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THE 1993 FISHWHEEL PROJECT ON THE NASS RIVER AND AN EVALUATION OF FISHWHEELS AS AN INSEASON MANAGEMENT AND STOCK ASSESSMENT TOOL FOR THE NASS RIVER

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ABSTRACT

Link, M. R. and K. K. English. 1996. The 1993 fishwheel project on the Nass River and an evaluation of fishwheels as an inseason management and stock assessment tool for the Nass River. Can. Tech. Rep. Fish. Aquat. Sci. 2130: 103 p.

Fishwheels were evaluated as a tool to: 1) live-capture salmon for stock assessment studies; 2) provide an index of the timing and abundance of Nass River salmon stocks; and 3) selectively harvest sockeye salmon. Three fishwheels were installed and operated on the Nass River near the village of Gitwinksihlkw, B.C., from 5 June to 15 September 1993. The fishwheels operated for a total 4,578 h. Catches included 10,963 sockeye, 3,944 pink, 911 chinook, 466 coho, 99 chum, and 67 steelhead. Of these, 8,862 sockeye, 825 chinook, 323 coho, and 62 steelhead were tagged. A total of 1,181 sockeye were selectively harvested from the fishwheel catch. We used counts of marked and unmarked fish from the Meziadin fishway to compute population estimates for sockeye (555,776) and coho (20,215, only a portion of the coho return) above Gitwinksihlkw. The fishwheels caught an estimated 2.0% of the sockeye run and 2.7% of the chinook run.

Daily tag release and recovery data were used to reconstruct sockeye migration timing in the lower river and assess the within season variation in the portion of the run caught by the fishwheels. The portion of the sockeye run captured by the fishwheels was higher in the middle of the run than early and late in the run. The 1992 and 1993 sockeye studies suggest that fishwheels may provide a better index of abundance than the current gillnet test fishery.

RÉSUMÉ

Link, M. R. and K. K. English. 1996. The 1993 fishwheel project on the Nass River and an evaluation of fishwheels as an inseason management and stock assessment tool for the Nass River. Can. Tech. Rep. Fish. Aquat. Sci. 2130: 103 p.

Cette étude avait pour objet d'évaluer l'utilité des tourniquets pour : 1) capturer des saumons aux fins de l'évaluation des stocks; 2) indiquer les temps de migration et les taux d'abondance des stocks de saumon dans la rivière Nass; 3) procéder à la récolte sélective du saumon rouge. Entre le 5 juin et le 15 septembre 1993, trois tourniquets ont été installés et mis en opération dans la rivière Nass, près du village de Gitwinksihlkw, en Colombie-Britannique. Ces tourniquets ont été fonctionnels pendant un total de 4 578 heures. Les captures effectuées se sont réparties comme suit : 10 963 saumons rouges, 3 944 saumons roses, 911 saumons quinnats, 466 saumons cohos, 99 saumons kétas, et 67 truites arc-en-ciel anadromes. De ces nombres, 8 862 saumons rouges, 825 saumons quinnats, 323 saumons cohos et 62 truites arc-en-ciel ont été étiquetés. Au total, 1 181 saumons rouges ont été récoltés par pêche sélective à l'aide du tourniquet. Nous avons utilisé les chiffres de saumons marqués et non marqués pour la passe migratoire de Meziadin afin d'établir le chiffre de population des saumons rouges (555 776), des saumons cohos (20 216, soit une partie seulement de l'effectif de remonte du saumon coho) en amont de Gitwinksihlkw. Les tourniquets ont permis de capturer environ 2,0 % de la remonte de saumon rouge et 2,7 % de la remonte de saumon quinnat.

Les chiffres d'étiquetage et de récupération ont été utilisés pour reconstituer les temps de migration du saumon rouge dans le cours inférieur de la rivière, et les variations infrasaisonnières dans l'effectif de remonte capté par les tourniquets. L'effectif de remonte de saumon rouge capté par les tourniquets était plus élevé au milieu de la période de remonte que plus tôt et plus tard dans la saison. Les études effectuées sur le saumon rouge en 1992 et en 1993 indiquent que les tourniquets peuvent fournir une meilleure indication du taux d'abondance des stocks de saumon que le moyen actuel de la pêche de sondage au filet maillant.

INTRODUCTION

The Nass River fishwheel project was initiated in 1992 to examine the feasibility of using fishwheels as a management and stock assessment tool on the Nass River (Link et al. 1996). This report documents the 1993 field season results and analysis. The project is a part of the Interim Measures Program (IMP), a program established by the Nisga'a Nation and the Canadian Government to conduct fisheries research in the Nisga'a Land Claim Area.

As a management tool, fishwheels were evaluated to determine if they could provide a better index of the sockeye salmon (*Oncorhynchus nerka*) escapement than the current gillnet test fishery and if they could be used to selectively harvest sockeye. As a stock assessment tool, the fishwheels were evaluated as a method to capture sockeye, chinook (*O. tshawytscha*), coho (*O. kisutch*) and steelhead (*O. mykiss*) for large scale radio- and spaghetti-tagging projects. The tagging projects were designed to evaluate the efficiency of the fishwheels and estimate the abundance, distribution and timing of Nass River salmon stocks. The fishwheels provided a means to non-destructively capture salmon and to tag them at a rate that was approximately proportional to their abundance.

The objectives of the 1993 Nass River fishwheel project were:

1. Evaluate the suitability of using fishwheels to index the abundance and timing of Nass River salmon returns;

2. Use the tagged fish from the fishwheels to estimate the total abundance of sockeye, coho and chinook returns to the river using a mark-recapture technique;

3. Capture chinook and steelhead for a large-scale radio tagging project;

4. Make changes to the fishwheel design and compare the efficiency of the new and old designs; and

5. Conduct a harvest of the sockeye that were in excess of the tagging program requirements.

STUDY AREA

The Nass River drains 20,500 km^2 and is the third largest watershed that lies entirely within British Columbia. The river originates in the Skeena Mountains and flows south and southwest for 400 km, entering the Pacific Ocean at Portland Inlet on the north coast of British Columbia (Fig. 1).

The Nass River supports significant populations of salmon. Sockeye salmon are the dominant species with an average estimated escapement of 190,000 for the period 1966 to 1991 (Table 1). Pink salmon are the next most abundant with an average escapement of 81,300. Coho salmon escapements have averaged 19,000 for the same period; chinook salmon 9,850, and chum salmon 3,660. Escapement values for sockeye probably represent most of the stock since a high portion of the total return is enumerated at the Meziadin fishway. Information from the 1992 radio tagging project suggest that historical chinook escapement estimates may represent only 40% of the total number of fish reaching the spawning areas. The accuracy of the estimates for the other species is unknown.

METHODS

FISHWHEEL CONSTRUCTION AND OPERATION

Design

A new fishwheel design was developed for the 1993 season. The fishwheel consisted of aluminum pontoons instead of wooden, larger live tanks, a hoist to raise and lower the axle and a balanced three-basket design instead of the two-basket design used in 1992. In addition to two new fishwheels, a wooden two-basket fishwheel from 1992 was retrofit and fished for a short period of time. The primary differences between the two designs (new and old) can be seen in Appendix A. The fishwheel design was modified in 1993 in order to decrease down time due to breakdowns and to decrease staffing costs by decreasing the sampling frequency and maintenance effort that was required to operate the old design fishwheels (Link et al. 1996).

The new fishwheel was designed by the senior author. The basket and hoist designs were derived from photographs of fishwheels used on the Columbia River 50 to 100 years ago (Donaldson and Cramer 1971). The pontoons were modelled after the 1992 fishwheel but were made of aluminum and the live tanks were fit inside the pontoons (they were outside the pontoon in 1992) for greater protection from debris and high water velocity. Each pontoon was composed of seven independent, sealed, pressure tested compartments. Two of the three baskets of fishwheel 1 were painted with a latex paint matching the colour of the Nass River in June (colour: "sharkskin"/E145-H-3W).

Fishwheel 3 (the wooden fishwheel) was to be operated for approximately one month around the peak of the sockeye run. To compare the differences in efficiency between the new and old designs, this fishwheel was to be operated nearby a new fishwheel and then switch sites between the two every 7 to 10 d. Catch per effort data were to be used to compare the efficiencies.

Operation

For a description of the fishwheel site selection procedures and maintenance, see Link et al. (1996). The principle difference between the new and old designs was that the new fishwheel required considerably less water velocity to operate. Instead of 2 to 3 m/s to operate the old fishwheel properly, only 0.5 to 1.5 m/s was required to operate the new fishwheels. This made it possible to locate the fishwheels in slightly more protected areas, out of the direct flow of the river.

EFFORT AND CATCH

Daily fishing effort by the fishwheels was measured in two ways. First, total effort was measured as the time each wheel was fishing from midnight to midnight. Second, the effort used to calculate catch per unit effort (CPE) was measured as the number of hours each fishwheel fished to obtain the daily catch. These two values were different because the time of the last sampling session on each day varied; this affected that day's and the following day's effort and catch. Effort was adjusted by halving for periods when only one live tank was attached to a fishwheel. We used the daily catch of each species to estimate daily CPE.

The speed of the fishwheel (RPM) was also recorded, but was not used to adjust effort estimates. We were unable to quantify effort in terms of RPM and fishing time because the relationship between RPM and catchability was not known.

TAGGING

The objective of the tagging program was to tag all uninjured chinook, sockeye, coho, and steelhead captured. Initially all uninjured chinook 72 cm or larger (nose-fork length) that were captured in the two new fishwheels (fishwheels 1 and 2) were to be tagged with radio transmitters (Koski et al. 1996). In addition to the radio transmitter, the fish were tagged with a white spaghetti tag as a secondary mark (see Link et al. 1996 for a description of the spaghetti tagging procedure). By 21 June we had applied over half the radio transmitters and the run was still building. Beginning 22 June, the tagging rate was reduced to approximately 50 percent of the large (>72 cm) chinook captured in fishwheel 1. Blue spaghetti tags were applied to the remainder of the chinook catch. All uninjured steelhead large enough to apply a radio transmitter were tagged.

All uninjured sockeye were tagged with individually numbered yellow spaghetti tags. Coho were tagged with individually numbered red spaghetti tags.

HARVESTING

All sockeye captured in the fishwheel 3 and a portion of sockeye captured in fishwheel 2 that were deemed in excess of the tagging program requirements and were harvested predominately food or sold as a part of the ESSR (excess salmon spawning requirement) license that was issued to the Nisga'a Tribal Council on 27 July 1993. Fish were dipnetted out of the live boxes, hit between the eyes with a stick and then bled by breaking the base of the gill arch. Some of the fish were distributed to Nisga'a living in Gitwinksihlkw and New Aiyansh. Fish that were sold were packed in an ice-water slurry in plastic totes, held over night and transported by truck to Prince Rupert for processing.

TAG RECOVERY

Tagged fish were recovered throughout the Nass River watershed using a variety of techniques and at different locations. The majority of tagged sockeye and coho were counted and/or recovered at the Meziadin fishway. Additional recoveries of tagged salmon were obtained from the in-river net and sport fisheries, the commercial fishery in Area 3-12, on spawning ground surveys and as recaptures in the fishwheels.

The Meziadin Lake sockeye stock contributes the majority of the fish to the overall Nass River sockeye escapement; as a result, the fishway provided a very large sample of fish to examine for tags applied in the lower Nass River. The field crew working at the fishway was instructed to count every tagged fish (sockeye, coho, chinook, and steelhead) that passed through the fishway and capture and record the numbers from as many tagged fish as was possible. Spaghetti tagged fish were enumerated as they swam through the counting chutes at the fishway. A portion of each day's tagged fish were removed from the holding area at the upper end of the fishway with a dipnet, the tag number was recorded (but not removed) and the fish was released upstream of the fishway. Note that this is different than the recovery/sampling method used in 1992 when tagged fish were trapped as they swam through the counting chutes and then dipnetted out. The counting chutes were left open through the night after visits by poachers on at least 3 occasions in 1993; therefore some tagged and untagged fish were not counted.

Radio-tagged chinook were located and recovered from spawning grounds using a combination of telemetry and carcass surveys. Information from the recovery of chinook salmon tagged in the fishwheels was used to estimate chinook escapement to the Nass River and its major tributaries (Koski et al. 1996).

POPULATION ESTIMATION

Population estimates were calculated for sockeye, coho and chinook salmon using the tag information from the fishwheels and the Meziadin fishway. Estimates for sockeye and coho are described in this report. Estimates of the chinook escapement are described in Koski et al. (1996). There were not enough tags applied or fish examined to estimate the steelhead population.

The sockeye escapement above the fishwheels was estimated using the modified Petersen formula (Ricker 1975). We estimated the escapement of the segment of coho run that passed the fishwheels while they were in operation with the modified Petersen formula and tag recoveries at the Meziadin fishway. Confidence limits for the mark-recapture estimates were determined using fiducial limits for the Poisson distribution (Ricker 1975).

RUN RECONSTRUCTION

To assess the suitability of the fishwheels as an inseason index of the sockeye escapement to the lower river, we reconstructed the sockeye run at the fishwheel site, compared fishwheel catch per effort with the reconstructed run, and examined the variation in the estimated portion of the run the fishwheels caught on a daily basis. A daily run reconstruction was possible because we had a daily record of the fish caught and marked in the fishwheels and a daily record of the marked and unmarked sockeye counted through the Meziadin fishway. Simpler approaches, such as simple back dating of the run observed at Meziadin, were deemed inappropriate because preliminary analysis indicated significant inseason variation in sockeye migration rates. This variation was probably the result of migration delays caused by variations in Nass River flow and counting "bottle necks" at the fishway during peak migration periods.

For this year's analysis we used a similar run reconstruction model to the one used in 1992 (Link et al. 1996). We modified the model because there was a greater number of tagged fish recovered at the fishway in 1993 and we believed that the precision of the model could be improved by utilizing these data.

The first step in our procedure to reconstruct the sockeye run at the fishwheels was to use the tag recoveries at the Meziadin fishway to determine the distribution of travel times for fish migrating from the fishwheel tagging site to the enumeration and recovery site (fishway). The distributions of the travel times were determined for sequential periods of 3 d across the entire run based on both tag release dates and recovery dates (i.e., two sets of distributions). We examined the sensitivity of the output to the period length for periods of 2 to 8 d. The lower and upper bounds of these distributions were set at 8 and 40 d to encompass more than 99% of the recoveries. We excluded eight recoveries where the travel times were between 41 and 59 d, based on the assumption that the lengthy migration was due in part to the tagging procedure. This method of determining the distribution of travel times for each period differs from the 1992 method where the mean and standard error of travel times were used to determine an upper and lower bound for the 95% confidence interval for the mean travel time. The relative frequencies (proportions) of different travel times were not used in the analysis of the 1992 data (Link et al. 1996).

The next step was to estimate the proportion of fishwheel caught fish passing through the fishway on each date. Not all fish captured in the fishwheel were tagged and therefore the number of tagged fish at the fishway had to be expanded by using a factor based on the portion of fish tagged each day at the fishwheel. The upper and lower bounds for the travel time distributions for each recovery period were used to define the range of fishwheel data that should be used to expand the number of tags observed at the Meziadin fishway to represent both the tagged and untagged sockeye previously caught in the fishwheels. The proportion of recoveries coming from each day in the past (travel time length earlier) were used to weight each of the portions of fish tagged at the fishwheels. The tag survival rate was also added to the model at this step.

$$MEZFWC_i = MEZTAGS_i \sum_{l=8}^{40} \frac{FWCOUNT_{i-l}}{FWTAGS_{i-l} * tagsur} * P_{k,l} \quad \textbf{(1)}$$

where $MEZFWC_i$ is the number of both tagged and untagged sockeye previously caught in the fishwheels; $MEZTAGS_i$ is the number of tagged sockeye observed at the Meziadin fishway on day i, $FWCOUNT_{i-l}$ is the number of sockeye caught by fishwheels on day $(i-l)$, $FWTAGS_{i-l}$ is the number of fish tagged at the fishwheels on day $(i-l)$, *tagsur* is the survival rate of the tagged fish (excluding natural mortality); and $P_{k,l}$ is the proportion of tag recoveries from tag recovery period k that took l days to travel from the fishwheels to the fishway. Recovery period k was set to 3 days for most run reconstructions.

The final step was to use the proportion of fishwheel caught fish at the fishway to expand the daily catches at the fishwheels to estimate the total number of sockeye passing the fishwheel location each day (RUN_j).

$$RUN_j = FWCOUNT_j \sum_{l=8}^{40} \frac{MEZCOUNT_{j+l}}{MEZFWC_{j+l}} * P_{k,l} \quad \textbf{(2)}$$

where $FWCOUNT_j$ is the number of fish caught in the fishwheels on day j; $MEZCOUNT_{j+l}$ is the number of sockeye counted through the Meziadin fishway on day $(j+l)$; $P_{l,k}$ is the proportion of tag recoveries from tag release period k (which includes day j) that took l days to reach the fishway; and all other variables are as described above.

An estimate of the daily efficiency was obtained by rearranging equation 2. A capture rate of 1 in 80 was used to estimate the abundance from periods where there were insufficient tag recoveries to estimate the fishwheel efficiency.

To examine the influence of the effects of capturing, holding (for up to 14 h) and tagging fish on the model results, we introduced a dropback subroutine to the model that attempted to lag the fish that were not tagged. We used two scenarios for the dropback relationship. First, we assumed a simple one day lag to account for the capturing and tagging procedure. Second, we used 90 recaptures of fish in fishwheel 1 that had originally been tagged in fishwheel 1 to construct a probability distribution of the length of dropback (1 to 8 d) from the fishwheels. This dropback function was then applied to the counts of fish at the fishway ($MEZCOUNT_i$) to create a new time series of counts that were estimates of the counts that would have been seen, had the untagged fish been held back like the fishwheel 1 recaptures.

The run reconstruction model code (QuickBASIC) is presented in Table B-1 and the flowcharts of the main model and the dropback subroutine are in Figures B-1 and B-2, respectively.

The run reconstruction model described above attempts to account for the inseason variability in marking rates at the fishwheels and travel times from the lower river to Meziadin, thereby permitting a direct evaluation of the inseason variability in the portion of the total run caught by the fishwheels. Unfortunately, there are no direct estimates of the inseason variability in sockeye migration rates from the gillnet test fishery (Monkley Dump) to the fishwheel sites, so we could not conduct a similar analyses for the gillnet test fishery.

AGE, LENGTH AND SEX SAMPLING

A portion of each day's catch (up to 25 of each species) was sampled for scales, length and sex. The nose-fork length was measured using a fabric measuring tape affixed to the inside of the tagging tray. Two scales were taken from the preferred area for sockeye, ten for coho, five for chinook and five for steelhead. Scales were mounted on numbered, gummed scale cards. All scale samples were sent to the Department of Fisheries and Oceans Scale Lab in Vancouver. Fish ages are presented using Gilbert-Rich notation. Sex was determined from visual inspection of the fish based on external morphology (Groot and Margolis 1991).

RESULTS

FISHWHEEL DESIGN AND OPERATION

Figure A-1 and A-2 show the side and top views of the new fishwheel design (fishwheels 1 and 2) and Figures A-3 and A-4 show the old fishwheel design (fishwheel 3).

Fishwheels 2 and 3 were moved on several occasions, while fishwheel 1 was moved very little and fished a short distance (30 m) upriver of where fishwheel 1 was for much of 1992. In addition, fishwheel 1 required very little maintenance. The water became so low (<2 m) by 10 August, that fishwheel 1 was no longer able to continue fishing. Fishwheel 2 was initially started out at the original site used at the beginning of 1992 because the water in the canyon was still too shallow. During the spring freshet, the fishwheel had to be shut down due to its exposure to debris and high water velocities at this location. It was subsequently moved up into the canyon adjacent to the new church in Gitwinksihlkw. The fishwheel turned at good speed and appeared to be fishing well. However, its catches of chinook were about 10% of those in fishwheel 1; so on 19 June it was shut down to move it to a location 30 m downstream of the suspension bridge.

Fishwheel 3 began the season with a good catch on its first night of fishing. However, by the next morning it was hitting bottom. The fishwheel was moved numerous times in the following 40 d with little success in finding a site with sufficient current and depth to operate the fishwheel properly. By mid-July, there was insufficient current or depth along the entire length of both sides of the canyon to power fishwheel 3 to a consistent speed above 1.5 RPM.

The total cost of the project was $226,000 which was $19,000 more than the 1992 project. Total labour spent on the study was 718 person days at a cost of $146,000. The labour costs include 40 days for data analysis and report writing. The capital cost, including construction of the three fishwheels (two with aluminum pontoons and holding tanks) and the purchase of a 7 m aluminum river boat was $46,000. Operating and maintenance costs for the project from 18 May - 30 September were $34,000. The operating costs included the transportation, food and commercial accommodation for the project manager and senior technician.

As in 1992, the true cost of obtaining the results presented in this report was higher than for the fishwheel budget alone. Tag recovery information and sockeye counts from the Meziadin fishway contributed significantly to the results presented here.

EFFORT AND CATCH

The fishwheels were operated on the Nass River from 9 May to 15 September (Fig. 2). The three fishwheels ran for an estimated 4,578 h (Table C-1). Fishwheel 1 operated for an estimated 1,401 h or 93% of the time it was in place; fishwheel 2 for 2,434 h or 74% of the time it was in place; and fishwheel 3 for 744 h or 72% of the time it was in place. The estimated effort for fishwheels 2 and 3 likely overestimate their effective fishing time because part of the time where they are listed as fishing these fishwheels fished at speeds that were ineffective for catching fish (1 RPM or less for fishwheel 2 and 1.5 RPM or less for fishwheel 3).

For much of the sockeye run the fishwheel effort remained fairly stable at 24 h per day (Fig. 2). However, during the occasional high water period the fishwheels were stopped and/or broke down. Fishwheel 1 fluctuated around 1.5 RPM for the first half of the season and around 2.5 RPM for the last half. By 10 August the water depth at the fishwheel 1 site had fallen to 2 m, making it impossible to operate the fishwheel. Fishwheel 2 operated at a slower speed, fluctuating around 2.0 RPM early in the season and then dropping down to between 1.5 and 0.5 RPM. By the end of August, fishwheel 2 was operating with long lags and it was obviously less efficient than earlier in the season.

A total of 16,458 fish were captured in 1993 (Table 2). The sockeye catch was the largest (10,963), followed by pink (3,944), chinook (919), coho (466), chum (99) and steelhead (67). Fishwheel 1 captured the most fish (9,971) followed by fishwheel 2 (4,840) and fishwheel 3 (1,647).

The peak catch of adult sockeye occurred with fishwheel 1 on 14 July with a daily catch of 272 and a CPE of 10.8 fish per hour (Table D-1, Fig. 3). There was a second, slightly higher peak in the CPE with fishwheel 1 on 26 July where it reached 11.7 fish per hour (based on only 15 h of fishing). The sockeye run exhibited characteristic weekly drops in abundance that were likely due to the removal of fish by the commercial fishery in the inlet (Fig. 3). As in 1992, the catches on these days were characterized by small, gillnet-marked fish.

Figure 4 shows the chinook catches and CPE for fishwheels 1 and 2. The peak catch of adult chinook occurred with fishwheel 1 on 26 June with a daily catch of 34 fish and a CPE of 1.4 fish per hour (Table D-2, Fig. 4). The first chinook was caught in fishwheel 2 on 2 June. There was a small peak of bright, summer run chinook in early to mid August with a total catch of 24 adults from 1 August to 15 August. A total of 50 chinook were caught in fishwheel 3 (Table D-3).

The peak catch of adult coho occurred with fishwheel 1 on 4 August with a daily catch of 42 fish and a CPE of 1.7 fish per hour (Table D-4, Fig. 5). Fishwheel 2 was down during this period and then fishwheel 1 stopped working on 10 August. Beyond 10 August and until 15 September, fishwheel 2 was not working effectively due to its slow speed and its low catches probably do not reflect the abundance of coho.

Daily steelhead catch was very low and showed no clearly defined peak (Table D-5, Fig. 6). In fishwheel 1, only three steelhead were caught before mid July and 45 were caught between 16 July and 10 August (when fishwheel 1 was shut down). Fishwheel 2 caught 18 steelhead and 12 of these were captured between 10 August and 13 September (when fishwheel 2 was shut down). These catches suggest that the bulk of the steelhead run moved upstream from mid July through to at least mid September in 1993. A comparison of the overall CPE between fishwheel 1 and fishwheel 2 for periods when both fishwheels were operating revealed that CPE for fishwheel 2 was only 50% of fishwheel 1 CPE.

The pink catches from fishwheel 1 showed two distinct peaks (Table D-5, Fig. 7). The first peak was on 22 July with a catch of 208 (CPE of 9.1/h) and on 3 August with a catch of 244 (CPE of 13.2/h). Fishwheel 2 showed a smaller, but similarly timed peak in July; but the August peak occurred after fishwheel 1 stopped working and was more protracted. Given the general tendency for lower catch rates in fishwheel 2 than in fishwheel 1, the bulk of the chum return moved past the fishwheels after mid August.

The chum catches showed two peaks. The smaller peak occurred in mid to late July with fishwheel 1 and in late August with fishwheel 2 (Table D-5, Fig. 8). The peak catch in fishwheel 1 was 3 fish (CPE of 0.13/h) on 22 and 23 July and the peak in fishwheel 2 was 10 fish (CPE of 0.42/h) on 31 August.

The Nass River water level quickly subsided after the spring freshet and then showed a slow steady declining trend through the remainder of the season (Fig. E-1).

TAGGING

A total of 8,862 sockeye, 825 chinook, 323 coho, and 62 steelhead were tagged at the fishwheels (Table 2). The total tag numbers represent 93%, 90%, 80% and 93% of the total catch for each species, respectively (not including fishwheel 3 catches). Of the fish tagged, 339 chinook and 52 steelhead were radio tagged and the remainder were spaghetti tagged. Fish that escaped before tagging, injured fish and sockeye and coho jacks were not tagged.

HARVESTING

A total of 1,181 sockeye were harvested from the fishwheels. There were 127 sockeye harvested from fishwheel 2 and 1,054 from fishwheel 3. Of these, 514 were given to residents of Gitwinksihlkw, 565 were given to residents of New Aiyansh and 102 were sold under the ESSR license. The remaining 119 sockeye caught in fishwheel 3 were released back to the river.

TAG RECOVERY

Over 95% of all sockeye tag recovery data were obtained from fish recovered or counted at the Meziadin fishway (4,966; Table F-1 and 3). For coho, 54% of all recoveries were at the fishway. Most of the recoveries of radio-tagged chinook were obtained through radio telemetry and carcass surveys of spawning grounds (Koski et al. 1996).

A total of 389,323 sockeye and 1,090 coho were counted at the Meziadin fishway (Table F-1). The peak count of 21,389 sockeye occurred on 17 July, just 1.5 d after staffing the fishway (Fig. 9). The count of 713 fish on the 15 July represents 2 h of counting in the evening. It is likely that a considerable number of marked and unmarked fish passed through the fishway before it was staffed (see Population Estimation section below for an estimate of the unmarked fish moving through before 15 July). The peak count of 174 tagged sockeye occurred on 26 July.

Of the 4,966 tagged sockeye observed at Meziadin, 1,554 (31%) were dipnetted out and their tag numbers were recorded (Table F-1). The remainder were simply counted as they passed through the viewing chute. Due to large numbers of fish and other extenuating circumstances, only one tag was recovered from the first 437 tagged fish observed passing through fishway during the first 5 d the fishway was staffed. There were 11 (0.7%) tag recoveries among the 1,554 where the numbers had been previously recorded as going through the fishway. This was due to either a misreading of the tag number or the tagged fish dropping back down the falls and re-ascending the fishway. Therefore, there were 1,543 recoveries used in the travel time analysis. Of the 13 tagged coho observed at the fishway, 10 were recovered and three were observed passing through (Table F-1).

POPULATION ESTIMATION

A range of Petersen population estimates for sockeye and coho salmon were computed based on the assumption that tagged fish may be selectively removed from the population and the rate of removal is probably between 0% and 20% (Table 4). The sockeye estimates ranged from 555,776 to 694,701. The computed population estimates from the run reconstruction analysis ranged from 490,900 to 610,000. Selective removal of tagged fish could have occurred as a result of several factors: 1) immediate mortality of tagged fish, 2) selective removal of tagged fish by the river gillnet fishery, 3) tag loss, and 4) poor detection of tags at the recovery site. The factors that could result in a differential rate of removal of marked fish from the population are examined below in our discussion of the mark-recapture and run reconstruction model assumptions.

An analysis of the travel time distribution of 1,543 tagged sockeye recovered at Meziadin and the numbers of fish tagged at the fishwheels suggests that there was at least 24,000 and possibly in excess of 57,000 fish that passed through the fishway before it was staffed (Table 5 and G-1). This range of values is based on a range of assumptions, from 1 in 40 of the fish captured in the fishwheels and 80% of the run going to Meziadin (24,358), to one in 80 of the fish captured in the fishwheels and 95% of the run going to Meziadin (57,850). Note that these estimates are based on the efficiency of the fishwheels early in the season and are independent of tag loss.

Our best point estimate for the number of fish passing through the fishway before 15 July is 49,325. This estimate is based on an estimate of the proportion of the run composed of Meziadin sockeye (90%, Les Jantz, DFO, pers. comm.) and our estimate of the overall efficiency of the fishwheels for 1993 of one in 72 or 1.4% (Table 5). Using the value of 49,325, our estimate of the sockeye escapement to Meziadin Lake is 438,648 (389,323 visually counted plus 49,325 not counted). The estimate of the number of fish moving through Meziadin prior to 15 July is sensitive to the overall mark rate. If the fishwheel efficiency was 2% (1 in 50) for this period, the estimate of uncounted fish through the fishway before 15 July would fall to 34,253 (Table 5; see discussion section for a description of how the estimates of fishwheel efficiencies early in the run could be bias).

We determined our best estimates of sockeye and coho escapement using a 20% differential tag removal (including the effect of under reporting). Therefore, our best estimates of sockeye and coho escapement past the fishwheel sites were 555,776 and 20,515, respectively (Table 4; see discussion section for the suspected sources of bias). Our estimate of the sockeye escapement (after harvesting above the fishwheels) is 547,095 based on an in-river harvest of 1,181 fish from the Nisga'a ESSR license, 2,500 Nisga'a food fish (Bob Bocking, LGL Limited, Sidney, B.C., pers. comm.) and 5,000 fish harvested by the Gitanyow (Les Jantz, DFO, Prince Rupert, B.C., pers. comm.). The coho estimate represents only a portion of the total run that migrated past the fishwheel site and, therefore, represents a minimum estimate only.

The proportions of the sockeye, chinook and coho run captured in the fishwheels based on the fishwheel catches and population estimates above Gitwinksihlkw, were 2.0%, 2.7%, 2.1%, respectively (see Table 6 for the range of the estimated proportions). Fishwheel 1 captured the greatest proportion of the run for all species.

RUN RECONSTRUCTION

Analysis of the 1,543 spaghetti tags recovered at Meziadin revealed a positively skewed distribution of travel times with a mode of 16 d and a mean of 19.2 d (Fig. 10, top). The mean travel times from the fishwheels to the Meziadin fishway revealed a pattern of shorter travel times in mid-July and mid-August (Table 7, Fig. 10, bottom). The longer travel times for fish tagged in late July and early August were probably a result of a significant rise in the water level of both the Nass and Meziadin rivers between 29 July and 2 August.

The mean travel times for fish tagged in late June and early July were the longest (37.0 and 29.2 d). These two means are likely biased upward because the recovery efforts at the fishway did not begin until 20 July (Table F-1). Therefore, only fish that took 18 or more days to travel to the fishway were subjected to recovery efforts, with the faster migrating fish having moved through the fishway before it was staffed. The mean travel time reached a minimum of 15 d for the fish tagged at the fishwheels from 13 to 15 August (Table 7). The standard error (SE) associated with the 3 d release periods ranged from 0.4 to 2.7 d, and SE values were less than 1.0 d in 64% of the periods.

The distributions of travel times across the periods used in the reconstruction analysis varied substantially. For example, the distribution of travel times for fish tagged from one period (22 to 24 July) was more protracted than the distribution from fish tagged earlier (10-12 July; Fig. 11).

The reconstructed abundance shows that the estimate of the efficiency of fishwheel 1 fluctuated between 0.5 and 1.1% until the second week of July, climbed to a maximum of 2.7% by mid-July, and then fell to below 1.5% by early August (Fig. 12). Beyond 10 August, the efficiency of fishwheel 2 fluctuated around 1% (Fig. 13, top).

When plotted with percent of run captured by fishwheel 1, the run reconstruction analysis suggests that the efficiency of the fishwheels was not density dependent through much of 1993 (Fig. 12). The cause of the low capture efficiencies from mid June to early July are difficult to determine and are not a result of less effort or poor operating conditions. Both fishwheels were operating through this period and water levels were sufficient to power the fishwheels to good fishing speeds. The decline of the fishwheel efficiency in early August is a probably a result of the very low water level and subsequent shutting down of fishwheel 1.

The population estimates from the run reconstruction analysis are lower than those from the Petersen method across the range of potential tag loss rates (Table 4). The run reconstruction model population estimates are less sensitive to errors in tag recovery data early in the recovery period because subsequent estimates are not affected.

