

Department of Fisheries and Oceans  
Canadian Stock Assessment Secretariat  
Research Document 97/35

Ministère des pêches et océans  
Secrétariat canadien pour l'évaluation des stocks  
Document de recherche 97/35

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Status of Atlantic salmon (*Salmo salar* L.) in Campbellton River,  
Notre Dame Bay (SFA 4), Newfoundland in 1996

by

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### **Abstract**

The status of Atlantic salmon in Campbellton River in 1996 was determined from the number of salmon counted through a portable fish counting weir (fence) located on the main stem just above head of tide as well as recreational fishery and biological characteristics data. The assessment was conducted in response to major management changes that were introduced in 1992 and continued in 1993-96. Specifically, there was a moratorium on the commercial Atlantic salmon fishery in insular Newfoundland and restrictions were placed on recreational fishing in each Salmon Fishing Area. The proportion of the conservation requirement achieved for Campbellton River in 1996 was 304%. On average for the period if 1993-96, Campbellton River achieved 283% of its conservation requirement. Adult returns averaged 3,554 small and large salmon, 1993-96. Historical records indicate that circa. 1800, adult returns to a harvesting weir were about 12,000 salmon.

### **Résumé**

L'état de la population de saumon de l'Atlantique de la rivière Campbellton en 1996 a été déterminé à partir des valeurs obtenues à une barrière de dénombrement portative située sur le cours principal de la rivière, tout juste en amont de la limite de la marée, de même qu'à partir des valeurs de la pêche à la ligne et de données biologiques. L'évaluation a été réalisée suite à d'importantes mesures de gestion imposées en 1992 et maintenues de 1993 à 1996. Plus précisément, un moratoire a été imposé à la pêche commerciale du saumon à l'île de Terre-Neuve et des limites ont été imposées à la pêche récréative dans toutes les zones de pêche du saumon. L'objectif de conservation de la rivière Campbellton a été atteint à raison de 304 % en 1996. En moyenne, l'objectif de conservation a été atteint à 283 % au cours de la période 1993-1996. Au cours de cette même période, la remontée moyenne des adultes a été de 3 554 petits et gros saumons. Les registres montrent que la remontée des adultes capturés par pêcherie fixe était de l'ordre de 12 000 saumons vers 1800.

## Introduction

The Campbellton River (Indian Arm River) flows in a northeasterly direction emptying into the sea at Indian Arm, Notre Dame Bay. In total, Campbellton River has a drainage area of approximately 296 km<sup>2</sup> with an axial length of 40.22 km (Porter et al. 1974) and is about average size for salmon rivers along the northeast coast of insular Newfoundland. The drainage area is also a protected water supply which provides domestic water for the town of Campbellton located at the mouth of the river. The river which is located in Salmon Fishing Area (SFA) 4 (Fig. 1), is in a very productive salmon zone (Table 1) which, on average accounts for about 40 percent of all salmon landed by the recreational fishery in the province of Newfoundland. During the early to mid 1980's Campbellton River attracted an average of just over 2,000 rod days. However in following years this figure dropped by 50 percent then increasing to approximately 1600 rod days (Table 2).

From 1993 to 1996 portable fish counting fences were used to enumerate and monitor salmon migration at various life stages. Also outmigrating smolts and kelts in the spring were enumerated and a portion of the kelts tagged to examine the survival rates.

## Management Measures

In 1992, a major change was introduced in the management of Atlantic salmon. A five-year moratorium was placed on the commercial fishery in insular Newfoundland while in Labrador, fishing continued under quota. In addition, a commercial license retirement program went into effect in both insular Newfoundland and Labrador. All of these management measures were aimed at increasing river escapements. Also, a moratorium on the Northern Cod Fishery was implemented in early July of 1992 which should have resulted in the elimination of by-catch in cod fishing gear in SFAs 1-9. The cod fishery moratorium continued in 1996. A moratorium on cod fishing was introduced in SFAs 10-14A in 1993 and remained in effect in 1996.

In the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each Salmon Fishing Area (SFA). The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, SFA recreational fishery quotas were eliminated. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date. Hook-and-release fishing was permitted throughout the fishing season. These measures remained in effect in 1996 and applied to salmon angling on Campbellton River. As in previous years, retention of large salmon was not permitted in insular Newfoundland.

In this paper, we examine the status of Atlantic salmon in Campbellton River. Counts obtained from smolt and adult counting fences are used in conjunction with recreational fishery data and biological characteristics data to calculate total river returns and spawning escapements. Stock

status is evaluated against a conservation requirement calculated in terms of fluvial and lacustrine habitats.

## Methods

### *RECREATIONAL FISHERY DATA*

Catch and effort data for Campbellton River as well as other rivers in Newfoundland and Labrador was collected by Department of Fisheries and Oceans (DFO) Fisheries Officers and processed by DFO Science Branch staff. Rivers with counting facilities have angling catches separated above and below the counting facilities where appropriate; however, this was not necessary for Campbellton River since angling does not take place below the counting fence. Procedures for the collection and compilation of recreational fishery data are described by Ash and O'Connell (1987).

### *UNRECORDED MORTALITIES*

Complete understanding of all life history factors including mortalities is an important part of any stock assessment (Ricker 1975). Mortalities due to fishing but not recorded as part of the catch statistics have been defined as non-catch fishing mortalities (Ricker 1976). Non-catch fishing mortality should include those fish killed due to both illegal and legal fishing activities. Legal fishing mortalities of salmon in Newfoundland and Labrador include catches in food (First Peoples), recreational, sentinel, and commercial fisheries. Illegal mortalities include poaching in both the freshwater and marine environments. Illegal mortalities by their very nature are extremely difficult to quantify. An indirect method of observing the effects of illegal removals is by observation of net marks on salmon at enumeration facilities. In 1993-96, occurrences of fish with visible net marks were observed at Campbellton River using the closed circuit video fish-counting system. These observations provide a minimum estimate of the incidence of net-marked fish, since light conditions or minor scarring could render some marks invisible to either the video camera or the naked eye. The incidence of net marks does not quantify unrecorded removals but does provide an indication that there were mortalities of Campbellton River salmon prior to entering freshwater.

Additional mortalities arising from the practice of hook and release fishing are also important for accurately assessing spawning escapement. To date there have been no definitive hook and release mortality studies on salmon in Newfoundland. However, studies elsewhere have shown that under certain conditions mortalities of hook and released 'bright' salmon do occur depending in part on the skill of the angler, method and length of time the fish are handled, length of residence of the salmon in freshwater prior to angling, and water temperature. Recent studies in New Brunswick indicate that rates of 0.1 are possible (Brobbel et al. 1996). Another source of unrecorded mortality is from poaching above the counting fence. Due to the illegal nature of

poaching no enumeration of the number of salmon caught illegally on Campbellton River is possible. However, these additional removals potentially result in a lower than indicated number of spawners. Thus, calculations of actual spawners should be regarded as potential.

### *SMOLT AND ADULT SALMON COUNTS*

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence was placed in the main stem of the river on April 24<sup>th</sup>, 1996 just above the site of the Old Horwood Dam, which was located approximately 300 m upstream from the highway bridge situated at the mouth of the river (Fig. 2). The entire fence was comprised of 32 sections, each 3 m in length, with a standard 2 m \* 2 m smolt trap which was installed across a 68 m section of the river on substrate characterized mainly by bedrock with large and small boulders. This site was chosen because it has stable and adequate water levels for fish passage. During the smolt run the trap was checked and fish released on a regular 2-hour basis from 0600 hrs to 2230 hrs. Also, at each trap check several environmental parameters were collected, i.e. water temperature, air temperature, and water level. During the peak smolt run, two 30 cm openings were made in the fence on each side of the smolt trap by removing several conduits and a light colour plywood board was positioned on the substrate to count fish passing through the fence on their downstream migration. After the smolt fence was removed remaining smolts were enumerated from the adult fence until June 30<sup>th</sup>. The smolt count is complete.

The adult fence was situated just below the Old Horwood Dam on a bedrock substrate in a 25 meter wide section of the river (Fig. 2). The fence had 16 sections (3 m long) and a 2 m \* 2 m adult trap and was operated from June 3 to August 20 (early removal due to budget restraints). A tunnel with a video camera system (VHS format) was installed in the trap giving an overhead view of salmon moving upstream. The video tape was reviewed the next day to count salmon and the count verified by a second viewing. This system has proven to be very successful since first installed in 1993 and has allowed salmon to move upstream through the fence on a continuous basis, especially during the night when visual monitoring became very difficult at the trap. Use of the camera system seemed to move salmon through the fence more quickly than what would have been the case with a standard trap operation. Also, during daylight hours, a 0.5 m section of the fence next to the trap was opened and manually monitored to facilitate the upstream migration of salmon, in 1996 this accounted for 50 % of upstream migrating salmon. All salmon counted were sized into two categories, viz. small salmon less than 63 cm and large salmon 63 cm or greater. This was done by placing marks 63 cm apart on the floor of the trap/counting device.

### *SEA SURVIVAL*

Sea survival was determined from the number of returning adults in year n+1 and the number of smolts of the preceding year n. The adult salmon counted at the fence consisted of several year classes including salmon spawning for the first time as grilse and salmon that had previously

spawned. Thus, sea survival with upstream migrating previous spawners removed from small salmon counts will provide a more accurate measure of sea survival when linked with smolts from the previous year. The number of spawners in the returning adults was determined by mark-recapture. In 1994, 95 and 96, 33 %, 24 % and 25 % respectively were marked with a different colored floy anchor tag for each year which could be identified by tagging position and color on the video screen of the counter. Counts of small and large salmon were then adjusted for the number of previous spawners based on the ratio of tagged to untagged in the returning run and the number of outgoing kelts originally tagged from respective years.

### *ENVIRONMENTAL DATA*

During field operations, environmental data were collected at both fence sites. Water temperatures were recorded by Hugrun thermograph set at 1 m from the surface at the fence site. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded.

### *EXPLOITATION RATES*

Exploitation rates for the recreational fishery were derived based on the number of small salmon counted at the fence and the number of salmon reported to have been caught by the recreational fishery.

### *BIOLOGICAL CHARACTERISTICS*

Estimated egg depositions in 1993-96 were based on percentage female, mean weights, and fecundity data which were used to convert conservation requirements in eggs to spawning requirements in number of fish and assess the percent of the conservation requirement deposition achieved. The biological characteristics data on adult Atlantic salmon were obtained for Campbellton River by sampling recreational catches in 1993-96. Biological characteristics were collected from the recreational salmon fishery on the Campbellton River in 1992-96 by post-secondary students hired by CEIC through the Challenge Program, under the guidance of DFO technical staff. These students were responsible for collection of information on fork length, weight, sex, scales and ovaries.

