A Pilot Study to Estimate Total Chinook Mortality Associated with Seine Fishing in Johnstone Strait during 1986

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A PILOT STUDY TO ESTIMATE TOTAL CHINOOK MORTALITY ASSOCIATED WITH SEINE FISHING IN JOHNSTONE STRAIT DURING 1986

by

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ABSTRACT

Nagtegaal, D. A., P. J. Starr, and B. Riddell. 1988. A pilot study to estimate total chinook mortality associated with seine fishing in Johnstone Strait during 1986. Can. MS Rep. Fish. Aquat. Sci. 1977: 55 p.

In 1986 the Fisheries Research Branch, Department of Fisheries and Oceans, conducted a pilot study in the Johnstone Strait sockeye seine fishery to assess total chinook mortality. The catch statistics presently recorded by the Department of Fisheries and Oceans are determined from records of chinook sales and are suspected to underestimate the catch of small (3 to 5 lb) and adult (over 5 lb) chinooks; and seriously underestimate the total mortality of all chinook. Data were collected for catch per seine set by species and size categories of chinook, the number of sets made by vessels per day, and the total number of vessels per day active in the fishery. Calculation of total catch involved extrapolating the estimated mean catch per set over all sets made and incorporated the Monte-Carlo bootstrap technique to determine the mean catch estimate and 95% confidence limit. Total chinook mortality in the Johnstone Strait sockeye fishery was estimated to be 27,802 of which 13,318 were recorded as juveniles, 2604 as smalls, and 11,880 as adults. Commercial records of sales for the 1986 season indicate a catch of 2642 small chinook and 11,975 adult.

RÉSUMÉ

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En 1986, le personnel de la Direction de la recherche sur les pêches du ministère des Pêches et des Océans a mené une étude pilote de la pêche du saumon rouge à la senne effectuée dans le détroit de Johnstone afin d'évaluer le taux de mortalité total du saumon quinnat. Les statistiques sur les prises cumulées jusqu'à maintenant par le ministère des Pêches et des Océans proviennent de données sur les ventes de saumon rouge. On considère qu'elles sous-évaluent les captures de petits (3 à 5 lb) et de gros (plus de 5 lb) saumons rouges ainsi que le taux de mortalité total de toutes les catégories. On a donc recueilli des données sur les prises par trait de senne par espèce et par catégorie de taille du samon rouge, sur le nombre de traits effectués par jour et sur le nombre total de bateaux participant chaque jour à la pêche. On a calculé les prises totales en extrapolant les prises moyennes estimatives par trait en fonction de tous les traits effectués et en utilisant la méthode Monte Carlo de simulation «bootstrap» pour déterminer les prises moyennes estimatives et l'intervalle de confiance à 95%. On a ainsi obtenu un taux de mortalité total de 27 802 saumons quinnats dans le cadre de la pêche du saumon rouge effectuée dans le détroit de Johnstone, dont 13 318 juvéniles, 2 604 petits individus et 11 880 adultes. Les données sur les ventes commerciales en 1986 révèlent des prises de 2 642 et 11 975 saumons quinnats de taille petite et adulte respectivement.

INTRODUCTION

In 1985 a treaty between the governments of the United States and Canada was instituted concerning Pacific salmon stocks. One commitment of the treaty and a concern raised by the Chinook Technical Committee was the recording of all sources of mortalities for chinook including landed catches and non-accounted fishing induced mortality.

Landed catch has been recorded by the Department of Fisheries and Oceans since 1951 by accumulating sales slips which record the sale of fish from fishermen to the primary processor. These documents record the location of catch, the gear type used, the category of fish sold (species and grade) and the associated weight. About half the time (dependent on gear type, fish processor, and area landed), the number of pieces sold is also recorded. Although there is no specific size limit for chinook for the seine fishery, there is a coast wide minimum size limit of 45 cm. Sub-legal sized chinook [less than 1.4 kg (3 lbs) round weight] are presumed to be either discarded by fishermen or sold inadvertently with pink salmon. Small chinook salmon [usually between 1.4-2.3 kg (3-5 lb) round weight] are traditionally sold by the piece (not by weight). It has been hypothesized that the landed catch recorded by the Department of Fisheries and Oceans seriously under estimates the total mortality of chinook in the smaller size categories.

Since the inception of the coastwide salmon sampling program (in the late 1960s), it has been hypothesized that the catch of chinook in seine fisheries is under-reported, particularly for small chinook (under 5 lb. round weight). This is based on the fact that the sampled catch frequently exceeds 50% of the reported catch (and occasionally even 100%), even though the sampling goals (based on vessel numbers) are nearer to 20% of the catch. This potential shortfall in reported catch has led to much speculation in the fishing industry as to the magnitude of the mortality of chinook salmon in the seine fisheries of B.C. Various user groups (depending on their point of view) have claimed that the actual catch is anywhere from 1 1/2 to over 10 times the reported catch. In the context of the Pacific Salmon Treaty, it is important to accurately know the magnitude of the chinook mortality in order to determine the productivity of chinook salmon. In addition, obtaining accurate estimates of total chinook catch in the seine fisheries is crucial to providing unbiased expansion factors for estimating total recoveries of Coded Wire Tags (CWT) in these fisheries.

Seine fisheries directed on sockeye, pink and chum salmon may potentially have a serious impact on chinook stocks through unassessed mortalities. In order to evaluate the impact of these fisheries on chinook, the Biological Sciences Branch, Department of Fisheries and Oceans, proposed to make an independent estimate of total chinook mortality. This estimate would not only be used as a comparison with the present sales slip data but also investigate the catch of sub-legal sized chinook. Sockeye seine fisheries are conducted in Juan de Fuca Strait, Johnstone Strait, Barkley Sound, and in the Central and North coast. Initially we propose a pilot study in Johnstone Strait to test our survey strategy.

The seine fleet in Johnstone Strait targets on sockeye (Oncorhynchus nerka), pink (O. gorbuscha), chum (O. keta), and incidentally encounters chinook (O. tshawytscha) and coho (O. kisutch) salmon. The fleet is active during the summer and fall months and may involve up to 400-500 seiners, some consistently fishing in traditional spots while others move throughout Johnstone Strait.

The purpose of this report is to present the methodology and results of a pilot study conducted during 1986 in Johnstone Strait, and to outline some of the possible sources of bias in the data.

METHODS

To accomplish the objectives of this program, three main items of information need to be known; i) catch per set, ii) no. of sets made, and iii) no. of vessels active. The overall concept of the program is to extrapolate the estimated mean catch per seine set over all sets made. Data were stratified by day and geographic area. Five study areas in Johnstone Strait (Fig. 1) were defined. Data were collected by day since this is the lowest level of time stratification reasonably possible. Johnstone Strait was split into five study areas corresponding to the management stratification presently used and to areas of major traditional fishing effort. Data were collected for every fishing day during the sockeye seine fishery and also during the first week of the chum fishery. Chum fishery data were collected in the same fashion as in the sockeye fishery except in only three of the five study areas (Gordon Group, Upper Johnstone Strait, Lower Johnstone Strait). Table 1 lists the dates of the survey and the dates during 1986 that the Johnstone Strait area was open to the commercial seine fleet.

i) Catch/set:

One set of observers equipped with an inflatable boat was assigned to each study area in Johnstone Strait. Data for the catch of individual sets were collected by observers randomly boarding seine vessels as the set was being brought on board. The basic procedure involved approaching the vessel and requesting permission from the skipper to board, recording the catch, and taking biological samples whenever possible. Observers could quite easily stand beside the drum on the stern of the vessel and see all the fish come on deck. Most fish were funnelled to the end of the net and were brought on deck over the stern. Undersized fish including juvenile chinook would sometimes be caught up in the web and rolled up on the drum as the catch was being brought aboard. Observation was more difficult when large catches were encountered. Portions of larger catches were lifted directly into the vessel hold using a brailer until all the catch was in the hold.

Chinook catch was recorded for adults [>2.3 kg (5 lb.), >57 cm fork length], jacks [1.4 kg-2.3 kg (3-5 lb.), 45-57 cm], and juveniles [<1.4kg (3 lb.), <45 cm]. Breakdown of the catch into these categories was done to correspond to the data recorded on the sales slips. The term 'jack' was used to describe the specific size category with no reference to the maturity of the fish. In all sets the numbers of chinook caught were counted by the observers. Observers counted the numbers of all other species caught when the catch was less than approximately 50 fish, and for large catches, numbers were estimated by either the observer or the skipper. Other pertinent data such as location, tide, and type of set were also recorded.

ii) Biological sampling:

Biological data (length/sex/maturity/scale) were collected (MacLellan, in prep) from most fish in the jack and juvenile categories. Some adult chinook were also sampled.

iii) No. of sets/day/vessel:

During each day observers would also ask vessel skippers for the number of sets made for that day in that area. Logbooks designed to obtain these data were issued to fishermen on a voluntary basis.

iv) Gear count:

A gear count of seine vessels was made for every day except the last day for each week of the fishery. Prior to the opening of fishing, a routine Departmental overflight was made. Extra flights were made when the fishery lasted more than one 24-hour period during a given week.

v) Cannery data:

An observer collected biological samples of chinook from Johnstone Strait seine catches brought to the B.C. Packers Ltd. cannery in Vancouver. These data were intended to be used to corroborate the survey biological data. These data were only collected during the sockeye fishery.

vi) Catch estimation and Monte-Carlo simulations of confidence regions:

Total catch for each species and/or size stratum was calculated according to the following equation:

$$T_{lj} = \sum_{k=1}^{m} \sum_{i=1}^{n} (\bar{C}_{ijkl} * \bar{S}_{ik} * V_{ik})$$

where

T_{1j} is the total catch estimate for category j of species 1 over the season

$\bar{C}$ is the average catch/set by fishing day (k) and geographic area (i) for category j of species 1

$\bar{S}$ is the average number of sets/day/vessel within each (i,k) stratum

V is the total number of vessels per (i,k) stratum

m is the number of days

n is the number of areas

Calculations were made for each of the five study areas over the five weeks of sockeye fishing in Johnstone Strait for adult, jack, and juvenile chinook and for sockeye on a daily basis. The Monte-Carlo simulation technique (Efron 1982) involved resampling with replacement the data for (catch/set and sets/day/vessel within each time and area stratum, and determining the average of these resampled data prior to each calculation of total catch. This process of calculating a mean value for each variable and estimating the total catch was repeated 1000 times for each day. The final estimate of total catch for that day was determined to be the mean of these 1000 iterations. This technique was only applied to data collected during the five weeks of the sockeye fishery. No estimate was made for the chum fishery.

Confidence regions about the average catch estimate were determined by excluding the upper and lower 2.5% of the distribution of catches resulting from the 1000 iterations. Although procedures exist to calculate confidence regions by combining the error associated with each of the three variables used to estimate total catch (Goodman 1960), these require assessing an underlying model regarding the distribution of the estimated parameters.

When sufficient data had been collected for a given day the data for catch/set and sets/day/vessel were resampled with replacement the same number of times as the number of data points collected for that variable on that day. Using a random number generator (subroutine GGUBFS of IMSL 1980) data points were selected from the data array for that variable. The mean was then calculated for each of the variables and incorporated into the equation to calculate total catch.

