximum count of 1,500,000. No chum salmon fry were ever visually identified from the boat during transect counts or searches for schools to sample for lengths and weights. Nevertheless, chum fry were collected, mostly in beach seines, in association with pink salmon fry. This reinforces the previously documented unreliability of visual estimates for identifying chum fry in large schools of mixed species (Jones et al. 1982).

Pink salmon fry in Tenakee Inlet increased from an average length and weight of 35.4 mm and 343.1 mg on April 28 to 49.9 mm and 1111.1 mg on June 1. This gives an average growth rate of 0.44 mm per day in length and 23.3 mg per day in weight. In comparison, last year's fry grew at a rate of 0.30 mm and 15.3 mg per day.

Temperature and salinity data from Tenakee Inlet is presented in Appendix 1. Unlike previous years, the temperatures did not show a relatively constant rise through time. Previous reports (Hofmeister et al. 1988) have listed temperature and salinity data from Tenakee Inlet at the 2 meter depth. The highest temperatures recorded at the 2 meter depth occurred on May 11, with a reading of 10.8 °C at the Hill point station. The temperature then dropped for the next two sample weeks and, by the last sample day on June 1, the temperature had only risen to 9.4 °C. In comparison, the highest temperature during a similar period in 1987 at hill point was 9.9 °C which occurred on the last day of sampling (June 2).

Ketchikan Area

Methods

Early marine survival studies in the Ketchikan area continued for the eleventh year in 1988. 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 (Figure 7) were monitored from April 2 through June 10 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 the graphs were standardized by assuming an out-migration of zero on March 3 and June 23. The above was required because beginning and ending fyke netting periods often did not include the entire out-migration period. The index of relative abundance was obtained by calculating the area under the out-migration curve rather than summing the catches because the number of sample days varied greatly between years.

The marine fry collection technique was changed in 1986 from after dark 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. The condition index given on graphs of the fry length frequency was calculated with the formula: (length) divided by (weight raised to the power of 3.5).

Estimating fry abundance along premeasured transects was added to the study in 1986. Those areas which were known to be important nursery areas from past years observations were selected as transect locations (Figure 7). 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. Three estuaries on the west coast of Prince of Wales Island were added to the study area in 1988 (Figure 8).

Results and Discussion

The maximum daily fyke net catch of pink salmon in Sunny Creek in 1988 occurred on April 25 (Figure 9). The calculated date of 50% out-migration occurred on May 11. The calculated pink out-migration index was 109,715 which was the highest of the study period. However, the data prior to 1985 can not be directly compared to the 1985 through 1988 data, because a fish ladder was installed in 1984 which opened up additional spawning areas.

Fyke net catches from Nigelius and Spit Creeks, along with streams temperatures, are listed in Table 6. Length frequency distributions of fry collected in the marine nursery areas during the early (April 15 through May 14) and late (May 15 through May 31) time periods are presented in Appendices 2 & 3. It should be stressed that changing the sampling technique in 1986 from dip netting to beach seining may have effected the length frequency distribution of fry sampled after 1986 relative to prior years.

Pink salmon fry abundance estimates by study area are listed in Appendix 4. Since only two returns have occurred since the visual abundance estimates were initiated, it is not possible to evaluate their usefulness in improving predictions. Two main problems which may restrict their reliability are the inability of different observers to accurately estimate the number of fry in large schools (100,000+), and the frequency of poor weather which restricts visibility.

The relationship between fry length 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 exhibits a correlation with return is the date of 50% out-migration from Sunny Creek (Figure 9). Since 1976, the beginning of the study, survival appears to increase as the date of out-migration gets later. In the 8 years for which data is available between 1976 and 1986, the relationship between brood-year escapement index, date of 50% of the out-migration, and subsequent adult return results in an r value of 0.86. Over that same time period the relationship between the brood year escapement index and return has an r value of 0.62. The out-migrations in 1986 and 1987 were both earlier than average. However, when the regression is run with 1987 and 1988 return data, the overall correlation drops to $r = 0.15$. While the partial correlation on date of 50% of the out-migration increases from $r = 0.07$ to 0.15, the partial correlation on escapement index decreases from $r = 0.62$ to -0.02.

PINK SALMON SEX RATIOS

Pink salmon sex ratios have been monitored in the southern Southeast Alaskan purse seine catch since 1981. The sampling was expanded in 1983 to include the northern Southeast Alaska seine catch. Sampling has been in cooperation with personnel from the Port Sampling Project (Oliver 1989). In all study years and areas, the pink salmon run has exhibited a predominance of males early in the run and a predominance of females late in the run. The goal of this study is to determine if sex ratios could be used as an indication of relative run timing between years. A run time parameter would be extremely useful to management biologists since, at present, they are required to use intuition in determining if large catches early in the season indicate a large return or an early return. Conversely, below average catches early in the season could indicate either a weak return or a late return.

A few of the consequences of misjudging relative run timing include:

1. An early, weak return could be over harvested since both catch per effort and escapements would be above average relative to the historical run timing early in the season.

2. A late, strong return would have below average catch per effort early in the season resulting in the majority of the harvest occurring in the latter part of the run, after the sex ratio in the catch has shifted to a predominance of females. The consequential predominance of males in the escapement is the opposite of what is desired for optimum production (Pain 1974).

3. A second consequence of misjudging the run strength of a late run is that, when the run strength finally becomes apparent, the fishing pressure required to harvest all fish above escapement needs can overtax the processing facilities. This results in the fleet being put on limits (restriction on number of pounds allowed to sell per day) which tends to shift the harvest later into the run, which further intensifies the disparity of sexes in the escapement.

Interpretation of the sex ratio data in Southeast Alaska is complicated by the fact that Southeast Alaska's pink salmon run consists of stocks with different run timing. The entire run can be characterized as having early, middle, and late timing segments (Sheridan 1962). Each of the segments is believed to arrive in the local fishing districts with first a predominance of males and then of females. An attempt is made here to use a maturity index for distinguishing between run timing segments. During the overlap of two segments of the run, the less mature fish are assigned to the first segment and the more mature, to the later segment.

Methods

The majority of the samples were taken from conveyer lines of local canneries as the packers were being off loaded. A sample of approximately 400 fish was taken from each packer, with the sampling spread over the entire off-loading process, so that the fish from the upper, middle, and lower portions of the hold were sampled. Samples were only collected from those packers which had received the majority of their fish from a single fishing district.

A small slit was made in the fish's abdominal cavity to determine sex. Fish length was measured to the nearest 0.5 cm (mid-eye to fork of tail) and fish weight was recorded to the nearest 0.1 kg. Both skeins of the fish's gonadal material were removed and weighed to the nearest 0.1 g. Adipose length was measured from the anterior portion of the fin, immediately posterior to the first body scale, to the posterior portion of the lobe. Vernier calipers were used to measure adipose length to the nearest 0.1 mm.

Parameters for a multiple linear regression maturity model were calculated using sex as the dependent variable (1 = male, 3 = female) and fish length, gonadal weight, and adipose length as the independent variables. In both sexes of pink salmon, the length of the adipose fin grows faster, proportionately, than the length of its body as the fish matures, and the growth is more pronounced in males (Beacham and Murray 1983). The weight of the fish's gonadal material also increases as the fish matures. Therefore, in applying the model to individual fish, the fish's predicted sex number (continuous variable) was assumed to be a relative measure of its maturity index. The theory behind this is that the most female-like males (e.g. smallest adipose fin relative to fish length and gonadal weight) were the least mature males and the most male-like females (e.g. largest adipose fin relative to fish length and gonadal weight) were the most mature females.

Timing for catches is recorded as "Statistical Week". A Statistical Week is a 7-day period beginning at 12:01 a.m. Sunday and running through 12:00 midnight the following Saturday. Each week of the year is sequentially numbered. The average mid-week date of the Statistical Weeks used in this report are defined in Table 7.

Results and Discussion

The sex ratios of pink salmon captured in the seine fishery, reported by Statistical Week by district by year, is shown in Figure 10. The numerous missing data points in Figure 10 are the result of a district not being open to fishing in a specific Statistical Week or no packers found in which the majority of the load consisted of fish being caught in a single district. The location of fishing districts is presented in Figure 11. Males predominate in the catch early in the season in all districts. A one-to-one ratio of males is usually achieved by Statistical Week 31 or 32 in the southern districts and a week or two later in the northern districts.

The geographic distribution of the three pink salmon timing segments is shown in Figure 11 (from Seridan 1962). It should be stressed that the map is a very rough approximation and that numerous exceptions to the timing by area occur. In fact, the escapements to some streams, i.e. Wilson River at the head of Smeaton Bay, are composed of fish from all three timing segments. The map may, however, help explain why the District 103 sex ratio during Statistical Week 32 in 1986 was the highest sex ratio ever obtained (86% males). A catch from District 103 would probably be composed of a much higher percent of late run fish than a catch from any other district, and the sex ratio of late run fish at that time of the year would exhibit a higher percent male parameter than the sex ratios of early or middle run fish.

The sex ratio of the cumulative catch, as well as the cumulative catch of males and females, is presented in Figure 12. Due to missing data points, Districts 101 through 104 data were combined from both weekly catch and weekly sex ratio information. In each of the years there were more females than males caught by the end of the season, although in 1986 the ratio was close to 1:1. The greatest difference occurred in 1983 when 2.5 million more females than males were harvested. It is thought that when females comprise a majority of the catch, the escapement sex ratio would be skewed toward males. Relatively complete pink salmon escapement sex ratio data is available from the last three years from three southern Southeast Alaskan weirs (Naha, Hugh Smith, and Karta) (ADF&G unpublished data). The data from those weirs shows a predominance of males in the escapement.

In the Districts 101 to 104 catches the week in which the 50% cumulative catch was taken usually coincided with the week in which the sex ratio dropped to 50% males (Figure 13). If this relationship can be verified it would be useful to management biologists, since they would have an indication of how many fish would be entering the fisheries in the coming weeks. That knowledge would allow management biologists to more precisely regulate the fishery to obtain optimum escapement levels. It should be noted, however, that cumulative catch may not be accurately reflecting run timing because it is affected by management actions related to the distribution of openings through the season, and in years of large returns the processors place their boats on limit (restrictions on the number of fish they are allowed to sell each day).

One problem in interpreting the sex ratio data is that there has not been any year in which the sex ratio has exhibited a consistently higher or lower proportion of males through all Statistical Weeks (Figure 13). This may be related to the fact that the catch is composed of two or three different timing segments and relative magnitude of each segment within the catch would have an influence on the sex ratio of the catch. The relative magnitude of the various timing segments within the catch would be determined by the relative magnitude of each timing segment within the overall return, the area of catch, and the date of catch. An attempt to remove some of the noise caused by differences in area of catch is presented in Figure 14. District 101 was selected because it is the area with the most complete data base. While there is still conflicting information (Statistical Week 29) it appears that the return in 1987 was the earliest of the study period. The above is consistent with area management biologists field observations.

The distribution of the maturity of fish in the catch at any given instance in time, could in theory, be used to determine the proportion of early, middle, and late run fish in the catch. The maturity index was calculated for 3,100 individual pink salmon (Figure 15). In this figure smaller numbers represent more mature fish. The figure shows that there is a measurable difference in the maturity index, at least at the one standard deviation level, between the average female index and average male index. The results of using the maturity index prediction to obtain separate sex ratios for early, middle, and late run fish in the District 101 seine catch in 1988 is presented in Table 8. The maturity indices are standardized to represent the proportion above or below the average maturity index for each sex. If the sex ratios from the above samples are not broken out by timing segments the sex ratios for the three sample days were 56, 45, and 47 percent males. When broken into timing segments the sex ratio of all three segments fell consistently from the first to the third sample day. An independent check on the reliability of run timing assignments was made by calculating the relative contribution of timing segment in the day's sample. This was also consistent with theory in that the early run fish showed a constant drop in percent of sample through time, while the late run fish showed a constant increase in their contribution to the overall catch (Table 8).

It should be stressed that 1988 was the first year in which maturity data was collected and, while the results were biologically logical, there has been no independent verification that the individual fish were accurately assigned to their correct timing segment. It is also important to note that the value selected as the break-off point for separating early and late run fish from middle run fish and the amounts added to the second and third days maturity index for new break-off points were arbitrarily assigned. This was done in an attempt to see if the data would yield biologically logical results. It will take additional years of information before the results can be verified.

The sex ratio data is currently being used by management biologists as one of the many parameters considered in making fishery opening decisions. Methods to distinguish between early, middle, and late run fish in the catch are still under development. The maturity data collected in 1988 was the first attempt to obtain data to do this. If a means is found to obtain sex ratios by timing segment, management biologists would have an extremely useful tool in estimating what percentage of the run has passed through the fishing districts. The above, combined with in-season escapement information, would give management biologists an earlier indication of run strength, thus allowing for increased harvesting pressure early in the season in large return years. Conversely, weak runs would be detected earlier, allowing for reduced fishing pressure to insure that escapement goals are achieved. Plans are currently underway to combine maturity data with electrophoretic data to obtain an independent evaluation of the run time assignments made with maturity data.

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Table 1. 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	160.5	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
Goal	2,000.0	600.0	1,700.0	500.0	600.0	600.0		6,000.0

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

Year	District 109	110	111	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	303.0	486.1	0.0	2,828.4
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	584.4	453.3	287.6	565.2	573.8	189.5	61.6	2,679.4
Goal	600.0	1,000.0	500.0	600.0	1,600.0	500.0		4,800.0

Table 3. Southern and northern Southeast Alaska harvest and escapement in thousands, and return per spawner for 1960-87.

	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

Table 4. Northern Southeast predictions using brood year escapement index and fry size as independent variables in a multiple linear regression (R^2 = .90).

Year of Return	Brood Year esc. Index in Millions	Fry Length in mm.	Return In Millions	Hindcast Return In Millions
1978	1.4	43.7	5.9	10.7
1979	4.2	39.1	8.9	8.6
1980	3.2	37.4	4.1	3.4
1981	5.1	36.8	9.4	6.4
1982	2.6	47.3	15.6	17.4
1983	4.1	39.7	10.8	5.9
1984	4.4	41.5	8.9	9.5
1985	4.8	52.0	30.1	28.9
1986	3.9	39.3	4.1	4.9
1987	9.0	38.3	9.2	10.3
1988	2.9	41.0	4.8	6.5
1989	4.4	40.3		11.2

Table 5. Visual estimates of pink salmon abundance in the early marine study areas of northern Southeast Alaska, Tenakee Inlet 1988.

