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ASSESSMENT OF SUMMER REARING HABITAT AND JUVENILE COHO ABUNDANCE IN THE KWINAGEESE RIVER, B.C., 1992

prepared by

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ABSTRACT

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Habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) was examined in the Kwinageese River, British Columbia, as part of the 1992-1993 Nisga'a Interim Measures Program (IMP). We conducted foot and snorkel surveys during August and September to quantify wetted area and juvenile coho abundance by habitat and cover type. To determine if coho production was limited by available habitats, comparisons of observed total coho abundance and densities (by habitat type) were made with those presented in the literature.

Linear densities of coho fry (coho/m) were the highest in small tributaries and pools with cover (8.0 and 7.0 coho/m, respectively), followed by runs with cover (3.7 coho/m). Runs and riffles no cover had the lowest densities (1.4 and 1.3 coho/m). Densities between habitats with cover and habitats without cover were significantly different (ANOVA) in some comparisons. Side channels accounted for the greatest total linear habitat (32.3%) and the highest total abundance of juvenile coho (34.1%). Pools contributed only 11.7% to total linear habitat but accounted for 16.5% of total abundance. Total estimated coho fry abundance was only 27% of the potential abundance estimated using a coho production model (Reeves et al. 1989). Comparison of maximum density and biomass estimates for 29 B.C. streams revealed that the Kwinageese maximum for age 1 coho (5.1 g/m^2) was similar to the average for interior and coastal streams, while age 2 coho maximum (19.4 g/m^2) was substantially higher than the maximum for all other streams surveyed. The average value for the 5 sites surveyed on the Kwinageese River was only 20% of these maximum levels. We conclude that factors such as escapement or winter rearing habitat are more likely to be limiting coho production in the Kwinageese River than summer rearing habitat.

RÉSUMÉ

Nass, B. L., K. K. English, and H. R. Frith. 1996. Assessment of summer rearing habitat and juvenile coho abundance in the Kwinageese River, B.C., 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2375: 56 p.

Cette étude avait pour objet d'examiner les densités d'occupation des saumons cohos juvéniles (*Oncorhynchus kisutch*) dans la rivière Kwinageese, en Colombie-Britannique, dans le cadre du Programme de mesures provisoires des Nisga'a pour l'année 1992-1993. Les campagnes de reconnaissance ont été effectuées à pied et en plongée libre (snorkel) en août et en septembre afin de quantifier les superficies sous eau et le taux d'abondance des saumons cohos juvéniles selon l'habitat et le couvert végétal. Pour déterminer si le taux de productivité du saumon coho était limité par les types d'habitats disponibles, on a comparé les taux d'abondance et de densité globaux observés (selon le type d'habitat) et les taux dont il est fait état dans la documentation sur le sujet.

La densité linéique des stocks d'alevins de cohos (nombre de cohos par m) était à son niveau maximal dans les petits tributaires et dans les fosses avec couvert végétal (8 et 7 cohos/m, respectivement), suivis des ruisselets avec couvert (3,7 cohos/m). Elle était à son niveau le plus bas dans les ruisselets et les rapides sans couvert (1,4 et 1,3 coho/m). Certaines comparaisons ont permis d'établir une différence notable entre les taux de densité observés dans les habitats avec couvert et dans les habitats sans couvert (ANOVA). Les chenaux latéraux représentaient la plus importante surface d'habitat linéique (32,3 %) et le plus haut taux d'abondance de cohos juvéniles (34,1 %). Les fosses représentaient seulement 11,7 % de la surface totale d'habitat linéique, mais 16,5 % du taux d'abondance total. Le taux d'abondance global des stocks d'alevins de cohos représentait seulement 27 % du taux d'abondance potentiel estimé selon un modèle de productivité du saumon coho (Reeves et al. 1989). L'étude comparative des chiffres de densité maximale et de biomasse pour 29 cours d'eau de la Colombie-Britannique révèle que la densité maximale du saumon coho dans la rivière Kwinageese, pour les cohortes de 1 an (5,1 g/m^2) était semblable à la moyenne observée dans les cours d'eau continentaux et côtiers, alors que pour les cohortes de 2 ans (19,4 g/m^2) elle était notablement plus élevée que pour tous les autres cours d'eau recensés. La valeur moyenne pour 5 sites recensés dans la rivière Kwinageese correspondait seulement à 20 % de ces maxima. Nous en concluons que des facteurs comme le taux d'échappement et les conditions des habitats de croissance hivernale sont davantage susceptibles d'avoir une incidence limitative sur la productivité des stocks de saumon coho de la rivière Kwinageese que les conditions des habitats de croissance estivale.

INTRODUCTION

As part of an agreement between the Nisga'a Tribal Council and the Canadian Government, an Interim Measures Program (IMP) was established in 1992 for fisheries research in the Nisga'a Land Claim Area, British Columbia. One objective of this large research initiative was to develop a comprehensive watershed management strategy for the Nass River drainage that includes all aspects of habitat management. Initial studies for 1992 were directed at the assessment of fish habitat in the Kwinageese watershed (Fig. 1). The Kwinageese was proposed as a focus for habitat assessment because of its high fisheries values, including sockeye, chinook, coho and steelhead salmon, and because of immediate plans for road construction and forest harvesting in the pristine watershed.

On 24 June 1992, a workshop was held to discuss plans for fish habitat studies in the Kwinageese. Participants included representatives of the Federal and Provincial Governments, the Nisga'a Tribal Council and personal consultants. At the workshop, it was generally agreed that the primary goal for this study should be to assess whether juvenile rearing habitat is limiting the production of major salmon species found in the Kwinageese watershed. Specifically, the following three tasks were identified:

1. Collect information on fish distribution, habitat, and physical features of the watershed;

2. Design a survey program to assess juvenile sockeye, coho, and chinook salmon populations and habitat; and

3. Identify opportunities and techniques for obtaining systematic information on other fish species (i.e., steelhead and trout species).

Studies were also conducted in 1992 to assess possible limitations of spawning habitat for sockeye salmon. The results from the adult and juvenile sockeye studies are being compiled in separate reports (Kim Hyatt, Dept. of Fisheries and Oceans, Nanaimo, B.C., pers. comm.). Since no juvenile chinook were observed in the Kwinageese study areas in 1992 during late summer, habitat limitations of this species were not addressed in 1992.

This report summarizes the results of coho studies in the Kwinageese watershed. The objective of the study was to quantify juvenile coho abundance in the Kwinageese River and to assess whether summer rearing habitat is limiting the production of juvenile coho. A second objective of the study was to collect data that would permit the identification of critical habitat regions for salmonid spawning and rearing.

Few studies have investigated the relationships between habitat characteristics and fish abundance in riverine systems (Nicholson 1992a), and there are no reported studies in British Columbia for which habitat and fisheries data have been collected simultaneously for stock assessment purposes. The temporal and spatial separation between the collection of habitat data and fish population data can confound any relationship between habitat characteristics and habitat use by juvenile salmonids.

Our approach in this study was to simultaneously collect data on juvenile coho abundance and distribution in various types of habitat and cover with data on riverine habitat quantity and composition. To assess the importance of different habitat types for juvenile coho in the Kwinageese, we followed methods similar to Nicholson (1992a). Data collection was planned to overlap with late summer, low flow conditions to emphasize the period when summer rearing habitat would most likely be at a minimum. We quantified habitat and juvenile fish abundance using standard stream habitat survey and juvenile population assessment techniques. Juvenile coho abundance was estimated from in-stream observations by snorkelling and total habitat was calculated from in-stream measures. We calculated total juvenile coho abundance for the Kwinageese study region and estimated their densities in different habitat-cover types. To assess whether summer habitat was limiting coho production, we used the Reeves et al. (1989) and the Burns and Tutty (1986) production models.

METHODS

KWINAGEESE WATERSHED AND STUDY REGION

The Kwinageese River in northwest British Columbia is a major tributary to the Nass River (Fig. 1) and flows through a pristine, unlogged watershed. The Kwinageese watershed is approximately 52,000 ha and the main channel has a total length of over 40 km (Thomas and Gordon 1991). From its headwaters in the alpine, it flows primarily southwest to Fred Wright Lake through a series of channelized canyons and meandering side channels. A falls impassable to fish exists approximately 8.1 km upstream of Fred Wright Lake. Kwinageese Lake and its outflow connect with the mainstem approximately 1.5 km upstream of Fred Wright Lake and provides accessible habitat for rearing and spawning. Another major tributary, Bonnie Creek, enters Fred Wright Lake and is a known spawning area for sockeye. The outflow from Fred Wright Lake heads in a northerly direction to Halfway Lake through cascading falls and chutes. The lower 1.2 km has a lower gradient with numerous side channels. North of Halfway Lake, the stream gradient decreases to produce long, relatively slow runs down to the confluence of Line Creek (approximately 3.1 km downstream of Halfway Lake). The stream gradient increases slightly from this point downstream to Saicote Creek; producing a larger proportion of riffles with occasional chutes. The entry of a number of relatively large creeks (e.g., Shanalope Creek) causes a moderate increase in flow regime beyond this point. At a point approximately 5 km upstream of the confluence of the Kwinageese River and the Nass River, the flow becomes strictly confined within a canyon and descends rapidly down a series of chutes and rapids. Partial or complete beaver dams occur in the upper and central mainstem and its tributaries. The Kwinageese River supports several species of salmonids including coho, chinook (*Oncorhynchus* tshawytscha), sockeye (*O. nerka*), rainbow trout (*O. mykiss*), and Dolly Varden (*Salvelinus malma*). Mean escapement estimates of coho, chinook and sockeye for the period 1980-1988 are 1,760, 1,056, and 9,533, respectively (Jantz et al. 1989).

A base camp was established at the lower end of reach 3 on the main river (Fig. 2). Helicopter services from Elseworth logging camp provided access to this location with a flight time of 0.5 h round trip. Field work was conducted during the period of 15 August - 23 September. There were a total of 31 d of field time, including travel. Transport of field crews and equipment to study regions from base camp required the use of a hovercraft, helicopter, or all terrain vehicle (ATV). The hovercraft was able to access reaches 2 and 3 and the helicopter and ATV were used to access the upper Kwinageese and the Shanalope region.

Research activities were restricted to sections of the Kwinageese River upstream of the confluence of Shanalope Creek (Fig. 2). A field sampling program was designed to include the most valuable rearing habitat for juvenile coho (based on overflight surveys). The study region was stratified into units representing habitat characteristics in the system. Ordered from largest to smallest, the four units are survey reaches, sections, areas, and sites. Reaches are comprised of one or more sections, and sections are comprised of one or more areas. Sites are sub-samples of areas and represent different habitat-cover types. Details of defining each type of unit is presented below.

<u>Defining a Survey Reach</u>

The Kwinageese River was stratified into six reaches (Fig. 2) according to standard classification procedures (Anon. 1989; Anon. 1992). Features used to define reach boundaries included flow regime (relative discharge) and stream morphology. Reach breaks occurred at lake inlets and outlets and major tributary confluences on the mainstem. The reaches from the headwaters to the Nass River are defined as:

(1) waterfalls to Fred Wright Lake (FWL) - 8.1 km;

(2) FWL to Halfway Lake - 2.7 km;

(3) Halfway Lake to the confluence of Saicote Creek - 8.7 km;

(4) Saicote Creek to the confluence of Shanalope Creek - 5.1 km;

(5) Shanalope Creek to the confluence of the Nass River - 12.1 km; and

(6) Shanalope Creek (upstream 8.7 km from its confluence with the Kwinageese).

These reach boundaries are consistent with previous studies in the Kwinageese (Scott and Sebastion 1974), except for the addition of Shanalope Creek as an additional reach. We conducted habitat and fisheries surveys in reaches 1, 2, and 3. However, surveys were incomplete in reaches 1 and 2 in the following ways. In reach 1, the lower 1.2 km were not surveyed due to high water. In reach 2, the upper 1.5 km were not surveyed because it was an unlikely habitat for coho (high gradient).

Defining a Survey Section

Reaches were partitioned into "sections" to reflect moderate changes in physical character such as channel gradient and confinement. In addition, habitats located off of the mainstem (e.g., lakes and tributaries) were designated as a separate section. A section was qualitatively defined as a length of stream having a repetitious pattern of habitat types which were sufficiently different in physical character from adjacent lengths of stream. For example, reach 1 is partitioned into three mainstem sections and 1 off channel section (Fig. 2). The upper most section is characterized by a mostly confined channel with relatively fast flowing water (high gradient) and quickly changing habitat types (run, riffle, pool). The middle section is less confined (more meandering), has slower flowing water, longer lengths of stream of the same habitat type (e.g., runs) and a moderate number of beaver ponds which feed the main channel. The lower section is mostly braided with many sloughs which amalgamate with the main channel during flooding.

Defining a Survey Area

Survey sections were partitioned into smaller units called "areas" which served as the standard unit at which habitat data was collected. Areas can be qualitatively defined as a length of stream for which the composition and contribution of habitat type, cover, and substrate could be effectively assessed by visual estimate. Area bounds usually coincided with moderate changes in habitat composition, cover or substrate. For example, in reach 1 - section 4, areas 1 and 2 are substantially different (Fig. 3). In area 1, the stream is unconfined, slow flowing, has a moderate amount of in-stream vegetation, and has a substrate of 100% fines. In contrast, area 2, which is adjacent to area 1, is mostly confined, is faster flowing, has no in-stream vegetation, and has a substrate of 60% boulder.

Defining a Survey Site

Survey sites were small stream lengths (10 - 100m) of homogeneous habitat in which juvenile coho abundance assessments were conducted. Survey sites are representative sub-samples of an area (Fig. 3). The area (m^2) of a survey site was determined by visual estimate or hip chain. Sites were defined according to habitat type and cover (Table 1).

Habitat type was defined according to standard classification procedures (Anon. 1989; Anon. 1992) and was described as pool, riffle, run, or side channel. Several other types of habitat were surveyed including lakes, beaver ponds, and small tributaries. In our analysis, beaver ponds were treated as pools. In addition, lakes were excluded from the analysis since the methods used in this study were not effective for counting juvenile coho in that habitat.

Cover for fish was defined according to the major types of structures present in and around the stream channel. This included in-stream vegetation (IV), over-vegetation (OV), woody debris (WD), and boulder (BD). A site was classified as possessing cover type if at least 20% of the survey area (m^2) possessed that structure. This percentage cover reflected whether or not the structure providing the cover was sufficient to enhance the habitat for juvenile fish. Survey sites with less than 20% of a cover type were classified as possessing no cover. Coverage (%) was visually estimated.