Fecundity was determined from ovaries collected in the recreational fishery. Ovaries were stored in Gilson's fluid until transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both small and large salmon was 2,100 eggs per kg and was derived from 78 samples taken in Campbellton River, 1993-95.

### *TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION*

The egg deposition was based on the number of spawning adult salmon and biological information collected from the recreational fishery 1992-96 (Table 3).

### Total river returns

Total river returns (TRR) were calculated as follows:

$$(1) \quad \text{TRR} = \text{RC}_b + \text{HRM}_b + C$$

where,

$\text{RC}_b$  = recreational catch below counting fence

$\text{HRM}_b$  = hook & release mortalities below counting fence (0.1 of hook & releases)

$C$  = count of fish at counting fence

### Spawning escapement

Spawning escapement (SE) was calculated as the difference between the number of fish released from the counting fence (FR), the recreational catch retained above the fence ( $\text{RC}_a$ ) and hook & release mortalities above the fence ( $\text{HRM}_a$ ).

$$(2) \quad \text{SE} = \text{FR} - \text{RC}_a - \text{HRM}_a$$

### Egg deposition

Egg deposition (ED) was calculated for small and large salmon as follows:

$$(3) \quad \text{ED} = \text{SE} \times \text{PF} \times \text{RF} \times \text{MW}$$

SE = number of spawners

PF = proportion of females

RF = relative fecundity (No. eggs/kg)

MW = mean weight of females

O'Connell and Dempson (1991) reported that unpublished evidence exists demonstrating that atresia (non-development of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Therefore, fecundity values should be regarded as potential values. Since conservation requirements are based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

## CONSERVATION REQUIREMENTS

The accessible parr rearing habitat for Campbellton River is 5,960 units (a unit being 100 m<sup>2</sup>) of fluvial habitat and 4037.3 ha of pond habitat (Reddin & Downton 1994). The ratio of lacustrine to fluvial habitat of 76.74 is lower than the mean for other SFA 4 rivers (O'Connell and Dempson 1991). Reddin & Downton (1994) derived potential smolt production for Campbellton River of 46,141 smolts by multiplying the amount of fluvial and lacustrine habitat by production parameter values of 3 smolts per unit (100 m<sup>2</sup>) of fluvial habitat and 7 smolts per ha of lacustrine habitat (O'Connell et al. 1991).

The conservation requirements for the Campbellton River of 2,916,126 eggs was derived using egg deposition rates of 240 eggs per 100 m<sup>2</sup> for fluvial parr rearing habitat (Elson 1957) and 368 eggs per ha for lacustrine habitat (O'Connell et al. 1991; Reddin & Downton 1994). Although these values may be habitat and river specific for river systems from which they were derived, they are used to represent a threshold or danger zone to be avoided (O'Connell et al. 1991). Conservation requirements in eggs were converted to adult small salmon by the following formula:

$$(2\ 916\ 126 / ((\% \text{ female} * \text{mean weight} * \text{fecundity}))$$

### *Effects of Moratorium*

The effects of the moratorium on commercial salmon fishing in insular Newfoundland should have increased spawning escapement in 1992-96 compared to previous years. If this were so for Campbellton River then the 1996 smolt class consisting of offspring from spawning in 1991 as 4+ smolt and 1992 as 3 + smolt should have increased for the 3 + component. Alternatively, if freshwater survival had changed either by increasing or decreasing then the smolt output would change but the relative proportion of 3+ and 4 + should not. This was examined by comparing the number of smolts after allocating them to their appropriate year classes.

## Results

### RECREATIONAL FISHERY

In 1996, the recreational salmon fishery on Campbellton River had a total of 1,964 rod days (a rod day being a day or any part thereof in which an individual fishes for salmon) for a retained catch of 463 small salmon (Table 2). The number rod days increased by 189 and retained catch increased by 70 small salmon compared to 1995. In 1992, the recreational fishery on Campbellton River had 916 rod days and a retained catch of 311 salmon (Table 2). These increases in effort and catch are attributed to anticipated increases in the salmon returns as a result of the closure of the commercial fishery in 1992. In 1996, there were 93 small salmon and



31 large salmon hooked and released. In 1996, the catch (retained plus released) per rod day was 0.30. The 31 large fish hooked in 1996 was the highest since 1975. This would be expected since 560 fish is the highest number recorded during the counting fence monitoring program after commercial fishery closure.

During the adult fence operation the river was closed to angling 43 meters above the counting fence at the Old Horwood Dam site and below the fence to saltwater. However, a section of the river referred to as the "V" located at the Old Horwood Dam received the most fishing pressure on the lower section of the river. This was mainly due to the easy access from the main highway and relatively good catches at this site. The next site of extensive angling was centered around the lower part of Second Pond resulting from an upgraded forestry road and new bridge constructed in 1992 which provided for easier access to this part of the river. The main stem between Fourth Pond and Indian Arm Pond and the lower portions of Indian Arm Brook and Neyles Brook were the other popular fishing sites for this system. Water temperatures and levels were generally good in 1996 which facilitated a speedy upstream migration of salmon as noticed by field staff and anglers.

#### *UNRECORDED MORTALITIES*

At the Campbellton River fence, visible net marks were recorded on a daily basis. Overall in 1996, there were 4.3% or 162 of the 3,768 upstream migrating Atlantic salmon with visible net marks. These marks were observed mainly on the head of the fish, which generally represents scaring that would occur from small mesh nets. Because the Campbellton counting fence is only 0.25 km from the sea, these marks had to have occurred sometime before the salmon entered freshwater. In 1994 and 1995, 6.2% and 5.0% of the upstream migrating salmon had net marks (O'Connell et al. 1996). It is concluded that there is some mortality at sea due to fishing, although the overall magnitude is unknown.

#### *SMOLT AND ADULT SALMON COUNTS*

In 1996, a total of 58,369 smolts and 1,971 kelts passed through the downstream fence along with several other species such as smelt and brook trout (Tables 4). The peak of the smolt run occurred in standard week 20 (May 14-20) which accounted for 25.4 percent of the total (Table 5). Of the four years for which smolt counts are available, 1996 smolt run was both the highest in number and the earliest to start (Fig. 3). The earlier run timing of the smolts probably reflects the warmer spring conditions in 1996.

In 1996, a total of 3,208 small and 560 large salmon were counted as they passed upstream through the adult fence (Table 6). The first adult salmon was counted on 4 June and the last fish was counted on 19 August. On average week 26 and 27 accounted for almost 50 percent of the upstream migration, 1993-96 (Table 7). Large salmon returns in 1996 represented 15 % of the run and is double the numbers in previous years.

In 1996, the adult counting fence was in operation from 3 June to 20 August. In previous years, salmon were enumerated at the counting fence after 20 August (Table 7). For small salmon, 1993-95 the percent entering after 20 August ranged from 0.6 to 0.8%. If the ratio after August 20 from previous years is applied to the 1996 counts up to August 20 then there may have been 18 to 27 small salmon entering the river after 20 August, 1996. For large salmon, the percent entering after 20 August ranged from 1.8 to 3.7% which may have resulted in 10 to 21 large salmon entering the river after 20 August, 1996.

Both smolt and adult runs at Campbellton River were considerably earlier in 1996 than in either of the other three years (Figs. 3&4). This was possibly the result of the warmer spring conditions that prevailed in 1996. Consequently, the number of adult salmon that may have entered after the 20 August may be lower than calculated from the run timing that occurred later in previous years. Before the adult fence was removed on 20 August, the river downstream from the fence was checked visually for any adult salmon and no salmon were observed remaining in the river downstream from the fence. Therefore, it is assumed that a complete upstream migration count of adult salmon was achieved.

#### SEA SURVIVAL

Smolt-to-adult survival for the 1995 smolt class from Campbellton River (SFA 4) was 8.08 % (Appendix 3). Estimates of smolt-to-adult survival were 9.05% and 7.28%, respectively for the 1993 and 1994 smolt classes (Appendices 1 & 2). These values are overestimates of survival from smolt to 1SW (grilse) salmon because some of the small salmon migrating upstream are in fact previous spawners that survived from grilse that migrated upstream in previous years. Kelts tagged passing through the downstream smolt fence allowed for correction of the number of previous spawners in the upstream run and calculation of sea survival rates. The results of the tagging study indicated that 11.5% of the small salmon returning to Campbellton River in 1996 were previous spawners. The corrected survival rate after removal of previous spawners is 7.15%. Thus, sea survival for salmon returning to Campbellton River averaged 6.8%, 1993-95. Overwintering survival of salmon spawning in Campbellton River averaged about 64% from 1994-96.

#### ENVIRONMENTAL DATA

Water temperatures ranged from a low of 6 °C in early April to a peak of about 23 °C in mid-August. Both water temperatures and levels stayed within a comfortable range for salmon migrations in 1996 (Fig. 5).

#### EXPLOITATION RATES

In 1996, a total of 3,208 small salmon passed through the counting fence and there was a catch of 587 small and large salmon (retained & released) by the recreational fishery above the fence. There were no salmon caught below the fence. The exploitation rate in the 1996 recreational

fishery was 15.6% (95% CI=12.4%, 18.8%). Overall exploitation has been increasing on Campbellton River, 1993-96. Exploitation on small salmon (retained only) has almost doubled between 1993 and 1996. Exploitation on the total population has increased by about 50% from 1993 to 1996. Rod days have increased from 1,355 in 1993 to 1,964 in 1996. Exploitation rates are in the following text table:

Year	Small - retained	Small - ret. + rel.	Large - released	Total
1993	7.9%	10.5%	0.0%	10.1%
1994	11.9%	12.0%	0.5%	11.3%
1995	12.9%	14.5%	0.5%	13.6%
1996	14.4%	17.3%	5.5%	15.6%

### *BIOLOGICAL CHARACTERISTICS*

The river ages of smolts sampled at the counting fence ranged from 2 to 6 years but fish of 3 river years predominated (Table 8). The number of river age 3 and 4 smolts in the 1996 smolt run increased from the 1993-95 average of 21,864 and 14,019, respectively to 34,479 and 20,359.

From 1993 to 1996, 210 adult salmon were sampled from the recreational fishery. Overall mean fork length of the grilse-only fishery for the Campbellton River was 52.8 cm and 77.4 % of aged fish had a freshwater life of 3 years (Tables 9 & 10). Twenty-four fish that were sampled during 1992-96 had previously spawned and were within the fork length set for retention in the recreational fishery. Also, two fish were sampled that returned to freshwater in the same summer that they went to sea as smolts.