Transect Date	Cannery Pt	Corner Bay	Tenakee Harbor	Trap Bay
02-May	-	-	-	200
03-May	170,850	21,600	31,800	-
10-May	-	37,410	5,300	-
11-May	102,750	-	-	1,085
17-May	41,000	66,550	-	65,850
18-May	-	-	12,725	-
24-May	75,000	12,750	6,660	6,410
01-Jun	278,000	20,185	-	10,900
02-Jun	-	-	885	-

Table 6. Number of pink and chum salmon fry trapped by fyke nets in Nigelius and Spit Creeks in Carroll inlet with stream temperature, 1986, 1987 and 1988.

	NIGELIUS						SPIT					
	1986		1987		1988		1986		1987		1988	
Date	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	-	-	4166	5	-	-	-	-	1941	5	-	-
10-Apr	-	-	-[b/]	-	-	-	-	-	4373	4[c/]	-	-
12-Apr	-	-	-	-	845	3	-	-	-	-	470	4
13-Apr	-	-	-	-	987	3	-	-	-	-	851	4
19-Apr	-	-	-	-	867	3	-	-	-	-	1022	5
20-Apr	-	-	-	-	529	3	-	-	-	-	485	5
22-Apr	-	-	1010	5.5	-	-	-	-	3010	4.2	-	-
23-Apr	-	-	1874	5.5	-	-	-	-	2720	3.3	-	-
26-Apr	-	-	-	-	438	4	-	-	-	-	764	4
30-Apr	-	-	342	7.5	-	-	-	-	3068	8	-	-
01-May	-	-	312	8	-	-	-	-	1838	9	-	-
02-May	1961	6	-	-	-	-	1208	6	-	-	-	-
03-May	2210	7	-	-	-	-	2590	8	-	-	-	-
05-May	-	-	94	7.8	-	-	-	-	575	7.5	-	-
06-May	-	-	80	7	-	-	-	-	219	6.8	-	-
07-May	-	-	-[d/]	9	-	-	-	-	-	8	-	-
08-May	2766	9	-	-	-	-	1533	8	-	-	-	-
09-May	-	9.8	-	-	-	-	-	8	-	-	-	-
10-May	-	-	-	-	17	-	-	-	-	-	13	-
13-May	384	9	-	-	-	-	616	6.5	-	-	-	-
14-May	302	9.5	-	-	-	-	303[e/]	7.5	-	-	-	-
16-May	-	-	-	-	-	-	-	-	14	6	-	-
19-May	-	-	0	9.5	-	-	48[f/]	8.5	1	6.5	-	-
20-May	-	-	-	-	-	-	-	-	0	11.5	-	-
25-May	18	11	-	-	-	-	53	9	-	-	-	-

Counts influenced by unusal circustances.

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 7. Average midweek date of statistical weeks.

Stat. Week	26	27	28	29	30	31	32	33	34	35	36
Date	06/25	07/02	07/09	07/16	07/23	07/30	08/06	08/13	08/20	08/27	09/03

Table 8. District 101 pink salmon sex ratio by timing segment based on maturity index, 1988.

Day	Run Segment	Male Maturity	# Fish	% Male	Female Maturity	# Fish	% Catch
209	Early	> 1.17	41	40	> 1.15	62	30
	Middle	> = 0.88 < = 1.17	112	60	> = 0.81 < = 1.15	74	65
	Late	< 0.88	37	70	< 0.81	16	15
217	Early	> 1.23	36	34	> 1.20	70	29
	Middle	> = 0.90 < = 1.23	64	69	> = 0.90 < = 1.20	99	47
	Late	< 0.90	58	68	< 0.90	27	24
222	Early	> 1.31	19	29	> 1.25	46	17
	Middle	> = 1.00 < = 1.31	52	36	> = 0.94 < = 1.25	90	37
	Late	< 1.00	111	62	< 0.94	66	46

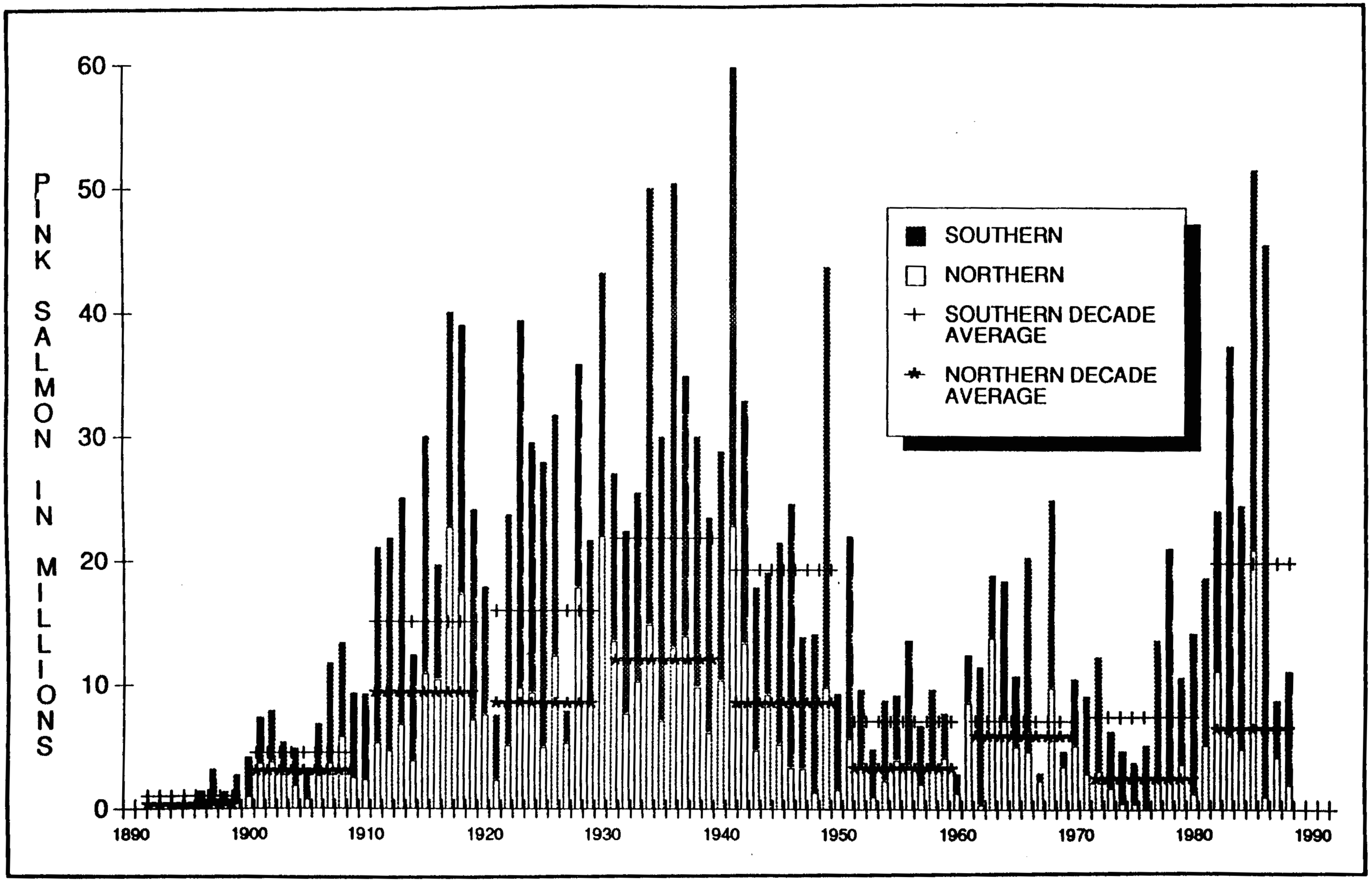

Figure 1. Northern and southern Southeast Alaska pink salmon harvest 1892 through 1988 with decade averages.

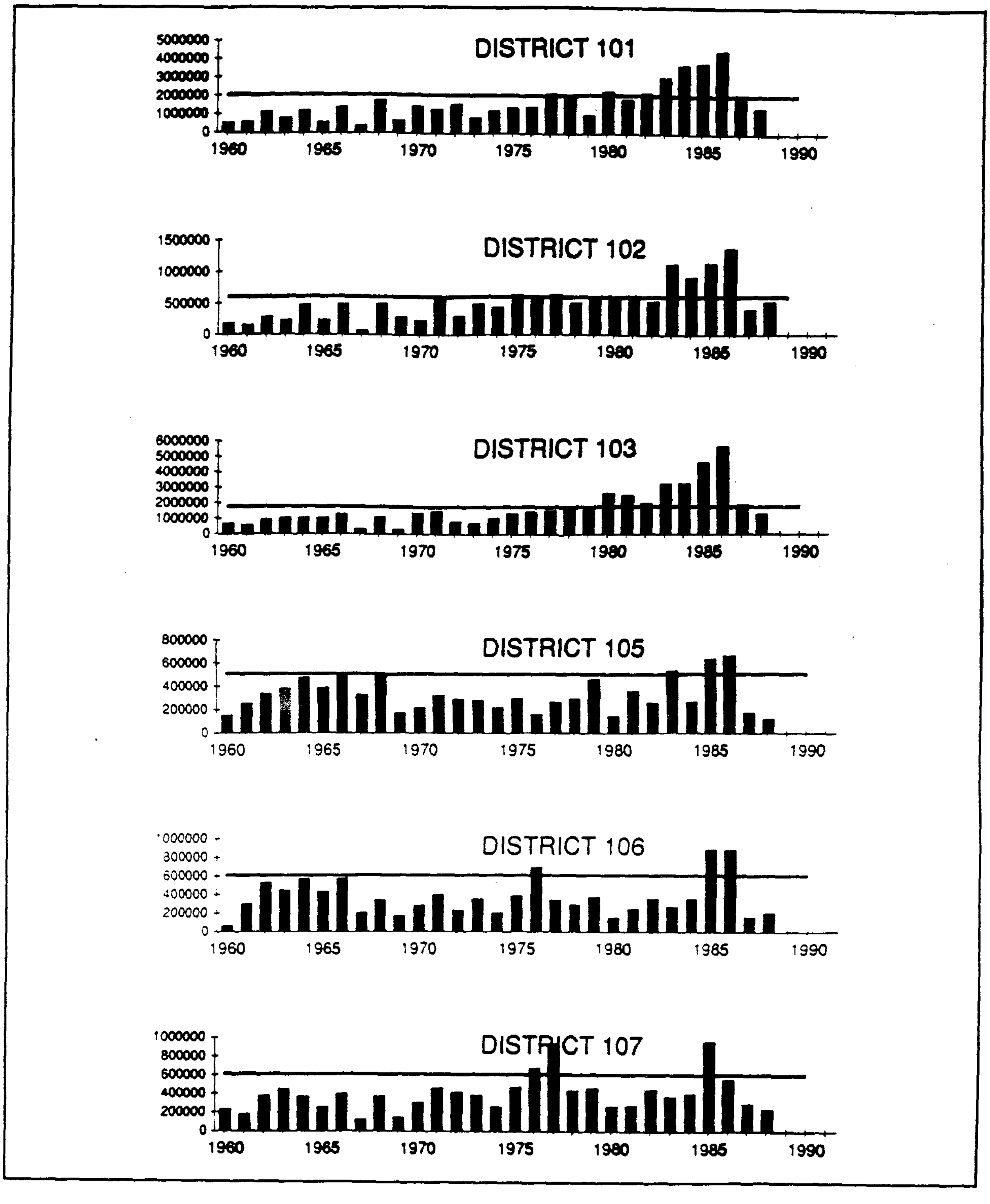

Figure 2. Southern Southeast Alaska pink salmon escapement index and escapement index goals by district and year.

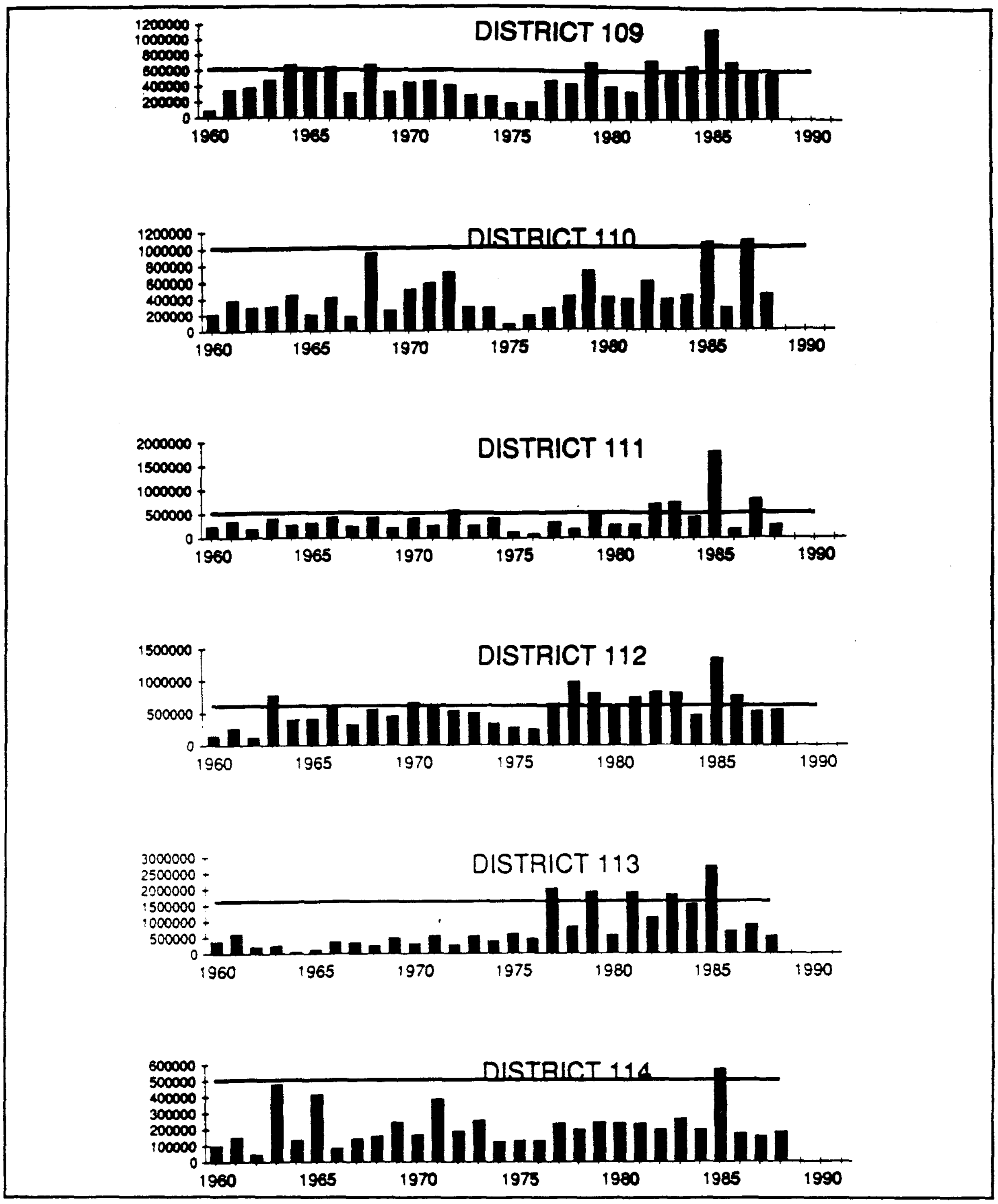

Figure 3. Northern Southeast Alaska pink salmon escapement index and escapement index goals by district and year.