HABITAT SURVEYS

Habitat surveys were performed simultaneously with fisheries surveys. Habitat data were collected according to standard methods (Anon. 1989; Anon. 1992). Data was collected for each habitat area and was combined to generate mean values for each section and reach.

Habitat parameters measured or estimated in the field included channel and wetted width, maximum depth, bars (%), cover (%), bed composition (%), habitat type (% of survey length), water stage, and any obstructions. Fish abundance and habitat character were recorded on the same data form (Table 2). Table A-1 is a list of abbreviations used in data collection. Preliminary information regarding reach, section, and site boundaries was recorded on 1:20,000 hydrologic maps.

Parameter measurements, other than habitat type composition, were determined primarily by a visual estimate with regular ground truthing using appropriate measuring devices. Channel width and stream lengths were measured using a hip chain and channel depth was measured using a marked walking stick. Substrate size was measured using callipers and measuring tapes. Habitat composition (%) was calculated by dividing the total length of a specific habitat-cover type in a survey area by the total length of the survey area. Bars (%), cover composition (%), and bed material composition (%) were not ground truthed.

FISHERIES SURVEYS

Snorkel Survey Techniques

Surveys for juvenile coho abundance were conducted in units called "sites" which represented habitat-cover types in an area. We attempted to survey at least three sites for each habitat-cover type in each reach.

Surveys for juvenile coho abundance and distribution were conducted by snorkelling. One person was responsible for conducting underwater counts of fish, detailing the types of structures present in the water (i.e., cover), and identifying characteristics of the environment or behaviour of the fish that would aid in visual counts. Other crew members would aid the snorkeller by directing him to structures or spots where juveniles were observed near the surface. Survey area (m^2) was determined by visual estimate or hip chain and was equal to the area (m^2) observed by the diver. Site area (m^2) was the length of the survey times the wetted width of the stream. In relatively small sites (short and narrow), the diver could see bank to bank or could effectively swim the entire area (m^2). In these cases, the survey width was equal to the total wetted width of the channel. However, in some surveys, the channel was too wide to be surveyed effectively and the diver would survey along one bank only. In these cases, survey width was less than the total wetted width of the stream.

Primary Abundance Estimates

The total number of fish observed, by species, was recorded for each survey site. Numbers of fish were generally low enough to allow for counts of individuals. However, in some cases, a high abundance of fish was encountered and group counts were used (i.e., an estimate of total individuals). In addition, the snorkeller was required to provide a primary abundance estimate. A primary estimate is the observed value corrected for the degree of habitat homogeneity across the channel and the level of observation difficultly due to water clarity and in-stream structures. Habitat homogeneity refers to whether or not there are differences in cover features between the stream banks (i.e., marginal vs mid-channel). Therefore, the primary estimate is the actual number of fish counted in the survey area (m^2), plus any additional coho perceived to be within the bounds of the survey site area (m^2). Primary estimates were determined for two purposes: (1) to provide a correction index for survey conditions, and (2) to provide an adjusted abundance estimate to compare with abundance estimates generated by other methods.

Independent Abundance Estimates

Juvenile coho abundance was estimated using other methods at selected sites. Independent abundance assessments were conducted to provide a measure of "true" abundance for use in calculating observer efficiency. A survey site qualified for an independent estimate if either of the following conditions existed: (1) a relatively high juvenile coho abundance was observed, or (2) expected low observer efficiency due to in-stream structures. The method of assessment varied depending on the environment and took the form of a second float (or independent snorkeller), a single removal by beach seine, or a mark-recapture using wire-mesh Gee traps. Second floats and beach seining trials were unreliable for determining "true" abundance estimates and, therefore, only data from mark-recapture trials was used.

Mark-recapture trials were conducted in several habitat-cover types using 3 mm mesh Gee traps baited with roe collected from pre-spawned salmon carcasses. Sites were unbounded (no block nets) due to water flow and adult salmon migration. Traps were deployed such that the trapping area was saturated (trap separation distance of between 1 to 3 m. Soak time varied between 3 and 24 h. Captured fish were identified and counted separately for each trap and recorded. Juvenile coho were anaesthetized and fin clipped.

After recovery, coho were released back into the area of capture. Duration between marking and recovery at a site ranged from 1 d to 1 wk.

Observer Efficiency

Visual enumeration methods are generally not considered to generate "true" abundance values because all individuals will not likely be counted due to the many environmental factors (in-stream structures, turbidity) which can limit visibility. Therefore, other abundance assessments were conducted at selected sites to calculate observer efficiency by habitat-cover type. Observer efficiency is defined as the proportion of the total population observed by the snorkeller. Our original goal was to obtain observer efficiency estimates for each habitat-cover type in each reach. True population estimates were determined from mark-recapture (adjusted Petersen estimator) trials as other methods of capture were unreliable. Stratified observer efficiency (*OE*) is calculated by:

$$OE_{r,s,a,st,h,c} = \frac{EC_{r,s,a,st,h,c}}{TC_{r,s,a,st,h,c}} \quad (1)$$

where *EC* is the estimated juvenile coho abundance in the survey site and *TC* is the true juvenile coho abundance in the survey site, stratified by reach (*r*), section (*s*), area (*a*), site (*st*), habitat (*h*), and cover type (*c*).

It was not possible to obtain observer efficiency estimates for all the different habitats or reaches due mostly to the ineffectiveness of the independent methodologies. In the end, our independent abundance trials resulted in only one reliable estimate (mark-recapture) for comparison with an observed abundance (Table 3). The calculated observer efficiency became the basis for estimating observer efficiency for other habitat types throughout the study region.

We determined estimates of observer efficiency for each habitat-cover type by defining a range of possible values based upon the calculated observer efficiency value and reasonable expected values by ranking habitats according to survey difficulty. This was accomplished by first establishing a set of observer efficiency values within the possible range in values (0.00 - 1.00). The minimum value (0.50) was set from the calculated value because it represented a habitat that was typically most difficult to survey (i.e., habitats with structural cover such as in-vegetation or large organic debris). The maximum value was determined as 0.90 since habitats with no cover are relatively easy to survey, but 100% efficiency was unlikely given the small size and behaviour of juvenile fish. The next step was to rank habitat-cover types according to the level of survey and observation difficultly (Table 4) and then assign appropriate values. This classification is based on observations made during snorkel surveys. Finally, to represent potential variability or error in our assumed observer efficiency values, we varied each observer efficiency value by 0.10. This procedure allowed us to determine the quantitative impact of these variations on the abundance estimates.

HABITAT AREA AND JUVENILE COHO ABUNDANCE

Total area (m^2) and estimates of juvenile coho abundance, stratified by reach, section, area, habitat type, and habitat cover, were calculated for the study area. A series of step wise relations were applied to the habitat and juvenile coho observation data to produce stratified abundance estimates. We conducted several hierarchial levels of calculations, each utilizing the data based on different assumptions of habitat continuity (Table 5). More specifically, we applied juvenile coho density values (calculated as the number of coho per unit length) from survey sites in a given strata with a specific habitat-cover type to wetted lengths of stream for the same habitat-cover type and in the same strata for which there were no coho surveys. This procedure requires the following steps (Fig. 4). First, area (m^2) and length for each habitat-cover type in each survey area is calculated. Next, an indexed search by habitat-cover type is performed on the coho survey data to determine if there are coho density estimates for a specific habitat-cover type within the area. If there are available estimates, a mean density is calculated and linked to those areas (Level 1 calculation). If there are no applicative densities, a second indexed search is performed to determine if there are coho density estimates for a specific habitat-cover type within the survey section to which the survey area belongs. If there are available estimates, a mean density is calculated and linked to those areas (Level 2 calculation). Similarly, if there no applicative densities at the second level, a third indexed search of coho density estimates is performed at the survey reach level. If there are available estimates, a mean density is calculated and linked to those areas (Level 3 calculation). Estimated abundances are then calculated by the product of the mean densities and the area or length of habitat. Finally, estimated abundances are corrected for observer efficiency. Details of each calculation are presented below.

Habitat area (*HA*) is calculated by:

$$HA_{r,s,a,h,c} = L_{r,s,a} * W_{r,s,a} * \frac{P_{r,s,a,h,c}}{100} \qquad (2)$$

where (L) is the length of river surveyed, (W) is the mean wetted width of the main channel, and (P) is the percent of the surveyed river length which is a habitat-cover type. Variables are stratified by reach (r), section (s), area (a), habitat type (h), and habitat cover (c).

Similarly, habitat length (*HL*) is calculated by:

$$HL_{r,s,a,h,c} = L_{r,s,a} * \frac{P_{r,s,a,h,c}}{100} \tag{3}$$

Next, total side channel area (*SCA*) and side channel length (*SCL*) are calculated respectively by:

$$SCA_{r,s,a} = L_{r,s,a} * 2 * \frac{PSC_{r,s,a}}{100} \tag{4}$$

$$SCL_{r,s,a} = L_{r,s,a} * \frac{PSC_{r,s,a}}{100} \tag{5}$$

where (*PSC*) is the percent of the surveyed river length that has side channel (in that area) and 2 is a constant representing the mean wetted width (meters) of side channels.

The calculation of juvenile coho density can take several different forms. We examined the effects of using three different methods (equations) in calculating coho abundance estimates and used the most applicable one in our final analysis. Each method is presented and discussed below.

For method 1, we calculated coho density (*CD*) by:

$$CD = \frac{OC}{SL*SW} \tag{6}$$

where (*OC*) is the number of coho observed within the bounds of the survey length (*SL*) and survey width (*SW*). When applied to respective habitat-cover type areas (m^2) of the stream for which there was not a coho survey, this equation tended to overestimate the total abundance. This is due to the snorkel survey methodology in which most habitats (where stream widths were large) were primarily examined at the margins or next to structures where coho were most likely to reside. Therefore, using this assumption, coho density calculated for the survey area (m^2) would be applied to the entire wetted area (m^2), including mid-channel locations or habitats with little or no suitability for inhabiting coho.

For method 2, we calculated coho density by:

$$CD = \frac{EC}{SL*WW} \tag{7}$$

where *(SL)* is the same as above, and *(EC)* is the estimated juvenile coho abundance and *(WW)* is the wetted width of the stream at the survey site. This equation has the advantage of using on site perceptions of the habitat by the diver and compensating for the observed abundances accordingly. However, when applied to wetted areas (m^2) of the stream in which there was no survey conducted, this equation tended to underestimate the coho abundance in many survey sites. This is due to the fact that usable marginal habitat does not always exist at both sides of the wetted surface area. In fact, because streams are generally continuously winding, good marginal habitat may only exist on the outside bend. Therefore, by including wetted width in the equation, counts are applied to the whole stream even though most fish may be found in one part of the site.

We chose to calculate coho abundance in terms of linear density (method 3) by:

$$CLD = \frac{EC}{SL} \tag{8}$$

where (*CLD*) is the mean juvenile coho linear density and (*EC*) is the estimated juvenile coho abundance in the survey site. In this method, numbers of juvenile coho are calculated according to unit lengths of stream habitat. Similar to method 2, this equation has the advantage of using on site perceptions of the habitat by the diver by using an abundance estimate, but also alleviates the problems with the first two methods (over and underestimation in the application) associated with unused portions of the stream channel. Therefore, we believe this is the most representative method of calculating density relative to the coho survey methodology.

As mentioned above, coho abundance surveys were not conducted in every habitat survey area or every habitat-cover type. We developed a series of hierarchial calculations that would generate a stratified mean linear density for the respective habitat-cover types in an area. For a Level 1 calculation, linear density values for a reach, section and area are calculated by:

$$CLD_{r,s,a,h,c} = \frac{\sum_{ST} \frac{EC_{r,s,a,h,c,st}}{SL_{r,s,a,h,c,st}}}{n_{r,s,a,h,c}} \tag{9}$$

where (*ST*) designates a survey site and (*n*) is the total number of sites within an area with the same habitat-cover type. Level 1 linear densities are applied to respective habitat-cover types in areas from which they were obtained.

However, if densities for the respective habitats can not be found within the area, then linear density values for a given reach and section were calculated by:

$$CLD_{r,s,h,c} = \frac{\sum_{A}\sum_{ST}\frac{EC_{r,s,h,c,a,st}}{SL_{r,s,h,c,a,st}}}{n_{r,s,h,c}} \tag{10}$$

where (*n*) is the total number of sites within a section with the same habitat-cover type. These Level 2 densities were applied to respective habitat-cover types in an area that were not assigned a value in the Level 1 calculation. The Level 2 calculation assumes that stratified densities calculated from samples in a section are applicable to respective habitat-cover types in that section.

Similarly, if densities for the respective habitats can not be found within the section, then linear density values for a given reach were calculated by:

$$CLD_{r,h,c} = \frac{\sum_{S}\sum_{A}\sum_{ST}\frac{EC_{r,h,c,s,a,st}}{SL_{r,h,c,s,a,st}}}{n_{r,h,c}} \tag{11}$$

where (*n*) is the total number of sites within a reach with the same habitat-cover type. These Level 3 densities are applied to respective habitat-cover types in an area that were not assigned a value in the Levels 1 and 2 calculation. The Level 3 calculation assumes that stratified densities calculated from samples in a reach are applicable to respective habitat-cover types in that reach.

In total, there were 109 classified lengths of stream to which coho densities were applied. Of these, 55 were Level 1 applications, 32 were Level 2, and 22 were Level 3 (Table 5).

Coho abundance (*CA*) was calculated from mean coho linear densities (*CLD*) and the lengths of river habitat (*HL*):

$$CA_{r,s,a,h,c} = CLD * HL_{r,s,a,h,c} \qquad (12)$$

where (CLD) is the appropriate linear density assigned from equations 10, 11, or 12.

Coho abundances were then corrected for observer efficiency (OE) according to their respective habitat-cover types by:

$$CCA_{r,s,a,h,c} = \frac{CA_{r,s,a,h,c}}{OE_{h,c}} \qquad (13)$$

where (CCA) is the corrected stratified coho abundance. An estimate of total juvenile coho for the study region is calculated by summing (CCA) across all strata.

Finally, to be consistent with other studies, we calculated mean coho densities (CD = no. of fish/unit area) for the study region, stratified by habitat and cover, by:

$$CD_{h,c} = \frac{\sum_{r,s,a} CCA_{r,s,a,h,c}}{\sum_{r,s,a} HA_{r,s,a,h,c}} \qquad (14)$$

BIOSAMPLING

Juvenile coho were sampled for length, weight, and scales (age) usually in conjunction with assessment surveys using seining or trapping techniques. We attempted to sample at random 25 juvenile coho from each survey site at which coho were captured. Fish were anaesthetized in a mild solution of MS-222, measured for fork length (mm), weighed on an Ohous electronic balance (0.1 g), and sampled for scales. Sampled fish were allowed to fully recover in a bucket of freshwater and then released into the area from which they were captured. Scale samples were interpreted by the Canada Department of Fisheries and Oceans Scale Lab, Vancouver, B.C. Secondary quality control checks were performed to ensure reliability of the age designations. Scale ages are reported in Gilbert-Rich notation where freshwater age 2 coho (having survived two winters from egg deposition) have a single freshwater annulus.