The percentage of female salmon sampled from the recreational fishery in 1992-96 was 75.48 % (Table 11). The mean weight for female small salmon was 1.51 kg (N=134 and SD=0.27). There were no samples for large salmon available from Campbellton River due to the mandatory release of large salmon in the recreational fishery introduced in 1984. Default values for mean weight and percent female of large salmon 3.13 and 76.9 were used that were derived from several rivers in SFA 4 (O'Connell et al. 1996).

Approximately 0.5% of the smolt migration was sampled each year 1993-96. The mean fork length and whole weight was slightly higher for female smolt (Table 12). The overall mean for fork length and whole weight was 177.3 mm 51.7 grams, respectively and had a mean age of 3.46 years.

## ACCURACY OF EGG DEPOSITION ESTIMATES

The precision of annual egg deposition values was examined by deriving egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. If the number of samples are adequate to define biological characteristics of either group then the egg depositions from the two methods should be similar. Egg depositions from kelts are based on the number of eggs per cm whereas eggs per kg are used for the upstream migrating salmon. Comparison of values derived on fresh run versus kelts shows 312% versus 304% in 1993, 239% versus 220% in 1994, and 279% versus 256% in 1995 (Table 13 a&b). Because the percentage of conservation requirements achieved is always slightly higher when based on fresh run salmon suggests there may be a tendency to overestimate rather than underestimate the percent of conservation requirements achieved. However, the similarity of the two values suggests that the tendency to overestimate is small.

## *SALMON POSTSMOLTS RETURNING TO FRESHWATER*

Stocks of Atlantic salmon exhibit various life history patterns including several alternate strategies. The entire life cycle can take place in freshwater; they can start life in the river, then migrate between river and estuary; they can migrate between river and estuary and then go to sea; or they can have the more typical anadromous life cycle of going to sea for one or more years before returning to freshwater (Power et al. 1987). In Newfoundland and Labrador, the most common life history type is starting life in the river migrating to sea at two to seven years of age and then returning to freshwater after spending at least one or more years in the sea. Salmon that have spawned one or more times after one or more years in the sea are also quite common. As evidenced by scale reading of a few salmon sampled that were caught by anglers or at enumeration facilities, a small minority of salmon exists that spend only a couple of months at sea before returning to freshwater. Because they do not spend a full year at sea, these salmon are typically very small being less than 40 cm fork length. Also, as they are uncommon the salmon nomenclature does not have a separate name for this life stage and they would be labelled as postsmolts (Allan and Ritter 1977).

In 1995, anglers reported for a number of rivers, e.g. Southwest Brook in Bay St. George, observing a high number of very small salmon migrating upstream. In 1993 and 1994, a few very small (<40 cm) salmon were noted at the counting fence ascending Campbellton River. In the spring of 1994, several of these small salmon were sampled as kelts descending through the smolt counting fence. In total, out of 907 kelts sampled there were four or 0.4% that had not completed a full year in the sea. Another 12 or 1.4% of the kelts had no complete sea year but showed 2 or more spawning marks but remains a relatively minor component of the run.

In 1995, a 30 cm line was installed in the tunnel of the video counting chamber in the adult counting fence in Campbellton River to better enable enumeration of these fish. In 1995, 13

salmon of approximately 28-35 cm in length were observed ascending through the Campbellton River counting fence. The total upstream run was 13 postsmolts, 3,035 small and 218 large salmon; thus, the upstream run consisted of 0.4% postsmolts. Therefore, it is concluded that for 1995, the presence of salmon postsmolts in the upstream run at Campbellton River is not unusual in that it also occurred in other years.

### *TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION*

#### **Total river returns**

#### **Target spawning requirements and potential smolt production**

The estimated conservation requirements for Campbellton River in terms of eggs as well as adult salmon were estimated as follows:

	<u>Lacustrine</u>	<u>Fluvial</u>	<u>Total</u>
Accessible habitat	4037.3 ha	5,960 units	-
Eggs (No. x 10 <sup>6</sup> )	1.486	1.430	2 916 126

Conservation requirements converted to numbers of small salmon (Reddin and Downton 1994):

$$\begin{aligned}
 &= \frac{2,916,126 \text{ eggs}}{(\% \text{ female} * \text{mean wt} * \text{fecundity})} \\
 &= \frac{2,916,126}{(0.745 * 1.493 * 1775)} \\
 &= \sim 1480 \text{ small salmon}
 \end{aligned}$$

Estimated potential smolt production are as follows:

$$\begin{aligned}
 \text{Fluvial smolt} &= 3 \text{ smolts/unit} * 5960 \text{ units} = 17,880 \\
 \text{Lacustrine smolt} &= 7 \text{ smolts/ha} * 4,037.3 \text{ ha} = 28,261 \\
 \\ 
 \text{Total potential smolt production} &= 46,141
 \end{aligned}$$

#### *Effects of Moratorium*

The smolt count at Campbellton in 1996 of 58,369 increased appreciably over that of the previous three year average of 37,652 (Table 5). For this increase to have been solely due to the effects of the moratorium on the commercial salmon fishery in insular Newfoundland then the increase in smolts should have been mainly 3+ river age to have been from the 1992 spawning class. Since the increase was derived from the 3+ and 4+ smolts suggests that it was due to an

increase in freshwater survival rather than an increase in spawning or possibly both.

### Discussion

Taylor (1985) discussed the historical catch record for many rivers in Newfoundland and Labrador. He states that Campbellton River's relatively high Atlantic salmon abundance made it valuable to the Beothucks and Europeans alike. The earliest catch record specific to Campbellton indicates that a John Ginn landed 90 tierces of salmon on or about the year 1816. Because the early European settlers fished by placing a weir across the entire river and there was no coastal gillnet fishery, these catches are an approximation of total production of the river when it was in a pristine state. The 90 tierces converts to 18,400 kg using the conversion factors of Taylor (1985). This weight of fish converts to about 12,000 salmon if the mean weights of 1993-96 period are used. The highest count in the 1993-96 period is 4,146 or about 30% of that which Campbellton River may have produced when it was in a more natural state.

At the conservation requirement of 1,480 spawners there is anticipated to be about 48,000 smolts produced from Campbellton River. At average survival rates and proportions large salmon, 48,000 smolts will produce about 4,600 adult salmon. If Campbellton River still has similar freshwater habitat to what was present in 1816 then perhaps the difference between the 4,600 adult salmon produced at conservation requirements and the 12,000 it produced in a more virgin state is its maximum production. Since the percent of the conservation requirement achieved on average for Campbellton, 1993-96 is about 300% it would be interesting and potentially very informative to be able to monitor adult returns in 1998-2001. Alternately, the presumed historic production of 12,000 salmon may have represented an extreme maximum value.

For Campbellton River, there was no detailed habitat survey available (Porter et al. 1974). Thus, the habitat values given in this paper should be regarded as preliminary and will be subject to further review. The Campbellton River watershed has had extensive logging activity in the past. Especially in the early 1900's when a 400 m long, 10 m high dam was erected by the Horwood Lumber Company near the mouth of the river to divert water into a 350 m rock-cut channel to run a pulp mill and hydro plant. At this time this company had timber rights to 596 km<sup>2</sup> and used the river as a means to float logs to the mill. However, this operation was short lived since the dam broke in 1916 and the company went into bankruptcy. Logging continued in and around the Campbellton River up to 1966 when 22 small dams were removed by Price (Nfld.) Ltd. under the supervision of the Department of Fisheries and Oceans. The structures from these historical logging activities are still visible in the remains of dams and tree trunks scattered at various points along the river. The remains of several dams located on the Crooked Brook tributary, which empties into Second Pond, still pose partial obstruction to migrating salmon during low water levels. In 1961, the upper watershed near Shirley Lake and Silt Lake was completely destroyed by fire, which only now has returned to a normal forest growth. The effect of these activities on the production of salmon in the system are unknown.

Since the habitat in Campbellton River has not been completely surveyed the conservation requirement may be an over- or under-estimate. The total number of adult salmon spawning in 1996 resulted in an egg deposition that was 304% over conservation requirements. It was noted during the helicopter survey that many of the spawning areas on the main stem were located between relatively small and shallow ponds. These shallow ponds may provide for an optimal utilization of rearing habitat and a higher rearing capacity much closer to that of the classical fluvial habitat may be more appropriate. Therefore, caution must be used when referring to conservation requirements until a full habitat survey is completed.

For Campbellton River, the smolt production of 58,369 for 1996 is 127 % above the calculated potential smolt production of 46,141. The modal smolt age for Campbellton River salmon is 3 years and thus, the 1996 smolt run is derived mainly from adults that spawned in the fall of 1992. For most Newfoundland rivers, spawning escapements were the lowest on record in the period 1989-91 (Dempson and O'Connell 1993). Escapements on northeast coast Newfoundland rivers rose beginning in 1992 with the beginning of the commercial salmon fishing moratorium and smolt production stemming from spawning escapements in post-moratorium years may be much closer to this potential figure.

Assumptions associated with the parameter values used to calculate the conservation spawning requirement have been discussed previously by O'Connell et al. (1991), O'Connell and Dempson (1991), O'Connell and Ash (1994) and will not be dealt with in detail here. The comments in O'Connell and Ash (1994) on further substantiation of parameter values for calculations related to egg deposition apply as well to Campbellton River. Also, it should be kept in mind that inaccuracies in catch statistics, losses to due poaching, losses due to hook and release mortality, and losses from natural mortality will influence the results.

### **Acknowledgments**

The project was funded by a Cooperation Agreement on Salmonid/Enhancement Conservation grant to the Lewisporte Area Development Association (LADA). The assistance of the following persons is gratefully acknowledged: Mr. N. Daley and staff at DFO Resource Management Branch, Lewisporte, the field staff provided by LADA, and Mr. R. Johnson, DFO Science Branch.

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Table 1 . The total rod days, total catch and catch per unit effort (CPUE) for Atlantic salmon retained in the recreational fishery for Insular Newfoundland ,Salmon Fishing Area 4 and the Campbellton River from 1953 to 1996.