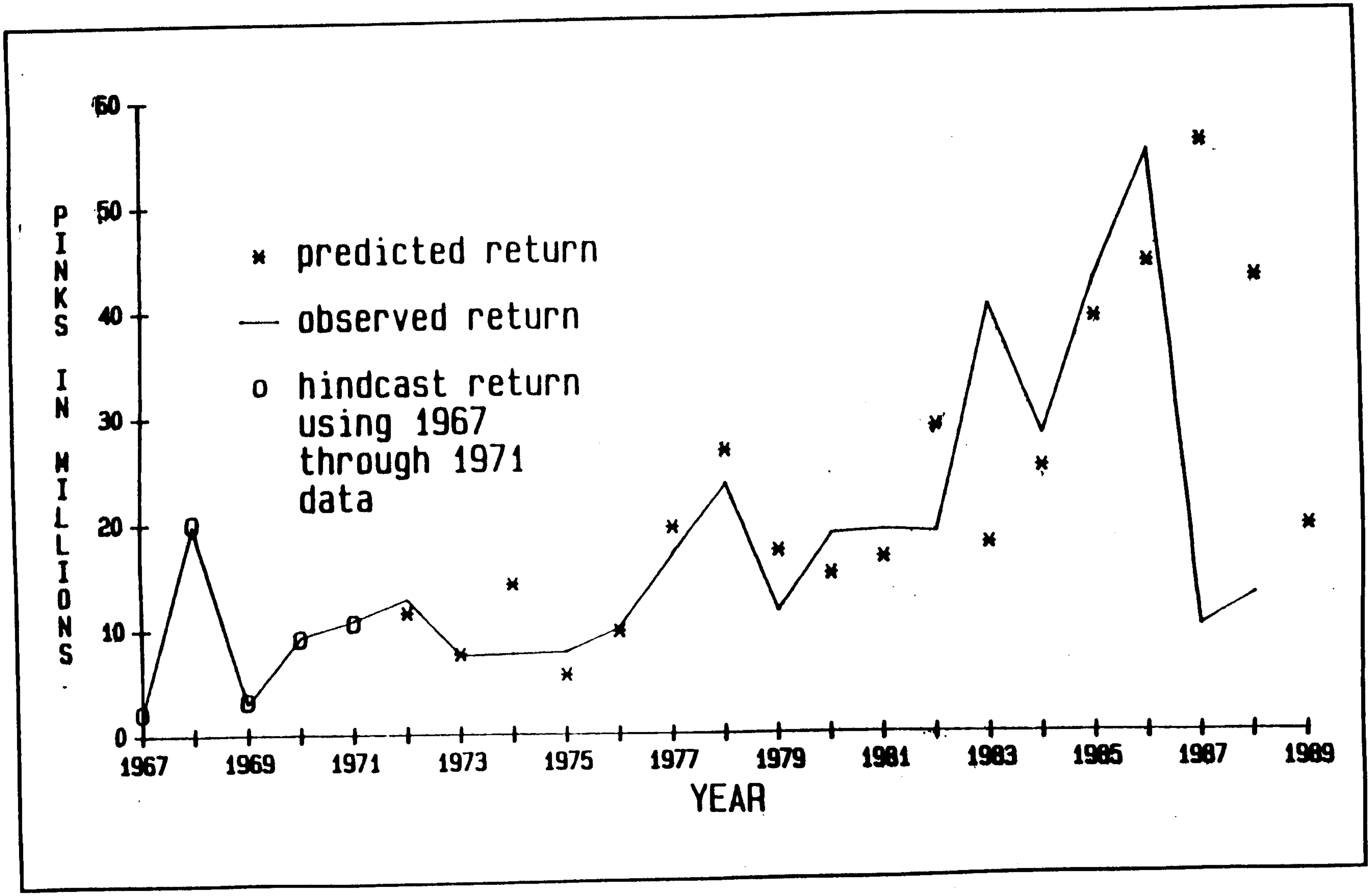

Figure 4. Southern Southeast Alaska pink salmon returns and predictions using escapement index, winter temperatures, and precipitation during the spawning season.

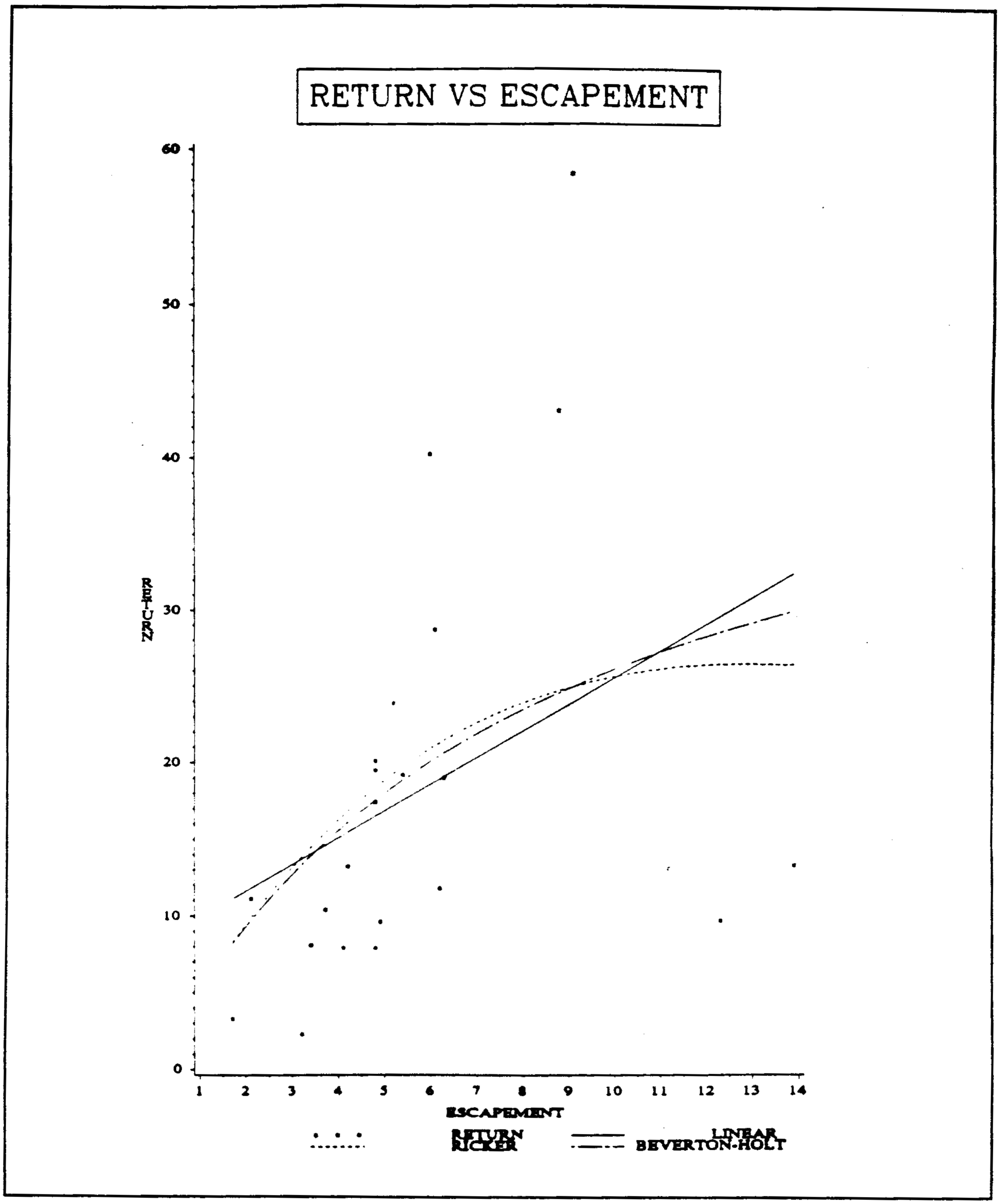

Figure 5. Linear, Ricker, and Beverton-Holt spawner recruit curves for southern Southeast Alaska.

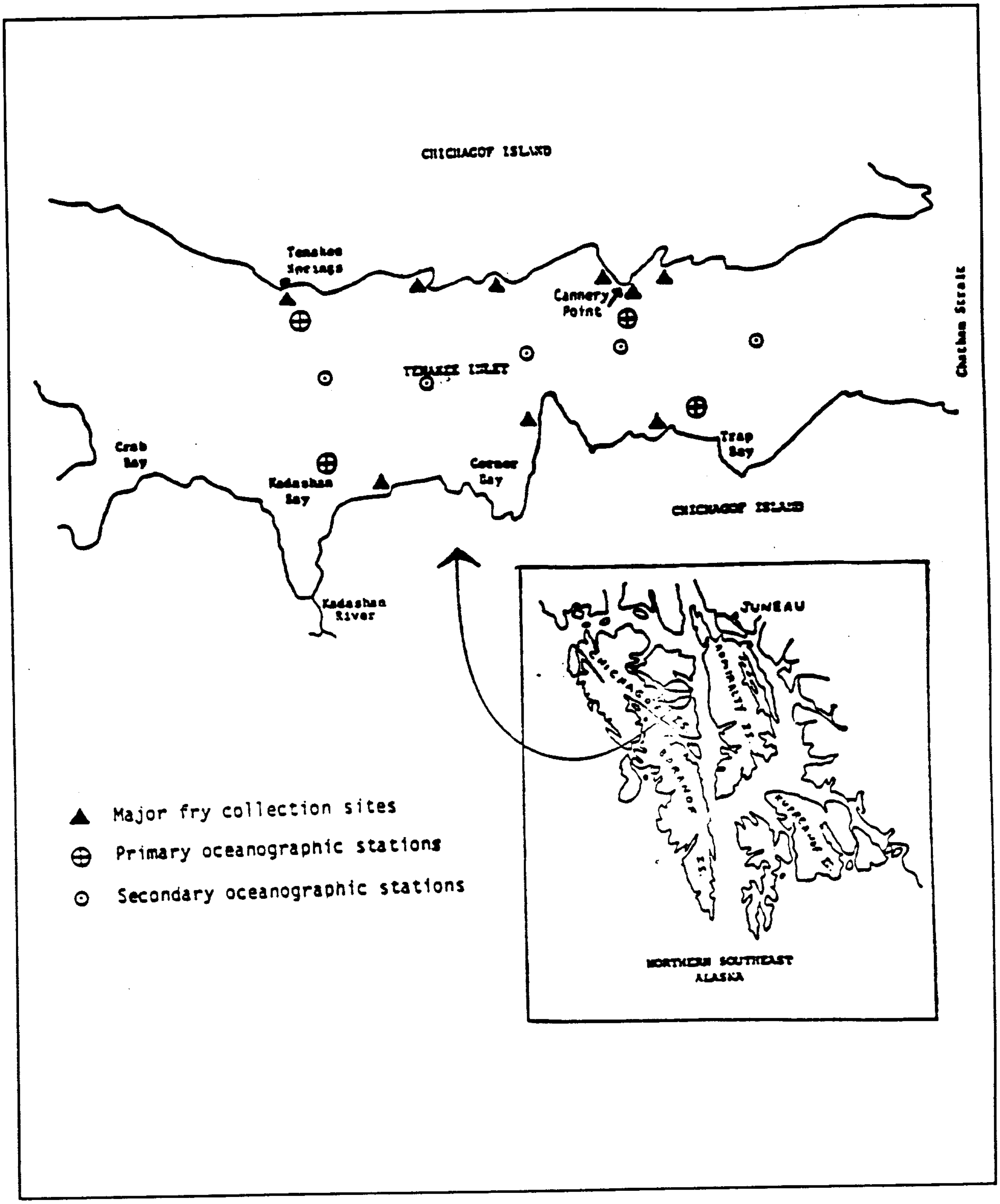

Figure 6. Major fry collection sites, primary and secondary oceanographic stations, and the location of Cannery Point in Tenakee Inlet.