ADDITIONAL PHYSICAL OBSERVATIONS

Temperature, pH, dissolved oxygen and conductivity were obtained for each section in reach 3 using an electronic probe (Hydrolab). Daily in-stream water level and temperature were monitored at base camp (unpublished data from Triton Environmental Consultants Ltd. Burnaby, B.C.). Single measures of temperature were taken for each survey section. In addition, we collected maximum and minimum water temperatures and levels for the period 28 October 1992 to 27 June 1993 using a Starlog 64K Data Logger equipped with an electronic thermistor (± 0.05 C) and pressure transducer (± 0.01 m), respectively. Measurements were collected at base camp in a main channel run.

RESULTS

HABITAT SURVEYS

Habitat data, stratified by reach and section, is summarized in Table B-1 and includes information on survey lengths, stream widths, habitat composition (%), and physical characteristics of the channel. We have restricted our analysis to reaches 1, 2, and 3.

Water levels were monitored at the base camp station in reach 3 from 17 July to 30 September (Fig. 5; unpubl. data from Triton Environmental Consultants, Burnaby, B.C.). Daily discharge was calculated using a stage-discharge relation derived from in-stream measures. Surveys corresponded with summer low flow conditions in which discharge ranged from 0.3 to 2.2 m^3/s.

In reach 1, 7.0 km of mainstem habitat were surveyed. In this section of the river, the channel was frequently confined within the bounds of the valley walls. Mean wetted width was 10 m and mean maximum depth was 1.5 m. Total mainstem wetted length consisted of 35% side channel, 33% riffle with no cover, and 12% run with no cover (Fig. 6). All other habitat-cover types accounted for less than 7% each. Total cover (30%) consisted primarily of large organic debris (62.5%) followed by boulder (20%) and deep pool (10%). Over-vegetation and cutbank comprised the remaining 7.5%. Bed material consisted of 45% larges, 45% gravels, and 10% fines. Water temperature ranged between 6 and 7 °C. In addition to the mainstem habitat, we surveyed 1.38 km of the Kwinageese Lake outflow (a tributary to the Kwinageese River). Mean wetted width was 5.7 m and mean maximum depth was 0.4 m. Side channels comprised 30% of the total length followed by riffles with cover (29%) and runs with cover (28%). Total cover was 60% and was due mostly to over-vegetation. Bed material consisted mainly of gravels (40%) although some survey areas were dominated more by either fines, larges, or bedrock. Water temperature was 12 °C. Many other small tributaries feed the mainstem in reach 1, but only Kwinageese lake outflow was surveyed.

We surveyed the lower 1.5 km of reach 2 (total length = 2.7 km). The channel course was occasionally confined by valley walls. Side channels were relatively extensive in this part of the reach. Mean wetted width was 38 m and mean maximum depth was 3 m. Total wetted length consisted of 47% side channel, 20% run with cover, 12% riffle with no cover (Fig. 6). Other habitat accounted for less than 8% each. Total cover was 30%. Deep pool, LOD, boulder and in-vegetation were similarly represented. Bed material was composed mostly of larges (40%). Gravels and fines comprised 30% and 20% of the bed material, respectively. Freshwater mussels were abundant in the lower 0.4 km of the reach. Water temperature was 14°C.

All of reach 3 was surveyed which totalled 8.8 km in length. This section of the river was frequently confined by the valley walls, however, extensive side channels exist for at least a third of its length. Mean wetted width was 19.1 m and mean maximum depth was 1.5 m. Total wetted length consisted of 31% riffle with no cover, 27% side channel, 18% run no cover, and 13% run with cover (Fig. 6). Pools comprised the remaining habitat (11%). Total cover (38%) consisted mostly of LOD (25%), boulder (25%), and deep pool (20%). Bed material was composed mostly of larges (53%) and gravels (30%). Freshwater mussels were extremely abundant in some run habitats (90% coverage of the substrate). Water temperature ranged between a minimum of 15°C and a maximum of 20°C.

FISHERIES SURVEYS

We conducted a total of 75 float surveys equalling 16% of the total wetted length in reaches 1, 2, and 3 of the Kwinageese study region (Table C-1). Riffles with no cover had 15 sites, and pools with cover and runs with cover had 14 sites. Pools with no cover had 11 sites, and runs with no cover had 9 sites. Small tributaries and side channels each had 6 survey sites. Table C-2 presents the snorkel survey statistics and coho density (fish/m^2) estimates for each of the sites surveyed in 1992.

Reach Analysis

In reach 1, side channels accounted for the highest abundance of coho (8,546) followed by small tributaries (6,746) and pools with cover (3,812) (Fig. 6, Table D-1). Despite the extensive amount of habitat in riffles no cover, zero coho were observed in this habitat-cover type. Runs with and without cover showed similar abundances. In reach 2, quality rearing habitat was minimal and we restricted our surveys to the lower 1.2 km. Side channels were extensive in the areas surveyed and accounted for the highest abundance (2,730) followed closely by runs with cover (2,494). The greatest numbers of coho were observed in reach 3. Side channels again accounted for the highest number of coho (13,093) followed by runs with cover (10,198). Extensive riffle with no cover habitat, surprisingly, produced the third largest number of coho (6,477). Pools contributed the least to total abundance. We estimate a total of 22,318, 8,127, and 41,071 juvenile coho in reaches 1, 2, and 3, respectively. Total length of wetted stream was 12,799, 2,895, and 11,998 m for the same reaches.

In reach 1, small tributaries had the highest density of coho (6.8 coho/m) (Fig. 7 and Table E-1) followed by pools with cover (4.7 coho/m). All other habitat-cover types had densities less than 2.0 coho/m. In reach 2, pools with no cover had the highest density (5.1 coho/m) followed by runs with cover (4.4 coho/m) and pools no cover (3.7 coho/m). All other habitat-cover types had densities less than 2.0 coho/m. Similarly, in reach 3, pools with cover had the highest density (6.6 coho/m) followed by runs with cover (6.3 coho/m). Densities were the highest in reach 3 for four of the six common habitat-cover types represented. Reach 1 typically had the lowest densities of any of the three reaches.

Study Region Analysis

Total abundance of juvenile coho for the Kwinageese study region was estimated at 71,516 (Fig. 8, Table D-1). Minimum and maximum estimates are 62,607 and 83,593 using maximum and minimum observer efficiencies, respectively. Minimum abundance is 12.5% less than the best estimate and maximum abundance is 16.9% greater than the best estimate.

Side channels accounted for the greatest total amount of linear habitat (32.3%) and the highest total abundance of juvenile coho (34.1%). Riffles had the second greatest contribution to habitat (27.9%), but accounted for only 10.1% of total coho abundance. Runs with no cover and runs with cover made up a similar amount of habitat (13.3% and 12.2% respectively), however, runs with cover accounted for twice as many coho (20.0% and 9.8%). Pools with no cover and pools with cover contributed only 5.0% and 5.7% to total habitat, respectively, but accounted for 4.6% and 11.9% of total coho.

We compared linear densities for habitat-cover types, pooled across reaches, using one-way ANOVA and multiple comparisons tests on transformed data. We found that mean densities in pools with cover (7.0 coho/m) (Fig. 9 and Table F-1) and small tributaries (8.0 coho/m) were significantly higher than densities in riffles (1.4 coho/m), runs (1.3 coho/m) and pools with no cover (2.1 coho/m). Densities for runs with cover and side channels were similar to all other habitat-cover type densities (3.7 and 2.9 coho/m, respectively). Some tests were very close to critical values and would likely be improved by increased sample size for some habitat-cover types. For densities ranked from lowest to highest, we found that the lowest densities were represented by habitats without cover and the highest densities are represented by habitats with cover.

BIOSAMPLING

We sampled a total of 150 juvenile coho from different reaches and habitat-cover types, for length, weight, and age (scales). More specifically, we sampled one run with cover and one side channel in reach 2, and one pool with cover, and two runs with cover in reach 3 (Table 6). Coho were 77.4% age 1 and 22.6% age 2. Proportions of age 1 and age 2 coho were similar for all reaches and habitat-cover types, except for pools with cover, in which age 1 coho represented 40% and age 2 represented 60%. The mean length of coho in pools with cover was significantly larger than coho from other habitat-cover types (one-way ANOVA). Age 1 coho had a mean length of 59.9 mm and a mean weight of 2.63 g. Age 2 coho had a mean length of 89.7 mm and a mean weight of 8.63 g. Condition factors were similar for both age classes (age 1 = 1.19, age 2 = 1.15) and were consistent with those reported in the literature (Hurst and Blackman 1988, Simpson 1991, Irvine and Bailey 1992).

Age 1 coho were most numerous in the 55-59 mm class and all but two were less than 74 mm. Only one of the age 2 coho was less than 74 mm and 33 of the 35 age 2 sampled were between 75 and 104 mm (Fig. 10).

ADDITIONAL PHYSICAL OBSERVATIONS

Daily maximum and minimum water levels and temperature for 28 October 1992 to 27 June 1993 are illustrated in Figure G-1. Water level rose 1.6 m above its minimum recorded level. Minimum water levels were observed in mid December and late March and a peak flood occurred on 18 May. Water level was 1.6 m at installation (28 October) and represented bank full conditions. Peak flooding observed in mid-May (2.5 m) was 0.9 m higher than the level observed at bank full. Water temperature ranged from a minimum of 0.0 C in late December to a maximum of 13.9 in mid-June. Temperatures below 1.0 C were observed in December, January, and February. Increasing temperatures corresponded with the spring freshet.

DISCUSSION

PRIMARY ABUNDANCE ESTIMATES

We compared our total estimated juvenile coho abundance with estimates generated using two different juvenile carrying capacity models. The first model was developed as a key to limiting factors of production in Oregon streams by Reeves et al. (1989) using updated densities from Nicholson et al. (1992a). In this model, habitat specific densities are applied to known habitat area to estimate the potential summer population. In the second model, a Fisheries and Oceans Canada biostandard is used in estimating potential summer capacity of juveniles in different watersheds (Burns and Tutty 1986). It assumes a density of 1 fry / m^2 of useable wetted habitat with a gradient less than 2%. We used habitat area from reaches 1, 2, and 3 (our analysis study area) in the calculations.

Predicted abundance estimates for the Kwinageese study area were 216,759 and 301,081 using Reeves et al. (1989) and Burns and Tutty (1986), respectively, compared to our total estimate of 71,516 (Fig. 11). The large discrepancy between our estimate and the model estimates could indicate several possibilities. First, it is possible that juvenile abundance in the Kwinageese is far below summer carrying capacity. In this case, it would be likely that some other seasonal period and combination of physical factors are limiting coho production. Potential factors limiting production are: limited spawning area, under seeding (low escapement), or winter rearing habitat. Limited spawning habitat is not likely in the Kwinageese River because of the extensive amounts of gravel documented during habitat surveys. Under-escapement is possible given the decline of many stocks of salmonids in coastal British Columbia, but is not possible to evaluate given limited escapement records (Jantz et al. 1989) and unknown egg to fry survivals. Lack of suitable winter rearing habitat is also a good possibility given that winter habitat has been shown to limit production in some systems (Nicholson et al. 1992a,b). Evaluation of this possibility would require winter habitat studies as there is currently no information on abundance of winter rearing habitat in the Kwinageese River.

Secondly, it is possible that both models are not applicable to the Kwinageese River system and their comparison is invalid. The Reeves et al. (1989) model was parameterized using data from coastal Oregon streams which are typically shorter in length, shorter in mean width, and have lower seasonal discharge compared to the Kwinageese River. Nicholson (T. Nicholson, Oregon Dept. of Fish & Wildlife, Corvallis, OR, pers. comm.) suggested that the model is not likely applicable to the Kwinageese without adjustments for survival rates and multiple cohort interactions. Similarly, the Burns and Tutty model (1986) was parameterized for watersheds on coastal Vancouver Island and has little data to support its fry density assumption. Finally, Shirvell (1989) illustrated for several habitat fishery models he investigated that models were only valid for the geographical region for which they were developed. Other potential explanations related to the calculation procedures are discussed below.

We collected habitat and fish abundance data and calculated estimates of total coho abundance stratified by reach, section, area, and habitat-cover type. This hierarchy of resolution was used to assign the most representative coho densities to respective habitat-cover type lengths of stream for which there was no snorkel survey. We found substantial differences in coho density for like habitat-cover types between the strata of reach, section, and area (Table D-1). We believe that sampling must be distributed throughout the system to obtain reliable estimates of abundance. Hankin and Reeves (1988) made similar observations and suggested that extrapolation from data collected in only one or several representative reaches could give a highly biased fish abundance and supports our use of stratified sampling.

In-stream and over-stream structures such as large organic debris, in-vegetation, and over-vegetation act as forms of cover for fish; both as protective structure and also as modifiers of stream flow (Habitat Inventory Committee 1986). The important role of cover in juvenile rearing is evident in the literature (Hartman 1965; Tschaplinski and Hartman 1983; Nechako River Project 1987; and Shirvell 1990). In these studies, clear preferences by juveniles for habitats with cover were illustrated. Yet, to our knowledge, there are no studies in which the estimation of juvenile abundance using snorkel enumeration (Hankin and Reeves 1988) or the application of carrying capacity models to streams (Nicholson 1992b) directly includes cover as part of the habitat classification. Significant differences were found in mean density between like habitats differing only in their cover component. These differences had a substantial impact on the total estimated number of juvenile coho for particular reaches of the Kwinageese. We argue that considerable inaccuracies in abundance estimates may occur if the proportion of habitats with and without cover is not considered. The combined effect of not stratifying the data by location and cover was a 20% increase in the estimated total abundance (Fig. 11; unstratified b).

We also tested the effect of calculating abundance using unstratified data and area densities (fish/m^2) (Fig. 11; unstratified c). We found a substantial increase in total estimated abundance to 211,507 coho when mean densities were applied to total rearing area, by habitat type. This estimate of total abundance is more consistent with values generated using the Nicholson et al. (1992a) and Burns and Tutty (1986) models. This example supports the possibility that the two models are inappropriate for large systems such as the Kwinageese. We argue that using total area as the principle factor in estimating juvenile carrying capacity may lead to over-estimates. This is likely due to the large quantity of wetted channel area (mean wetted widths greater than 10 m) that is not utilized by juvenile coho.