Since gear count per day was only a point estimate, the data could not be resampled in the way described above. An approximation of the level of error for overflight data was determined by looking at differences in gear counts for all areas combined between consecutive days within a fishing week. It was assumed that no movement of vessels occurred in or out of Johnstone Strait in a given fishing week and therefore the changes in total gear count may be attributed to counting error. The coefficient of variation ranged from 6-16% based on weeks 3 and 4 of the fishery. Although the assumption of movement may be unrealistic, the results may at least be an indication of the possible level of error. Overflight data were also compared to the total number of different vessels reporting catch from the sales slip data (Table 2). Although some differences exist, no trend was evident. Based on these results the error was set at 10%. This was incorporated in the calculation of catch by using a random normal deviate procedure (Subroutine GGNML of IMSL 1980) to include the error as follows:

Standard Deviation (S) = (10% error * gear count)/100

and

Y(I)=(RND(I) * S) + M

Where the new value Y is equal to the product of the random normal deviate (RND) and the standard deviation (S) added to the mean (M), in this case the original point estimate. This new value served as the resampled estimate of gear and used in the next iteration of total catch.

vii) Missing data:

Due to equipment failures and inclement weather it was impossible to collect data each day of the fishery. Missing data cells were filled according to the following procedures.

a) Catch per set: A cell was considered empty if fewer than 5 sets were observed in that day and study area. If less than 5 sets were observed in a given day then one of two choices had to be made. Firstly, if the total number of sets observed during that fishing week was greater than 5 then the average catch/set calculated for that week within the study area was assumed to be the value for that day. Secondly, if the total number of sets observed for that week was less than 5 then the average catch per set calculated for the following week in that study area was assumed to be the value for that day. Justification for this method comes from a simple analysis of variance of catch per set by day (Table 11). In virtually all cases the variance within a given day was greater than among days and therefore it was assumed that it would be reasonable to use the mean for a given week.

b) Sets per day per vessel: Since the number of sets per day varied with the length of the fishing day and a limited amount of data were collected for each type of fishing day, all information for a given area for each week was pooled to calculate a single estimate of the number of sets per hour. This estimate was then weighted by the total number of hours available for fishing for a given day. These estimates were calculated for all days in that week, including those days for which some data had been collected. The number of available hours in a fishing day was arbitrarily set as follows for each week:

Opening day (6 PM to sunset): 3.5 hours
Complete fishing day (sunrise to sunset): 15.5 hours
Last fishing day (sunrise to 6 PM): 12.0 hours

c) Gear counts: Missing data by day were estimated to be the average daily number of vessels counted during that fishing week within the study area. These counts were compared with the number of boardings made in that area on that day and if the number of unique boardings was greater than the overflight count the boarding data were assumed to be a better estimate.

RESULTS

A total of 788 observer boardings were made during the five weeks of the sockeye seine fishery from Aug. 3-Sept. 2, 1986. There were 436 adult, 80 jack, and 356 juvenile chinook recorded by the observers. A total of 238 different vessels were boarded. During the first week of the chum fishery, 56 boardings were made. Only 16 adult, 3 jack, and 4 juvenile chinook were recorded. It was very difficult to assess if the geographical coverage of each study area was adequate, but observers attempted to cover all areas of the sampling region. Coverage of the Upper Johnstone Strait study area was not complete since the area from Robson Bight to Kelsey Bay was not surveyed due to the large size of the area. Some sections of this area, however, were closed during the fishery (Fig. 1).

i) Catch per set:

Catch per set was recorded by day and study area within each fishing week (Table 3). Catch per set for juvenile and jack chinook ranged from 0-15 and for adults from 0-30. The overall mean catch per set ranged from 0-3.0 for adults, from 0-3.4 for juveniles and from 0-1.8 for jacks. Distribution of the catch by set was highly skewed. In fact no adult or juvenile chinook catch was recorded in 77% of the total sets observed. No jacks were recorded in 95% of the sets (Figs. 2-5). A simple two factor analysis of variance was used to examine the effect of area and time (week) on catch per set for each of the three categories (Table 4). The proportion of variance attributed to area for juvenile chinook was 44%, for jacks was 12%, and for adults was 6%. The proportion attributed to week for juveniles was 27% and for both jacks and adults was 36%. We note that the effect of area was the greatest on juveniles and the effect of week on jacks and adults, although the majority of the variance was attributed to a combination of these two factors.

Catch per set was examined by vessel to determine whether specific vessels may have targetted on chinook. A cursory look at the average catch per set by vessel for chinook revealed that only three out of 238 different vessels boarded recorded one set with a catch greater than plus or minus 2 standard errors about the mean catch/set. This preliminary examination seems to indicate that specific vessels are not targetting on chinook. Catch of adult chinook relative to sockeye was also examined since it has been suggested that the seine fleet as a whole may target on adult chinook as sockeye catch decreases towards the end of a given fishing week. Catch by day relative to total weekly catch was examined by day for sockeye and adult chinook during weeks 3 and 4 of the fishery (Fig. 6). Initially data were examined by study area but since sufficient data were not available for each area, all areas were combined for this comparison. It should be noted that the catch patterns that exist in the upper Johnstone Strait study area greatly influence the trends evident in the data when all areas are combined since this study area recorded approximately 49% of the total Johnstone Strait adult chinook catch. In both weeks the catch for chinook increased toward the end of the week while the catch for sockeye peaked during the middle of the week and decreased toward the end. These results suggest that during the last day of each of the two longest weeks of the fishery some targetting on chinook may occur.

Examination of the distribution of catch per set by type of set revealed that the chinook catch was consistently higher for beach sets than for open sets in all study areas except for the North Shore area where virtually all sets made (99%) were open (Table 5).

ii) Biological sampling:

During the sockeye fishery a total of 141 juveniles, 82 jacks, and 16 adult chinook were sampled for length/sex/maturity/scale data (Tables 6 and 7). Inadvertently the category (adult, jack or juvenile) that a given fish was assigned to in the catch data during the survey was not recorded when sampling. Sampled fish were placed in the appropriate category based on the length of the fish (length/weight relationship from Argue et al. 1967). The cutoff point for adults was >57cm, for jacks was 45-57cm, and for juveniles was <45cm.

Biological data collected from the cannery are listed in Table 8. Size ranges and modes were very similar between cannery and survey data for juvenile, jack and adult chinook. Length-frequencies for juveniles and jacks combined were converted to cumulative percent frequencies and compared for each sex and sexes combined using a Kolmogorov-Smirnov two sample test (Zar 1984). No signficant differences were detected ($D_{obs} < D_{alpha}$ for both sexes and totals) between cannery and survey data. If fishermen discarded considerable numbers of juvenile chinook prior to the sale of their catch, one might expect to find chinook < 3 lb (45 cm) absent from the cannery length-frequency data and present in the survey data. Lack of any significant differences indicate that either discarding is unbiased with respect to length or that very few are discarded. It is presumed that these juvenile chinook may be sold as other species (e.g., pink salmon) or simply not accounted for. The proportion of immature males and females in both the jack and juvenile categories was less for the fish sampled at the cannery. The differences in maturity data in part may be due to the level of expertise in assessing chinook maturity among the observers. The person who collected data at the cannery had considerable experience in determining maturities whereas some of the other observers had very little experience.

iii) No. of sets/day/vessel:

The number of sets made per day ranged from 2 to 30 depending on the length of the day and the area (Table 9). Although observers recorded the number of sets per day by randomly interviewing skippers, data were not collected for each day and sometimes only a few estimates were collected for a given day. Secondly, no distinction was made as to what proportion of the effort for that day was expended on open or beach sets. Seine vessels choose between open and beach set strategy and the number of sets that a vessel is able to make in a given day is significantly affected by the number of vessels in the area and the number of good fishing spots (Ledbetter 1986). It should be noted that in each study area the geography may play a key role in determining the proportion of open or beach sets made. For example, the average number of sets made per day tended to be considerably higher in the Gordon Group and North Shore where mostly open sets were made.

iv) Gear count:

The number of vessels active in the fishery ranged from approximately 115 at the beginning of the fishery to 226 at its' peak (Table 10). On some days and in some areas it was impossible to count vessels due to fog and inclement weather. Vessel count was highest during weeks 3 and 4 of the fishery. Vessel count was also consistently higher for the Upper Johnstone Strait area for all fishing days.

v) Total catch estimate:

A summary of total catch estimates for the sockeye fishery using the bootstrap technique as well as the sales slip information is listed in Tables 12 and 13. Catch estimates for adult chinook (>5 lbs) and for sockeye agree well with the published catch statistics compiled by the Dept. of Fisheries and Oceans in both the time and area breakdown. Total numbers of jack chinook also agree well but do not exhibit the same time and area splits. The estimated catch of juvenile chinook approximately equals that for adults in magnitude but the week and area distribution differ. No comparison is available with sales slip data. Catch estimates were also complied by study area although no comparison could be made with sales slip data since they are compiled by statistical area only. The Upper Johnstone Strait study area accounted for 49% of the total adult chinook catch in Johnstone Strait. Most of the juvenile chinook catch was recorded in the Gordon group (40%) and Upper Johnstone Strait (36%) study areas.

The bootstrap technique produces an essentially unbiased estimate of the associated variance of these catch estimates since no assumptions are made concerning the distributional attributes of the error of the variables. An examination of the minimum and maximum values of these estimates and a plot of their frequency distribution (Figs. 7-10) indicates that the catch distribution is skewed. This is not unexpected since the catch/set distribution is highly skewed.

DISCUSSION

Comparison of the sales slip data with our estimates of catch show that the sales slip data lies well within the confidence range of our estimates, except in a few cases. When data were summarized by week (Table 12) we notice that there is some discrepancy between our estimates and sales slip data for jack chinook, but when the data were compiled by statistical area these differences are not evident. In statistical area 13 (Table 13) we note differences in adult catch estimates while these are not as noticeable in the summary by week. Differences in total catch estimates between sales slip and survey data for jack and adult chinook and sockeye are <1%, 1.5%, and 4%, respectively. The differences noted between our weekly jack chinook catch estimates and the sales slip data may be explained by the hypothesis that the jack category in the sales slip data does not refer to the same body of fish as in our survey data. We believe that the jack category in the sales slip data represents a subset of the total jack and juvenile catch recorded in the survey data. Evidence for this comes from the comparison of biological samples, since no differences were detected between the samples of jacks from the cannery and the samples of jacks and juveniles combined from the survey. Secondly, when we plot the cummulative catch by week and compare jacks (saleslip) with jacks (survey) and jacks plus juveniles (survey) (Fig. 11), the catch distribution for jacks (saleslip) is more similar to jacks plus juveniles (survey) than to jacks (survey).

i) Survey strategy:

To determine the sensitivity of the bootstrap technique to different levels of stratification we compiled the mean catch per set and gear count data by week instead of by day and redid the analysis. Sets per day data were calculated as before. Differences in total catch estimates for juvenile and adult chinook were less than 1% while a 2% increase was recorded for jack chinook and sockeye. The minor differences noted here indicate that on the basis of this year's data the bootstrap technique is relatively insensitive to the stratification level chosen.

Both the analysis of variance (Table 11) and the sensitivity test indicate that catch per set could be collected and compiled on a weekly basis. In terms of survey strategy this could eliminate the need to collect data from all study areas each day and allow us to be somewhat less concerned about small gaps in the data during a given week due to equipment failures or bad weather. More intense sampling for fewer days during a given week and area may prove to be more cost effective than our present strategy.

ii) Data considerations:

Two areas of particular interest that could significantly affect our catch estimates are the treatment of missing data cells and the question of representative sampling as it pertains to the three variables used in the calculation. Consideration of these aspects is important in assessing the value of our technique.

Treatment of missing data cells was dealt with by taking the average value for the data collected in each area and time strata and applying it to the missing point. Since a limited amount of data were collected for sets per day, all the data had to be pooled and converted to sets per hour. As indicated earlier, no distinction was made in the analyses between type of sets made. This concern could have a considerable effect on the number of sets made per day, but it was assumed that dealing with this variable in terms of sets per hour would smooth out the differences between types of sets made. For future surveys, it is imperative that more sets per day data be collected by type of set to examine whether the conversion to sets per hour is representative of the different fishing strategies in each area. Filling in missing data cells for overflight data was also accomplished by using the mean for the week. This was done with some concern, since differences in the overflight gear count between days in a given week and study area varied considerably and in some cases was as high as 55%. We could not possibly anticipate such a major shift in effort, but it was assumed that the 10% error would account for most of the possible changes in effort from day to day. Comparison of the gear count with sales slip data indicated that no consistent appreciable bias in the overflight data was evident. Further work is necessary to gain a better understanding of the error associated with overflight data.