Sensitivity Analysis

The model results were relatively insensitive to the model assumptions with the exception of the assumption that the capture, holding and tagging procedures did not affect the temporal distribution of the fish (migration rate). Table H-1 summarizes the results of varying the input parameters on the output. The results (estimates of the daily efficiency of the fishwheels and subsequent population estimates) indicate that the model output is sensitive to the assumption we make as to the effect of capture and tagging have on the migration rate of the tagged fish. The estimates of the daily efficiency of the fishwheel are substantially different if we assume as little as one day lag between the tagged and untagged fish (Fig. 13, top and middle). The results from assuming a greater than 1 d lag appear anomalous as the model output shows daily efficiencies declining during the first two weeks of July when we expect the efficiency to be the greatest because of the most favourable operating conditions of the season (Fig 13, bottom). In addition, the results from assuming any lag appear to be inaccurate at representing the abundance because population estimates become unrealistically high (>660,000) if we assume as little as a one day lag (Table 4).

AGE, LENGTH AND SEX SAMPLING

Total age four (28%) and total age five (67%) were the dominant age classes for sockeye (Table 8, Fig. 14). Age 5_2 and 6_3 sockeye were the largest of all age classes having each spent 3 yr at sea (63.9 and 65.5 cm, respectively; Table 9). Age 4_2 and 5_3 sockeye were also of similar size after 2 yr at sea (57.0 and 60.0 cm, respectively). The 5-yr old sockeye dominated the catch for all but the middle 3 wk of the run. The proportion of 4-yr old fish peaked in week 29 when it approached 50% (Fig. 15, top). The proportion of age 6-yr old sockeye remained relatively constant over the summer and was the largest later in the season. The age 5_2 fish were predominant early in the run, but decreased steadily over the summer while the age 5_3 fish were low early in the summer and increased steadily over the summer (Fig. 15, bottom). Tables I-1, I-2 and I-3 provide a complete summary of the sockeye age data.

Of the 4-yr olds captured in the fishwheels (brood year 1989), 94% left the freshwater environment during their second year of life (age 4_2, Table 8). Of the 5-yr olds (brood year 1988), 64% left freshwater during their 3 yr of life (age 5_3). Apart from the 4 and 5-yr olds, the remainder of the sockeye captured in the fishwheels were total age 3 (0.1%) and total age 6 (5%). The overall sex ratio for sockeye salmon sampled at the fishwheels was 44% male and 56% female.

Chinook salmon sampled at the fishwheels were predominantly 5-yr old fish (brood year 1988) that left freshwater during their second year of life (43%; Table 8). The remaining age classes of chinook were 3_2 (2%), 4_2 (27%) and 6_2 (25%). In contrast to the 1992 data where there were no "sub 1" chinook, these data suggest that 1% of the chinook that returned in 1993 had one fresh water annulus.

Age 3_2 chinook were 43.8 cm on average, age 4_2 were 65.5 cm, age 5_2 were 85.9 cm and age 6_2 were 96.2 cm (Table 9, Fig. 14). The minimum size cut-off for radio-tagged chinook was 72.0 cm and, therefore, the radio-tagged fish were predominantly age 5_2 and age 6_2. The three main age groups were represented by similar weekly proportions relative to each other through the entire run (Fig. 16, top). There was a slight tendency for the 6_2 fish to arrive later than the 4_2 and 5_2 fish.

The majority of coho salmon captured in the fishwheels were 3-yr olds (brood year 1990) that had spent 1+ years in freshwater (53%). The remaining coho captured were 4-yr old fish that left freshwater in their third year of life (45%) and 5-yr old fish that smolted in their fourth year of life (1.5%). The overall sex ratio for coho was 57.1% male and 42.9% female. Age 3_2 coho had a mean length of 55.8 cm, age 4_3 had a mean length of 59.6 cm and the four age 5_4 fish had a mean length of 53.5 cm (Table 9, Fig. 16, bottom).

DISCUSSION AND RECOMMENDATIONS

OPERATIONAL EVALUATION

Design

The new fishwheel design tested in 1993 was superior to the 1992 design for several reasons: 1) the greater structural strength and the ability to raise the baskets and live boxes out of the water resulted in fewer breakdowns (less staffing costs) and more complete data collected than with the old design; 2) the larger live boxes allowed for less frequent sampling/tagging sessions each day than last season (lower staffing costs); and 3) the three-basket design required considerably less water velocity to operate, thereby allowing the placement of the fishwheels in more protected locations and made them capable of fishing during the very low water levels (and velocities) experienced in 1993 (less down time).

The design of the baskets based on a nine-spoke wheel, with two connections to the axle for each basket and greater angles between the baskets and the bracing resulted in a very strong structure. The old design, where each basket had a single connection to the axle and bracing was done at very oblique angles (see Appendix A) was much weaker and resulted in an inefficient use of the strength of the lumber. The tower and hoist assembly on the new fishwheel made it possible to remove the valuable components of the fishwheel from the water and out of the way of debris during high water events. This reduced the down time and maintenance costs.

The new fishwheels were capable of fishing effectively nearly all of the 1993 salmon run whereas the 1992 design (fishwheel 3) operated poorly and caught a fraction (25%) of the fishwheel 1 catch during the period the two were operating at the same time. The inability to properly operate fishwheel 3 made it impossible to compare the differences in the efficiency of the new and old fishwheel designs in optimal operating conditions. However, given the low water conditions of 1993, the new design was considerably more efficient than the old, largely because of the new design's ability to operate at low water velocities.

As was found in 1992, the number of potential full-season fishwheels sites on the Nass River is limited in and around the Gitwinksihlkw canyon area. Very low river levels rendered many sites inadequate due to insufficient depth for the fishwheel to revolve. The ability to operate the fishwheel at shallow depths by raising the booms was difficult in 1993. The axle and booms were unstable when we tried to operate the fishwheel with the booms off the deck. The forward bracing for the posts (Fig. A-1) could have provided support for the boom had it been placed nearer the axle. If done, this brace would stabilize the axle boom and allow the axle and baskets to be raised while the fishwheel is still running. This feature should allow the fishwheel to operate in up to 1 m less water depth than with the axle booms on the pontoon deck.

Considering that the new fishwheel can still operate at high water, requires less staff to operate, and there is a high probability that future water levels will be similar to those observed in 1993, we recommend that future fishwheel operations on the Nass be done with the new design.

A reconnaissance trip was made to the canyon above Grease Harbour on 11 August and very similar water depths were found along the sides of the canyon as those in the Gitwinksihlkw canyon. Therefore, Grease Harbour would be of limited value in avoiding low water problems like those encountered in 1993.

Although the fishwheels catch sufficient fish to be used as a stock assessment tool, any improvement to their efficiency would increase their viability as a harvesting tool. New sites should be tested in an effort to find sites with efficiencies greater than those observed in 1992-93. Increases in the efficiency may be achieved by modifying the area around the fishwheel. The ability of the new fishwheel to operate in calmer, more protected areas may make it possible to build and operate leads that direct fish into the path of the revolving baskets (see Donaldson and Cramer 1971 for examples of leads used with fishwheels on the Columbia River).

Leads are fence like structures downstream of the fishwheels that direct fish into the fishable area of the baskets and may increase the efficiency of the fishwheels. Many fishwheel operators on the Columbia River considered leads to be a necessity for the successful operation of fishwheels (Donaldson and Cramer 1971). Unfortunately, the efficacy of leads has not been documented. Certainly the expense of constructing and maintaining leads in the Nass River would approach or exceed the cost of a new fishwheel.

In addition, deposition of the sediment load in the river around the leads may create problems with maintaining sufficient flow to operate the fishwheel.

If fishwheels are to be considered as a harvesting tool on the Nass, we recommend that new fishwheel sites be tested and that leads should be considered and sites evaluated. Any pilot project should be carefully designed. The rapidly changing physical environment (water levels, debris, river topography, etc.) and large changes in the abundance of fish over short time periods will make it difficult to separate the influences of causal factors on the efficiency of the fishwheels and to evaluate of the benefits of using leads.

Operation

Although the total cost of the project was higher than in 1992, the operating costs were considerably lower. The total cost includes the designing and construction of the new fishwheels. Three fishwheels were built in 1993 instead of the two in 1992 and the 1993 project ran longer than the 1992 project (137 d instead of 112 d). When these factors are considered, there was a significant reduction in the daily operating cost of the 1993 project. In addition, several capital expenditures ($60,000) were made on items that will last considerably longer than the 1993 field season. These items include the aluminum pontoons, tower structure used for the axle hoist, aluminum holding tanks and the 7 m aluminum river boat. If these capital costs are amortized over 5 yr, this year's operating cost would fall further. As the crew becomes more experienced and more familiar with operating fishwheels in the canyon, supervisory and training costs will decrease further.

If the fishwheels were to be used strictly as an inseason population estimation technique, it may be possible to further reduce the operating costs. This could be done by eliminating the tagging of fish if, after additional years of data, we find a consistent relationship between sockeye abundance and fishwheel catches. Without the need to tag fish, staffing levels could be significantly reduced and in years with above optimum escapement, the fishwheel catch could be harvested and sold to recover some of the costs of the operation similar to the way the existing gillnet test fishery is funded. The sale of the catch from two fishwheels could provide from $50,000 to $100,000 revenue per season.

USE OF FISHWHEELS AS A STOCK ASSESSMENT TOOL

As we found in 1992, the fishwheels were successful in capturing sufficient numbers of sockeye and chinook to be used as a stock assessment tool. More than 2,300 fish were sampled for sex, length and successfully aged. Sufficient numbers of chinook and steelhead were captured for a large scale radio-tagging project that the results were used to estimate the distribution, timing and abundance of chinook and steelhead in the Nass watershed (Koski et al. 1996).

USE OF FISHWHEELS FOR POPULATION ESTIMATION

The Petersen population estimate for the total Nass sockeye escapement (694,701 without any bias correction) was considerably higher than that estimated from the test fishery stock composition data using scale pattern analysis (450,000, scale analysis, Les Jantz, DFO, pers. comm.). Some of this difference can be attributed to the DFO estimates do not include fish moving through the fishway before it was staffed. Another source of difference may be the result of biases in each of the sampling/estimation techniques (representativeness of the scale sample, scale pattern analysis and the Petersen method).

Biases in Petersen estimates can occur when the principal assumptions of the estimation procedure are violated (p. 81-82, Ricker 1975). The relevant assumptions are:

1. The marked fish suffer the same natural mortality as the unmarked fish;

2. The marked fish are subject to the same fishing mortality as the unmarked fish;

3. The marked fish are equally vulnerable to the recapture technique as are the unmarked fish;

4. The marked fish do not lose their marks;

5. The marks are applied randomly over the entire run; and/or marked fish become randomly mixed with the unmarked fish; and/or the recovery effort is proportional to the number of fish present in different reaches of the system; and

6. All marks are recognized and reported on recovery.

In the following paragraphs we examine the assumptions of the mark-recapture method and identify possible sources of bias in our mark-recapture estimates.

1. The marked fish suffer the same natural mortality as the unmarked fish.

Higher differential mortality of marked fish has been suggested as one of the reasons why mark-recapture data tend to overestimate salmon escapements (Cousens et al. 1982). The basic argument is that increased stress during capture and handling will result in some immediate mortality of marked fish. Eames et al. (1981) provides a good review of this assumption for a variety of adult salmon tagging studies and concludes that mature salmon captured in freshwater environments are highly resistant to stress, so little (if any) tagging mortality will occur.

Direct information from our 1992 radio-tagging program indicated that mortality and other tagging losses accounted for less than 9% of the radio-tagged chinook and more than half of these losses were probably due to tag regurgitations and non-functional tags. Given the less stressful nature of our spaghetti tagging operations for sockeye and coho, we would expect lower mortality rates than that estimated for the radio-tagged chinook (i.e., less than 5%).

One additional source of selective mortality on the tagged fish is from the seals that frequent the holding areas above and below the canyon. If we assume the tagged fish spend more time in these areas recovering from the stress of handling, they would be subjected to higher predation rate than the fish not tagged. An estimate of the predation rate of seals on sockeye and coho in the Nass River would be useful in at least estimating the potential magnitude of this source of bias.

2. *The marked fish are subject to the same fishing mortality as the unmarked fish.*

Several studies have documented instances of the selective removal of tagged fish in ocean and freshwater fisheries (Gazey et al. 1983, English et al. 1984). The degree of selectivity is highly dependent on the nature of the fishery (e.g., large or small mesh gillnets) and the type of tag used. There is evidence for selective removal of spaghetti tags by gillnet fisheries. The recovery rate for the spaghetti tags applied to sockeye in the 1983 North Coast Salmon Tagging Study was five times higher in the terminal Area 4 gillnet fishery than at the Babine fence (English et al. 1984).

As a part of the 1993 Nisga'a catch monitoring program, we obtained a subsample of the gillnet catch that was visually examined. A total of 850 sockeye captured in set and drift gillnets in the Nass River upstream of the fishwheels and saw 21 tags. Albeit a small sample, these data indicated a mark rate of 1 in 40 in the gillnet catch. This estimate may be bias (exaggerate the selectivity) because catches that had a tagged fish in them may have been more likely to have been examined by the catch monitoring interviewers.

If the mark rate in the upstream gillnet fisheries was 1.8 times that observed at the Meziadin fishway in 1993 (1/40 vs. 1/73) , the harvesting effort from these fisheries (7,500 sockeye, Bob Bocking, LGL Limited, pers. comm.) could have selectively removed 85 tags from the marked population. This selective removal of 85 tags represents a fishing mortality bias of less than one percent.

3. *The marked fish are equally vulnerable to the recapture technique as are the unmarked fish.*

The recapture technique used in this study was the observation of fish in the counting chutes at the Meziadin fishway. There is nothing about the counting chutes that would bias the recapture sample. There is the potential that a portion of the marked fish moving through the fishway were not detected, and this is discussed under the sixth assumption below.

4. The marked fish do not lose their marks.

English et al. (1985) and Bocking et al. (1988) reported moderate to high rates of tag loss for spaghetti tags applied to adult pink and coho salmon. In both of these studies tag loss appeared to be related to specific taggers or the tag application method (e.g., tag knot). In studies where spaghetti tags were tied off with a single overhand hitch, there have been few incidence of tag loss (McGregor et al. 1991). When salmon are spaghetti tagged and the tag is later removed, tag entry and exit holes are readily seen and provide a form of secondary mark. If we assume that the fish tagged at the fishwheels drop back below the fishwheels before reascending the canyon, we would expect approximately 155 recaptures in the fishwheels (1.4%). As evidence that there was little or no immediate tag loss, there were 11,053 sockeye captured at the fishwheels and there were no fish observed with a tag hole and missing a tag. There were 211 sockeye recaptured at the fishwheels in 1993 (more than we would expect, probably biased upward because not all tagged fish drop out of the canyon and redistribute themselves between both sides of the canyon). In addition, over 1,000 fish were sampled for scales, length, sex and fins at the Meziadin fishway and there were no incidences reported of fish with tag holes only (i.e., missing tags).

5. The marks are applied randomly over the entire run; and/or marked fish become randomly mixed with the unmarked fish; and/or the recovery effort is proportional to the number of fish present in different reaches of the system.

This assumption is usually the most difficult to fulfil and evaluate. In this study, the release and recapture methods provided a rare opportunity to mark and recover fish continuously over the duration of the sockeye run. The daily fishwheel catch, Meziadin fishway counts and variability in travel times have been used to reconstruct the sockeye run at the fishwheel site. The unusually large sockeye return to the Meziadin provides us with a high degree of confidence that we examined a large portion of the run (probably in excess of 85%). The available data indicates that this assumption was valid for sockeye. Marks were applied randomly over the entire run. The 14-21 d travel time from the fishwheels to Meziadin along with the accumulation of fish at the fishway provided excellent conditions for mixing of marked and unmarked fish. Recovery efforts at Meziadin were certainly proportional to the number of fish present (all fish using the fishway were counted).

One could also argue that components of this assumption were reasonably well satisfied for a portion of the upstream coho stocks, but the data are much more limited than those for sockeye. At best our coho escapement estimate only represents that portion of the total coho population that migrated through the lower river in July and August on its way to upper Nass tributaries. Given the difficulties encountered with operating the fishwheels at low flows, it is unlikely that tagging was proportional to coho abundance. However, the lengthy migration to Meziadin and daily enumeration of mark and unmarked fish at the fishway provide us some confidence that a reasonable estimate can be generated for the portion of the run marked. Given the large number of coho streams in the lower Nass, the limited time period covered by the tags applied, and the potential for substantial coho returns after the tagging and recovery periods, our coho escapement estimate (20,215) probably represents a small fraction of the total coho escapement to the Nass River system.

6. All marks are recognized and reported on recovery.

Our population estimates are very sensitive to violation of this assumption. It is possible that not all tagged fish passing through the fishway were recognized or reported. The count of adult sockeye to Meziadin Lake in 1993 (389,323) was the second largest in the last 27 years the fishway has been operated and only one counting chute was operated. The density of fish in this counting chute were very high through much of the peak migration, ranging from 9,000 to 21,000 per day in the first 11 d of operation (Table F-1). There were over 160,000 sockeye counted during this period (16 July to 26 July). Considering that many fish travelled through the chute "stacked" on top off each other and that the spaghetti tag covers only a fraction of the area posterior to the dorsal fin, some tags may have been missed but the tagged fish still counted. Missing tagged fish would result in an inflation of the Petersen estimate.

Some indication that there may have been observer efficiencies of less than 100% is the observation that the percentage of marked fish was very low in the first few days of counting (mean was 0.6% of the 86,753 fish during the first 6 d). As reported in the results section, the fishwheels were fully operational during the period that these fish moved through the lower river and we would expect the proportion of fish captured to be greater than in August when the river level was much lower and there was only one fishwheel operating poorly much of the time (two until 10 August). If the actual percentage of tag fish had been 1.4% for this period, the base (bias correction) population estimate would have been reduced by 85,000 to 609,535 fish.

Other evidence that suggests tagged sockeye may not have been recognized in the counting chutes is number of spaghetti-tagged chinook that moved through the fishway unnoticed. Koski et al. (1996) found that at least one, and as many as six of the 12, spaghetti/radio-tagged chinook that passed through the fishway while it was staffed were not recorded by the observers. The uncertainty in the actual number lies in whether or not the other five missed radio-tagged chinook still had their spaghetti tags when they went through the fishway (one of the six fish was observed with its tag during carcass surveys). The overall estimate of tag loss for chinook carcasses in 1993 was 48% (Koski et al. 1996). Given that the aggressive behaviour during spawning probably accounts for much of the tag loss, the rate of tag loss for fish prior to spawning is considerably lower. It is unlikely that the remaining five missed fish that were not subsequently observed above the fishway were tagless and therefore, we could assume that the number of fish missed was in the range of three to five of the 12 tagged fish going through the fishway. These numbers represent a miss rate of 25 to 42%. The tagged sockeye would likely be more difficult to detect than the larger chinook which take up more room in the counting chute and as a result, are exposed to the observer in less crowded conditions. If 25% of the tagged sockeye were missed in the counting chutes in 1993, the unadjusted population estimate would be reduced by 173,656 fish down to an estimate of 521,045.

Although plenty of sockeye were tagged and subsequently examined to generate a precise population estimate, apparent violations of the mark-recapture assumptions made the 1992 and 1993 escapement estimates less reliable. The precision of the escapement estimates are dependent on an estimate of the differential tag removal which we have been unable to accurately estimate with data. The usefulness these (1992 and 1993) and future mark-recapture estimates will depend on determining the sources of biases and if possible eliminating them or at least quantifying them so that we can accurately correct the mark-recapture estimates. Effort should be allocated in 1994 to identify and quantify the sources of bias in the mark-recapture estimates.

The coho escapement estimate is similarly problematic. However, in addition to the violations of the mark-recapture, there are at least three other problems associated with using fishwheels to estimate coho escapement in the Nass River. First, there are few locations in the watershed to subsequently examine large numbers of fish for marks. Identifying sites besides the Meziadin fishway will help improve recapture sample sizes in the future. Second, the fishwheels appear unable to catch large numbers of coho late in the season when river levels are low. The low water level caused two problems, insufficient current to turn the fishwheels and too little water depth to allow the fishwheel to revolve without hitting the bottom. Improvement to the axle boom should allow the fishwheels to fish at shallower depths. Powering the fishwheels provides an opportunity to fish at lower water velocities. The new fishwheel design appears amenable to powering. Third, we expect that a significant portion of the Nass River coho stocks may spawn below the fishwheels. If the contribution of upriver stocks is consistent between years then the monitoring the upriver stocks may provide an index of total coho escapement. If the fishwheels are used to monitor coho escapements it should be done in concert with some other form of assessment of the lower river stocks to determine the relationship, if there is one, between the abundance of upper and lower river stocks.

In summary, we are unable to estimate the escapement of sockeye and coho with the accuracy that the precision (narrow confidence limits in Table 4) of the estimates may suggest. The results from this and previous studies would support our contention that differential natural mortality, fishing mortality, tag loss and tag detection could have accounted for up to 20% of the spaghetti tags applied to sockeye and coho salmon in 1993. As this 20% correction is only an estimate, the confidence limits are narrower than if we included uncertainty around the 20% estimate.

RUN RECONSTRUCTION

The run reconstruction model output is sensitive to the assumption concerning the effect of capturing, holding and tagging on the migration rate of the tagged fish. We chose to assume no lag in the migration rate for the tagged fish for use in the model. We expect the delay associated with the capturing and tagging procedures to be small when compared with the overall length of the migration (mean 19.2 d) and the variability around the mean travel time. During the peak migration, most of the fish were tagged during continual tagging sessions on the fishwheels. Many of these fish were tagged from a few minutes to two hours after capture. Recaptures of tagged fish in the fishwheels from this period indicate that tagged fish spent little time (<1 d) recovering.

Another factor that would minimize the observed effect of the capturing and tagging procedure on migration rates is the substantial bottleneck to migration that the Meziadin fishway creates. The entrance to the fishway is very small when compared with the width of the river at the fishway and the volume of water flowing through the fishway is a small fraction of the total flow of the river. The water around the fishway is very turbulent due to the falls. There is probably considerable mixing of new fish arriving at fishway and fish that have been attempting to ascend the falls and the fishway for several days. This delay and mixing creates variation in the travel times that could be large relative to the day or two lag due to capturing and tagging. At least some and maybe a large portion of the variation observed in the travel times from the recovered fish may be a result of this delay and mixing phenomenon (Fig. 10, top).

USE OF FISHWHEELS AS A TEST FISHING INDEX OF ABUNDANCE

Many of the aspects of fishwheel design and operation suggest that it should be an excellent in-river test fishing gear, especially for salmon species that tend to migrate close to shore. The fishwheel's most important features for test fishing are: 1) live capture, 2) its efficiency is not affected by the number of fish it catches (does not saturate), and 3) its ability to continuously sample through the day and night hours. Its greatest limitations are associated with the very specific site requirements and the potential for year to year difference in catch rates if the fishwheels must be moved or river flow conditions change.

It is likely that the limitations associated with site requirements will be less severe than the problem created by saturation of gillnet test fishing gear during peak migration periods and other, as yet undetermined, factors that affect the efficiency of the gillnet between years. For the second year in a row, the gillnet test fishery drastically underestimated the sockeye abundance. The estimate of the number of sockeye entering the Nass River derived from the Monkley Dump test fishery was 258,664 (Les Jantz, DFO, pers. comm.).

The lack of reliability of the gillnet test fishery appears to be linked the variability in its catchability. The Monkley Dump test fishery data and total escapement estimates for the past 29 years provide an estimate of the between year variation in catch rates and how the catchability tends to decrease with increasing abundance (Fig. 17). In 1992 and 1993, the end-of-the-season average catchabilities of the test fishery were 35 and 36% of the 1964-91 mean, respectively. Over the 1964-93 period the catchability varied by five fold (Fig. 17). This magnitude of change in catchability is not surprising given the very limited time periods that gillnets can be fished at the test fishery site (averaging <50 min/d) and how much the river channel can change between years.

This imprecision in inseason estimates in the past has led to an inability to effectively manage effort to meet the escapement goals. The result has been that the historical escapement is more or less a linear function of the number of fish approaching the fishery (Fig. 18). Escapement past test fishery (before in-river harvests) has been below the current target of 250,000 when the total return is less than 600,000 and over escapement occurs when the total return is above 600,000 (with the exception of one year). Without a precise inseason estimation tool to determine the magnitude of the return early, managers have been unable to reduce harvesting effort in years of low abundance nor increase harvesting effort in years of high abundance. The harvest rate appears almost independent of run strength (Fig. 19).

The magnitude of the variation in the catchability is probably not important if the variation can be predicted *a priori* by monitoring site and gear parameters on a daily basis. We recommend that the historical test fishery database be examined to determine if there are quantifiable relationships between catchability and factors affecting catchability (number of fish in the net, water level and temperatures, tides, gear dimensions, size of the returning fish, etc.)

Link et al. (1996) suggest that a large portion of the drop in catchability in 1992 may be caused by gear saturation at peak abundances. However, in 1993 the sockeye run was much more protracted than in 1992 (with correspondingly smaller daily catches) and the test fishery still substantially underestimated the sockeye escapement. In terms of reflecting the changes in abundance, the test fishery index appears to have tracked the abundance reasonable well when compared with the fishwheel catches and the reconstructed run (Fig. 18).

The problem with the test fishery index in 1993 appears to have had more to do with a large drop in the efficiency of the gear when compared with the average from previous years. The expansion factor ($1/q$) used to expand the daily test fishery catch to the daily escapement during the season in 1993 was 783. The corrected expansion factor based on an escapement of 535,776 is 1,621. The cause of this decline in the average, end-of-the-season catchability of the gear, may be due to one or more of a variety of causes. Most notably, there was a change in the operator of the test fishery vessel in 1993 and this could have affected the catchability of the test fishery. In addition, there may have been a change in the bathymetry at the test fishery site and/or a change in migration patterns of fish in and around the site.

For the fishwheels to be used as an inseason tool, the most critical period to determine their efficiency is during the first half of the run. It will be during this period that identification of the run strength is critical to effectively protecting small runs and harvesting surpluses from large runs. Unfortunately, due to staffing the fishway late, the estimates of the fishwheel efficiency from the late June to early July are the poorest. Clearly, staffing the fishway before the onset of the sockeye migration through the fishway will be of great value in assessing the usefulness of fishwheels as an inseason management tool.

Although the overall percentage of the run captured by fishwheels 1 and 2 changed very little between 1992 and 1993, the daily efficiency exhibited unexplained variation. For the fishwheels to be successfully used inseason to index the sockeye escapement, the variation in the daily efficiency must be small or, vary in a predictable manner.

The peak in the estimated daily efficiency of the fishwheels may have been caused by several factors acting alone or together. First, under reporting of tags at the beginning of 1993 would have decreased the estimated efficiency of the fishwheels early in the run, and caused the pronounced peak in estimated daily efficiencies (Fig. 12 and 13). Second, the high water levels have occurred during the periods of peak abundances in 1992 and 1993. We expect the efficiency of the fishwheels to be greater during periods of high water (for a discussion of the relationship between water level and efficiency, see Link et al. 1996). Third, the distribution of fish within the water column may change with abundance, independent of water conditions. Sockeye migrating past sonar sites on several river systems flowing into Cook Inlet, Alaska, exhibit a distinct shift in their distribution relative to shore during the peak abundances (King and Tarbox 1989). During the early and late segments of the run, the majority of the sockeye are located in the middle of the river. During the peak migration periods when most of the sockeye migrate past the sonar sites, the distribution changes substantially as the majority of the fish migrate close to shore.

In summary, although the fishwheel catches have closely followed the actual daily escapement, the data from the last two years are not sufficient to fully assess the capability of the fishwheels to provide a reliable inseason index of sockeye escapement to the lower Nass River. Additional years data are required to determine:

1. *the long term average catchability of the fishwheels so that it could be used to provide early inseason estimates of the escapement;*

2. *the causes of within year variation of the catchability of the fishwheels to improve the precision of inseason escapement estimates;*

3. *the variability in the efficiency of the fishwheels between years to assess the reliability of their indexing ability; and*

4. *resolve the ongoing questions related to tag recovery bias.*

SUMMARY AND CONCLUSIONS

The fishwheels were successful in capturing sufficiently large numbers of salmon for tagging studies which allowed us to reconstruct the daily sockeye abundances in the lower river and generate post-season population estimates for chinook, sockeye and coho. The new fishwheel design experimented with in 1993 was superior to the 1992 model and we recommend that the new design be used in the future.

The population estimates were not as accurate as we would expect with such large numbers of fish tagged and examined due to apparent violations of the mark-recapture assumptions. In order to improve the accuracy in the future, we recommend that the Meziadin fishway be staffed prior to the onset of the sockeye migration in the Meziadin River. In addition, we recommend that several initiatives be undertaken in 1994 to assess the potential sources of error:

1. *The degree of tag loss should be estimated by marking fish with a secondary mark and examining fish at the fishway for the presence or absence of the secondary mark;*

2. *The tag recognition rate at the Meziadin fishway should be determined by implementing an additional person to count or a video counting system in conjunction with the traditional method of a single person visually observing fish swimming through the counting chute; and*

3. *The degree of selective mortality of tagged fish due to the gillnet fishery should be determined by rigorously inspecting a greater proportion of the gillnet catch for tagged and untagged fish.*

The estimated daily catchabilities of the fishwheels varied less in 1992 and 1993 than the seasonal average catchabilities of the test fishery from the last 29 years data. If the variation in the estimated daily catchabilities of the fishwheels from the last two years are an indication of the inter-year variation we can expect, fishwheels may be more suitable than the current gillnet test fishery to index the sockeye abundance on an inseason basis. Additional years' data are required to determine the variation in the capture efficiency of the fishwheels between years and the source of this variation.

In both 1992 and 1993, the efficiency of the fishwheels appears to have peaked at peak abundances. The pronounced peak in efficiency of the fishwheels in 1993 may have been an artifact of errors in tag recognition at the Meziadin fishway or, alternatively, the changes in efficiency may be caused by factors affecting the catchability of the fishwheels such as temporal changes in the water level, behaviour of the fish and/or spatial distribution of fish.

To improve the precision of inseason estimates derived from fishwheels, the cause of the observed peak in efficiency needs to be determined and if possible, quantified. In addition to estimating the tag recognition rate at the Meziadin fishway, we recommend that physical conditions and the distribution of fish in the vicinity of the fishwheel sites be monitored in 1994 to test alternative hypotheses of what may cause temporal changes in the efficiency of the fishwheels.

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REFERENCES

Bocking, R.C., J.R. Irvine, K.K. English, and M. Labelle. 1988. Evaluation of random and indexing sampling designs for estimating coho salmon (Oncorhychus kisutch) escapement to three Vancouver Island streams. Can. Tech. Rep. Fish. Aquat. Sci. 1639: 95 p.

Cousens, N.B.F., G.A. Thomas, C.G. Swann and M.C. Healey. 1982. A review of salmon escapement enumeration techniques. Can. Tech. Rep. Fish. Aquat. Sci. 1108: 122 p.

Donaldson, I. J., and F. K. Cramer. 1971. Fishwheels of the Columbia. Binfords and Mort, Publishers, Portland, Oregon. 124 p.

Eames, M., T. Quinn, K. Reidinger and D. Haring. 1981. Northern Puget Sound 1976 adult coho and chum tagging studies. State of Washington, Dep. Fish. Tech. Rep. No. 64. 217 p.

English, K.K., W.J. Gazey, A.R. Maltby and J.A. Taylor. 1985. Part D. The 1984 North Coast Salmon Tagging Project. In: Gazey, W.J. and D.A. Birdsall (eds.) Design and execution of a stock interception study. Unpubl. Rep. by LGL Limited for Fisheries and Oceans Canada.

English, K.K., W.J. Gazey and J.Taylor. 1984. Part C. 1983 North Coast tagging study. In: Gazey, W.J. and D.A. Birdsall (eds.). Design and execution of a stock interception study. Unpubl. Rep. by LGL Limited for Fisheries and Oceans Canada.

Gazey, W.J., J. Taylor, K.K. English, T. Webb and D.A. Birdsall. 1983. Part B. 1982 North Coast tagging study. In" Gazey, W.J. and D.A. Birdsall (eds.). Design and execution of a stock interception study. Unpubl. Rep. by LGL Limited and ESSA Environmental Social Systems Analysts Ltd. for Fisheries and Oceans Canada.

Groot, C., and L. Margolis (editors). 1991. Pacific Salmon Life Histories. UBC Press, Vancouver, British Columbia.

King, B. E. and K. E. Tarbox. 1989. Upper Cook Inlet salmon escapement studies, 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries. Technical Fisheries Report 89-11, Juneau. 115 p.

Koski, W. R., R. Alexander, and K. K. English. 1996. Distribution, timing, fate and numbers of chinook salmon returning to the Nass River watershed in 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2371: xi + 143 p.

Link, M. R., K. K. English and R. C. Bocking. 1996. The 1992 Fishwheel Project on the Nass River and an Evaluation of Fishwheels as an Inseason Management and Stock Assessment Tool for the Nass River. Can. Manuscr. Rep. Fish. Aquat. Sci. 2372: x + 82 p.

McGregor, A. J., P. A. Milligan and J. E. Clark. 1991. Adult mark-recapture studies of Taku River salmon stocks in 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 91-05; Juneau.

Milligan, P. A., W. O. Rublee, D. D. Cornett and R. A. C. Johnston. 1985. The distribution and abundance of chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Yukon River Basin as determined by a radio tagging and spaghetti tagging program: 1982-1983. Can. Tech. Rep. Fish. Aquat. Sci. No. 1352. 161 p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 191: 382 p.

TABLES

Table 1. Estimates of salmon escapement to the Nass River, 1966-92.