Year	Rod days			Total catch (ret. + rel. )			CPUE		
	Insular NFLD	SFA 4	Campbellton River	Insular NFLD	SFA 4	Campbellton River	Insular NFLD	SFA 4	Campbellton River
1953	27,955	8,630	346	8,226	3,485	126	0.29	0.40	0.36
1954	16,974	7,344	587	3,630	1,600	102	0.21	0.22	0.17
1955	11,183	5,125	56	5,098	2,616	61	0.46	0.51	1.09
1956	33,532	10,672	341	8,269	4,350	119	0.25	0.41	0.35
1957	17,514	8,789	291	8,617	4,950	105	0.49	0.56	0.36
1958	16,593	5,888	592	10,054	5,001	447	0.61	0.85	0.76
1959	17,570	6,321	325	8,685	4,220	303	0.49	0.67	0.93
1960	17,530	7,051	313	7,366	3,950	265	0.42	0.56	0.85
1961	13,730	5,277	209	4,778	2,280	146	0.35	0.43	0.70
1962	21,641	8,842	397	9,912	4,879	147	0.46	0.55	0.37
1963	26,824	10,910	1,242	10,673	4,042	421	0.40	0.37	0.34
1964	34,886	15,608	1,066	16,281	7,917	496	0.47	0.51	0.47
1965	34,083	13,749	647	12,443	4,551	468	0.37	0.33	0.72
1966	34,073	15,249	881	13,745	6,627	689	0.40	0.43	0.78
1967	38,067	13,915	815	9,569	4,226	487	0.25	0.30	0.60
1968	40,004	15,318	1,577	16,616	6,139	743	0.42	0.40	0.47
1969	40,347	13,807	992	16,470	4,138	534	0.41	0.30	0.54
1970	38,933	15,759	660	15,665	4,896	437	0.40	0.31	0.66
1971	38,417	11,379	622	13,151	3,841	299	0.34	0.34	0.48
1972	33,487	10,778	452	12,798	3,468	210	0.38	0.32	0.46
1973	46,180	14,544	1,344	19,450	6,759	971	0.42	0.46	0.72
1974	67,894	22,038	1,956	15,689	5,455	505	0.23	0.25	0.26
1975	60,191	22,384	1,768	16,304	6,109	487	0.27	0.27	0.28
1976	64,853	24,787	2,042	16,722	6,871	834	0.26	0.28	0.41
1977	69,057	28,117	2,134	22,561	9,482	912	0.33	0.34	0.43
1978	63,599	24,131	1,314	20,339	9,276	429	0.32	0.38	0.33
1979	50,199	21,496	53	18,228	8,353	23	0.36	0.39	0.43
1980	66,625	25,172	2,293	24,093	9,921	1,112	0.36	0.39	0.48
1981	77,884	32,282	2,950	30,980	13,897	1,549	0.40	0.43	0.53
1982	85,200	32,929	1,674	26,518	10,231	473	0.31	0.31	0.28
1983	82,167	26,649	1,619	22,311	9,251	597	0.27	0.35	0.37
1984	79,740	29,633	2,657	24,878	9,915	992	0.31	0.33	0.37
1985	82,783	34,329	3,219	26,527	12,190	782	0.32	0.36	0.24
1986	79,009	31,650	1,791	24,182	9,293	422	0.31	0.29	0.24
1987	47,809	18,564	803	13,013	5,453	169	0.27	0.29	0.21
1988	73,566	27,413	1,837	23,960	9,854	636	0.33	0.36	0.35
1989	53,862	17,767	854	11,525	3,786	148	0.21	0.21	0.17
1990	64,494	23,533	693	17,409	5,661	106	0.27	0.24	0.15
1991	52,173	21,999	693	11,132	4,892	126	0.21	0.22	0.18
1992	39,242	19,485	916	12,271	6,810	341	0.31	0.35	0.37
1993	58,943	30,598	1,355	14,947	13,114	419	0.25	0.43	0.31
1994	141,508	43,242	1,484	39,381	12,158	345	0.28	0.28	0.23
1995	143,275	36,717	1,775	40,818	11,329	441	0.28	0.31	0.25
1996	156,432	44,285	1,964	53,204	17,598	587	0.34	0.40	0.30
Mean	53,637	19,640	1,173	17,238	6,928	455	0.34	0.38	0.44
Mean percent of Island		36.6%	2.2%		40.2%	2.6%			

Table 2. Atlantic salmon recreational statistics for Campbellton River, Norte Dame Bay, SFA 4, 1974-96.

River: Campbellton River

Code: 0708210

Year	Effort Rod Days	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			CPUE
		Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	
1974	1956	505	.	505	0	.	0	505	.	505	0.26
1975	1768	424	.	424	63	.	63	487	.	487	0.28
1976	2042	834	.	834	0	.	0	834	.	834	0.41
1977	2134	895	.	895	17	.	17	912	.	912	0.43
1978	1314	426	.	426	3	.	3	429	.	429	0.33
1979	53	23	.	23	0	.	0	23	.	23	0.43
1980	2298	1112	.	1112	0	.	0	1112	.	1112	0.48
1981	2950	1547	.	1547	2	.	2	1549	.	1549	0.53
1982	1674	471	.	471	2	.	2	473	.	473	0.28
1983	1619	597	.	597	0	.	0	597	.	597	0.37
1984	2657	991	.	991	1	.	1	992	.	992	0.37
1985	3219	782	.	782	*	.	0	782	.	782	0.24
1986	1791	422	.	422	*	.	0	422	.	422	0.24
1987	803	169	.	169	*	.	0	169	.	169	0.21
1988	1837	636	.	636	*	.	0	636	.	636	0.35
1989	854	148	.	148	*	.	0	148	.	148	0.17
1990	693	106	.	106	*	.	0	106	.	106	0.15
1991	693	126	.	126	*	.	0	126	.	126	0.18
1992	916	311	30	341	*	0	0	311	30	341	0.37
1993	1355	316	103	419	*	0	0	316	103	419	0.31
1994	1484	340	4	344	*	1	1	340	5	345	0.23
1995	1775	393	47	440	*	1	1	393	48	441	0.25
1996**	1964	463	93	556	*	31	31	463	124	587	0.30
84-89 X	2071.6	595.8	.	595.8	.	.	.	596.0	.	596.0	0.29
95% CL	1123.4	403.8	.	403.8	.	.	.	404.2	.	404.2	0.00
N	5	5	0	5	0	0	0	5	0	5	5
86-91 X	1173.6	287.6	.	287.6	.	.	.	287.6	.	287.6	0.25
95% CL	730.6	289.8	.	289.8	.	.	.	289.8	.	289.8	0.00
N	5	5	0	5	0	0	0	5	0	5	5
92-95 X	1382.5	340.0	46.0	386.0	.	0.5	0.5	340.0	46.5	386.5	0.28
95% CL	568.3	59.7	66.7	81.1	.	0.9	0.9	59.7	66.2	81.2	0.00
N	4	4	4	4	0	4	4	4	4	4	4

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1996 AND ON RETAINED FISH ONLY PRIOR TO 1992.

\* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

\*\*PRELIMINARY

Table 3. Campbellton River adult salmon returns, spawning escapement and egg deposition, 1993-96.

**SPAWNING ESCAPEMENT**

$$SE = (FR - RCT) - (HRM)$$

SE= Spawning escapement  
 FR= Fish released by counting fence  
 RCT= Recreational catch (retained)  
 RCL= Recreational catch (released)  
 HRM= Recreational mortality (RCL \*0.1)

		YEAR				
		93	94	95	96	AVERAGE
FR	Small	4001	2857	3035	3208	3275
	Large	145	191	218	560	279
RCL	Small	103	4	47	93	62
	Large	0	1	1	31	8
HRM	Small	10	0	5	9	6
	Large	0	0	0	3	1
RCT	Small	316	340	393	463	378
	Large	0	0	0	0	0
SE	Small	3675	2517	2637	2736	2891
	Large	145	191	218	557	278

**EGG DEPOSITION**

$$ED = SE * PF * RF * MW$$

ED= Egg deposition  
 SE= Spawning escapement  
 PF= Proportion females  
 RF= Relative fecundity (eggs/kg)  
 MW= Mean weight of females

		YEAR				
		93	94	95	96	AVERAGE
SE	Small	3675	2517	2637	2736	2891
	Large	145	191	218	557	278
PF	Small	0.736	0.727	0.818	0.667	0.756
	Large	0.769	0.769	0.769	0.769	0.769
RF	Small	2100	2100	2100	2100	2100
	Large	2100	2100	2100	2100	2100
MW	Small	1.47	1.56	1.55	1.58	1.51
	Large	3.13	3.13	3.13	3.13	3.13
ED	Small	8,344,498	5,996,139	7,023,765	6,051,671	6,929,788
	Large	732,922	964,930	1,101,405	2,814,927	1,403,546
Total		9,077,421	6,961,069	8,125,171	8,866,598	8,333,334
Target		2,916,000	2,916,000	2,916,000	2,916,000	2,916,000
% Target met		311	239	279	304	286

The PF and MW for large salmon are default values calculated from several rivers in Notre Dame Bay (O'Connell et al. 1996).

Table 4. Daily count of downstream migrating fish at Campbellton River through the counting fence in 1996.

	Parr	Smolt	Kelt	Ouananiche	Precocious Smolt	Trout	Smelt	Eel
24-Apr-96	11	0	1	0	0	1	5	0
25-Apr-96	5	0	2	0	0	3	2	0
26-Apr-96	16	5	6	0	0	6	3	0
27-Apr-96	16	7	3	0	0	19	10	0
28-Apr-96	13	27	55	0	0	24	25	0
29-Apr-96	5	5	8	0	0	21	22	0
30-Apr-96	21	48	91	0	4	86	17	0
01-May-96	14	24	58	1	2	50	18	0
02-May-96	39	302	113	10	2	98	24	0
03-May-96	19	482	125	0	4	87	10	1
04-May-96	7	624	207	5	11	169	13	0
05-May-96	5	408	69	1	1	69	1	0
06-May-96	2	258	144	0	0	50	0	0
07-May-96	0	239	53	0	1	25	4	0
08-May-96	1	265	27	0	0	12	2	0
09-May-96	2	263	39	1	0	17	0	0
10-May-96	0	499	78	1	0	42	1	0
11-May-96	2	819	22	0	2	52	2	0
12-May-96	1	285	5	2	0	26	2	0
13-May-96	1	782	169	2	2	27	7	0
14-May-96	5	1773	14	2	0	24	8	0
15-May-96	3	918	7	2	0	29	4	0
16-May-96	3	1319	169	3	3	45	9	0
17-May-96	5	2040	62	4	3	85	6	0
18-May-96	7	3422	23	2	2	105	12	0
19-May-96	6	2732	5	2	2	69	4	0
20-May-96	15	2629	10	2	2	62	14	0
21-May-96	12	3533	3	0	0	53	24	0
22-May-96	12	968	6	1	2	45	20	0
23-May-96	9	1119	6	1	0	24	31	0
24-May-96	9	1666	6	1	0	22	27	0
25-May-96	10	2850	35	2	2	32	14	0
26-May-96	10	2190	29	0	0	36	23	0
27-May-96	5	1917	25	0	0	23	20	0
28-May-96	8	2081	34	14	3	38	17	0
29-May-96	20	2324	29	3	0	44	27	0
30-May-96	11	2027	36	3	4	59	17	0
31-May-96	7	1730	15	1	0	50	5	0

Cont

Table 4 ( continued ). Daily count of downstream migrating fish at Campbellton River through the counting fence in 1996.