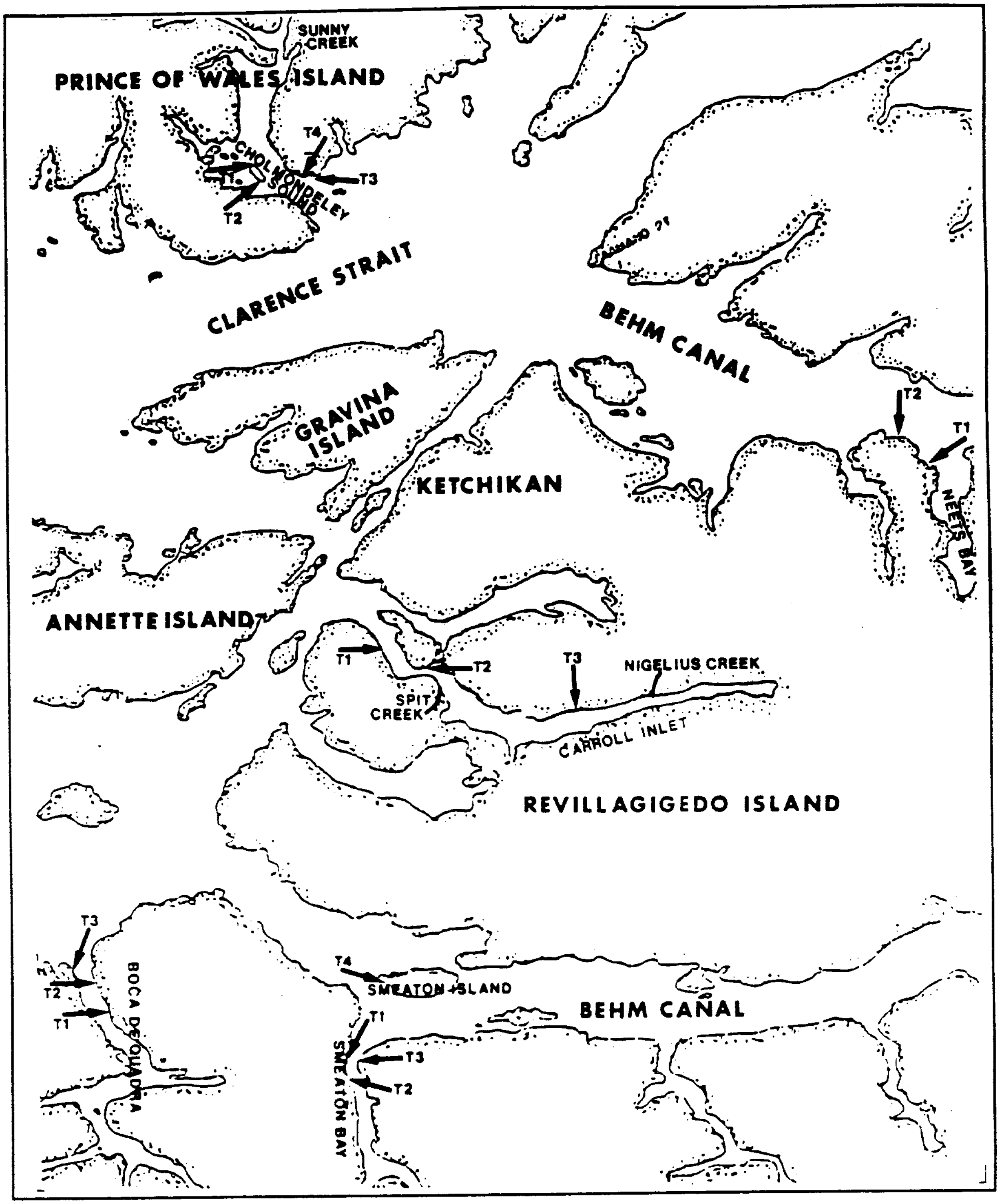

Figure 7. Map of early marine study area and transect locations in southern Southeast Alaska (east coast of Prince of Wales Island).

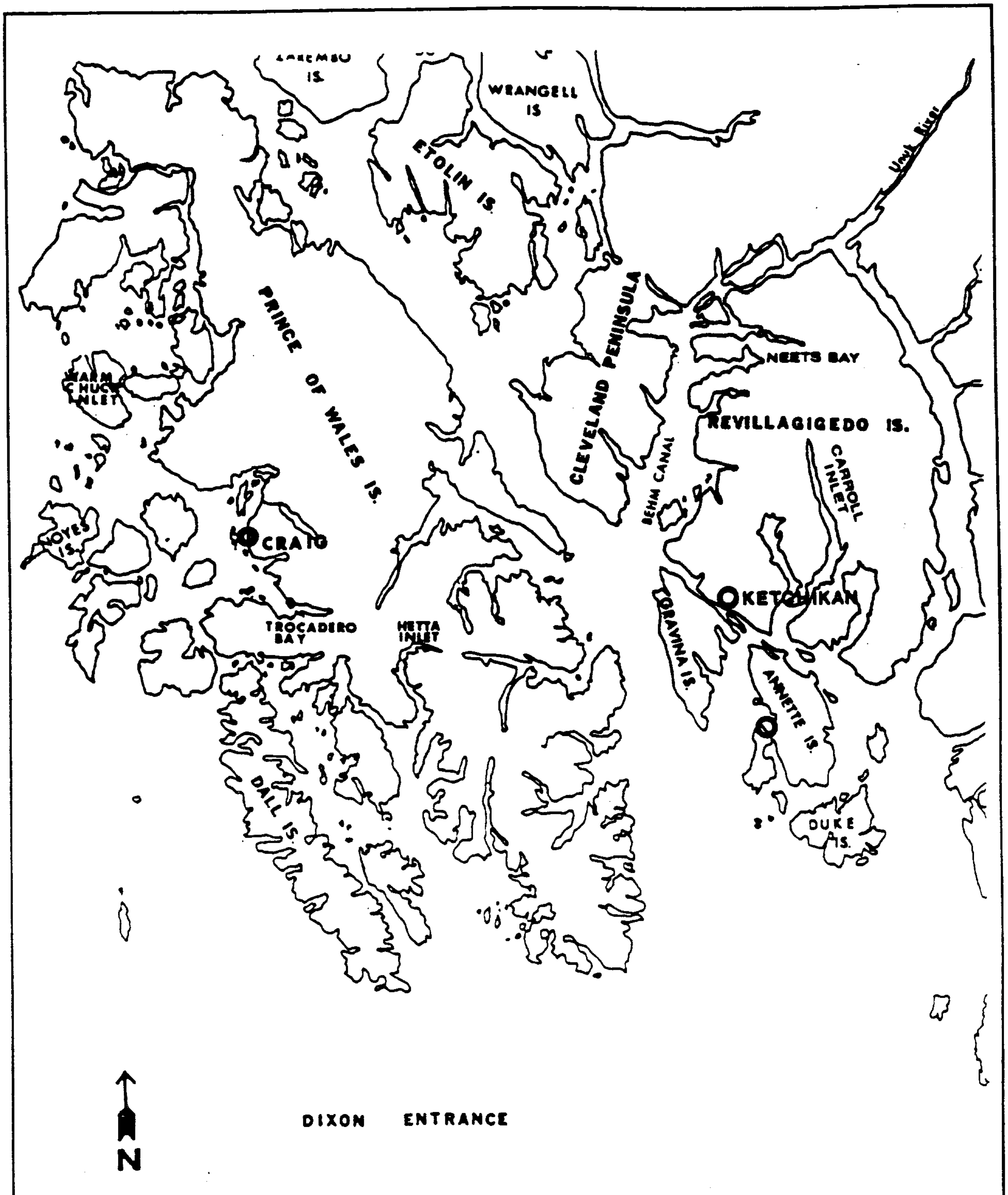

Figure 8. Map of early marine study areas in southern Southeast Alaska (west coast of Prince of Wales Island).

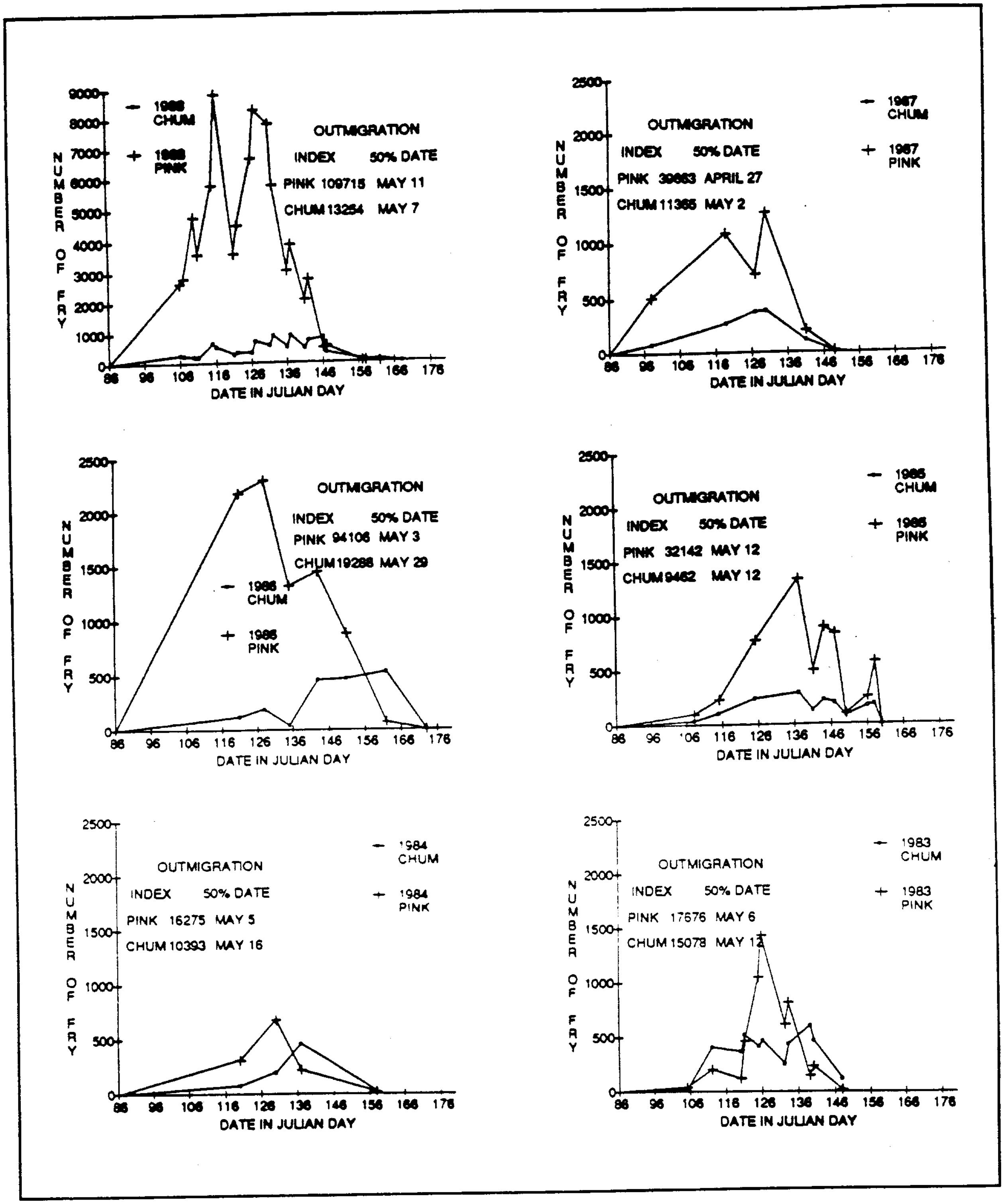

Figure 9. Pink and chum salmon out-migration from Sunny Creek 1976 through 1988.

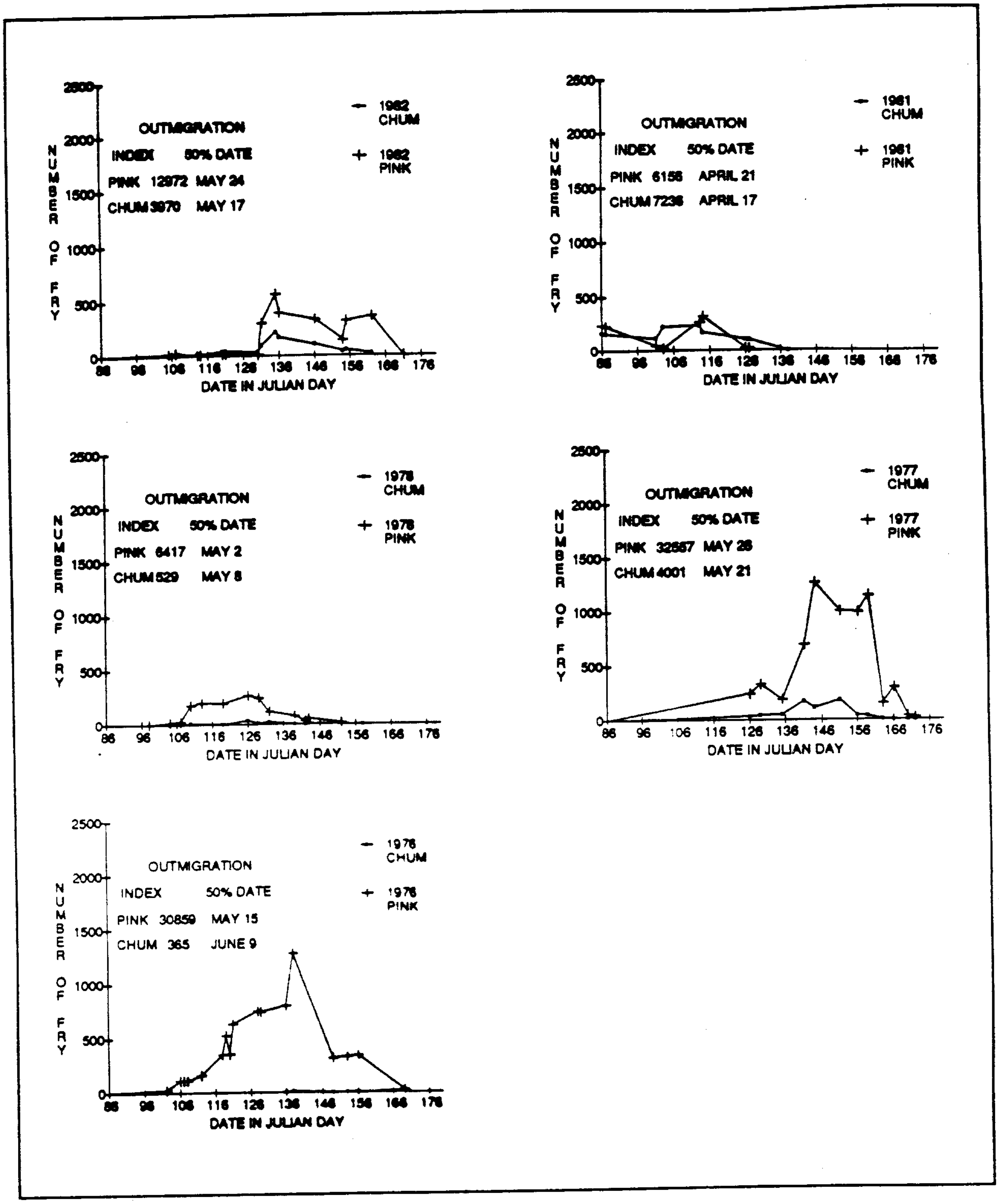

Figure 9. (page 2 of 2.)

