Angler Effort and Catch in Four Fraser River Chinook Salmon Sport Fisheries, 1994, and a Retrospective on Nine Years of Upper Fraser River Sport Fishery Management and Assessment

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ABSTRACT

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The retention of chinook salmon (*Oncorhynchus tshawytscha*) adults in Fraser River system sport fisheries was eliminated in 1980 in response to escapement declines. Since 1986, improved escapements permitted the reopening of sport fisheries for chinook adults in a number of Fraser River locations. In 1994, chinook fisheries were opened in the Bowron, Cariboo, Clearwater, lower Fraser, Quesnel, lower and middle Shuswap, North Thompson, South Thompson, Thompson and Vedder-Chilliwack rivers and Mabel Lake. The fisheries were regulated through harvest ceilings, time and area restrictions or daily and annual angler harvest limits. Fisheries in the lower and middle Shuswap and Thompson rivers and Mabel Lake were assessed in 1994. A total of 3,700 anglers were interviewed, and an estimated 42,837 angler hours were expended to harvest an estimated 1,624 chinook adults, 14 chinook jacks, 31 kokanee (*O.nerka*), 39 rainbow trout (*O. mykiss*), 2 Dolly Varden char (*Salvelinus malma*) and 19 squawfish (*Ptychocheilus oregonensis*); 225 of the chinook adults were marked with adipose fin clips. Estimated releases totalled 334 chinook adults, 6 chinook jacks, 3 coho adults (*O. kisutch*), 6 kokanee, 17 rainbow trout and 10 squawfish.

The report reviews nine years of chinook salmon sport fishery management in the upper Fraser River system, describes assessment methods, discusses case studies and concludes with recommendations for the management and assessment of future fisheries.

Key words: upper Fraser River, sport fisheries, chinook salmon, sockeye salmon angler effort, harvest, release.

RÉSUMÉ

Schubert, N.D. 1995. Angler effort and catch in four Fraser River chinook salmon sport fisheries, 1994, and a retrospective on nine years of upper Fraser River sport fishery management and assessment. Can. Manuscr. Rep. Fish. Aquat. Sci. 2275: 93 p.

Le déclin des échappées de saumon quinnat (*Oncorhynchus tshawytscha*) dans le bassin du Fraser a rendu nécessaire d'interdire aux pêcheurs sportifs de conserver les saumons adultes à partir de 1980. L'accroissement des échappées noté depuis 1986 a permis d'autoriser de nouveau les pêcheurs sportifs à conserver les adultes capturés en plusieurs endroits. En 1994, la pêche du quinnat était autorisée dans le bas-Fraser, les rivières Bowron, Cariboo, Clearwater, Quesnel, Lower et Middle Shuswap, North Thompson, South Thompson, Thompson et Vedder-Chilliwack et le lac Mabel. La pêche était régie par des maximums de capture, des restrictions portant sur le moment et l'endroit et des limites de catures quotidiennes et annuelles. Les pêches de la Lower et de la Middle Shuswap, de la Tompson et du lac Mabel ont été évaluées en 1994. Au total, 3 700 pêcheurs ont été interrogés et l'on a estimé que 42 837 heures-pêcheurs avaient été consacrées à la capture de 1 624 quinnats adultes, 14 jeunes quinnats mâles, 31 saumons kokani (*O. nerka*), 39 truites arc-en-ciel (*O. mykiss*), 2 ombles Dolly Varden (*Salvelinus malma*) et 19 sauvagesses du nord (*Ptychocheilus oregonensis*). Des quinnats adultes, 225 ont été marqués par coupe de la nageoire adipeuse. On estime que 334 quinnats adultes, 6 jeunes quinnats mâles, 3 saumons cohos (*O. kisutch*), 6 saumons kokanis, 17 truites arc-en-ciel et 10 sauvagesses du nord ont été remis à l'eau.

L'auteur donne un aperçu de neuf années de gestion de la pêche sportive en rivière du saumon quinnat dans le bassin du Fraser et conclut par des recommandations pour la gestion et l'évaluation des prochaines pêches.

Mots clés: Haut-Fraser, pêche sportive, saumon quinnat, effort de pêche, capture, remise à l'eau.

INTRODUCTION

Poor returns of chinook salmon (*Oncorhynchus tshawytscha*) to the Fraser River system led to the closure in 1980 of all river sport fisheries for chinook adults. Since then, returns have improved to an extent which permitted the reopening of sport fisheries in selected areas (Schubert 1988, 1989, 1990, 1992a, 1992b, 1995a, 1995b, 1995c; Schubert and Whyte 1992). In 1994, sport fisheries were opened in the Bowron, Cariboo, Clearwater, lower Fraser, Quesnel, lower and middle Shuswap, South Thompson, North Thompson, Thompson and Vedder-Chilliwack rivers (Fig. 1) and Mabel Lake. In Mabel Lake and three rivers, the lower and middle Shuswap and Thompson, structured studies monitored fishery performance, evaluated stock impacts and provided the data upon which future management decisions could be made.

This report describes the study design and field procedures and documents the results (angler effort, harvest and release by species) of the 1994 studies in the lower and middle Shuswap and Thompson rivers and Mabel Lake. The report reviews nine years of chinook salmon sport fishery management in the upper Fraser River system, describes assessment methods, discusses case studies and concludes with recommendations for the management and assessment of future fisheries.

STUDY AREA

SHUSWAP RIVER SYSTEM

The Shuswap River originates in the Monashee Mountains of south-central British Columbia and flows northwest for almost 200 km, entering Mara Lake east of Salmon Arm (Fig. 2). The system, which includes three major lakes, drains a watershed of approximately 5,000 km^2 and has a mean daily discharge of 88 $m^3 \cdot s^{-1}$ (1911-1979; Environment Canada 1980).

Sport fisheries were opened in the lower Shuswap River between the highway bridge at Mara (km 6) and Mabel Lake (km 70), in Mabel Lake north of a boundary sign located 4 km south of the lake outlet, and in the middle Shuswap River between Mabel Lake (km 90) and the Wilsey Dam (km 114) (Fig. 2). All of these fisheries were assessed in 1994.

Fishing effort in the lower Shuswap River is heaviest in the upper river and more scattered in the lower 30 km where the river is slower and deeper. Anglers access the river by road (Highway 97A or Mabel Lake Road) and boat. In many areas, access is restricted by private property or the distance from the road; consequently, angler effort is concentrated near road access points. Angling occurs 24-hours per day, with pronounced peaks in the early morning and evening. The lower Shuswap is the principle chinook stock harvested in this fishery.

Fishing effort in Mabel Lake is heaviest near the lake outlet. Fishing occurs entirely from boats, with most of the boats concentrated within 1 km from the lake outlet. Most of the boats enter the lake at boat launch ramps at the lake outlet and at the resort north of the outlet; a small number originate from cabins along the lake shore. Lower Shuswap chinook, which hold in the lake before dropping back into the river, are the principle stock harvested in this fishery.

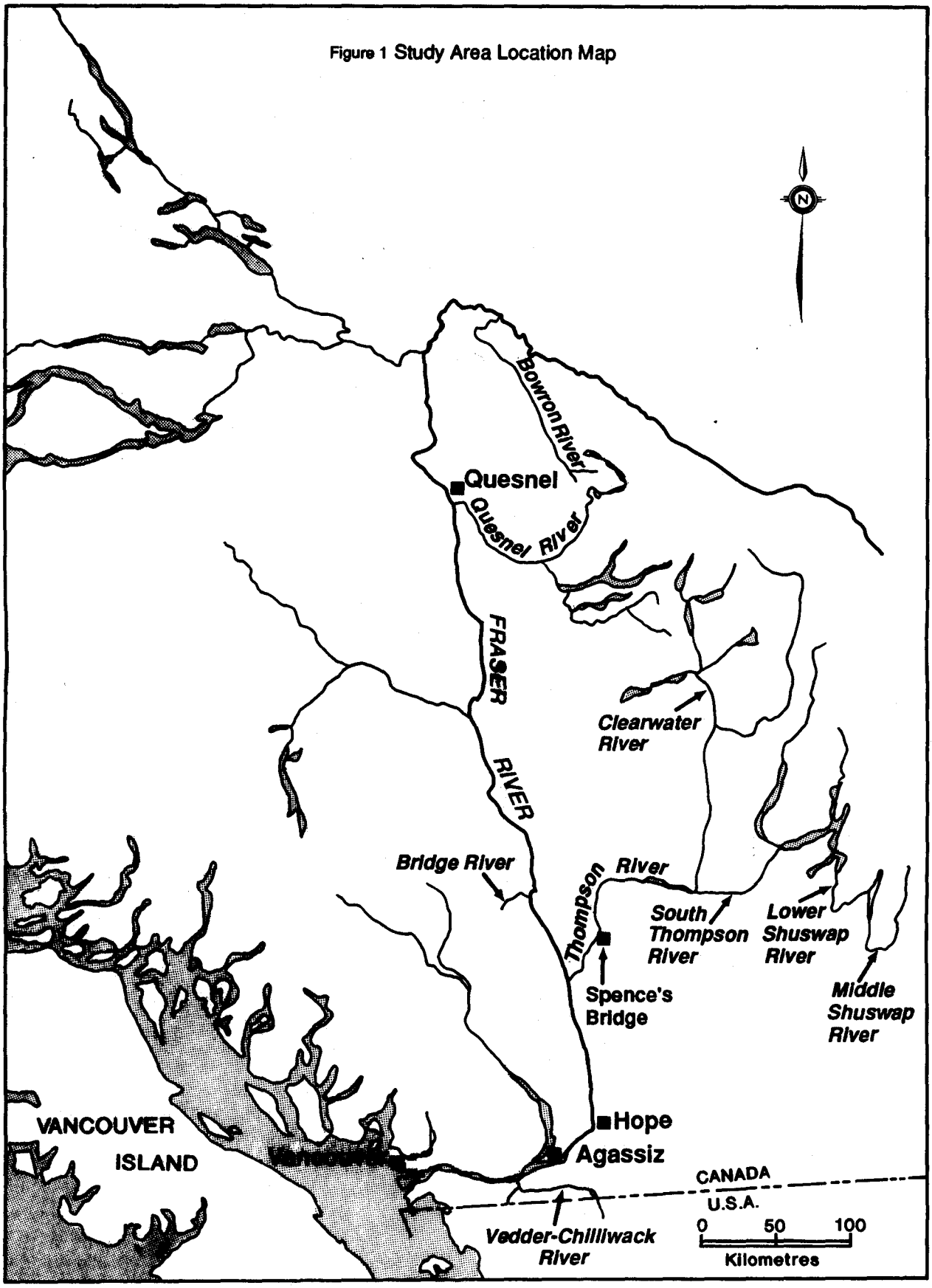
Fishing effort is also heavy in the upper part of the middle Shuswap River, where anglers access the fishery by road or boat. Anglers avoid the lower 13 km section where the gradient is low and the river meanders across the flood plain (Schubert 1988). Consequently, this section was excluded from the 1994 study. In the upper river, angler effort is concentrated near road access points where angling occurs 24-hours per day. Middle Shuswap chinook, the only stock harvested in this fishery, migrate to the river through the lower Shuswap River and Mabel Lake. Their migration is largely complete before the fisheries open in those areas.

THOMPSON RIVER

The Thompson River flows southwest from Kamloops Lake for 109 km, entering the Fraser River at Lytton (Fig. 3). The Thompson River receives the flows from the North and South Thompson rivers. With a mean daily discharge of 743 $m^3 \cdot s^{-1}$ (1911-1951; Environment Canada 1980), the Thompson is the largest river in the Fraser River system (Northcote and Larkin 1989).

The chinook fishery occurs at the Nicola River confluence and along the opposite shore. The entire fishery is accessible by road and is

Figure 1 Study Area Location Map



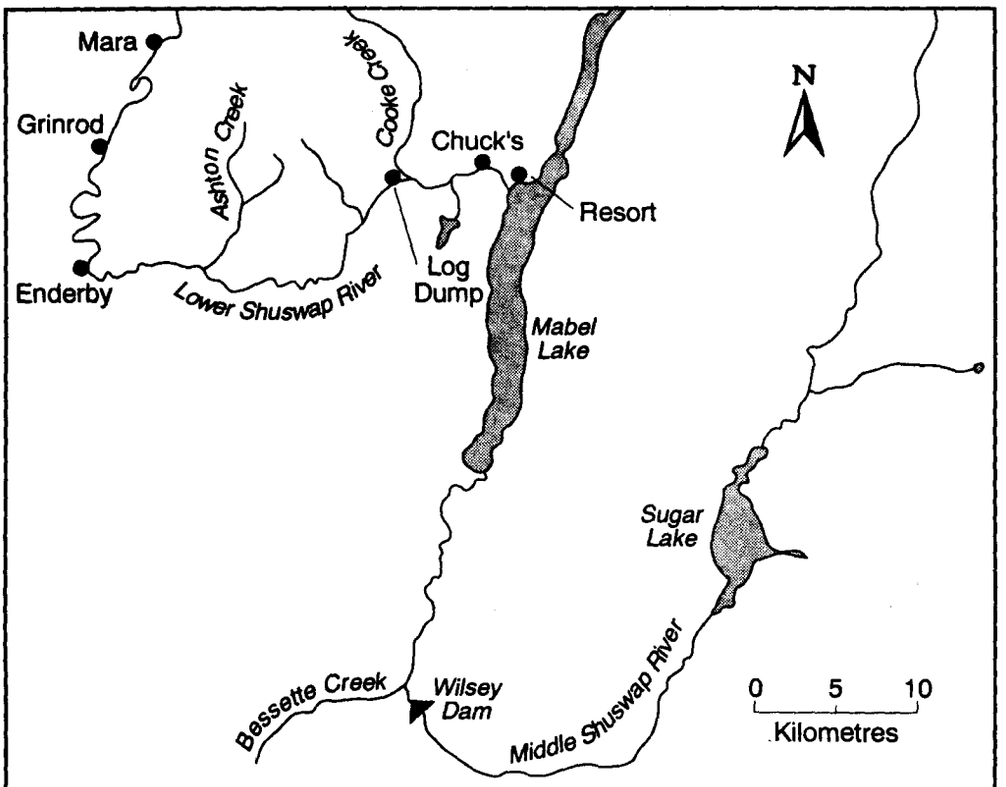


Figure 2. Shuswap River System sport fishery location map.

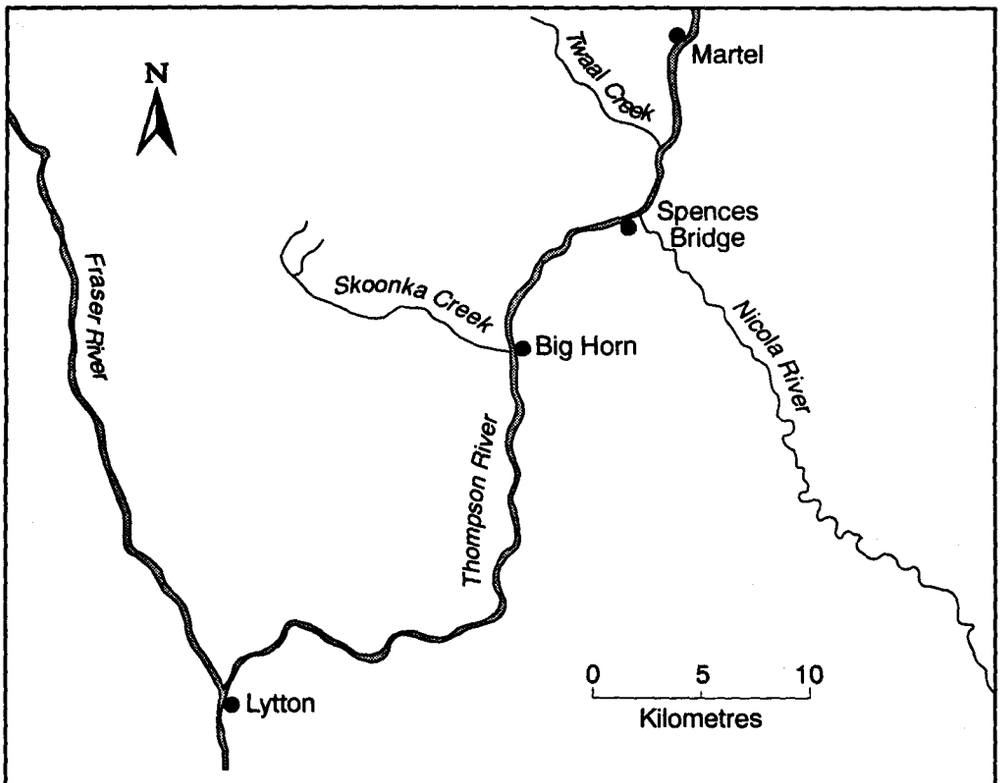


Figure 3. Thompson River sport fishery location map.

Table 1. Sport fishery regulations in the 1994 Fraser River study areas.