The question of representative sampling in reference to catch/set also presented some concerns. On short days (Sunday evenings for example) or when equipment failures occurred, it may not have been possible to observe a representative number of sets made in that area for that day. The need for representative sampling is always important but becomes especially critical considering the highly skewed distribution of catch per set. Only few vessels were observed to have large catches of either chinook or sockeye, but when these were encountered in a given day they would significantly affect the data for that day. It is imperative therefore not only to increase sample size but also to maintain good coverage of the whole study area.

Some other sources of potential error are also noted. Recording of chinook catch posed some problems when large catches of sockeye were encountered, especially when brailling took place. This was not a major concern in this survey, however, considering the small number of large catches of sockeye (>500) encountered. When no opportunity for close examination was allowed, some juvenile coho or pink salmon may have been recorded as chinook.

The favourable comparison with the sales slip data indicates that although these concerns are real, our procedures may have not caused serious under or over estimation of the total catch. Evidence for this comes from the sockeye catch estimate. From Table 13 we note that the difference between our total estimate for sockeye and the sales slip data is only 4%.

iii) Chinook mortality:

The estimate of total chinook mortality in Johnstone Strait during the sockeye seine fishery in 1986 was determined to be 27,802 of which 13,318 were recorded as juveniles, 2604 as jacks, and 11,880 as adults. The additional estimate of previously unrecorded juvenile mortality essentially doubles the total chinook landed catch of 14,617 as recorded in the sales slip data for 1986.

Since we suggest that the jack category in the sales slip data is a subset of the jack and juvenile catch recorded in the survey we want to emphasize that the real measure of unreported chinook catch is the comparison of these two values. We propose therefore that the chinook catch less than 5 lb is 15,922/2642 = 6.03 times greater than the present amount recorded as jacks in the sales slip data.

The fate of these unreported chinook is unclear. Comparison of biological samples from the cannery and the survey suggest that most fishermen do not bother to discard juvenile chinook or sort their catch. This is probably the case since an average of less than one juvenile is caught in a given set and it is not cost effective for them to spend the time sorting. If the majority of small chinook landed reach the processor, it is not clear what criteria are used to determine whether these chinook are recorded as chinook or other species on the sales slip.

To determine the proportion of mature males in the jack and juvenile categories, both the sex ratio and percent maturity values from the biological sampling data were applied to the total estimates. Application of these values from Table 6 yielded a total of 4502 mature males in the juvenile category and 921 in the jack category. The proportion of mature females only amounted to 373 for both the juvenile and jack categories. Subtracting these values from the totals yields 8490 juveniles and 1635 jacks, representing the number of fish that could have contributed to future reproductive effort. We must remember, however, that these values are based on somewhat questionable maturity data.

To put our estimate in perspective in terms of the total fishing effort in Johnstone Strait, the survey was conducted when >99% of the sockeye, 89% of the chum, and 96% of the pink salmon catch was taken in 1986 (Table 14). Relatively speaking, the ratio between our estimate of chinook catch and the total catch of sockeye from the sales slip data was .02 amounting to approximately one chinook caught for every 50 sockeye. The ratio of juvenile to adult chinook was approximately 1:1.

This pilot study provides us with an independent estimate of the magnitude of the total as well as juvenile chinook mortality during the Johnstone Strait sockeye seine fishery. Several more years of study will be required to measure chinook mortality rates and to assess whether any changes in mortality rates may be due to differences in fishing effort by the sockeye seine fleet or related to chinook stock size. We will need to examine the variation in the ratio of juvenile to adult catch over time. This ratio may in future offer us some measure of the status of Georgia Strait chinook stocks and the level of recruitment to the fishery one to two years after the survey.

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Table 1. 1986 openings for the Seine fishery in Johnstone Strait[1].

DATES OF SURVEY	SCHEDULED FISHING DATES
SOCKEYE FISHERY	
AUG. 3-4	AUG. 3-4
10-12	10-12
17-20	17-20
24-27	24-27
SEPT. 1-2	SEPT. 1-2
CHUM FISHERY	
SEPT. 16-17	SEPT. 16-17
	OCT. 5-6
	13-14
	23

[1]Includes statistical areas 12 and 13.

Table 2. Number of vessels that reported catch by week for statistical area 12 and 13 combined compared with overflight data.

WEEK	Sales slip count[1]	Overflight count
Aug. 3-4	96	115
Aug. 10	178	176
11		140
Aug. 17	216	226
18		209
Aug. 24	243	226
Sept. 1	183	193

[1]Unique CFV Nos. delivering catch, compiled from sales slip data, weekly totals only

Table 3. Average catch/set by Study area and category compiled from data collected during the sockeye and chum fisheries.

GORDON GROUP

	CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
SOCKEYE FISHERY				
AUG. 3	0.00(0.00)[a]	3.00(0.00)	3.00(0.00)	15.00 (0.00)
4	0.47(0.94)	1.82(3.76)	1.76(2.05)	14.70(24.10)
AUG. 10	0.83(1.33)	0.17(0.41)	0.50(0.84)	7.90 (9.60)
11	1.41(1.87)	0.00(0.00)	0.88(1.22)	18.70 (13.50)
12	0.42(0.79)	0.17(0.58)	0.58(1.00)	38.90(113.90)
AUG. 17	0.00(0.00)	0.00(0.00)	3.40(3.21)	21.20 (22.50)
18	0.00(0.00)	0.08(0.28)	1.23(2.77)	83.60(124.80)
19	0.58(1.24)	0.00(0.00)	0.00(0.00)	23.30 (24.10)
20	0.00(0.00)	0.00(0.00)	0.86(0.90)	27.50 (23.90)
AUG. 24	0.00(0.00)	0.00(0.00)	0.00(0.00)	23.40 (40.50)
25	0.10(0.31)	0.00(0.00)	0.30(0.57)	10.60 (13.90)
26	0.67(1.03)	0.00(0.00)	0.00(0.00)	8.90 (14.00)
27	0.00(0.00)	0.10(0.32)	0.40(0.52)	52.60(123.50)
SEPT. 1	0.60(0.89)	0.40(0.89)	0.00(0.00)	4.80(8.60)
2		NO DATA		
MEAN[b]	0.43(1.03)	0.31(1.48)	0.80(1.58)	26.60(64.6)
CHUM FISHERY				
SEPT. 16	1.33(1.15)	0.33(0.58)	0.67(1.15)	
17		NO DATA		

[a]Standard deviation in parenthesis.
[b]Weighted mean catch/set, all weeks combined.

Table 3 (cont'd)

NORTH SHORE

SOCKEYE FISHERY

	CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
AUG. 3	2.00(0.00)[a]	0.00(0.00)	3.50(0.71)	16.50(12.10)
4	0.45(0.93)	0.27(0.90)	2.00(2.32)	17.60(11.10)
AUG. 10	3.00(5.35)	0.00(0.00)	2.00(3.37)	140.00(127.30)
11	0.17(0.39)	0.25(0.45)	0.67(0.65)	14.90 (12.20)
12	0.35(0.49)	0.00(0.00)	0.65(1.14)	33.60 (69.50)
AUG. 17	0.00(0.00)	0.00(0.00)	0.00(0.00)	10.00 (0.00)
18	0.35(1.00)	0.00(0.00)	1.35(3.60)	37.70(56.40)
19	0.08(0.28)	0.00(0.00)	0.46(1.66)	31.20(40.70)
20	0.13(0.35)	0.00(0.00)	0.33(0.49)	37.40(35.90)
AUG. 24	0.00(0.00)	0.00(0.00)	0.00(0.00)	466.70(361.80)
25	0.10(0.32)	0.00(0.00)	0.60(1.58)	17.90 (32.20)
26	0.06(0.25)	0.00(0.00)	0.06(0.25)	37.00 (48.40)
27		NO DATA		
SEPT. 1		NO DATA		
2	0.43(1.16)	0.19(0.51)	0.90(0.94)	8.00(6.10)
MEAN[b]	0.34(1.14)	0.07(0.35)	0.81(1.79)	38.40(89.80)

CHUM FISHERY

SEPT. 16		NO DATA		
17				

[a]Standard deviation in parenthesis.
[b]Weighted mean catch/set, all weeks combined.

Table 3 (cont'd)

UPPER JOHNSTONE STRAIT

SOCKEYE FISHERY

	CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
AUG. 3	0.00(0.00)[a]	0.00(0.00)	0.00(0.00)	125.00(0.00)
4		NO DATA		
AUG. 10	0.67(1.15)	0.00(0.00)	0.67(1.15)	133.40(231.40)
11	0.31(0.48)	0.85(1.52)	1.00(1.47)	128.80(169.90)
12	0.36(1.08)	0.00(0.00)	0.71(1.14)	18.30 (19.30)
AUG. 17	2.25(2.63)	0.00(0.00)	2.75(2.22)	122.50 (78.20)
18	0.31(0.48)	0.00(0.00)	0.38(0.65)	62.70 (91.30)
19	0.55(1.21)	0.18(0.60)	0.09(0.30)	124.80(358.00)
20	1.00(2.34)	0.17(0.58)	0.33(0.49)	26.20 (58.70)
AUG. 24	0.50(1.00)	0.00(0.00)	0.00(0.00)	28.00 (48.10)
25	0.00(0.00)	0.00(0.00)	0.67(0.98)	110.30(182.00)
26	0.61(2.35)	0.00(0.00)	0.33(0.49)	70.10(233.40)
27	1.00(2.45)	0.00(0.00)	0.17(0.41)	2.00 (1.70)
SEPT. 1		NO DATA		
2	0.33(0.66)	0.05(0.22)	0.14(0.48)	8.70(12.90)
MEAN[b]	0.52(1.45)	0.12(0.58)	0.48(0.96)	53.50(151.80)

CHUM FISHERY

	ADULT	JACK	JUVENILE
SEPT. 16	0.00(0.00)	0.00(0.00)	0.14(0.38)
17	0.06(0.24)	0.06(0.24)	0.00(0.00)
MEAN[b]	0.04(0.20)	0.04(0.20)	0.04(0.20)

[a]Standard deviation in parenthesis.
[b]Weighted mean catch/set, all weeks combined.

Table 3 (cont'd)

LOWER JOHNSTONE STRAIT

SOCKEYE FISHERY

	CHINOOK ADULT	CHINOOK JACK	CHINOOK JUVENILE	SOCKEYE
AUG. 3	20.00(13.23)[a]	0.00(0.00)	0.00(0.00)	101.70(130.50)
4	1.36 (2.16)	0.00(0.00)	0.00(0.00)	33.40 (42.90)
AUG. 10	1.00(0.82)	0.00(0.00)	0.75(0.96)	30.00(47.10)
11	0.24(0.70)	0.00(0.00)	0.10(0.44)	65.10(87.10)
12	1.33(1.94)	0.06(0.24)	0.28(0.57)	14.60 (9.90)
AUG. 17	1.00(1.73)	0.00(0.00)	0.00(0.00)	0.00 (0.00)
18	1.29(1.74)	0.05(0.22)	0.19(0.40)	237.00(337.00)
19	0.59(0.71)	0.00(0.00)	0.18(0.53)	150.10(255.60)
20	0.39(0.85)	0.00(0.00)	0.78(1.70)	72.70 (98.20)
AUG. 24	0.00(0.00)	0.00(0.00)	0.25(0.46)	39.40 (70.70)
25	0.33(1.24)	0.00(0.00)	0.17(0.38)	149.00(337.30)
26	0.18(0.46)	0.00(0.00)	0.08(0.27)	223.90(581.20)
27	0.39(0.95)	0.06(0.25)	0.10(0.30)	88.80(241.70)
SEPT. 1	0.00(0.00)	0.00(0.00)	0.00(0.00)	37.40(52.00)
2	0.56(0.96)	0.06(0.25)	0.06(0.25)	53.40(76.40)
MEAN[b]	0.78(2.72)	0.02(0.14)	0.18(0.61)	102.90(289.20)

CHUM FISHERY

	CHINOOK ADULT	CHINOOK JACK	CHINOOK JUVENILE
SEPT. 16	0.13(0.35)	0.00(0.00)	0.13(0.35)
17	0.53(1.30)	0.07(0.26)	0.00(0.00)
MEAN[b]	0.39(1.08)	0.04(0.21)	0.04(0.21)

[a]Standard deviation in parenthesis.
[b]Weighted mean catch/set, all weeks combined.