Coho densities were calculated in a linear form (fish/m) to eliminate the bias introduced when calculating densities or applying densities by area (fish/m^2) from stream margins to less suitable areas for rearing juvenile coho. In the Kwinageese River, juvenile coho were observed primarily at the margins where there was usually some cover. These findings are consistent with other observations of juvenile placement in streams (Nechako River project, 1987). Mid-channel areas of the stream were usually void of cover and occasionally held predators, such as Dolly Varden. Snorkel surveys emphasized the examination of marginal habitat. For large systems such as the Kwinageese, where mid-channel habitat is substantial and relatively unimportant (at least during the day), we believe that linear densities will produce more accurate estimates of total juvenile coho abundance.

Information on the maximum fry densities and biomass estimates for juvenile coho from other B.C. streams provides an indication of the relative productivity of summer rearing habitat on the Kwinageese River (Table 7). The maximum densities and biomass estimate for age 1 coho from the Kwinageese surveys was similar to the average of the maximum values from 8 interior and 20 coastal streams. However, our maximum values for age 2 coho appear to be substantially higher than any reported for B.C. streams. While most of the available data is for age 1 fish, these comparisons provide some support for the argument that the Kwinageese River has some excellent coho habitat and could produce substantially more coho if a larger portion of the available habitat was fully utilized.

OBSERVER EFFICIENCY

Difficulties encountered in our attempts at determining true coho abundances using beach seining and trapping in survey sites severely limited our ability to estimate observer efficiencies in 1992. As a result, our observer efficiency estimates were based on only one reliable mark-recapture sample and our observations on survey difficulty in different habitat-cover types. The resulting estimates (Table 4) gave a range of observer efficiency values between 0.5 (50%) and 0.9 (90%). Habitats with cover were given lower observer efficiency values compared to habitats without cover. Channel configuration and its impact on the divers ability to see fish was also considered. The lower bound for our observer efficiency values (50%) was calculated from a comparison of the snorkel survey estimate with the mark-recapture estimate for a mainstem pool with considerable large organic debris

(Table 3). The efficiency of a diver in counting juvenile salmon varies substantially with the physical characteristics of a site and the behaviour and preferences of the fish.

The above observer efficiencies represent the conversion between estimate coho abundance and total coho abundance. The literature generally reports observer efficiency as the portion of the total abundance observed. Since our surveyors observed counts were generally between 30% and 70% of estimated abundance (Table C-2), the above percentages would convert into a typical observer efficiency of 15% to 63%.

Gardiner (1984) calculated observer efficiencies between 82% and 94% for juvenile Atlantic salmon (*Salmo salar*) in a Scottish stream with relatively good visibility. Cunjak et al. (1988) found low observer efficiencies (mean = 43.7%) for juvenile Atlantic salmon in three eastern Canada streams. Observer efficiency varied widely between streams (4% - 132%) and the investigators concluded the method was unreliable for accurately estimating populations in small to medium rocky streams (50% boulder substrate). Heggenes et al. (1990) also found widely varying observer efficiencies (6% - 67%) for juvenile brown trout (*Salmo trutta*) and atlantic salmon depending on the habitat and cover of the survey site. Observer efficiency for pools and riffles in a small stream was estimated to be 99% and 74%, respectively, for age 2 coho and steelhead by Hankin and Reeves (1988). Young of year (age 1) were excluded from their analysis as snorkel counts were judged ineffective for the smaller juveniles. Rodgers et al. (1992) conducted snorkel counts in pools in Oregon streams with known stocked numbers of juvenile coho. Their results indicate that snorkelling accounted for approximately 40% of the known abundance and between 50% and 70% of the mark-recapture estimate. The findings would tend to support the factors used in this report to calculate total coho abundance for the portion of the Kwinageese River surveyed in 1992.

In this study, combined habitat and fishery surveys provided detailed information on habitat composition and respective coho abundances. In addition, we were able to estimate total juvenile coho abundance for the study area and describe important rearing habitats, both at the site level and the system level. By conducting sampling stratified by location and habitat-cover type, we believe that snorkel surveys provided the most effective and non-destructive means of estimating abundance in a large system, despite the problems of validating snorkel counts.

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TABLES

Table 1. Habitat and cover classifications used to describe survey site characteristics on the Kwinageese River, 1992.

Feature	Notes
Habitat	
Pool	reduced water velocity, relatively deep, includes offchannel beaver areas
Riffle	relatively fast water velocity, high surface agitation
Run	relatively fast water velocity, low surface aggitation
Small tributaries	shallow (> 0.5 m), narrow (> 5 m)
Side channel	connected and unconnected offchannel water
Cover	
No cover	having no instream or overstream structures
Cover	possessing woody debris, in-vegetation, cutbank or over-vegetation (>20% by area)

Table 2. Kwinageese River habitat and fishery survey form with example data [a].

DATE: 8 Sept

RCH	SCN	ARA	CW	WW	MDH	% BAR	% CVR	% BDM	HAB	%survey length	SIT	OCO	ECO	OTR	SUR ARA	VIS
1	*1*	*4*	*13.5*	*13.0*	*0.3*	*75*	*TCV 30*	*F 10*	*RN*	*20*	*1*	*35*	*50*	*1JDV*	*20x5*	*0.5*
			15.0	*5.0*	*0.7*		*LOD 80*	*G 30*	*RN/W*	*10*	*2*	*0*	*0*		*25x3*	*3.0*
							BLD 20	*L 60*	*RF*	*50*	*3*	*10*	*15*		*20x5*	*1.0*
									P	*10*						
									P/W	*10*						
									SC	*75*						

COMMENTS: *total length = 1020m, freq. confined, several log jams but no major obstructions, water stage = low, temp = 7*

[a] see Table A1 for definitions of parameter abbreveations; italics are example data entires.

Table 3. Petersen population estimate and calculated observer efficiency for juvenile coho in site 3, Kwinageese River, 1992. Confidence limits are from fudicial limits for the Poisson distribution using Pearson's formulae when R is greater than 50 (Ricker 1975, p. 343).

Site	No. marked	No. recovered	No. marked recovered	Petersen estimate	Lower 95% CL	Upper 95% CL	Survey estimate	Observer efficiency
3	132	96	22	561	377	872	300	0.53

Table 4. Habitat-cover types ranked according to survey and observer efficiency, Kwinageese River, 1992.

Group	Habitat	Cover	Observer efficiency (ranked)	Observer efficiency (range)
1	run	no	0.9	0.8 to 1.0
	pool	no	0.9	0.8 to 1.0
2	side channel	[a]	0.8	0.7 to 0.9
	run	yes	0.8	0.7 to 0.9
3	riffle	no	0.6	0.5 to 0.7
4	pool	yes	0.5	0.4 to 0.6
	riffle	yes	0.5	0.4 to 0.6

[a] not applicable - cover was not differenciated in the data at the area level of stratification for side channels.

Table 5. Analysis levels used to expand stratified coho densities to various habitats in the Kwinageese River, 1992 (n = number of applications).

Level	Reach	Section	Area	Habitat	Cover	n
1	X	X	X	X	X	55
2	X	X		X	X	32
3	X			X	X	22

Table 6. Coho length, weight and density statistics by age for five sites sampled on the Kwinageese River, 1992.

Reach	Section	Area	Habitat	Sample Size (n)	Mean Length (mm)	Mean Weight (g)	Coho Density (#/m2)	Coho Biomass (g/m2)
Age 1								
2	2	1	Run w/ cover	12	65.8	3.23	0.67	2.17
2	2	2	Side Channel	28	58.8	2.46	1.70	4.18
3	2	1	Pool w/ cover	10	68.7	3.72	1.38	5.13
3	1	1	Run w/ cover	40	56.7	2.32	0.41	0.95
3	1	2	Run w/ cover	19	59.8	2.58	0.51	1.31
Mean				109	59.9	2.63	0.93	2.45
SD					8.2	1.17		
Age 2								
2	2	1	Run w/ cover	0				
2	2	2	Side Channel	5	91.6	8.46	0.30	2.56
3	2	1	Pool w/ cover	15	91.2	9.36	2.07	19.38
3	1	1	Run w/ cover	9	89.7	8.59	0.09	0.79
3	1	2	Run w/ cover	6	84.7	6.98	0.16	1.12
Mean				35	89.7	8.63	0.66	5.66
SD					8.2	2.42		
Total								
2	2	1	Run w/ cover	14	65.8	3.22	0.67	2.16
2	2	2	Side Channel	36	63.6	3.32	2.00	6.64
3	2	1	Pool w/ cover	25	82.2	7.10	3.45	24.51
3	1	1	Run w/ cover	50	62.7	3.45	0.50	1.73
3	1	2	Run w/ cover	25	65.8	3.64	0.67	2.44
Mean				150	67.0	4.04	1.46	5.89
SD					14.9	2.96		

Table 7. Maximum coho densities and biomass estimates for various B.C. streams. Interior an coastal data from Ron Ptolemy, Ministry of Environment, Lands and Parks, Victoria.

Area/Stream	Year	Size (g)	Density (#/m2)	Biomass (g/m2)
Kwinageese Age 1	92	3.72	1.38	5.13
Kwinageese Age 2	92	9.36	2.07	19.38
Kwinageese Combined	92	7.10	3.45	24.51
Interior				
Dryden	85	2.36	1.07	2.53
Danforth	84	6.90	0.41	2.83
Chinks	69	2.52	1.66	4.18
Salmon	85	3.17	1.55	4.91
Louis	81	7.53	0.80	6.02
Louis	81	2.09	2.90	6.06
Birkenhead	86	2.32	2.73	6.33
Duteau	85	2.30	2.78	6.39
Seiber	85	2.40	3.37	8.09
Interior Mean		3.51	1.92	5.26
Coastal				
Springer	85	1.15	1.70	1.96
Wolf	70	2.54	1.02	2.59
Chehalis	85	2.12	1.23	2.61
Snow	85	1.87	1.52	2.84
Keogh	86	3.29	0.88	2.90
Stowe	76	3.77	0.81	3.05
Carnation	71	0.70	4.40	3.08
Silverdale	85	2.31	1.50	3.47
Carnation	70	1.84	1.95	3.59
Mamin	84	2.30	1.77	4.07
Deer	59	3.90	1.10	4.29
Banon	80	7.80	0.61	4.76
Chester	87	2.36	2.02	4.77
Chilliwack	89	2.22	2.24	4.97
York	87	2.30	2.17	4.99
Bush	73	0.96	5.60	5.38
Salmon (Fort Langley)	79	1.58	4.58	7.24
Little Straamus	85	2.70	3.54	9.56
Stoney	90	5.24	2.03	10.64
Nathan	86	4.44	2.50	11.10
Colquitz	78	3.83	3.13	11.99
Coastal Mean		2.82	2.20	5.23

FIGURES

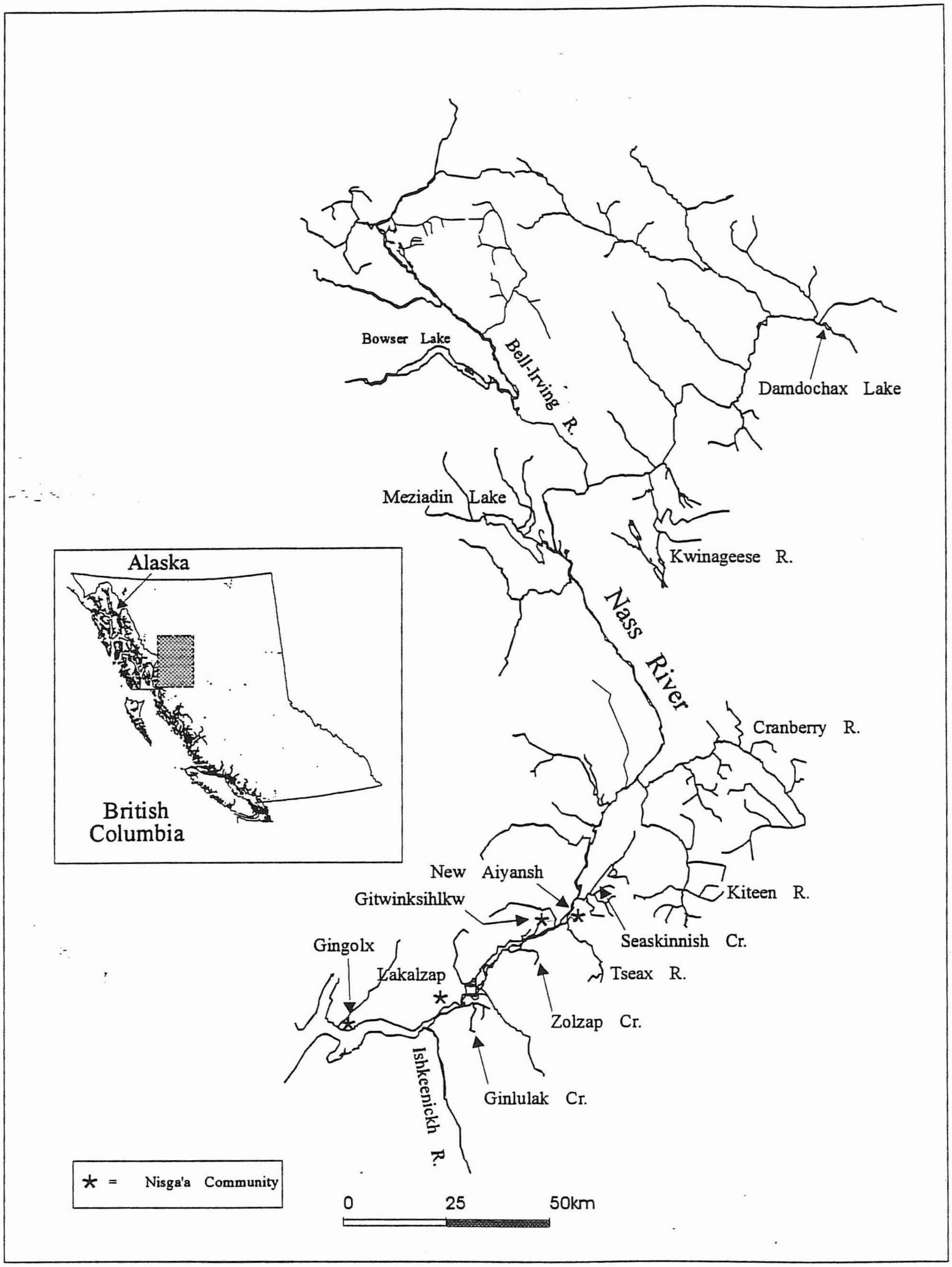


Figure 1. The Nass River watershed, British Columbia.