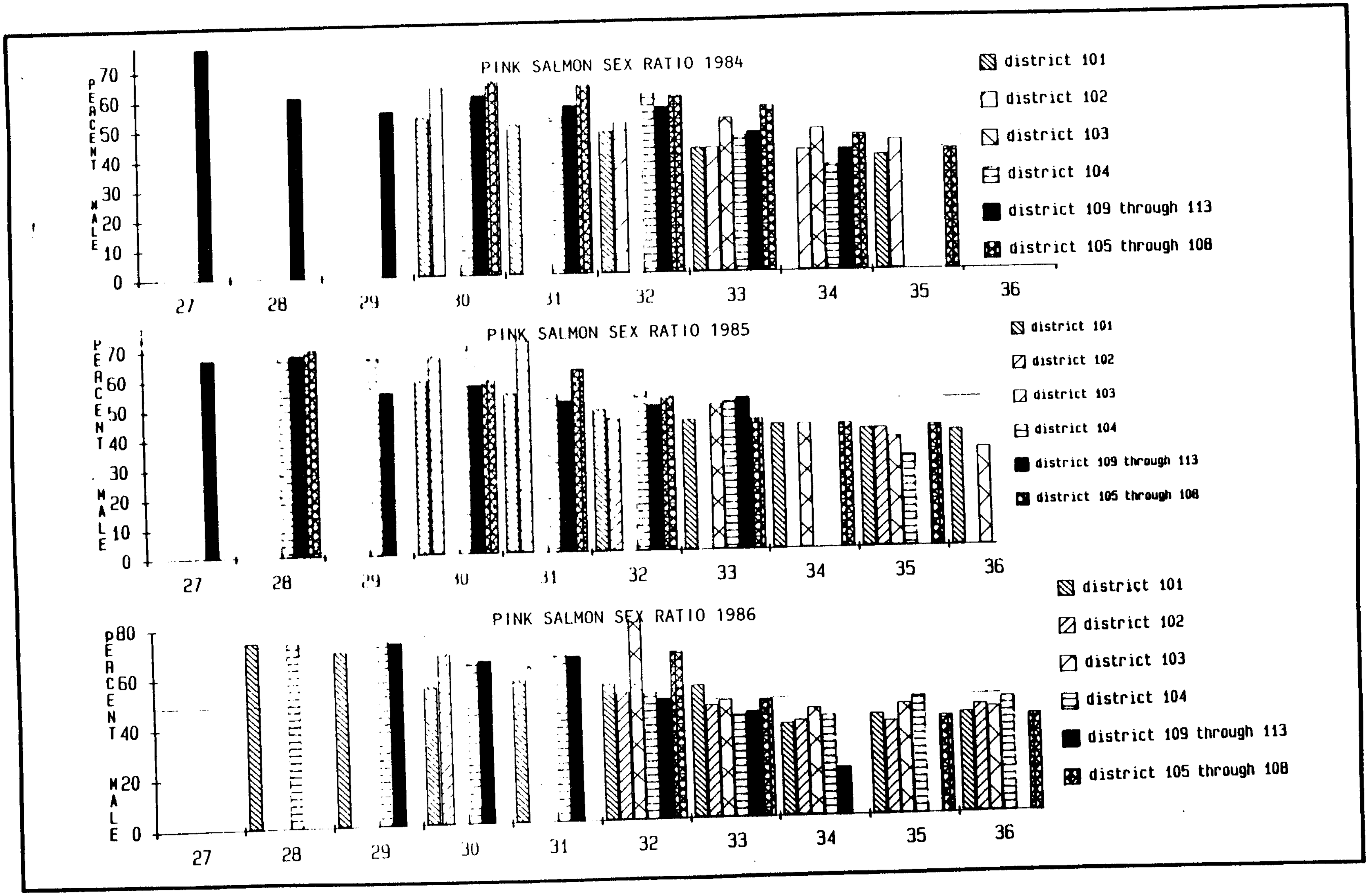

Figure 10. Pink salmon sex ratios for Districts 101 through 113, 1984 through 1988.

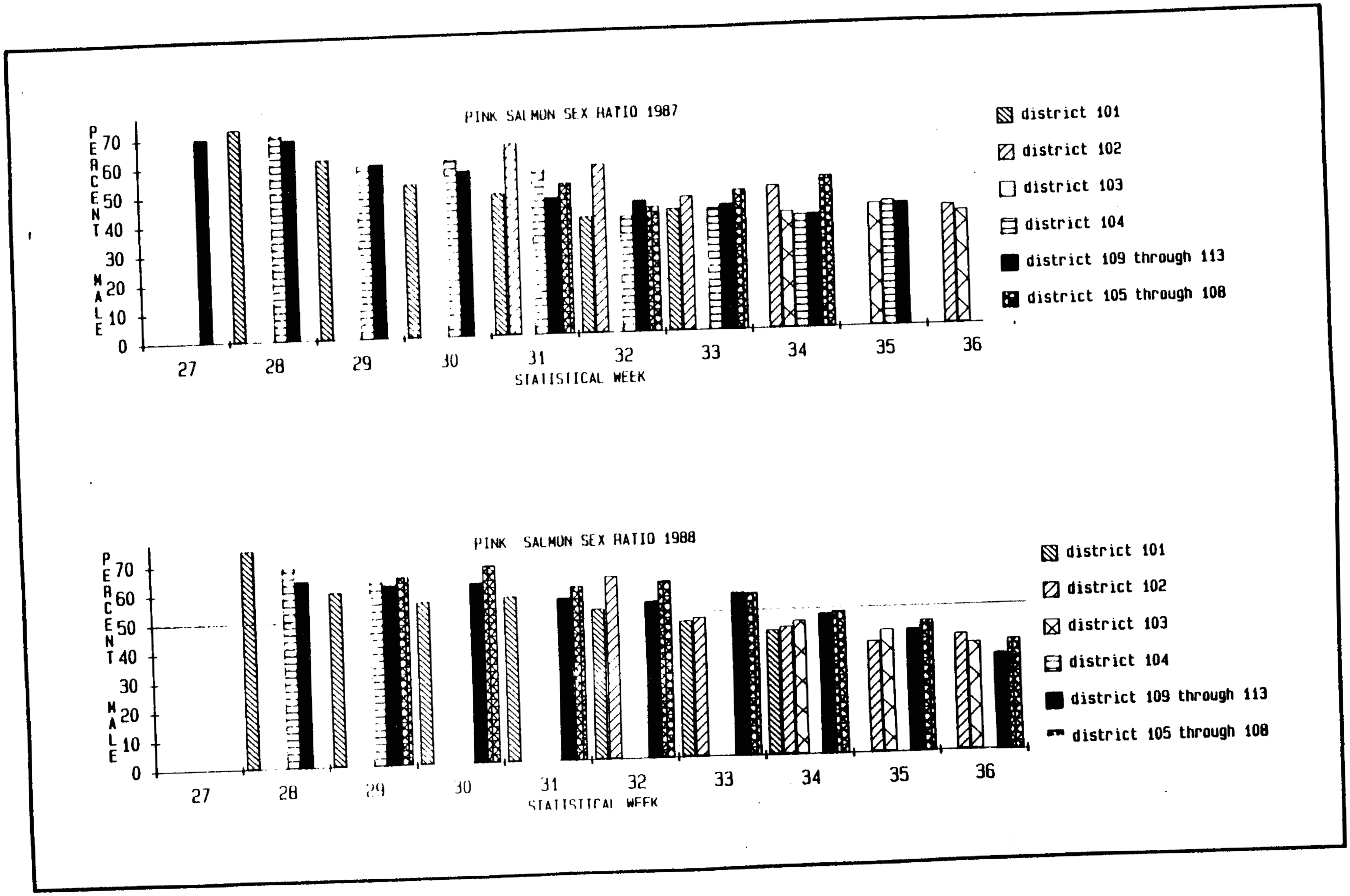

Figure 10. (page 2 of 2.)

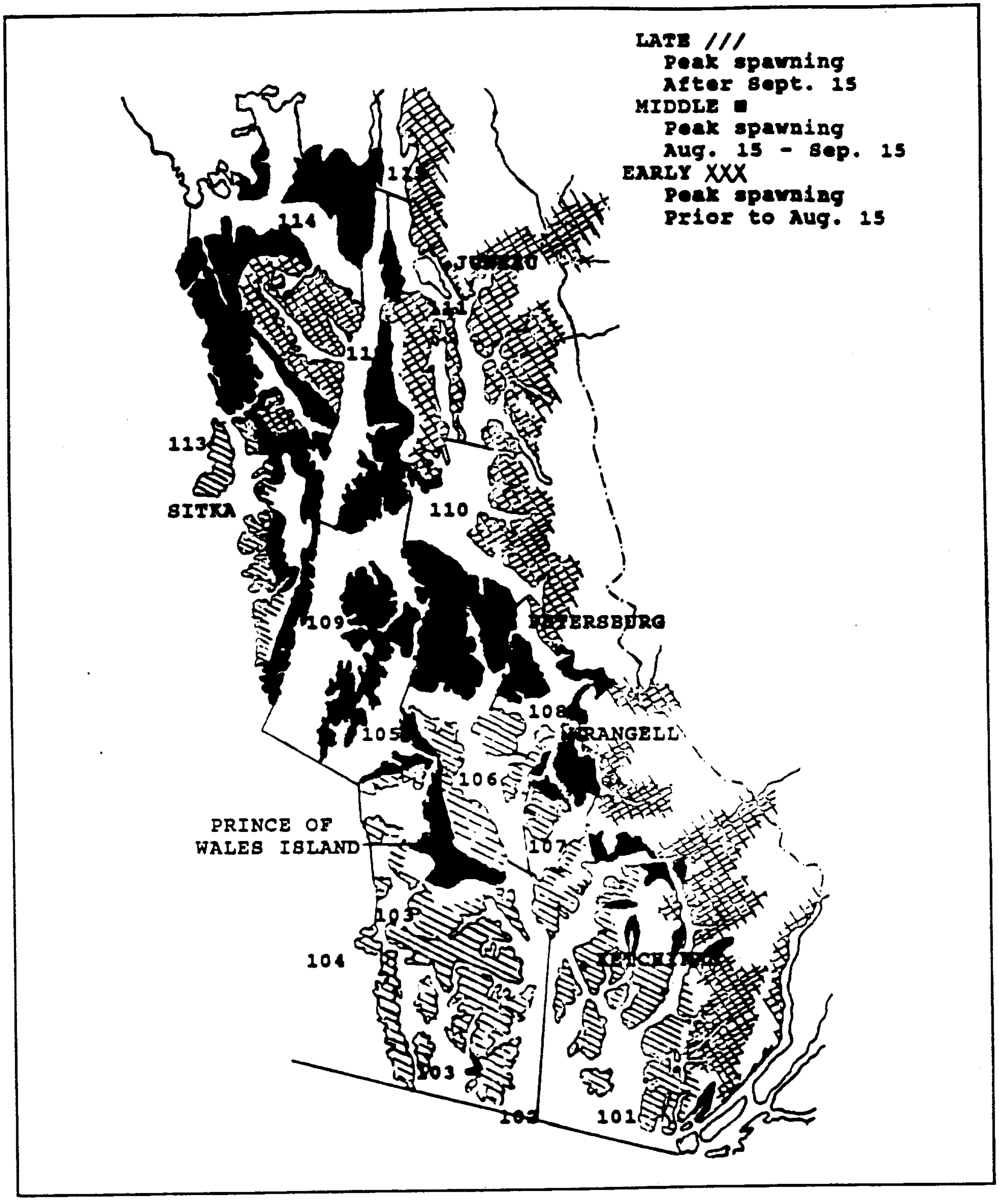

Figure 11. Geographic distribution of pink salmon run time segments.

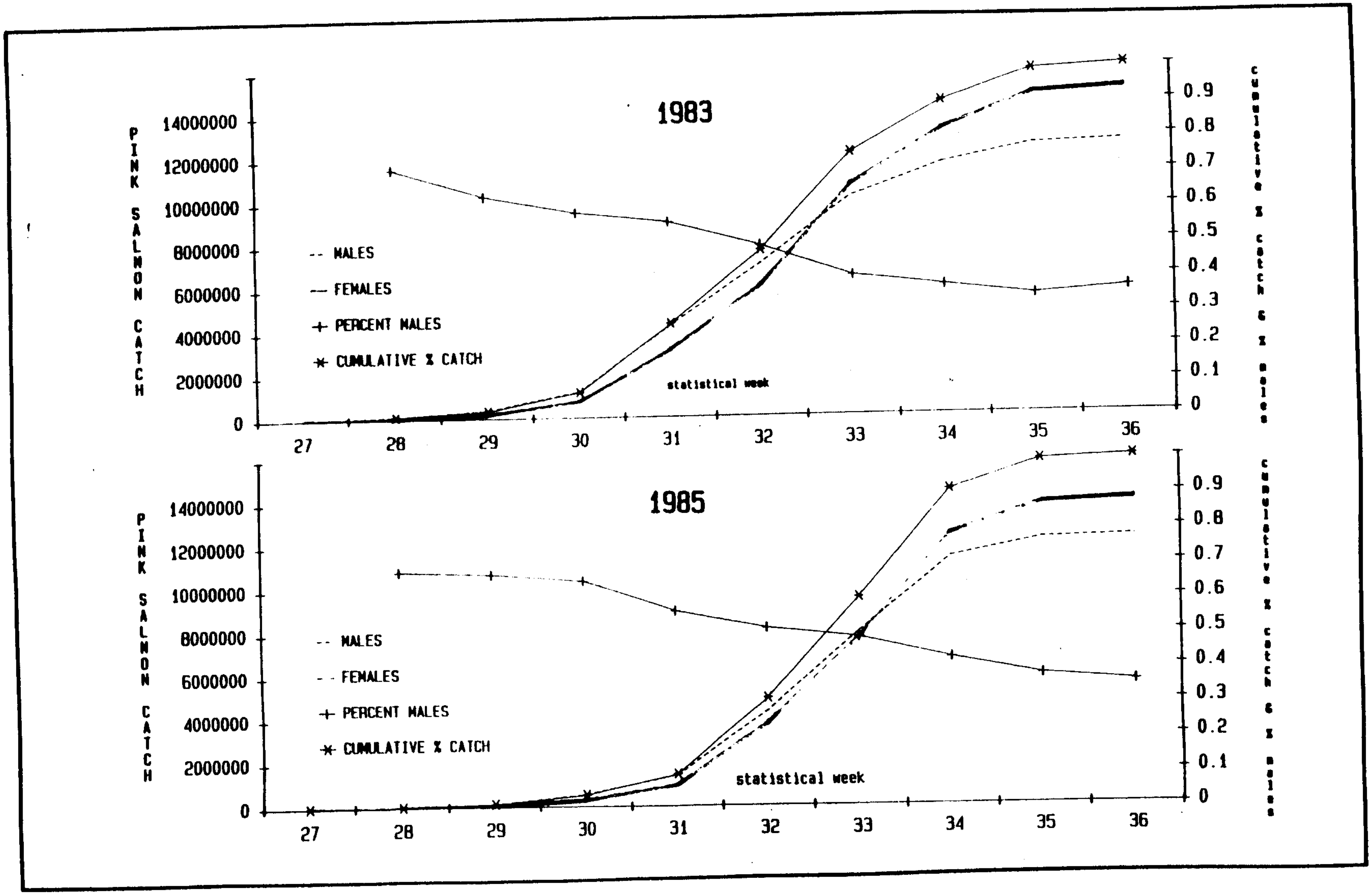

Figure 12. Cumulative catch by sex, cumulative percent catch, and sex ratios, District 101 through 104 combined 1983, 1985, 1986 and 1987).