	Sockeye					
Year	Meziadin	Total Nass	Chinook	Coho	Pink	Chum
1966	64,684	105,959	7,135	40,225	39,075	3,650
1967	41,278	79,228	21,450	16,850	21,750	4,950
1968	71,730	94,805	17,100	28,250	25,325	3,575
1969	135,328	179,228	25,950	14,075	6,475	600
1970	77,078	113,953	14,900	30,750	21,475	2,300
1971	191,674	246,774	13,550	25,625	41,675	2,625
1972	129,525	177,216	16,400	10,500	29,900	2,500
1973	234,627	284,082	3,250	5,150	14,036	3,350
1974	165,259	193,203	2,000	8,485	19,665	4,145
1975	54,095	70,874	4,525	10,210	52,258	250
1976	102,430	142,805	4,040	21,850	20,525	5,550
1977	242,351	399,821	6,760	28,430	131,005	725
1978	111,018	147,218	7,990	22,325	45,005	15,730
1979	200,000	212,890	6,880	13,405	24,400	3,087
1980	142,000	155,265	8,422	17,150	25,465	6,760
1981	214,193	255,643	7,250	23,365	111,190	1,980
1982	250,000	306,070	5,400	17,505	31,685	9,725
1983	170,000	185,100	7,575	21,090	574,850	4,025
1984	140,000	182,350	11,920	27,150	130,800	10,200
1985	290,000	362,540	7,402	29,739	181,254	1,850
1986	115,543	187,426	16,265	26,160	35,950	2,370
1987	143,989	184,212	7,275	21,800	162,496	1,475
1988	116,984	136,760	5,972	5,581	20,650	1,000
1989	50,000	112,307	12,075	6,600	222,860	2,035
1990	120,954	155,442	11,388	16,400	29,018	595
1991	250,000	269,848	3,309	6,027	94,550	80
1992	592,118	634,759	6,730	5,157	17,185	50
1966-91 Average	147,105	190,039	9,853	19,027	81,282	3,659

Table 2. Numbers of each species of salmon caught and tagged at three fishwheels on the Nass River in 1993.

	Fishwheel 1		Fishwheel 2		Fishwheel 3		Total	
Species	Catch	Tagged	Catch	Tagged	Catch	Tagged	Catch	Tagged
Sockeye	6245	5835	3291	3027	1427	0	10963	8862
Chinook [a]	613	556	256	227	50	42	919	825
Coho	213	164	189	159	64	0	466	323
Steelhead [a]	48	46	18	15	1	1	67	62
Chum	26	0	73	0	0	0	99	0
Pink	2826	0	1013	0	105	0	3944	0
Total	9971	6601	4840	3428	1647	43	16458	10072

a - The totals of tagged fish include radio-tagged fish: 339 chinook and 52 steelhead (see tables D-3 and D-5 for breakdown among fishwheels).

Table 3. Summary of tag recoveries for the tags applied at the Nass River fishwheels in 1993.

		Tag recoveries							
Tag/species	Number of fish tagged	Meziadin fishway	Spawning grounds [b]	Native fisheries	Sport fisheries	Fishwheel recaptures	Commercial fishery	Total [c]	Percent
Spaghetti tags									
Sockeye	8862	4996	24	48	0	211	4	5072	57
Chinook	486	11	36	42	13	32	0	102	21
Coho	323	13	2	1	1	6	1	18	6
Steelhead	10	0	0	0	0	1	0	0	0
Radio tags tracked [a]									
Chinook	339	22	214	90	5	20	0	331	98
Steelhead	52	2	35	5	1	1	0	43	83
Total	10072	5044	311	186	20	271	5	5566	55

a - See Koski et al. (1994) for a more detailed breakdown.

b - Spawning grounds outside the Meziadin system.

c - Fishwheel recaptures were returned to the river and are excluded from the totals.

Table 4. Population estimates derived from tagging of adult salmon at the Nass River fishwheels and recovery of tags at the Meziadin fishway, 1993 (see text for description of methods). Jacks were not included in the analysis.

	Sockeye			Coho
Number tagged	8,862			323
Number recovered	389,323			1,090
Number of tagged fish recovered	4,966			13
Population estimates				
		Run reconstruction		
Differential tag removal	Petersen	No dropback	One day dropback	Petersen
0%	694,701	630,478	823,784	25,249
5%	659,970	600,749	783,098	23,990
10%	625,239	570,878	742,457	22,732
20%	555,776	510,285	663,457	20,215
Bounds for Petersen estimate - No Bias				
Lower 95 % CL	675,649			15,201
Upper 95 % CL	714,289			41,168
Bounds for Petersen estimate - 20% tag removal				
Lower 95 % CL	540,535			13,686
Upper 95 % CL	571,448			37,064

Table 5. Range of estimates for the number of sockeye passing through the Meziadin fishway prior to 15 July; based on a range of fishwheel capture rates and proportion of total run that was bound for Meziadin Lake (see Table G-1 for the derivation of the 1/72 estimates).

Capture rate	Proportion Meziadin			
(1/portion)	80%	85%	90%	95%
40	**24,358**	25,880	27,403	28,925
50	30,447	32,350	34,253	36,156
60	36,537	38,820	41,104	43,387
70	42,626	45,290	47,955	50,619
72	43,844	46,584	**49,325**	52,065
80	48,716	51,760	54,805	**57,850**

Table 6. The estimated percentages of adult chinook, sockeye and coho captured with three fishwheels on the Nass River, 1993. The sockeye and coho percentages were derived using the Petersen escapement estimates and 95% confidence intervals computed with the assumption of 20% differential tag mortality (Table 4). Chinook percentages are based on the best population estimate of 33,178 (37,178 escapement to the Nass, Koski et al. 1994; minus 4,000 fish harvest below fishwheels, R.C. Bocking, LGL Ltd, Sidney, pers. comm.).

	Fishwheel 1			Fishwheel 2			Fishwheel 3			Total		
		Range			Range			Range			Range	
Species	Percent	Lower	Upper	Percent	Lower	Upper	Percent	Lower	Upper	Percent	Lower	Upper
Sockeye	1.1	1.2	1.1	0.6	0.6	0.6	0.3	0.3	0.2	2.0	2.0	1.9
Chinook	1.8			0.7			0.1			2.7		
Coho	0.9	2.4	1.1	0.8	2.2	1.0	0.3	0.8	0.4	2.1	5.4	2.4
Average	1.3			0.7			0.2			2.2		

Table 7. Means, standard errors and 95% confidence intervals for sockeye travel times from the fishwheels to the Meziadin fishway for 3 day tag release and recovery periods with greater than 3 recoveries, 1993.

Period ending date	Number of recoveries	Mean travel time (d)	Standard error	95 % Confidence Interval Lower	Upper
Release periods					
28-Jun	3	37.0	11.1	14.7	59.3
1-Jul	5	29.2	3.9	21.5	36.9
4-Jul	22	21.2	0.9	19.3	23.0
7-Jul	52	19.9	0.8	18.3	21.6
10-Jul	96	18.3	0.6	17.1	19.6
13-Jul	148	17.1	0.4	16.4	17.9
16-Jul	161	17.9	0.6	16.8	19.0
19-Jul	137	19.0	0.5	18.0	20.0
22-Jul	146	22.9	0.5	21.9	23.9
25-Jul	95	21.2	0.6	20.0	22.4
28-Jul	164	20.2	0.4	19.4	21.0
31-Jul	30	23.3	1.0	21.4	25.2
3-Aug	52	20.0	0.9	18.3	21.7
6-Aug	99	18.0	0.6	16.8	19.1
9-Aug	83	18.4	0.7	17.1	19.7
12-Aug	55	17.3	0.7	15.8	18.7
15-Aug	74	15.2	0.5	14.1	16.2
18-Aug	28	17.4	1.3	14.9	20.0
21-Aug	17	19.3	1.7	16.0	22.6
24-Aug	17	18.9	1.8	15.3	22.4
27-Aug	29	19.8	0.6	18.5	21.0
30-Aug	5	20.8	1.1	18.6	23.0
2-Sep	4	18.3	1.1	16.0	20.5
Recovery periods					
22-Jul	42	14.2	0.5	13.3	15.2
25-Jul	93	14.7	0.4	14.0	15.4
28-Jul	171	15.2	0.3	14.6	15.7
31-Jul	67	16.3	0.5	15.4	17.3
3-Aug	41	18.3	0.6	17.1	19.5
6-Aug	119	19.6	0.3	19.0	20.2
9-Aug	88	20.7	0.5	19.6	21.8
12-Aug	120	20.6	0.4	19.7	21.5
15-Aug	120	20.8	0.4	20.0	21.5
18-Aug	111	22.0	0.6	20.9	23.1
21-Aug	118	20.1	0.6	18.9	21.2
24-Aug	105	19.3	0.6	18.1	20.6
27-Aug	96	18.8	0.7	17.3	20.3
30-Aug	89	18.9	0.7	17.5	20.3
2-Sep	39	20.7	1.4	18.0	23.5
5-Sep	15	20.3	2.1	16.0	24.5
8-Sep	15	22.9	2.4	18.1	27.6
11-Sep	5	20.0	3.0	14.0	26.0
14-Sep	23	24.9	2.0	20.8	29.0
17-Sep	21	26.7	1.8	23.1	30.3
20-Sep	17	28.4	2.7	22.9	33.8
23-Sep	9	27.8	3.1	21.5	34.0
All periods combined	1527	19.2	0.2	18.9	19.5

Table 8. Sex and age composition of salmon sampled and aged from the Nass River fishwheel catch, 1993.

	Males		Females		Total	
Species/brood year/age	n	percent	n	percent	n	percent
Sockeye						
1991 21	1	100.0	0	0.0	1	0.1
1990						
31	1	0.1	0	0.0	1	0.1
32	0	0.0	0	0.0	0	0.0
Total	1	0.1	0	0.0	1	0.1
1989						
41	6	0.9	9	1.1	15	1.0
42	163	24.3	234	27.4	397	26.0
43	10	1.5	0	0.0	10	0.7
Total	179	26.6	243	28.5	422	27.7
1988						
52	203	30.2	162	19.0	365	23.9
53	243	36.2	417	48.9	660	43.3
Total	446	66.4	579	67.9	1025	67.2
1987						
62	1	0.1	0	0.0	1	0.1
63	45	6.7	31	3.6	76	5.0
Total	46	6.8	31	3.6	77	5.0
Total	**672**		**853**		**1526**	
Chinook						
1990 31	1	0.3	0	0.0	1	0.2
32	12	3.8	0	0.0	12	2.1
Total	13	4.1	0	0.0	13	2.3
1989 41	2	0.6	0	0.0	2	0.4
42	138	43.1	17	6.9	155	27.3
Total	140	43.8	17	6.9	157	27.7
1988 51	2	0.6	1	0.4	3	0.5
52	111	34.7	133	53.8	244	43.0
53	1	0.3	0	0.0	1	0.2
Total	114	35.6	134	54.3	248	43.7
1987 62	51	15.9	90	36.4	141	24.9
63	2	0.6	4	1.6	6	1.1
Total	53	16.6	94	38.1	147	25.9
1986 72	0	0.0	1	0.4	1	0.2
73	0	0.0	1	0.4	1	0.2
Total	0	0.0	2	0.8	2	0.4
Total	**320**		**247**		**567**	
Coho						
1990 32	91	56.5	53	48.2	144	53.1
1989 43	68	42.2	55	50.0	123	45.4
1988 54	2	1.2	2	1.8	4	1.5
Total	**161**		**110**		**271**	

Table 9. Mean nose-fork length (cm) by age of salmon sampled at the Nass River fishwheels, 1993.

Species	Age class	Number of fish aged	Mean (cm)	Standard deviation
Sockeye	41	15	60.3	4.0
	42	397	57.0	4.1
	43	10	44.0	0.9
	52	367	63.9	3.8
	53	661	60.0	4.3
	62	1	72.0	na
	63	76	65.5	4.3
Chinook	31	1	68.0	na
	32	12	43.8	5.5
	41	1	77.0	na
	42	155	65.5	8.1
	51	3	90.5	na
	52	244	85.9	9.0
	53	1	70.0	na
	62	141	96.2	14.2
	63	6	85.3	3.6
	72	1	96.0	na
	73	1	90.0	na
Coho	32	144	55.8	8.1
	43	123	59.6	8.0
	54	4	53.5	8.6

FIGURES

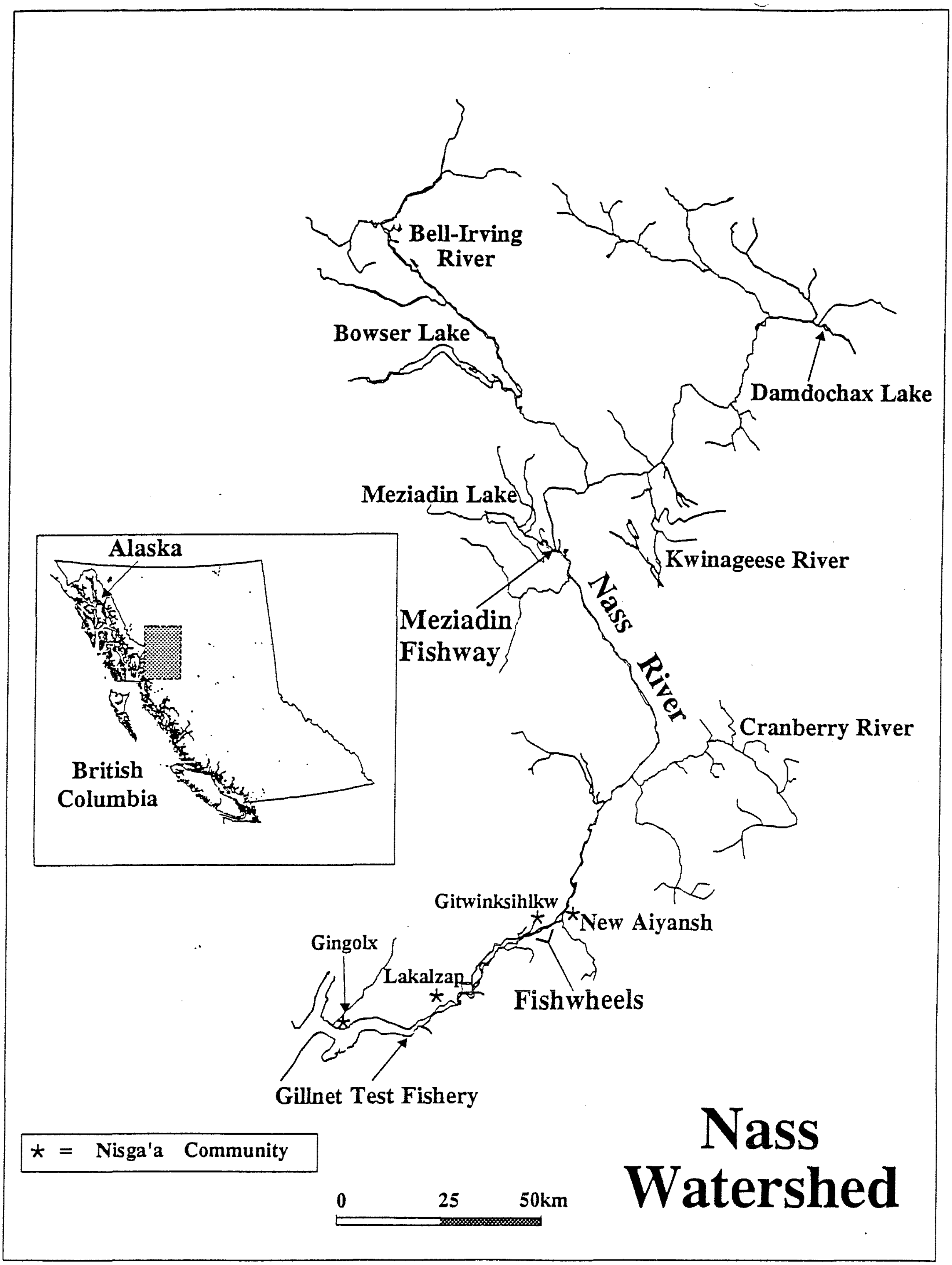


Figure 1. Nass Watershed study area.

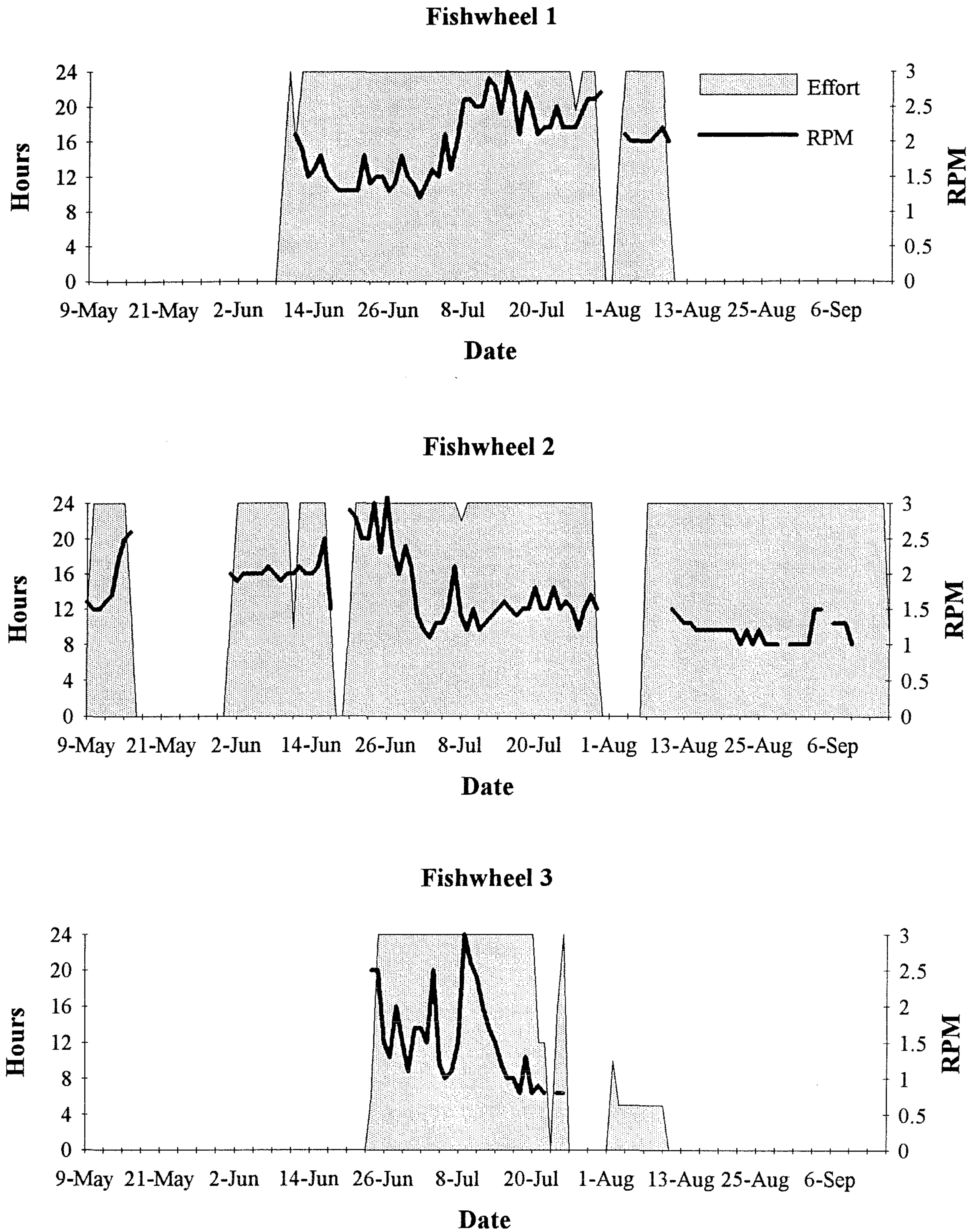
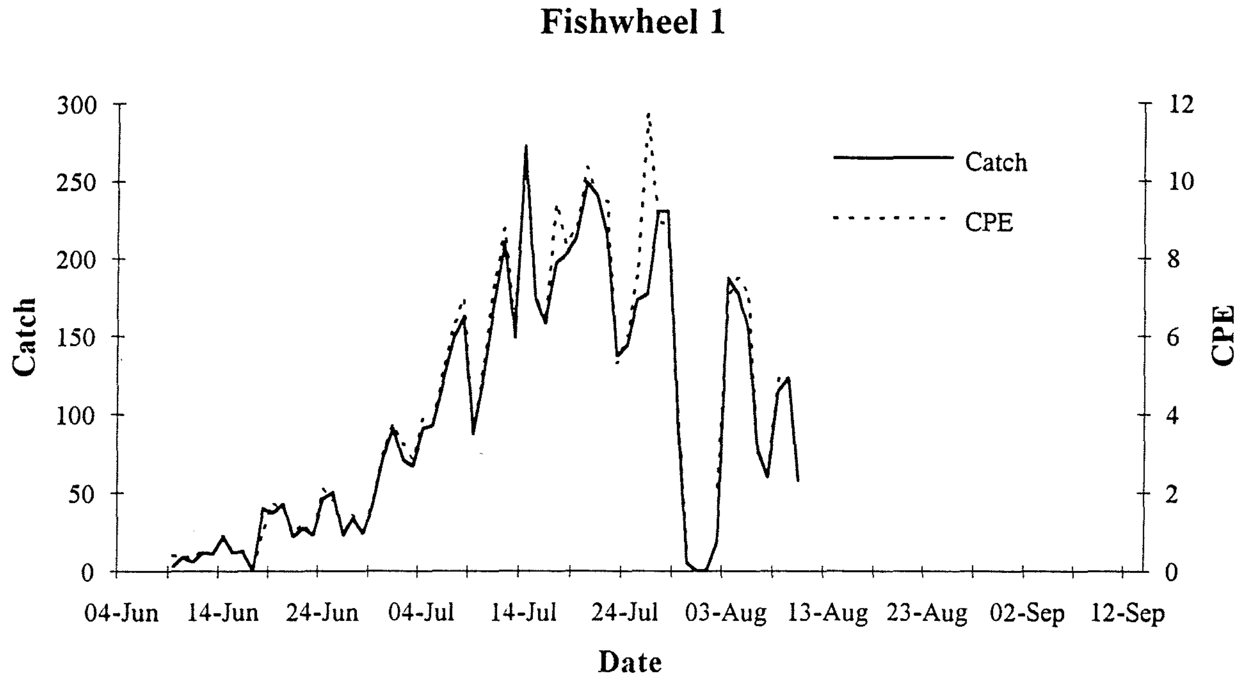


Figure 2. Fishwheel effort (hours) and speed (RPM) for three fishwheels on the Nass River, 1993.



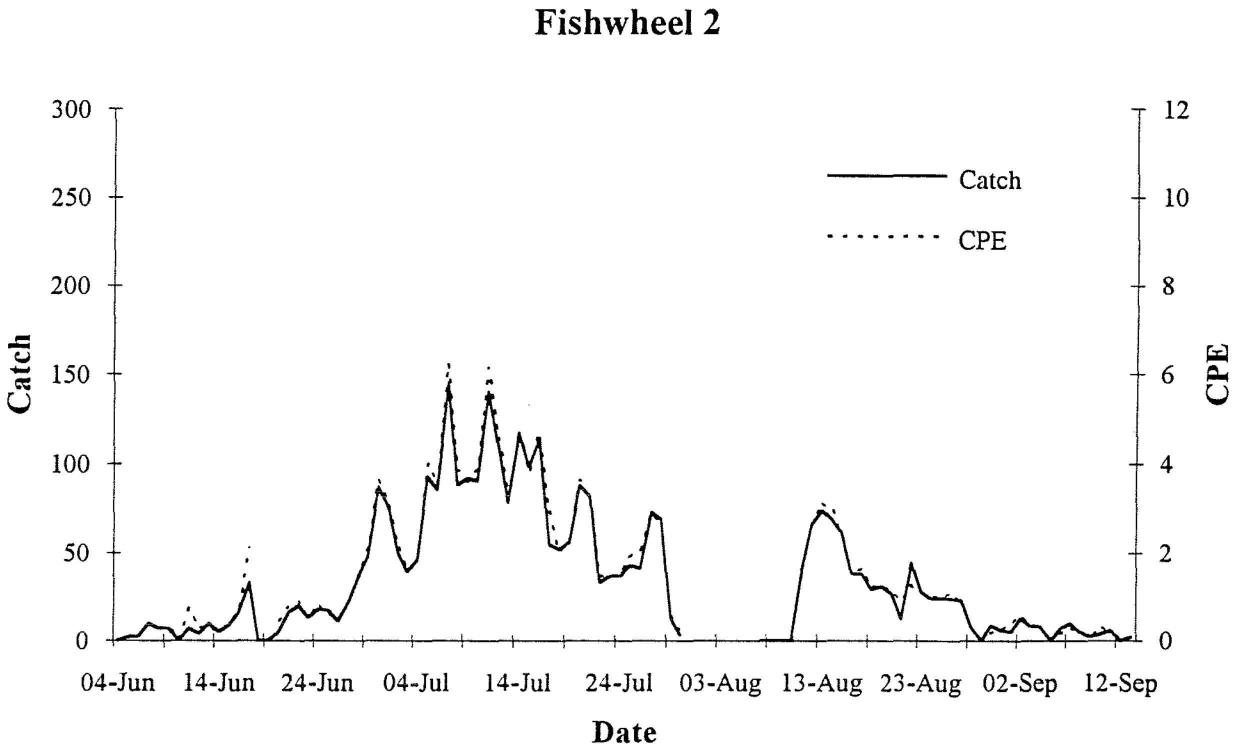
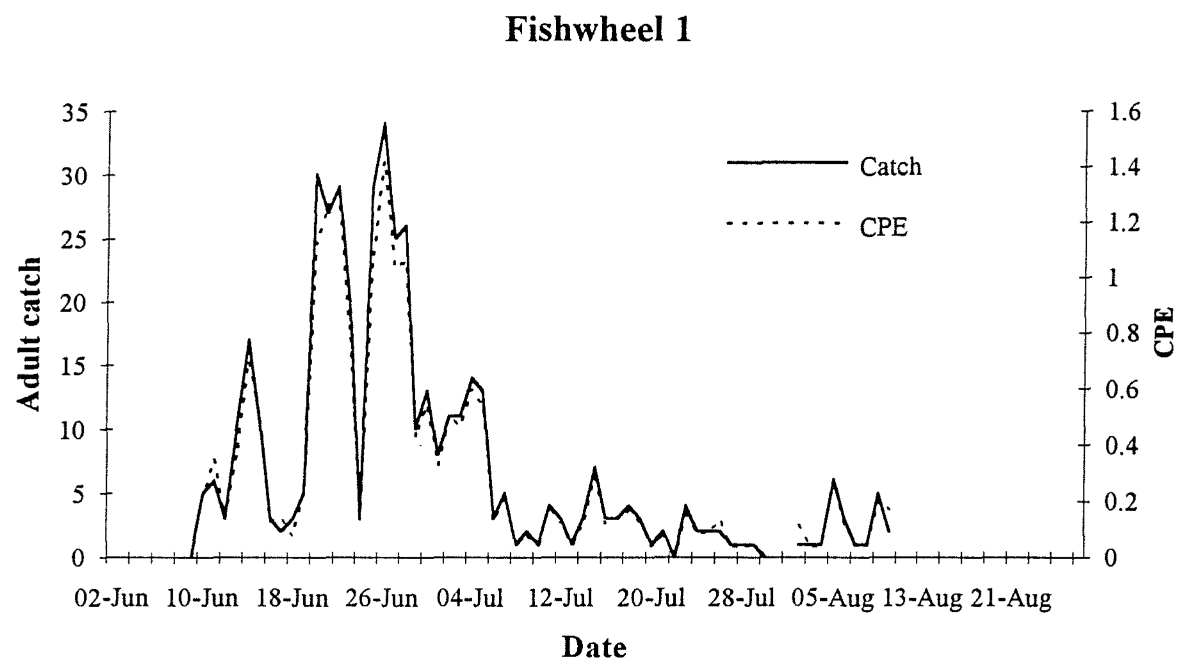


Figure 3. Fishwheel catches and CPE (catch/wheel hour) for adult sockeye salmon captured with fishwheels 1 and 2 on the Nass River, 1993.



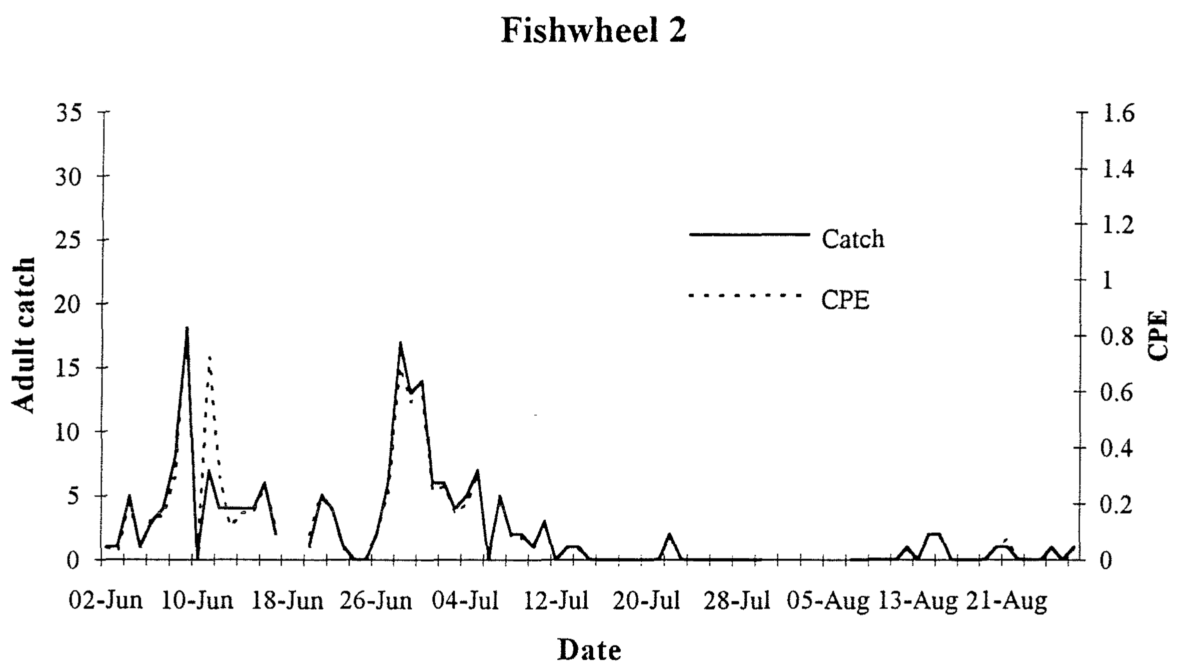
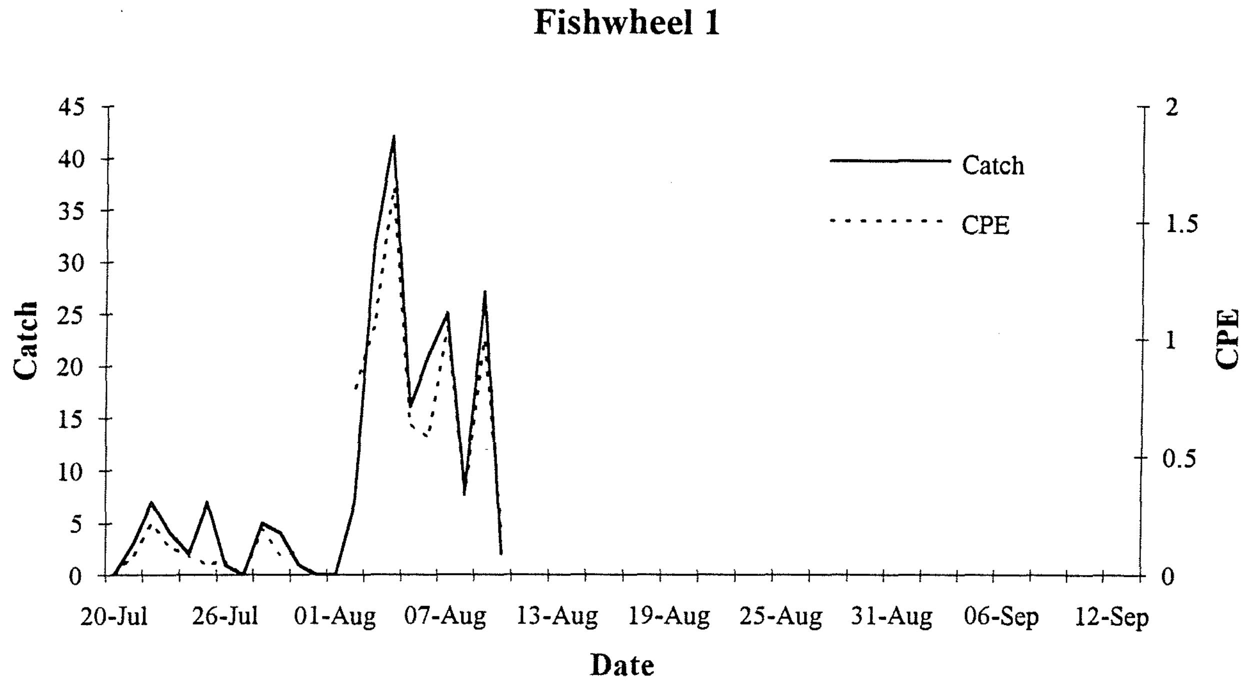


Figure 4. Fishwheel catches and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheels 1 and 2 on the Nass River, 1993.