Location	Species	Open Period	Angler harvest limits: Daily	Angler harvest limits: Annual	Days open per week	Total days open	Harvest ceiling
Shuswap River, lower a	Chinook	15-Aug to 12-Sep b	2	10	7	28	500
Mabel Lake a	Chinook	15-Aug to 12-Sep b	2	10	7	28	200
Shuswap River, middle a	Chinook	25-Jul to 8-Aug b	2	10	7	14	none
Thompson River	Chinook	16-Jul to 15-Aug c	1	10	3	15	150

a. There is a monthly harvest limit of 6 chinook adults from the Shuswap River system.

b. Fishery opened and closed at noon.

c. Daily open time was 6 a.m. to 9 p.m.

visible from a single vantage point. Angling is restricted by regulation to 6 a.m. to 9 p.m. to permit a complete census of the fishery; angler effort generally peaks in the morning. Although a large number of chinook stocks migrate through the area, the Nicola is the principle stock harvested in this fishery.

FISHERY REGULATIONS

In general, the 1994 sport fisheries were managed through restrictions in fishing time, daily and annual angler harvest limits, fishery-specific harvest ceilings, and gear restrictions (single barbless hook) (Table 1). The 1994 study area regulations were identical to those in place in 1993 (Schubert 1995c).

METHODS

STUDY DESIGN

Lower Shuswap River

The lower Shuswap River chinook fishery was assessed, using a hybrid design, from August 15 to September 11, 1994. Three surveyors worked one of two eight hour shifts (5 a.m. to 1 p.m.; 1 p.m. to 9 p.m.) which encompassed all daylight hours and permitted the surveyors to contact the early morning anglers expected in this fishery. The study period was stratified into weekday and weekend/holiday day types, with weekly assessment of up to three of the former and all of the latter; 20 of the 28 open days were assessed.

Access point surveyors stationed at Chuck's and Log Dump pools (the areas of maximum expected angler effort) conducted hourly rod counts and exit interviews. The interviews recorded trip length (to time of interview and expected additional time), target species, number and species harvested or released, marks on harvested fish (fin or maxillary clip), gear type and annual chinook adult harvest to date. If the angler had fished the lower Shuswap River within two weeks, trip duration and harvest were recorded for the most recent trip. When possible, harvest was inspected to confirm species and mark identification. An interview form was completed for each angler; however, if the angler was unresponsive or if response reliability was questionable, the form was voided. At the end of each shift, all remaining anglers were interviewed.

The roving surveyor travelled a predetermined route by vehicle, with a randomly selected start point and direction of travel. The surveyor's rate of travel was standardized to ensure that a complete circuit encompassed 6.5 hours. Anglers were approached on foot and interviewed as above. In addition to the interviews, the surveyor counted all rods fishing in the study area during one of the two periods of expected daily effort maxima (beginning at 6:30 a.m. or 6:30 p.m., depending on the shift). Because the study area was large (70 km), the count required about 1.5 hours. No interviews were conducted during the rod count.

Mabel Lake

The Mabel Lake fishery was assessed, using an access point study design (DPA MS 1982),

from August 15 to September 11, 1994. Two surveyors worked one of two eight hour shifts (5 a.m. to 1 p.m.; 1 p.m. to 9 p.m.) which encompassed all daylight hours; 20 of the 28 open days were assessed.

Surveyors were stationed at boat launch ramps at the lake outlet and the resort, the two main access points to Mabel Lake. The survey procedures were similar to those described for the lower Shuswap River except the hourly boat counts, conducted by the surveyor at the resort, were considered complete counts for the entire fishery.

Middle Shuswap River

The middle Shuswap River chinook fishery was assessed, using a hybrid design (Schubert 1988), from July 25 to August 7, 1994. Two surveyors worked one of two eight hour shifts (5 a.m. to 1 p.m.; 1 p.m. to 9 p.m.) which encompassed all daylight hours; 10 of the 14 open days were assessed.

One surveyor was stationed at the Canyon Pool, the area of maximum expected angler effort, while a roving surveyor assessed the remaining areas by boat. Access point and roving survey procedures were similar to those described above, except the instantaneous rod count occurred daily at 7 a.m. or 7 p.m.

Thompson River

The Thompson River chinook fishery was assessed by complete census from July 16 to August 15, 1994. Surveyors, working the entire weekly open period (6 a.m. to 9 p.m., Saturday to Monday), were stationed at the Nicola River mouth and on the west bank opposite the Nicola River. Because the entire open area was within sight, a surveyor was able to contact anglers fishing at other sites before they left the river. Procedures were identical to the lower Shuswap River except instantaneous rod counts were not required and the harvest was sampled for size (nose-fork length and weight), flesh colour, sex, adipose fin status and scales.

DATA MANAGEMENT

Data storage and analysis were conducted on a microcomputer. A custom designed data entry program (DPA Group Inc. MS 1985b) generated ASCII files which were either imported into an analysis program (hybrid or access point studies) (DPA Group Inc. MS 1986) or a spreadsheet program (census) for analysis.

The data were verified in three steps. First, all field data sheets were examined for compliance with study procedures. Second, the data entry program performed 31 automatic error checks, including duplication detection, code validity, and range and consistency verification. Third, the ASCII data files were imported to a spreadsheet program for final verification with the field data sheets.

DATA ANALYSIS

Lower Shuswap River

Angler Effort: Angler effort profiles were generated from hourly rod counts at Chuck's and Log Dump pools, with effort outside the survey shifts reconstructed from the interview data. Mean sample day angler effort (hours) for each day type stratum was the ratio of the mean rod count and the proportion of daily effort occurring during the rod count time block. Total angler effort was the product of the mean daily angler effort and the number of days in the stratum. The mathematical relationships are reported below; variance calculations are detailed in Appendix 14.

1) Estimated total rods fishing ($\hat{R}_{hj}$), by hour and day type (weekday or weekend):

$$\hat{R}_{hj} = \sum_i N_h / n_{hij} \sum_k r_{hijk}$$

2) Estimated proportion of the daily angler effort occurring during the instantaneous rod count time block ($\bar{p}_{hj*}$), by day type:

$$\bar{P}_{hj*} = \frac{\hat{R}_{hj*}}{\sum_j \hat{R}_{hj}}$$

3) Estimated mean rod count during the instantaneous rod count time block ($\bar{y}_{hj*}$), by day type:

$$\bar{y}_{hj^*} = \sum_k \frac{y_{hj^*k}}{n_{hj^*}}$$

4) Estimated angler effort (E_h), by day type, in hours:

$$E_h = N_h \frac{\bar{y}_{hj^*}}{\bar{p}_{hj^*}}$$

5) Estimated study period angler effort (E), in hours:

$$E = \sum_h E_h$$

where:

N_h = total study period days of day type h (weekday or weekend);

n_{hij} = number of interview sample days on day type h at site i during hour j;

r_{hijk} = rod count on day type h at site i at hour j on day k;

$\hat{R}_{hj^*}$ = estimated total effort (hours) on day type h during the instantaneous rod count time block (j^*);

y_{hj^*k} = instantaneous rod count on day type h on day k;

n_{hj^*} = number of instantaneous rod counts on day type h.

Catch Per Unit Effort: CPUE was calculated by day type for each species and mark group using a total ratio estimator (Von Geldern, Jr. and Thomlinson 1973; Malvestuto 1983). Estimates were derived from interview data which was weighted to account for the hourly proportion of anglers leaving the site without an interview. CPUE was calculated separately for harvested (HPUE) and released (RPUE) fish; however, RPUE was not calculated by mark type because angler mark recognition was unreliable. The mathematical relationships are reported below.

6) Estimated study period catch to time of interview at the survey sites ($\hat{X}_h$), by day type:

$$\hat{X}_h = \sum_i \sum_l \frac{1}{a_{hil}} \sum_f \sum_q \sum_u \frac{x_{hilfqu}}{a_{hilfq}}$$

7) Estimated study period angler hours to time of interview at the survey sites ($\hat{T}_h$), by day type:

$$\hat{T}_h = \sum_i \sum_l \frac{1}{a_{hil}} \sum_f \sum_q \sum_u \frac{t_{hilfqu}}{a_{hilfq}}$$

8) Estimated catch per angler hour at the survey sites ($\bar{c}_h$), by day type:

$$\bar{c}_h = \frac{\hat{X}_h}{\hat{T}_h}$$

where:

a_{hil} = proportion of the study period stints of type l for site i on day type h which were surveyed;

a_{hilfq} = proportion of anglers leaving in time block q on stint f of stint type l at site i on day type h who were interviewed;

x_{hilfqu} = catch to time of interview by angler u leaving in time block q on stint f of stint type l at site i on day type h;

t_{hilfqu} = hours fished to time of interview by angler u leaving in time block q on stint f of stint type l at site i on day type h.

Before calculating CPUE, the raw interview data were tested for significant differences in CPUE between all interviews and complete trip interviews. The test used, from Cochran (1977), was:

9) Estimated variance of the difference between two ratios ($\mathrm{Var}(\bar{c}_c - \bar{c}_t)$:

$$Var(\bar{c}_c - \bar{c}_t) = Var(\bar{c}_c) + Var(\bar{c}_t)$$

where:

$\mathrm{Var}(\bar{c}_c)$ = variance of CPUE from complete trip interviews:

$$\frac{1}{n(n-1)\bar{t}^2}\left(\sum x_u^2 - 2\bar{c}_c \sum x_u t_u + \bar{c}_u^2 \sum t_u^2\right)$$

$\mathrm{Var}(\bar{c}_t)$ = variance of CPUE from all interviews, calculated as above.

$\bar{t}$ = mean time to interview.

If $(\bar{c}_c - \bar{c}_t) \pm$ (t-table, 0.95) $(\mathrm{Var}(\bar{c}_c - \bar{c}_t))$ did not

include zero, the difference was significant. In that case, incomplete trip interviews were excluded from the analysis for that site. If a significant difference in CPUE was noted between sites, then equations 6, 7 and 8 were replaced with the following:

10) Estimated total catch to time of interview ($\hat{X}_{hi}$), by site and day type:

$$\hat{X}_{hi} = \sum_{l} \frac{1}{a_{hil}} \sum_{f} \sum_{q} \sum_{u} \frac{x_{hilfqu}}{a_{hilfq}}$$

11) Estimated total angler hours to time of interview ($\hat{T}_{hi}$), by site and day type:

$$\hat{T}_{hi} = \sum_{l} \frac{1}{a_{hil}} \sum_{f} \sum_{q} \sum_{u} \frac{t_{hilfqu}}{a_{hilfq}}$$

12) Estimated catch per angler hour ($\bar{c}_{hi}$), by site and day type:

$$\bar{c}_{hi} = \frac{\hat{X}_{hi}}{\hat{T}_{hi}}$$

13) Estimated mean catch per angler hour at all sites (weighted by site angler effort) ($\bar{c}_{h}$), by day type:

$$\bar{c}_{h} = \frac{\sum_{i} \bar{c}_{hi} E_{hi}}{\sum_{i} E_{hi}}$$

where:

E_{hi} = $N \frac{\bar{y}_{hij*}}{\bar{P}_{hj*}}$

= estimated total angler effort at site i on day type h;

$\bar{y}_{hij*}$ = mean rod count at site i on day type h during the instantaneous rod count time block.

Harvest and Release: Study period harvest and release, estimated by species and mark group, was the sum of the weekday and weekend/holiday strata estimates. For each stratum, harvest and release was the product of stratum effort and the corresponding value of HPUE or RPUE.

14) Total study period catch (C):

$$C = \sum_{h} \bar{c}_{h} E_{h}$$

Harvest Rate: In all study areas, the harvest rate was the ratio of the estimated harvest and the sum of the estimated harvest and the observed escapement (from field staff). Harvest rates were not calculated for other species because total abundance was unknown.

Angler Characteristics: The following unweighed angler attributes were summarized by week: party size, mean angler day length (from complete trip, incomplete trip and all interviews), preferred species, gear type, mean angler day length and harvest on the angler's most recent trip, and chinook harvest to date. Study period mean angler day length, calculated from complete trip interviews, was estimated from site-specific data weighted by estimated angler effort.

Mabel Lake

The Mabel Lake data were analyzed using the procedures described for the lower Shuswap River. Angler effort was calculated from the profile observed from the resort and from the 8 a.m. angler effort (the product of the 8 a.m. boat count and the average number of anglers per boat). CPUE data were collected at the lake outlet and the resort.

Middle Shuswap River

The Middle Shuswap River data were analyzed using the procedures described for the lower Shuswap River. Angler effort was calculated from the profile observed at the Canyon Pool and from the instantaneous counts from the Canyon Pool and the roving survey. CPUE data were collected at all sites.

Thompson River

Thompson River angler effort, CPUE and catch were censused: angler effort and catch were summed from the interviews; and CPUE was the ratio of catch and effort. The mathematical relationships are reported below.

Table 2. Harvest, release and angler effort in the 1994 Fraser River study areas (95% confidence limits are in parentheses).

	Lower Shuswap River		Mabel Lake		Middle Shuswap River		Thompson River	
Number of Interviews	1,288	(-)	1,322	(-)	295	(-)	795	(-)
Angler effort (hour)	19,266	(15,794)	14,488	(4,645)	6,255	(14,918)	2,828	(-)
Percent interviewed a	22%	(-)	38%	(-)	14%	(-)	100%	(-)
Angler effort (day)	4,940	(-)	3,293	(-)	1,691	(-)	808	(-)
Harvest								
Chinook adult	639	(547) b	468	(227)	163	(367) c	354	(-) d
Chinook jack	12	(20)	2	(4)	-	(-)	-	(-)
Kokanee	-	(-)	31	(18)	-	(-)	-	(-)
Rainbow	5	(10)	34	(33)	-	(-)	-	(-)
Dolly Varden	-	(-)	2	(4)	-	(-)	-	(-)
Squawfish	19	(20)	-	(-)	-	(-)	-	(-)
Release								
Chinook adult	100	(102)	-	(-)	7	(33)	227	(-)
Chinook jack	-	(-)	6	(8)	-	(-)	-	(-)
Coho	-	(-)	3	(6)	-	(-)	-	(-)
Kokanee	-	(-)	6	(12)	-	(-)	-	(-)
Rainbow	5	(12)	12	(14)	-	(-)	-	(-)
Squawfish	10	(8)	-	(-)	-	(-)	-	(-)

a. Ratio of observed (from interviews) and estimated effort.
b. Includes 4 with an adipose fin clip.
c. Includes 12 with an adipose fin clip.
d. Includes 209 with an adipose fin clip.

15) Total angler effort (E), in hours:

$$E = \sum_i \sum_u t_{iu}$$

16) Total study period catch (C):

$$C = \sum_i \sum_u x_{iu}$$

17) Total catch per angler hour ($\bar{c}$):

$$\bar{c} = \frac{C}{E}$$

RESULTS

Study results for the four chinook sport fisheries are summarized in Tables 2, 3 and 5. Based on 3,700 interviews, 42,837 angler hours (10,731 angler days) were expended to harvest (release) 1,624 (334) chinook adults, 14 (6) chinook jacks, (3) coho adults (*Oncorhynchus kisutch),* 31 (6) kokanee (*O. nerka*) 39 (17) rainbow (*O. mykiss*), 2 Dolly Varden (*Salvelinus malma*) and 19 (10) squawfish (*Ptychocheilus oregonensis*). Chinook adult harvest rates ranged from 3.9% to 6.4%. The 1994 chinook fisheries were successful in attracting anglers primarily interested in harvesting chinook salmon. The average angler fished for approximately four hours per day using bait, lures or a combination of the two; few fished with flies. The average angler expended 8 to 38 hours to harvest one chinook adult.

LOWER SHUSWAP RIVER

Survey Effort

The 1994 study period, from August 15 to September 12, included 19 weekdays and 9

Table 3. Angler characteristics in the 1994 Fraser River study areas.

	Lower Shuswap River	Mabel Lake	Middle Shuswap River	Thompson River
Mean angler day length (hr)	3.9	4.4	3.7	3.5
Target species (%)				
Chinook	99.1%	87.9%	98.3%	99.5%
Rainbow	0.9%	1.2%	1.7%	0.1%
Trout	0.0%	0.0%	0.0%	0.4%
Anything	0.0%	11.0%	0.0%	0.0%
Gear (%)				
Bait	37.5%	0.2%	27.5%	91.4%
Lure	46.5%	98.7%	20.6%	5.4%
Baited lure	15.4%	0.7%	50.9%	3.1%
Fly	0.6%	0.4%	1.0%	0.1%

weekend or holiday days (August 15 and September 12 were half days only) of which 11 (58%) and 9 (100%), respectively, were sampled. Angler interviews totalled 1,288 (Table 2; Appendix 1), 83% of which were from five sites: Chuck's Pool (38%), Log Dump Pool (17%), Enderby Bridge (10%), Grinrod Bridge (9%) and Slide Pool (9%). Survey efficiency, defined as the percent of the total angler effort which was interviewed, was 22%.