	Parr	Smolt	Kelt	Ouananiche	Precocious Smolt	Trout	Smelt	Eel
01-Jun-96	8	1571	43	0	2	27	7	0
02-Jun-96	5	1310	52	0	2	33	4	0
03-Jun-96	10	2315	5	0	0	25	7	0
04-Jun-96	8	1825	12	0	0	28	11	0
05-Jun-96	14	1288	5	0	0	24	7	0
06-Jun-96	15	1665	25	1	0	14	11	1
07-Jun-96	24	842	10	0	0	13	3	0
08-Jun-96	18	1343	3	0	0	8	6	0
09-Jun-96	9	619	1	0	0	7	7	0
10-Jun-96	10	682	2	1	0	3	6	0
11-Jun-96	3	661	3	0	0	4	1	0
12-Jun-96	0	275	5	1	0	3	0	0
13-Jun-96	3	378	1	0	0	3	4	0
14-Jun-96	4	335	10	0	0	3	5	0
15-Jun-96	21	266	2	0	0	3	11	0
16-Jun-96	17	211	0	0	0	3	5	0
17-Jun-96	1	30	0	0	0	0	1	0
18-Jun-96	0	51	1	0	0	0	0	0
19-Jun-96	0	26	0	0	0	1	0	0
20-Jun-96	0	9	0	0	0	0	0	0
21-Jun-96	0	18	0	0	0	0	0	0
22-Jun-96	0	0	0	0	0	0	0	0
23-Jun-96	0	3	0	0	0	0	0	0
24-Jun-96	0	14	0	0	0	0	0	0
25-Jun-96	0	10	0	0	0	0	0	0
26-Jun-96	0	19	0	0	0	0	0	0
27-Jun-96	0	7	0	0	0	0	0	0
28-Jun-96	0	10	0	0	0	0	0	0
29-Jun-96	0	5	1	0	0	1	0	0
30-Jun-96	0	1	1	0	0	0	0	0
<b>Total</b>	<b>507</b>	<b>58369</b>	<b>1971</b>	<b>69</b>	<b>56</b>	<b>1932</b>	<b>546</b>	<b>2</b>

Table 5. Smolt migration by standard week through the counting fence on the Campbellton River, 1993-96.

			Year and percent									
Dates	Standard week		1993	%	1994	%	1995	%	1996	%	Mean	%
April	23-29	17	0	0.00	0	0.00	0	0.00	44	0.08	11	0.03
May	30-06	18	0	0.00	1	0.00	0	0.00	2,146	3.68	537	1.25
	07-13	19	0	0.00	16	0.04	3	0.01	3,152	5.40	793	1.85
	14-20	20	125	0.40	224	0.54	15	0.04	14,833	25.41	3,799	8.87
	21-27	21	6,607	20.92	2,137	5.13	826	2.08	14,243	24.40	5,953	13.90
	28-03	22	7,071	22.39	7,842	18.84	8,228	20.72	13,358	22.89	9,125	21.30
June	04-10	23	9,915	31.40	17,297	41.55	14,409	36.28	8,264	14.16	12,471	29.12
	11-17	24	4,518	14.31	12,091	29.04	11,566	29.12	2,156	3.69	7,583	17.70
	18-24	25	3,012	9.54	1,876	4.51	4,020	10.12	121	0.21	2,257	5.27
	25-01	26	253	0.80	147	0.35	495	1.25	52	0.09	237	0.55
July	02-08	27	76	0.24	32	0.08	98	0.25	0	0.00	52	0.12
	09-15	28	0	0.00	0	0.00	55	0.14	0	0.00	14	0.03
<b>Total</b>			<b>31,577</b>		<b>41,663</b>		<b>39,715</b>		<b>58,369</b>		<b>42,831</b>	

Table 6. The upstream migration of Atlantic salmon through the counting fence on Campbellton River, 1996.

Date	Small	Large	Total
03-Jun	0	0	0
04-Jun	0	0	0
05-Jun	0	1	1
06-Jun	1	1	2
07-Jun	1	0	1
08-Jun	4	1	5
09-Jun	14	2	16
10-Jun	13	4	17
11-Jun	21	1	22
12-Jun	28	5	33
13-Jun	35	6	41
14-Jun	18	0	18
15-Jun	114	5	119
16-Jun	116	20	136
17-Jun	73	5	78
18-Jun	129	7	136
19-Jun	37	1	38
20-Jun	164	18	182
21-Jun	85	4	89
22-Jun	81	15	96
23-Jun	94	8	102
24-Jun	139	4	143
25-Jun	150	11	161
26-Jun	107	6	113
27-Jun	43	9	52
28-Jun	92	6	98
29-Jun	66	14	80
30-Jun	166	16	182
01-Jul	113	35	148
02-Jul	149	21	170
03-Jul	103	26	129
04-Jul	84	20	104
05-Jul	66	26	92
06-Jul	67	19	86
07-Jul	115	29	144
08-Jul	61	20	81
09-Jul	31	7	38
10-Jul	83	11	94
11-Jul	52	16	68
12-Jul	28	13	41
13-Jul	21	0	21
14-Jul	182	53	235



Table 6 ( continued ). The upstream migration of Atlantic salmon through the counting fence on Campbellton River ,1996.

Date	Small	Large	Total
15-Jul	42	20	62
16-Jul	10	7	17
17-Jul	14	6	20
18-Jul	21	11	32
19-Jul	19	7	26
20-Jul	6	4	10
21-Jul	5	5	10
22-Jul	18	6	24
23-Jul	4	3	7
24-Jul	9	1	10
25-Jul	12	1	13
26-Jul	7	0	7
27-Jul	13	4	17
28-Jul	13	4	17
29-Jul	11	5	16
30-Jul	12	2	14
31-Jul	4	0	4
01-Aug	6	1	7
02-Aug	7	3	10
03-Aug	3	0	3
04-Aug	3	0	3
05-Aug	2	0	2
06-Aug	1	0	1
07-Aug	0	0	0
08-Aug	2	1	3
09-Aug	3	0	3
10-Aug	2	1	3
11-Aug	0	0	0
12-Aug	2	1	3
13-Aug	1	0	1
14-Aug	1	0	1
15-Aug	3	0	3
16-Aug	2	0	2
17-Aug	1	0	1
18-Aug	3	0	3
19-Aug	0	1	1
20-Aug	0	0	0
Total	3208	560	3768

Table 7. Upstream migration of adult Atlantic salmon through the counting facility on the Campbellton River, 1993-96.

Dates	Standard week	1993		1994		1995		1996		1993-96			
		Small	Large	Small	Large	Small	Large	Small	Large	Total	Mean	Percent	
June	04-10	23						33	9	42	11	0.30	
	11-17	24	14	0	3	0	4	2	405	42	470	118	3.31
	18-24	25	217	6	234	28	322	28	729	57	1621	405	11.40
	25-01	26	1023	40	525	11	867	30	737	97	3330	833	23.43
July	02-08	27	1351	42	721	22	693	13	645	161	3648	912	25.66
	09-15	28	727	25	353	15	279	4	439	120	1962	491	13.80
	16-22	29	340	12	215	19	394	35	93	46	1154	289	8.12
	23-29	30	155	7	538	47	297	45	69	18	1176	294	8.27
August	30-05	31	59	1	118	18	78	23	37	6	340	85	2.39
	06-12	32	53	4	114	17	39	23	10	3	263	66	1.85
	13-19	33	25	3	16	7	40	11	11	1	114	29	0.80
	20-26	34	17	2	13	1	19	4			56	14	0.39
	27-02	35	12	0	3	3	3	0			21	5	0.15
September	03-09	36	8	3	4	3					18	5	0.13
Total			4001	145	2857	191	3035	218	3208	560	14215		
Percent			95.5	3.5	93.7	6.3	93.3	6.7	85.0	15.0			
Start date			10-Jun		13-Jun		14-Jun		03-Jun				
End date			07-Sep		12-Sep		29-Aug		20-Aug				

Table 8. River age and percent of sampled smolts from 1993-96 applied to the downstream smolt migrations for Campbellton River, 1993-96.

River age and percent											
Year	2	%	3	%	4	%	5	%	6	%	Total
93	0	0.00	15,709	49.75	15,233	48.24	635	2.01	0	0.00	31,577
94	208	0.00	24,954	59.89	13,198	31.68	3,095	7.43	208	0.50	41,663
95	290	0.73	24,929	62.77	13,626	34.31	870	2.19	0	0.00	39,715
96	543	0.93	34,479	59.07	20,359	34.88	2,988	5.12	0	0.00	58,369
<b>Mean</b>	260	0.61	25,018	58.41	15,604	36.43	1,897	4.43	52	0.12	42,831

Table 9. Biological characteristics of small salmon sampled in the recreational fishery at Campbellton River, 1992-96.

Year	Sex	Fork length (cm)					Whole weight (kgs)					River age (years)				
		Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max
92	Male	55.88	4	3.97	52.0	60.0	1.83	3	0.58	1.50	2.50	3.50	4	1.00	3	5
	Female	52.82	14	5.67	42.0	62.5	1.38	2	0.53	1.00	1.75	3.50	14	0.65	3	5
	All	53.50	18	5.39	42.0	62.5	1.65	5	0.55	1.00	2.50	3.50	18	0.71	3	5
93	Male	53.03	23	3.50	48.0	62.0	1.55	23	0.29	1.16	2.50	3.09	23	0.29	3	4
	Female	52.42	64	2.49	46.0	57.5	1.47	61	0.22	0.76	1.92	3.03	61	0.36	2	4
	All	52.58	87	2.78	46.0	62.0	1.49	84	0.25	0.76	2.50	3.05	84	0.34	2	4
94	Male	55.76	10	3.13	52.5	60.5	1.79	10	0.36	1.40	2.31	3.17	12	0.39	3	4
	Female	52.71	31	3.13	46.3	59.5	1.56	28	0.28	0.94	2.16	3.25	32	0.51	3	5
	All	53.45	41	3.36	46.3	60.5	1.62	38	0.31	0.94	2.31	3.23	44	0.48	3	5
95	Male	53.69	10	3.55	49.0	61.0	1.72	9	0.38	1.13	2.30	3.30	10	0.48	3	4
	Female	52.47	45	3.44	43.0	62.0	1.55	38	0.32	0.97	2.42	3.30	44	0.51	2	4
	All	52.69	55	3.46	43.0	62.0	1.58	47	0.33	0.97	2.42	3.30	54	0.50	2	4
96	Male	50.63	3	1.87	48.5	52.0	1.44	3	0.10	1.33	1.50	3.50	2	0.71	3	4
	Female	51.50	6	4.23	45.0	55.0	1.58	5	0.41	1.10	2.10	3.33	6	0.52	3	4
	All	51.21	9	3.50	45.0	55.0	1.53	8	0.33	1.10	2.10	3.38	8	0.52	3	4
1992-96	Male	53.79	50	3.57	48.0	62.0	1.64	48	0.35	1.13	2.50	3.20	51	0.45	3	5
	Female	52.49	160	3.29	42.0	62.5	1.51	134	0.27	0.76	2.42	3.20	157	0.49	2	5
All		52.80	210	3.40	42.0	62.5	1.55	182	0.30	0.76	2.50	3.20	208	0.48	2	5

Table 10. River age and percent of salmon sampled in the recreational fishery at Campbellton River, 1992-96.