Table 3 (cont'd)

DISCOVERY PASS

	SOCKEYE FISHERY CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
AUG. 3		NO DATA		
4		"		
AUG. 10	0.00(0.00)[a]	0.00(0.00)	0.33(0.58)	26.70 (20.30)
11	0.44(1.01)	0.11(0.33)	0.33(0.71)	25.40 (29.30)
12	0.43(0.65)	0.07(0.27)	0.43(0.65)	33.80 (34.40)
AUG. 17	0.20(0.45)	0.20(0.45)	0.00(0.00)	6.00 (8.00)
18	0.67(0.96)	0.11(0.42)	0.26(0.53)	86.00(100.70)
19	1.29(3.44)	0.00(0.00)	0.05(0.22)	39.30 (42.70)
20	0.50(0.71)	0.00(0.00)	0.00(0.00)	2.50 (2.20)
AUG. 24	0.75(0.96)	0.00(0.00)	0.00(0.00)	179.50(315.10)
25	0.33(0.69)	0.00(0.00)	0.17(0.51)	120.60(190.30)
26	0.00(0.00)	0.18(0.60)	0.18(0.60)	9.60 (16.10)
27	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.50 (0.80)
SEPT. 1		NO DATA		
2	0.07(0.27)	0.00(0.00)	0.00(0.00)	31.10 (47.80)
MEAN[b]	0.52(1.55)	0.06(0.30)	0.18(0.47)	54.40(106.40)
		CHUM FISHERY		
SEPT. 16		NO DATA		
17	0.33(0.52)	0.00(0.00)	0.00(0.00)	

[a]Standard deviation in parenthesis.
[b]Weighted mean catch/set, all weeks combined.

Table 3 (cont'd)

ALL AREAS COMBINED (SOCKEYE FISHERY)	CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
Mean	0.55(1.87)	0.11(0.69)	0.45(1.18)	66.79(194.36)

Table 4. Two-way analysis of variance of catch/set vs area and week.

	SOURCE OF VARIATION	DF	SS	MS	% ERROR	F_{OBS}	$F_{.05}$
JACKS	TOTAL	825	377.86				
	MODEL	23	64.09	2.79			
	ERROR	802	313.76	.39		7.12	1.53
	AREA	4	7.64	1.91	12%	4.88	2.37
	WEEK	4	22.81	5.70	36%	14.58	"
	AREA*WEEK	15	33.65	2.24	52%	5.73	1.67
JUVENILES	TOTAL	825	1106.57				
	MODEL	23	149.95	6.52			
	ERROR	802	956.62	1.19		5.47	1.53
	AREA	4	66.17	16.54	44%	13.87	2.37
	WEEK	4	39.93	9.98	27%	8.37	"
	AREA*WEEK	15	43.85	2.92	29%	2.45	1.67
ADULTS	TOTAL	825	2783.10				
	MODEL	23	381.96	16.61			
	ERROR	802	2401.14	2.99		5.55	1.53
	AREA	4	22.08	5.52	6%	1.84	2.37
	WEEK	4	138.86	34.72	36%	11.60	"
	AREA*WEEK	15	221.01	14.73	58%	4.92	1.67

Table 5. Comparison between type of set and mean chinook catch/set by study area. (Standard error of the mean in parenthesis.)

	N	Adults	Jacks	Juveniles
Gordon Group				
Open	113	.44(.09)	0.12(.04)	.49(.08)
Beach	21	.38(.21)	1.29(.76)	2.43(.65)
North Shore				
Open	143	.35(.09)	.07(.03)	.80(.15)
Beach	2	0	0	1.5(1.50)
Upper Johnstone Strait				
Open	41	.22(.08)	.09(.07)	.44(.17)
Beach	89	.66(.18)	.13(.07)	.51(.09)
Lower Johnstone Strait				
Open	54	.19(.08)	0	.11(.05)
Beach	192	.95(.22)	.03(.01)	.19(.05)
Discovery Passage				
Open	25	.16(.09)	.08(.08)	.08(.08)
Beach	105	.60(.16)	.06(.03)	.20(.05)
Total[1]				
Open	376	.33(.05)	.08(.02)	.52(.07)
Beach	409	.77(.12)	.12(.04)	.39(.05)
Total[2]				
Open	233	.31(.05)	.08(.02)	.35(.05)
Beach	407	.77(.12)	.12(.04)	.38(.05)

[1]All areas combined
[2]All areas combined except North Shore

Table 6. Summary of chinook biological samples collected during the survey.

JUVENILES			JACKS			ADULTS		
LENGTH (CM)	M	F	LENGTH (CM)	M	F	LENGTH (CM)	M	F
29		1(2)[a]	43	16(28)	2(8)	58	1(14)	
30	2(2)	0	44	8(15)	4(15)	59	0	1(11)
31	1(1)	0	45	3(5)	1(4)	60	2(29)	0
32	4(4)	2(4)	46	7(14)	6(23)	61	0	1(11)
33	1(1)	1(2)	47	2(3)	3(11)	65	0	1(11)
34	4(4)	2(4)	48	4(7)	3(11)	68	2(29)	0
35	4(4)	5(11)	49	3(5)	1(4)	73	0	1(11)
36	9(9)	3(7)	50	6(11)	0	75	0	1(11)
37	10(10)	7(16)	51	3(5)	3(11)	83	0	1(11)
38	17(18)	7(16)	52	1(2)	1(4)	88	0	2(23)
39	10(10)	4(9)	53	0	1(4)	91	0	1(11)
40	13(13)	4(9)	54	2(3)	0	94	1(14)	
41	12(12)	2(4)	55	0	0	97	1(14)	
42	10(10)	6(14)	56	0	0			
			57	1(2)	1(4)			
TOTAL	97	44		56	26		7	9
WEIGHTED MEAN LENGTH	37.2	36.9		46.4	46.9		71.9	76.0
PERCENT IMMATURE	51%	95%		48%	80%			
SEX RATIO (% MALES)	69%			68%			44%	

[a]Percent frequency in parenthesis.

Table 7. Summary of age samples collected during survey.

ADULTS				JACKS				JUVENILES			
AGE[a]	M	F	TOTAL	AGE	M	F	TOTAL	AGE	M	F	TOTAL
0.1	0	1	1	0.0	2	4	6	0.0	2	6	8
0.2	2	3	5	0.1	33	10	43	0.1	55	19	74
0.3	2	3	5	0.2	1	1	2	1.0	6	3	9
				1.1	8	5	13	1.1	2	1	3
				2.1	1	1	2				
TOTAL:	4	7	11	TOTAL:	45	21	66	TOTAL	65	29	94

[a]European notation.

Table 8. Summary of chinook biological samples collected at the B.C. Packer Ltd. cannery in Vancouver.

	JUVENILES[1]			JACKS			ADULTS	
LENGTH (CM)	M	F	LENGTH (CM)	M	F	LENGTH (CM)	M	F
29								
30								
31	1	0	43	29(18)	9(23)	58		1(20)
32	3(1)	1(2)[a]	44	28(17)	12(31)	59		2(40)
33	8(3)	3(7)	45	15(9)	2(5)	60		0
34	8(3)	4(9)	46	22(14)	2(5)	61		0
35	11(4)	4(9)	47	11(7)	3(8)	62		1(20)
36	24(8)	3(7)	48	14(8)	1(2)	63		1(20)
37	29(10)	6(14)	49	11(7)	1(2)			
38	37(12)	4(9)	50	8(5)	4(10)			
39	51(17)	4(9)	51	7(4)	3(8)			
40	53(18)	7(16)	52	3(2)	0			
41	35(12)	4(9)	53	8(5)	1(2)			
42	35(12)	3(7)	54	3(2)	0			
			55	2(1)	1(2)			
			56	1(1)	0			
TOTAL	295	43		162	39		0	5
WEIGHTED MEAN LENGTH	38.7	36.8		46.7	45.0		-	60.2
PERCENT IMMATURE	22%	97%		37%	100%			
SEX RATIO (% MALES)	87%			84%			0%	

[a]Percent frequency in parenthesis.

[1]For purposes of comparison with the survey data we split the cannery sample data in to jacks and juvenile according to the criteria used for the survey data.

Table 9. Average number of sets made per vessel by day and study area.

	SOCKEYE FISHERY														
	AUGUST													SEPT	
	3	4	10	11	12	17	18	19	20	24	25	26	27	1	2
GORDON GROUP	-	-	5	18	19	-	-	17	-	6	18	20	20	-	-
NORTH SHORE	2	-	-	21	14	6	18	19	15	-	22	20	-	-	-
UPPER JOHNSTONE STRAIT	-	-	3	11	-	-	11	12	11	-	10	10	8	-	10
LOWER JOHNSTONE STRAIT	2	7	4	9	6	2	9	7	10	4	7	9	13	3	-
DISCOVERY PASS	-	-	3	-	-	3	16	13	-	3	15	12	-	2	-

	CHUM FISHERY	
	SEPT	
	16	17
UPPER JOHNSTONE STRAIT	5	11
LOWER JOHNSTONE STRAIT	3	12

Table 10. Overflight count of seiners by area and day.

	SOCKEYE FISHERY																
	AUGUST													SEPT			
	3	4[a]	10	11	12[a]	17	18	19	20[a]	24	25	26	27[a]	1	2[a]	16	17[a]
GORDON GROUP	25	–	30	52	–	29	44	64	–	8	30	17	–	3	–	20	–
NORTH SHORE	12	–	6	14	–	30	43	43	–	15	22	25	–	4	–	10	–
UPPER JOHNSTONE STRAIT	58	–	93	27	–	128	96	94	–	164	148	144	–	130	–	159	–
LOWER JOHNSTONE STRAIT	16	–	31	33	–	27	16	b	–	35	b	b	–	31	–	38	–
DISCOVERY PASS	4	–	16	14	–	12	10	b	–	4	b	b	–	25	–	31	–
TOTAL	115		176	140		226	209	201		226	200	186		193		258	

[a]No flight was made.
[b]Unable to count vessels due to inclement weather.

Table 11. Comparison of variance of chinook (adults, jacks, and juveniles combined) catch within and among days.