Twenty rod counts were conducted in 1994 (Appendix 2). The rod counts did not include anglers who where not visible from the access points; however, most of the river was visible, and unattended boat trailers were counted to partially mitigate this factor. Morning and evening rod counts averaged 47 and 69 on weekdays and 67 and 102 on weekends. Angling occurred near road access points throughout the lower Shuswap River. On weekdays and weekends, respectively, 37% and 34% of the anglers were observed between Mabel Lake and the bottom of Skookumchuck Rapids, 16% and 17% between Fall and Cooke creeks and 14% and 18% between the Mara and Grinrod bridges. Few (less than 6%) angled between Cooke Creek and Skookumchuck (Appendix 2).

Angler Effort

Fishing effort was bimodal with peaks at 7 a.m. (9% of the daily effort) and 8 p.m. (7%) on weekdays, and 6 a.m. (8%) and 8 p.m. (8%) on weekends (Fig. 4; Appendix 3). Effort during the morning and afternoon rod count time blocks averaged 9% and 6% on weekdays and 8% and 8% on weekends.

Angler effort totalled 19,266 hours or 4,940 days (Table 2). Fifty-nine percent (11,277 hours) of the effort occurred on weekdays. Geographically, 22% of the effort occurred at Chuck's Pool, 12% at Log Dump Pool, 15% at Slide Pool, 9% at Grinrod Bridge, 5% at Enderby Bridge, and 37% in the remaining areas.

Catch Per Unit Effort

Chinook adult CPUE, expressed as fish per hour, was 0.0384; HPUE and RPUE were 0.0332 and 0.0052, respectively. Chinook adult HPUE estimated from complete trip (0.0392) and all (0.0314) interviews was not significantly different ($p > 0.05$); consequently, all interviews were used in the analysis. Chinook adult HPUE at the Log Dump Pool (0.0182) was significantly lower ($p < 0.05$) than at Chuck's Pool (0.0342) and in the roving survey (0.0341) (Appendix 4); therefore, CPUE was weighted by site-specific angler effort. Chinook adult HPUE was higher in September (0.0407) versus August (0.0229), and among anglers leaving the river in the morning (0.0462) versus the afternoon and evening (0.0235); both differences were significant ($p < 0.05$). HPUE was also higher among anglers us-

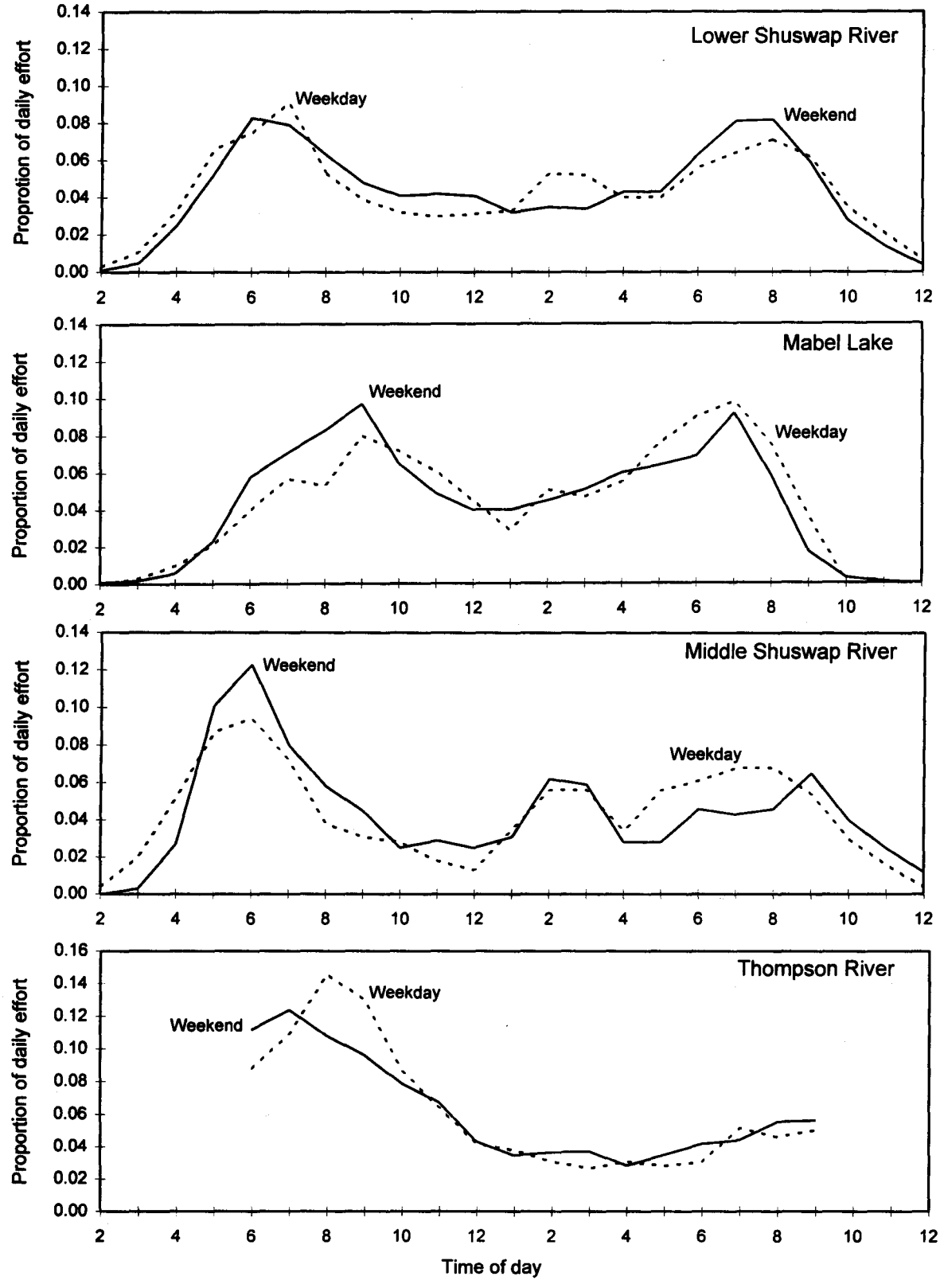


Fig. 4. Hourly angler effort profiles on weekdays and weekend days in the 1994 sport fisheries in the lower and middle Shuswap and Thompson rivers and Mabel Lake.

ing bait (0.0362) versus those using lures (0.0295) and baited lures (0.0262); however, the difference was not significant ($p > 0.05$).

Catch

Harvest (release) was estimated at 639 (100) chinook adults, 12 chinook jacks, 5 (5) rainbow, and 19 (10) squawfish (Table 2). Four (0.6%) of the harvested chinook adults had an adipose fin clip (AFC); none have yet been decoded.

Angler Characteristics

Angler trips ranged from 0.5 to 14.0 hours, averaging 3.9 hours (Table 3). Anglers attempted to harvest chinook (99%) or trout (1%). Lures were the most commonly used gear (47%), followed by bait (38%) and baited lures (15%); less than 1% used flies.

Seventy percent of the interviewed anglers had fished for chinook in the lower Shuswap River within two weeks of the interview (Appendix 1). Their estimated mean angler day length (5.1 hours) was longer than that estimated from direct interview; however, the chinook adult HPUE on the most recent trip (0.0388) was not significantly different ($p > 0.05$).

Weekly changes among anglers in the seasonal harvest of lower Shuswap River chinook adults are shown in Fig. 5. In the first week of the fishery, 87% of the anglers had not harvested a chinook adult, and only 2% had harvested more than two. By the last week of the fishery, the proportion of anglers who had not harvested a chinook adult had declined to 58%; 19% had harvested three or more.

MABEL LAKE

Survey Effort

The 1994 study period, from August 15 to September 12, included 19 weekdays and 9 weekend or holiday days (August 15 and September 12 were half days only), of which 11 (58%) and 9 (100%), respectively, were sampled. Angler interviews totalled 1,322 (Table 2; Appendix 5), 553 (42%) from the lake outlet and 769 (58%) from the resort. Survey efficiency was 38%.

Hourly rod counts were made from the resort during each survey shift. Rod counts at 9 a.m. and 7 p.m. averaged 34 and 45 on weekdays and 65 and 55 on weekends. Angling occurred almost exclusively within 1 km to 2 km of the lake outlet; however, a small proportion of the boats may not have been visible to the surveyor.

Angler Effort

Fishing effort was bimodal with peaks at 9 a.m. (8% of the daily effort) and 7 p.m. (10%) on weekdays, and 9 a.m. (10%) and 7 p.m. (9%) on weekends (Fig. 4; Appendix 3).

Angler effort totalled 14,488 hours or 3,293 days (Table 2), of which 56% (8,052 hours) occurred on weekdays.

Catch Per Unit Effort

Chinook adult CPUE was 0.0323; all landed chinook were harvested. Chinook adult HPUE estimated from complete trip (0.0312) and all (0.0305) interviews was not significantly different ($p > 0.05$); consequently, all interviews were used in the analysis. Chinook adult HPUE was significantly higher ($p < 0.05$) among anglers interviewed at the lake outlet (0.0406) versus those interviewed at the resort (0.0227) (Appendix 7), and among anglers leaving the river in the morning (0.0473) versus those leaving in the afternoon and evening (0.0206). CPUE for other species is provided in Appendix 7.

Catch

Harvest (release) was estimated at 468 chinook adults, 2 (6) chinook jacks, (3) coho, 31 (6) kokanee, 34 (12) rainbow and 2 Dolly Varden (Table 2). None of the harvested chinook adults had an AFC.

Angler Characteristics

Angler trips ranged from 0.5 to 12.0 hours, averaging 4.4 hours (Table 3). Anglers attempted to harvest chinook (88%), trout (1%), or anything (11%). Lures were the most commonly used gear (99%); less than 1% used each of bait, baited lures or flies (Table 3).

Seventy percent of the interviewed anglers had fished for chinook in Mabel Lake within two

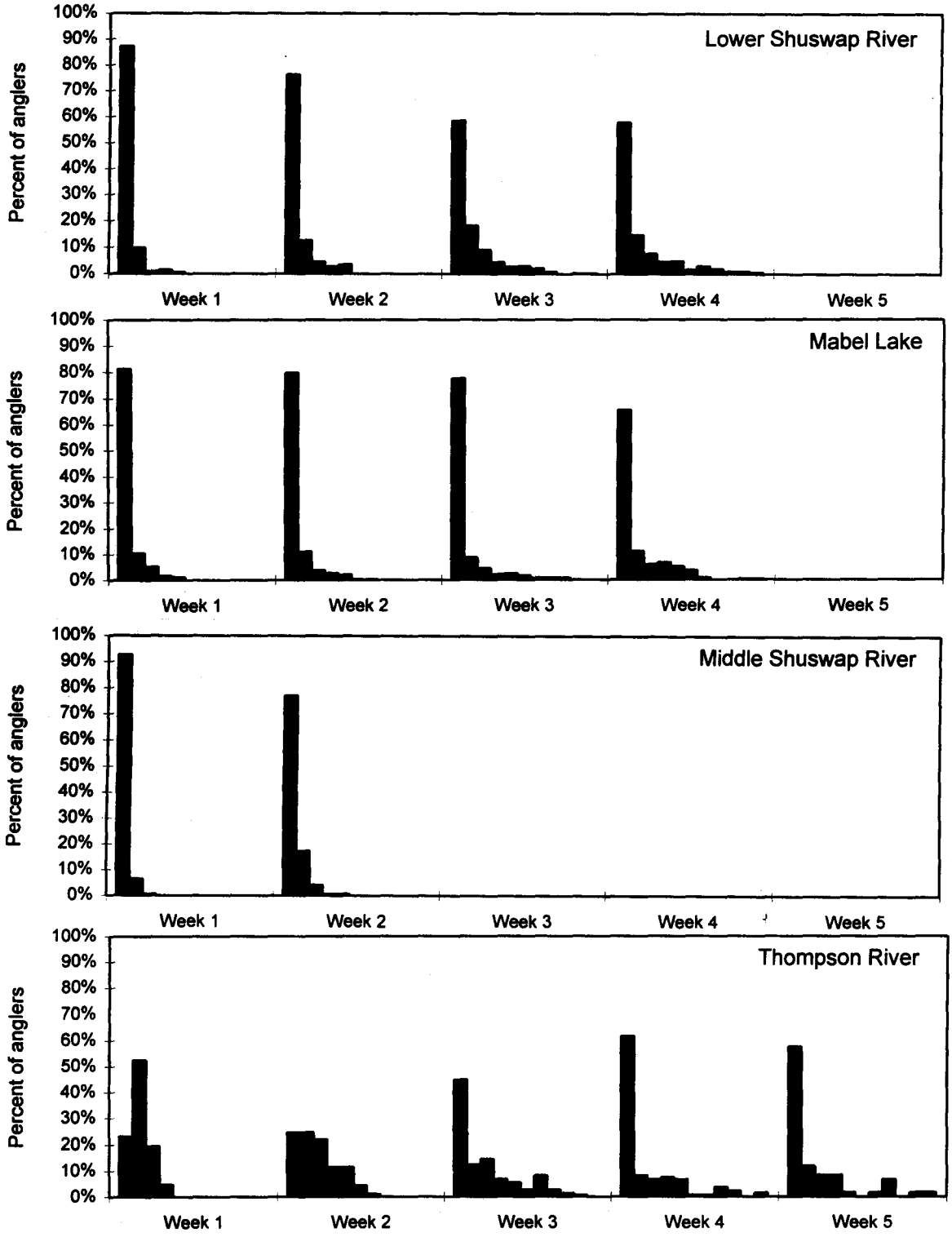


Fig. 5. Seasonal harvest of chinook adults among anglers interviewed in the 1994 sport fisheries in the lower and middle Shuswap and Thompson rivers and Mabel Lake. Data are aggregated by fishery week and show the percent of anglers who had harvested 0, 1, 2, ... 10 chinook adults in that fishery to that point in the year.

weeks of the interview (Appendix 5). Their estimated mean angler day length (4.9 hours) was slightly longer than that estimated from direct interviews, and the chinook adult HPUE (0.0047) on the most recent trip was significantly lower ($p < 0.05$).

Weekly changes among anglers in the seasonal harvest of Mabel Lake chinook are shown in Fig. 5. In the first week of the fishery, 81% of the anglers had not harvested a chinook adult, and only 3% had harvested more than two. By the last week of the fishery, the proportion of anglers who had not harvested a chinook adult declined to 66%, and 17% had harvested three or more.

MIDDLE SHUSWAP RIVER

Survey Effort

The 1994 study period, from July 25 to August 8, included 9 weekdays and 5 weekend or holiday days (July 25 and August 8 were half days only), of which 5 (56%) and 5 (100%), respectively, were sampled. Angler interviews totalled 295 (Table 2; Appendix 8), 141 (48%) from the Canyon Pool and 154 (52%) from the roving survey. Survey efficiency was 14%.

Ten rod counts were conducted in 1994 (Appendix 9). Morning and evening rod counts averaged 27 and 42 on weekdays and 30 and 19 on weekends. Angling occurred near road access points in the upper part of the river; the lower part of the river was not surveyed. About half of the anglers were observed between the canyon and the Iron Pin, below the Bessette Creek mouth. The balance were scattered over the remaining areas.

Angler Effort

Fishing effort peaked at 6 a.m. on weekdays (9% of the daily effort) and weekends (12%) (Fig. 4; Appendix 3); a second, smaller peak occurred in the evening. Effort during the morning and evening rod count time blocks averaged 7% and 7% on weekdays and 8% and 4% on weekends.

Angler effort totalled 6,255 hours or 1,691 days (Table 2). Sixty-six percent (4,134 hours) of the effort occurred on weekdays; 41% occurred at the Canyon Pool, and 59% in the remaining areas.

Catch Per Unit Effort

Chinook adult CPUE was 0.0272; HPUE and RPUE were 0.0261 and 0.0011, respectively. Chinook adult HPUE estimated from complete trip (0.0310) and all (0.0272) interviews was not significantly different ($p > 0.05$); consequently, all interviews were used in the analysis. Chinook adult HPUE at the Canyon Pool (0.0320) was higher than in the remaining areas (0.0199) (Appendix 10); however, the difference was not significant ($p > 0.05$). HPUE was slightly higher among anglers leaving the river in the morning (0.0274) versus those leaving in the afternoon and evening (0.0271), and among anglers fishing with bait (0.0372) versus those fishing with lures (0.0366) and baited lures (0.0202); however, the differences were not significant ($p > 0.05$).

Catch

Harvest (release) was estimated at 163 (7) chinook adults (Table 2). Twelve (7.4%) of the harvested chinook adults had an AFC; none have yet been decoded.

Angler Characteristics

Angler trips ranged from 0.5 to 12.0 hours, averaging 3.7 hours (Table 3). Anglers attempted to harvest chinook (98%) and rainbow (2%). Baited lures were the most commonly used gear (51%), followed by bait (28%) and lures (21%); 1% used flies (Table 3).