Year	River Age								Total
	2		3		4		5		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
92			11	61.11	5	27.78	2	11.11	18
93	3	3.57	74	88.10	7	8.33			84
94			35	79.55	8	18.18	1	2.27	44
95	1	1.85	36	66.67	17	31.48			54
96			5	62.50	3	37.50			8
Total	4	1.92	161	77.40	40	19.23	3	1.44	208

Table 11. Percent male and female for adult salmon sampled in the recreational fishery at Campbellton River, 1992-16.

Year	Male		Female		Total
	Number	Percent	Number	Percent	
1992	4	22.22	14	77.78	18
1993	23	27.38	61	72.62	84
1994	12	27.27	32	72.73	44
1995	10	18.52	44	81.48	54
1996	2	25	6	75	8
1992-96	51	24.52	157	75.48	208

Table 12. Mean fork length, Whole weight and River age of salmon smolts sampled from the smolt fence at Campbellton River, 1993-96.

Sex	Fork length ( mm )					Whole weight ( grams )					Mean river age ( yrs )				
	Mean	Nunber	STD	Min.	Max.	Mean	Number	STD	Min.	Max.	Mean	Number	STD	Min.	Max.
Male	176.5	204	18.0	135.0	275.0	50.4	204	17.6	22.4	175.6	3.47	204	0.59	3	5
Female	177.6	549	19.6	127.0	267.0	52.2	549	19.5	19.1	174.0	3.46	549	0.60	2	6
All	177.3	753	19.2	127.0	275.0	51.7	753	19.0	19.1	175.6	3.46	753	0.60	2	6

Table 13a. Summary of assessment of Campbellton River salmon stock based on upstream migrating adults.  
Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality				Spawning escapement		Mean WW female		Percent female		Fecundity (eggs/kg)		Egg deposition		Total	Percent of Conservation requirement
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		
93	4001	145	316	10	0	0	3685	145	1.47	3.13	73.56	76.90	2100	2100	8367887.7	732922	9100810	312
94	2857	191	340	0	0	0	2517	191	1.56	3.13	72.73	76.90	2100	2100	5997091.8	965436	6962527.5	239
95	3035	218	393	5	0	0	2637	218	1.55	3.13	81.82	76.90	2100	2100	7022966.5	1101911	8124877.4	279
96	3208	560	463	9	0	3	2736	557	1.58	3.13	66.67	76.90	2100	2100	6052334.6	2815433	8867767.4	304

Table 13b. Summary of assessment of Campbellton River salmon stock based on downstream migrating kelts from the next year.  
Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality				Spawning escapement		Mean FL kelts		Percent female		Fecundity (eggs/cm)		Egg deposition		Total	Percent of Conservation requirement
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		
93	4001	145	316	10	0	0	3675	145	52.03	65.17	73.56	76.90	59.97	59.97	8435036	435788.85	8870824.8	304
94	2857	191	340	0	0	0	2517	191	53.25	65	72.73	76.90	59.97	59.97	5845887.6	572541.69	6418429.3	220
95	3035	218	393	5	0	0	2637	218	52.33	68.37	81.82	76.90	59.97	59.97	6771024.6	687357.16	7458381.7	256



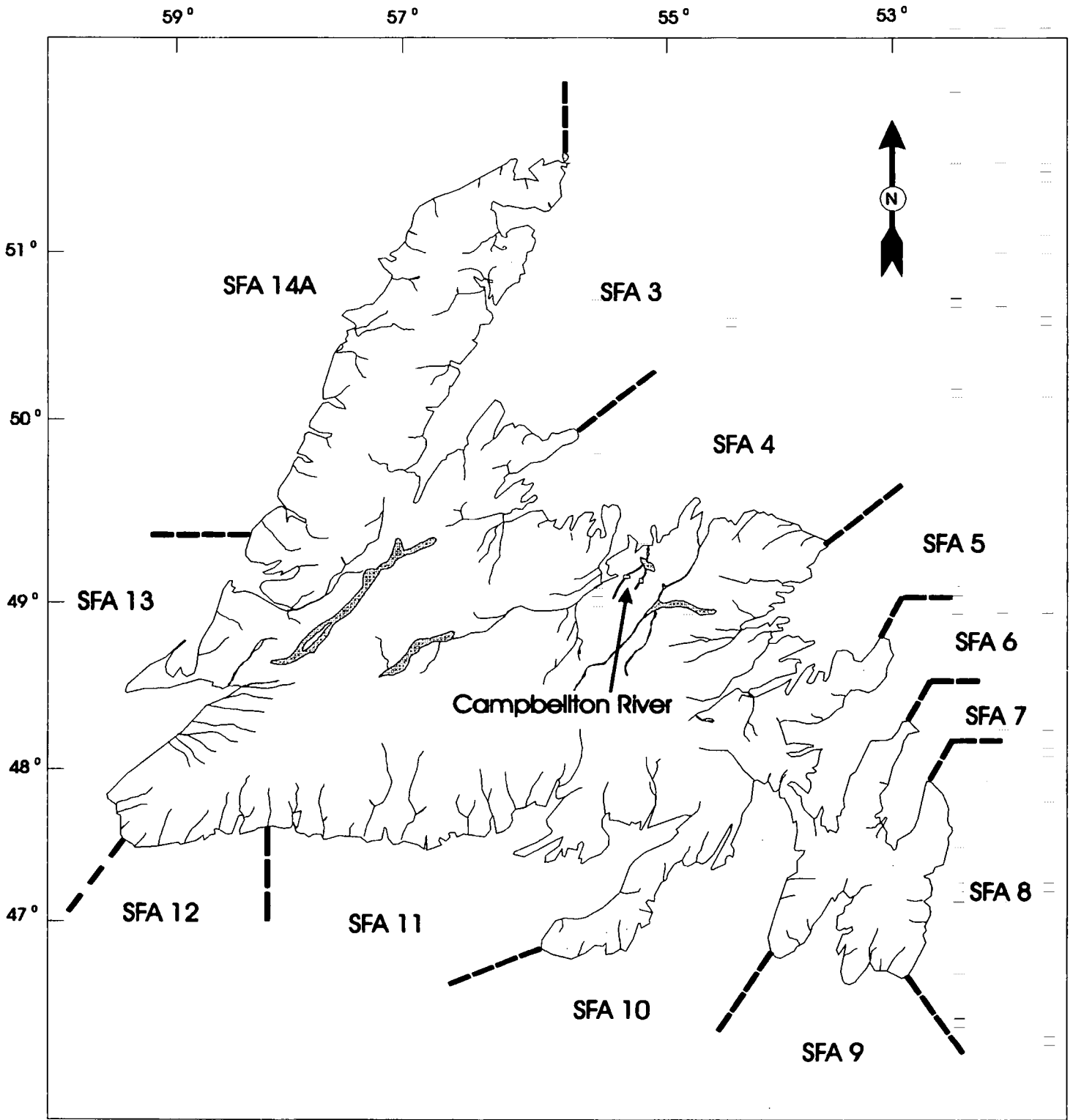


Figure 1. Salmon Fishing Areas on the Island of Newfoundland with reference to the Campbellton River.

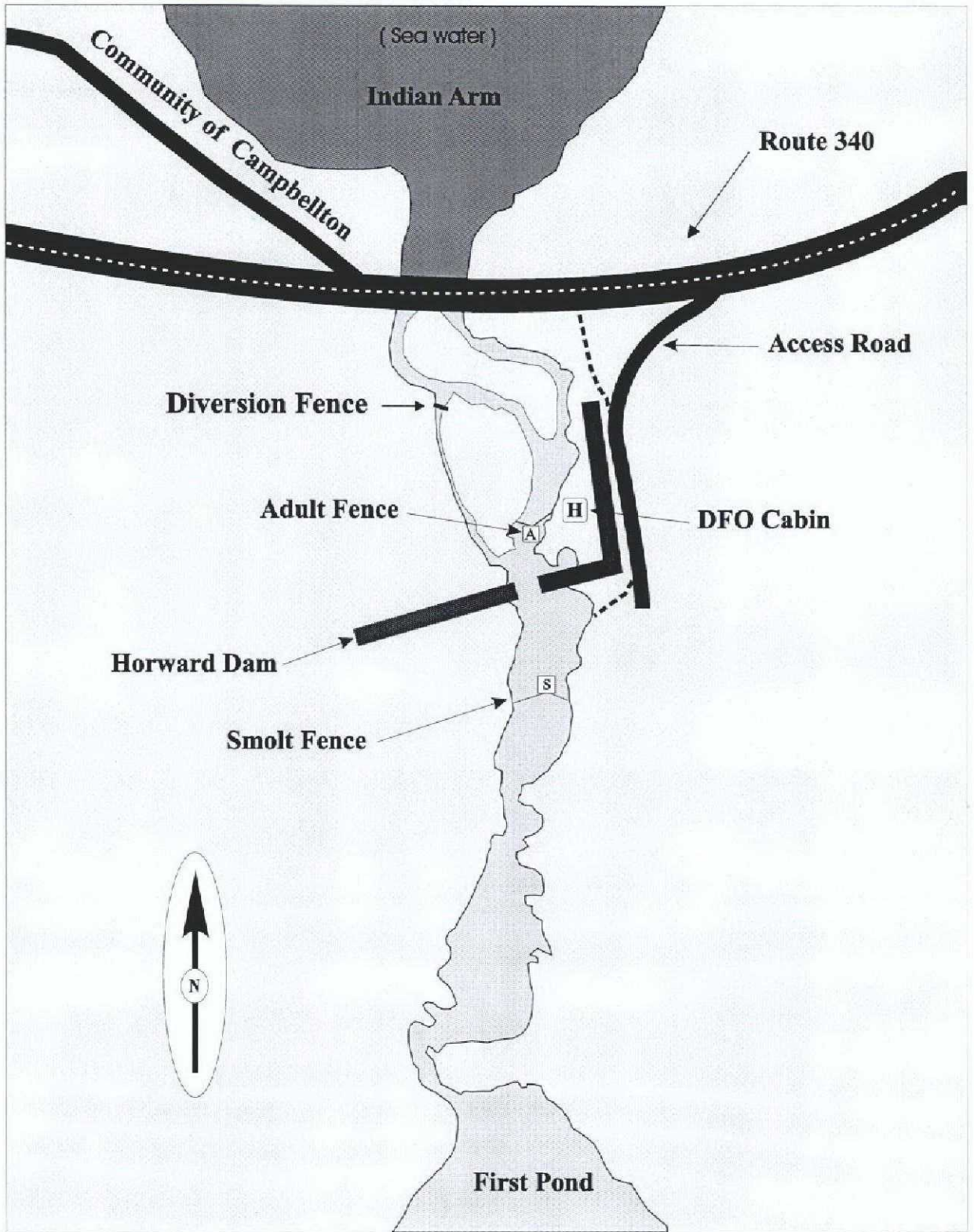


Figure 2. Campbellton River showing locations of Smolt and Adult Counting Fences.