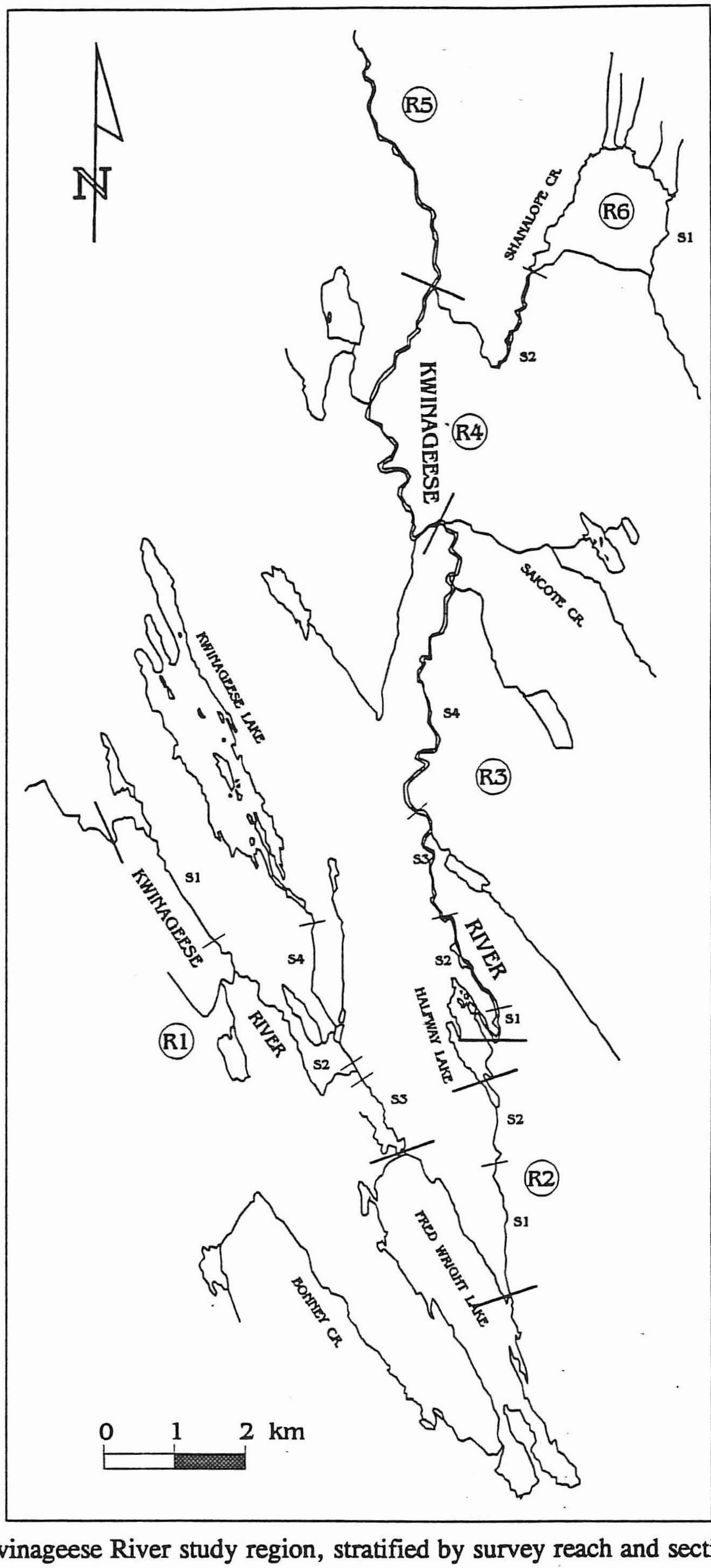


Figure 2. Kwinageese River study region, stratified by survey reach and section, 1992.

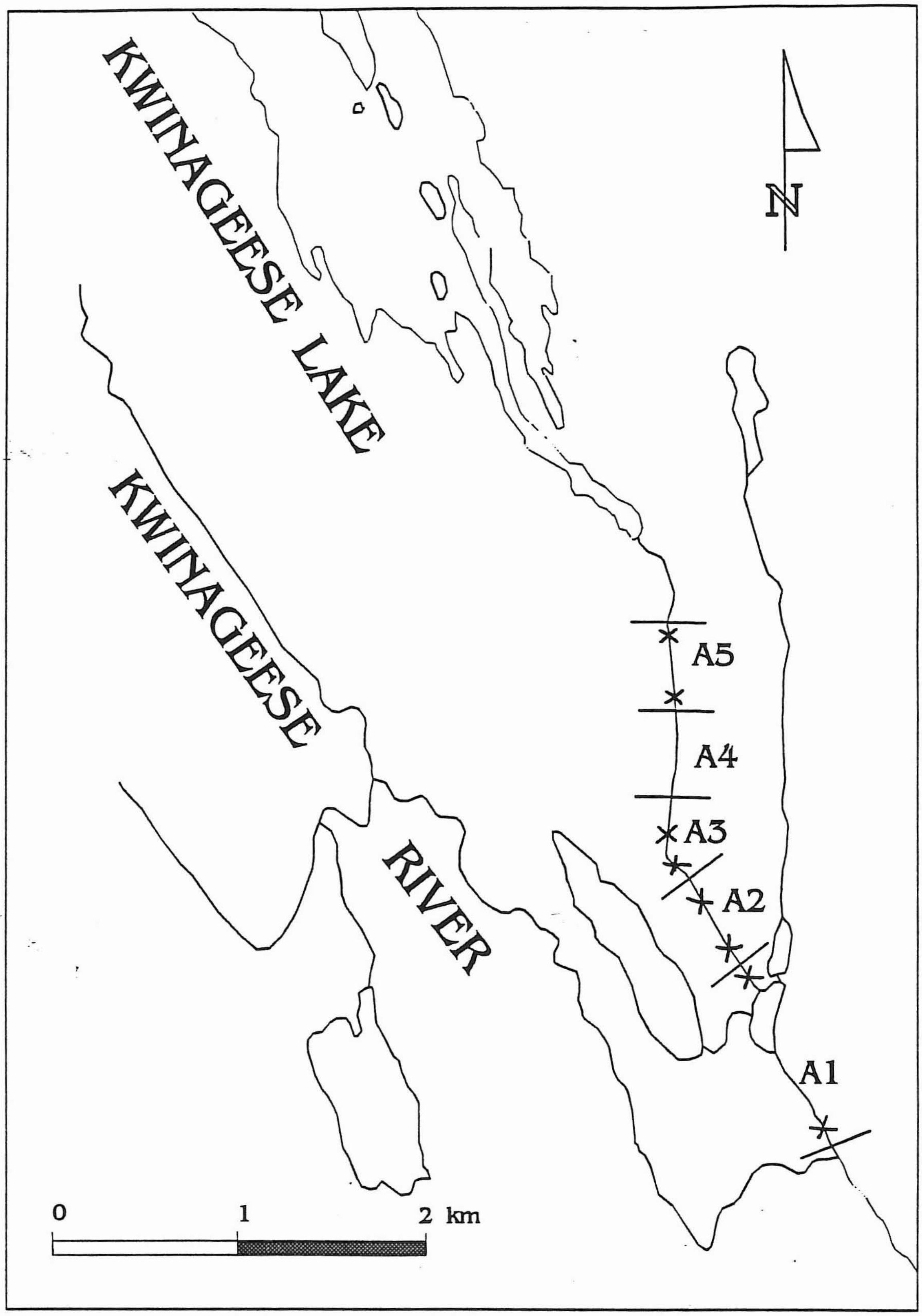


Figure 3. Reach 1 - section 4 survey areas (A#) and sites (X), Kwinageese River, 1992.

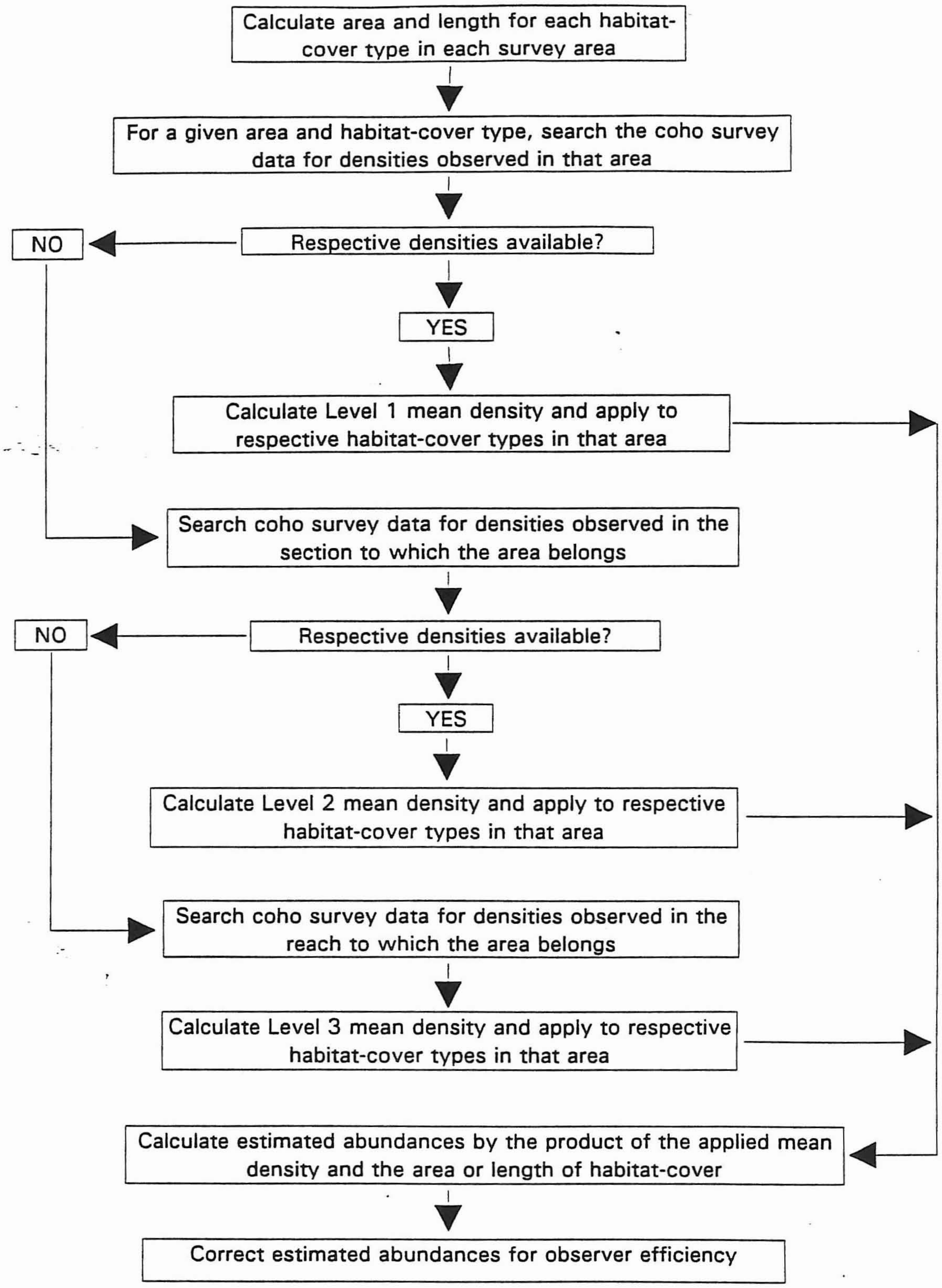


Figure 4. Procedure for calculating quantity of habitat-cover types, juvenile coho densities, and total juvenile coho abundance for Kwinageese River, 1992.

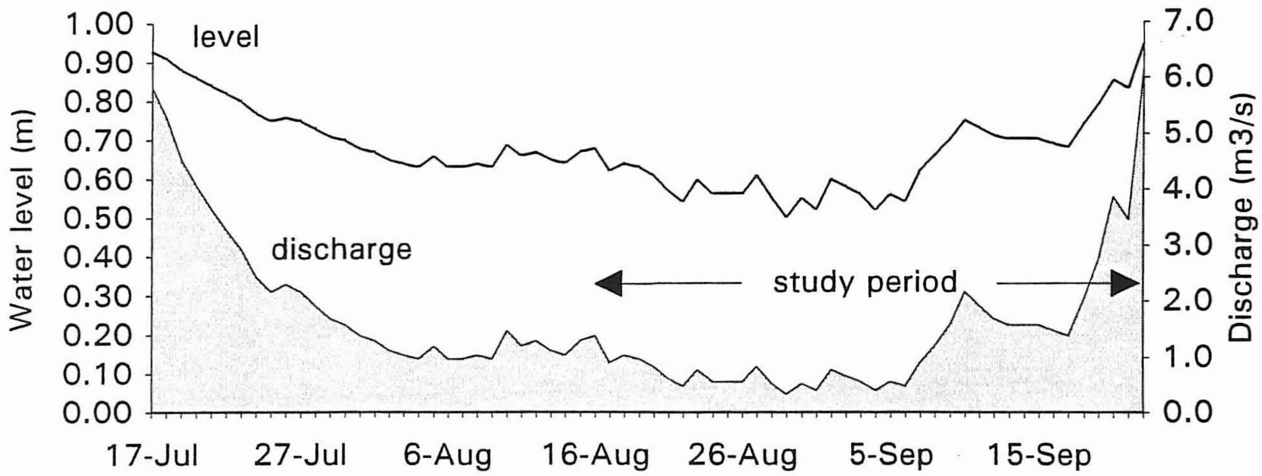


Figure 5. Water level and discharge in reach 3, Kwinageese River, 1992.