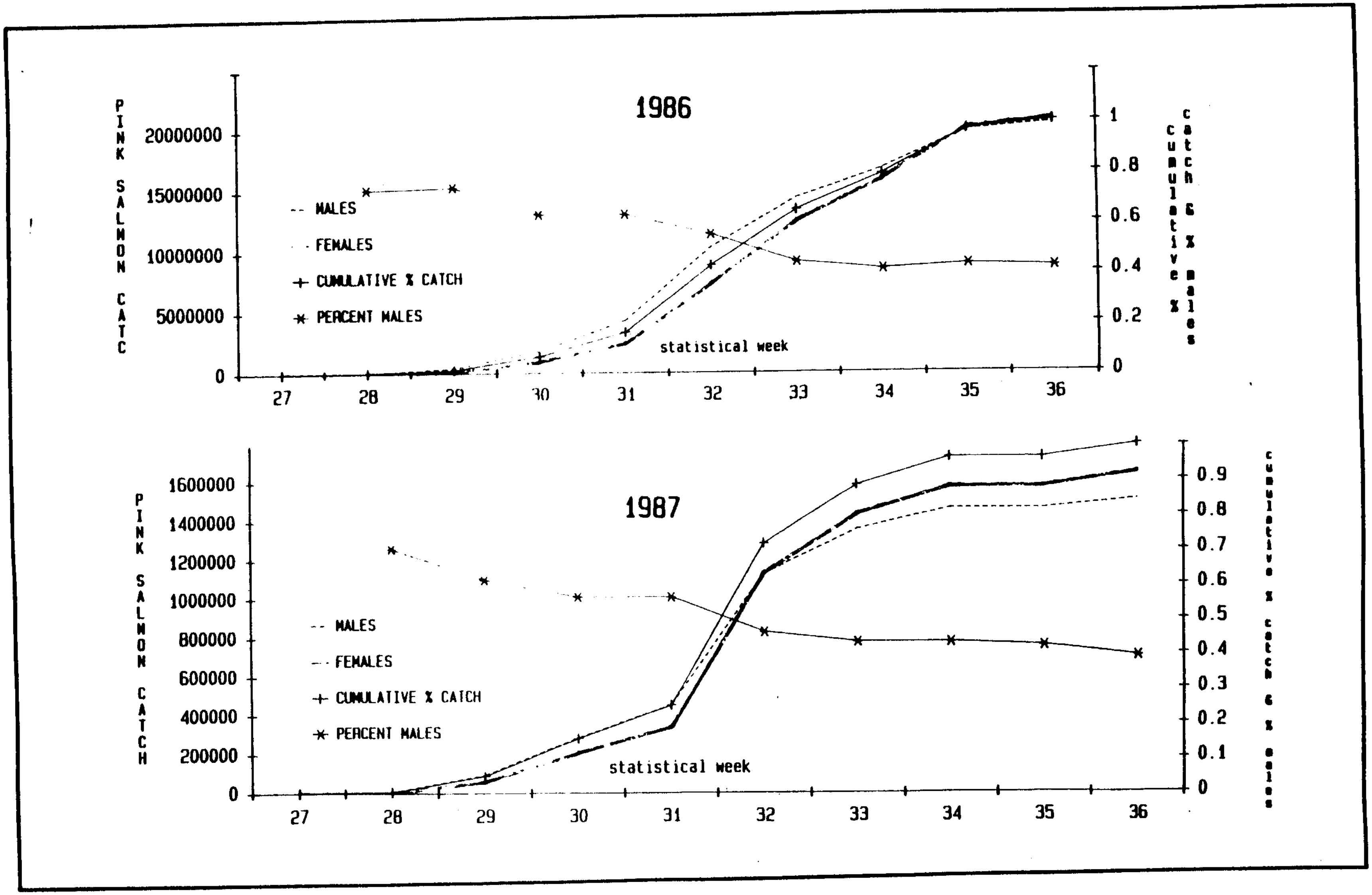

Figure 12. (page 2 of 2.)

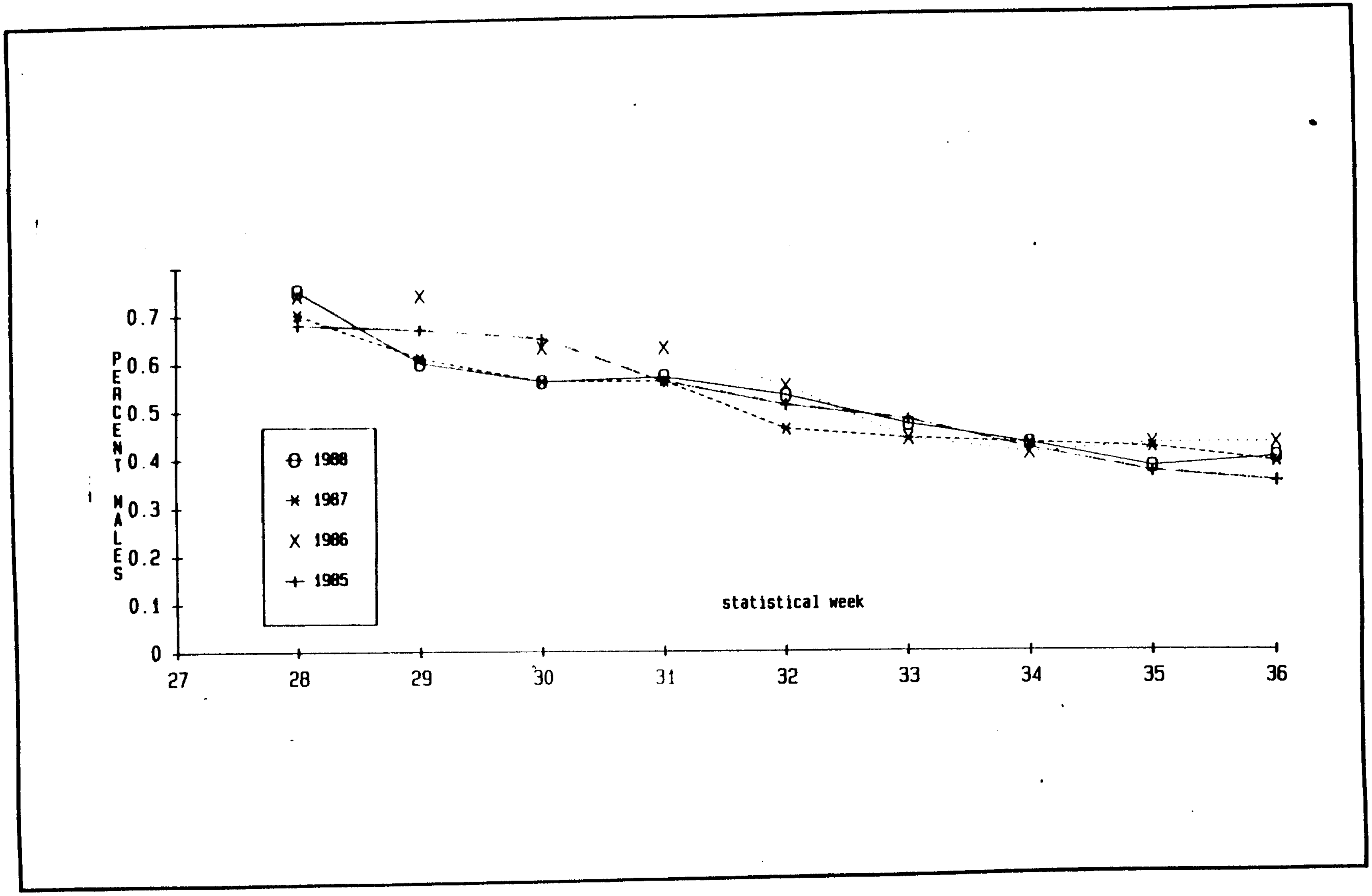

Figure 13. Districts 101 through 104 sex ratios, 1985 through 1988.

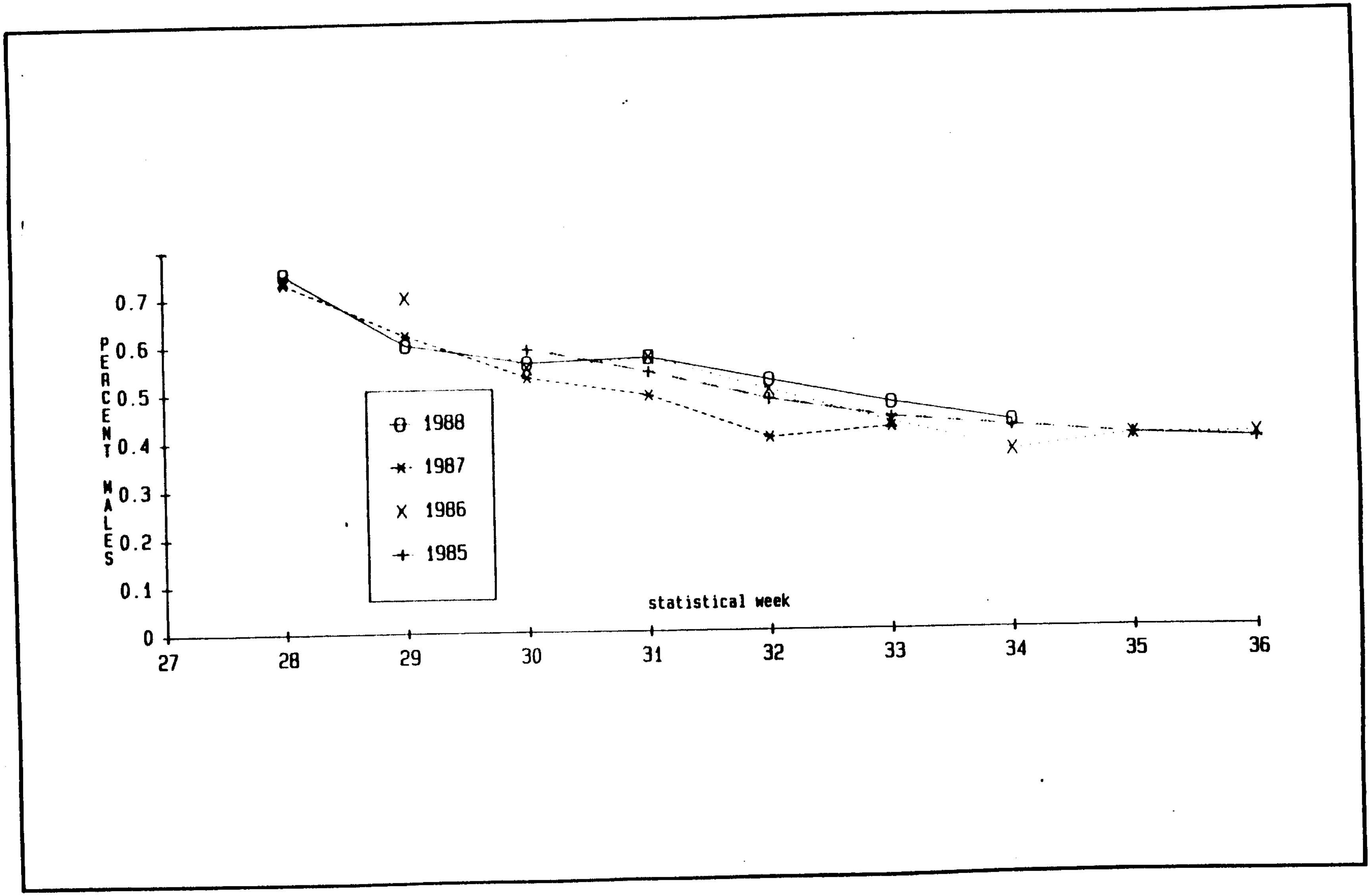

Figure 14. District 101 sex ratios, 1985 through 1988.