Figure 3. Smolt run timing at the counting fence Campbellton River, 1993-96.

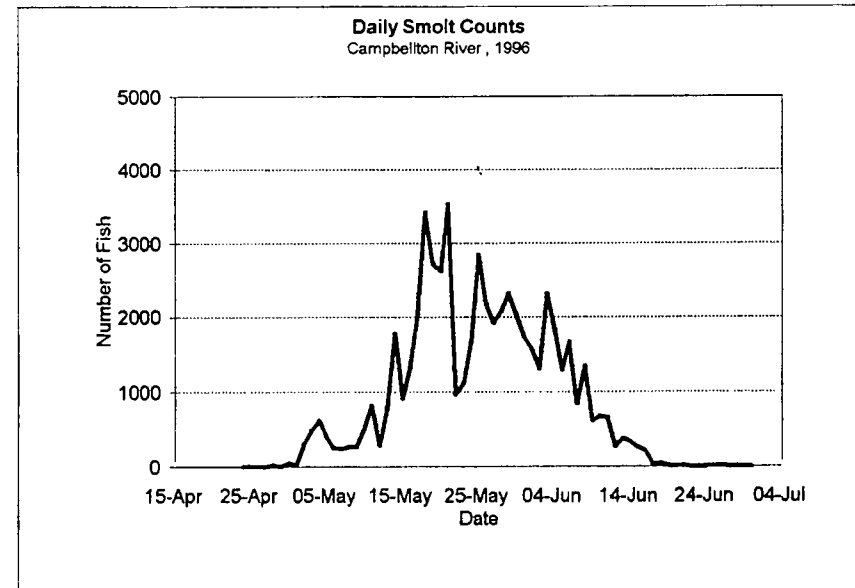
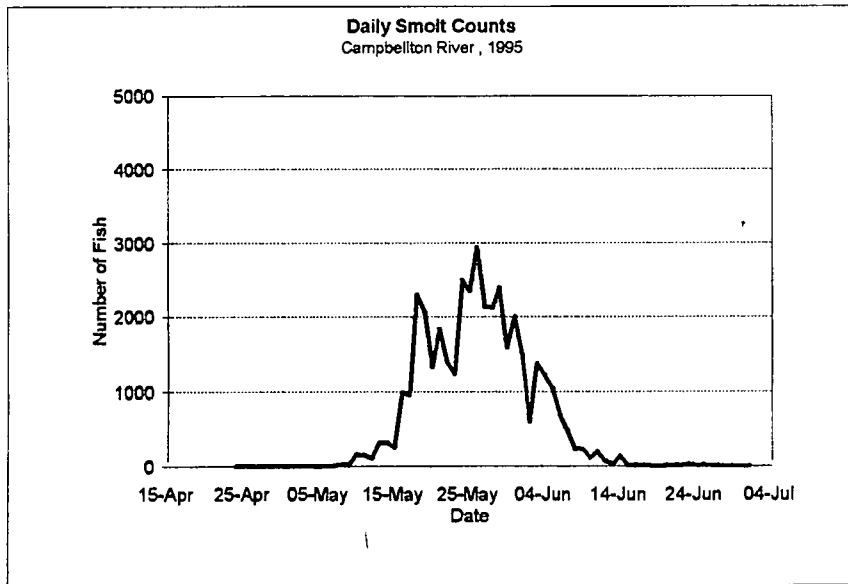
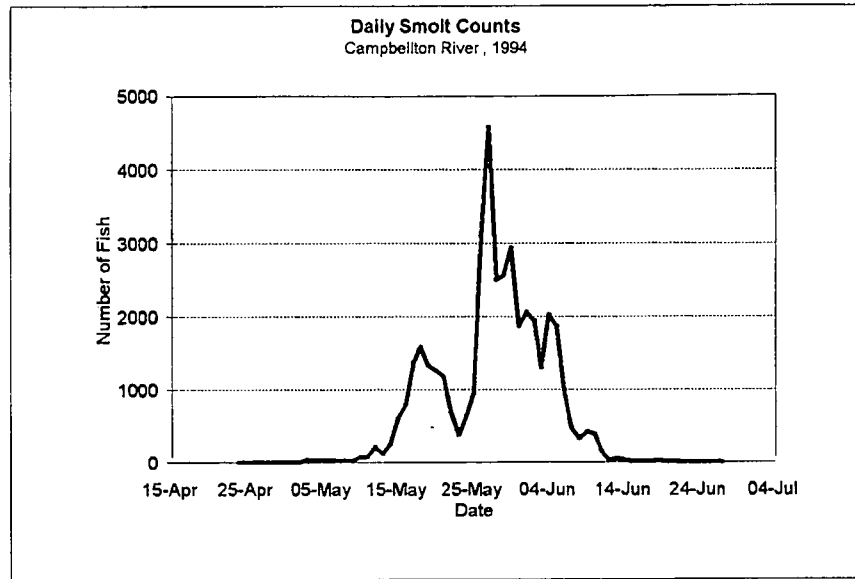
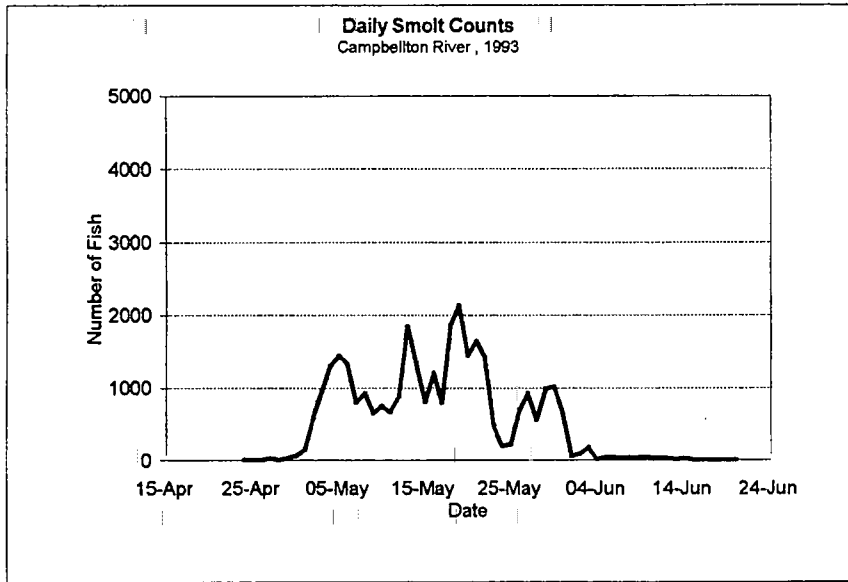
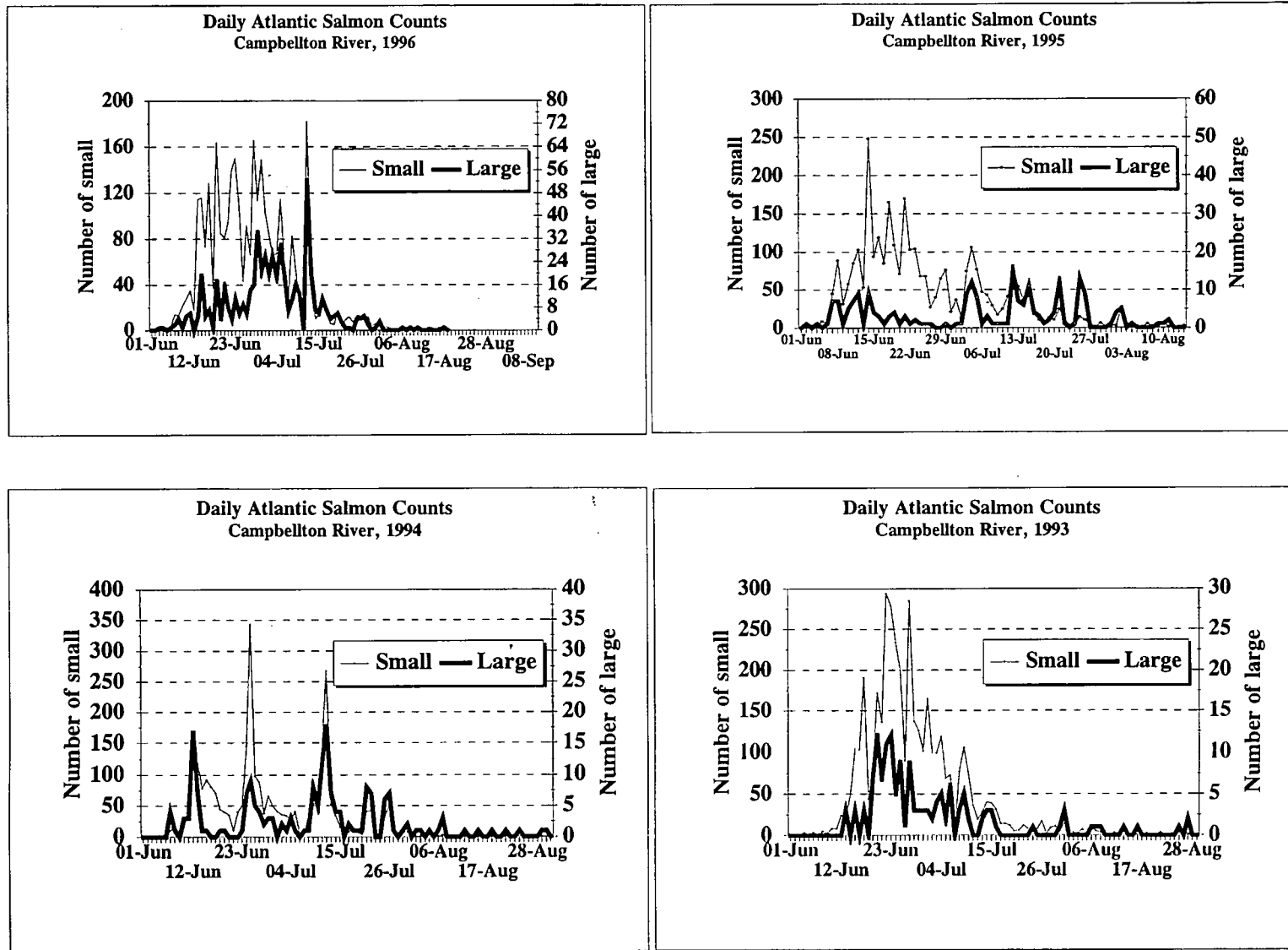


Fig. 4 Adult run timing at the counting fence on Campbellton River, 1993-96.