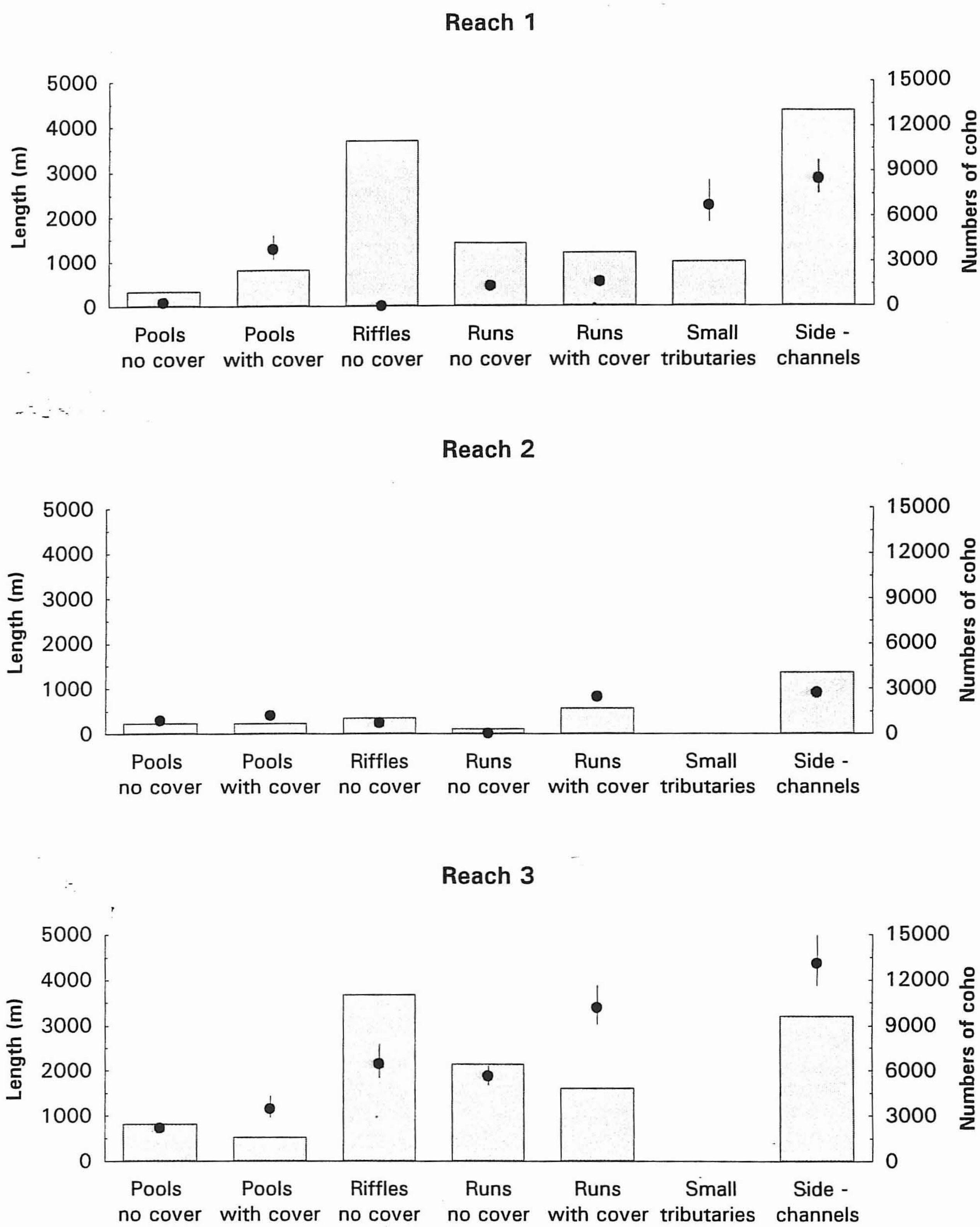


Figure 6. Total length of stream and total juvenile coho abundance by habitat-cover type, Kwinageese River, 1992.

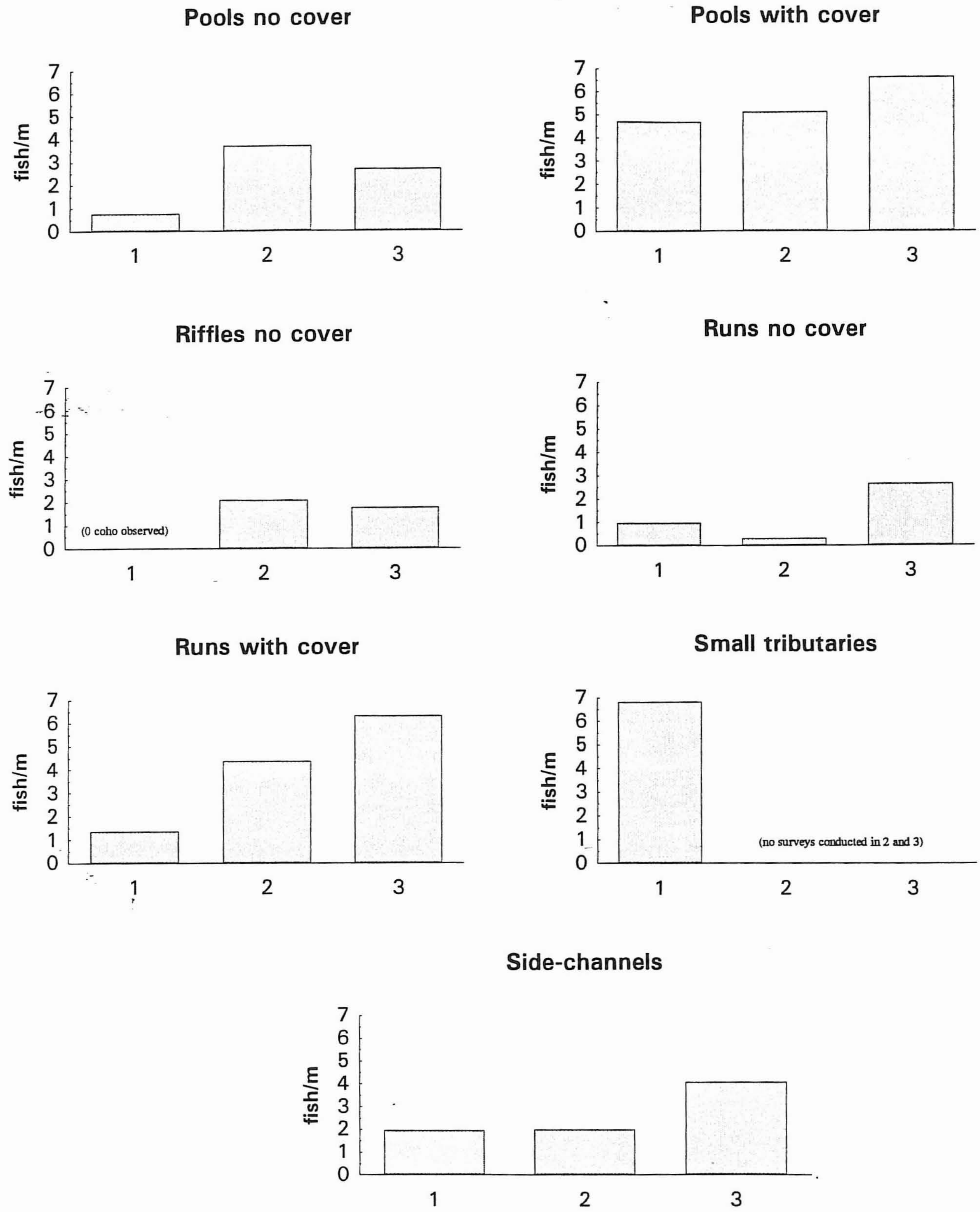


Figure 7. Linear density of juvenile coho by habitat type and reach for Kwinageese River, 1992.

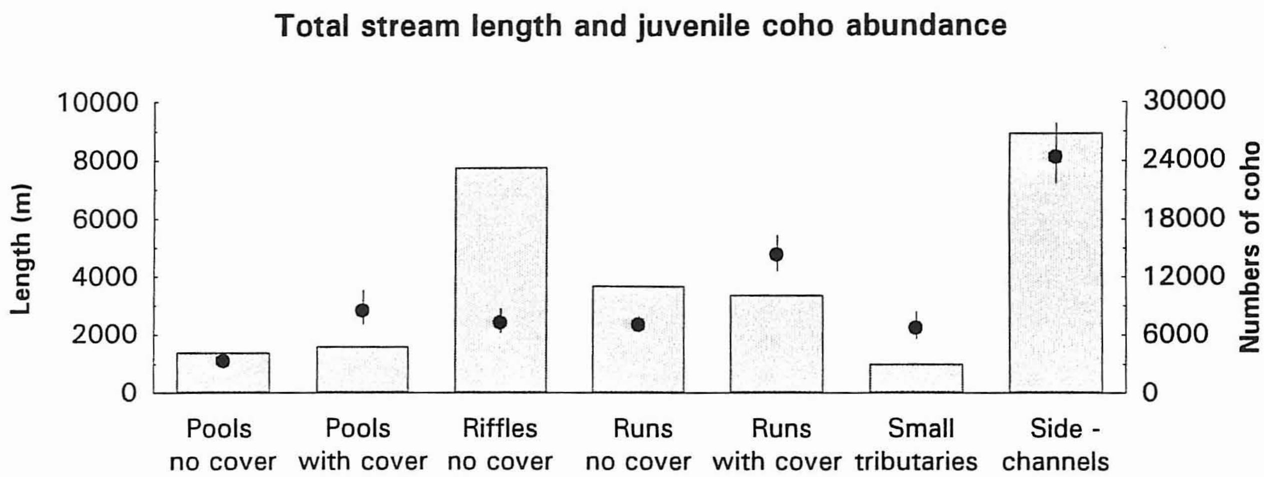


Figure 8. Total stream length and total juvenile coho abundance, by habitat-cover type, Kwinageese study region, 1992.

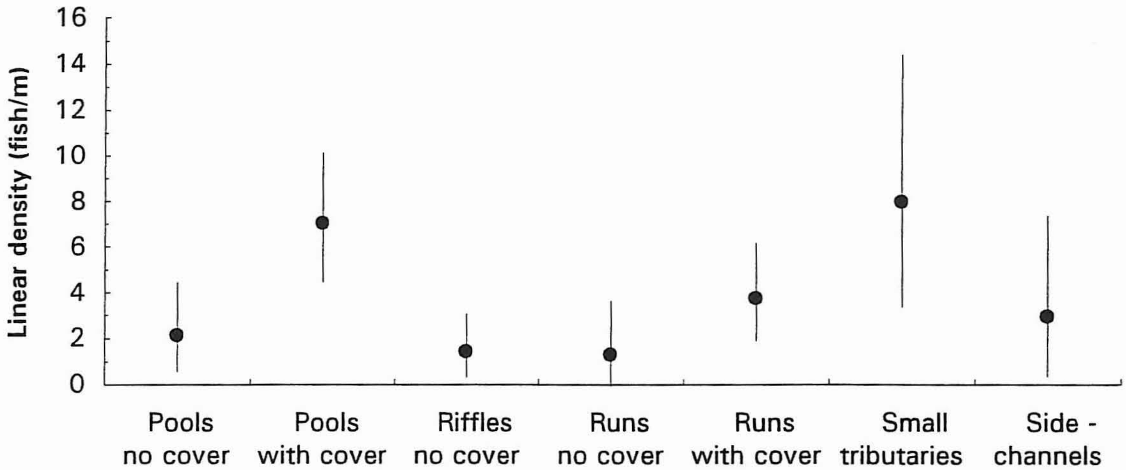


Figure 9. Mean linear densities of juvenile coho, by habitat-cover type, for the Kwinageese River study region, 1992. Bars are 95% confidence intervals.

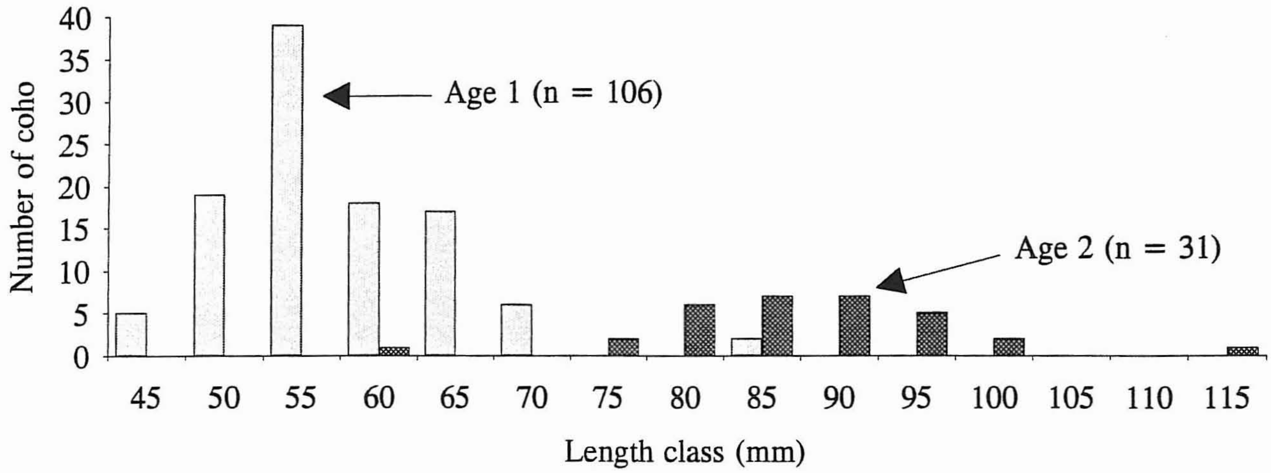


Figure 10. Length-frequency distribution of juvenile coho, Kwinageese River, 1992.

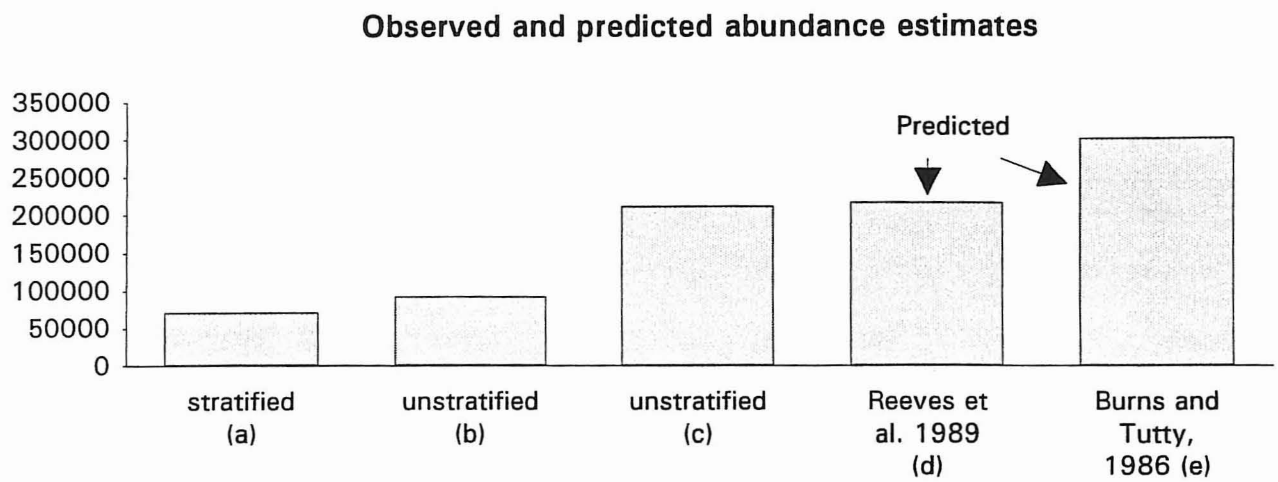


Figure 11. Estimated total coho abundance in Kwinageese River study region, 1992, calculated from this study, and different juvenile carrying capacity models.
(a) Uses linear densities by location and habitat-cover type.
(b) Uses linear densities by habitat type.
(c) Uses area densities (fish/m2) by habitat type.
(d) Uses densities for Oregon streams (Nickelson et al. 1992) applied to respective habitats.
(e) Uses 1 fry / m2 of wetted area with gradient < 2% applied to total useable habitat.