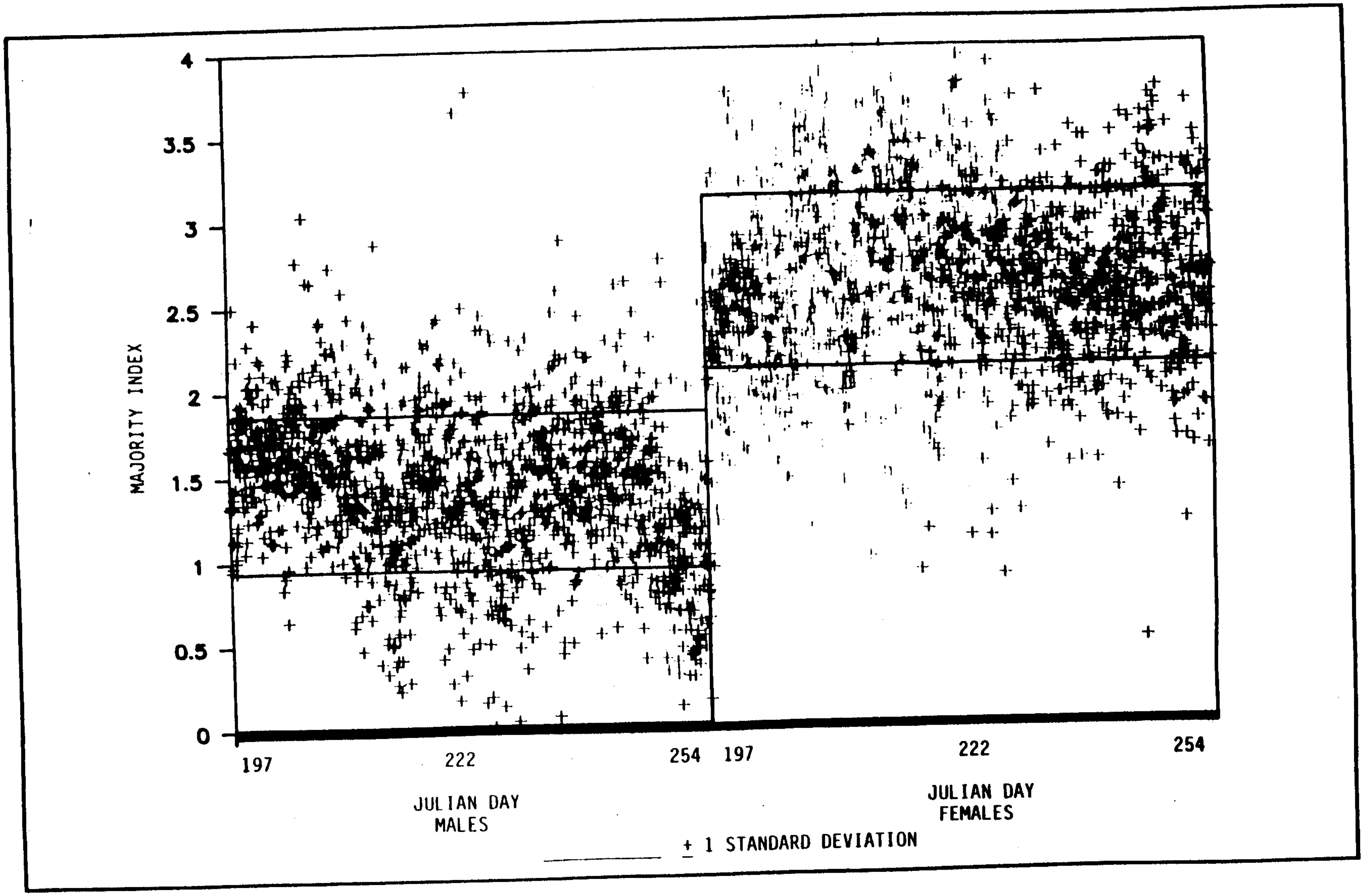

Figure 15. Pink salmon maturity index based on length of fish compared to length of adipose fin and weight of gonadal material.

APPENDICES

Appendix A.1. Water temperatures and salinities (T/S) from surface to 10 meters of depth, and associated secchi disk readings, Tenakee Inlet in 1988.

Nearshore Stations:		Trap Bay		Cannery Pt		Tenakee		Kadashan	
	Depth	T	S	T	S	T	S	T	S
03-May	0	7.1	29.1	7.1	29.0	8.5	28.0	8.8	26.6
	1	6.9	29.4	6.6	29.3	7.8	28.1	8.2	26.9
	2	6.9	29.2	6.6	29.3	7.0	28.8	8.0	27.3
	3	6.6	29.6	6.0	29.9	6.5	29.3	8.0	27.3
	4	6.2	30.0	6.0	29.9	6.5	29.2	7.8	28.1
	5	6.1	29.9	6.0	29.9	6.2	29.4	7.8	28.2
	6	6.0	29.9	5.8	29.9	6.2	29.4	7.5	28.2
	7	6.0	29.9	5.6	30.1	6.2	29.4	7.5	28.4
	8	6.0	29.9	5.6	30.2	6.2	29.4	7.2	28.7
	9	6.0	29.9	5.6	30.2	6.2	29.4	7.0	28.9
	10	6.0	29.9	5.6	30.2	6.2	29.4	6.9	29.0
Secchi		4.0		4.5		4.0		5.5	
11-May	0	10.1	26.8	10.5	26.3	11.0	23.1	11.5	23.3
	1	9.8	27.9	10.3	27.8	10.8	24.8	11.5	23.3
	2	9.6	28.0	9.1	28.6	10.8	27.0	11.7	23.2
	3	9.2	28.2	8.0	29.3	10.2	27.5	10.0	26.8
	4	8.7	29.0	7.8	29.7	10.1	27.5	9.6	27.5
	5	8.0	29.3	7.5	29.8	9.9	27.9	9.1	28.0
	6	7.5	29.4	7.5	29.8	9.4	28.2	8.2	28.5
	7	7.4	29.6	7.5	29.9	8.0	29.1	7.9	28.7
	8	7.1	29.7	7.3	29.9	7.8	29.2	7.1	29.3
	9	6.8	29.8	7.2	30.0	7.3	29.4	6.9	29.8
	10	6.5	29.9	7.2	30.0	7.1	29.7	6.9	29.8
Secchi		7.0		7.5		8.0		8.0	
17-May	0	10.4	20.3	9.2	21.5	9.5	23.2	11.6	19.2
	1	10.2	20.6	9.8	22.8	9.8	21.6	11.2	21.3
	2	10.1	20.7	9.2	23.2	9.8	22.0	9.3	26.9
	3	10.1	20.8	9.0	25.0	8.0	28.6	8.7	28.2
	4	10.1	21.0	8.8	26.5	7.7	29.0	8.2	28.8
	5	10.0	21.1	8.1	28.2	7.7	29.0	8.0	28.9
	6	10.0	21.4	7.8	29.0	7.5	29.1	7.9	29.1
	7	9.9	22.7	7.2	29.5	7.1	29.3	7.6	29.3
	8	7.6	29.0	6.9	29.8	7.0	29.6	7.4	29.3
	9	6.6	29.8	6.9	29.8	7.0	29.6	7.2	29.5
	10	6.2	30.0	6.9	29.9	7.0	29.6	7.1	29.7
Secchi		8.0		8.0		8.0		12.0	
24-May	0	8.5	20.5	9.2	21.0	10.0	19.8	10.1	22.0
	1	8.9	24.0	8.5	26.0	10.0	20.2	10.0	22.3
	2	8.9	24.9	8.1	27.4	9.9	21.5	10.0	23.1
	3	8.8	26.0	7.6	28.8	9.8	22.8	9.5	25.0

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Appendix A.1. (page 2 of 3.)

Nearshore Stations:		Trap Bay		Cannery Pt		Tenakee		Kadashan	
	Depth	T	S	T	S	T	S	T	S
	4	8.8	26.6	7.2	29.2	9.5	25.6	9.4	25.5
	5	8.6	27.3	7.0	29.5	9.0	26.8	9.0	26.4
	6	8.0	28.6	6.9	29.9	8.6	28.2	9.0	27.5
	7	7.5	29.2	6.6	30.0	8.1	28.8	8.7	28.1
	8	7.2	30.0	6.5	30.0	8.0	29.2	8.5	28.7
	9	7.1	30.0	6.4	30.0	7.8	29.3	7.9	29.1
	10	6.9	30.1	6.4	30.0	7.6	29.0	7.6	29.4
Secchi		7.0		8.5		7.0		6.5	
01-Jun	0	9.1	25.3	9.5	26.4	11.0	23.7	10.8	22.6
	1	9.1	25.3	8.8	28.0	10.8	24.0	10.7	22.6
	2	9.1	26.2	8.4	28.5	10.5	24.8	10.6	23.0
	3	9.0	26.2	8.1	28.6	10.1	25.9	10.2	24.5
	4	8.9	27.5	7.5	29.5	10.0	26.1	10.0	24.9
	5	8.9	27.8	7.2	29.8	9.6	27.2	9.8	26.0
	6	8.8	28.0	7.0	29.9	9.1	27.8	9.1	27.4
	7	8.7	28.0	7.0	29.9	8.7	28.8	8.9	28.2
	8	8.5	28.8	7.0	29.9	8.3	28.9	8.5	28.5
	9	8.0	29.1	7.0	29.9	8.0	29.2	8.5	28.5
	10	8.0	29.1	7.0	29.9	7.8	29.6	8.1	28.9
Secchi		6.0		7.5		6.7		7.6	

Mid-inlet Stations:		Tenakee-Kadashan		Hill Pt		Cannery Pt		Columbia Pt		Sunshine Pt	
	Depth	T	S	T	S	T	S	T	S	T	S
03-May	0	7.4	29.1	7.0	29.2	7.0	29.3	8.2	27.2	8.9	27.0
	1	7.1	29.1	6.9	29.2	6.5	29.2	7.2	28.6	8.4	27.0
	2	7.0	29.1	6.9	29.2	6.3	29.8	7.0	28.8	8.0	27.5
	3	6.2	29.8	6.8	29.2	6.2	29.8	7.0	28.9	7.8	28.2
	4	6.0	29.8	6.5	29.2	6.1	29.5	6.8	28.9	7.2	28.6
	5	5.9	29.8	6.2	29.3	6.0	29.9	6.6	29.4	6.9	29.0
	6	5.8	30.0	6.0	29.9	5.9	29.9	6.2	29.8	6.9	29.0
	7	5.8	30.0	6.0	29.9	5.8	30.0	6.0	29.9	6.8	29.0
	8	5.8	30.0	5.9	30.1	5.8	30.0	6.0	29.9	6.8	29.2
	9	5.8	30.0	5.9	30.1	5.8	30.0	6.0	29.9	6.5	29.2
	10	5.8	30.0	5.5	30.2	5.8	30.0	6.0	29.9	6.2	29.6
Secchi		3.5		4.0		4.0		3.5		4.5	
11-May	0	11.0	26.5	10.8	26.1	11.0	*	11.0	25.2	11.0	22.6
	1	11.0	26.7	10.1	27.9	10.9	26.1	10.8	25.3	11.0	24.3
	2	10.8	27.1	9.8	28.1	10.2	26.8	10.8	26.1	10.5	26.2
	3	9.1	28.6	9.6	28.4	9.8	28.0	10.5	27.1	9.7	26.3

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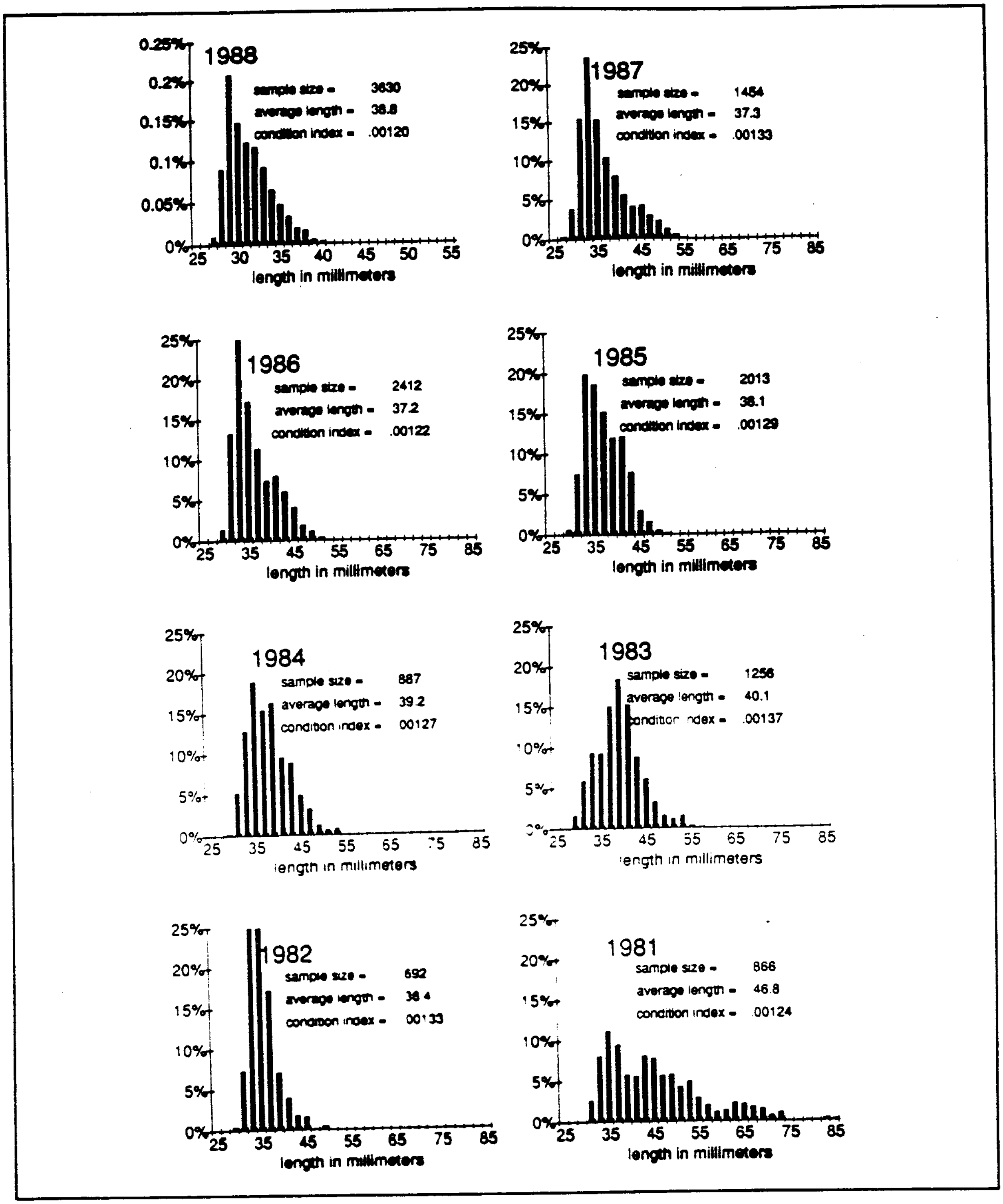
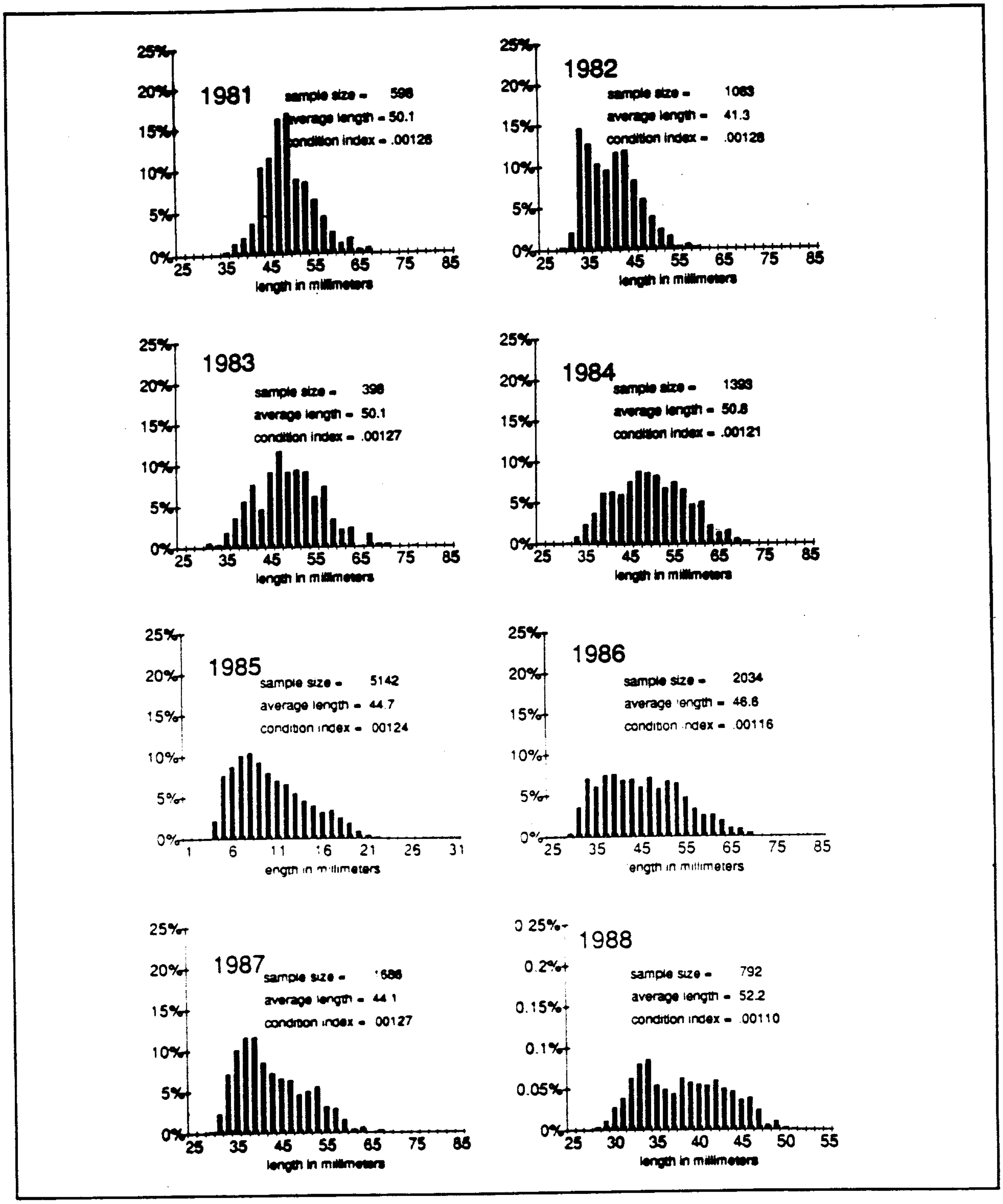
Appendix A.1. (page 3 of 3.)