Fifty-one percent of the interviewed anglers had fished for chinook in the middle Shuswap River within two weeks of the interview (Appendix 8). Their estimated mean angler day length (4.6 hours) was longer than that estimated from direct interviews; however, the chinook adult HPUE (0.0398) on the most recent trip was not significantly different ($p > 0.05$) than that estimated from direct interviews.

Weekly changes among anglers in the seasonal harvest of middle Shuswap River chinook is shown in Fig. 5. In the first week of the fishery, 93% of the anglers had not harvested a chinook adult, and none had harvested more than two. By the last week of the fishery, the

proportion of anglers who had not harvested a chinook adult was 77%; only 1% had harvested three or more.

THOMPSON RIVER

Survey Effort

The 1994 study period, from July 16 to August 15, included 4 weekdays and 11 weekend or holiday days, all of which were censused. Angler interviews totalled 795 (Table 2; Appendix 11) of which 493 (62%) were from the east shore near the Nicola River mouth. Because the study was a complete census, survey efficiency was 100%.

Hourly rod counts were made on the east and west shores for the entire duration of the fishery. Rod counts at the daily peak averaged 21 (8 a.m.) on weekdays and 39 (7 a.m.) on weekends. Angling occurred almost exclusively at the Nicola River mouth and along the opposite shore.

Angler Effort

The 1994 fishery was restricted by regulation to 6 a.m. and 9 p.m. Within that period, fishing effort peaked at 8 a.m. (15% of the daily effort) on weekdays and 7 a.m. (12%) on weekends (Fig. 4; Appendix 3). Daily angling effort then declined for most of the day, with a slight increase in effort beginning at 5 p.m. Effort patterns were similar between sites and day types, although the proportion of daily effort which occurred in the morning was larger on weekdays than on weekends.

Angler effort totalled 2,828 hours or 808 days (Table 2); 63% (1,787 hours) occurred near the Nicola River mouth and 84% (2,382 hours) occurred on weekends. Study period effort peaked during the week ending July 18 (34% of the study period total) and remained at about 20% in each of the next three weeks. Effort in the last week of the fishery was low (7%).

Catch Per Unit Effort

Chinook adult CPUE was 0.2054; HPUE and RPUE were 0.1252 and 0.0803, respectively. Chinook adult HPUE on the east shore (Nicola River) (0.1354) was higher than on the west shore (0.1076) (Appendix 12). Chinook adult HPUE declined between July (0.1671) and August (0.0338), with the highest HPUE recorded in the weeks ending July 18 (0.1883) and July 25 (0.1764). HPUE was higher among anglers leaving the river in the morning (0.2051) than those leaving in the afternoon and evening (0.0655). The latter demonstrates the poor success among anglers who fished long trips or fished exclusively in the afternoon or evening. There was little difference in HPUE among anglers using bait (0.1223), lures (0.1518) and baited lures (0.1000).

Catch

Harvest (release) totalled 354 (227) chinook adults (Table 2). Two hundred and nine (59.0%) of the adults had an AFC. This high proportion reflected the regulatory change to a marked fish only fishery implemented on July 23.

About 94% of the chinook adults were harvested in July and 68% (242) were landed on the east shore (Appendix 11). Peak harvest (182 chinook adults) occurred during the week ending July 18. Most (70%) of the harvested adults were landed before noon.

The 1994 harvest consisted of red (94.9%) and white (5.1%) fleshed chinook; 32.2% were male and 67.8% were female (Appendix 13). Size averaged 71.1 cm nose-fork length and 4.0 kg. The harvest consisted of ages 5_2 (2%), 4_2 (74%), 4_1 (4%), 3_2 (less than 1%) and 3_1 (19%); females had higher proportion of age 4_2. Heads were recovered from most of the fish with an AFC; however, recovery data are currently unavailable.

Angler Characteristics

Angler trips ranged from 0.5 to 16.0 hours, averaging 3.5 hours (Table 3). Anglers were attempting almost exclusively to harvest chinook salmon (99.5%); less than 1% fished for trout. Bait was the most commonly used gear (91%), followed by lures (5%) and baited lures (3%); less than 1% used flies.

Fifty-nine percent of the interviewed anglers had fished for chinook in the Thompson River within two weeks of the interview (Appendix 11). Their estimated mean angler day length (7.0 hours) was considerably longer than that

estimated from direct interviews, and the chinook adult HPUE on the most recent trip (0.0652) was considerably lower than that estimated by direct interview.

Weekly changes among anglers in the seasonal harvest of Thompson River chinook are shown in Fig. 5. In the first week of the fishery, only 23% of the anglers had not harvested a chinook adult, and 5% had harvested more than two. By the last week of the fishery, the proportion of anglers who had not harvested a chinook adult increased to 58%; 22% had harvested three or more.

DISCUSSION

Other reports in this series concluded with a discussion which was specific to the results of studies conducted in that year. In contrast, this report provides a broader discussion of nine years of management and assessment of the chinook sport fisheries in the upper Fraser River system. The discussion draws on data reported by Schubert (1988, 1989, 1990, 1992a, 1995a, 1995b, 1995c) and Schubert and Whyte (1992), and from unpublished sources. It is structured in four sections. The first section reviews the 1986 criteria by which stocks and locations were selected for new fisheries. This section also evaluates how well those criteria have been addressed since 1986. The second section provides a brief overview of nine years of management practices in the upper Fraser River fisheries. The third section reviews fishery assessment practices, including a description of the main study design types and how they were selected for the 37 creel surveys conducted in 1986-1994. Also discussed are insights gained into specific attributes of these fisheries. The fourth section provides case studies of the four largest and most intensively assessed fisheries, in the lower and middle Shuswap and Thompson rivers and Mabel Lake.

CRITERIA FOR OPENING A FISHERY

To place into context a discussion of the Fraser River sport fishery policy developed in 1986, it is important to understand the management actions implemented during the previous thirty years in response to chinook conservation concerns. Chinook abundance in the terminal area declined from 1951 to the late 1970's (Fraser *et al.* 1982) causing a progressive reduction in fishing time in the Fraser River. Reductions in the commercial gill net and Indian fisheries began in the 1950's and 1977, respectively, resulting in a gradual increase in escapements (Farwell *et al.* 1987) despite a decline in the return to the river. From 1977 to 1980, however, the chinook return declined by almost 50% and, more significantly, escapements declined by about 10%. This led in 1980 to the implementation of management and enhancement actions intended to increase chinook escapements. The spring commercial gill net and all chinook adult sport fisheries were closed, and fishing time was progressively reduced in the spring Indian fishery. At the same time, chinook enhancement began in the upper Fraser River system, initially through the construction of the Quesnel River Hatchery and later through hatcheries on the Nicola, Clearwater, Eagle and middle Shuswap rivers. In 1985, the management plan for the river fisheries was complimented by actions in the marine fisheries implemented under the Pacific Salmon Treaty (Anon. 1985). The treaty process developed marine fishery harvest ceilings which were intended to reduce brood year exploitation rates by 15 percentage points, and established an evaluation framework which measured rebuilding performance against interim escapement goals provided by the national agencies.

The escapement of most Fraser River chinook stocks increased sharply between 1980 and 1986. This led to pressure to reopen the sport fisheries from representatives of several angler organizations who felt their groups had borne a disproportionate share of the conservation burden. Consequently, the Fraser River Division developed a policy under which four criteria must be met before a fishery would open. These criteria are described below and are evaluated relative to how successfully each was addressed in 1986-1994. Much of the source data for this discussion is presented in Tables 4-5 and in Appendix 15.

Rebuilding Criterion

The rebuilding criterion linked fishery openings to a stock's rebuilding response by restricting fisheries to areas where single stocks were rebuilding ahead of schedule (Anon. 1986a). Although a rebuilding schedule was not defined, this

Table 4. Annual regulations, including open period, angler harvest limits, days open per week, total days open and annual harvest ceilings, in the 1986-1994 upper Fraser River chinook sport fisheries.

Location	Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
			Daily	Monthly a	Annual			
Bowron River	1986	15-Jul to 15-Aug	1	none	10	2	10	300
	1987	25-Jul to 09-Aug	1	none	10	7	16	300
	1988	23-Jul to 07-Aug	2	none	10	7	16	300
	1989	22-Jul to 06-Aug	2	none	10	7	16	300
	1990	21-Jul to 05-Aug	2	none	10	7	16	300
	1991	20-Jul to 12-Aug	2	none	10	7	24	300
	1992	20-Jul to 15-Aug	2	none	10	7	27	300
	1993	20-Jul to 15-Aug	2	none	10	7	27	300
	1994	20-Jul to 15-Aug	2	none	10	7	27	300
Bridge River	1987	12-May to 31-Jul b	1	none	10	1-2	15	300
	1988	24-May to 26-Jul c	1	none	10	1	1	300
Cariboo River	1992	03-Aug to 07-Aug	2	none	10	7	5	none
	1993	02-Aug to 08-Aug	2	none	10	7	7	none
	1994	01-Aug to 07-Aug	2	none	10	7	7	none
Clearwater River	1986	15-Jul to 15-Aug	1	none	10	2	10	300
	1987	31-Jul to 30-Aug	1	none	10	3	15	300
	1988	05-Aug to 04-Sep	2	none	10	3	15	300
	1989	04-Aug to 03-Sep	2	none	10	3	15	300
	1990	03-Aug to 02-Sep	2	none	10	3	15	300
	1991	02-Aug to 01-Sep	2	6	10	3	15	300
	1992	01-Aug to 31-Aug	2	6	10	7	31	300
	1993	01-Aug to 31-Aug	2	6	10	7	31	300
	1994	01-Aug to 31-Aug	2	6	10	7	31	300
Mabel Lake	1990	29-Aug to 08-Sep d	2	none	10	7	10	100
	1991	29-Aug to 12-Sep d	2	6	10	7	10	200
	1992	15-Aug to 12-Sep d	2	6	10	7	28	200
	1993	15-Aug to 12-Sep d	2	6	10	7	28	200
	1994	15-Aug to 12-Sep d	2	6	10	7	28	200
North Thompson River	1992	01-Aug to 07-Aug	2	6	10	7	7	e
	1993	01-Aug to 14-Aug	2	6	10	7	14	e
	1994	01-Aug to 31-Aug	2	6	10	7	31	e
Quesnel River, Lower	1987	14-Jul to 15-Aug	1	none	10	2	10	200
	1988	16-Jul to 16-Aug	2	none	10	2	10	200
	1989	04-Aug to 10-Sep	2	none	10	3	18	200
	1990	03-Aug to 09-Sep	2	none	10	3	18	200
	1991	02-Aug to 08-Sep	2	none	10	3	18	200
	1992	17-Jul to 06-Sep	2	none	10	3	24	200
	1993	16-Jul to 05-Sep	2	none	10	3	24	200
	1994	15-Jul to 04-Sep	2	none	10	3	24	200

a. Monthly limits are specific to the North Thompson (N. Thompson and Clearwater), South Thompson and Shuswap (lower and middle Shuswap rivers and Mabel Lake) systems.

b. Twelve hour daily openings.

c. The fishery cancelled after one day due to a user group conflict.

d. Fishery opened and closed at noon.

e. Included in the Clearwater River ceiling.

Table 4. Annual regulations, including open period, angler harvest limits, days open per week, total days open and annual harvest ceilings, in the 1986-1994 upper Fraser River chinook sport fisheries, continued.

Location	Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
			Daily	Monthly a	Annual			
Quesnel River, Upper	1986	01-Aug to 29-Aug	1	none	10	2	9	200
	1987	04-Aug to 08-Sep	1	none	10	2	11	200
	1988	06-Aug to 10-Sep	2	none	10	2	11	200
	1989	04-Aug to 10-Sep	2	none	10	2	12	200
	1990	04-Aug to 09-Sep	2	none	10	2	12	200
	1991	02-Aug to 08-Sep	2	none	10	3	18	200
	1992	16-Aug to 06-Sep	2	none	10	7	22	200
	1993	16-Aug to 06-Sep	2	none	10	7	22	200
	1994	16-Aug to 05-Sep	2	none	10	7	21	200
Shuswap River, Lower	1986	29-Jul to 08-Aug	1	none	10	2	4	50
	1986	09-Sep to 23-Sep	1	none	10	2	5	450
	1987	01-Sep to 22-Sep	1	none	10	2	7	500
	1988	24-Aug to 07-Sep b	2	none	10	7	14	500
	1989	16-Aug to 06-Sep b	2	none	10	7	21	500
	1990	15-Aug to 12-Sep b	2	none	10	7	28	500
	1991	15-Aug to 12-Sep b	2	6	10	7	28	500
	1992	15-Aug to 12-Sep b	2	6	10	7	28	500
	1993	15-Aug to 12-Sep b	2	6	10	7	28	500
	1994	15-Aug to 12-Sep b	2	6	10	7	28	500
Shuswap River, Middle	1986	29-Jul to 08-Aug	1	none	10	2	4	g
	1991	01-Aug to 08-Aug b	2	6	10	7	7	100
	1992	25-Jul to 08-Aug b	2	6	10	7	14	none
	1993	25-Jul to 08-Aug b	2	6	10	7	14	none
	1994	25-Jul to 08-Aug b	2	6	10	7	14	none
South Thompson River	1987	11-Sep to 25-Sep	1	none	10	2	5	200
	1988	07-Sep to 16-Sep b	2	none	10	7	9	200
	1989	30-Aug to 13-Sep b	2	none	10	7	14	200
	1990	29-Aug to 19-Sep b	2	none	10	7	21	300
	1991	29-Aug to 26-Sep b	2	6	10	7	28	300
	1992	29-Aug to 26-Sep b	2	6	10	7	28	300
	1993	29-Aug to 26-Sep b	2	6	10	7	28	300
	1994	29-Aug to 26-Sep b	2	6	10	7	28	300
Thompson River	1988	22-Jul to 26-Aug c	1	none	10	1	6	150
	1989	08-Jul to 27-Aug d	1	none	10	1-2	12	100
	1990	23-Jun to 03-Sep e	1	none	10	3	33	300
	1991	13-Jul to 19-Aug e	1	none	10	3	18	150
	1992	18-Jul to 17-Aug e,f	1	none	10	3	15	150
	1993	17-Jul to 16-Aug e	1	none	10	3	15	150
	1994	16-Jul to 15-Aug e	1	none	10	3	15	150

a. Monthly limits are specific to the North Thompson (N. Thompson and Clearwater), South Thompson and Shuswap (lower and middle Shuswap rivers and Mabel Lake) systems.

b. Fishery opened and closed at noon.

c. Open between 8 a.m. and 8 p.m. daily.

d. Initially open 6 a.m. to 2 p.m. daily, but was extended to 6 a.m. to 9 p.m. after July 30.

e. Open between 6 a.m. and 9 p.m. daily.

f. Open upstream to Martel.

g. Included in the lower Shuswap River ceiling.

Table 5. Annual survey techniques, angler effort, chinook adult harvest and escapement, harvest rate, catchability and harvest per unit effort (HPUE) in the 1986-1994 upper Fraser River chinook sport fisheries.

Fishery	Year	Estimation technique	No. of angler interview	Angler effort (hour)	Chinook adult harvest	Chinook adult escapement	Catchability coefficient (x 10^-6)	Harvest rate (%)	Mean HPUE
Bowron River	1986	Hybrid	411	3,179	13	9,465	0.43	0.1%	0.0041
	1987	Hybrid	407	4,769	121	10,900	2.30	1.1%	0.0254
	1988	Hybrid	444	5,804	105	5,908	3.01	1.7%	0.0181
	1989	a	n/a	n/a	150	6,000	n/a	2.4%	n/a
	1990	a	n/a	n/a	100	6,500	n/a	1.5%	n/a
	1991	a	n/a	n/a	75	4,200	n/a	1.8%	n/a
	1992	a	n/a	n/a	200	4,670	n/a	4.1%	n/a
	1993	a	n/a	n/a	200	6,140	n/a	3.2%	n/a
	1994	a	n/a	n/a	450	9,104	n/a	4.7%	n/a
Bridge River	1987	Census	887	2,671	115	65,344	0.66	0.2%	0.0431
	1988 b	Census	45	148	11	59,877	1.25	0.0%	0.0746
Cariboo River	1992	a	n/a	n/a	50	1,000	n/a	4.8%	n/a
	1993	a	n/a	n/a	20	2,480	n/a	0.8%	n/a
	1994	Roving	6	c	0	2,500	n/a	0.0%	n/a
Clearwater River	1986	Roving	84	626	3	5,500	0.87	0.1%	0.0048
	1987	a	n/a	n/a	80	3,000	n/a	2.6%	n/a
	1988	a	n/a	n/a	240	6,300	n/a	3.7%	n/a
	1989	a	n/a	n/a	225	2,200	n/a	9.3%	n/a
	1990	a	n/a	n/a	308	7,320	n/a	4.0%	n/a
	1991	a	n/a	n/a	91	2,219	n/a	3.9%	n/a
	1992	a	n/a	n/a	141	2,370	n/a	5.6%	n/a
	1993	a	n/a	n/a	87	2,700	n/a	3.1%	n/a
	1994	a	n/a	n/a	232	5,450	n/a	4.1%	n/a
Mabel Lake	1990	Overflight	n/a	8,866	100	n/a	n/a	n/a	n/a
	1991	a	n/a	n/a	150	n/a	n/a	n/a	n/a
	1992	a	n/a	n/a	280	n/a	n/a	n/a	n/a
	1993	Access Pt.	1,291	9,447	62	n/a	n/a	n/a	0.0066
	1994	Access Pt.	1,322	14,488	468	n/a	n/a	n/a	0.0323
North Thompson River	1992	a	n/a	n/a	7	2,020	n/a	0.3%	n/a
	1993	a	n/a	n/a	10	2,400	n/a	0.4%	n/a
	1994	a	n/a	n/a	74	4,164	n/a	1.7%	n/a
Quesnel River, Lower	1987	Roving	74	1,211	16	9,014	1.46	0.2%	0.0132
	1988	a	n/a	n/a	n/r	4,497	n/a	n/a	n/a
	1989	a	n/a	n/a	20	6,314	n/a	0.3%	n/a
	1990	a	n/a	n/a	25	3,040	n/a	0.8%	n/a
	1991	a	n/a	n/a	20	6,245	n/a	0.3%	n/a
	1992	a	n/a	n/a	50	4,430	n/a	1.1%	n/a
	1993	a	n/a	n/a	20	3,405	n/a	0.6%	n/a
	1994	a	n/a	n/a	20	5,053	n/a	0.4%	n/a

a. Estimated by fishery officers using a variety of subjective techniques.

b. Closed after 1 day due to a user group conflict.

c. Unable to estimate total effort due to very low angler effort.