APPENDICES

Table A-1. Abbreviations of parameters in habitat and fisheries survey database for the Kwinageese River, 1992 [a].

DAT	date
RCH	reach
SCN	section
ARA	area
LEN	length (m)
CW	width (m)
WW	wetted width (m)
MDH	max. depth (m)
BAR	% bars within channel
SCH	% length of stream that is side channel
CVR	cover
TCV	% area total cover
DPL	% area deep pad
LOD	% area large debris
BLD	% area boulder
IVG	% area in vegetation
OVG	% area over vegetation
CUT	% area cut bank
BDM	bed material
BDF	% bed material - fines (f)
BDG	% bed material - gravels (g)
BLD	% bed material - larges (l)
BDR	% bed material - bedrock (br)
HAB	habitat - cover type
HTP	habitat type
HCV	habitat cover
PCT	% of stream length that is a habitat-cover type
SIT	habitat site
SLN	float survey length
SWH	float survey width (visual)
OCO	observed number juvenile coho in survey site
ECO	estimated number juvenile coho in survey site
OTR	other species of fish observed
JRB	observed no. juvenile rainbow
JDV	observed no. juvenile dolly varden
ACH	observed adult chinook
ASO	observed adult sockeye
AST	observed adult steelhead
ARB	observed juvenile rainbow
ADV	observed adult dolly varden
AWF	observed adult whitefish
MTH	method of independent abundance assessment
CND	conditions relative to method
EFT	effort of method
VIS	visibility (m)

COMPACTION
(1) low
(2) medium
(3) high

CONFINEMENT
(1) entrenched
(2) confined
(3) frequently confined
(4) occasionally confined
(5) unconfined

STAGE
(1) dry
(2) low
(3) medium
(4) high
(5)flood

BRAIDING
0 = no
1 = yes

HABITAT (as % of survey length)
P = pool
R = riffle
RN = run
SC = side-channel
TR = tributary

COVER (>20% of survey site area)
BD = boulder
CB = cut-bank
IV = in-vegetation
LOD = large organic debris
OV = over-vegetation
W = woody debris

[a] Physical parameters are as defined in Anon., 1989.

Table B-1. Habitat data, by reach and section, for Kwinageese River, 1992 [a].

	R1S1	R1S2	R1S4	R1	R2S2 (R2)	R3S1	R3S2	R3S3	R3S4	R3
Location	mainstem	mainstem	off-channel	mainstem	mainstem	mainstem	mainstem	mainstem	mainstem	mainstem
Date	12-Sep	12-Sep	11-Sep		5-Sep	8-Sep	8-Sep	8-Sep	6-Sep	
Length	3270	3690	1380	8340	1530	630	1700	1550	4900	8780
Channel width	22.0	28.0	18.5	22.8	42.6	23.0	30.0	20.5	20.0	23.4
Wetted width	10.0	10.0	5.7	8.6	38.0	17.5	24.5	17.5	17.0	19.1
Maximum depth	2.0	1.1	0.4	1.2	3.0	1.2	1.6	1.2	2.0	1.5
% Pool, no cover	4	2	0	3	8	26	3	3	8	7
% Pool, with cover	4	11	1	7	8	0	15	6	0	4
% Riffle, no cover	49	19	5	33	12	51	18	6	45	31
% Run, no cover	6	16	7	12	4	7	23	3	24	18
% Run, with cover	2	9	28	6	20	0	12	38	4	13
% Small tributary	1	6	29	4	0	0	0	0	0	0
% Sidechannel	34	36	30	35	47	17	29	44	19	27
% Debris	10	30	10	17	5	5	10	5	5	6
% Total cover	20	40	60	40	30	40	40	40	30	38
% Deep pool	10	10	0	7	30	20	10	40	10	20
% LOD	50	75	30	52	20	10	50	10	30	25
% Boulder	40	0	10	17	20	50	0	0	50	25
% Invegetation	0	0	0	0	30	5	5	30	0	10
% Overvegetation	0	10	60	23	0	15	30	10	10	16
% Cutbank	0	5	0	2	0	0	5	10	0	4
% Canopy	5	5	30	13	5	5	5	5	10	6
% Fines	10	10	20	13	20	0	10	20	10	10
% Gravels	30	60	40	43	30	10	40	50	20	30
% Larges	60	30	30	40	40	70	50	30	60	53
% Bedrock	0	0	10	3	10	20	0	0	10	8
Compaction	2	1	1	1	3	2	1	2	2	2
Confinement	3	4	3	3	4	2	4	4	3	3
Stage	3	2	1	2	2	2	2	2	2	2
Braiding	1	1	1	1	1	0	1	1	1	1
% Bars	30	65	30	42	30	10	30	25	20	21
Temperature	6	7	12	8	14	17	17	18		17

[a] Analysis restricted to areas surveyed. R = reach, S = section. Refer to Table A1 for definitions.

Table C-1. Snorkel survey sampling effort, stratified by habitat-cover types, for the Kwinageese River, 1992 [a].

Habitat	Cover	Total Area (m2)	Total Length (m)	No. sites	Area surveyed	% of total area	Length surveyed	% of total length
Reach 1								
Pool	no cover	3384	330	1	30	0.9	15	4.5
Pool	with cover	8147	815	5	776	9.5	77	9.4
Riffle	no cover	39306	3690	2	225	0.6	55	1.5
Run	no cover	14651	1420	5	655	4.5	125	8.8
Run	with cover	13972	1195	5	190	1.4	1140	95.4
Small tributary	with cover	6350	990	6	626	9.9	242	24.4
Sidechannel	n.a.	8718	4359	2	110	1.3	55	1.3
Totals		94528	12799	26	2612	2.8	1709	13.4
Reach 2								
Pool	no cover	4800	240	1	180	3.8	30	12.5
Pool	with cover	4800	240	3	540	11.3	120	50.0
Riffle	no cover	7200	360	1	240	3.3	80	22.2
Run	no cover	2400	120	1	750	31.3	75	62.5
Run	with cover	18990	570	2	1950	10.3	195	34.2
Small tributary	with cover	0	0	0	0	0.0	0	0.0
Sidechannel	n.a.	2730	1365	2	350	12.8	150	11.0
Totals		40920	2895	10	4010	9.8	650	22.5
Reach 3								
Pool	no cover	14741	818	9	2714	18.4	296	36.2
Pool	with cover	9067	525	6	3635	40.1	311	59.2
Riffle	no cover	65382	3678	11	1555	2.4	469	12.8
Run	no cover	40843	2145	3	472	1.2	108	5.0
Run	with cover	29168	1616	7	5308	18.2	727	45.0
Small tributary	with cover	0	0	0	0	0.0	0	0.0
Sidechannel	n.a.	6432	3216	2	665	10.3	157	4.9
Totals		165633	11998	38	14349	8.7	2068	17.2

Table C-1 (cont.). Snorkel survey sampling effort, stratified by habitat-cover types, for the Kwinageese River, 1992 [a].

Habitat	Cover	Total Area (m2)	Total Length (m)	No. sites	Area surveyed	% of total area	Length surveyed	% of total length
Reaches 1, 2, 3								
Pool	no cover	22925	1388	11	2924	12.8	341	24.6
Pool	with cover	22014	1580	14	4951	22.5	508	32.2
Riffle	no cover	111888	7728	14	2020	1.8	604	7.8
Run	no cover	57894	3685	9	1877	3.2	308	8.4
Run	with cover	62130	3381	14	7448	12.0	2062	61.0
Small tributary	with cover	6350	990	6	626	9.9	242	24.4
Sidechannel	n.a.	17880	8940	6	1125	6.3	362	4.0
Totals		301081	27692	74	20971	7.0	4427	16.0

[a] Analysis restricted to areas surveyed

Table C-2. Raw data on habitat type, survey area and coho abundance for each snorkel survey location on the Kwinageese River, 1992.

	Reach	Section	Area	Site	Habitat Type	Habitat Cover	Habitat Code	Survey Length	Survey Width	Total Width	Survey Area	Total Area	Coho Observed	Coho Estimated	Survey Density	Obs. Eff.
12-Sep-92	1	2	2	1	1	0	1	15	2	2	30	30	10	10	0.33	100%
12-Sep-92	1	1	2	2	1	1	2	10	3	3	30	30	10	20	0.67	50%
12-Sep-92	1	1	3	1	1	1	2	20	10	10	200	200	20	100	0.50	20%
12-Sep-92	1	2	1	2	1	1	2	15	10	10	150	150	5	10	0.07	50%
12-Sep-92	1	2	2	2	1	1	2	20	15	15	300	300	10	30	0.10	33%
12-Sep-92	1	2	2	4	1	1	2	12	8	8	96	96	30	60	0.63	50%
12-Sep-92	1	1	2	1	2	0	3	30	5	5	150	150	0	0	0.00	
12-Sep-92	1	1	4	2	2	0	3	25	3	3	75	75	0	0	0.00	
08-Sep-92	1	4	2	1	2	1	4	40	3	3	120	120	100	150	1.25	67%
08-Sep-92	1	4	2	2	2	1	4	40	3	3	120	120	68	125	1.04	54%
08-Sep-92	1	4	3	2	2	1	4	40	3	3	120	120	250	350	2.92	71%
11-Sep-92	1	4	5	1	2	1	4	42	3	3	126	126	21	30	0.24	70%
11-Sep-92	1	4	5	2	2	1	4	30	3	3	90	90	41	60	0.67	68%
12-Sep-92	1	1	3	2	2	1	4	50	1	1	50	50	100	150	3.00	67%
08-Sep-92	1	4	3	1	3	0	5	10	4	4	40	40	50	75	1.88	67%
12-Sep-92	1	1	2	3	3	0	5	20	5	5	100	100	0	0	0.00	
12-Sep-92	1	2	1	1	3	0	5	15	5	5	75	75	0	0	0.00	
12-Sep-92	1	2	3	1	3	0	5	20	4	4	80	80	0	0	0.00	
12-Sep-92	1	2	5	1	3	0	5	60	6	8	360	480	11	20	0.06	55%
08-Sep-92	1	4	1	1	3	1	6	80	6	10	480	800	50	100	0.21	50%
08-Sep-92	1	4	1	2	3	1	6	55	8	10	440	550	63	120	0.27	53%
12-Sep-92	1	1	4	1	3	1	6	20	5	5	100	100	35	50	0.50	70%
12-Sep-92	1	1	4	3	3	1	6	20	5	5	100	100	10	15	0.15	67%
12-Sep-92	1	2	2	3	3	1	6	15	8	8	120	120	5	5	0.04	100%
12-Sep-92	1	1	1	1	4	1	7	30	2	2	60	60	50	60	1.00	83%
12-Sep-92	1	2	1	3	4	1	7	25	2	2	50	50	15	30	0.60	50%
05-Sep-92	2	2	2	4	1	0	1	30	6	30	180	900	75	100	0.56	75%
05-Sep-92	2	2	2	2	1	1	2	30	1	5	30	150	50	100	3.33	50%
05-Sep-92	2	2	2	6	1	1	2	30	5	10	150	300	40	80	0.53	50%
05-Sep-92	2	2	2	7	1	1	2	60	6	20	360	1200	40	100	0.28	40%

Table C-2 (cont.). Raw data on habitat type, survey area and coho abundance for each snorkel survey location on the Kwinageese River, 1992.

	Reach	Section	Area	Site	Habitat Type	Habitat Cover	Habitat Code	Survey Length	Survey Width	Total Width	Survey Area	Total Area	Coho Observed	Coho Estimated	Survey Density	Obs. Eff.
05-Sep-92	2	2	2	5	2	0	3	80	3	30	240	2400	50	100	0.42	50%
05-Sep-92	2	2	2	1	3	0	5	75	10	15	750	1125	10	20	0.03	50%
05-Sep-92	2	2	1	1	3	1	6	150	10	15	1500	2250	20	50	0.03	40%
05-Sep-92	2	2	1	2	3	1	6	45	10	20	450	900	150	300	0.67	50%
05-Sep-92	2	2	2	3	4	1	7	50	5	5	250	250	30	60	0.24	50%
05-Sep-92	2	2	2	8	4	1	7	100	1	1	100	100	100	200	2.00	50%
06-Sep-92	3	3	2	1	1	0	1	17	30	30	510	510	40	150	0.29	27%
03-Sep-92	3	2	1	4	1	0	1	40	5	14	200	560	20	50	0.25	40%
03-Sep-92	3	1	1	2	1	0	1	3	5	5	15	15	0	0	0.00	
03-Sep-92	3	1	1	4	1	0	1	20	6	15	120	300	0	5	0.04	0%
03-Sep-92	3	1	2	1	1	0	1	75	6	30	450	2250	17	100	0.22	17%
03-Sep-92	3	1	2	3	1	0	1	50	8	40	400	2000	20	100	0.25	20%
03-Sep-92	3	1	2	6	1	0	1	50	6	20	300	1000	22	100	0.33	22%
06-Sep-92	3	4	1	5	1	0	1	10	13	13	130	130	25	35	0.27	71%
06-Sep-92	3	4	1	7	1	0	1	31	19	19	589	589	1	10	0.02	10%
08-Sep-92	3	3	1	3	1	1	2	52	4	14	208	728	70	315	1.51	22%
06-Sep-92	3	3	2	2	1	1	2	60	40	40	2400	2400	100	500	0.21	20%
07-Sep-92	3	3	2	5	1	1	2	30	15	20	450	600	0	0	0.00	
03-Sep-92	3	2	1	3	1	1	2	29	3	5	87	145	100	300	3.45	33%
04-Sep-92	3	2	2	9	1	1	2	50	8	27	400	1350	10	50	0.13	20%
04-Sep-92	3	2	3	10	1	1	2	90	1	15	90	1350	4	50	0.56	8%
03-Sep-92	3	2	1	2	2	0	3	39	5	25	195	975	125	150	0.77	83%
03-Sep-92	3	2	1	7	2	0	3	30	4	25	120	750	25	100	0.83	25%
03-Sep-92	3	1	1	1	2	0	3	15	4	10	60	150	0	5	0.08	0%
03-Sep-92	3	1	1	3	2	0	3	55	4	15	220	825	0	5	0.02	0%
03-Sep-92	3	1	1	5	2	0	3	20	3	15	60	300	1	5	0.08	20%
03-Sep-92	3	1	2	2	2	0	3	15	4	15	60	225	0	5	0.08	0%
03-Sep-92	3	1	2	4	2	0	3	50	4	20	200	1000	50	100	0.50	50%
03-Sep-92	3	1	2	5	2	0	3	15	4	15	60	225	1	5	0.08	20%
03-Sep-92	3	1	2	7	2	0	3	25	4	17	100	425	0	5	0.05	0%

Table C-2 (cont.). Raw data on habitat type, survey area and coho abundance for each snorkel survey location on the Kwinageese River, 1992.