	Source of variation	DF	SS	MS	F_{OBS}	$F_{.05}$
GORDON GROUP						
Week 1	Model(among)	1	5.49	5.49		
	Error(within)	16	354.12	22.13	.25	4.49
	Total	17	359.61			
Week 2	Model	2	.25	.13		
	Error	32	39.35	1.23		
	Total	34	39.60		.10	3.32
Week 3	Model	3	41.93	13.98		
	Error	33	136.83	4.15		
	Total	36	178.76		3.37	2.92
Week 4	Model	3	1.19	.39		
	Error	35	10.70	.31		
	Total	38	11.89		1.31	2.87
Week 5			INSUFFICIENT DATA			
NORTH SHORE						
Week 1	Model	1	2.55	2.55		
	Error	11	98.68	8.97		
	Total	12	101.28		.28	4.84
Week 2	Model	2	6.09	3.04		
	Error	33	67.47	2.04		
	Total	35	73.56		1.49	3.32
Week 3	Model	3	10.96	3.65		
	Error	43	244.45	5.68		
	Total	46	255.41		.64	2.84
Week 4	Model	2	1.97	.99		
	Error	26	23.34	.89		
	Total	28	25.31		1.10	3.37
Week 5			INSUFFICIENT DATA			

Table 11 (cont'd)

	Source of variation	DF	SS	MS	F_{OBS}	$F_{.05}$
UPPER JOHNSTONE STRAIT						
Week 1			INSUFFICIENT DATA			
Week 2	Model	2	9.58	4.79		
	Error	27	75.22	2.79		
	Total	29	84.80		1.72	3.35
Week 3	Model	3	.74	.25		
	Error	53	53.40	1.01		
	Total	56	51.14		.24	3.18
Week 4	Model	3	1.87	.63		
	Error	36	15.50	.43		
	Total	39	17.37		1.45	2.87
Week 5			INSUFFICIENT DATA			
LOWER JOHNSTONE STRAIT						
Week 1			INSUFFICIENT DATA			
Week 2	Model	2	1.63	.81		
	Error	40	12.56	.31		
	Total	42	14.19		2.59	3.23
Week 3	Model	3	5.69	1.89		
	Error	72	60.34	.84		
	Total	75	66.04		2.27	2.74
Week 4	Model	3	.27	.09		
	Error	97	11.79	.12		
	Total	100	12.06		.74	2.70
Week 5	Model	1	.10	.10		
	Error	25	3.75	.15		
	Total	26	3.85	.68	4.24	

Table 11 (cont'd)

	Source of variation	DF	SS	MS	F_{OBS}	$F_{.05}$
DISCOVERY PASSAGE						
Week 1		INSUFFICIENT DATA				
Week 2	Model	2	.07	.04		
	Error	23	14.39	.63		
	Total	25	14.46		.06	3.42
Week 3	Model	3	1.48	.49		
	Error	57	16.16	.28		
	Total	60	17.64		1.74	2.76
Week 4	Model	3	.55	.18		
	Error	31	19.05	.61		
	Total	34	19.60		.30	2.92
Week 5		INSUFFICIENT DATA				

Table 12. Comparison of bootstrap estimates and sales slip data (numbers caught) by week.

	CHINOOK			
	ADULT	JACK	JUVENILE	SOCKEYE
Aug. 3-4	940[a] (468-1495)[b] 957[c]	1285 (404-3821)[b] 334	1977 (1119-3156)[b] d	70,617 (36,631-128,184)[b] 53,869
Aug. 10-12	2846 (1248-4650) 3338	599 (124-1390) 775	2841 (1682-4347) d	161,651 (100,747-273,039) 192,014
Aug. 17-20	4094 (2060-7901) 3965	513 (57-1841) 790	5437 (2500-9197) d	560,357 (328,633-957,437) 488,483
Aug. 24-27	3283 (791-10,760) 3078	79 (7-230) 597	2746 (1306-5254) d	541,357 (249,099-1,031,101) 624,183
Sept. 1-2	717 (228-1479) 637	128 (14-473) 146	317 (80-1152) d	32,227 (18,497-50,113) 62,542
TOTALS	11,880 (6376-19,318) 11,975	2604 (1225-5750) 2642	13,318 (9484-18,550) d	1,366,210 (840,432-1,944,024) 1,421,091

[a]Bootstrap estimates
[b]Upper and lower 95% confidence limits
[c]Sales slip data collected by the Dept. of Fisheries and Oceans, (Mar. 1987)
[d]No data recorded for juveniles in sales slip data.

Table 13. Comparison of bootstrap estimates and sales slip data (numbers caught) by statistical area.

STATISTICAL AREA	CHINOOK ADULT	CHINOOK JACK	CHINOOK JUVENILE	SOCKEYE
12	9820[a] (5000-16,894)[b] 8446[c]	2473 (1241-5503) 2467	12,619 (8964-17,650) d	1,043,009 (588,018-1,545,030) 1,090,601
13	2060 (1430-2997) 3529	131 (46-248) 175	699 (444-1102) d	323,201 (212,627-486,781) 330,490
TOTALS	11,880 (6376-19,318) 11,975	2604 (1225-5750) 2642	13,318 (9484-18,550) d	1,366,210 (840,432-1,944,024) 1,421,091

[a]Bootstrap estimate
[b]Upper and lower 95% confidence limits
[c]Sales slip data collected by Dept. of Fisheries and Oceans (Rec'd Mar. 1987)
[d]No data recorded for juveniles in sales slip data

Table 14. Comparison of the seine commercial catch by species inJohnstone Strait during the survey and total commercial catch for 1986.

	SOCKEYE	CHUM	PINK
TOTAL CATCH RECORDED DURING SURVEY	1,407,151	84,104	358,685
TOTAL 1986[a] CATCH	1,421,091	964,600	373,295
DIFFERENCE	>99%	9%	96%

[a]Sales slip data collected by Dept. of Fisheries and Oceans (Rec'd. Mar. 1987).

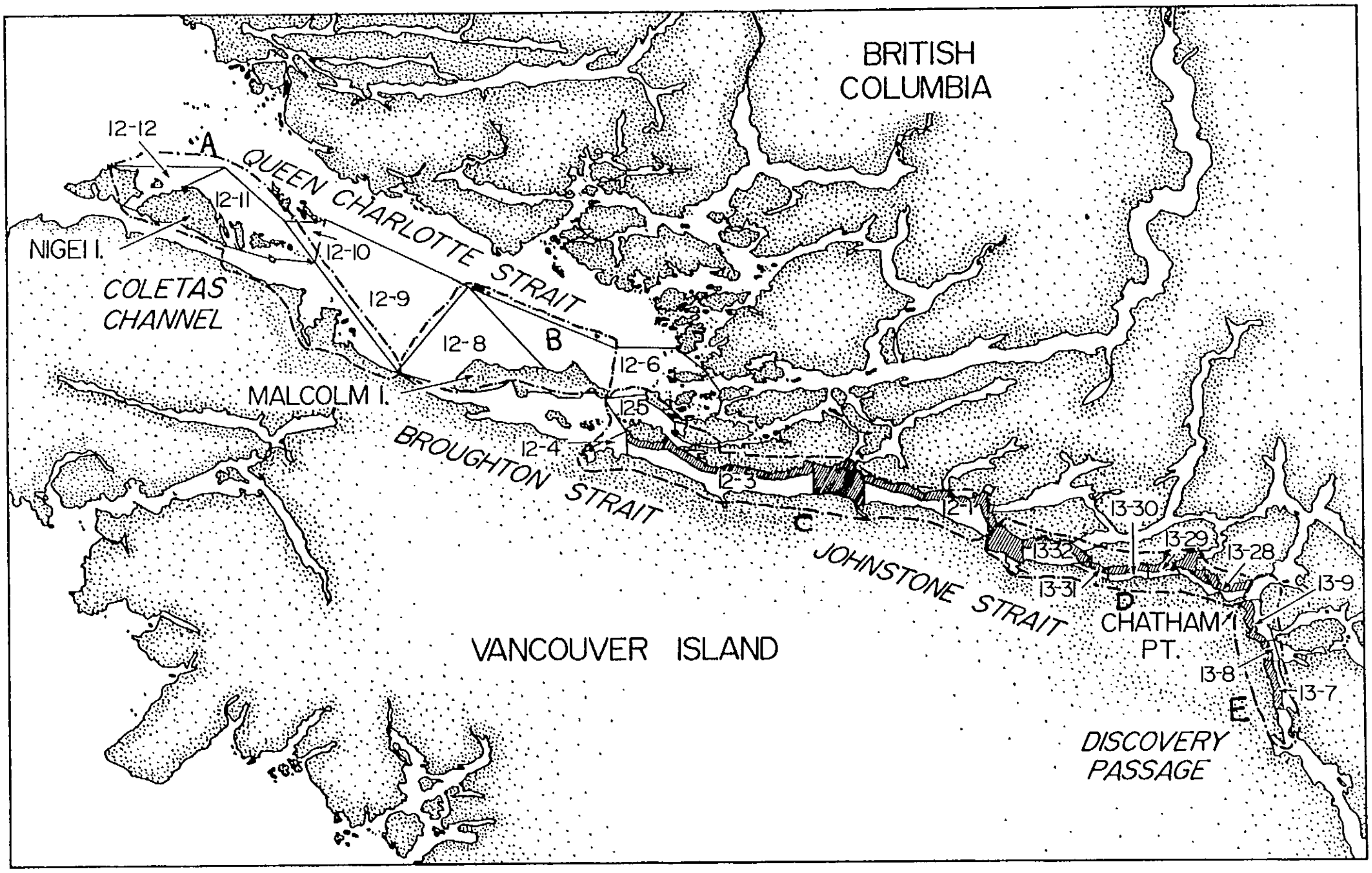
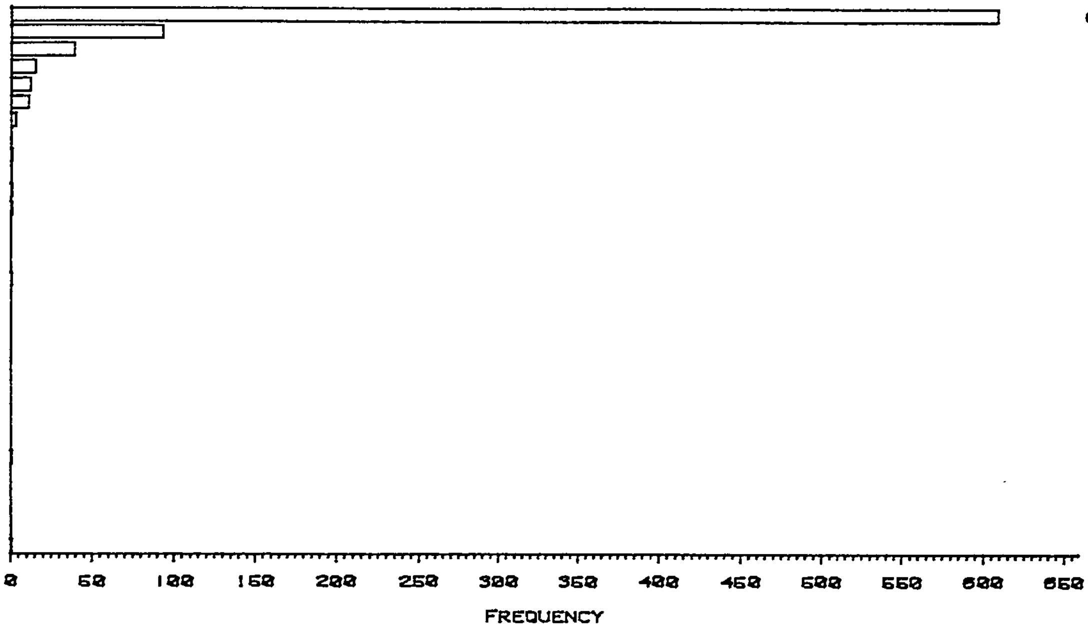


Fig. 1. Locations of management areas and study areas (A - Gordon Group, B - North Shore, C - Upper Johnstone Strait, D - Lower Johnstone Strait, E - Discovery Passage). Hatched sections represent areas closed to commercial fishing.