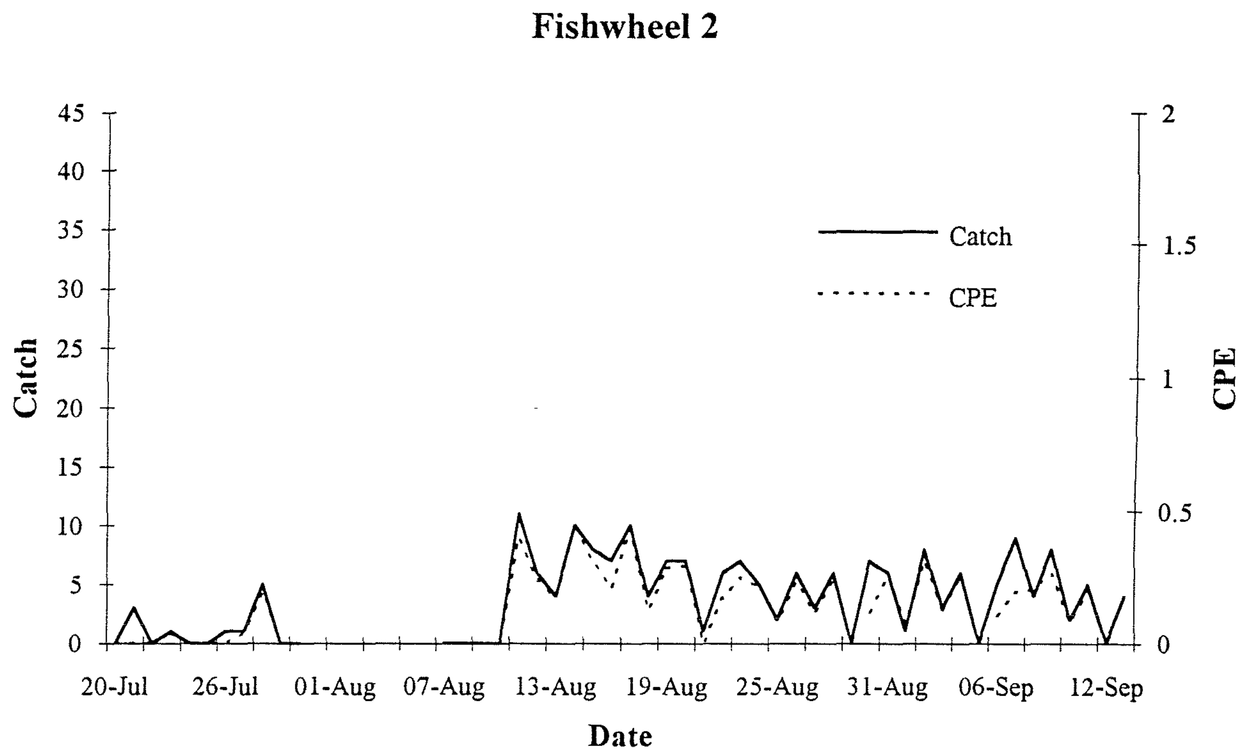
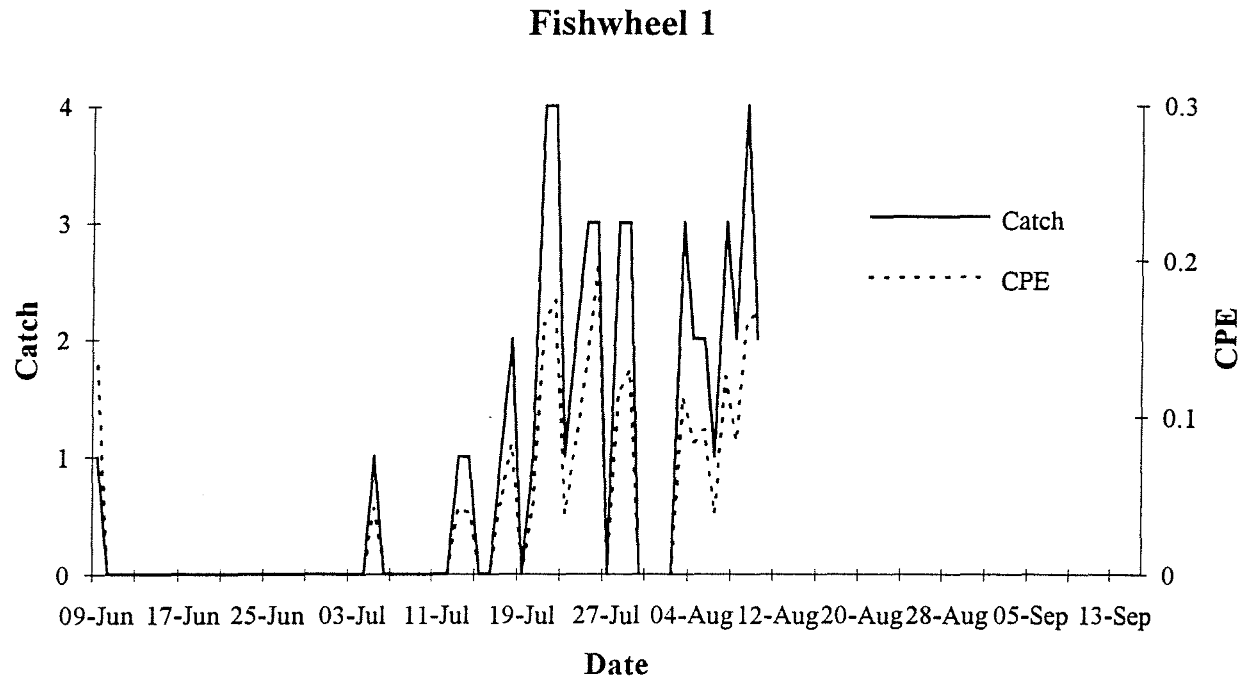


Figure 5. Fishwheel catches and CPE (adult catch/wheel hour) for coho salmon captured with fishwheels 1 and 2 on the Nass River, 1993.



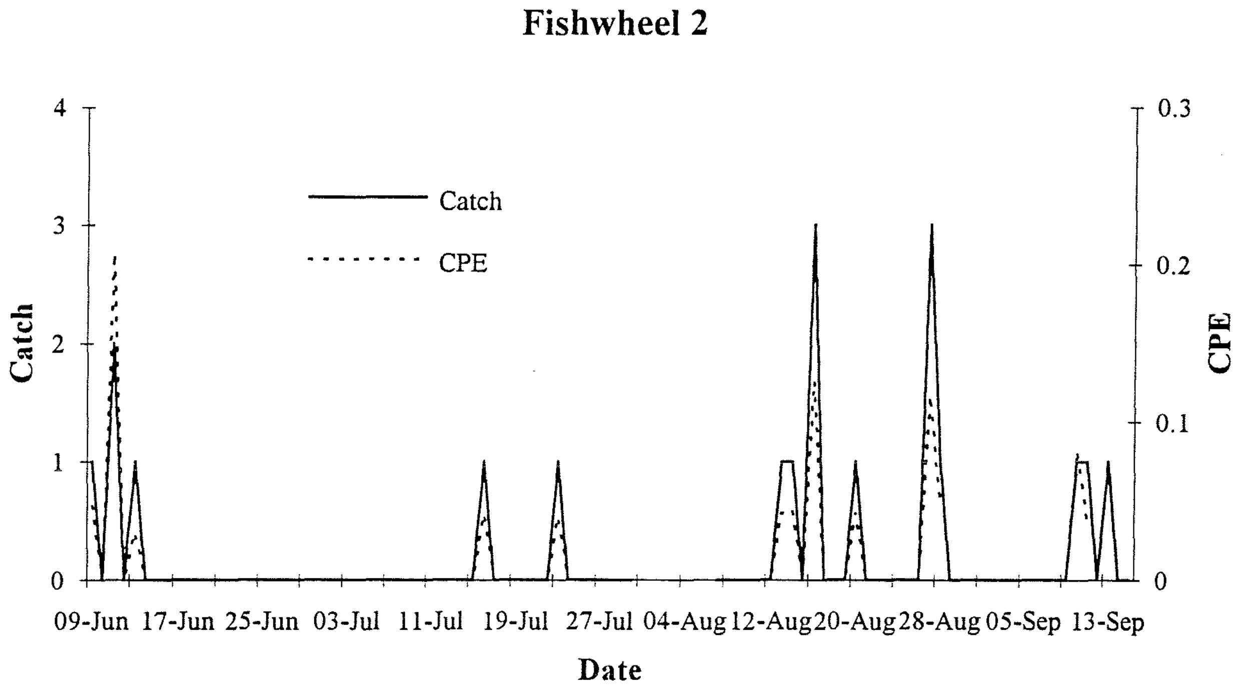


Figure 6. Fishwheel catches and CPE (catch/wheel hour) for steelhead captured with fishwheels 1 and 2 on the Nass River, 1993.

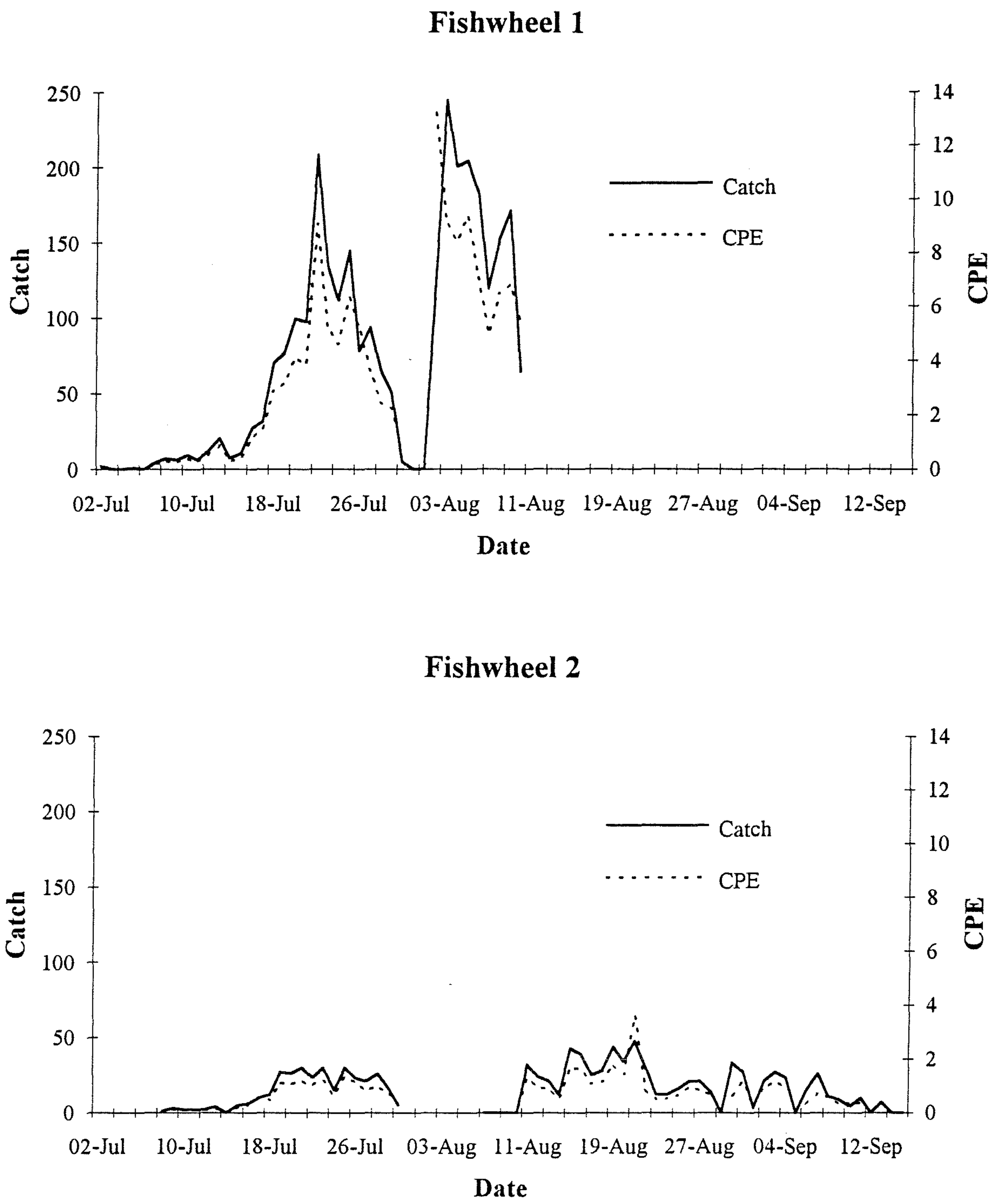
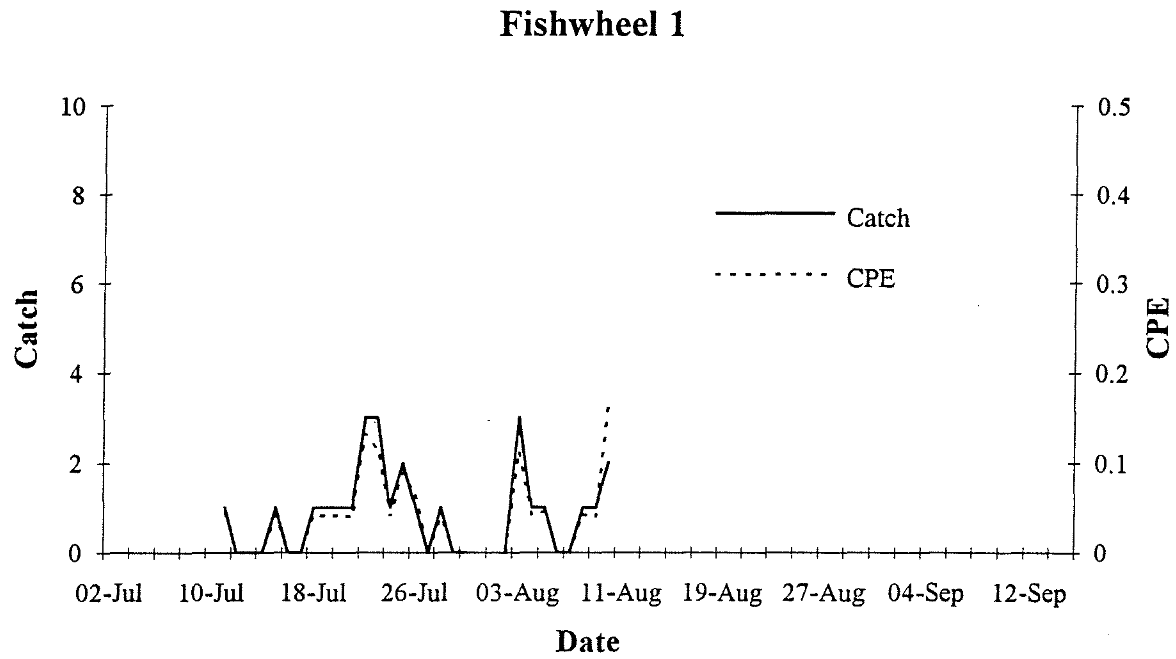


Figure 7. Fishwheel catches and CPE (catch/wheel hour) for pink salmon captured with fishwheels 1 and 2 on the Nass River, 1993.



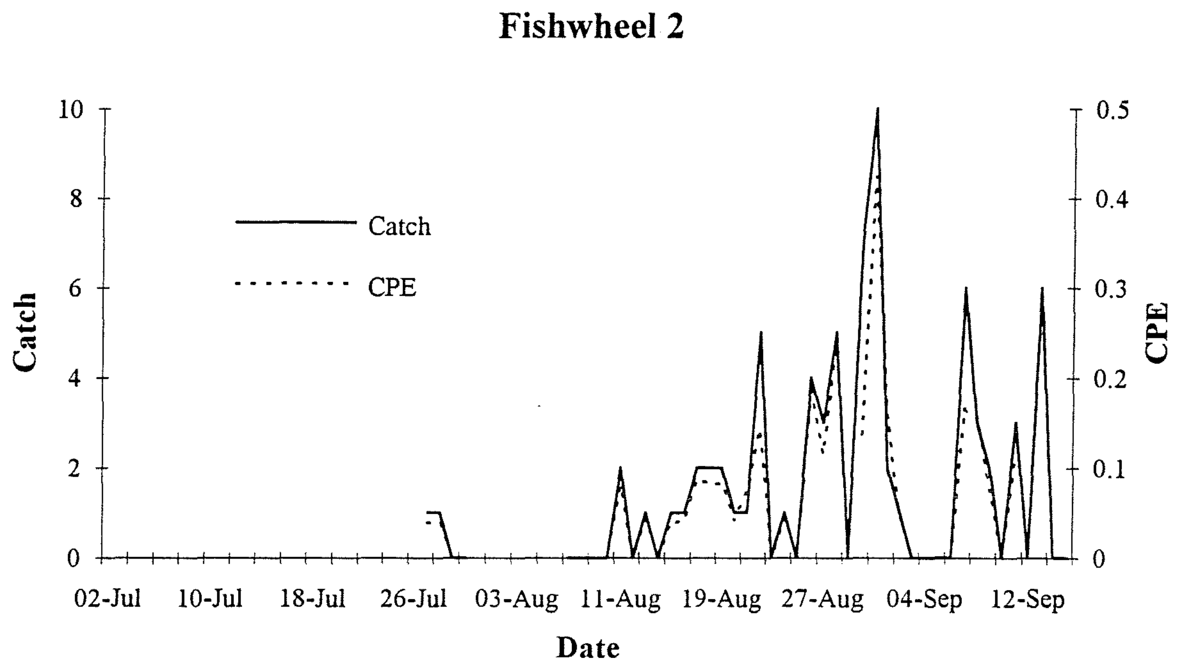


Figure 8. Fishwheel catches and CPE (catch/wheel hour) for chum salmon captured with fishwheels 1 and 2 on the Nass River, 1993.

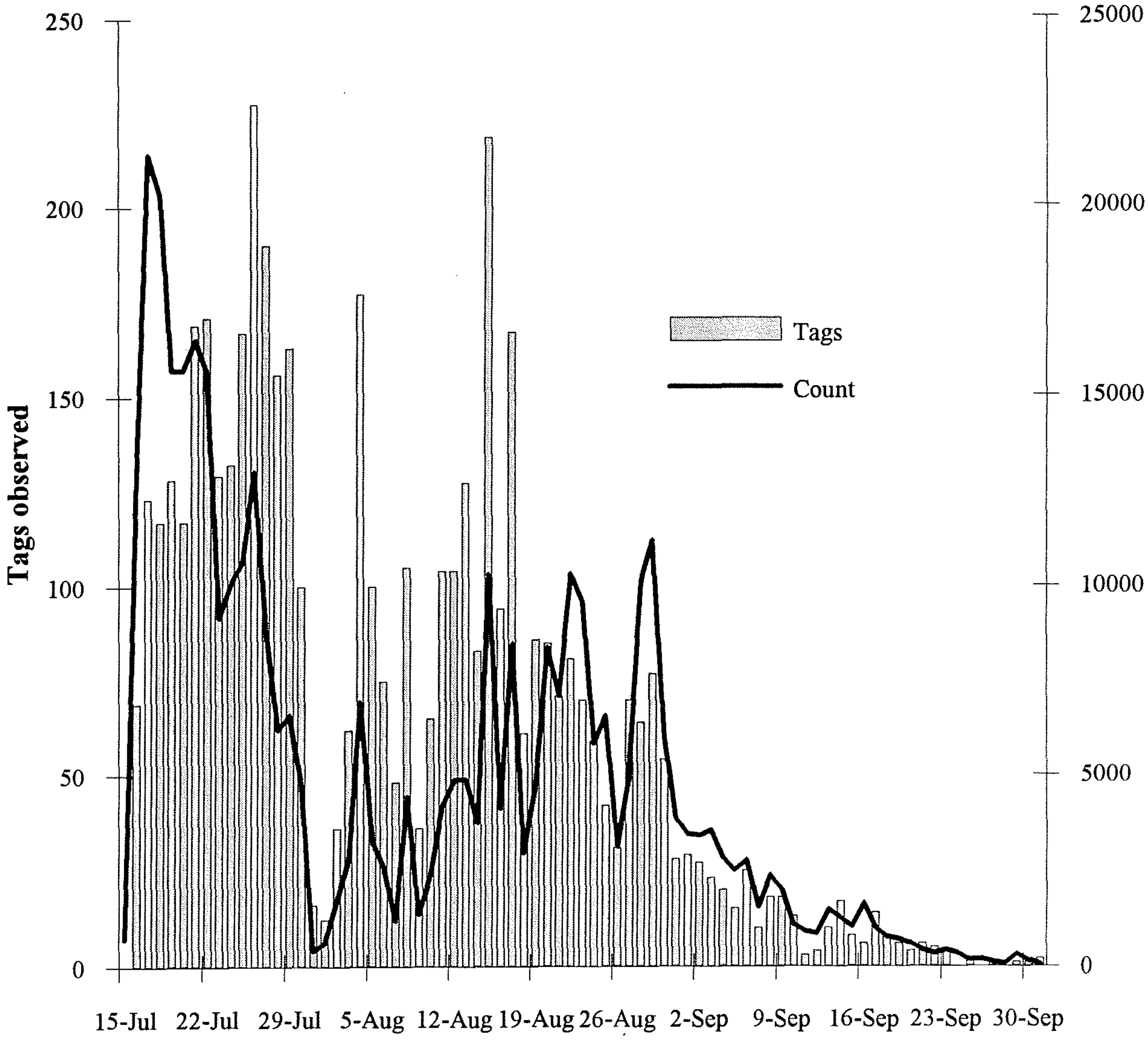


Figure 9. Daily counts of total and tagged sockeye at the Meziadin fishway, 1993. Note that count for 15 July represents only two hours of counting in the evening.

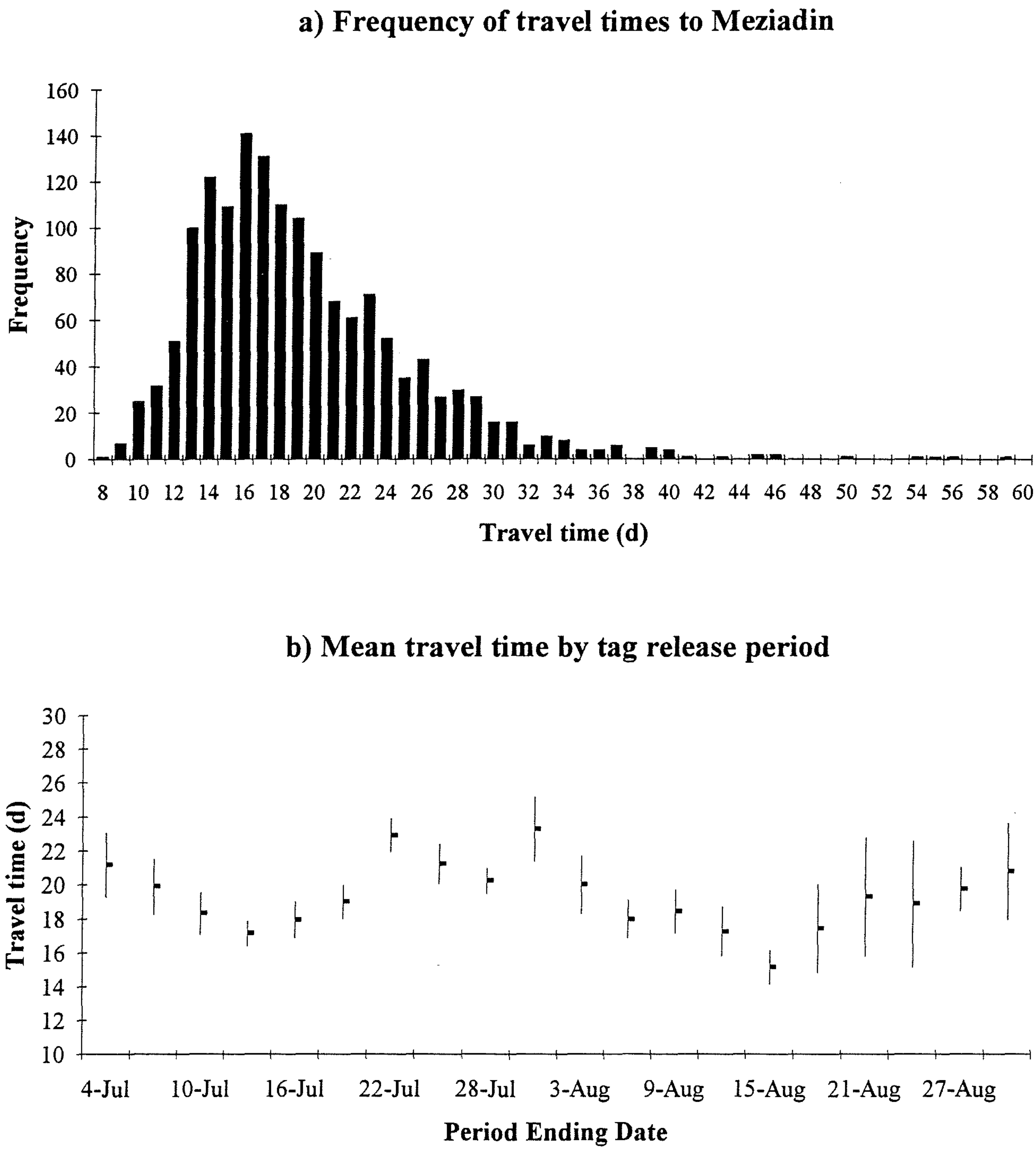
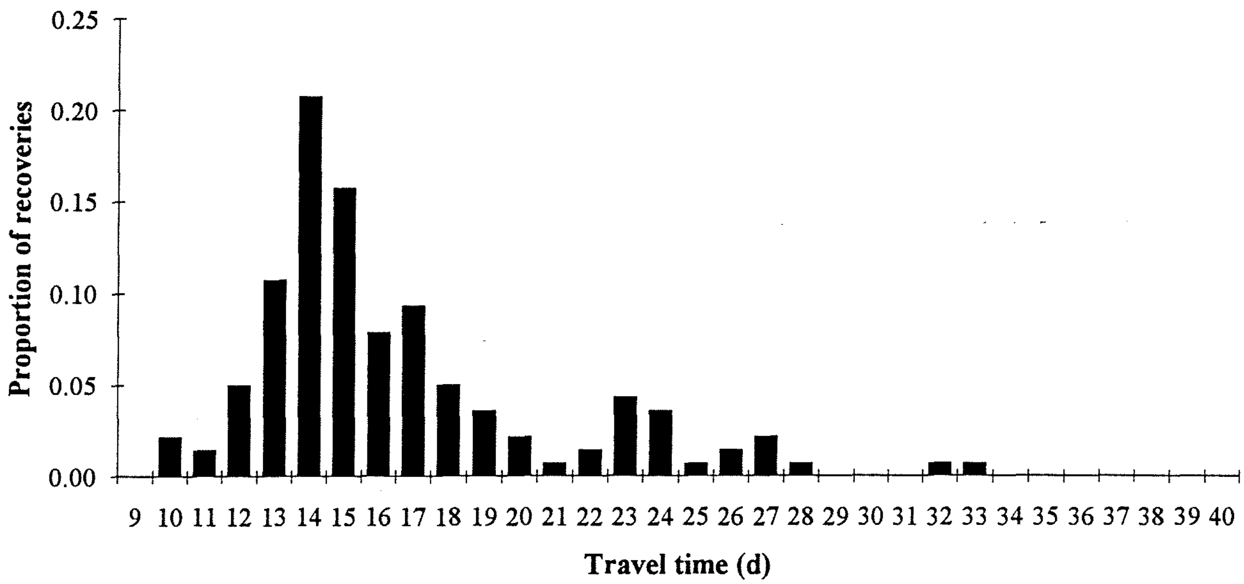


Figure 10. a) The distribution of travel times (d) to the Meziadin fishway for sockeye salmon tagged at the Nass River fishwheels and recovered at the Meziadin fishway. a) Mean travel time (with 95% confidence intervals) for 3 day tag release periods ending from 4 July to 30 August.

a) 10-12 July.



b) 22-24 July.

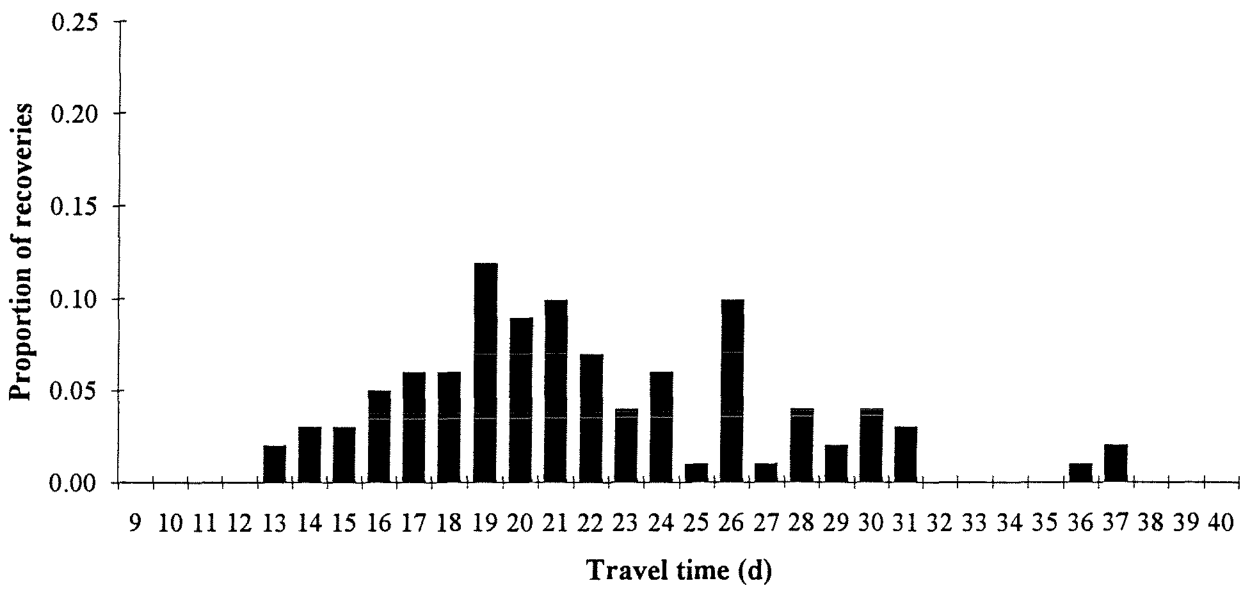


Figure 11. Distributions of travel times (d) from recoveries of tagged fish travelling from the Nass River fishwheels to the Meziadin fishway for two tag release periods (10-12 July and 22-24 July).

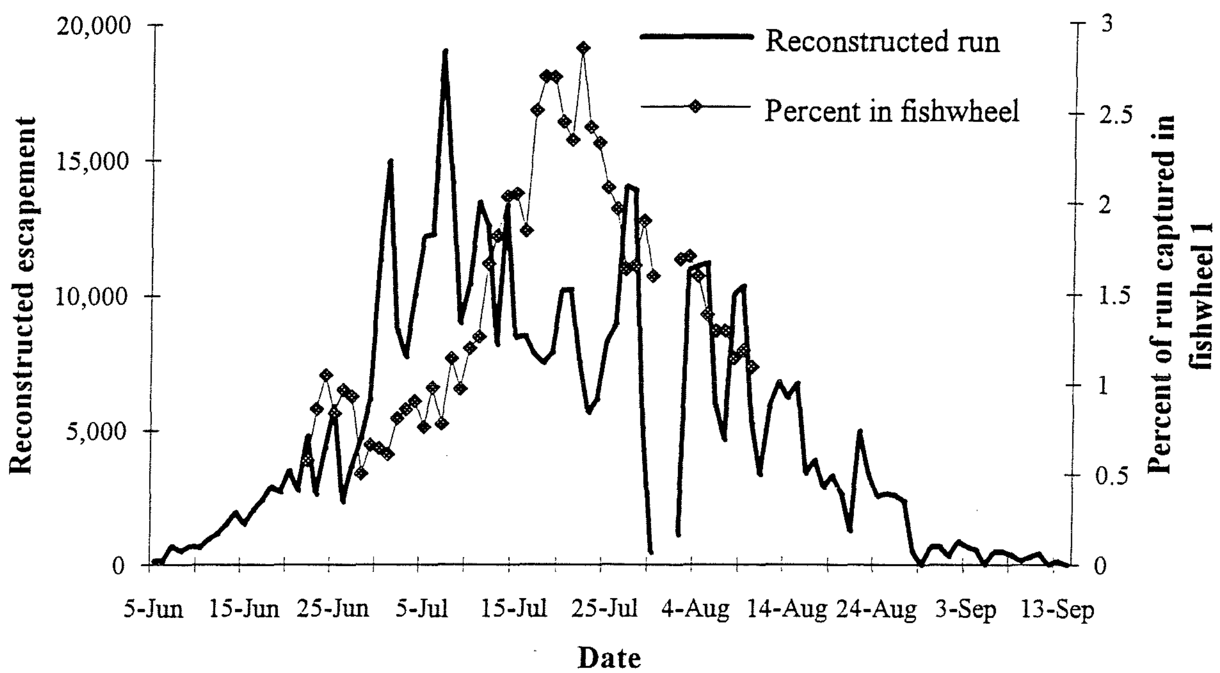


Figure 12. The reconstructed escapement at Gitwinksihlkw and the estimated percent of the run captured in fishwheel 1. Run reconstruction model output based on 3 d tag recovery periods, no lag effect due to capturing and tag survival rate of 0.8.