Continued

Table 5. Annual survey techniques, angler effort, chinook adult harvest and escapement, harvest rate, catchability and harvest per unit effort (HPUE) in the 1986-1994 upper Fraser River chinook sport fisheries, continued.

Fishery	Year	Estimation technique	No. of angler interview	Angler effort (hour)	Chinook adult harvest	Chinook adult escapement	Catchability coefficient (x 10^-6)	Harvest rate (%)	Mean HPUE
Quesnel River, Upper	1986	Roving	319	1,484	14	9,000	1.05	0.2%	0.0094
	1987	a	n/a	n/a	166	4,331	n/a	3.7%	n/a
	1988	Roving	121	1,164	14	6,300	1.90	0.2%	0.0120
	1989	Roving	126	1,832	40	3,000	7.18	1.3%	0.0218
	1990	a	n/a	n/a	50	6,195	n/a	0.8%	n/a
	1991	a	n/a	n/a	30	4,400	n/a	0.7%	n/a
	1992	a	n/a	n/a	30	3,375	n/a	0.9%	n/a
	1993	a	n/a	n/a	25	5,028	n/a	0.5%	n/a
	1994	a	n/a	n/a	0	1,549	n/a	0.0%	n/a
Shuswap River, Lower	1986 b	Roving	99	2,022	39	1,053	17.66	3.6%	0.0193
	1986 c	Hybrid	487	6,145	237	12,000	3.15	1.9%	0.0386
	1987	Hybrid	364	6,071	215	10,000	3.47	2.1%	0.0354
	1988	Hybrid	660	14,288	174	14,000	0.86	1.2%	0.0122
	1989	Hybrid	1,136	19,449	120	11,000	0.55	1.1%	0.0062
	1990	Hybrid	1,121	28,708	1,415	13,000	3.42	9.8%	0.0493
	1991	Roving	630	28,891	378	10,000	1.26	3.6%	0.0131
	1992	a	n/a	n/a	315	13,300	n/a	2.3%	n/a
	1993	Hybrid	1,528	21,545	785	6,000	5.37	11.6%	0.0364
	1994	Hybrid	1,288	19,266	639	16,150	1.98	3.8%	0.0332
Shuswap River, Middle	1986	Roving	115	1,786	53	1,000	28.18	5.0%	0.0297
	1991	Hybrid	560	5,622	482	5,000	15.64	8.8%	0.0857
	1992	Hybrid	384	8,964	307	5,000	6.45	5.8%	0.0342
	1993	Hybrid	370	5,542	459	2,500	27.99	15.5%	0.0828
	1994	Hybrid	295	6,255	163	4,000	6.26	3.9%	0.0261
South Thompson River	1987	Hybrid	269	5,671	36	8,500	0.74	0.4%	0.0063
	1988	a	n/a	n/a	180	12,000	n/a	1.5%	n/a
	1989	Hybrid	581	12,118	259	10,000	2.08	2.5%	0.0214
	1990	Hybrid	437	4,227	39	6,000	1.53	0.6%	0.0092
	1991	a	n/a	n/a	100	8,000	n/a	1.2%	n/a
	1992	a	n/a	n/a	100	12,000	n/a	0.8%	n/a
	1993	a	n/a	n/a	100	4,000	n/a	2.4%	n/a
	1994	a	n/a	n/a	75	2,800	n/a	2.6%	n/a
Thompson River	1988	Census	315	1,289	109	2,490	32.54	4.2%	0.0846
	1989	Census	346	1,174	104	3,500	24.58	2.9%	0.0886
	1990	Census	820	2,537	187	2,300	29.64	7.5%	0.0737
	1991	Census	748	2,729	290	2,500	38.09	10.4%	0.1063
	1992	Census	1,025	4,117	197	3,368	13.42	5.5%	0.0479
	1993	Census	704	2,659	162	4,000	14.64	3.9%	0.0609
	1994	Census	795	2,828	354	7,970	15.04	4.3%	0.1252

a. Estimated by fishery officers using a variety of subjective techniques.

b. Early fishery targetting on middle Shuswap River chinook.

c. Late fishery targetting on lower Shuswap River chinook.

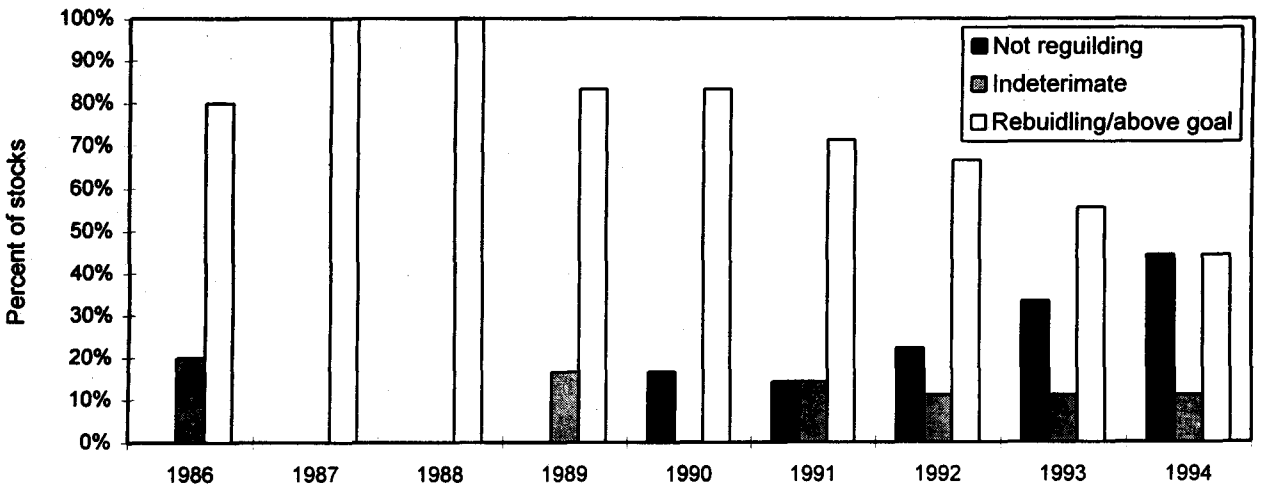


Fig. 6. Annual stock status evaluations of the upper Fraser River chinook stocks which supported sport fisheries in 1986-1994. The evaluation criteria are from the 1994 Canada/U.S. Chinook Technical Committee report (Anon. 1994).

criterion was intended to limit fisheries to stocks which were classified (under the Canada/U.S. Chinook Technical Committee evaluation framework; see Anon. 1994) as *Rebuilding* or *Above Goal* and which were projected to rebuild before the 1998 treaty target date. This criterion, therefore, permitted the harvest of rapidly rebuilding stocks while protecting the weaker stocks. The single stock aspect of this criterion was modified in 1987 to permit mixed stock fisheries if the stock aggregate was rebuilding and if ceilings would constrain harvest rates to a level which would minimize the impact on the weakest stock.

The annual rebuilding status of the stocks which supported fisheries is shown in Fig. 6. In the first three years, fisheries were permitted on stocks which were classified as *Above Goal* or *Rebuilding*, and on one *Indeterminate* stock (Quesnel) which had shown a positive response which was too recent to be captured by the evaluation framework. A strong rebuilding response early in the program was general among Fraser chinook stocks. Some (Bowron, Cariboo, and middle Shuswap) subsequently remained in the *Rebuilding/Above Goal* category, while others either peaked in the late 1980's and equilibrated below their interim escapement goal (Clearwater, lower Shuswap) or declined from the goal (Nicola, South Thompson). These trends resulted in a decline in the stock status evaluations as escapements fell below the base to goal line. By 1994, half of the stocks with fisheries were classified as unlikely to rebuild by 1998.

Despite an erosion in stock status, all of the fisheries remained open and a new fishery opened on one stock classified as *Not Rebuilding*. Once opened, managers have found it difficult to close fisheries in response to changes in stock status. In fact, there appears to have been an implicit decision to continue the fisheries based on the assumption that factors other than the terminal sport fisheries determine stock status. For example, Nicola chinook changed from *Rebuilding* in 1988 to *Not Rebuilding* in 1990-1994 because the 1987-1993 escapement fell below the base period average. Despite a clearly poor response to the rebuilding program, the Thompson fishery remained open and, indeed, other than actions to increase the enhanced component of the harvest, there was little effort to limit the harvest to the ceiling. In addition to a failure to respond to changes in stock status, the rebuilding criterion has become less rigorously applied when planning new fisheries. For example, the 1992 North Thompson fishery opened despite being classified as *Not Rebuilding*. These observations suggests that, although the rebuilding criterion was very important when these fisheries first opened, it has become less important, especially in established fisheries where anglers have an expectation that the fishery will continue.

Table 6. Identification of stocks, by year and abundance, which exceeded the 5% harvest rate and harvest ceiling limits.

Fishery	Year	Exceeded 5% harvest rate	Exceeded harvest ceiling	Terminal abundance
EXCEEDED 5% HARVEST RATE AND THE HARVEST CEILING				
Lower Shuswap/Mabel	1990	Yes	Yes	High
Lower Shuswap/Mabel	1993	Yes	Yes	Low
Lower Shuswap/Mabel	1994	Yes	Yes	High
Middle Shuswap	1986	Yes	Yes	Low
Thompson	1991	Yes	Yes	Low
Thompson	1992	Yes	Yes	Medium
EXCEEDED 5% HARVEST RATE BUT LESS THAN THE HARVEST CEILING				
Clearwater	1989	Yes	No	Low
Clearwater	1992	Yes	No	Low
Lower Shuswap/Mabel	1991	Yes	No	Medium
Thompson	1990	Yes	No	Low
LESS THAN 5% HARVEST RATE BUT EXCEEDED THE HARVEST CEILING				
Bowron	1994	No	Yes	High
Clearwater	1990	No	Yes	High
Clearwater/N. Thompson	1994	No	Yes	High
South Thompson	1989	No	Yes	High
Thompson	1989	No	Yes	High
Thompson	1993	No	Yes	High
Thompson	1994	No	Yes	High

Manageability Criterion

The manageability criterion provided a clear statement that the fisheries would be managed in a way which would protect the rebuilding status of the stocks. Restrictive management actions were implemented in each area to limit the fishery harvest rates to less than 5%. This value, although arbitrary, was considered sufficiently low to address this objective while at the same time providing a legitimate fishing opportunity. While harvest rate was the most important parameter, it could not be accurately measured in-season because the fish were difficult to see before they moved onto the spawning grounds. Instead, a stock-specific harvest ceiling (set at 5% of the 1985 escapement) was used for in-season management. If the harvest rate exceeded 5% in any year, either the regulations were made more restrictive or the ceiling was reduced the following year. The management plans for all of the fisheries called for a closure when the season or ceiling was reached, which ever came first, or if abundance was low (Fraser MS 1986).

In general, the 1986-1994 fisheries were managed within the harvest ceiling and harvest rate limits. The harvest was less than the ceiling in 80% of the fisheries, and harvest rates were less than 5% in 83% of the fisheries (Table 6). Only the middle Shuswap fishery had overages in the first three years; this fishery was subsequently closed for four years to permit the stock to rebuild. Since 1989, about 20% of the fisheries have exceeded the ceiling each year (Fig. 7). Not surprisingly, most of the overages occurred in the more effective fisheries.

Many fisheries attracted few anglers and had low catch rates. In these cases, it was fishery ineffectiveness rather than the management actions which limited the harvest and produced low

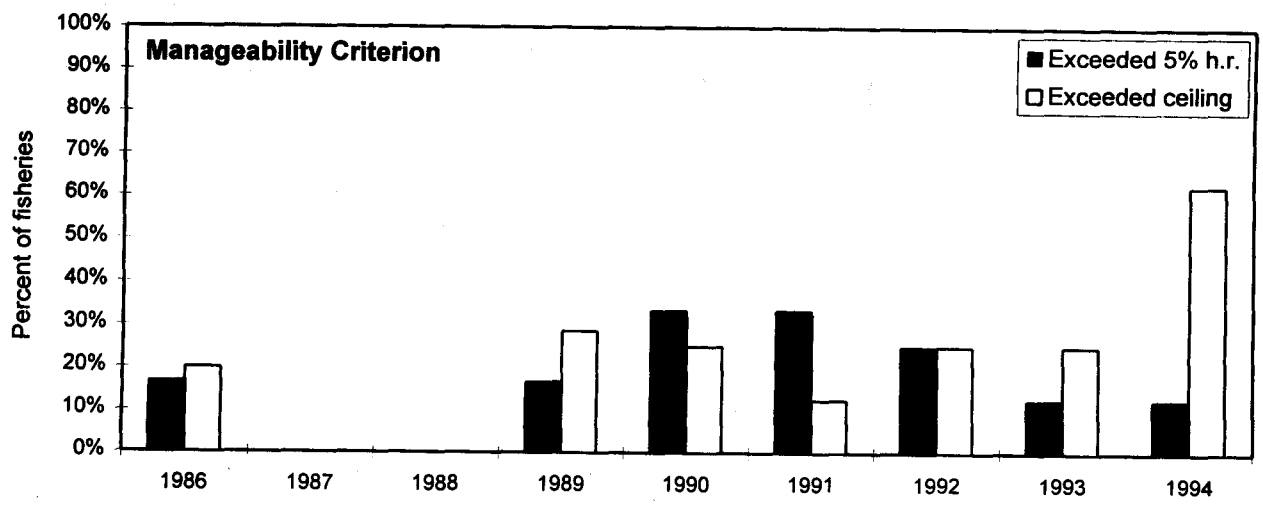


Fig. 7. Annual proportion of the 1986-1994 upper Fraser River chinook sport fisheries where harvest exceeded the harvest ceiling or the 5% harvest rate constraint.

harvest rates. In contrast, the more effective fisheries were managed within the ceilings only about half of the time. For example, the Shuswap and Thompson fisheries (excluding the 1991-1994 middle Shuswap) exceeded the harvest ceiling and harvest rate limit 53% and 47% of the time, respectively. When overages occurred, they fell into two general classes. First, there were fisheries which exceeded the harvest rate regardless of whether the ceiling was exceeded (Table 6). This was the most serious case because harvest rates were generally high when abundance was low (the lower Shuswap was an exception because fishing power in this fishery was sufficient to exceed the harvest rate limit even in years of high abundance). All fisheries in this category were monitored by creel surveys which provided inseason harvest estimates. The decision to exceed a harvest ceiling, therefore, was a deliberate one based on the assumption that a high catch rate reflected high abundance. In such cases where low abundance resulted in harvest rates in excess of 10%, this assumption was clearly incorrect. Second, there were fisheries which exceeded the harvest ceiling but not the harvest rate limit (Table 6). Overages in fisheries in this category occurred when abundance was high and, therefore, resulted in stock impacts which were within acceptable bounds. When abundance is high, managers have considerable flexibility in exceeding the harvest ceilings with little risk of damage to the stocks. Because risk is elevated when abundance is low, flexibility is dependant on the manager's ability to estimate abundance inseason. If greater management flexibility is required, then a reliable abundance indicator must be developed for the stocks harvested in each of the most effective fisheries. Otherwise, the harvest ceilings should be strictly adhered to if harvest rates in excess of 5% are to be avoided.