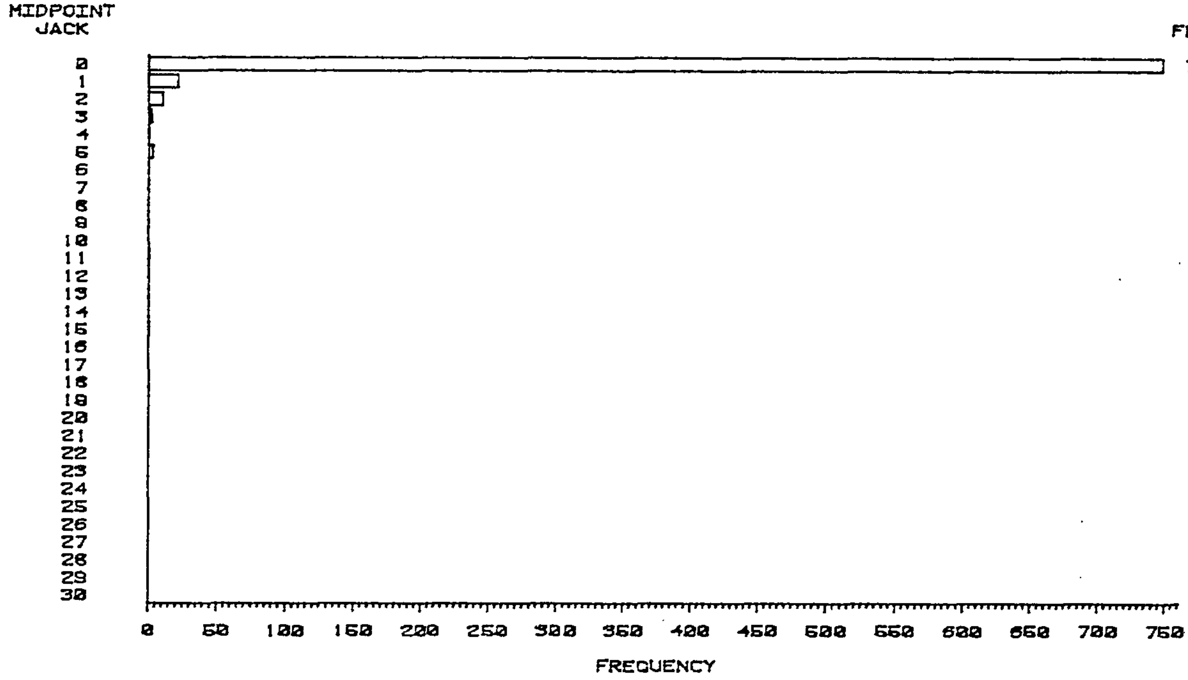
FREQUENCY HISTOGRAM FOR CATCH/SET FOR ADULTS



MIDPOINT ADULT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	609	609	77.28	77.28
1	93	702	11.80	89.09
2	39	741	4.95	94.04
3	15	756	1.90	95.94
4	12	768	1.52	97.46
5	11	779	1.40	98.86
6	3	782	0.38	99.24
7	0	782	0.00	99.24
8	1	783	0.13	99.37
9	0	783	0.00	99.37
10	1	784	0.13	99.49
11	1	785	0.13	99.62
12	0	785	0.00	99.62
13	0	785	0.00	99.62
14	0	785	0.00	99.62
15	1	786	0.13	99.75
16	0	786	0.00	99.75
17	0	786	0.00	99.75
18	0	786	0.00	99.75
19	0	786	0.00	99.75
20	0	786	0.00	99.75
21	0	786	0.00	99.75
22	0	786	0.00	99.75
23	0	786	0.00	99.75
24	0	786	0.00	99.75
25	1	787	0.13	99.87
26	0	787	0.00	99.87
27	0	787	0.00	99.87
28	0	787	0.00	99.87
29	0	787	0.00	99.87
30	1	788	0.13	100.00

Fig. 2. Frequency histogram of adult chinook catch per set.

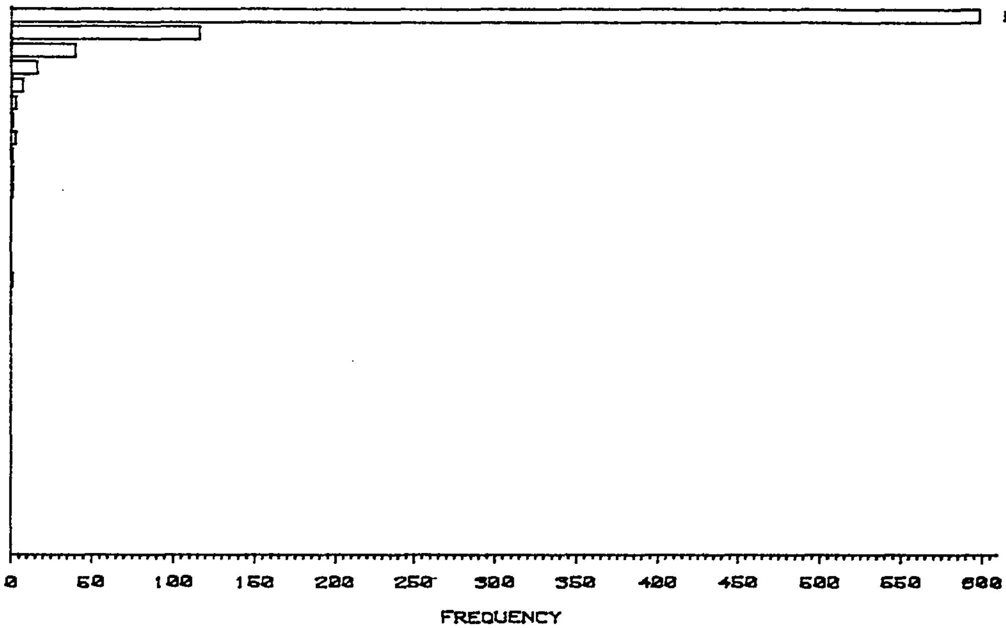
FREQUENCY HISTOGRAM FOR CATCH/SET FOR JACKS



MIDPOINT JACK	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	749	749	96.26	96.26
1	22	771	2.79	97.64
2	11	782	1.40	99.24
3	2	784	0.25	99.49
4	0	784	0.00	99.49
5	3	787	0.38	99.87
6	0	787	0.00	99.87
7	0	787	0.00	99.87
8	0	787	0.00	99.87
9	0	787	0.00	99.87
10	0	787	0.00	99.87
11	0	787	0.00	99.87
12	0	787	0.00	99.87
13	0	787	0.00	99.87
14	0	787	0.00	99.87
15	1	788	0.13	100.00
16	0	788	0.00	100.00
17	0	788	0.00	100.00
18	0	788	0.00	100.00
19	0	788	0.00	100.00
20	0	788	0.00	100.00
21	0	788	0.00	100.00
22	0	788	0.00	100.00
23	0	788	0.00	100.00
24	0	788	0.00	100.00
25	0	788	0.00	100.00
26	0	788	0.00	100.00
27	0	788	0.00	100.00
28	0	788	0.00	100.00
29	0	788	0.00	100.00
30	0	788	0.00	100.00

Fig. 3. Frequency histogram of jack chinook catch per set.

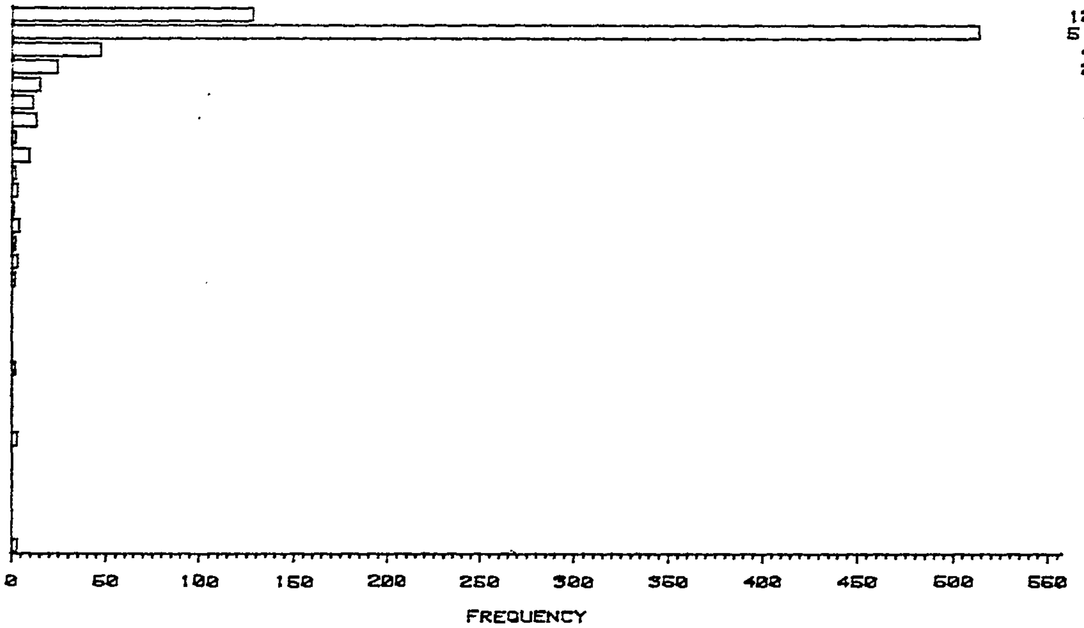
FREQUENCY HISTOGRAM FOR CATCH/SET FOR JUVENILES



MIDPOINT JUVENILE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	598	598	75.89	75.89
1	116	714	14.72	90.61
2	40	754	5.08	95.69
3	16	770	2.03	97.72
4	7	777	0.89	98.60
5	3	780	0.38	98.98
6	1	781	0.13	99.11
7	3	784	0.38	99.49
8	1	785	0.13	99.62
9	1	786	0.13	99.75
10	1	787	0.13	99.87
11	0	787	0.00	99.87
12	0	787	0.00	99.87
13	0	787	0.00	99.87
14	0	787	0.00	99.87
15	1	788	0.13	100.00
16	0	788	0.00	100.00
17	0	788	0.00	100.00
18	0	788	0.00	100.00
19	0	788	0.00	100.00
20	0	788	0.00	100.00
21	0	788	0.00	100.00
22	0	788	0.00	100.00
23	0	788	0.00	100.00
24	0	788	0.00	100.00
25	0	788	0.00	100.00
26	0	788	0.00	100.00
27	0	788	0.00	100.00
28	0	788	0.00	100.00
29	0	788	0.00	100.00
30	0	788	0.00	100.00

Fig. 4. Frequency histogram of juvenile chinook catch per set.