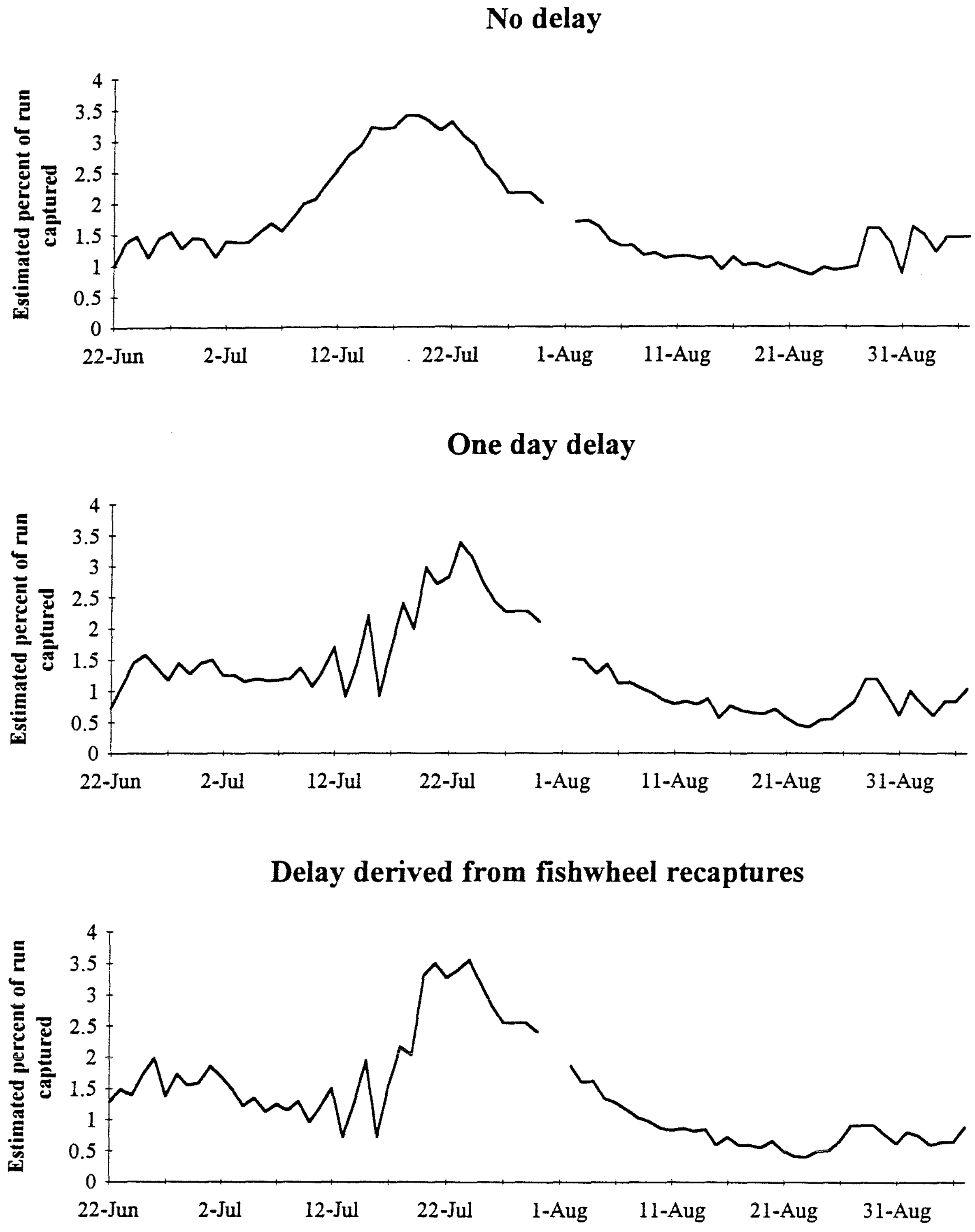
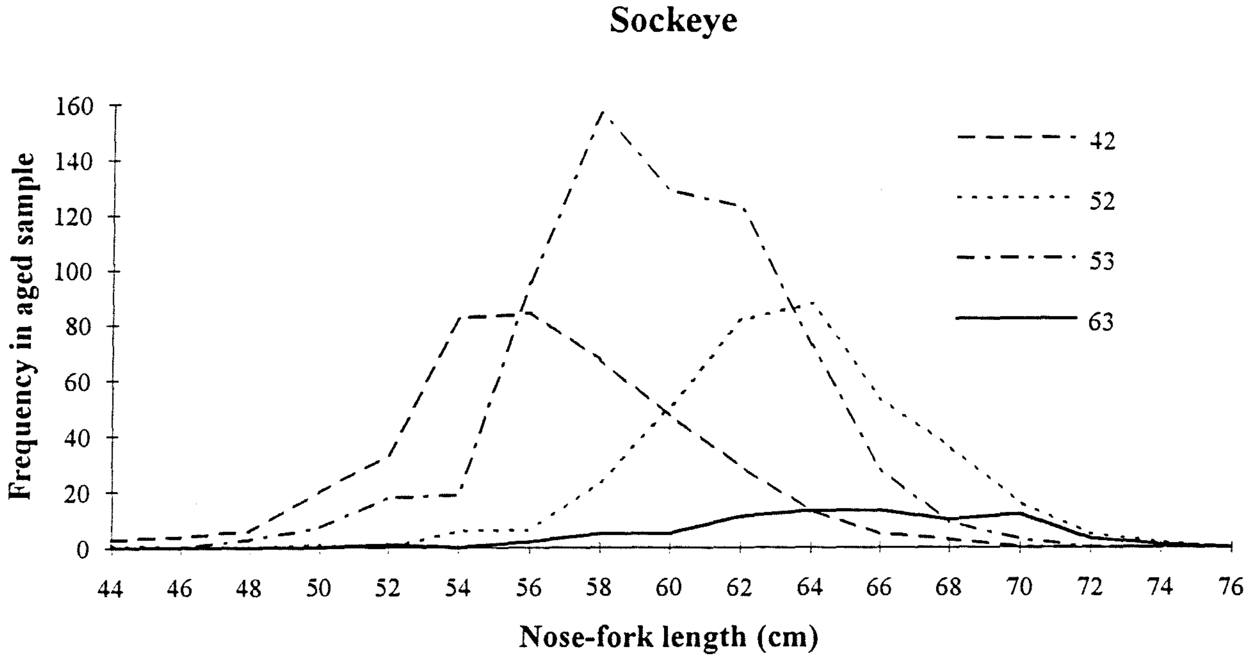


Figure 13. A comparison of model results using three assumptions about the effect of tagging on the migration rate of the tagged fish. The estimated percent captured includes fishwheel 1 and 2 catches.



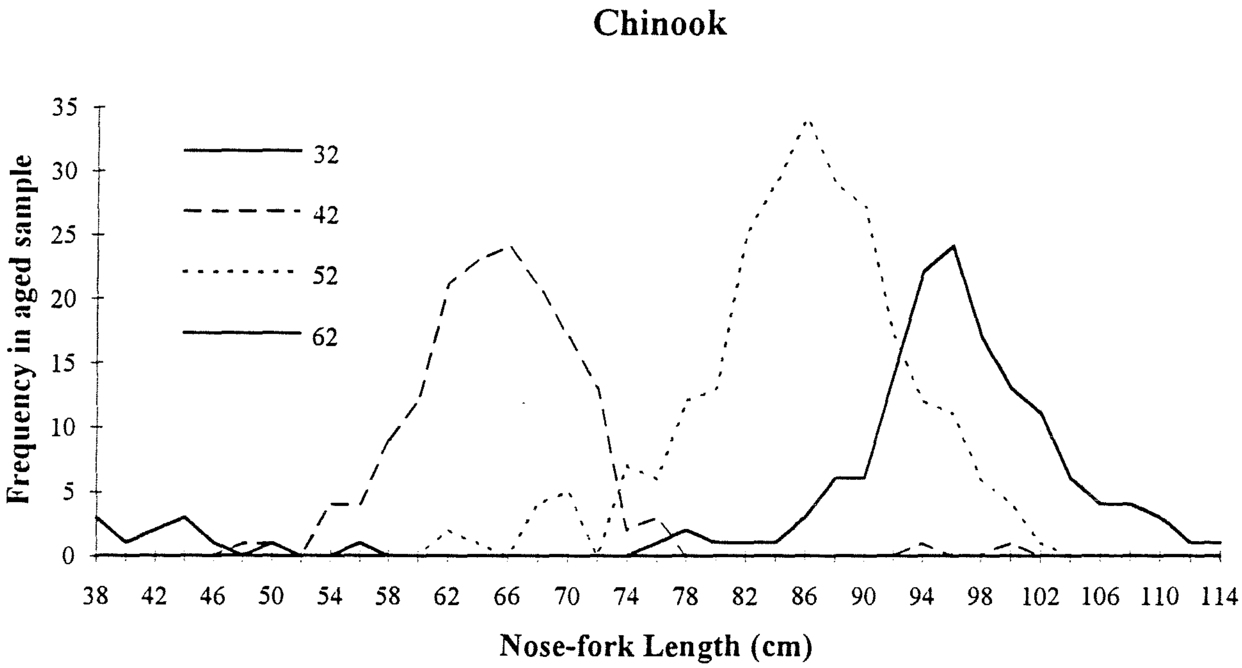


Figure 14. Age-length distributions for sockeye and chinook salmon successfully aged from the fish sampled at the Nass River fishwheels, 1993 (the less common ages were ommitted for clarity, see Table 8 for a complete age composition).

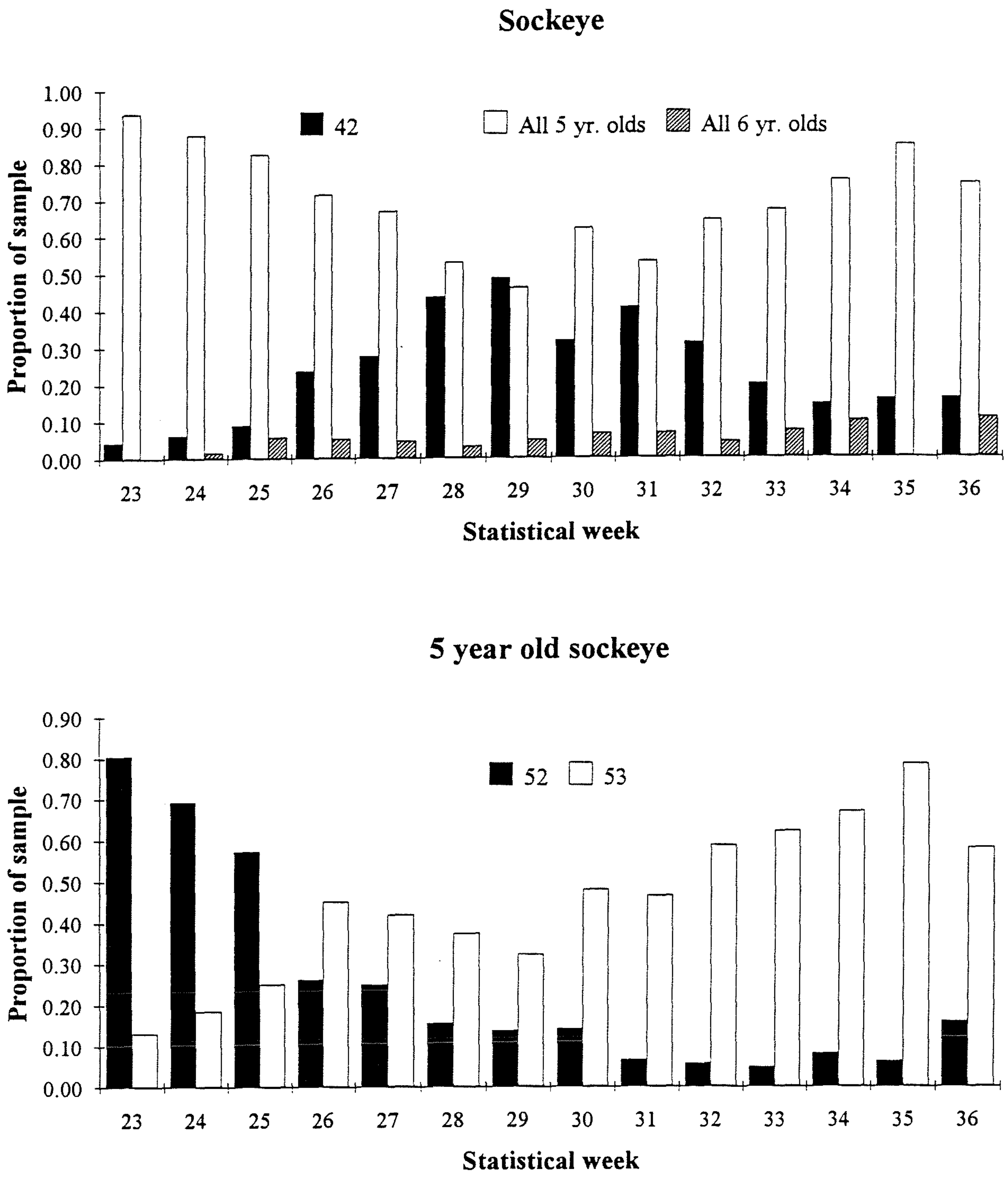
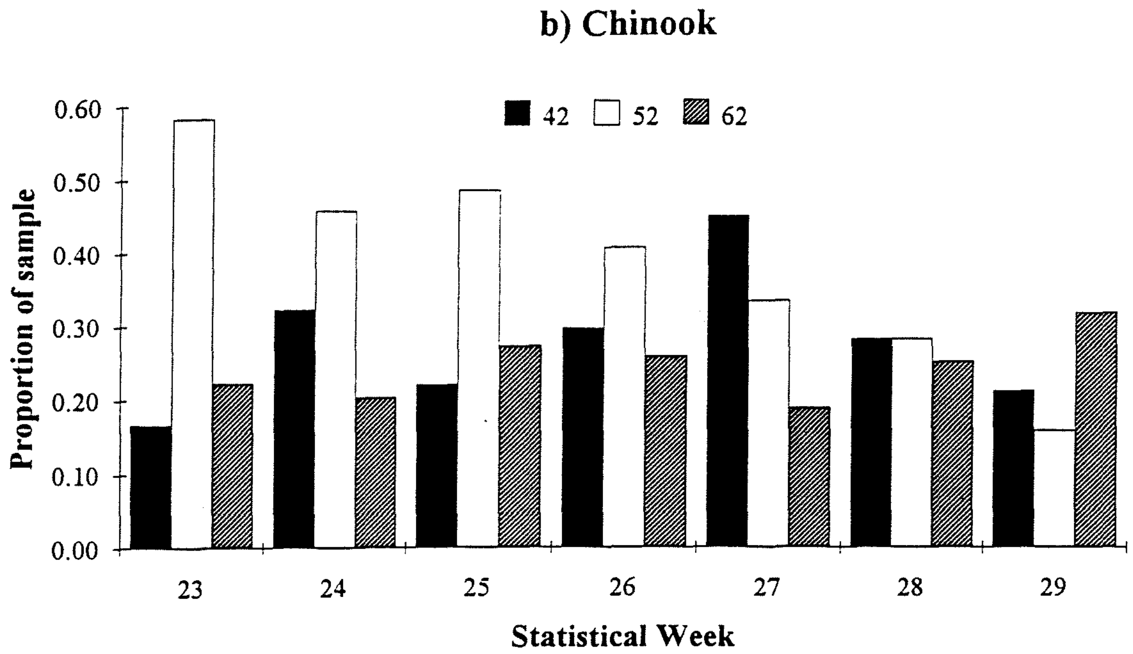


Figure 15. Weekly age composition of sockeye salmon successfully aged from the fish sampled at the Nass River fishwheels, 1993 (Most common age classes shown for clarity, see Table 8 for overall age composition of the sample).



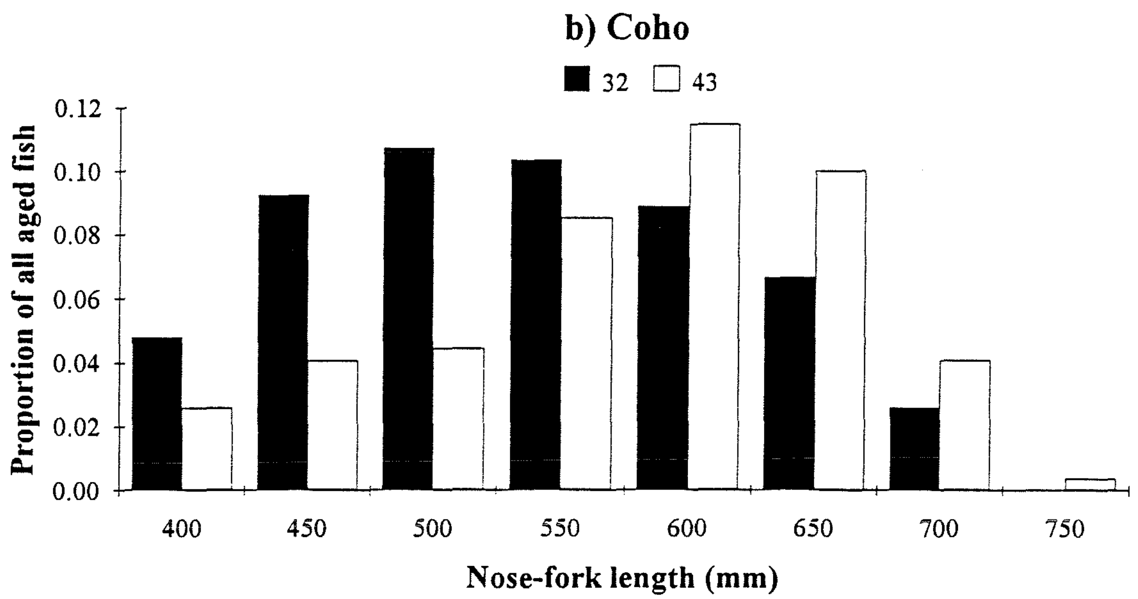


Figure 16. a) Weekly age composition of chinook salmon successfully aged from fish sampled at the Nass River fishwheels, 1993 (weeks 23-29 only, most common age classes shown for clarity, see Table 8 for overall age composition of the sample). b) Age-length frequency for coho salmon successfully aged from fish sampled at the Nass River fishwheels, 1993.

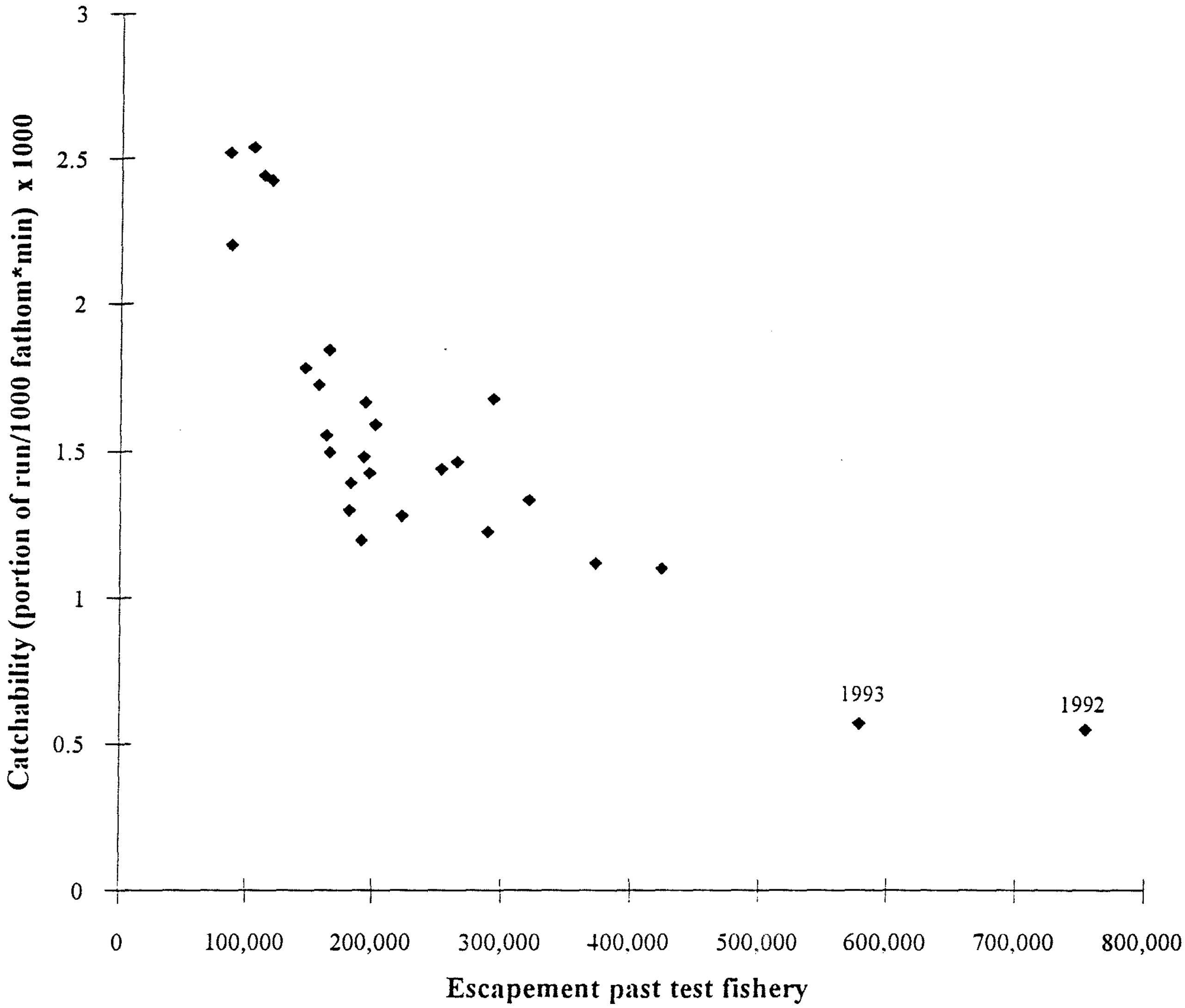


Figure 17. The relationship between the catchability (q) of the Monkley Dump test fishery and the total sockeye escapement past the test fishery, 1967-1993.

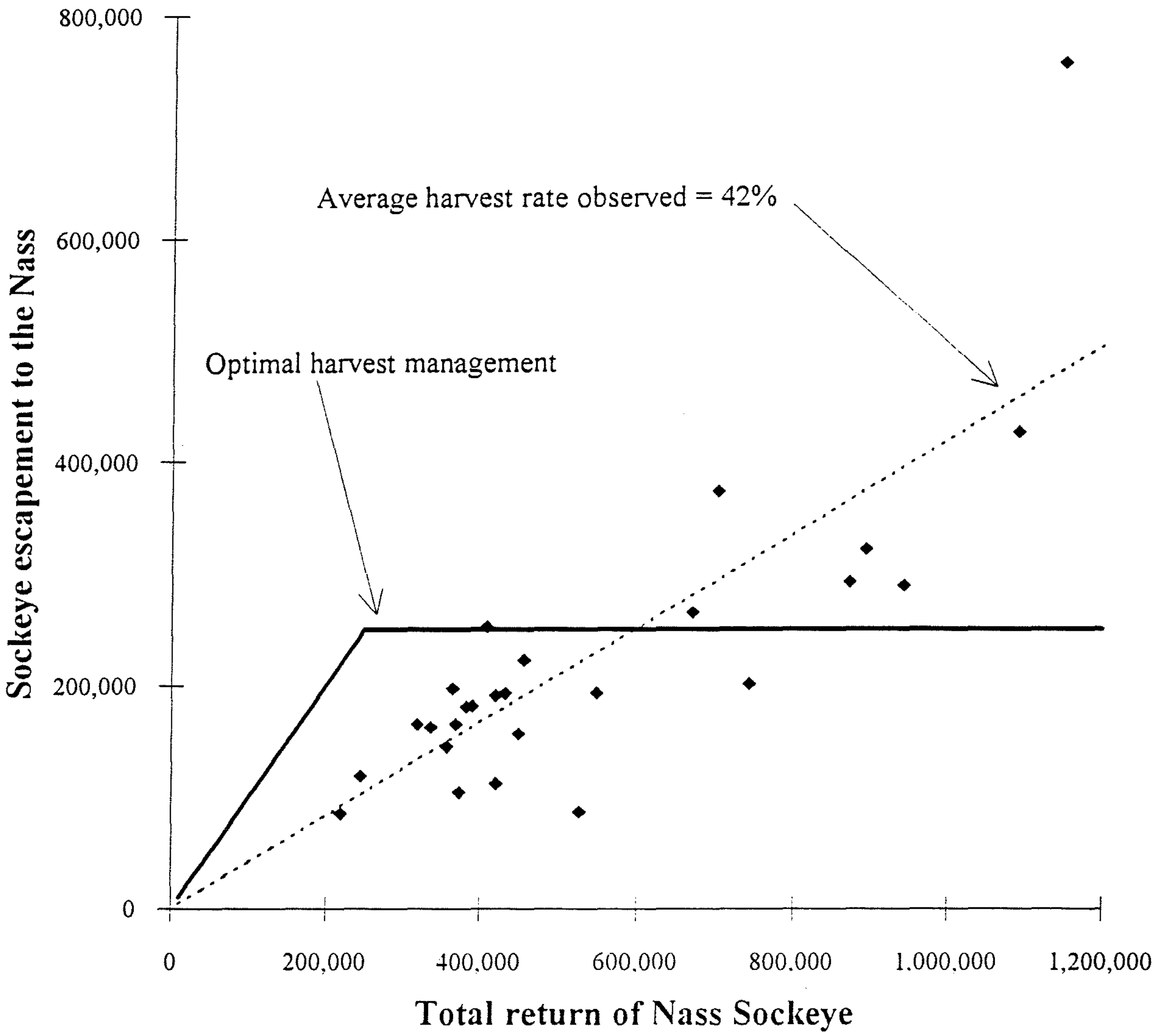


Figure 18. The relationship between the total return of sockeye to the Nass River and the escapement past the fishery, 1967-1992. Optimal management refers to perfect allocation of harvest effort to meet the current escapement goal of 250,000 (has varied historically from 200-250,000) sockeye past the test fishery. The average harvest rate was derived from the slope of the regression line fit through the data.

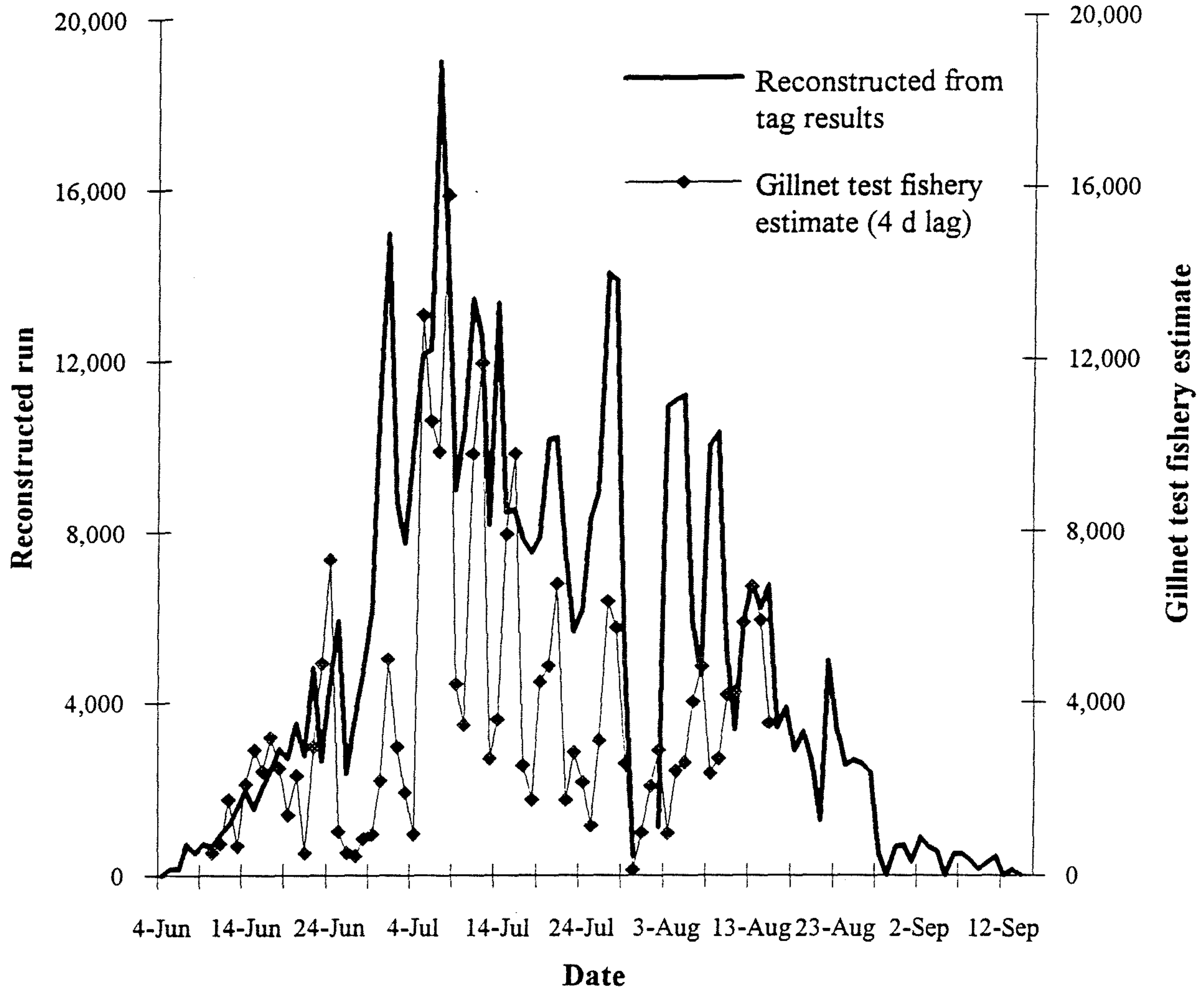


Figure 19. A comparison between the daily gillnet test fishery escapement estimates and the reconstructed escapement based on fishwheel catches and tag return information. The test fishery estimates have been lagged 4 d to account for travel time from Monkley Dump to Gitwinksihlkw. Run reconstruction model output based on 3 d tag recovery periods, no lag effect due to capturing and a tag survival rate of 80%.

APPENDICES

Table A-1. List of materials for the construction of fishwheels 1 and 2, 1993.

Component		Description	Quantity per fishwheel	Units
Aluminum Pontoons		3'x18"x36'	2	each
Cross-walks				
	main beams	3"x12"x22'	5	each
	rear middle deck	5/8" T&G plywood	3	each
	rear outside deck	5/8" std plywood	2	each
	front deck	1/2" plywood	3	each
	bolts	1/2"x 4 1/2" GRADE 5	40	each
	nuts	1/2"	40	each
	washers	1/2"	80	each
Axle				
	main shaft	4"x4" steel tube	3.7	m
	ends	14"x 2 7/16" solid steel shaft	0.7	m
	hubs	3/16" steel plate	2	sq. m
	sleeves in hub	1 1/2" x 3 1/2" steel channel	2.5	m
	bearings	2 7/16" pillow block	2	each
	bearing bolts	1/2"x6"	4	each
Baskets				
	long ribs	2"x4"x12'	12	each
	short ribs	2"x4"x10'	15	each
	end ribs	2"x4"x8"	9	each
	stringers	2"x4"x10'	24	each
	upright braces	2"x4"x10'	12	each
		2"x4"x8'	6	each
	slide	2"4"x8"	15	each
		1/2" plywood	4	each
	seine mesh	13x16 salmon bunt (3 7/8")	10	fathoms
	bolts	3/8"x2 1/2"	33	each
		3/8"x3 1/2"	36	each
		3/8"x5"	15	each
		3/8"x6"	72	each
	nuts	3/8"	156	each
	washers	3/8"	246	each
	mesh fasteners	1 1/4" fencing staples	15	lbs
Hoist				
	Winches	2000 lb boat winches	2	each
	Post	2"x6"x20'	8	each
	Boom	2"x6"x16'	6	each
	cap for posts	2"x6"x16'	1	each
		2"x8"x16'	1	each

Table A-1. List of materials for the construction of fishwheels 1 and 2, 1993.

Component	Description	Quantity per fishwheel	Units
Hoist (con't)			
	2"x4"x14'	1	each
forward brace	2"x8"x12'	2	each
rear brace	2"x8"x16"	2	each
Pin	3/4"x7" bolt with locking nut	2	each
bushing	1" dia. x 4.5" aluminum tube	2	each
bolts (for winch)	1/2"x 7"	6	each
nuts	1/2"	6	each
washers	1/2"	12	each
Rigging			
Two shorelines	1/2" wire rope	100	m
	1" poly-propellene rope	100	m
	1/2" clamps	12	each
	1/2" thimble	2	each
	5/8" shackle	2	each
Bridles and fasteners	15' and 20' of 1/2" wire rope with eyes through D-ring	1	each
	1/2" thimbles	2	each
	1/2" clamps	6	each
	1"shackle	2	each
	5/8" shackle	2	each
	3/4" poly rope bridle	15	m
Tow line	1" poly-propellene	30	m
Boom line	5/16" wire rope	24	m
	5/16" clamps	4	each
	5/16" thimble	2	each
	3/8" wire rope	2	m
	3/8" clamps	4	each
	3/8" shackles	2	each
Boom line blocks	4" steel blocks (pulleys)	3	each
	5/16" wire rope	2	m
	5/16" clamps	8	each
hoist bracing	1/4" wire rope	14	m
cable clamps	1/4"	8	each
thimble	1/4"	4	each
5/16" x 4 1/2 " hook & eye turnbuckles		2	each
eye bolts	3/8"x 4 1/2"	4	each
Miscellaneous			
screws	1 3/4" flooring screws	5	lbs
nails	3 1/2" common	50	lbs
waterproof glue		10	litres

Table A-1. List of materials for the construction of fishwheels 1 and 2, 1993.