Mid-inlet Stations:	Depth	Tenakee-Kadashan T	Tenakee-Kadashan S	Hill Pt T	Hill Pt S	Cannery Pt T	Cannery Pt S	Columbia Pt T	Columbia Pt S	Sunshine Pt T	Sunshine Pt S
	4	8.3	29.2	9.0	28.9	9.4	28.3	9.8	27.3	9.0	27.7
	5	8.1	29.2	8.7	29.2	9.0	28.6	8.8	28.5	8.5	28.6
	6	7.8	29.7	8.5	29.5	8.7	29.0	8.2	29.0	8.1	28.8
	7	7.6	29.7	8.2	29.2	8.2	29.2	8.1	29.2	7.6	29.1
	8	7.2	29.7	7.8	29.6	8.0	29.3	7.5	29.7	7.1	29.5
	9	7.0	29.8	7.5	29.7	7.8	29.3	7.5	29.7	7.0	29.5
	10	6.8	29.8	7.4	29.5	7.5	29.5	7.1	29.8	7.0	29.5
Secchi		7.5		8.0		7.5		7.5		7.5	
17-May	0	9.7	24.0	10.2	20.1	10.6	21.2	10.9	18.5	10.9	18.8
	1	9.6	24.0	10.5	20.7	9.9	24.1	10.9	19.4	10.9	19.2
	2	9.2	25.5	10.1	23.3	9.0	26.9	10.9	20.2	10.1	24.5
	3	9.0	25.9	9.6	25.9	8.8	27.1	10.3	22.2	9.0	27.8
	4	8.9	26.9	8.6	28.3	8.7	27.8	8.0	28.5	8.5	28.6
	5	8.5	28.3	7.8	29.1	8.0	28.5	7.5	29.2	8.1	28.8
	6	8.2	28.7	7.8	29.2	7.9	28.6	7.1	29.3	7.7	29.2
	7	7.8	29.2	7.8	29.2	7.9	28.8	7.0	29.7	7.5	29.2
	8	7.4	29.3	7.4	29.2	7.8	29.0	7.0	29.8	7.1	29.3
	9	7.2	29.6	7.1	29.6	7.5	29.1	7.0	29.8	7.1	29.3
	10	7.1	29.8	7.1	29.6	7.2	29.2	7.0	29.8	7.0	29.6
Secchi		7.5		7.5		8.0		7.5		7.5	
24-May	0	9.2	21.8	9.8	22.5	10.0	23.0	10.0	22.3	10.0	22.1
	1	9.2	21.8	9.8	22.8	9.8	23.3	10.0	22.3	10.0	22.1
	2	9.3	24.8	9.1	24.9	9.8	23.3	10.0	22.4	10.0	22.1
	3	9.0	26.2	9.1	25.3	9.6	24.8	10.0	22.4	9.8	23.5
	4	8.1	28.1	9.1	25.8	9.1	25.6	9.5	24.0	9.1	25.1
	5	7.9	28.8	8.8	25.5	9.0	26.5	8.9	27.5	8.9	26.7
	6	7.5	29.1	7.5	29.3	8.9	26.9	8.2	28.9	8.5	28.1
	7	7.1	29.5	7.3	29.2	8.5	28.6	8.0	29.0	8.1	29.0
	8	6.9	29.8	7.2	29.3	8.0	29.0	7.6	29.3	7.9	29.1
	9	6.7	30.0	7.2	29.3	7.1	29.7	7.3	29.3	7.5	29.5
	10	6.7	30.0	7.1	29.4	6.9	29.9	7.1	29.6	7.2	29.5
Secchi		8.0		7.5		6.5		7.0		6.5	
01-Jun	0	10.0	25.8	10.2	25.2	10.5	24.0	11.1	21.5	11.1	23.1
	1	9.8	26.6	9.9	26.2	10.2	24.8	11.1	22.4	11.1	23.3
	2	9.4	27.2	9.7	27.1	10.0	25.8	11.0	23.1	10.8	24.0
	3	9.2	27.5	8.9	27.8	10.0	25.9	11.0	23.2	10.2	25.2
	4	9.0	27.8	8.6	28.1	9.9	26.2	10.9	23.9	10.1	26.2
	5	8.7	28.1	8.0	28.8	9.6	26.9	10.0	25.2	9.7	27.2
	6	8.5	28.2	7.8	29.1	9.2	27.8	8.8	27.2	9.1	28.0
	7	8.5	28.2	7.5	29.4	8.3	28.5	8.3	28.6	8.9	28.1
	8	8.0	29.1	7.5	29.4	7.9	29.0	7.9	29.0	8.5	28.9
	9	7.8	29.4	7.5	29.4	7.7	29.2	7.2	29.6	8.0	29.1
	10	7.5	29.6	7.5	29.4	7.5	29.3	7.1	29.8	7.9	29.4
Secchi		6.0		7.0		7.0		8.7		7.5	



Appendix A.2. Length frequency of pink salmon collected in marine study areas of southern Southeast Alaska, April 15 through May 14.



Appendix A.3. Length frequency of pink salmon collected in marine study areas of southern Southeast Alaska, May 15 through May 31.

Appendix A.4. Visual estimates of pink salmon abundance in the early marine study areas of southern Southeast Alaska.

Cholmondeley Sound	Transect 1			Transect 2			Transect 3			Transect 4		
Date	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
08-Apr	-	14	-	-	3570	-	-	380	-	-	-	-
14-Apr	-	-	400	-	-	1100	-	-	4000	-	-	50
27-Apr	-	2000	-	-	22200	-	-	2100	-	-	14400	-
28-Apr	-	34900	-	-	41000	-	-	7740	-	-	24400	-
01-May	20	-	-	150	-	-	-	-	-	-	-	-
04-May	-	-	5500	-	-	8600	-	-	2100	-	-	900
07-May	2000	-	-	610	-	-	1360	-	-	490	-	-
09-May	-	9000	-	-	56000	-	-	15300	-	-	9800	-
11-May	-	-	8200	-	-	50100	-	-	11900	-	-	6000
14-May	200	-	-	2600	-	-	150	-	-	1150	-	-
19-May	-	7700	-	-	3870	-	-	14700	-	-	15900	-
20-May	-	-	6900	-	-	71800	-	-	-	-	-	-
21-May	1500	-	-	8800	-	-	-	-	-	19400	-	-
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	1986	1987	1988	1986	1987	1988	1986	1987	1988
16-Apr	-	-	9100	-	-	50	-	-	600	-	-	2100
21-Apr	-	-	50	-	-	0	-	-	500	-	-	1500
22-Apr	-	6400	-	-	1000	-	-	2500	-	-	250000	-
23-Apr	-	0	-	-	200000	-	-	4000	-	-	3200	-
30-Apr	-	30	-	-	20	-	-	120	-	-	14400	-
02-May	-	-	-	30	-	-	100	-	-	20	-	-
06-May	-	-	600	-	-	900	-	-	10100	-	-	11950
07-May	-	9100	-	-	300	-	-	75	-	-	3400	-
08-May	30	-	-	1800	-	-	-	-	-	-	-	-
13-May	-	-	6300	-	-	900	-	-	600	-	-	20100
15-May	15	-	-	2700	-	-	400	-	-	11200	-	-

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Smeaton Bay Date	Transect 1 1986	Transect 1 1987	Transect 1 1988	Transect 2 1986	Transect 2 1987	Transect 2 1988	Transect 3 1986	Transect 3 1987	Transect 3 1988	Transect 4 1986	Transect 4 1987	Transect 4 1988
17-May	-	9100	-	-	-	-	-	-	-	-	-	-
18-May	-	9100	-	-	450	-	-	600	-		11700	-
29-May	200	750	-	0	500	-	300	400	-	700	30700	-
04-Jun	94	-	-	3000	-	-	1300	-	-	2500	-	-

Boca de Quadra Date	Transect 1 1986	Transect 1 1987	Transect 1 1988	Transect 2 1986	Transect 2 1987	Transect 2 1988	Transect 3 1986	Transect 3 1987	Transect 3 1988
15-Apr	-	-	900	-	-	100	-	-	100
21-Apr	-	-	0	-	-	100	-	-	100
23-Apr	-	2000	-	-	-	-	-	2000	-
30-Apr	-	1420	-	-	2630	-	-	-	-
05-May	-	-	0	-	-	850	-	-	950
07-May	-	5400	-	-	2400	-	-	-	-
09-May	600	-	-	-	-	-	-	-	-
12-May	-	-	0	-	-	600	-	-	600
16-May	-	-	-	-	-	-	3	-	-
18-May	-	363000	-	-	22000	-	-	-	-
22-May	500	-	-	50	-	-	0	-	-
30-May	250	-	-	0	-	-	65	-	-
05-Jun	300	-	-	0	-	-	15	-	-

Carroll Inlet Date	Transect 1 1986	Transect 1 1987	Transect 2 1986	Transect 2 1987	Transect 3 1986	Transect 3 1987
02-Apr	-	-	-	20000	-	-
08-Apr	-	14	-	3570	-	380
10-Apr	-	-	-	-	-	0
17-Apr	-	230	-	2830	-	0
22-Apr	-	2870	-	5010	-	0
23-Apr	-	120	-	620	-	125
29-Apr	-	860	-	-	-	-
30-Apr	-	3400	-	11300	-	40

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Carroll Inlet	Transect 1		Transect 2		Transect 3	
Date	1986	1987	1986	1987	1986	1987
03-May	0	-	150	-	25	-
05-May	-	3	-	43800	-	27
07-May	-	90	-	139000	-	5
08-May	500	-	50	-	2000	-
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	-	6200	-	-
23-May	17400	-	700	-	125	-
28-May	240000	-	300	-	25	-
04-Jun	150	50	300	259	150	220
06-Jun	8	-	200	-	-	-
12-Jun	4800	-	6000	-	0	-
16-Jun	50	-	400	-	0	-

Neets Bay	Transect 1		Transect 2	
Date	1986	1987	1986	1987
24-Apr	-	11	-	200
08-May	-	6540	-	22300
17-May	-	5600	-	2400
28-May	1400	-	1200	-
01-Jun	400	-	-	-
07-Jun	1200	-	-	-
08-Jun	4800	-	15800	-
14-Jun	2100	-	7100	-

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Appendix A.4. (page 4 of 4.)

1988 early marine visual estimates of pink salmon abundance for the west coast of Prince of Wales Island.

Area	Hetta		Trocadero		Warm Chuck	
Transect	1	2	1	2	1	2
24-Apr	-	-	-	-	0	700
25-Apr	-	-	15600	210000	-	-
26-Apr	2000	-	-	-	-	-
04-May	-	-	3500	1700	0	-
05-May	-	-	-	-	50	28000
06-May	-	-	92300	9600	-	-
07-May	2950	68900	-	-	-	-
12-May	-	-	-	-	0	200
14-May	-	-	148200	-	0	200
16-May	-	-	44100	-	-	-
18-May	0	0	-	-	-	-
20-May	-	-	-	-	0	0
22-May	-	-	29800	44200	-	-
27-May	0	0	-	-	-	-