	Reach	Section	Area	Site	Habitat Type	Habitat Cover	Habitat Code	Survey Length	Survey Width	Total Width	Survey Area	Total Area	Coho Observed	Coho Estimated	Survey Density	Obs. Eff.
06-Sep-92	3	4	1	2	2	0	3	50	2	20	100	1000	10	20	0.20	50%
06-Sep-92	3	4	1	3	2	0	3	100	3	20	300	2000	20	40	0.13	50%
06-Sep-92	3	4	1	4	2	0	3	70	2	20	140	1400	50	100	0.71	50%
08-Sep-92	3	3	1	1	3	0	5	28	4	16	112	448	49	100	0.89	49%
03-Sep-92	3	1	2	8	3	0	5	40	6	15	240	600	0	5	0.02	0%
06-Sep-92	3	4	1	1	3	0	5	40	3	30	120	1200	50	100	0.83	50%
07-Sep-92	3	3	1	6	3	1	6	100	10	20	1000	2000	270	500	0.50	54%
26-Aug-92	3	3	1	6	3	1	6	100	10	20	1000	2000	250	500	0.50	50%
06-Sep-92	3	3	2	3	3	1	6	150	10	20	1500	3000	300	1000	0.67	30%
03-Sep-92	3	2	1	1	3	1	6	214	6	24	1284	5136	200	400	0.31	50%
03-Sep-92	3	2	1	5	3	1	6	107	4	25	428	2675	300	400	0.93	75%
03-Sep-92	3	2	1	6	3	1	6	220	4	25	880	5500	100	200	0.23	50%
06-Sep-92	3	4	1	6	3	1	6	50	10	25	500	1250	75	250	0.50	30%
07-Sep-92	3	3	2	4	4	1	7	40	2	2	80	80	70	150	1.88	47%
04-Sep-92	3	2	1	8	4	1	7	117	5	5	585	585	100	300	0.51	33%
Mean Values					**Sample Size**											
Pools					25			34	9	17	315	691	29	95	0.58	33%
Riffles					21			41	3	13	129	596	43	72	0.62	38%
Runs					23			71	7	15	507	1327	87	183	0.40	45%
Side Channels					6			41	2	2	90	90	44	83	0.95	47%

Table D-1. Estimates of juvenile coho abundance and survey observer efficiency, stratified by habitat-cover types, for the Kwinageese River, 1992 [a].

					Minimum estimate		Best estimate		Maximum estimate	
Habitat	Cover	Total Area (m2)	Total Length (m)	Uncorrected abundance	maximum obs.eff.	abundance	median obs.eff.	abundance	minimum obs.eff.	abundance
Reach 1										
Pool	no cover	3384	330	220	1.0	220	0.9	244	0.8	275
Pool	with cover	8147	815	1906	0.6	3177	0.5	3812	0.4	4765
Riffle	no cover	39306	3690	0	0.7	0	0.6	0	0.5	0
Run	no cover	14651	1420	1220	1.0	1220	0.9	1356	0.8	1525
Run	with cover	13972	1195	1291	0.9	1434	0.8	1614	0.7	1844
Small tributary	with cover	6350	990	3373	0.6	5622	0.5	6746	0.4	8433
Sidechannel	n.a.	8718	4359	6837	0.9	7597	0.8	8546	0.7	9767
Totals		94528	12799	14847		19270		22318		26609
Reach 2										
Pool	no cover	4800	240	800	1.0	800	0.9	889	0.8	1000
Pool	with cover	4800	240	614	0.6	1023	0.5	1228	0.4	1535
Riffle	no cover	7200	360	450	0.7	643	0.6	750	0.5	900
Run	no cover	2400	120	32	1.0	32	0.9	36	0.8	40
Run	with cover	18990	570	1995	0.9	2217	0.8	2494	0.7	2850
Small tributary	with cover	0	0	0	0.6	0	0.5	0	0.4	0
Sidechannel	n.a.	2730	1365	2184	0.9	2427	0.8	2730	0.7	3120
Totals		40920	2895	6075		7142		8127		9445
Reach 3										
Pool	no cover	14741	818	1972	1.0	1972	0.9	2191	0.8	2465
Pool	with cover	9067	525	1734	0.6	2890	0.5	3468	0.4	4335
Riffle	no cover	65382	3678	3886	0.7	5551	0.6	6477	0.5	7772
Run	no cover	40843	2145	5080	1.0	5080	0.9	5644	0.8	6350
Run	with cover	29168	1616	8158	0.9	9064	0.8	10198	0.7	11654
Small tributary	with cover	0	0	0	0.6	0	0.5	0	0.4	0
Sidechannel	n.a.	6432	3216	10474	0.9	11638	0.8	13093	0.7	14963
Totals		165633	11998	31304		36195		41071		47539

Table D-1 (cont.). Estimates of juvenile coho abundance and survey observer efficiency, stratified by habitat-cover types, for the Kwinageese River, 1992 [a].

					Minimum estimate		Best estimate		Maximum estimate	
Habitat	Cover	Total Area (m2)	Total Length (m)	Uncorrected abundance	maximum obs.eff.	abundance	median obs.eff.	abundance	minimum obs.eff.	abundance
Reaches 1, 2, 3										
Pool	no cover	22925	1388	2992	1.0	2992	0.9	3324	0.8	3740
Pool	with cover	22014	1580	4254	0.6	7090	0.5	8508	0.4	10635
Riffle	no cover	111888	7728	4336	0.7	6194	0.6	7227	0.5	8672
Run	no cover	57894	3685	6332	1.0	6332	0.9	7036	0.8	7915
Run	with cover	62130	3381	11444	0.9	12715	0.8	14306	0.7	16348
Small tributary	with cover	6350	990	3373	0.6	5622	0.5	6746	0.4	8433
Sidechannel	n.a.	17880	8940	19495	0.9	21662	0.8	24369	0.7	27850
Totals		301081	27692	52226		62607		71516		83593

[a] Analysis restricted to areas surveyed

Table E-1. Estimates of juvenile coho density, stratified by habitat-cover types, for the Kwinageese River, 1992 [a].

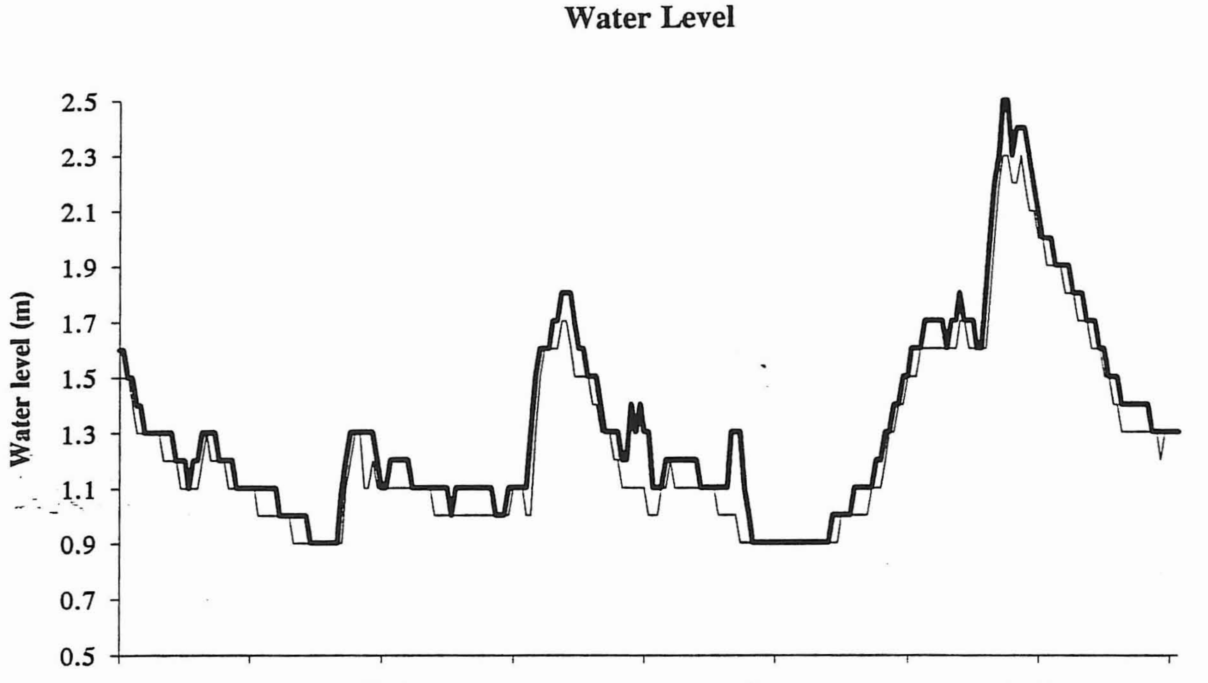
		Best estimate		
Habitat	Cover	abundance	Density by area (m2)	Density by length (m)
Reach 1				
Pool	no cover	244	0.1	0.7
Pool	with cover	3812	0.5	4.7
Riffle	no cover	0	0.0	0.0
Run	no cover	1356	0.1	1.0
Run	with cover	1614	0.1	1.4
Small tributary	with cover	6746	1.1	6.8
Sidechannel	n.a.	8546	1.0	2.0
Totals		22318		
Reach 2				
Pool	no cover	889	0.2	3.7
Pool	with cover	1228	0.3	5.1
Riffle	no cover	750	0.1	2.1
Run	no cover	36	0.0	0.3
Run	with cover	2494	0.1	4.4
Small tributary	with cover	0	0.0	0.0
Sidechannel	n.a.	2730	1.0	2.0
Totals		8127		
Reach 3				
Pool	no cover	2191	0.1	2.7
Pool	with cover	3468	0.4	6.6
Riffle	no cover	6477	0.1	1.8
Run	no cover	5644	0.1	2.6
Run	with cover	10198	0.3	6.3
Small tributary	with cover	0	0.0	0.0
Sidechannel	n.a.	13093	2.0	4.1
Totals		41071		
Reaches 1, 2, 3				
Pool	no cover	3324	0.1	2.4
Pool	with cover	8508	0.4	5.4
Riffle	no cover	7227	0.1	0.9
Run	no cover	7036	0.1	1.9
Run	with cover	14306	0.2	4.2
Small tributary	with cover	6746	1.1	6.8
Sidechannel	n.a.	24369	1.4	2.7
Totals		71516		

[a] Analysis restricted to areas surveyed

Table F-1. Mean linear density of juvenile coho, by habitat-cover type, for Kwinageese River study region, 1992 [a].

Habitat	Cover	n	Mean	Lower 95% CL	Upper 95% CL
Pool	no cover	11	2.1	0.5	4.5
Pool	with cover	14	7.0	4.5	10.1
Riffle	no cover	15	1.4	0.3	3.1
Run	no cover	9	1.3	0.0	3.6
Run	with cover	14	3.7	1.9	6.1
Small tributary	with cover	6	8.0	3.4	14.3
Sidechannel	n.a.	6	2.9	0.3	7.3

[a] Analysis restricted to areas surveyed



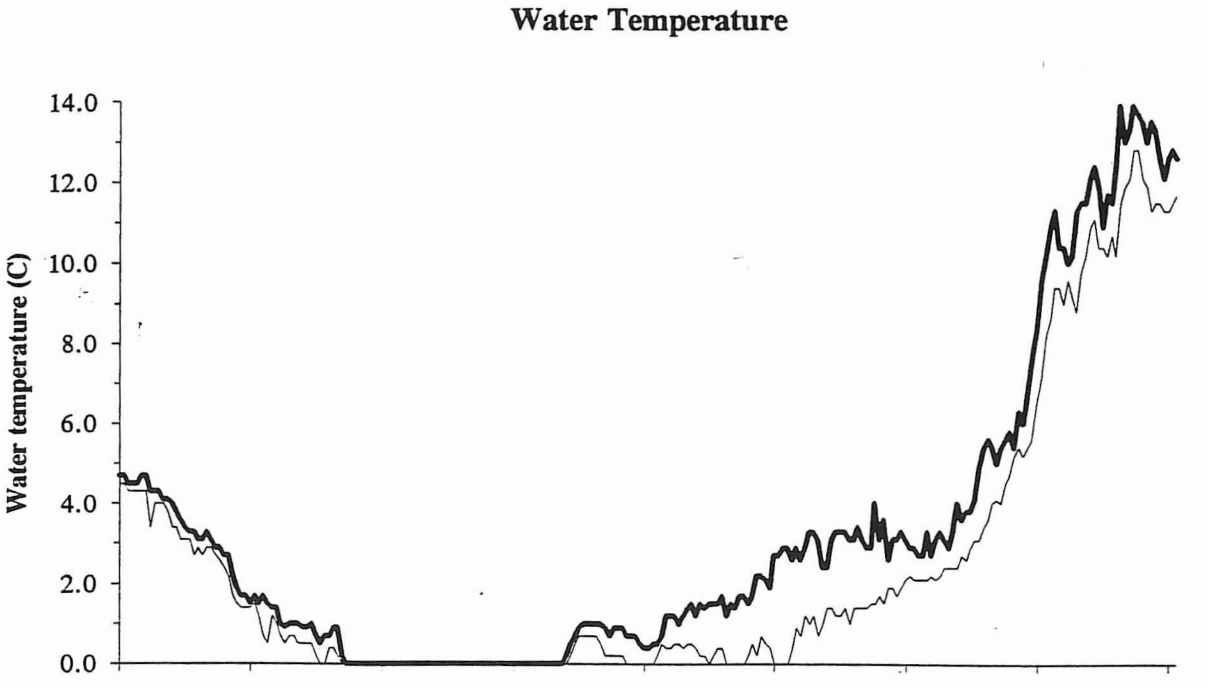


Figure G1. Maximum and minimum water level and temperature for Kwinageese River.