Component	Description	Quantity per fishwheel	Units
Miscellaneous (con't)			
dock cleats	12"	3	each
drill bits	1 3/8" wood	1	each
	1" wood	1	each
	3/4" steel	1	each
	1/2" steel x 5"	2	each
	3/8" steel x 5"	1	each
	3/8" x 10" steel	1	each
	1/4" steel	2	each

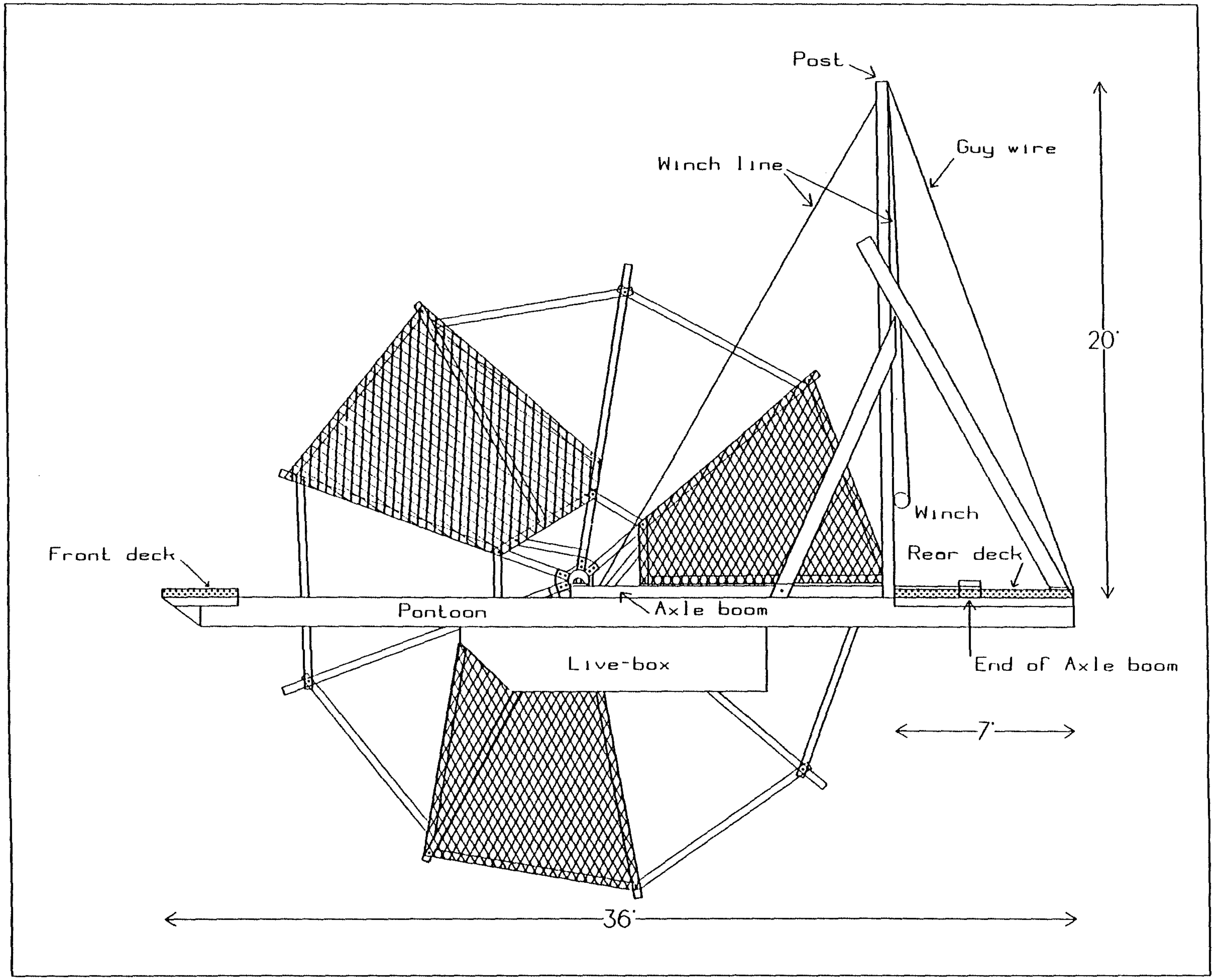


Figure A-1. Side view of an aluminum pontooned fishwheel used on the Nass River, 1993.

Table A-2. List of materials for the construction of fishwheel 3, 1993.

Component	Description	Quantity
Axles		
main shaft	4"x4" steel tube	4.25 m
shaft ends	1 15/16" dia. steel	0.65 m
basket brackets	3"x3" angle iron	6.5 m
bearings	1 15/16" pillow block bearings	2
Rigging		
shore anchor line	5/8" wire rope	75 m
safety line to shore	1" poly-propylene rope	100 m
fasteners for bridle and anchor line	5/8" shackles	3
safety line	1" shackles	1
shoreline fasteners	5/8" cable clamps	10
	5/8" thimbles	4
	6" custom braced eye bolts	2
	5/8" D-ring	1
Lumber		
decking, holding boxes, bracing	1/2"x4'x8' plywood	25
fish slides inside baskets	5/8"x4'x8' plywood	4
cross-walks	4"x12"x22' planks	4
pontoons	2"x12"x12'	28
axle and live box mounts	4"x4"x8'	4
uprights, holding boxes and paddles	2"x6"x10"	8
live boxes	2"x6"x8'	12
basket braces	2"x4"x16'	4
basket braces	2"x4"x14"	4
basket ribs	2"x4"x12"	4
basket ribs, slide braces	2"x4"x10"	21
live boxes and assorted bracing	2"x4"x8'	14
Flotation		
flotation inside pontoons	10"x20"x8' closed cell foam billets	8
Hardware		
assorted fastening	3.5" common nails	10 kg
bolt baskets to axle	3/8"x3.5" bolts, with washers and nuts	20
bolt upright framing to baskets	3/8"x5" bolts, washers and nuts	20
bolt upright framing to baskets	3/8"x6" bolts, washers and nuts	10
bolt upright and bracing together	1/2"x6" bolts, washers and nuts	4
bolt live boxes to pontoon	3/8"x4" lag bolts	8
assorted fastening	3/8"x5" lag bolts	16
hold spar log in place	14" custom steel spar log keeper	2

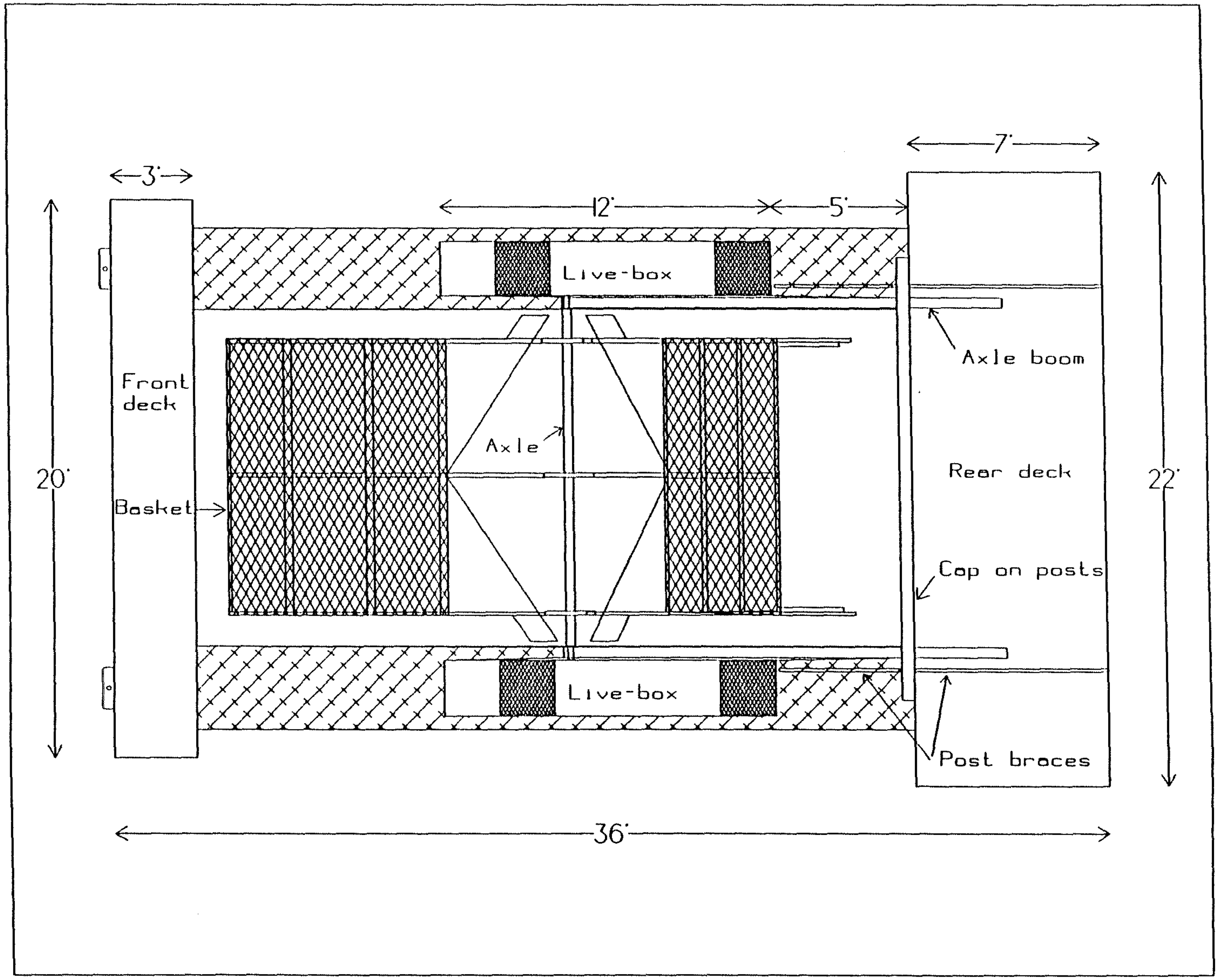


Figure A-2. Top view of an aluminum pontooned fishwheel used on the Nass River, 1993.

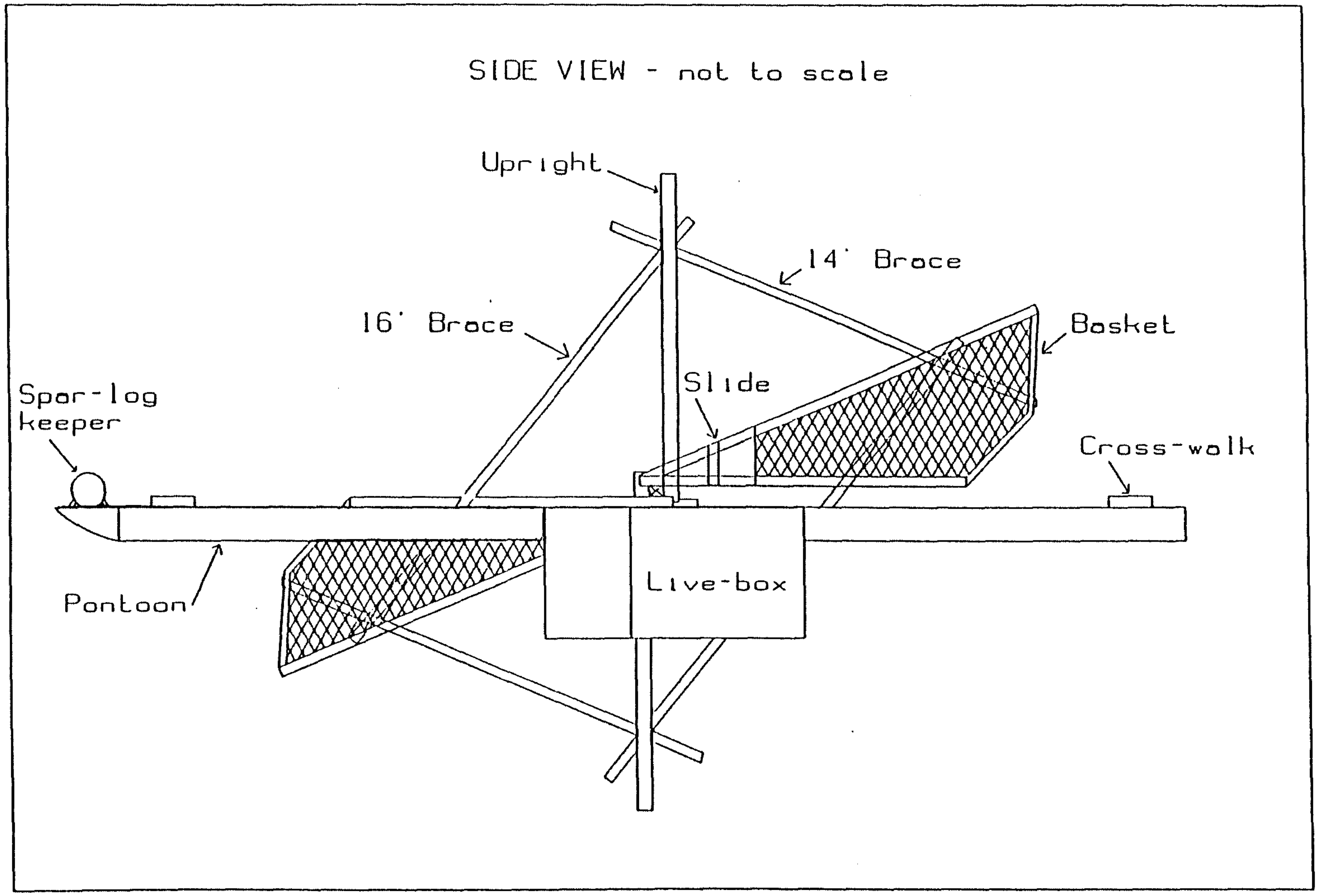


Figure A-3. Side view of a wooden pontooned fishwheel used on the Nass River, 1993.

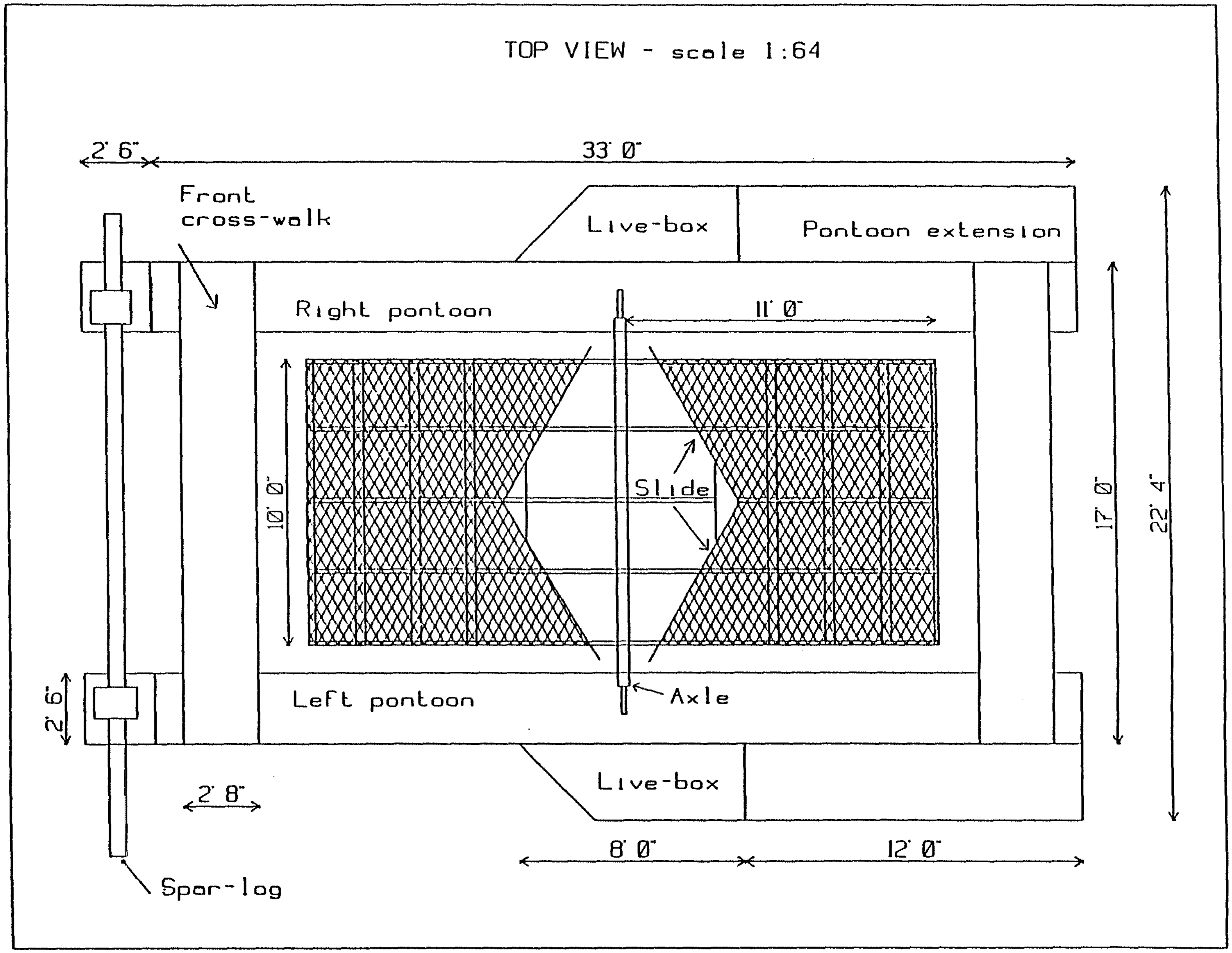


Figure A-4. Top view of a wooden pontooned fishwheel used on the Nass River, 1993.

Table B-1. Program code (QuickBASIC) for the run reconstruction model.

```
'Run reconstruction model for Nass River sockeye (1993) using fishwheel tag data, meziadin
'fishway counts and tag recoveries.
'By Michael R. Link and Karl K. English, November 1993.

'STEP 1: Declare subroutines and dimension arrays used in model.

DECLARE SUB dropback (mezcount(), pdback(), ndd)
DECLARE SUB plot (trun!(), fwcount!())
DIM wkend(100), cum(6), wday(140), week(140)
DIM fcount(150, 30), tcount(150), ptt(150, 30)
DIM cdate(140), jdate(140), fwtag(140), fwcount(140), meztag(140)
DIM mezcount(140), trun(140), mezfw(140), pdback(15)

'STEP 2: Choose the length of the period to use for pooling tag recovery data and choose a tag
'        survival rate.  Choose to send model output to file or to screen.

INPUT "Enter number of days in interval:", interval
INPUT "Enter tag survival rate:", tagsur
INPUT "Output to data file (3) or screen (6)", unit
IF unit = 3 THEN
  file3$ = "model93.out"
  OPEN file3$ FOR OUTPUT AS #3
ELSE
  OPEN "scrn:" FOR OUTPUT AS #6
END IF

'STEP 3: Define the days of the fishing periods ("weeks") from 5 June (34125) to 15 September
'        (34227).

iw = 1
iend = 34227 - 34125
FOR i = 1 TO iend
   ic = ic + 1
   IF ic = interval + 1 THEN
     ic = 1
     iw = iw + 1
   END IF
   wday(i) = ic
   week(i) = iw
   wkend(iw) = i
NEXT i
wmax = iw
PRINT "Number of intervals = "; wmax
```

Table B-1. Cont'd

```
'STEP 4: Read in the data from Meziadin fishway and fishwheels. Count the number of
'        recoveries within each period that took from 8 to 30 days to travel to Meziadin.

lower = 8: upper = 30
file$ = "count93.csv"
OPEN file$ FOR INPUT AS #1
FOR i = 1 TO 6: INPUT #1, dummy$: NEXT i
id = 1
DO UNTIL EOF(1)
 INPUT #1, cdate(id), jdate(id), fwtag(id), fwcount(id), meztag(id), mezcount(id)
 id = id + 1
LOOP
CLOSE #1
nd = id - 1
PRINT "Records read = "; nd

'first day for fishwheels = June 5 or 34125
jstart = 34125

file$ = "tagrec93.csv"
OPEN file$ FOR INPUT AS #1
'FOR i = 1 TO 6: INPUT #1, dummy$: NEXT i
rec = 1
DO UNTIL EOF(1)
 INPUT #1, cdaterec, cdaterel, jdaterec, jdaterel, tag
 inc = INT(rec / 100)
 IF rec = inc * 100 THEN PRINT "record=", rec
 rec = rec + 1
 dayrec = jdaterec - jstart
 dayrel = jdaterel - jstart
 iwrel = week(dayrel)
 iwrec = 70 + week(dayrec)
 itt = dayrec - dayrel
 IF itt >= lower AND itt <= upper THEN
  fcount(iwrel, itt) = fcount(iwrel, itt) + 1
  tcount(iwrel) = tcount(iwrel) + 1
  fcount(iwrec, itt) = fcount(iwrec, itt) + 1
  tcount(iwrec) = tcount(iwrec) + 1
 END IF
LOOP
CLOSE #1
```

Table B-1. Cont'd

```
'STEP 5: Calculate the proportion of recoveries from each period that took from 8 to 30 days
'        to reach Meziadin (travel time array).

PRINT #unit, "Interval Length = "; interval; " Tag Survival = "; tagsur
FOR iw = 1 TO wmax + 70
  n = tcount(iw)
  IF iw = 1 THEN PRINT #unit, "By release date"
  IF iw = 71 THEN PRINT #unit, "By recovery date"
  IF n > 0 THEN
    IF iw < 71 THEN
      PRINT #unit, USING "######"; cdate(wkend(iw));
    ELSE
      PRINT #unit, USING "######"; cdate(wkend(iw - 70));
    END IF
    FOR itt = lower TO upper
     ptt(iw, itt) = fcount(iw, itt) / tcount(iw)
     PRINT #unit, USING "###"; 100 * ptt(iw, itt);
    NEXT itt
    PRINT #unit, " "
  END IF
NEXT iw

'STEP 6: Produce a new Meziadin count array by lagging counts with dropback proportions for
'        1 to "ndd" days.

ndd = 8
DATA 0.28, 0.39, 0.13, 0.08, 0.05, 0.03, 0.02, 0.02
FOR i = 1 TO ndd: READ pdback(i): NEXT i
'call subroutine
CALL dropback(mezcount(), pdback(), ndd)

'STEP 7: Reconstruct the run at Meziadin fishway. Adjust the tags observed at Meziadin upward
'        to correct for <100% marking at fishwheels and tag loss. Weight the mark rate by
'        proportion for each travel time.

PRINT #unit, "Reconstruct run at Meziadin fishway"
'do analysis for July 16 to October 1 (Meziadin Fishway Interval)
sum = 0
FOR id = 41 TO 122
  iw = 70 + week(id)
  factor = 0: mr = 0
  FOR itt = lower TO upper
    idd = id - itt
    IF fwtag(idd) > 0 THEN mr = fwcount(idd) / (fwtag(idd) * tagsur)
```

Table B-1. Cont'd

```
    factor = factor + mr * ptt(iw, itt)
   NEXT itt
   mezfw(id) = meztag(id) * factor
   sum = sum + mezfw(id)
 'calculate the percent of the run that fishwheel caught fish.
   IF mezcount(id) > 0 THEN per = 100 * mezfw(id) / mezcount(id)
   cum = cum + mezcount(id)
   PRINT #unit, USING "######"; cdate(id);
   PRINT #unit, USING "########"; mezfw(id); mezcount(id); cum;
   PRINT #unit, USING "#####.##"; per; factor
 NEXT id
 PRINT #unit, "Number of fishwheel fish at Meziadin = ", sum

 'STEP 8: Reconstruct the run at the fishwheels using same technique as in step 6.

 PRINT #unit, "Reconstruct run at Fishwheels"
 'do analysis for June 5 to September 15
 cum = 0
 FOR id = 1 TO 103
   iw = week(id)
   factor = 0: mr = 0
   FOR itt = lower TO upper
     idd = id + itt
     IF mezfw(idd) > 0 THEN mr = mezcount(idd) / mezfw(idd)
     IF idd < 45 THEN mr = 80
     factor = factor + mr * ptt(iw, itt)
   NEXT itt
   trun(id) = fwcount(id) * factor
   cum = cum + trun(id)
 'calculate the percent of the run caught on day id
   IF trun(id) > 0 THEN per = 100 * fwcount(id) / trun(id)
   PRINT #unit, USING "######"; cdate(id);
   PRINT #unit, USING "########"; fwcount(id); trun(id); cum;
   PRINT #unit, USING "#####.##"; per; factor
 NEXT id
 PRINT "Total sockeye escapement =", cum
 'plot results
 CALL plot(trun(), fwcount())

 END
```

Table B-1. Cont'd

```
'Subroutine to move Meziadin counts back to make them appear as they might have had, had
'they been held, tagged and dropped back. Produces a new mezcount array to feed back into
'main model.  This is STEP 6 continued.

SUB dropback (mezcount(), pdback(), ndd)
DIM mezmove(140, 15), smezmove(140), ssmezmv(140), adjust(140), sumezcnt(140)

'For each day of the time series, take the Meziadin count and assign those fish
'to dates 1 to "ndd" days into the future.

FOR id = 24 TO 122
     FOR idb = 1 TO ndd
       mezmove(id, idb) = mezcount(id) * pdback(idb)
       smezmove(id) = smezmove(id) + mezmove(id, idb)
     NEXT idb

'Make the # of fish moved forward proportional to the total count that was
'actually seen on that date (so that # fish is proportional to tags recovered)
'Do this by multiplying each group of moved fish by the ratio of the actual
'mezcount on that day to the average mezcount for "ndd" days starting at the
'first day of the "moved fish array" (mezmove).
     mezsum = 0
     mezavg = 0
     FOR k = id TO id + ndd
       mezsum = mezsum + mezcount(k)
     NEXT k
     mezavg = mezsum / ndd
     IF mezavg > 0 THEN
     FOR idb = 1 TO ndd
       mezmove(id, idb) = mezmove(id, idb) * mezcount(id + idb) / mezavg
     NEXT idb
     END IF

'Adjust the moved counts downward to account for the biasing caused by the
'previous step.

     FOR idb = 1 TO ndd
       ssmezmv(id) = ssmezmv(id) + mezmove(id, idb)
     NEXT idb

     IF mezcount(id) > 0 AND ssmezmv(id) > 0 THEN
       adjust(id) = ssmezmv(id) / mezcount(id)
     END IF
       sum = 0
```

Table B-1. Cont'd

```
     IF adjust(id) > 0 THEN
     FOR idb = 1 TO ndd
       mezmove(id, idb) = mezmove(id, idb) / adjust(id)
       sum = sum + mezmove(id, idb)
     NEXT idb
     END IF

NEXT id

'Sum the fish moved to a given date from previous dates to come up with the
'new Meziadin count array.

FOR id = 40 TO 122
     FOR idb = 1 TO ndd
       sumezcnt(id) = sumezcnt(id) + mezmove(id - idb, idb)
     NEXT idb

     mezcount(id) = sumezcnt(id)

NEXT id

END SUB
```

Figure B-1. Flow chart of the run reconstruction model.

START

STEP 1
Declare subroutines and dimension arrays used in model.

STEP 2
Choose the length of the period to use for pooling tag recovery data and choose a tag survival rate. Choose to send model output to file or to screen.

STEP 3
Define the days of the fishing periods weeks from 5 June to 15 September

STEP 4
Read in the count and tag data from the Meziadin fishway and the fishwheels. Count the number of recoveries within each period that took from 8 to 30 days to travel to Meziadin fishway.

STEP 5
Calculate the proportion of recoveries from each period that took from 8 to 30 days to reach Meziadin (travel time array).

STEP 6
Produce a new Meziadin count array by lagging counts with dropback proportions for 1 to n days (call subroutine, see Fig. B-2).

STEP 7
Reconstruct the run at Meziadin fishway.

STEP 8
Reconstruct the run at the fishwheels.

END

Figure B-2. Flowchart of the subroutine used to adjust Meziadin counts with dropback function.

START

STEP 1
For each day of the Meziadin count time series, take the count and assign those fish to dates 1 to n days into the future using the proportions for each dropback length.

STEP 2
Make the number of fish moved forward to day i proportional to the total count that was actually seen on day i.

STEP 3
Adjust the moved counts downward to account for the biasing upward caused by the previous step.

STEP 4
Sum the fish moved to a given date from all previous dates to come up with the new Meziadin count array.

END

Table C-1. Summary of daily fishwheel effort (hours), effort used to calculate CPE and fishwheel speed (RPM) for three fishwheels used on the Nass River in 1993.

	Fishwheel 1				Fishwheel 2				Fishwheel 3					
Date	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total hours	Comments
9-May					12.0	50	12.0	1.6					12.0	Fw2 started at site where
10-May					24.0	100	24.0	1.5					24.0	fw 2 was at start of 1992.
11-May					24.0	100	24.0	1.5					24.0	
12-May					24.0	100	24.0	1.6					24.0	
13-May					24.0	100	24.0	1.7					24.0	
14-May					24.0	100	24.0	2.2					24.0	
15-May					24.0	100	24.0	2.5					24.0	
16-May					12.0	50	12.0	2.6					12.0	Wheel shut down, high water
17-May					0.0	0	0.0						0.0	and lots of debris.
18-May					0.0	0	0.0						0.0	
19-May					0.0	0	0.0						0.0	
20-May					0.0	0	0.0						0.0	
21-May					0.0	0	0.0						0.0	
22-May					0.0	0	0.0						0.0	
23-May					0.0	0	0.0						0.0	
24-May					0.0	0	0.0						0.0	
25-May					0.0	0	0.0						0.0	
26-May					0.0	0	0.0						0.0	
27-May					0.0	0	0.0						0.0	
28-May					0.0	0	0.0						0.0	
29-May					0.0	0	0.0						0.0	
30-May					0.0	0	0.0						0.0	
31-May					0.0	0	0.0						0.0	
1-Jun					12.0	50	12.0	2.0					12.0	Fw2 started next to new
2-Jun					24.0	100	22.3	1.9					24.0	church in Gitwinksihlkw.
3-Jun					24.0	100	32.1	2.0					24.0	
4-Jun					24.0	100	25.5	2.0					24.0	

Table C-1. Summary of daily fishwheel effort (hours), effort used to calculate CPE and fishwheel speed (RPM) for three fishwheels used on the Nass River in 1993.

	Fishwheel 1				Fishwheel 2				Fishwheel 3					
Date	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total hours	Comments
5-Jun					24.0	100	22.3	2.0					24.0	
6-Jun					24.0	100	20.0	2.0					24.0	
7-Jun					24.0	100	25.7	2.1					24.0	
8-Jun					24.0	100	27.5	2.0					24.0	
9-Jun	12.0	50	7.5		24.0	100	21.3	1.9					36.0	
10-Jun	24.0	100	23.1		24.0	100	26.1	2.0					48.0	
11-Jun	16.0	67	17.2	2.1	9.7	40	9.7	2.0					25.7	
12-Jun	24.0	100	21.3	1.9	24.0	100	13.8	2.1					48.0	
13-Jun	24.0	100	27.1	1.5	24.0	100	33.9	2.0					48.0	
14-Jun	24.0	100	24.3	1.6	24.0	100	24.0	2.0					48.0	
15-Jun	24.0	100	21.5	1.8	24.0	100	23.4	2.1					48.0	
16-Jun	24.0	100	23.4	1.5	24.0	100	23.5	2.5					48.0	
17-Jun	24.0	100	14.5	1.4	10.3	43	15.8	1.5					34.3	Fw2 shut down due to low
18-Jun	24.0	100	38.3	1.3	0.0	0	0.0						24.0	catches relative to fw1.
19-Jun	24.0	100	21.2	1.3	0.0	0	0.0						24.0	
20-Jun	24.0	100	26.6	1.3	11.0	46	11.0	2.9					35.0	
21-Jun	24.0	100	21.4	1.3	24.0	100	21.3	2.8					48.0	Started fw2 30m below
22-Jun	24.0	100	23.0	1.8	24.0	100	22.7	2.5					48.0	suspension bridge.
23-Jun	24.0	100	25.0	1.4	24.0	100	25.5	2.5					48.0	
24-Jun	24.0	100	22.1	1.5	24.0	100	21.5	3.0	6.0	25	6.0	2.5	54.0	Started fw3 50 m below
25-Jun	24.0	100	27.6	1.5	24.0	100	27.6	2.3	24.0	100	30.0	2.5	72.0	fw2. Fw3 moved almost
26-Jun	24.0	100	24.0	1.3	24.0	100	21.7	3.1	24.0	100	22.5	1.5	72.0	daily for first 3 weeks due
27-Jun	24.0	100	24.0	1.4	24.0	100	25.2	2.4	24.0	100	24.6	1.3	72.0	to too little water depth.
28-Jun	24.0	100	24.5	1.8	24.0	100	24.8	2.0	24.0	100	24.7	2.0	72.0	
29-Jun	24.0	100	23.3	1.5	24.0	100	23.0	2.4	24.0	100	23.3	1.5	72.0	
30-Jun	24.0	100	24.0	1.4	24.0	100	24.0	2.1	24.0	100	23.5	1.1	72.0	
1-Jul	24.0	100	24.4	1.2	24.0	100	24.1	1.4	24.0	100	24.5	1.7	72.0	
2-Jul	24.0	100	21.9	1.4	24.0	100	23.0	1.2	24.0	100	23.0	1.7	72.0	
3-Jul	24.0	100	23.5	1.6	24.0	100	23.9	1.1	24.0	100	23.7	1.5	72.0	
4-Jul	24.0	100	23.5	1.5	24.0	100	25.5	1.3	24.0	100	25.2	2.5	72.0	
5-Jul	24.0	100	24.0	2.1	24.0	100	23.3	1.3	24.0	100	23.7	1.2	72.0	

Table C-1. Summary of daily fishwheel effort (hours), effort used to calculate CPE and fishwheel speed (RPM) for three fishwheels used on the Nass River in 1993.