FREQUENCY HISTOGRAM FOR CATCH/SET FOR SOCKEYE

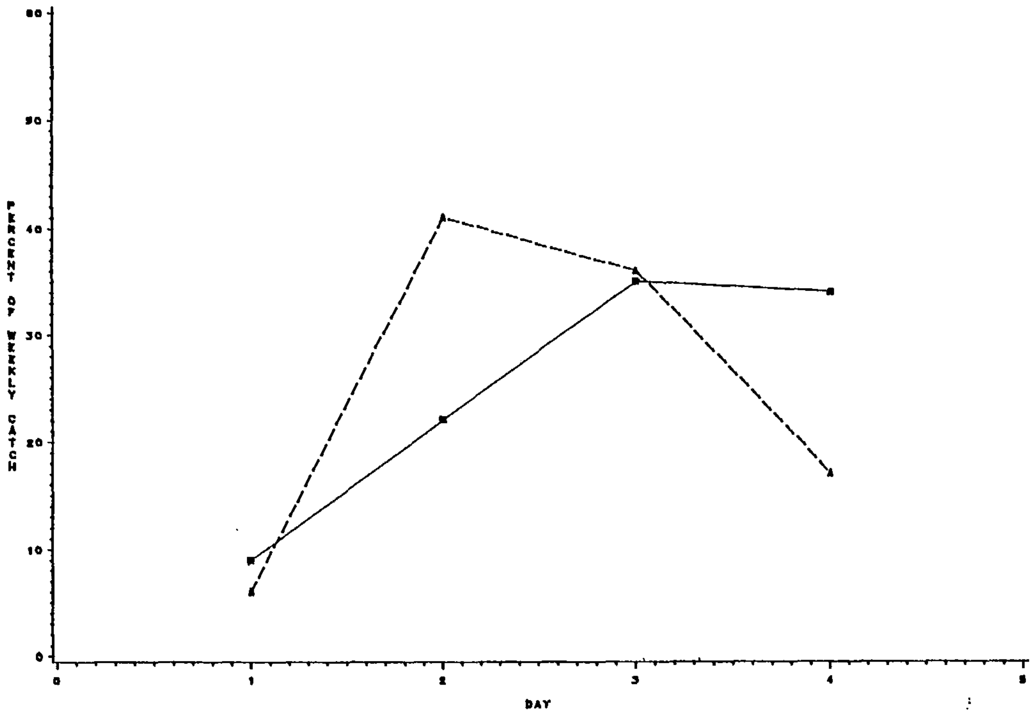


MIDPOINT SOCKEYE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	128	128	16.24	16.24
50	514	642	65.23	81.47
100	47	689	5.96	87.44
150	24	713	3.05	90.48
200	15	728	1.90	92.39
250	11	739	1.40	93.78
300	13	752	1.65	95.43
350	2	754	0.25	95.69
400	9	763	1.14	96.83
450	2	765	0.25	97.08
500	3	768	0.38	97.46
550	1	769	0.13	97.59
600	4	773	0.51	98.10
650	2	775	0.25	98.35
700	3	778	0.38	98.73
750	2	780	0.25	98.98
800	0	780	0.00	98.98
850	0	780	0.00	98.98
900	0	780	0.00	98.98
950	0	780	0.00	98.98
1000	2	782	0.25	99.24
1050	0	782	0.00	99.24
1100	0	782	0.00	99.24
1150	0	782	0.00	99.24
1200	3	785	0.38	99.62
1250	0	785	0.00	99.62
1300	0	785	0.00	99.62
1350	0	785	0.00	99.62
1400	0	785	0.00	99.62
1450	0	785	0.00	99.62
1600	3	788	0.38	100.00

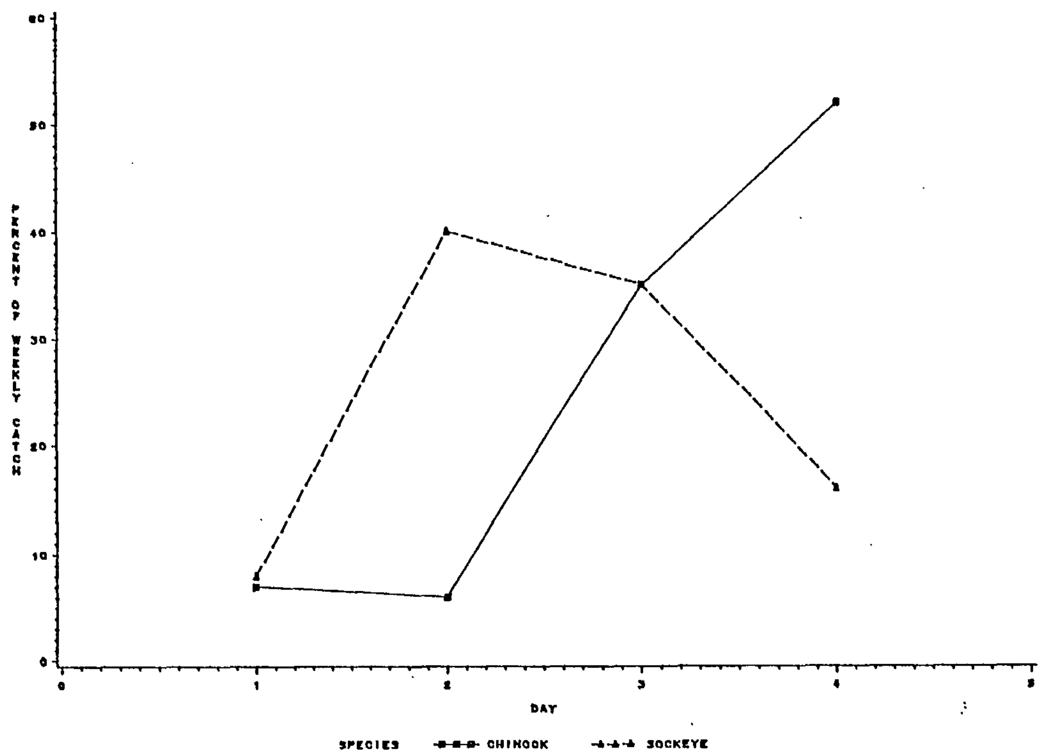
Fig. 5. Frequency histogram of sockeye catch per set.

Fig. 6. Catch by day relative to total weekly catch for sockeye and adult chinook during weeks 3 and 4 of the fishery in Johnstone Strait.

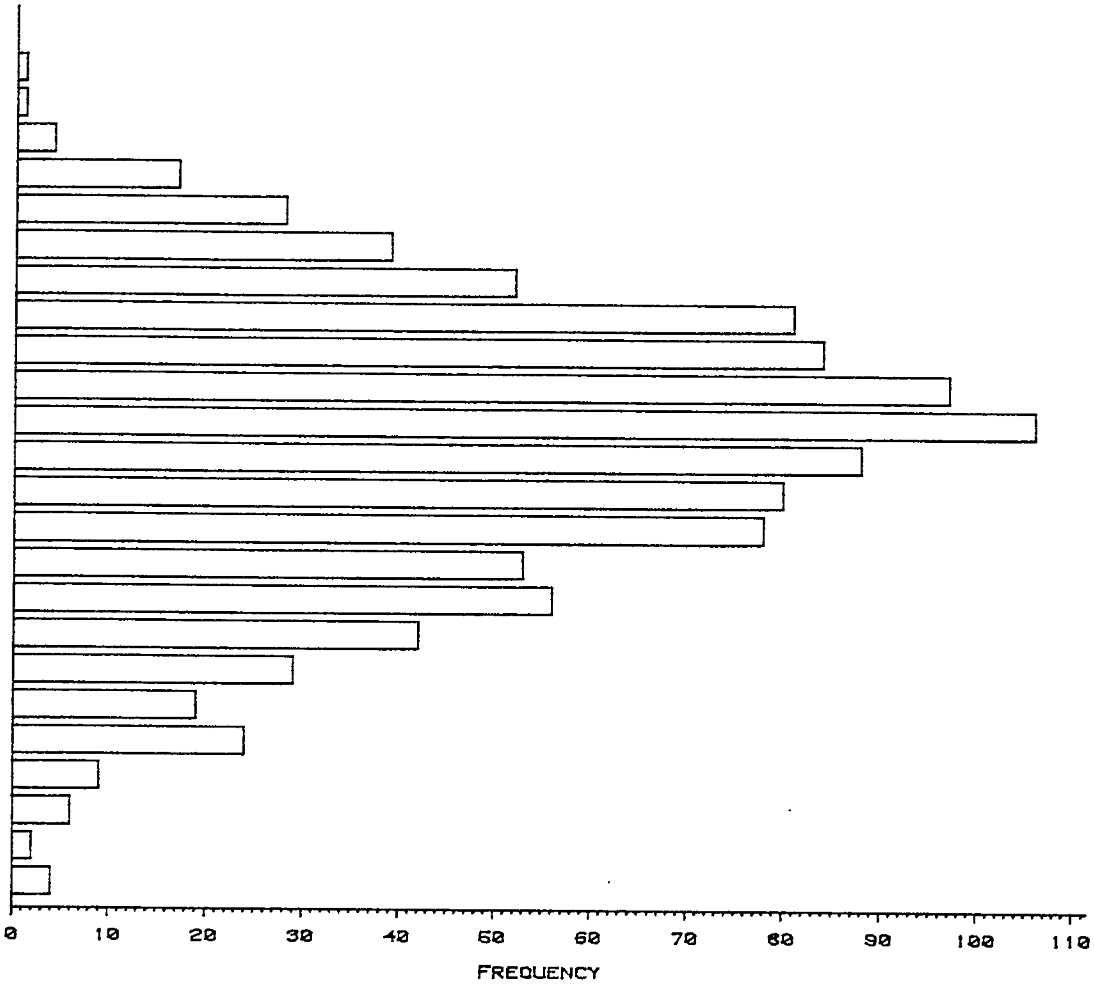
COMPARISON OF ADULT CHINOOK AND SOCKEYE CATCH
WEEK-3



COMPARISON OF ADULT CHINOOK AND SOCKEYE CATCH
WEEK-4



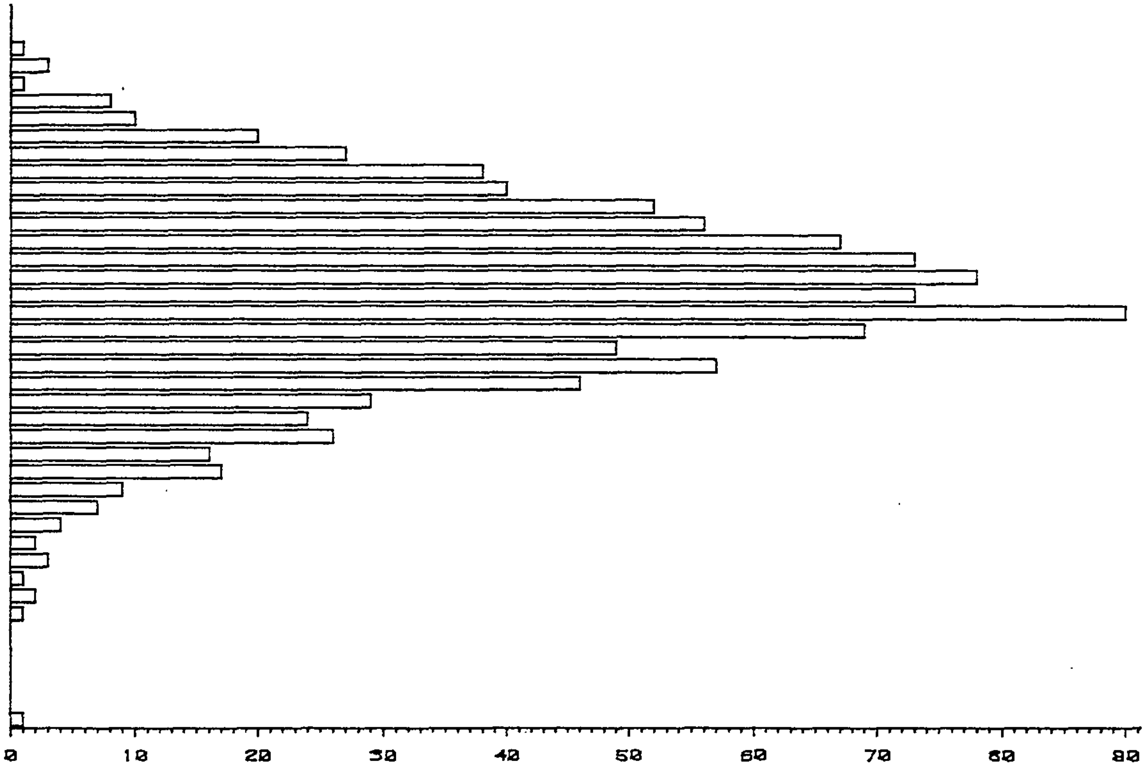
HISTOGRAM FOR BOOTSTRAP ESTIMATES OF ADULT CATCH



MIDPOINT ADULT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
6000	0	0	0.00	0.00
6500	1	1	0.10	0.10
7000	1	2	0.10	0.20
7500	4	6	0.40	0.60
8000	17	23	1.70	2.30
8500	28	51	2.80	5.10
9000	39	90	3.90	9.00
9500	52	142	5.20	14.20
10000	81	223	8.10	22.30
10500	84	307	8.40	30.70
11000	97	404	9.70	40.40
11500	106	510	10.60	51.00
12000	88	598	8.80	59.80
12500	80	678	8.00	67.80
13000	78	756	7.80	75.60
13500	53	809	5.30	80.90
14000	56	865	5.60	86.50
14500	42	907	4.20	90.70
15000	29	936	2.90	93.60
15500	19	955	1.90	95.50
16000	24	979	2.40	97.90
16500	9	988	0.90	98.80
17000	6	994	0.60	99.40
17500	2	996	0.20	99.60
18000	4	1000	0.40	100.00

Fig. 7. Histogram of bootstrap estimates of adult chinook catch.