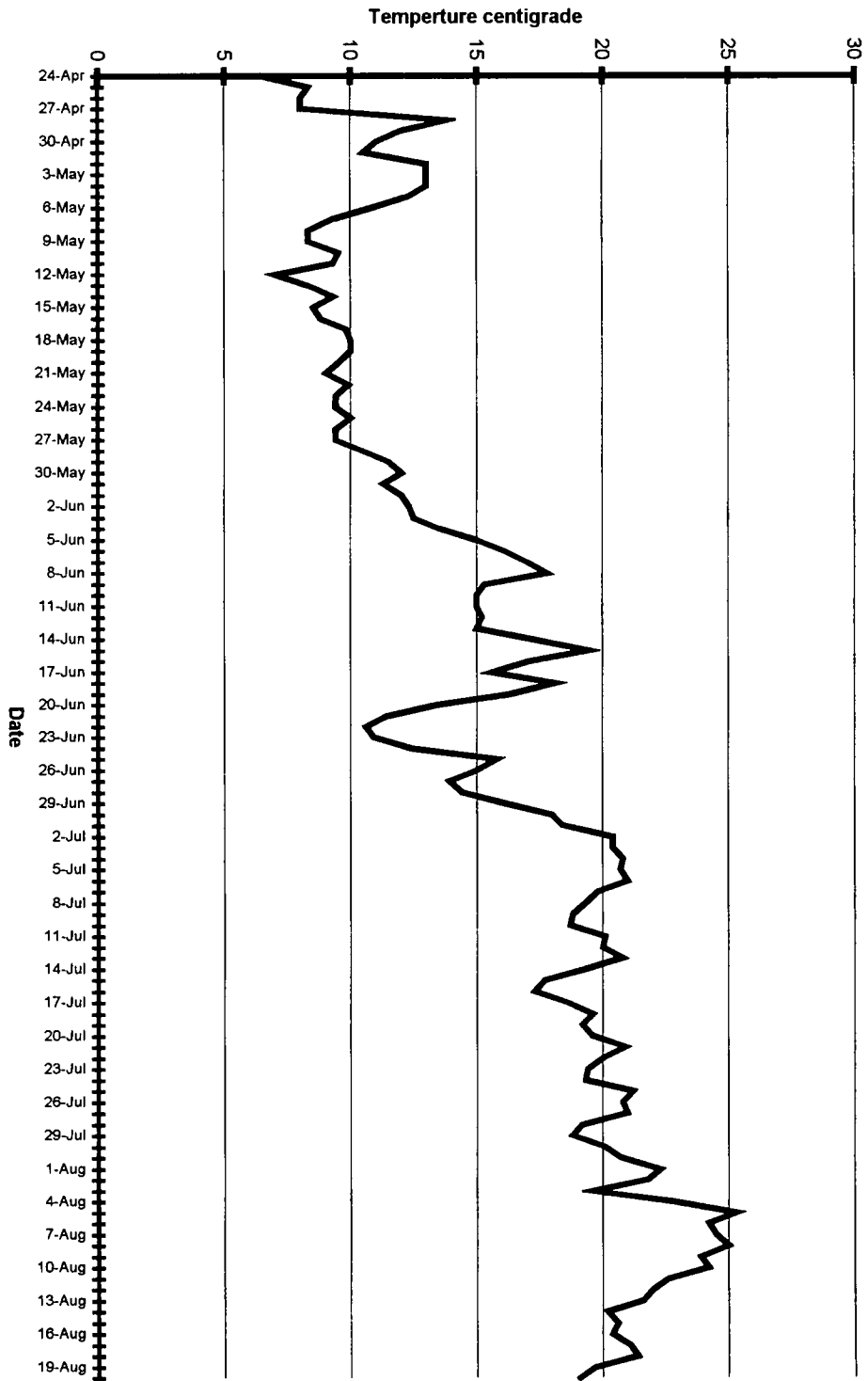


Figure 5. Mean daily water temperatures for Campbellton River, 1996.

## APPENDIX 1

**Sea survival rates for  
Campbellton River salmon**

**Sea survival rates for 93 smolt class**

Smolt count - 93	31,577
Adult count (small only) - 94	2,857
Sea survival rate - 93	$2,857 / 31,577 = 9.05\%$

**Previous spawners:**

Kelts (downstream) - 94	2,838
Tagged kelts (downstream) - 94	942
Ratio untagged:tagged (total)	$2,838 / 942 = 3.01$
Overwintering survival - 93/94	$2,838 / 4,146 = 68.5\%$

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

UPSTREAM MIGRANTS				
	Tagged	Est. previous spawners	Total '94	% previous spawners
Small	190	572	2,857	20.0
Large	51	154	191	80.6
Total	241	726	3,048	23.8

**Sea survival rates with correction for previous spawners:**

Smolt count - 93	31,577
Upstream grilse - 94	2,285 (2,857-572)
Corrected sea survival - 93	$2,285 / 31,577 = 7.2\%$
Previous spawners survival 3 mo	$726 / 2,838 = 25.6\%$

## APPENDIX 2

**Sea survival rates for  
Campbellton River salmon**

**Sea survival rates for 94 smolt class**

Smolt count - 94	41,663
Adult count (small only) - 95	3,035
Sea survival rate - 94	$3,035 / 41,663 = 7.28 \%$ (uncorrected)

**Previous spawners:**

Kelts (downstream) - 95	1,874
Tagged kelts (downstream) - 95	600 (448 from '95 & 152 from '94)
Ratio untagged:tagged (total)	$1,874 / 600 = 3.12$
Overwintering survival - 94/95	$1,874 / 3,048 = 61.5 \%$

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

UPSTREAM MIGRANTS				
	Tagged	Est. previous spawners	Total '95	% previous spawners
Small	160	500	3,035	16.5
Large	49	153	218	70.2
Total	209	653	3,253	20.1

**Sea survival rates with correction for previous spawners:**

Smolt count - 94	41,663
Upstream grilse - 95	2,535 (3,035-500)
Corrected sea survival - 94	$2,535 / 41,663 = 6.1 \%$
Previous spawners survival 3 mo	$653 / 1,874 = 34.9 \%$

## APPENDIX 3

**Sea survival rates for  
Campbellton River salmon**

**Sea survival rates for 95 smolt class**

Smolt count - 95	39,715
Adult count (small only) - 96	3,208
Sea survival rate - 95	$3,208 / 39,715 = 8.08 \%$ (uncorrected)

**Previous spawners:**

Kelts (downstream) - 96	1,971
Tagged kelts (downstream) - 96	584 (484 tagged in '96 & 100 from '94-95)
Ratio untagged:tagged (total)	$1,971 / 584 = 3.38$
Overwintering survival - 95/96	$1,971 / 3,253 = 60.6 \%$

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

UPSTREAM MIGRANTS				
	Tagged	Est. previous spawners	Total '96	% previous spawners
Small	109	368	3,208	11.5
Large	121	409	560	73.0
Total	230	777	3,768	20.6

**Sea survival rates with correction for previous spawners:**

Smolt count - 95	39,715
Upstream grilse - 96	2,840 (3,208-368)
Corrected sea survival - 95	$2,840 / 39,715 = 7.15 \%$
Previous spawners survival 3 mo	$777 / 1,971 = 39.4 \%$



## Appendix 4

**STOCK:** Campbellton River (SFA 4)**Drainage area:** 296 km<sup>2</sup> (accessible)**CONSERVATION REQUIREMENT:** 2.916 million eggs (~1480 small salmon) calculated as fluvial area x 2.4 eggs/m<sup>2</sup> and 368 eggs per hectare of pond habitat.

Year	1991	1992	1993	1994	1995	1996	MIN	MAX	MEAN
<b>Total returns:</b>									
Small	-	-	4001	2857	3035	3208	2857	4001	3275
Large	-	-	145	191	218	560	145	560	279
<b>Recreational harvest (small salmon)<sup>1</sup></b>									
Retained	126	311	316	340	393	463	23	1547	1824
Released	-	30	103	4	47	93	4	103	55
<b>Recreational harvest (large salmon)<sup>2</sup></b>									
Retained	0	0	0	0	0	0	0	0	0
Released	-	0	0	1	1	31	1	31	7
<b>Other mortalities</b>									
Small	0	0	0	0	0	0	0	0	0
Large	0	0	0	0	0	0	0	0	0
<b>Spawners:</b>									
Small	-	-	3675	2517	2637	2736	2517	3675	2891
Large	-	-	145	191	218	557	145	557	278
<b>Conservation requirement</b>									
% eggs met:			311	239	279	304	239	311	283
<b>Smolt count<sup>3</sup></b>			31577	41633	39715	58369	31577	58369	42831
<b>Sea survival<sup>4</sup></b>			7.2	6.1	7.2		6.1	7.2	6.8

<sup>1</sup> Min, max and mean recreational harvest for period 1974-96; other mean data for 1986-91 to coincide with the pre-moratorium period. Angling harvests are DFO statistics.

<sup>2</sup> Min., max. and mean for the period 1993-96.

<sup>3</sup> Sea survival of smolt to 1SW salmon returns. Min. and max. are for 1993-96 smolt migrations.

**Data and methodology:** Smolts were enumerated by a counting fence. Returning adult salmon are enumerated at a fishing counting fence with a video camera system. A hook-and-release mortality of 10% was used in the calculation of spawning escapements for the years 1993-96.

**State of the stock:** Target requirements were met from 1993 to 1996.

**Forecast:** Adult returns in 1997 from the smolt migration in 1996 should be approximately 4,000 fish plus repeat spawners at average 22% survival rate thus giving an upstream migration of 5,100 fish.