	Fishwheel 1				Fishwheel 2				Fishwheel 3					
Date	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total hours	Comments
6-Jul	24.0	100	23.8	1.6	24.0	100	24.0	1.5	24.0	100	23.8	1.0	72.0	
7-Jul	24.0	100	23.8	2.0	24.0	100	23.3	2.1	24.0	100	24.8	1.1	72.0	
8-Jul	24.0	100	23.3	2.6	22.0	92	22.9	1.4	24.0	100	21.8	1.5	70.0	
9-Jul	24.0	100	25.2	2.6	24.0	100	25.5	1.2	24.0	100	25.3	3.0	72.0	
10-Jul	24.0	100	23.6	2.5	24.0	100	23.2	1.5	24.0	100	23.5	2.6	72.0	
11-Jul	24.0	100	23.0	2.5	24.0	100	22.8	1.2	24.0	100	25.7	2.4	72.0	
12-Jul	24.0	100	24.0	2.9	24.0	100	23.5	1.3	24.0	100	21.7	2.0	72.0	
13-Jul	24.0	100	23.8	2.8	24.0	100	23.7	1.4	24.0	100	23.3	1.7	72.0	
14-Jul	24.0	100	25.3	2.4	24.0	100	25.3	1.5	24.0	100	24.7	1.5	72.0	
15-Jul	24.0	100	24.8	3.0	24.0	100	25.8	1.6	24.0	100	23.6	1.2	72.0	
16-Jul	24.0	100	24.8	2.7	24.0	100	24.3	1.5	24.0	100	28.2	1.0	72.0	
17-Jul	24.0	100	21.0	2.1	24.0	100	18.5	1.4	24.0	100	21.1	1.0	72.0	
18-Jul	24.0	100	24.3	2.7	24.0	100	25.6	1.5	24.0	100	24.3	0.8	72.0	
19-Jul	24.0	100	24.2	2.5	24.0	100	24.4	1.5	24.0	100	22.2	1.3	72.0	Fw3 fishing slow and
20-Jul	24.0	100	24.1	2.1	24.0	100	24.3	1.8	24.0	100	22.3	0.8	72.0	sporadically.
21-Jul	24.0	100	25.1	2.2	24.0	100	25.4	1.5	12.0	50	12.3	0.9	60.0	
22-Jul	24.0	100	22.9	2.2	24.0	100	22.3	1.5	12.0	50	12.3	0.8	60.0	
23-Jul	24.0	100	25.8	2.5	24.0	100	25.3	1.8	0.0	0	0.0		48.0	
24-Jul	24.0	100	24.0	2.2	24.0	100	24.0	1.5	16.0	67	16.0	0.8	64.0	
25-Jul	24.0	100	22.8	2.2	24.0	100	22.8	1.6	24.0	100	22.8	0.8	72.0	
26-Jul	19.5	81	15.1	2.2	24.0	100	20.0	1.5	0.0	0	0.0		43.5	
27-Jul	24.0	100	25.7	2.4	24.0	100	25.3	1.2	0.0	0	0.0		48.0	
28-Jul	24.0	100	26.0	2.6	24.0	100	26.3	1.5	0.0	0	0.0		48.0	
29-Jul	24.0	100	23.1	2.6	24.0	100	22.5	1.7	0.0	0	0.0		48.0	
30-Jul	10.0	42	10.0	2.7	7.5	31	11.0	1.5	0.0	0	0.0		17.5	High water due to heavy
31-Jul	0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	rain, basket on fw2 damaged;
1-Aug	0.0	0	0.0		0.0	0	0.0		0.0	0	0.0		0.0	Baskets raised out.
2-Aug	14.0	58	8.8		0.0	0	0.0		10.0	42	10.0	0.8	24.0	Fw3 turning occasionally;
3-Aug	24.0	100	26.7	2.1	0.0	0	0.0		5.0	21			29.0	Hole found inside box, fw1;
4-Aug	24.0	100	23.7	2.0	0.0	0	0.0		5.0	21			29.0	replaced box with one
5-Aug	24.0	100	21.8	2.0	0.0	0	0.0		5.0	21			29.0	from fw2.

Table C-1. Summary of daily fishwheel effort (hours), effort used to calculate CPE and fishwheel speed (RPM) for three fishwheels used on the Nass River in 1993.

	Fishwheel 1				Fishwheel 2				Fishwheel 3					
Date	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total hours	Comments
6-Aug	24.0	100	25.8	2.0	0.0	0	0.0		5.0	21			29.0	Fw3 checked occassionally.
7-Aug	24.0	100	23.9	2.0	24.0	100	12.0		5.0	21			53.0	Outside live box on fw2.
8-Aug	24.0	100	23.5	2.1	24.0	100	12.0		5.0	21			53.0	
9-Aug	24.0	100	25.1	2.2	24.0	100	12.0		5.0	21			53.0	
10-Aug	9.0	38	11.8	2.0	24.0	100	12.0		5.0	21			38.0	Water too shallow for
11-Aug	0.0				24.0	100	25.2	1.5	0.0				24.0	fw1 to turn, so was shut down.
12-Aug	0.0				24.0	100	25.2	1.4	0.0				24.0	Fw2 moved short distances
13-Aug	0.0				24.0	100	23.6	1.3	0.0				24.0	up and down river and away
14-Aug	0.0				24.0	100	22.8	1.3	0.0				24.0	from shore several times
15-Aug	0.0				24.0	100	25.8	1.2	0.0				24.0	over next 3 weeks.
16-Aug	0.0				24.0	100	24.0	1.2	0.0				24.0	
17-Aug	0.0				24.0	100	23.3	1.2	0.0				24.0	
18-Aug	0.0				24.0	100	23.9	1.2	0.0				24.0	
19-Aug	0.0				24.0	100	24.5	1.2	0.0				24.0	
20-Aug	0.0				24.0	100	23.7	1.2	0.0				24.0	
21-Aug	0.0				24.0	100	13.3	1.2	0.0				24.0	
22-Aug	0.0				24.0	100	35.1	1.0	0.0				24.0	
23-Aug	0.0				24.0	100	24.4	1.2	0.0				24.0	
24-Aug	0.0				24.0	100	23.2	1.0	0.0				24.0	
25-Aug	0.0				24.0	100	24.5	1.2	0.0				24.0	
26-Aug	0.0				24.0	100	21.8	1.0	0.0				24.0	
27-Aug	0.0				24.0	100	25.8	1.0	0.0				24.0	
28-Aug	0.0				24.0	100	20.8	1.0	0.0				24.0	
29-Aug	0.0				24.0	100	0.0		0.0				24.0	Fw2 not checked for fish.
30-Aug	0.0				24.0	100	51.0	1.0	0.0				24.0	
31-Aug	0.0				24.0	100	23.6	1.0	0.0				24.0	
1-Sep	0.0				24.0	100	12.9	1.0	0.0				24.0	
2-Sep	0.0				24.0	100	22.6	1.0	0.0				24.0	
3-Sep	0.0				24.0	100	23.7	1.5	0.0				24.0	
4-Sep	0.0				24.0	100	23.7	1.5	0.0				24.0	
5-Sep	0.0				24.0	100	0.0		0.0				24.0	

Table C-1. Summary of daily fishwheel effort (hours), effort used to calculate CPE and fishwheel speed (RPM) for three fishwheels used on the Nass River in 1993.

	Fishwheel 1				Fishwheel 2				Fishwheel 3					
Date	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total	Percent of time running	Effort for CPE [a]	RPM	Total hours	Comments
6-Sep	0.0				24.0	100	47.3	1.3	0.0				24.0	
7-Sep	0.0				24.0	100	36.3	1.3	0.0				24.0	
8-Sep	0.0				24.0	100	19.3	1.3	0.0				24.0	
9-Sep	0.0				24.0	100	27.0	1.0	0.0				24.0	
10-Sep	0.0				24.0	100	12.3		0.0				24.0	Fw2 turning sporadically.
11-Sep	0.0				24.0	100	26.0		0.0				24.0	
12-Sep	0.0				24.0	100	0.0		0.0				24.0	Fw2 not checked for fish.
13-Sep	0.0				24.0	100	58.0		0.0				24.0	
14-Sep	0.0				24.0	100	13.0		0.0				24.0	
15-Sep	0.0				9.0	100	14		0.0				9.0	Fw2 shut down.
Total [b]	**1401**	**93**	**1392**		**2434**	**74**	**2386**		**744**	**72**	**704**		**4578**	

a - The total effort is the time the wheel was fishing from midnight to midnight whereas the effort used to calculate the CPE is the number of hours the wheel fished to obtain that date's catch. These two values are are different because the time of the last sampling session on each day varied and this affected the following day's effort and catch. Effort was halved for periods when only one live box was functional.

b - The total percent of time running based on fishwheel 1 fishing from 9 June to 10 August (63 d); fishwheel 2 from 2 May to 15 September (137 d); and fishwheel 3 from 29 June to 10 August (43 d).

Table D-1. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for sockeye salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
4-Jun								0	0	0	0	0	0	0.00		
5-Jun								2	2	2	2	0	0	0.09		
6-Jun								2	4	2	4	0	0	0.10		
7-Jun								10	14	10	14	0	0	0.39		
8-Jun								7	21	6	20	1	0	0.25		
9-Jun	3	3	2	2	1	0	0.40	7	28	6	26	1	0	0.33		
10-Jun	9	12	8	10	1	0	0.39	0	28	0	26	0	0	0.00		
11-Jun	6	18	6	16	0	0	0.35	7	35	7	33	0	0	0.72		
12-Jun	12	30	11	27	1	0	0.56	4	39	3	36	1	0	0.29		
13-Jun	11	41	10	37	1	0	0.41	10	49	9	45	1	0	0.30		
14-Jun	22	63	19	56	3	0	0.91	5	54	5	50	0	1	0.21		
15-Jun	12	75	12	68	0	0	0.56	9	63	9	59	0	0	0.38		
16-Jun	12	87	12	80	0	0	0.51	16	79	14	73	2	0	0.68		
17-Jun	0	87	0	80	0	0	0.00	33	112	31	104	2	0	2.09		
18-Jun	40	127	39	119	1	0	1.04	0	112	0	104	0	0			
19-Jun	37	164	34	153	3	0	1.75	0	112	0	104	0	0			
20-Jun	43	207	40	193	3	0	1.62	5	117	5	109	0	0	0.45		
21-Jun	22	229	21	214	1	0	1.03	16	133	16	125	0	0	0.75		
22-Jun	28	257	27	241	1	0	1.22	20	153	19	144	1	0	0.88		
23-Jun	23	280	23	264	0	0	0.92	13	166	11	155	2	0	0.51		
24-Jun	46	326	45	309	1	0	2.08	18	184	18	173	0	0	0.84		
25-Jun	50	376	48	357	2	0	1.81	17	201	16	189	1	0	0.62	53	53
26-Jun	23	399	20	377	3	0	0.96	11	212	9	198	2	0	0.51	16	69
27-Jun	34	433	31	408	3	0	1.42	22	234	18	216	4	0	0.87	16	85
28-Jun	24	457	23	431	1	0	0.98	36	270	33	249	3	0	1.45	14	99
29-Jun	41	498	40	471	1	0	1.76	48	318	46	295	2	0	2.09	24	123
30-Jun	73	571	67	538	6	1	3.05	87	405	83	378	4	0	3.63	15	138
1-Jul	91	662	88	626	3	0	3.74	77	482	74	452	3	0	3.20	9	147
2-Jul	71	733	65	691	6	0	3.24	50	532	44	496	6	0	2.17	37	184
3-Jul	67	800	62	753	5	0	2.85	39	571	37	533	2	0	1.63	27	211
4-Jul	91	891	88	841	3	0	3.87	46	617	44	577	2	0	1.81	46	257
5-Jul	93	984	84	925	9	1	3.88	93	710	69	646	24	0	4.00	70	327

Table D-1. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for sockeye salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
6-Jul	121	1105	121	1046	0	0	5.09	85	795	84	730	1	0	3.54	97	424
7-Jul	149	1254	146	1192	3	0	6.27	145	940	141	871	4	1	6.22	140	564
8-Jul	162	1416	151	1343	11	1	6.95	88	1028	85	956	3	0	3.84	75	639
9-Jul	88	1504	75	1418	13	0	3.49	92	1120	78	1034	14	0	3.61	38	677
10-Jul	125	1629	122	1540	3	0	5.30	90	1210	88	1122	2	0	3.88	58	735
11-Jul	170	1799	161	1701	9	0	7.39	140	1350	137	1259	3	0	6.14	94	829
12-Jul	210	2009	194	1895	16	1	8.75	109	1459	96	1355	13	0	4.64	76	905
13-Jul	149	2158	138	2033	11	0	6.27	78	1537	74	1429	4	1	3.29	32	937
14-Jul	272	2430	264	2297	8	0	10.77	117	1654	114	1543	3	0	4.63	50	987
15-Jul	174	2604	164	2461	10	0	7.03	98	1752	90	1633	8	0	3.81	86	1073
16-Jul	158	2762	148	2609	10	0	6.38	114	1866	87	1720	27	0	4.69	40	1113
17-Jul	197	2959	175	2784	22	0	9.38	55	1921	51	1771	4	1	2.98	37	1150
18-Jul	203	3162	175	2959	28	13	8.35	52	1973	45	1816	7	0	2.03	23	1173
19-Jul	213	3375	202	3161	11	1	8.80	56	2029	51	1867	5	1	2.30	39	1212
20-Jul	249	3624	233	3394	16	0	10.33	88	2117	85	1952	3	0	3.63	56	1268
21-Jul	240	3864	232	3626	8	0	9.58	82	2199	82	2034	0	0	3.23	23	1291
22-Jul	216	4080	210	3836	6	3	9.43	33	2232	32	2066	1	0	1.48	0	1291
23-Jul	137	4217	119	3955	18	0	5.31	37	2269	36	2102	1	1	1.46	20	1311
24-Jul	144	4361	128	4083	16	3	6.00	37	2306	35	2137	2	1	1.54	14	1325
25-Jul	173	4534	165	4248	8	0	7.59	43	2349	41	2178	2	1	1.89		1325
26-Jul	177	4711	172	4420	5	0	11.72	41	2390	38	2216	3	0	2.05		1325
27-Jul	230	4941	218	4638	12	3	8.95	73	2463	64	2280	9	0	2.89		1325
28-Jul	230	5171	220	4858	10	0	8.85	69	2532	65	2345	4	0	2.63		1325
29-Jul	97	5268	91	4949	6	0	4.20	13	2545	12	2357	1	0	0.58		1325
30-Jul	6	5274	0	4949	6	0	0.60	3	2548	0	2357	3	0	0.27		1325
31-Jul	0	5274	0	4949	0	0			2548		2357					1325
1-Aug	0	5274	0	4949	0	0			2548		2357					1325
2-Aug	19	5293	15	4964	4	0	2.16		2548		2357					1325
3-Aug	187	5480	174	5138	13	4	7.00		2548		2357					1325
4-Aug	177	5657	161	5299	16	3	7.47		2548		2357					1325

Table D-1. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for sockeye salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
5-Aug	155	5812	140	5439	15	5	7.11		2548		2357					1325
6-Aug	77	5889	72	5511	5	2	2.98		2548		2357					1325
7-Aug	60	5949	57	5568	3	0	2.51	0	2548	0	2357	0	0	0.00	42	1367
8-Aug	115	6064	105	5673	10	0	4.89	0	2548	0	2357	0	0	0.00		1367
9-Aug	123	6187	110	5783	13	0	4.90	0	2548	0	2357	0	0	0.00		1367
10-Aug	58	6245	52	5835	6	1	4.92	0	2548	0	2357	0	0	0.00	60	1427
11-Aug								38	2586	34	2391	4	0	1.51		
12-Aug								66	2652	62	2453	4	0	2.62		
13-Aug								74	2726	71	2524	3	0	3.14		
14-Aug								69	2795	62	2586	7	7	3.03		
15-Aug								61	2856	57	2643	4	2	2.36		
16-Aug								38	2894	37	2680	1	3	1.58		
17-Aug								38	2932	35	2715	3	1	1.63		
18-Aug								29	2961	29	2744	0	3	1.21		
19-Aug								31	2992	29	2773	2	8	1.27		
20-Aug								27	3019	23	2796	4	1	1.14		
21-Aug								12	3031	9	2805	3	2	0.90		
22-Aug								44	3075	42	2847	2	1	1.25		
23-Aug								28	3103	26	2873	2	0	1.15		
24-Aug								24	3127	22	2895	2	1	1.03		
25-Aug								24	3151	20	2915	4	0	0.98		
26-Aug								24	3175	21	2936	3	1	1.10		
27-Aug								23	3198	21	2957	2	0	0.89		
28-Aug								8	3206	5	2962	3	1	0.38		
29-Aug								0	3206	0	2962	0	0			
30-Aug								9	3215	6	2968	3	2	0.18		
31-Aug								6	3221	5	2973	1	0	0.25		
1-Sep								5	3226	5	2978	0	0	0.39		
2-Sep								13	3239	12	2990	1	0	0.58		
3-Sep								8	3247	6	2996	2	1	0.34		

Table D-1. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for sockeye salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Adult catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
4-Sep								8	3255	8	3004	0	2	0.34		
5-Sep								0	3255	0	3004	0	0			
6-Sep								7	3262	5	3009	2	0	0.15		
7-Sep								10	3272	9	3018	1	2	0.28		
8-Sep								5	3277	4	3022	1	0	0.26		
9-Sep								2	3279	2	3024	0	2	0.07		
10-Sep								4	3283	2	3026	2	0	0.33		
11-Sep								6	3289	0	3026	6	0	0.23		
12-Sep								0	3289	0	3026	0	0			
13-Sep								2	3291	1	3027	1	0	0.03		
Totals	**6245**		**5835**		**410**	**42**	**268.04**	**3291**		**3027**		**264**	**48**	**139.09**	**1427**	

Table D-2. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheels 1 and 2 on the Nass River in 1993. Jacks were fish less than 72 cm nose-fork length.

	Fishwheel 1									Fishwheel 2								
	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult
Date	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE
2-Jun										0	0	0	1	0	0	1	1	0.04
3-Jun										0	0	0	1	0	0	1	2	0.03
4-Jun										1	0	1	2	2	0	5	7	0.20
5-Jun										0	0	0	1	0	0	1	8	0.04
6-Jun										0	0	0	3	0	0	3	11	0.15
7-Jun										0	2	2	4	0	0	6	17	0.16
8-Jun										0	0	0	5	3	0	8	25	0.29
9-Jun	0	0	0	0	0	0	0	0	0.00	3	0	3	10	5	1	19	44	0.85
10-Jun	0	1	1	5	0	0	6	6	0.22	0	0	0	0	0	0	0	44	0.00
11-Jun	0	1	1	6	0	0	7	13	0.35	2	0	2	3	2	0	7	51	0.72
12-Jun	0	1	1	3	0	0	4	17	0.14	0	0	0	4	0	1	5	56	0.29
13-Jun	1	3	4	9	0	0	13	30	0.37	0	2	2	4	0	0	6	62	0.12
14-Jun	0	4	4	15	2	0	21	51	0.70	0	1	1	4	0	0	5	67	0.17
15-Jun	0	4	4	11	0	0	15	66	0.51	1	1	2	3	0	0	5	72	0.17
16-Jun	0	2	2	2	1	0	5	71	0.13	0	3	3	6	0	0	9	81	0.26
17-Jun	0	0	0	2	0	0	2	73	0.14	0	1	1	2	0	0	3	84	0.13
18-Jun	0	4	4	3	0	0	7	80	0.08	0	0	0	0	0	0	0	84	
19-Jun	0	0	0	5	0	0	5	85	0.24	0	0	0	0	0	0	0	84	
20-Jun	0	3	3	29	1	0	33	118	1.13	0	1	1	1	0	0	2	86	0.09
21-Jun	1	2	3	24	2	2	31	149	1.26	4	0	4	1	0	0	5	91	0.23
22-Jun	9	10	19	18	2	0	39	188	1.26	3	2	5	1	0	0	6	97	0.18
23-Jun	8	2	10	12	0	0	22	210	0.80	1	0	1	0	0	0	1	98	0.04
24-Jun	0	2	2	3	0	0	5	215	0.14	0	0	0	0	0	0	0	98	0.00
25-Jun	11	5	16	15	3	0	34	249	1.05	0	2	2	0	0	0	2	100	0.00
26-Jun	16	4	20	16	2	1	39	288	1.42	2	0	2	0	0	0	2	102	0.09
27-Jun	8	9	17	15	2	0	34	322	1.04	6	2	8	0	0	0	8	110	0.24
28-Jun	10	3	13	12	4	1	30	352	1.06	16	8	24	0	1	1	26	136	0.69

Table D-2. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheels 1 and 2 on the Nass River in 1993. Jacks were fish less than 72 cm nose-fork length.

	Fishwheel 1									Fishwheel 2								
	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult
Date	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE
29-Jun	4	1	5	6	0	0	11	363	0.43	12	2	14	0	1	0	15	151	0.57
30-Jun	5	6	11	8	0	1	20	383	0.54	13	6	19	0	1	1	21	172	0.58
1-Jul	3	2	5	5	0	0	10	393	0.33	5	3	8	0	1	0	9	181	0.25
2-Jul	6	8	14	5	0	0	19	412	0.50	6	4	10	0	0	0	10	191	0.26
3-Jul	4	12	16	5	2	0	23	435	0.47	2	2	4	0	2	0	6	197	0.17
4-Jul	11	4	15	3	0	1	19	454	0.60	5	0	5	0	0	0	5	202	0.20
5-Jul	8	7	15	5	0	2	22	476	0.54	4	2	6	3	0	0	9	211	0.30
6-Jul	2	3	5	1	0	1	7	483	0.13	0	5	5	0	0	0	5	216	0.00
7-Jul	0	7	7	5	0	1	13	496	0.21	2	4	6	3	0	0	9	225	0.21
8-Jul	0	4	4	1	0	1	6	502	0.04	1	2	3	1	0	0	4	229	0.09
9-Jul	1	0	1	1	0	1	3	505	0.08	2	0	2	0	0	0	2	231	0.08
10-Jul	0	1	1	1	0	0	2	507	0.04	0	1	1	0	1	0	2	233	0.04
11-Jul	1	3	4	2	1	0	7	514	0.17	3	0	3	0	0	0	3	236	0.13
12-Jul	2	2	4	1	0	2	7	521	0.13	0	1	1	0	0	2	3	239	0.00
13-Jul	0	0	0	1	0	0	1	522	0.04	1	0	1	0	0	0	1	240	0.04
14-Jul	0	3	3	3	0	0	6	528	0.12	1	0	1	0	0	0	1	241	0.04
15-Jul	5	0	5	0	2	0	7	535	0.28	0	0	0	0	0	0	0	241	0.00
16-Jul	1	2	3	1	1	0	5	540	0.12	0	0	0	0	0	0	0	241	0.00
17-Jul	1	3	4	2	0	2	8	548	0.14	0	0	0	0	0	0	0	241	0.00
18-Jul	3	2	5	1	0	1	7	555	0.16	0	1	1	0	0	1	2	243	0.00
19-Jul	2	2	4	1	0	1	6	561	0.12	0	0	0	0	0	0	0	243	0.00
20-Jul	1	0	1	0	0	6	7	568	0.04	0	0	0	0	0	0	0	243	0.00
21-Jul	0	3	3	1	1	1	6	574	0.08	0	0	0	0	0	0	0	243	0.00
22-Jul	0	0	0	0	0	0	0	574	0.00	2	0	2	0	0	0	2	245	0.09
23-Jul	2	0	2	2	0	1	5	579	0.16	0	0	0	0	0	1	1	246	0.00
24-Jul	1	0	1	0	1	0	2	581	0.08	0	0	0	0	0	0	0	246	0.00
25-Jul	1	1	2	0	1	0	3	584	0.09	0	0	0	0	0	0	0	246	0.00

Table D-2. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheels 1 and 2 on the Nass River in 1993. Jacks were fish less than 72 cm nose-fork length.

	Fishwheel 1									Fishwheel 2								
	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult
Date	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE
26-Jul	0	0	0	2	0	0	2	586	0.13	1	0	1	0	0	0	1	247	0.05
27-Jul	0	1	1	1	0	0	2	588	0.04	0	0	0	0	0	0	0	247	0.00
28-Jul	0	0	0	1	0	0	1	589	0.04	0	0	0	0	0	0	0	247	0.00
29-Jul	0	0	0	1	0	0	1	590	0.04	0	0	0	0	0	0	0	247	0.00
30-Jul								590	0.00								247	0.00
31-Jul								590									247	
1-Aug	0	0	0	0	0	0	0	590									247	
2-Aug	0	0	0	0	1	0	1	591	0.11								247	
3-Aug	0	0	0	1	0	1	2	593	0.04								247	
4-Aug	1	0	1	0	0	0	1	594	0.04								247	
5-Aug	5	0	5	1	0	0	6	600	0.28								247	
6-Aug	3	1	4	0	0	0	4	604	0.12								247	
7-Aug	1	0	1	0	0	0	1	605	0.04	0	0	0	0	0	0	0	247	0.00
8-Aug	1	0	1	0	0	0	1	606	0.04	0	0	0	0	0	0	0	247	0.00
9-Aug	4	0	4	0	1	0	5	611	0.20	0	0	0	0	0	0	0	247	0.00
10-Aug	2	0	2	0	0	0	2	613	0.17	0	0	0	0	0	0	0	247	0.00
11-Aug								613		0	0	0	0	0	0	0	247	0.00
12-Aug								613		1	0	1	0	0	0	1	248	0.04
13-Aug								613		0	0	0	0	0	0	0	248	0.00
14-Aug								613		1	0	1	0	1	0	2	250	0.09
15-Aug								613		2	0	2	0	0	0	2	252	0.08
16-Aug								613		0	0	0	0	0	0	0	252	0.00
17-Aug								613		0	0	0	0	0	0	0	252	0.00
18-Aug								613		0	0	0	0	0	0	0	252	0.00
19-Aug								613		0	0	0	0	0	0	0	252	0.00
20-Aug								613		0	0	0	1	0	0	1	253	0.04
21-Aug								613		0	0	0	0	1	0	1	254	0.08

Table D-2. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheels 1 and 2 on the Nass River in 1993. Jacks were fish less than 72 cm nose-fork length.

	Fishwheel 1									Fishwheel 2								
	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult	Spaghetti tagged			Radio	Adults not	Jacks not	Total	Cum.	Adult
Date	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE	Adults	Jacks	Total	tagged	tagged	tagged	catch	catch	CPE
22-Aug								613		0	0	0	0	0	0	0	254	0.00
23-Aug								613		0	0	0	0	0	0	0	254	0.00
24-Aug								613		0	0	0	0	0	0	0	254	0.00
25-Aug								613		0	0	0	1	0	0	1	255	0.04
26-Aug								613		0	0	0	0	0	0	0	255	0.00
27-Aug								613		0	0	0	1	0	0	1	256	0.04
Totals	**145**	**138**	**283**	**273**	**30**	**27**	**613**		**18.97**	**103**	**58**	**161**	**66**	**21**	**8**	**256**		**8.67**

Table D-3. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for chinook salmon captured with fishwheel 3 on the Nass River in 1993. Jacks were fish less than 72 cm nose-fork length.

	Spaghetti tagged			Adults not	Jacks not	Total	Cum.	Adult
Date	Adults	Jacks	Total	tagged	tagged	catch	catch	CPE
25-Jun	15	5	20	0	0	20	20	0.50
26-Jun	0	1	1	0	0	1	21	0.00
27-Jun	9	0	9	0	0	9	30	0.37
28-Jun	0	2	2	0	2	4	34	0.00
29-Jun	6	1	7	1	0	8	42	0.30
30-Jun	0	0	0	1	0	1	43	0.04
1-Jul	0	0	0	0	1	1	44	0.00
2-Jul	1	0	1	0	0	1	45	0.04
3-Jul	0	0	0	0	0	0	45	0.00
4-Jul	0	0	0	1	0	1	46	0.04
5-Jul	0	0	0	1	0	1	47	0.04
6-Jul	1	0	1	0	0	1	48	0.04
7-Jul	0	0	0	0	0	0	48	0.00
8-Jul	0	0	0	0	1	1	49	0.00
9-Jul	0	1	1	0	0	1	50	0.00
Totals	32	10	42	4	4	50		

Table D-4. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for coho salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Total catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
20-Jul	0	0	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0
21-Jul	3	3	0	0	2	1	0.08	3	3	0	0	0	3	0.00	1	1
22-Jul	7	10	0	0	5	2	0.22	0	3	0	0	0	0	0.00	0	1
23-Jul	4	14	0	0	3	1	0.12	1	4	0	0	1	0	0.04	0	1
24-Jul	2	16	0	0	2	0	0.08	0	4	0	0	0	0	0.00	1	2
25-Jul	7	23	0	0	1	6	0.04	0	4	0	0	0	0	0.00		2
26-Jul	1	24	0	0	1	0	0.07	1	5	0	0	0	1	0.00		2
27-Jul	0	24	0	0	0	0	0.00	1	6	0	0	1	0	0.04		2
28-Jul	5	29	5	5	0	0	0.19	5	11	5	5	0	0	0.19		2
29-Jul	4	33	2	7	0	2	0.09	0	11	0	5	0	0	0.00		2
30-Jul	1	34	0	7	1	0	0.10	0	11	0	5	0	0	0.00		2
31-Jul		34		7					11		5					2
1-Aug		34		7					11		5					2
2-Aug	7	41	7	14	0	0	0.80		11		5					2
3-Aug	31	72	28	42	0	3	1.05		11		5					2
4-Aug	42	114	37	79	2	3	1.65		11		5					2
5-Aug	16	130	12	91	2	2	0.64		11		5					2
6-Aug	21	151	15	106	0	6	0.58		11		5					2
7-Aug	25	176	25	131	0	0	1.05	0	11	0	5	0	0	0.00	17	19
8-Aug	8	184	7	138	1	0	0.34	0	11	0	5	0	0	0.00		19
9-Aug	27	211	24	162	1	2	1.00	0	11	0	5	0	0	0.00		19
10-Aug	2	213	2	164	0	0	0.17	0	11	0	5	0	0	0.00	45	64
11-Aug								11	22	9	14	1	1	0.40		
12-Aug								6	28	6	20	0	0	0.24		
13-Aug								4	32	4	24	0	0	0.17		
14-Aug								10	42	9	33	1	0	0.44		
15-Aug								8	50	8	41	0	0	0.31		
16-Aug								7	57	5	46	0	2	0.21		
17-Aug								10	67	10	56	0	0	0.43		
18-Aug								4	71	3	59	0	1	0.13		
19-Aug								7	78	7	66	0	0	0.29		
20-Aug								7	85	6	72	1	0	0.30		

Table D-4. Daily catches, numbers tagged and CPE (adult catch/wheel hour) for coho salmon captured with three fishwheels on the Nass River in 1993. Jacks were fish less than 40 cm nose-fork length.

	Fishwheel 1							Fishwheel 2							Fishwheel 3	
					Not tagged							Not tagged				
Date	Total catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch	Total tagged	Cum. tagged	Adults	Jacks	Adult CPE	Total catch	Cum. catch
21-Aug								1	86	0	72	0	1	0.00		
22-Aug								6	92	6	78	0	0	0.17		
23-Aug								7	99	6	84	0	1	0.25		
24-Aug								5	104	4	88	1	0	0.22		
25-Aug								2	106	2	90	0	0	0.08		
26-Aug								6	112	5	95	0	1	0.23		
27-Aug								3	115	2	97	1	0	0.12		
28-Aug								6	121	4	101	1	1	0.24		
29-Aug									121		101					
30-Aug								7	128	5	106	1	1	0.12		
31-Aug								6	134	6	112	0	0	0.25		
1-Sep								1	135	0	112	1	0	0.08		
2-Sep								8	143	6	118	1	1	0.31		
3-Sep								3	146	3	121	0	0	0.13		
4-Sep								6	152	6	127	0	0	0.25		
5-Sep									152		127					
6-Sep								5	157	5	132	0	0	0.11		
7-Sep								9	166	7	139	0	2	0.19		
8-Sep								4	170	3	142	1	0	0.21		
9-Sep								8	178	7	149	0	1	0.26		
10-Sep								2	180	1	150	0	1	0.08		
11-Sep								5	185	5	155	0	0	0.19		
12-Sep								0	185	0	155	0	0			
13-Sep								4	189	4	159	0	0	0.07		
Totals	**213**		**164**		**21**	**28**	**8.25**	**189**		**159**		**12**	**18**	**6.72**	**64**	

Table D-5. Daily catches, numbers tagged and CPE (catch/wheel hour) for pink, chum and steelhead salmon captured with three fishwheels on the Nass River in 1993.