Two special cases, the Clearwater and Thompson fisheries, warrant further discussion. The Clearwater fishery alternated between exceeding the harvest ceiling (but not the harvest rate limit) one year and the harvest rate limit (but not the harvest ceiling) in a subsequent year. This reflected two fishery attributes: a) the fishery progressively expanded in the first few years and was quite effective after 1988; and b) Clearwater chinook had variable escapements which fluctuated from below the base period one year to above goal the next (Appendix 15, page 80). These attributes increased management risk because the ceilings were too high to limit the harvest rates to 5% in years when abundance was low, an event which was frequent. Managers should avoid opening new fisheries on stocks with variable escapement unless an inseason estimate of abundance is available. If a fishery already exists, the harvest ceiling should be reduced to a level which will protect the stock when abundance is low, and the fishery should be strictly managed to that ceiling. The Thompson fishery, on the other hand, was an extremely

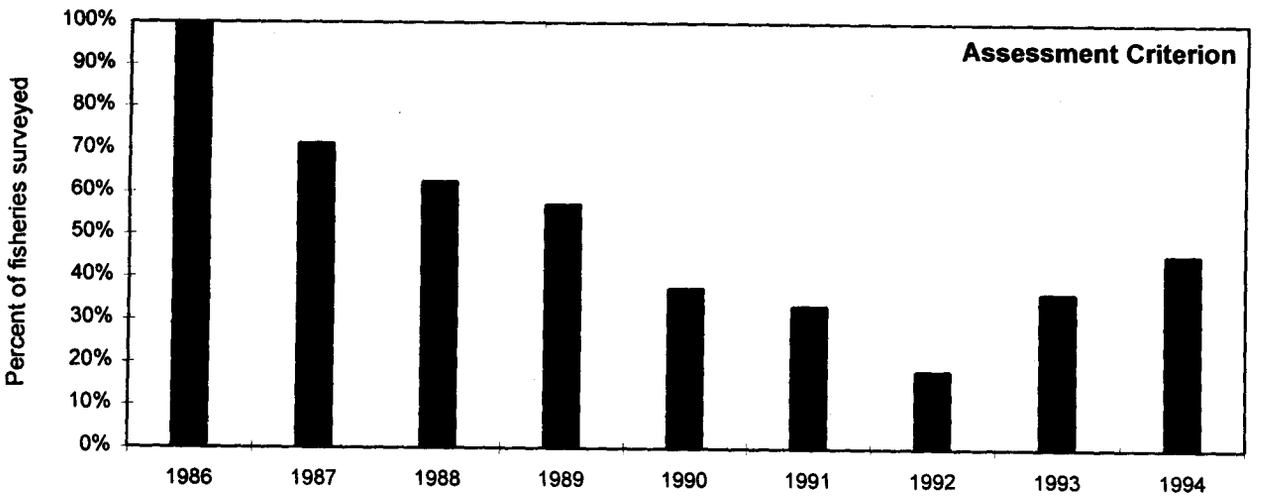


Fig. 8. Annual proportion of the 1986-1994 upper Fraser River chinook sport fisheries which were evaluated using structured creel surveys.

effective one which harvested a weak, rather than a fluctuating, stock. In seven years, this fishery exceeded the harvest rate limit and the ceiling twice, the harvest rate limit but not the ceiling once, and the ceiling but not the harvest rate limit three times. This raises two issues. First, because the stock was relatively small and depressed, in years of low abundance the ceiling was too high to constrain harvest to the harvest rate limit. Second, despite permitting a fishery on a stock of concern (Nicola has been classified as *Not Rebuilding* since 1990), managers have been unsuccessful in constraining harvest to the ceiling. Although the harvest rate limit was exceeded in only two years, the status of this stock suggests that greater control is warranted.

Ultimately, the best measure of success in achieving the manageability criterion's objective to protect the rebuilding status of stocks is to simulate stock status in the absence of the fisheries. A simplistic evaluation (which ignores factors such as subsequent production from foregone catch) was made by applying the Chinook Technical Committee criteria to the sum of the sport fishery harvest and the escapement. In every case but one, there was no change in stock status; the only exception was the 1993-1994 lower Shuswap evaluation which changed from *Indeterminate* to *Rebuilding*. This indicates that, despite the deficiencies noted with the major fisheries, this criterion was successfully addressed in almost all cases.

In summary, the objective of the manageability criterion was achieved in most of the fisheries opened in 1986-1994. Concerns persist, however, regarding the managers ability to constrain the most effective fisheries within the stated limits. The relaxation of harvest ceilings in response to high inseason catch rates increases the conservation risk to the stocks. Although the impact on the stock rebuilding program has been minor, a cumulative impact could alter stock status in the future. This practice should be discontinued if inseason abundance estimation procedures are not improved.

Assessment Criterion

The assessment criterion linked the fishery openings to structured monitoring studies. This recognized that, following closures of at least six years, little was known about the potential effectiveness of these fisheries. Defensible data were required to define basic fishery attributes and to permit an evaluation of how well the manageability criterion was being addressed. An assessment policy was developed in 1986 to provide these data. The policy had three components: a) all new fisheries would be assessed until the angler effort and catch rate had stabilized. This recognized that annual effort would likely plateau after a period of rapid expansion, and that anglers would require time to learn how to catch the fish; b) the largest and most effective fisheries would be identified and each would be assessed

by ongoing creel surveys; and c) the less effective fisheries with low, stable effort and harvest would be identified and each would be assessed using less intensive techniques. In most years, fishery officers would monitor the fisheries using subjective techniques, with creel surveys conducted every three to five years to document fishery changes.

The annual proportion of the fisheries monitored by creel surveys is shown in Fig. 8. The expectation under the assessment policy was that, in the initial years, all of the fisheries would be assessed by creel surveys. This proportion would then gradually fall below 50% as subjective surveys replaced creel surveys in the stable and less effective fisheries. The observed pattern was similar to this expectation, reflecting the successful implementation of two components of the assessment policy. First, the majority of the new fisheries, including all of those opened in 1986-1989, were assessed by creel surveys in their first year. More recently, however, there has been a significant level of noncompliance with this component of the policy. For example, none of the fisheries opened since 1990 (Cariboo, North Thompson, Mabel Lake) were assessed in their first year. Because the Cariboo fishery opened on a stock classified as *Above Goal* and attracted little angler effort, subjective assessment was unlikely to have introduced substantial management risk. Similarly, the North Thompson fishery attracted little angler effort; however, because it opened on a stock classified as *Not Rebuilding*, more structured and intensive assessment is required to demonstrate that this fishery will not negatively impact the status of this stock. The Mabel Lake fishery was a relatively effective one which, according to the assessment policy, should have been assessed by creel surveys each year since it opened in 1990. This introduced uncertainty in our assessment of the lower Shuswap stock in the first two years of this fishery. Second, the objective of monitoring the largest and most intensive fisheries was also well addressed. The Bridge, Shuswap and Thompson fisheries, by far the most effective of those opened in the upper Fraser system, were assessed by creel surveys almost every year. The fisheries were jointly monitored by the Department and community groups, the former providing the study design, staff training, deployment plan and analytic support, the latter providing assessment staff. These groups aggressively solicited funds from a number of sources and, in the Thompson, lower Shuswap and Mabel Lake fisheries, provided almost all of the assessment staff. Given the limited departmental resources allocated to river sport fishery assessment, this objective could not have been achieved without this level of local community involvement.

Despite successfully addressing two parts of the assessment policy, the monitoring objective for the less intensive fisheries has not been achieved. Fishery officers subjectively assessed most of the fisheries in most years; however, the more intensive studies required to update the assessment data have not been implemented due to inadequate resources. Some fisheries have not been intensively surveyed for up to eight years. For example, the Clearwater fishery has not had a creel survey since it opened in 1986 despite dramatic changes in both fishery performance and stock status. Likewise, the Bowron and South Thompson fisheries have not been creeled since 1988 and 1990, respectively. These fisheries should be reassessed to update the fishery data base.

Enhancement Criterion

The enhancement criterion linked fisheries to stocks which were being enhanced (enhancement was defined as the expected return of adults from at least two brood years). This was a risk-averse approach where, should wild production be unexpectedly low, fishing induced damage to the rebuilding program would be partially mitigated by the incremental enhanced returns.

Five hatcheries in the upper Fraser River system, the Quesnel, Clearwater, Eagle, Shuswap Falls and Spius, used outplants from a central hatchery to augment the production from a number of stocks. In 1986, less than half of the stocks with fisheries had major enhanced components (Fig. 9) because the production from some of the hatcheries was not fully on-line. In 1987-1992, over 80% of the stocks with fisheries were being enhanced. This proportion declined in 1993 due to changes within hatcheries among stocks, and to the closure of the Quesnel and Clearwater hatcheries. This decline is expected to continue for the balance of the decade as a result of these closures and the recent closure of the Eagle River Hatchery. The importance to

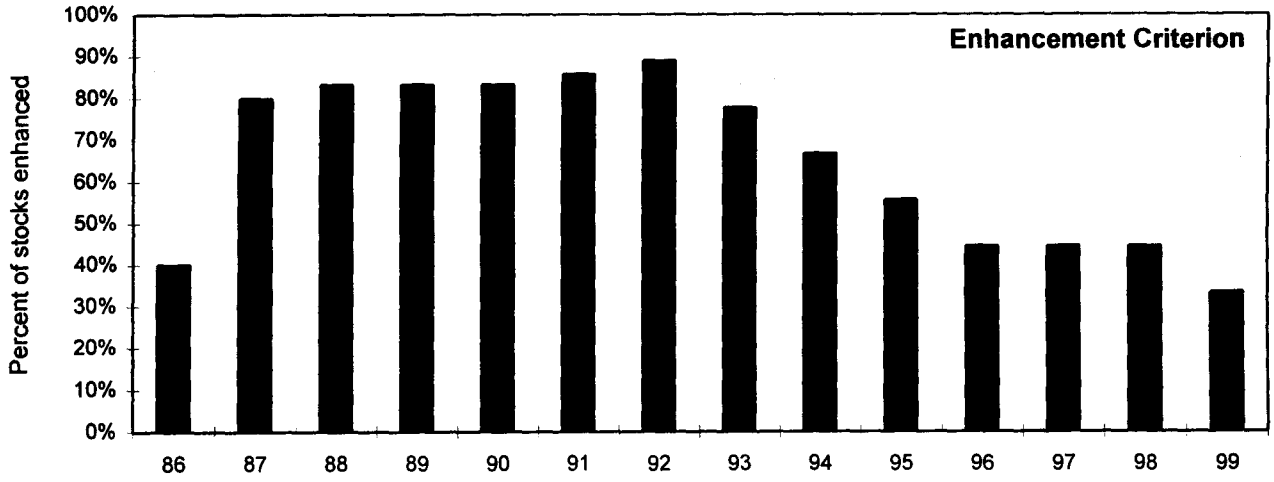


Fig. 9. Annual proportion of the upper Fraser River chinook stocks which supported sport fisheries in 1986-1994 where returns were augmented by enhancement.

sport fishery management of reduced hatchery production is dependent upon the rebuilding status of the stocks with fisheries. The loss of enhancement in a large, rebuilding stock presents little management risk (assuming the manageability criterion is addressed) because the enhanced component would be a small proportion of the total return. For example, the termination of outplants to the Bowron River was unlikely to have impacted this stock because its status had been above goal for 12 years. In contrast, the loss of enhanced production in stocks which are not rebuilding will increase the risk of overfishing a poor return. The loss of enhanced Clearwater production, for example, will likely deepen the escapement oscillations and increase the risk of overfishing in poor years. The loss of enhanced Nicola production would likely eliminate the stock's recent rebuilding response and would remove the option of a mark-only fishery. In such a scenario, a total fishery closure would be required.

Enhancement played an important role in the development of the middle Shuswap River fishery. When the 1986 middle Shuswap assessment showed a fishery with a capacity in excess of what the stock could support, managers closed the fishery and made an explicit decision to use enhancement to rapidly increase the return to the river. This addressed the overharvest concern and recognized the potential for a viable, highly effective fishery when the stock was rebuilt. Returns increased sharply (Appendix 15, p. 90), with enhancement playing an integral role in the elevation of the status of this stock to *Above Goal* in 1990. The fishery reopened in 1991 and continues to be extremely effective in most years. Given the current stock status, the fishery is constrained only by the available assessment resources; fishing time could be substantially increased if funds were available for an expanded creel survey. Potential fishing opportunities similar to the middle Shuswap are available throughout the Shuswap basin, especially in Mara and Shuswap lakes, provided a similar rebuilding response is achieved by other chinook stocks in this complex (lower Shuswap, Salmon, Eagle and Adams).

Enhancement also played a recent role in the Thompson River fishery. The enhanced component of Nicola chinook has contributed to the stock's recent rebuilding response (Appendix 15, page 82). Because this component is also marked at a high rate, it was possible to manage the 1994 Thompson fishery using a mark-only regulation. Harvest in the first week exceeded the ceiling; however, instead of closing the fishery, it was assumed that abundance was high and that an ongoing fishery targeted on enhanced returns would not damage the rebuilding program. In retrospect, this decision was correct; however, managers must acknowledge four points before considering this option in the future: a) the fishery catch rate is not a reliable indicator of run size;

b) the large 1994 escapement was not directly related to recent management or enhancement actions and its sustainability is suspect; c) enhanced fish must not be considered surplus to spawning ground requirements in a stock classified as *Not Rebuilding*. In such cases, the enhanced returns are an integral part of the rebuilding program and, and like wild fish, must be permitted to spawn; and d) catch and release fisheries in British Columbia's Interior Dry Zone add dangerous incremental stresses to fish which hold in areas where water temperatures commonly exceed 20 degrees celsius. Because stress-related mortality is very difficult to document in large rivers like the Thompson, catch and release fisheries must be avoided.

Summary

In general, the upper Fraser chinook sport fisheries have been managed in a way which has protected the rebuilding status of the stocks. The Department developed a set of realistic, attainable and measurable objectives in 1986, and implemented a risk averse, conservative management approach which achieved most of those objectives in the initial years of the fisheries. A fishery was not opened unless the stock was rebuilding and management controls could constrain the fishery to a 5% harvest rate. Most of the fisheries were assessed by creel surveys and almost all of the stocks were being enhanced. More recently, however, management has become less risk averse and the rules under which the fisheries are managed have become less well defined. There are four areas of concern:

- Stock status no longer plays a preeminent role in determining whether a new or existing fishery will open in a given year. A large proportion of the fisheries now target on stocks which are unlikely to rebuild by 1998;
- Enhancement contributes to the return of a progressively smaller proportion of the stocks with fisheries. While the loss of enhancement is a concern only among stocks which are not rebuilding (currently only the Clearwater and North Thompson), a further loss of enhanced returns to stocks with intensive fisheries (e.g. Shuswap and Thompson) would put those fisheries at risk;
- The creel survey program failed to periodically assess the small and medium fisheries, and new fisheries opened without intensive assessment in the first year;
- Recent fisheries were permitted to continue after the ceiling was reached based on the unsubstantiated assumption that terminal abundance was large.

While these fisheries in general continue to be well managed, the risk that they will damage these stocks is greater now than when the fisheries first opened. This risk is expected to grow, especially in view of new competing demands for the resource, unless the assessment of inseason abundance and fishery performance improves and the rules under which the fisheries are managed are more clearly defined.

FISHERY MANAGEMENT

A conservative management strategy was adopted for the upper Fraser chinook fisheries because: our knowledge of fishery performance was poor following their extended closure; the rebuilding program was in its initial years and its sustainability was uncertain; and the fisheries had a high profile among other user groups and could not be permitted to damage the rebuilding program. In 1986, only five fisheries were opened, all on stocks which were being enhanced and had clear rebuilding trends. They were managed using three types of regulations, harvest rate, effort and efficiency controls. These regulations are discussed later in this section.

At the end of each season, a fishery review was conducted by the managers, biologists, fishery officers and enhancement staff. The fisheries which were managed within the constraints discussed in the previous section were permitted to gradually expand, with increases in the season length, number of open days per week, total open days (Table 4), and open area. In almost all cases, the original ceilings were adequate to control the fisheries within the harvest rate objective; consequently, the ceilings have remained largely unchanged since 1986.

Harvest Rate Controls

The harvest ceiling in each fishery was intended to limit the fishery harvest rate to less than 5% in years of average or above average abundance. In years of poor abundance, the fisheries were to be closed. Abundance was to be assessed inseason by a test fishery in the

lower Fraser River (Schubert *et al.* 1988) and by terminal area observations (Fraser MS 1986). It became apparent, however, that the test fishery could not index the abundance of individual stocks, and that chinook could not be seen while holding at river mouths, in deep pools, or in lakes, the areas where angling tended to occur. It was only after the fisheries had closed that the fish moved onto the spawning grounds where their abundance could be estimated. Closures based on inseason abundance, therefore, could not be implemented. Instead, regulatory adjustments were made postseason if the review showed that the previous year's harvest rate had exceeded 5%.