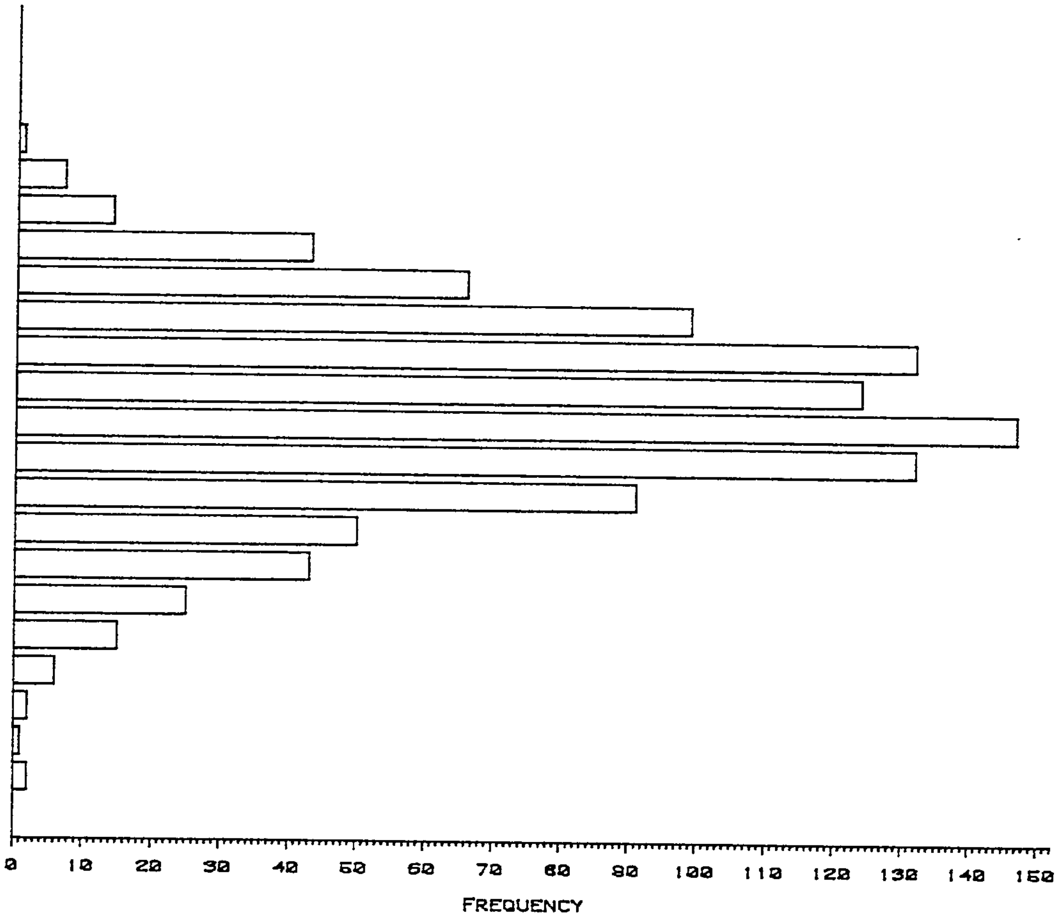
HISTOGRAM FOR BOOTSTRAP ESTIMATES OF JACK CATCH



MIDPOINT JACK	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1000	0	0	0.00	0.00
1100	0	0	0.00	0.00
1200	1	1	0.10	0.10
1300	3	4	0.30	0.40
1400	1	5	0.10	0.50
1500	8	13	0.80	1.30
1600	10	23	1.00	2.30
1700	20	43	2.00	4.30
1800	27	70	2.70	7.00
1900	38	108	3.80	10.80
2000	40	148	4.00	14.80
2100	52	200	5.20	20.00
2200	56	256	5.60	25.60
2300	67	323	6.70	32.30
2400	73	396	7.30	39.60
2500	78	474	7.80	47.40
2600	73	547	7.30	54.70
2700	90	637	9.00	63.70
2800	69	706	6.90	70.60
2900	49	755	4.90	75.50
3000	57	812	5.70	81.20
3100	46	858	4.60	85.80
3200	29	887	2.90	88.70
3300	24	911	2.40	91.10
3400	26	937	2.60	93.70
3500	16	953	1.60	95.30
3600	17	970	1.70	97.00
3700	9	979	0.90	97.90
3800	7	986	0.70	98.60
3900	4	990	0.40	99.00
4000	2	992	0.20	99.20
4100	3	995	0.30	99.50
4200	1	996	0.10	99.60
4300	2	998	0.20	99.80
4400	1	999	0.10	99.90
4500	0	999	0.00	99.90
4600	0	999	0.00	99.90
4700	0	999	0.00	99.90
4800	0	999	0.00	99.90
4900	0	999	0.00	99.90
5000	1	1000	0.10	100.00

Fig. 8. Histogram of bootstrap estimates of jack chinook catch.

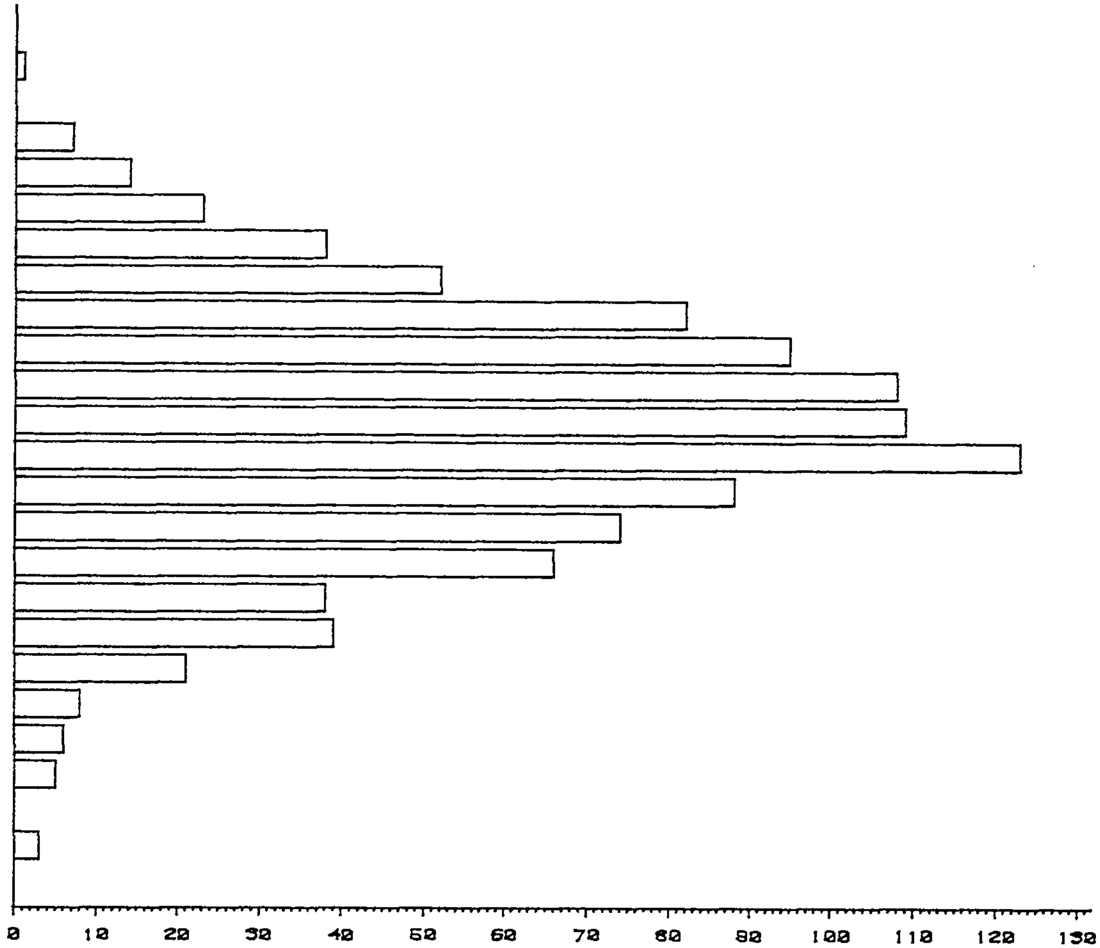
HISTOGRAM FOR BOOTSTRAP ESTIMATES OF JUVENILE CATCH



MIDPOINT JUVENILE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
8000	0	0	0.00	0.00
8500	0	0	0.00	0.00
9000	0	0	0.00	0.00
9500	1	1	0.10	0.10
10000	7	8	0.70	0.80
10500	14	22	1.40	2.20
11000	43	65	4.30	6.50
11500	66	131	6.60	13.10
12000	99	230	9.90	23.00
12500	132	362	13.20	36.20
13000	124	486	12.40	48.60
13500	147	633	14.70	63.30
14000	132	765	13.20	76.50
14500	91	856	9.10	85.60
15000	50	906	5.00	90.60
15500	43	949	4.30	94.90
16000	25	974	2.50	97.40
16500	15	989	1.50	98.90
17000	6	995	0.60	99.50
17500	2	997	0.20	99.70
18000	1	998	0.10	99.80
18500	2	1000	0.20	100.00
19000	0	1000	0.00	100.00

Fig. 9. Histogram of bootstrap estimates of juvenile chinook catch.

HISTOGRAM FOR BOOTSTRAP ESTIMATES OF SOCKEYE CATCH



MIDPOINT NEWSOCK	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
8000	0	0	0.00	0.00
8500	1	1	0.10	0.10
9000	0	1	0.00	0.10
9500	7	8	0.70	0.80
10000	14	22	1.40	2.20
10500	23	45	2.30	4.50
11000	38	83	3.80	8.30
11500	52	135	5.20	13.50
12000	82	217	8.20	21.70
12500	95	312	9.50	31.20
13000	108	420	10.80	42.00
13500	109	529	10.90	52.90
14000	123	652	12.30	65.20
14500	88	740	8.80	74.00
15000	74	814	7.40	81.40
15500	66	880	6.60	88.00
16000	38	918	3.80	91.80
16500	39	957	3.90	95.70
17000	21	978	2.10	97.80
17500	8	986	0.80	98.60
18000	6	992	0.60	99.20
18500	5	997	0.50	99.70
19000	0	997	0.00	99.70
19500	3	1000	0.30	100.00
20000	0	1000	0.00	100.00

Fig. 10. Histogram of bootstrap estimates of sockeye catch.

Fig. 11. Comparison of sales slip and survey cumulative catch distribution.

COMPARISON OF SALES SLIP AND SURVEY CUMULATIVE CATCH DISTRIBUTION