	Fishwheel 1											Fishwheel 2											Fishwheel 3		
	Pink			Chum			Steelhead					Pink			Chum			Steelhead					Pink	Chum	Steelhead
									Tagged											Tagged					
Date	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Daily catch	Daily catch
9-Jun							1	1	0	0	0.13							1	1	1	0	0.05			
10-Jun							0	1	0	0	0.00							0	1	0	0	0.00			
11-Jun							0	1	0	0	0.00							2	3	1	0	0.21			
12-Jun							0	1	0	0	0.00							0	3	0	0	0.00			
13-Jun							0	1	0	0	0.00							1	4	1	0	0.03			
14-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
15-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
16-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
17-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
18-Jun							0	1	0	0	0.00							0	4	0	0				
19-Jun							0	1	0	0	0.00							0	4	0	0				
20-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
21-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
22-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
23-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
24-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
25-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
26-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
27-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
28-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
29-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
30-Jun							0	1	0	0	0.00							0	4	0	0	0.00			
1-Jul							0	1	0	0	0.00							0	4	0	0	0.00			
2-Jul	2	2	0.09				0	1	0	0	0.00							0	4	0	0	0.00			
3-Jul	0	2	0.00				0	1	0	0	0.00							0	4	0	0	0.00			
4-Jul	0	2	0.00				0	1	0	0	0.00							0	4	0	0	0.00			
5-Jul	1	3	0.04				0	1	0	0	0.00							0	4	0	0	0.00	1	0	0
6-Jul	0	3	0.00				0	1	0	0	0.00							0	4	0	0	0.00	0	0	0
7-Jul	4	7	0.17				0	1	0	0	0.00							0	4	0	0	0.00	0	0	0

Table D-5. Daily catches, numbers tagged and CPE (catch/wheel hour) for pink, chum and steelhead salmon captured with three fishwheels on the Nass River in 1993.

	Fishwheel 1											Fishwheel 2											Fishwheel 3		
	Pink			Chum			Steelhead					Pink			Chum			Steelhead					Pink	Chum	Steelhead
									Tagged											Tagged					
Date	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Daily catch	Daily catch
8-Jul	7	14	0.30				0	1	0	0	0.00	1	1	0.04				0	4	0	0	0.00	0	0	0
9-Jul	6	20	0.24				0	1	0	0	0.00	3	4	0.12				0	4	0	0	0.00	1	0	0
10-Jul	9	29	0.38				0	1	0	0	0.00	2	6	0.09				0	4	0	0	0.00	0	0	0
11-Jul	6	35	0.26	1	1	0.04	0	1	0	0	0.00	2	8	0.09				0	4	0	0	0.00	1	0	0
12-Jul	12	47	0.50	0	1	0.00	0	1	0	0	0.00	2	10	0.09				0	4	0	0	0.00	2	0	0
13-Jul	20	67	0.84	0	1	0.00	1	2	0	1	0.04	4	14	0.17				0	4	0	0	0.00	0	0	0
14-Jul	7	74	0.28	0	1	0.00	1	3	0	1	0.04	0	14	0.00				0	4	0	0	0.00	2	0	0
15-Jul	10	84	0.40	1	2	0.04	0	3	0	0	0.00	5	19	0.19				0	4	0	0	0.00	0	0	0
16-Jul	27	111	1.09	0	2	0.00	0	3	0	0	0.00	6	25	0.25				1	5	0	1	0.04	0	0	0
17-Jul	31	142	1.48	0	2	0.00	1	4	0	1	0.05	10	35	0.54				0	5	0	0	0.00	5	0	0
18-Jul	70	212	2.88	1	3	0.04	1	5	0	1	0.04	12	47	0.47				0	5	0	0	0.00	3	0	0
19-Jul	77	289	3.18	1	4	0.04	0	5	0	0	0.00	27	74	1.11				0	5	0	0	0.00	6	0	0
20-Jul	99	388	4.11	1	5	0.04	1	6	0	1	0.04	26	100	1.07				0	5	0	0	0.00	0	0	0
21-Jul	97	485	3.87	1	6	0.04	4	10	0	4	0.16	30	130	1.18				0	5	0	0	0.00	0	0	0
22-Jul	208	693	9.08	3	9	0.13	4	14	0	4	0.17	23	153	1.03				0	5	0	0	0.00	0	0	0
23-Jul	135	828	5.23	3	12	0.12	1	15	0	1	0.04	30	183	1.19				1	6	0	1	0.04	0	0	0
24-Jul	111	939	4.63	1	13	0.04	2	17	0	1	0.08	15	198	0.63				0	6	0	0	0.00	25	0	0
25-Jul	144	1083	6.32	2	15	0.09	3	20	2	1	0.13	30	228	1.32				0	6	0	0	0.00			
26-Jul	78	1161	5.17	1	16	0.07	3	23	1	2	0.20	23	251	1.15				0	6	0	0	0.00			
27-Jul	93	1254	3.62	0	16	0.00	0	23	0	0	0.00	21	272	0.83	1	1	0.04	0	6	0	0	0.00			
28-Jul	64	1318	2.46	1	17	0.04	3	26	0	3	0.12	26	298	0.99	1	2	0.04	0	6	0	0	0.00			
29-Jul	51	1369	2.21	0	17	0.00	3	29	0	3	0.13	17	315	0.76	0	2	0.00	0	6	0	0	0.00			
30-Jul	5	1374	0.50	0	17	0.00	0	29	0	0	0.00	5	320	0.45	0	2	0.00	0	6	0	0	0.00			
31-Jul		1374			17			29					320			2			6						
1-Aug		1374			17			29					320			2			6						
2-Aug	116	1490	13.18	0	17	0.00	0	29	0	0	0.00		320			2			6						
3-Aug	244	1734	9.14	3	20	0.11	3	32	0	3	0.11		320			2			6						
4-Aug	200	1934	8.44	1	21	0.04	2	34	0	2	0.08		320			2			6						
5-Aug	204	2138	9.36	1	22	0.05	2	36	0	2	0.09		320			2			6						

Table D-5. Daily catches, numbers tagged and CPE (catch/wheel hour) for pink, chum and steelhead salmon captured with three fishwheels on the Nass River in 1993.

	Fishwheel 1											Fishwheel 2											Fishwheel 3		
	Pink			Chum			Steelhead					Pink			Chum			Steelhead					Pink	Chum	Steelhead
									Tagged											Tagged					
Date	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Daily catch	Daily catch
6-Aug	182	2320	7.05	0	22	0.00	1	37	0	1	0.04		320			2			6						
7-Aug	119	2439	4.98	0	22	0.00	3	40	0	3	0.13	0	320	0.00	0	2	0.00	0	6	0	0	0.00	14	0	1
8-Aug	152	2591	6.47	1	23	0.04	2	42	1	1	0.09	0	320	0.00	0	2	0.00	0	6	0	0	0.00			
9-Aug	171	2762	6.81	1	24	0.04	4	46	0	4	0.16	0	320	0.00	0	2	0.00	0	6	0	0	0.00			
10-Aug	64	2826	5.42	2	26	0.17	2	48	0	2	0.17	0	320	0.00	0	2	0.00	0	6	0	0	0.00	45	0	0
11-Aug												32	352	1.27	2	4	0.08	0	6	0	0	0.00			
12-Aug												24	376	0.95	0	4	0.00	0	6	0	0	0.00			
13-Aug												21	397	0.89	1	5	0.04	1	7	0	1	0.04			
14-Aug												12	409	0.53	0	5	0.00	1	8	0	1	0.04			
15-Aug												43	452	1.67	1	6	0.04	0	8	0	0	0.00			
16-Aug												39	491	1.63	1	7	0.04	3	11	0	2	0.13			
17-Aug												25	516	1.07	2	9	0.09	0	11	0	0	0.00			
18-Aug												28	544	1.17	2	11	0.08	0	11	0	0	0.00			
19-Aug												44	588	1.80	2	13	0.08	0	11	0	0	0.00			
20-Aug												34	622	1.43	1	14	0.04	1	12	0	0	0.04			
21-Aug												48	670	3.61	1	15	0.08	0	12	0	0	0.00			
22-Aug												30	700	0.85	5	20	0.14	0	12	0	0	0.00			
23-Aug												12	712	0.49	0	20	0.00	0	12	0	0	0.00			
24-Aug												12	724	0.52	1	21	0.04	0	12	0	0	0.00			
25-Aug												16	740	0.65	0	21	0.00	0	12	0	0	0.00			
26-Aug												21	761	0.96	4	25	0.18	0	12	0	0	0.00			
27-Aug												21	782	0.81	3	28	0.12	2	14	2	0	0.08			
28-Aug												14	796	0.67	5	33	0.24	1	15	0	1	0.05			
29-Aug												0	796		0	33		0	15	0	0				
30-Aug												33	829	0.65	7	40	0.14	0	15	0	0	0.00			
31-Aug												27	856	1.14	10	50	0.42	0	15	0	0	0.00			
1-Sep												3	859	0.23	2	52	0.16	0	15	0	0	0.00			
2-Sep												21	880	0.93	1	53	0.04	0	15	0	0	0.00			
3-Sep												27	907	1.14	0	53	0.00	0	15	0	0	0.00			

Table D-5. Daily catches, numbers tagged and CPE (catch/wheel hour) for pink, chum and steelhead salmon captured with three fishwheels on the Nass River in 1993.

	Fishwheel 1											Fishwheel 2											Fishwheel 3		
	Pink			Chum			Steelhead					Pink			Chum			Steelhead					Pink	Chum	Steelhead
									Tagged											Tagged					
Date	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	CPE	Daily catch	Cum. catch	Spag.	Radio	CPE	Daily catch	Daily catch	Daily catch
4-Sep												23	930	0.97	0	53	0.00	0	15	0	0	0.00			
5-Sep												0	930		0	53		0	15	0	0				
6-Sep												16	946	0.34	0	53	0.00	0	15	0	0	0.00			
7-Sep												26	972	0.72	6	59	0.17	0	15	0	0	0.00			
8-Sep												11	983	0.57	3	62	0.16	0	15	0	0	0.00			
9-Sep												9	992	0.33	2	64	0.07	0	15	0	0	0.00			
10-Sep												4	996	0.33	0	64	0.00	1	16	0	1	0.08			
11-Sep												10	1006	0.38	3	67	0.12	1	17	1	0	0.04			
12-Sep												0	1006		0	67		0	17	0	0				
13-Sep												7	1013	0.12	6	73	0.10	1	18	0	1	0.02			
Totals	**2826**			**26**			**48**		**4**	**42**		**1013**			**73**			**18**		**6**	**9**		**105**	**0**	**1**

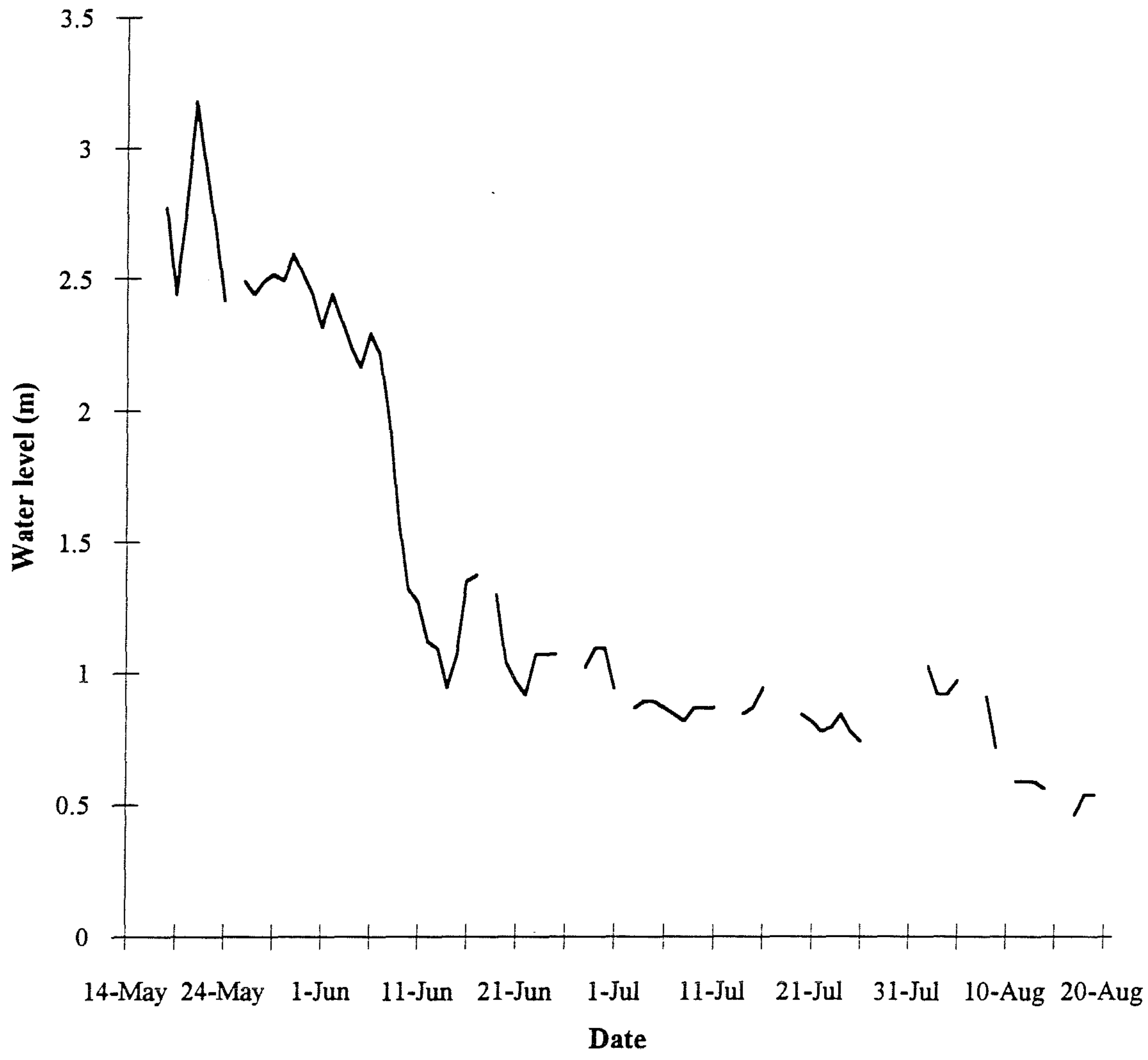


Figure E-1. Water level of the Nass River measured at the "A-frame" near Shumal Creek, 1993.

Table F-1. Daily counts and number of tag recoveries for sockeye and coho passing through the Meziadin fishway, 1993.

			Tag recoveries					
	Daily count (adults)		Bypassed a		Recovered		Total	
Date	Sockeye	Coho	Sockeye	Coho	Sockeye	Coho	Sockeye	Coho
15-Jul	713	0	0	0	0	0	0	
16-Jul	12878	0	68	0	1	0	69	0
17-Jul	21389	0	123	0	0	0	123	0
18-Jul	20348	0	117	0	0	0	117	0
19-Jul	15723	0	128	0	0	0	128	0
20-Jul	15702	0	105	0	12	0	117	0
21-Jul	16529	0	157	0	12	0	169	0
22-Jul	15689	0	153	0	18	0	171	0
23-Jul	9189	0	103	0	26	0	129	0
24-Jul	10071	0	105	0	27	0	132	0
25-Jul	10619	0	127	0	40	0	167	0
26-Jul	13018	0	174	0	53	0	227	0
27-Jul	8776	0	126	0	64	0	190	0
28-Jul	6208	0	101	0	55	0	156	0
29-Jul	6596	0	117	0	46	0	163	0
30-Jul	4697	0	71	0	29	0	100	0
31-Jul	397	0	6	0	10	0	16	0
1-Aug	615	0	7	0	5	0	12	0
2-Aug	1693	0	25	0	11	0	36	0
3-Aug	2756	0	37	0	25	0	62	0
4-Aug	6951	0	116	0	61	0	177	0
5-Aug	3244	0	66	0	34	0	100	0
6-Aug	2585	0	50	0	25	0	75	0
7-Aug	1183	0	16	0	32	0	48	0
8-Aug	4439	0	66	0	39	0	105	0
9-Aug	1341	0	18	0	18	0	36	0
10-Aug	2381	0	47	0	18	0	65	0
11-Aug	4170	0	52	0	52	0	104	0
12-Aug	4853	0	52	0	52	0	104	0
13-Aug	4884	0	61	0	66	0	127	0
14-Aug	3764	0	63	0	20	0	83	0
15-Aug	10294	0	182	0	36	0	218	0
16-Aug	4111	1	64	0	30	0	94	0
17-Aug	8483	0	117	0	50	0	167	0
18-Aug	2974	0	29	0	32	0	61	0
19-Aug	4751	3	40	0	46	0	86	0
20-Aug	8388	6	56	0	29	0	85	0
21-Aug	7116	2	31	0	40	0	71	0
22-Aug	10333	17	47	0	34	1	81	1
23-Aug	9591	33	37	0	33	1	70	1
24-Aug	5846	14	23	0	36	0	59	0

Table F-1. Daily counts and number of tag recoveries for sockeye and coho passing through the Meziadin fishway, 1993.

	Daily count (adults)		Tag recoveries: Bypassed [a]		Tag recoveries: Recovered		Tag recoveries: Total	
Date	Sockeye	Coho	Sockeye	Coho	Sockeye	Coho	Sockeye	Coho
25-Aug	6571	29	20	0	22	0	42	0
26-Aug	3128	12	6	0	25	0	31	0
27-Aug	4922	21	20	0	50	0	70	0
28-Aug	10131	22	33	0	31	0	64	0
29-Aug	11203	28	45	0	32	0	77	0
30-Aug	5989	23	26	0	28	0	54	0
31-Aug	3858	25	15	0	13	0	28	0
1-Sep	3461	33	19	0	10	1	29	1
2-Sep	3408	26	11	0	16	0	27	0
3-Sep	3544	16	14	0	9	0	23	0
4-Sep	2832	16	15	0	5	0	20	0
5-Sep	2495	10	12	0	3	1	15	1
6-Sep	2766	59	20	0	5	0	25	0
7-Sep	1538	22	6	0	4	1	10	1
8-Sep	2371	32	11	0	7	0	18	0
9-Sep	1992	28	16	1	2	0	18	1
10-Sep	1091	15	11	0	2	0	13	0
11-Sep	907	28	2	0	1	0	3	0
12-Sep	844	34	3	0	1	0	4	0
13-Sep	1474	46	3	0	7	0	10	0
14-Sep	1269	68	2	0	15	1	17	1
15-Sep	1022	29	0	0	8	1	8	1
16-Sep	1639	62	1	0	5	0	6	0
17-Sep	985	34	6	0	8	1	14	1
18-Sep	770	26	0	0	8	0	8	0
19-Sep	703	56	1	0	5	1	6	1
20-Sep	588	41	0	1	4	0	4	1
21-Sep	428	22	2	0	4	1	6	1
22-Sep	325	17	4	0	1	0	5	0
23-Sep	423	27	0	1	4	0	4	1
24-Sep	329	33	0	0	0	0	0	0
25-Sep	150	8	0	0	2	0	2	0
26-Sep	177	12	0	0	0	0	0	0
27-Sep	114	5	1	0	0	0	1	0
28-Sep	62	4	0	0	0	0	0	0
29-Sep	317	34	1	0	0	0	1	0
30-Sep	158	7	1	0	0	0	1	0
1-Oct	51	4	2	0	0	0	2	0
Total	**389323**	**1090**	**3412**	**3**	**1554**	**10**	**4966**	**13**

a - These are tagged fish that were seen passing through fishway but the fish were not captured to record tag number.

Table G-1. Calculation of a range of estimates of the number of sockeye passing through the Meziadin fishway prior to 15 July. Assumes the fishwheels were capturing 1 in 72 sockeye and that these fish exhibited the same travel time distribution as the 1543 tagged fish recovered at Meziadin in 1993.

Capture date	Number of fish captured	Number of fish catch represents	Number of days until 15-Jul	Proportion of fish expected to reach fishway prior to 15 July	Expected number of fish to reach fishway	Number of fish moving through fishway assuming range of Meziadin proportions 80%	85%	90%	95%
05-Jun	2	144	40	0.99	143	114	122	129	136
06-Jun	2	144	39	0.99	143	114	122	129	136
07-Jun	10	720	38	0.99	713	570	606	642	677
08-Jun	6	432	37	0.99	426	341	362	384	405
09-Jun	8	576	36	0.99	568	455	483	512	540
10-Jun	8	576	35	0.98	566	453	481	510	538
11-Jun	13	936	34	0.98	918	734	780	826	872
12-Jun	14	1008	33	0.98	986	788	838	887	936
13-Jun	19	1368	32	0.97	1330	1064	1131	1197	1264
14-Jun	24	1728	31	0.97	1669	1335	1419	1502	1586
15-Jun	21	1512	30	0.96	1455	1164	1236	1309	1382
16-Jun	26	1872	29	0.95	1781	1425	1514	1603	1692
17-Jun	31	2232	28	0.94	2100	1680	1785	1890	1995
18-Jun	39	2808	27	0.92	2593	2074	2204	2333	2463
19-Jun	34	2448	26	0.90	2212	1770	1880	1991	2102
20-Jun	45	3240	25	0.89	2871	2296	2440	2584	2727
21-Jun	37	2664	24	0.86	2285	1828	1942	2057	2171
22-Jun	46	3312	23	0.83	2765	2212	2350	2489	2627
23-Jun	34	2448	22	0.80	1960	1568	1666	1764	1862
24-Jun	63	4536	21	0.75	3421	2737	2908	3079	3250
25-Jun	64	4608	20	0.71	3291	2633	2798	2962	3127
26-Jun	29	2088	19	0.67	1398	1119	1189	1259	1328
27-Jun	49	3528	18	0.61	2157	1726	1833	1941	2049
28-Jun	56	4032	17	0.54	2190	1752	1862	1971	2081
29-Jun	86	6192	16	0.47	2917	2334	2480	2626	2772
30-Jun	150	10800	15	0.39	4161	3329	3537	3745	3953
01-Jul	162	11664	14	0.29	3417	2733	2904	3075	3246
02-Jul	109	7848	13	0.22	1738	1391	1478	1564	1651
03-Jul	99	7128	12	0.14	1009	807	858	908	958
04-Jul	132	9504	11	0.08	722	578	614	650	686
05-Jul	153	11016	10	0.04	469	375	399	422	446
06-Jul	205	14760	9	0.02	319	255	271	287	303
07-Jul	287	20664	8	0.01	108	87	92	97	103
					Totals:	**43844**	**46584**	**49325**	**52065**

Table H-1. Results from the sensitivity analysis of the model results (escapement estimates, variation in estimates of the daily percent captured and mean percent captured) to changes in the interval length used for tag recoveries, tag survival rate and the assumed effect of tagging on the migration rate of tagged fish (dropback).

No dropback

Escapement estimate from daily reconstruction

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	452199	444882	447105	450810	454440	440815	461207
0.75	517535	478929	500950	468632	490217	504011	484441
0.8	545839	510285	511066	519090	523200	510719	546972
0.85	575033	540781	565912	565429	554948	543334	566350
0.9	604666	570878	571176	568473	586039	600972	586806
0.95	634548	600749	627664	620182	616739	616067	604650
1	664584	630478	630316	615657	647187	663077	659625

Coefficient of variation of the daily percent captured

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	45.9	45.4	45.0	43.7	44.0	43.2	45.0
0.75	47.2	45.4	44.8	43.8	44.0	44.9	44.6
0.8	46.3	44.9	44.0	44.3	43.9	43.6	44.9
0.85	46.1	44.6	44.5	45.0	43.8	43.9	44.2
0.9	46.0	44.3	43.5	43.5	43.7	43.4	44.0
0.95	45.9	44.0	44.3	44.0	43.6	43.1	43.8
1	46.0	43.9	43.1	42.8	43.5	42.6	42.7

mean percent (from mean of dailys)

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	2.0	2.0	2.0	2.0	2.0	2.1	2.0
0.75	1.8	1.9	1.8	1.9	1.8	1.8	1.9
0.8	1.7	1.8	1.7	1.7	1.7	1.8	1.7
0.85	1.6	1.6	1.6	1.6	1.6	1.6	1.5
0.9	1.5	1.6	1.6	1.6	1.5	1.5	1.5
0.95	1.4	1.5	1.4	1.4	1.4	1.5	1.5
1	1.4	1.4	1.4	1.4	1.4	1.4	1.4

One day dropback

Escapement estimate from daily reconstruction

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	554669	593628	641260	659062	653922	651326	650926
0.75	634277	625935	714854	669162	692077	670759	693935
0.8	669247	663457	695761	731850	731388	728008	737155
0.85	707675	702676	792232	786818	771333	791654	776081
0.9	747508	742457	767455	795868	811681	815997	820732
0.95	788059	783098	873011	854529	852307	875591	868173
1	829029	823784	843512	857621	893134	890532	898798

Coefficient of variation of the daily percent captured

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	54.2	57.8	45.4	160.6	158.9	46.2	157.8
0.75	156.8	57.0	48.4	46.0	158.3	49.1	46.2
0.8	155.8	56.5	44.9	45.1	157.5	44.0	44.2
0.85	155.0	56.3	48.4	46.8	156.9	159.6	44.3
0.9	154.5	56.1	45.0	44.8	156.2	41.8	46.7
0.95	154.0	56.0	48.5	46.0	155.7	156.8	45.9
1	153.7	55.9	45.2	44.4	155.1	41.3	43.8

mean percent (from mean of dailys)

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	1.5	1.5	1.3	1.6	1.6	1.3	1.6
0.75	1.7	1.4	1.3	1.3	1.5	1.3	1.3
0.8	1.6	1.3	1.2	1.2	1.4	1.2	1.2
0.85	1.5	1.2	1.1	1.1	1.3	1.3	1.1
0.9	1.4	1.2	1.1	1.1	1.3	1.1	1.1
0.95	1.3	1.1	1.0	1.0	1.2	1.2	1.0
1	1.3	1.0	1.0	1.0	1.1	1.0	1.0

Dropback from fishwheel recaptures

Escapement estimate from daily reconstruction

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	610007	695305	762786	796673	785763	786818	777720
0.75	705406	722127	832110	792792	818807	778621	824755
0.8	735485	758227	803623	855773	855707	856423	857559
0.85	771558	797261	902618	912303	894507	936470	898916
0.9	810017	837624	872536	919496	934422	935774	951015
0.95	849677	878710	981071	975576	975059	1011902	1007798
1	890031	920237	948504	982194	1016197	1006763	1027148

Coefficient of variation of the daily percent captured

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	58.9	67.2	55.8	475.9	472.2	57.7	472.6
0.75	438.8	65.9	96.8	57.3	469.6	65.8	62.0
0.8	436.9	65.2	54.8	55.5	467.5	55.9	59.2
0.85	435.8	64.8	95.2	59.9	465.6	475.9	59.8
0.9	434.5	64.5	54.7	55.4	464.0	52.6	65.9
0.95	433.7	64.3	94.1	59.7	462.5	470.1	62.4
1	433.0	64.1	54.9	55.4	461.1	51.6	58.8

mean percent (from mean of dailys)

tag	interval length						
survival	2	3	4	5	6	7	8
0.7	1.5	1.4	1.3	2.7	2.7	1.3	2.7
0.75	3.0	1.4	1.4	1.2	2.5	1.3	1.3
0.8	2.8	1.3	1.2	1.2	2.4	1.2	1.2
0.85	2.6	1.2	1.2	1.1	2.2	2.2	0.7
0.9	2.5	1.2	1.1	1.0	2.1	1.1	1.2
0.95	2.3	1.1	1.1	1.0	2.0	2.0	1.1
1	2.2	1.0	1.0	1.0	1.9	1.0	1.0

Table I-1. Numbers of fish by age and length from sockeye salmon sampled at the Nass River fishwheels, 1993.

Nose-fork	Number of fish by age class											Number of fish sampled but could not be aged [a]							Portion
length (cm)	31	32	41	42	43	52	53	62	63	64	Total	1M	2M	3M	RG	S2	S3	Total	not aged
34-35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
36-37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
38-39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
40-41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
42-43	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0.00
44-45	0	0	0	2	6	1	0	0	0	0	9	0	0	0	0	0	0	0	0.00
46-47	0	0	0	4	0	0	0	0	0	0	4	1	0	0	1	0	0	2	0.33
48-49	0	0	0	6	0	0	3	0	0	0	9	0	0	0	0	0	0	0	0.00
50-51	0	0	0	20	0	1	7	0	0	0	28	0	2	0	0	0	0	2	0.07
52-53	0	0	0	34	0	0	18	0	1	0	53	0	2	0	2	0	0	4	0.07
54-55	0	0	1	82	0	6	19	0	0	0	108	0	5	1	3	1	0	10	0.08
56-57	0	0	3	84	0	6	95	0	2	0	190	0	8	1	7	1	0	17	0.08
58-59	0	0	3	67	0	23	156	0	5	0	254	0	14	2	7	1	0	24	0.09
60-61	0	0	4	46	0	50	128	0	5	0	233	0	25	3	12	2	1	43	0.16
62-63	0	0	1	29	0	81	122	0	11	0	244	0	14	6	13	1	1	35	0.13
64-65	0	0	1	13	0	87	72	0	13	0	186	0	8	10	9	3	5	35	0.16
66-67	0	0	1	7	0	53	28	0	13	0	102	0	9	8	8	3	0	28	0.22
68-69	0	0	0	3	0	36	9	0	10	0	58	0	2	6	6	2	3	19	0.25
70-71	0	0	1	0	0	16	3	0	12	0	32	0	2	5	3	3	2	15	0.32
72-73	0	0	0	0	0	5	0	1	3	0	9	0	0	2	2	3	1	8	0.47
74-75	0	0	0	0	0	2	0	0	1	0	3	0	0	0	1	1	3	5	0.63
Totals	0	0	15	397	10	367	660	1	76	0	1526	1	91	44	74	21	16	247	0.14

a - Age error codes: 1M, 2M, 3M refers to 1,2 or 3 marine annuli; RG, regenerated; S2, sub-two (1 fresh water annulus); S3, sub-three (2 fresh water annuli).

Table I-2. Summary of weekly age composition of sockeye sampled at the Nass River fishwheels, 1993.

Week	Stat.	Number of fish by age class											Proportions by week									
ending	week	31	32	41	42	43	52	53	62	63	64	Total	31	32	41	42	43	52	53	62	63	64
5-Jun	22	0	0	0	0	0	2	0	0	0	0	2	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
12-Jun	23	0	0	1	2	0	37	6	0	0	0	46	0.00	0.00	0.02	0.04	0.00	0.80	0.13	0.00	0.00	0.00
19-Jun	24	0	0	6	8	0	91	24	0	2	0	131	0.00	0.00	0.05	0.06	0.00	0.69	0.18	0.00	0.02	0.00
26-Jun	25	0	0	4	11	0	71	31	0	7	0	124	0.00	0.00	0.03	0.09	0.00	0.57	0.25	0.00	0.06	0.00
3-Jul	26	0	0	0	36	0	40	69	0	8	0	153	0.00	0.00	0.00	0.24	0.00	0.26	0.45	0.00	0.05	0.00
10-Jul	27	0	0	1	42	1	38	64	0	7	0	153	0.00	0.00	0.01	0.27	0.01	0.25	0.42	0.00	0.05	0.00
17-Jul	28	0	0	1	56	0	20	48	0	4	0	129	0.00	0.00	0.01	0.43	0.00	0.16	0.37	0.00	0.03	0.00
24-Jul	29	0	0	1	71	0	19	47	0	7	0	145	0.00	0.00	0.01	0.49	0.00	0.13	0.32	0.00	0.05	0.00
31-Jul	30	0	0	0	29	0	13	44	0	6	0	92	0.00	0.00	0.00	0.32	0.00	0.14	0.48	0.00	0.07	0.00
7-Aug	31	0	0	0	49	0	8	56	1	7	0	121	0.00	0.00	0.00	0.40	0.00	0.07	0.46	0.01	0.06	0.00
14-Aug	32	0	0	1	44	0	8	83	0	6	0	142	0.00	0.00	0.01	0.31	0.00	0.06	0.58	0.00	0.04	0.00
21-Aug	33	0	0	0	25	8	6	78	0	9	0	126	0.00	0.00	0.00	0.20	0.06	0.05	0.62	0.00	0.07	0.00
28-Aug	34	0	0	0	16	1	9	74	0	11	0	111	0.00	0.00	0.00	0.14	0.01	0.08	0.67	0.00	0.10	0.00
4-Sep	35	0	0	0	5	0	2	25	0	0	0	32	0.00	0.00	0.00	0.16	0.00	0.06	0.78	0.00	0.00	0.00
11-Sep	36	0	0	0	3	0	3	11	0	2	0	19	0.00	0.00	0.00	0.16	0.00	0.16	0.58	0.00	0.11	0.00
Totals		0	0	15	397	10	367	660	1	76	0	1526	0.00	0.00	0.01	0.26	0.01	0.24	0.43	0.00	0.05	0.00

Table I-3. Summary of the numbers and mean length (nose-fork, cm) of sockeye salmon successfully aged from the Nass River fishwheel catch, 1993.

	June			July			August			September			All fish		
Age class	N	Mean	SD [a]	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
41	11	59.5	3.1	3	60.0	4.0	1	70.0		0			15	60.3	4.0
42	43	57.2	2.8	212	57.4	4.1	135	56.4	4.2	7	56.0	6.0	397	57.0	4.1
43	0			1	45.0		9	43.9	0.9	0	0.0	0.0	10	44.0	0.9
52	223	63.4	3.0	108	64.9	4.0	31	63.9	5.2	5	61.0	10.3	367	63.9	3.8
53	103	59.0	6.5	231	59.6	3.4	296	60.7	3.8	31	60.5	3.9	661	60.0	4.3
62	0			0			1	72.0		0			1	72.0	
63	15	65.5	3.5	26	64.7	3.6	33	66.5	4.8	2	58.5	2.1	76	65.5	4.3
Totals	395	61.6	4.9	581	60.0	4.7	506	59.8	5.4	45	59.8	5.3	1527	60.3	5.1

a - Standard deviation