Effort Controls

Angler effort was controlled by limiting both the seasonal duration of the fishery and the number of days (or even hours) that it was open each week (Table 4). Most fisheries opened for two days per week (a weekday and weekend day) in the first year, although some opened for only 12 hours. Fishing time increased in subsequent years if the incremental effort was unlikely to result in harvest rates of 5% or more. Most of the fisheries are now open seven days per week and for seasonal periods which are considerably longer than in the initial years of the fishery (Table 4). Effort was also controlled by initially opening only short sections of a river. For example, the 1986 Bowron fishery was opened only in the lower 60 km where access was limited to two road crossings, but expanded in 1987 to 115 km of river which included several areas of ready access.

Efficiency Controls

Efficiency was controlled with angler bag limits of one chinook adult per day and ten per year. In 1988, the daily limit was doubled in the fisheries assessed by creel surveys because Schubert (1989) showed that the previous limit could bias CPUE estimates. In 1991, a monthly bag limit was introduced in the North and South Thompson and Shuswap systems. This regulation was intended to reallocate harvest to the less effective anglers and to pace the fisheries, permitting them to remain open without exceeding the harvest ceilings. It has been largely unsuccessful in achieving these objectives (see the Fishery Assessment section).

FISHERY ASSESSMENT

Study Design

Thirty-seven creel surveys were conducted in the upper Fraser River chinook fisheries in 1986-1994. Each fishery was assessed using one of four study types, roving, access point and hybrid surveys or a complete census. The attributes of each study type and the selection rationale for a given fishery are discussed below.

Roving Surveys: The design and analytic procedures used in roving creel surveys have been described in the literature (Carlander *et al.* 1958; Robson 1960, 1961, 1991; Malvestuto *et al.* 1978; Malvestuto 1983). Roving surveys are conducted by a mobile surveyor who travels through the fishery to interview anglers in the act of fishing. The surveyor follows a prescribed route that includes every potential angling location. The daily start point and direction of travel are randomized, and the surveyor moves through the fishery at a standardized rate of travel. Angler effort and CPUE are calculated from angler counts (conducted during randomly selected 1-hour blocks) and interviews recorded by the surveyor.

Roving surveys are most applicable in dispersed access fisheries with low angler effort. Most are not labour intensive, yet they permit sample sizes which are large relative to the survey effort and the number of anglers because the surveyor visits all potential angling locations. This survey type has several notable weaknesses, however, the most serious of which is the high proportion of the interviews which are obtained from anglers still in the process of fishing. Catch rates estimated from incomplete trip interviews are reliable only if catch rate is independent of trip length. If independence cannot be demonstrated, then incomplete trip interviews will provide biased catch rate estimates and must be discarded. Because each fishery presents a unique combination of angler characteristics and fishery regulations, the independence of this relationship must be verified in each fishery. For example, this assumption will probably be violated in fisheries with restrictive daily bag limits because successful anglers (those who harvest a fish early in their trip) leave the fishery and, consequently, will not be vulnerable to contact by the surveyor. This case is discussed in more de-

Table 7. Estimation precision (standard error and coefficient of variation (C.V.)) relative to sampling effort and the duration of the opening in selected upper Fraser chinook sport fisheries.

					Chinook adult harvest			Angler effort		
Fishery	Year	Percent of effort interviewed	Total days open	Total days sampled	Number	Standard error	CV [a]	Hours	Standard error	CV [a]
Bowron	1986	52%	10	10	13	6	47%	3,179	213	7%
	1987	30%	16	12	121	32	27%	4,769	541	11%
	1988	32%	16	10	105	21	20%	5,804	519	9%
Clearwater	1986	33%	10	10	3	4	136%	626	136	22%
Mabel Lake	1993	49%	28	20	62	13	21%	9,447	1,072	11%
	1994	38%	28	20	468	116	25%	14,488	2,370	16%
Lower Quesnel	1987	23%	10	10	16	22	137%	1,211	n/a	n/a
Upper Quesnel	1986	30%	9	9	14	7	51%	1,484	229	15%
	1988	27%	11	11	14	8	58%	1,164	n/a	n/a
	1989	13%	12	12	40	5	13%	1,832	n/a	n/a
Lower Shuswap	1986 [b]	14%	4	4	92	33	36%	3,808	646	17%
	1986	36%	5	5	237	28	12%	6,145	637	10%
	1987	25%	7	7	215	192	89%	6,071	3,209	53%
	1988	16%	14	10	174	140	80%	14,288	7,939	56%
	1989	17%	21	16	120	23	19%	19,449	1,934	10%
	1990	14%	28	19	1,415	218	15%	28,708	2,199	8%
	1993	23%	28	20	785	208	27%	21,545	5,886	27%
	1994	22%	28	20	639	279	44%	19,266	8,058	42%
Middle Shuswap	1991	29%	7	7	482	99	21%	5,622	718	13%
	1992	15%	14	10	307	209	68%	8,964	5,839	65%
	1993	22%	14	10	459	373	81%	5,542	5,047	91%
	1994	14%	14	10	163	187	115%	6,255	7,611	122%
South Thompson	1987	17%	5	5	36	23	65%	5,671	3,866	68%
	1990	26%	21	15	39	14	35%	4,227	818	19%

a. CV = (Standard error/estimate) x 100.

b. Early fishery which included the middle Shuswap River.

All of these factors favoured the use of hybrid surveys (or censuses) over roving surveys. When resourcing levels dictated the use of roving surveys, they were limited to: the first year of a fishery when they were used to define angler distributions; fisheries where the catch rate was expected to be low; and fisheries amenable to the *bus stop* modification. Overall, 24% of the fisheries were assessed using roving surveys, 46% using hybrid surveys, 5% using access point surveys and 24% (Bridge and Thompson) using censuses. Hybrid surveys continue to be favoured in most fisheries because: a) after the studies had been established for a few years, continuity dictated the use of the same study design; and b) this type of study is amenable to the generation of inseason catch estimates (discussed later in this section).

Sampling Effort Allocation and Stratification

Estimation precision was not explicitly addressed in the design of the upper Fraser sport fishery surveys because surveyor effort was fixed, thereby constraining precision, and not enough was initially known about the fisheries to permit the design modifications needed to improve precision. Sztramko (1991) found no agreement in the literature on the desired level of precision for estimates of angler effort and harvest. Malvestuto *et al.* (1978) felt that coefficients of variation (CVs) of 40% were excessive, while others (Neuhold and Lu 1957; Grosslein 1962; Johnson and Wroblewski 1962) considered CVs of 7% to 15% to be acceptable. Malvestuto (1983) recommended that CVs be kept as small as practicable and suggested an arbitrary value

of 20%, while Palsson (1991) used a target range of 20%-30%.

CV's in the upper Fraser sport fisheries ranged from 7% to 137% (Table 7). Effort precision was typically superior to harvest precision, with the former frequently less than 20% and the later regularly exceeding 30%. This pattern, although common in creel surveys (Malvestuto *et al.* 1978; Palsson 1991), is a concern because an objective of the upper Fraser surveys was to document harvest relative to the harvest ceilings. This could not be reliably assessed in fisheries such as the lower Shuswap in 1994 because the harvest estimate was near the ceiling level but precision was poor. Overall, precision has improved over the 1986-1994 period and now approaches acceptable levels in most fisheries; however, precision needs to be improved in fisheries such as the middle Shuswap, and the lower Shuswap in 1994.

There are three ways to improve precision in sport fishery surveys: increase the sampling effort by increasing the number of days sampled or the amount of sampling effort expended during existing sample days; adjust the allocation of effort so that it is more proportional to the distribution of the estimated parameter; or stratify the sampling frame to reduce heterogeneity in the estimated parameter. These approaches are discussed in more detail below. It should be understood, however, that a specific level of estimation precision caused by factors external to the survey may be an inherent characteristic of a fishery, and that estimator precision in a given fishery may change between years despite similar sampling regimes. To illustrate this point, imagine one stock which is catchable only when it rains, and a second stock which is catchable regardless of the weather. Estimation precision in fisheries targeting on the former stock would be inherently poor relative to the latter because weather tends to be variable. In rare years of uniform weather, however, estimation precision would increase in the former fishery and remain static in the latter. In this hypothetical case, these patterns would likely be recorded regardless of alterations to the level of sampling effort.

Total Sampling Effort: Sampling effort in the upper Fraser fisheries was controlled by the duration of the opening and the available assessment budget. Because budgets tended to be fixed at a level which permitted five survey days per week, fishery duration was the most important effort-related determinant of precision. Initially, the fisheries opened for a maximum of 14 days, of which up to 10 days were surveyed (Table 7). Precision in these fisheries was poor (CVs averaged 67% for harvest and 45% for effort) despite conducting surveys on every open day in many fisheries. CVs in the expanded (15+ days) fisheries improved to an average 26% and 17% for harvest and effort, respectively. This improvement resulted from a management strategy which permitted the progressive expansion of the duration of these fisheries. Similar future improvements are limited to the middle Shuswap fishery, the only surveyed fishery which currently opens for substantially less than a month (Table 4) and where precision remains poor (Table 7). While this stock can support increased fishing pressure, the fishery is an effective one which should be expanded only if additional assessment resources are identified.

The option of increasing sampling effort in existing fishery openings, while available in most of the upper Fraser fisheries, is unlikely to be adopted for three reasons. First, assessment budgets are fixed, and it is unlikely that additional resources will be allocated to river sport fishery assessment during a period of fiscal restraint. Second, survey efficiency (the proportion of the total angler hours which was recorded by the interviews) is already high, averaging about 25% in the fisheries assessed by creel surveys (Table 7). In contrast, survey efficiency averaged 5% in the 1983-1988 Strait of Georgia sport fisheries (Shardlow and Collicutt 1989), 6% in the 1984-1988 Barkley Sound fisheries (J.O. Thomas and Associates MS 1988) and 11% in the lower Fraser River fisheries (Schubert 1992b). Third, precision responses to sampling effort changes are unpredictable and not necessarily in the expected direction. For example, the precision in several fisheries actually decreased with increased sampling effort (Table 7) and was variable in others despite a similar number of sampling days. Malvestuto *et al.* (1978) found that precision was largely independent of sample size within a range of five to ten sample days per month, while Heggenes (1987) noted that poor precision was a common attribute in fisheries with low absolute catch and effort. Although more precise estimates would be preferred in some fisheries, sampling effort in many cases

would have to increase beyond practical or affordable levels with no guarantee that this goal would be achieved.

Allocation of Sampling Effort: The proper allocation of sampling effort among strata can increase the efficiency of sampling while at the same time decrease the variance of the estimates (Stanovick and Neilsen 1991). Sampling effort can be allocated in proportion to harvest, catch rate or angler effort. Although harvest is an important parameter in the upper Fraser fisheries, it is often difficult to directly determine its distribution, in part because it is estimated from catch rate and effort. The allocation of survey effort in proportion to angler effort is the preferred approach because anglers are readily observable and tend to distribute in proportion to catch. The optimal spatial and temporal allocation of survey effort requires either a prior knowledge of angler distributions (from previous surveys) or some kind of inseason predictor. For example, Spiller *et al.* (1988) improved sampling efficiency by an inseason reallocation of sampling effort based short term weather forecasts.

To determine whether precision in the upper Fraser fisheries could be improved by better allocating sampling effort, I compared sampling and angler effort distributions in three categories: portion of the day; day type; and temporal component of the fishery (Table 8). The Shuswap system fisheries were selected as an example; however, similar evaluations could be made in the other fisheries. Although sampling effort has generally been allocated in proportion (within 5%) to angler effort, some improvements are possible by: a) reallocating effort between morning and afternoon shifts and between weekday and weekend strata in the lower and middle Shuswap fisheries; b) increasing Mabel Lake sampling effort in August; and c) increasing lower Shuswap sampling effort in September. Because there is considerable inter-annual variability in certain fisheries, some inseason adjustment of any allocation decision would likely be required.

Stratification: If estimator variance remains high despite the appropriate allocation of adequate sampling effort, there may be a high degree of heterogeneity in some attribute associated with the parameter being estimated. When heterogeneity occurs, stratification can improve precision by partitioning the data into more homogeneous groups provided that each group is sampled randomly and estimation precision is approximately equal. Malvestuto (1983) noted that the gain in precision due to stratification depends on the degree of heterogeneity in the total population and the extent to which it is alleviated by the stratification strategy.

The upper Fraser data were stratified by day type and, when appropriate, river segment. Malvestuto and Knight (1991) reported that stratification by day type increased precision by 10%-25%; similar improvements were probable in the upper Fraser fisheries. Further improvements could be realized by stratifying the fisheries by time of day, temporally through the fishery, and by gear type or target species (Table 9). The most promising stratification strategies are by time of day, temporal component and gear type because the catch rate differences were often large and each stratum had a significant proportion of the total angler effort. There were also large, statistically significant differences in catch rate when the sample was stratified by target species; anglers interested in catching chinook adults were in all cases more effective at harvesting chinook. The potential improvement in precision is limited, however, because almost all anglers fish for chinook. An exception was the Mabel Lake fishery, where a larger proportion of the anglers fish for other species.

Hayne (1991) warned that excessive stratification can generate so many strata, each with a demand for a minimum level of sampling effort, that the optimal allocation of sampling effort becomes impossible. Some level of stratification may be necessary to address the most important areas of heterogeneity, while other less important areas can be addressed by proportional effort allocation. The combination needed to optimize precision will be determined by the attributes of each fishery and the resources available for assessment. An optimum strategy must be developed on a fishery-specific basis.

Estimation of Angler Day Length

Fishing effort can be estimated in units of angler hours or angler days. The former is most commonly used in the literature (e.g. Malvestuto *et al.* 1978); however, the latter enjoys considerable popularity in the assessment of the major marine sport fisheries in British Columbia (J.O.

Table 8. Allocation of sampling effort relative to angler effort distribution patterns in the 1989-1994 Shuswap River system chinook sport fisheries. a

		Effort during the morning (to 1 p.m.)				% of total effort which occurred on weekdays		% of weekday effort which occurred in Month 1 b	
		Weekday		Weekend					
Fishery	Year	Angler effort	Sampling effort	Angler effort	Sampling effort	Angler effort	Sampling effort	Angler effort	Sampling effort
Mabel Lake	1993	55%	55%	52%	56%	56%	55%	64%	55%
	1994	47%	45%	54%	56%	56%	55%	77%	64%
Lower Shuswap	1989	43%	44%	46%	57%	61%	56%	n/a	89%
	1990	47%	40%	52%	44%	62%	53%	56%	80%
	1991	46%	55%	51%	56%	63%	55%	58%	64%
	1993	50%	55%	49%	56%	60%	55%	58%	55%
	1994	50%	45%	51%	56%	59%	55%	60%	64%
Middle Shuswap	1991	49%	60%	68%	67%	48%	63%	n/a	n/a
	1992	52%	60%	65%	60%	58%	50%	53%	60%
	1993	73%	60%	69%	60%	46%	50%	41%	60%
	1994	50%	40%	55%	60%	66%	50%	81%	60%

a. "Angler Effort" refers to the percent of the total angler effort which occurred in a given category. For example, the proportion in the first column (weekday morning effort) refers to the percent of the total weekday effort which occurred before 1 p.m. "Sampling Effort" is analogous, but refers to the percent of total sampling effort allocated to time periods of that type.

b. The first month of a fishery spanning two months; weekends excluded because every weekend day was sampled.

Table 9. Stratification options based on differences in chinook adult catch rate by time of day (A.M. or P.M.), month (early or late fishery), gear type and target species in the 1989-1994 Shuswap River system chinook sport fisheries.

		HPUE by time of day		HPUE by month a		HPUE by gear type			HPUE by target	
Fishery	Year	A.M.	P.M.	First	Last	Bait	Lure	Baited lure	Chinook adult	Other species
Mabel Lake	1993	0.007	0.006	0.008	0.006	0.000	0.007	0.000	0.007	0.000
	1994	0.047	0.021	0.031	0.030	0.000	0.031	0.000	0.033	0.000
Lower Shuswap	1989	0.019	0.004	0.010	0.008	0.029	0.008	0.003	0.010	0.000
	1990	0.062	0.032	0.208	0.049	0.075	0.030	0.025	0.040	0.000
	1991	0.023	0.006	0.013	0.013	0.025	0.008	0.007	0.012	0.000
	1993	0.039	0.029	0.029	0.040	0.042	0.025	0.023	0.033	0.000
	1994	0.046	0.024	0.023	0.041	0.036	0.030	0.026	0.031	0.000
Middle Shuswap	1991	0.142	0.059	n/a	n/a	0.164	0.077	0.062	0.100	0.000
	1992	0.039	0.031	0.057	0.017	0.043	0.056	0.008	0.035	0.000
	1993	0.075	0.061	0.081	0.060	0.096	0.057	0.031	0.068	0.000
	1994	0.027	0.027	0.026	0.028	0.037	0.037	0.020	0.028	0.000

a. First/last months were July/August in the middle Shuswap and August/September in the lower Shuswap and Mabel Lake.

Thomas and Associates MS 1988; Shardlow and Collicut 1989). While angler day or trip estimates are useful in the economic evaluation of a fishery (Malvestuto 1983), such statistics are of limited utility in general fishery assessments because of the inherent variability in the amount of effort the unit represents. Such units make little sense when the study objective is to compare catch rate or effort among fisheries or among strata within a fishery because trip length can vary with weather, fishing success, time of day, location or week/month. The angler hour was selected as the most appropriate unit for the upper Fraser sport fisheries. Ancillary angler day estimates were also provided; however, they are suspect for the reasons discussed below.

Average trip length, as estimated from angler interviews, is the sum of the hours spent fishing to the time of the interview and the angler's expected additional time to the end of the trip. These data are often adjusted for length of stay (Lucas 1963) and frequency of use (Sinclair and Morley 1975) biases before estimating the average trip length. Such estimates are valid only if the angler can correctly recall trip length to the time of the interview and accurately predict how much longer he/she will continue to fish. Recall and prediction ability were evaluated in the lower Fraser and lower Shuswap fisheries in 1989. Anglers were able to accurately recall trip length. The average and maximum deviation between estimated and actual trip length was +0.1 and -4 hours, respectively, with 86% of the estimates within one hour of the true trip length (Schubert 1992a). These findings were not surprising since an angler's ability to recall trip length is constrained only by short term memory. Similar results were reported by McEachron *et al.* (1986) and Phippen and Bergersen (1991).

While anglers were able to accurately recall trip length to the time of interview, they predicted subsequent trip length with a large positive bias. The average and maximum deviation between the estimated and actual subsequent fishing time was +2 and +15 hours, respectively, with only 56% of the estimates within one hour of the true fishing time. This bias was apparent in the estimates of angler trip length generated from incomplete trip versus complete trip interviews; the former exceeded the latter in the 1986-1994 studies by an average of 2.5 hours (e.g. Appendices 1, 5, 8). This level of prediction inaccuracy likely reflected a variety of factors, such as post-interview changes in weather, angling success, hunger, etc. which could affect an angler's decision to continue fishing. Regardless of the source of error, it is clear that angler day length cannot be accurately estimated from incomplete trip interviews.

Because incomplete trip interviews provided misleading estimates of angler day length, only complete trip interviews were used after 1987. There is evidence, however, that complete trip interviews may have underestimated angler trip length. In 1991-1994, anglers who had fished within two weeks of the interview were questioned regarding the length of their most recent trip. Trip length averaged 1.5 hours longer than that estimated from complete trip interviews and about 1 hour less than that estimated from incomplete trip interviews. The discrepancy between the complete and previous trip estimates may result from recall bias or the incorrect recording as a complete trip of a portion of a trip interrupted by a mid-day break. The former is unlikely given the short recall period; the latter should be investigated in future studies. Until the reason for this difference is determined, study estimates of angler day length and total effort estimated in angler day units should be interpreted with caution.

Incomplete Trip Interview Bias

An important assumption underlying the design of creel surveys is that catch rate estimated from an incomplete fishing trip will provide an unbiased estimate of the same statistic when the trip is complete. This assumption has been verified by other studies (Von Geldern and Tomlinson 1973; Malvestuto *et al.* 1978); however, under certain circumstances the violation of this assumption is likely. For example, MacKenzie (1991) reported a higher harvest per angler hour near the end of a trip because anglers became more willing to retain smaller fish. A bias also occurred in the upper Fraser fisheries regulated to a daily bag limit of one chinook adult. Successful anglers tended to leave these fisheries after filling their daily bag, reducing their vulnerability to a roving surveyor to the short period between when the fish was hooked and the angler left the river. The anglers most vulnerable to the roving surveyor were the unsuccessful ones who

Table 10. Comparison by fishery and year of chinook adult daily bags, and harvest per angler hour from complete and incomplete trip interviews in fisheries regulated by daily bag limits of one and two chinook adults.

Fishery	Year	Daily bag limit	% of anglers who harvested 0-2 chinook adults per trip			Harvest per angler hour		Significant HPUE difference (p = 0.05)
			0	1	2	Incomplete fishing trip	Complete fishing trip	
Bowron	1986	1	98%	2%	0%	0.0018	0.0066	No
	1987	1	95%	5%	0%	0.0087	0.0258	Yes
	1988	2	93%	5%	2%	0.0148	0.0248	No
Clearwater	1986	1	99%	1%	0%	0.0000	0.0190	No
Lower Quesnel	1987	1	99%	1%	0%	0.0000	0.0132	No
Upper Quesnel	1986	1	99%	1%	0%	0.0108	0.0155	No
	1988 a	2	97%	3%	0%	0.0179	0.0000	Yes
	1989	2	98%	1%	2%	0.0000	0.0926	No
Lower Shuswap	1986	1	82%	18%	0%	0.0245	0.0462	Yes
	1987	1	93%	7%	0%	0.0000	0.0393	Yes
	1988	2	97%	3%	0%	0.0091	0.0141	No
	1989	2	97%	3%	0%	0.0076	0.0127	No
	1990	2	88%	10%	2%	0.0273	0.0504	Yes
	1991	2	96%	4%	0%	0.0116	0.0284	No
	1993	2	91%	8%	1%	0.0252	0.0398	Yes
	1994	2	91%	9%	1%	0.0266	0.0392	Yes
Middle Shuswap	1986	1	93%	7%	0%	0.0093	0.1111	Yes
	1991 a	2	78%	16%	6%	0.1069	0.0828	No
	1992	2	85%	11%	4%	0.0299	0.0849	No
	1993 a	2	82%	14%	4%	0.0758	0.0623	No
	1994	2	92%	7%	0%	0.0246	0.0310	No
South Thompson	1987	1	97%	3%	0%	0.0031	0.0214	Yes
	1989	2	94%	6%	1%	0.0213	0.0277	No
	1991	2	98%	2%	0%	0.0079	0.0088	No

a. HPUE higher in incomplete trip interviews.

still hoped to harvest a fish. This bias was identified in 1987 (Schubert 1989) and was addressed in 1988 (Schubert 1990) when the daily bag was increased to two chinook adults in fisheries assessed by creel surveys (Table 4). This phenomena is a serious one if harvest (rather than catch and release) is the angler's primary objective and if the fishery is managed to a restrictive daily bag limit; it can also introduce bias regardless of the bag limit in fisheries where the catch rate is high. The initial surveys of any new fishery should maximize the proportion of the interviews which are from complete trips to permit the assessment of this assumption in each fishery.

The procedure used in the 1986-1994 studies, to test for catch rate differences between complete trip and all interviews, was less sensitive than the alternate test of complete trip versus incomplete trip interviews. This test was used because it addressed the practical question of whether the difference in the catch estimate caused by the inclusion of incomplete trip interviews was statistically significant; at no time did I intend to use only incomplete trip interviews. When significant differences were detected, the incomplete trip interviews were excluded from the analysis to enable the generation of an unbiased, if less precise, catch estimate.

Bag Limits

A bag limit is a type of allocated catch quota that restricts the number of animals a fisher can keep per unit of time (Porch and Fox 1990). Daily and annual bag limits have been used to regulate all of the upper Fraser River chinook sport fisheries since they were reopened in 1986, and a monthly limit was used in selected fisheries since 1991. All three types of limits functioned by removing anglers from the fishery after they had harvested their quota. Their purpose was to better pace the fisheries so that the harvest ceiling could be achieved without the need for an early closure, and to allocate the total harvest more equitably among anglers.

Daily: A daily bag limit was applied in all of the upper Fraser fisheries. Their effectiveness was dependant upon catchability, which varies annually, temporally and spatially within a fishery and among fisheries. The daily limit was initially set at one chinook adult, but was increased to two in 1988 when it became apparent that the lower limit biased the creel survey catch rate estimates. Because anglers tend to leave a fishery after catching their limit, a successful daily bag regulation will result in higher catch rates when they are estimated from complete trip versus incomplete trip interviews (see the previous section). This difference, therefore, can serve as an indicator of the effectiveness of the daily limit. The one chinook adult limit was highly successful in 1986-1987, even in the less effective fisheries (Table 10). The average HPUE was five times higher among the complete trip interviews, and the difference was large even in the fisheries where it was not statistically significant. Effectiveness decreased in 1988-1994 when the daily limit increased to two chinook adults. HPUE averaged about 1.5 times higher among complete trip interviews, but the differences were significant only in the intensive lower Shuswap fishery in some years. These results suggest that a daily bag limit of one will constrain virtually any fishery where the catch rate is greater than zero. Increasing the daily limit, however, will eliminate the utility of this regulation in all but the most effective fisheries.

Monthly: A monthly bag limit of six chinook adults was applied in the Shuswap, North and South Thompson River systems in 1991-1994. Their effectiveness was dependent on the number of open days, total fishing effort, the frequency of use pattern among anglers, and angler success, which can be influenced by fish abundance, environmental factors and angler skill. The selection of six as a monthly limit was an arbitrary decision made by managers in the absence of data on the temporal accumulation of seasonal bags and the angler's frequency of use.

The monthly bag limit was evaluated using data collected in 1991-1994 in the three Shuswap fisheries; it was not evaluated in the South and North Thompson because creel surveys were not conducted in those fisheries. Although this evaluation did not consider the cumulative catch by anglers fishing all three Shuswap fisheries, it is unlikely that the monthly limit was effective because: a) catch rates at the observed angler frequencies of use were usually too low to permit an angler to harvest six chinook adults in a month; b) the fisheries spanned two months, elevating the monthly limit to the level of the annual limit; c) the short duration of the middle Shuswap fishery did not permit the monthly limit to be effective except when the catch rate was high; and d) even when the catch rate and fishery duration were sufficient for the limit to effect total harvest and its distribution among anglers, noncompliance dissipated much of the response. The monthly limit could be made effective in the Shuswap system: if compliance was improved by increased enforcement in years when the catch rate is high; if the bag limit was reduced or its effective period expanded to cover the duration of all three fisheries; or if the middle Shuswap fishery was expanded to increase the size of the bags in that fishery, thereby reducing angler effort in the lower Shuswap fishery. It is unlikely that the monthly limit had any effect in the South and North Thompson rivers, however, because the catch rate in those fisheries was considerably lower than in the Shuswap system (Table 5).

Annual: An annual bag limit of ten chinook adults from any freshwater area applied to all of the upper Fraser fisheries. The effectiveness of this regulation was not assessed because the data were collected on a fishery-specific basis; however, less than 1% of the anglers had harvested ten chinook adults in a given fishery. Given the low catch rates in these fisheries and their tendency to attract local anglers, it is doubtful that the annual bag limit effected total harvest or its between-angler distribution.

Table 11. Results of regressions of chinook abundance on sport fishery catch rate in the upper Fraser fisheries. a

Fishery	Years with creel survey data			Regression r-squared
Bowron	1986	1987	1988	0.00
Upper Quesnel	1986	1988	1989	0.83
Lower Shuswap	1986	1989	1993	0.01
	1987	1990	1994	-
	1988	1991	-	-
Middle Shuswap	1986	1992	1994	0.04
	1991	1993	-	-
South Thompson	1987	1989	1990	0.35
Thompson River	1988	1991	1994	0.41
	1989	1992	-	-
	1990	1993	-	-

a. Regression input data are from Table 5.

Inseason Harvest Projection

Projections of total seasonal harvest were generated inseason for fisheries in the Thompson and lower and middle Shuswap rivers and Mabel Lake. These projections provided the manager an early indicator of whether regulatory adjustments would be required to ensure that the harvest would not exceed the ceilings. In the fisheries assessed using hybrid surveys, inseason projections were made in two steps. In the first fishery week, there was insufficient data to estimate the diel effort pattern. Consequently, harvest was projected from the previous years' average diel effort profile and the inseason rod counts and harvest per angler hour estimates. When two morning and afternoon shifts accumulated in the weekday and weekend strata, the estimation of the diel effort pattern switched from previous years' to inseason data. These projections were made under the assumption that the catch rate and angler effort observed to date would be representative of the entire opening and that the fishery would remain open for the scheduled period. This permitted the managers to evaluate the need for inseason regulatory adjustments or fishery closures. Projections made within a week of the closure ranged from -42% to +2% of the final harvest estimate.

A consequence of the need to provide inseason harvest projections was that the hybrid surveys had to be designed using representative rather than random sampling to permit the estimation of the diel effort pattern as early in the fishery as possible. This was addressed by allocating two morning and two afternoon shifts in both weekday and weekend strata in the first four sampling days in each stratum.

Inseason Abundance Estimation

An assumption made in the initial years of the upper Fraser fisheries was that catch per angler hour could be used as an inseason abundance indicator. This assumption permitted managers the flexibility of continuing fisheries after the ceiling was reached when catch rate was high because abundance was also assumed to be high (the fishery would not be closed when catch rate was low because harvest would not be near the ceiling). The validity of this assumption was examined by regressing abundance (harvest plus escapement) on fishery catch (harvest plus release) per angler hour. The relationship was very poor in most fisheries; only the upper Quesnel fishery showed a strong relationship, with an r-squared of 0.83 (Table 11). This was an inverse relationship, however, which made little biological sense. The relationship in the Thompson River fishery shows greater promise as a predictive tool (r^2 = 0.41); however, it is defined by the anomalous 1994 data point (Table 5). Further observations in this range of abundance and catch rate are required to better define this relationship.

It was noted in a previous section (page 22) that managers have the flexibility to exceed the harvest ceiling provided abundance is high, but that a reliable inseason abundance indicator is required if potential damage to the stocks is to be avoided. The analysis presented here indicates that fishery catch rate does not provide a useful abundance indicator. Alternate techniques must be developed in the more effective fisheries if management flexibility is to be maintained.

CASE STUDIES

This section provides an overview of the four largest and most intensively assessed upper Fraser chinook sport fisheries, in the lower and middle Shuswap and Thompson rivers and Mabel Lake. The discussion is based on empirical information, and on a synthesis of data presented in previous reports in this series and summarized in Appendix 15, tables 4-5 and figures 10-17. Most of the figures (and much of the discussion) provide generalized patterns developed from data collected over a number of years rather than specific to a single year.

Lower Shuswap River

The lower Shuswap fishery reopened in 1986 and has consistently been the largest (in angler effort) and most successful (in chinook adult harvest) among the upper Fraser fisheries (Table 5). Annual angler effort averaged 18,000 hours or about 945 hours per open day, with rod counts of up to 140 during the peak activity period. Harvest averaged 475 chinook adults and, with the exception of the anomalously high 1990 harvest of 1,415, has increased progressively since 1989 (Table 5; Appendix 15, page 88). These estimates are from creel surveys which were conducted every year except 1992. Intensive hybrid surveys were used each year except 1991, when insufficient resources mandated the use of a modified roving survey. With that exception, assessments methods were comparable between years.

Annual angler effort was mediated by two factors. First, the season progressively expanded during the study period, from 5 days in 1986 to 28 days in 1990-1994 (Table 4). This resulted in an increase in effort from about 6,000 hours in 1986-1987 to 29,000 hours in 1990-1991 (Fig. 10). At the same time, the average effort per day remained constant at about 1,020 hours, indicating that the number of anglers participating in the fishery was static. Second, because there are relatively few effective angling sites, the river fishery was crowded during peak hours. The 1990 Mabel Lake fishery opening permitted anglers to move from the river to the lake, resulting in a 30% decline in the 1993-1994 river effort. The combined river and lake effort, however, slowly increased by about 4% per year in 1990-1994 (Table 5). Crowding will limit future river effort to near the 1991-1992 level, except perhaps through the increased use of boats. Any future effort increases are likely to be absorbed by the Mabel Lake fishery.

The diel effort profiles in the lower and middle Shuswap were unique among the upper Fraser fisheries because angling occurred at all hours of the day (Fig. 10). In 1986-1987, when the fishery opened twice per week, some anglers fished the full 24 hours; many of those nocturnal anglers still participate in the fishery. The diel effort profile was bimodal with peaks in the early morning (6-7 a.m.) and early evening (7-8 p.m.). This pattern reflected an angler preference to fish before and after work, to avoid the heat of the day, and to leave the river before mid-day when the catch rate was low (Fig. 11). The most effective fishing time (approximated by an hourly stratification of HPUE by time of interview) was before 11 a.m. This suggests that a significant proportion of the harvest occurred early in the morning. The critical period could not be identified more precisely, however, because the actual time of harvest was not recorded and some anglers may have continued fishing after they had harvested a chinook.

Anglers clustered at a number of sites which was small relative to the length of the open area; the five most popular sites accounted for over 60% of the effort (Fig. 10). Over half of the anglers fished in the upper 20 km of the river, especially at Chuck's, Log Dump (Cooke Creek) and Dale's pools. Few anglers fished in the lower 40 km where the river is slow moving and deep; those who did fished from the highway bridges at Ashton Creek, Enderby and Grinrod, and at Mara (Fig. 2) before illegal activities forced the closure of that area in 1990. The spatial distribution of harvest was similar (but not identical) to the angler distribution (Fig. 11).

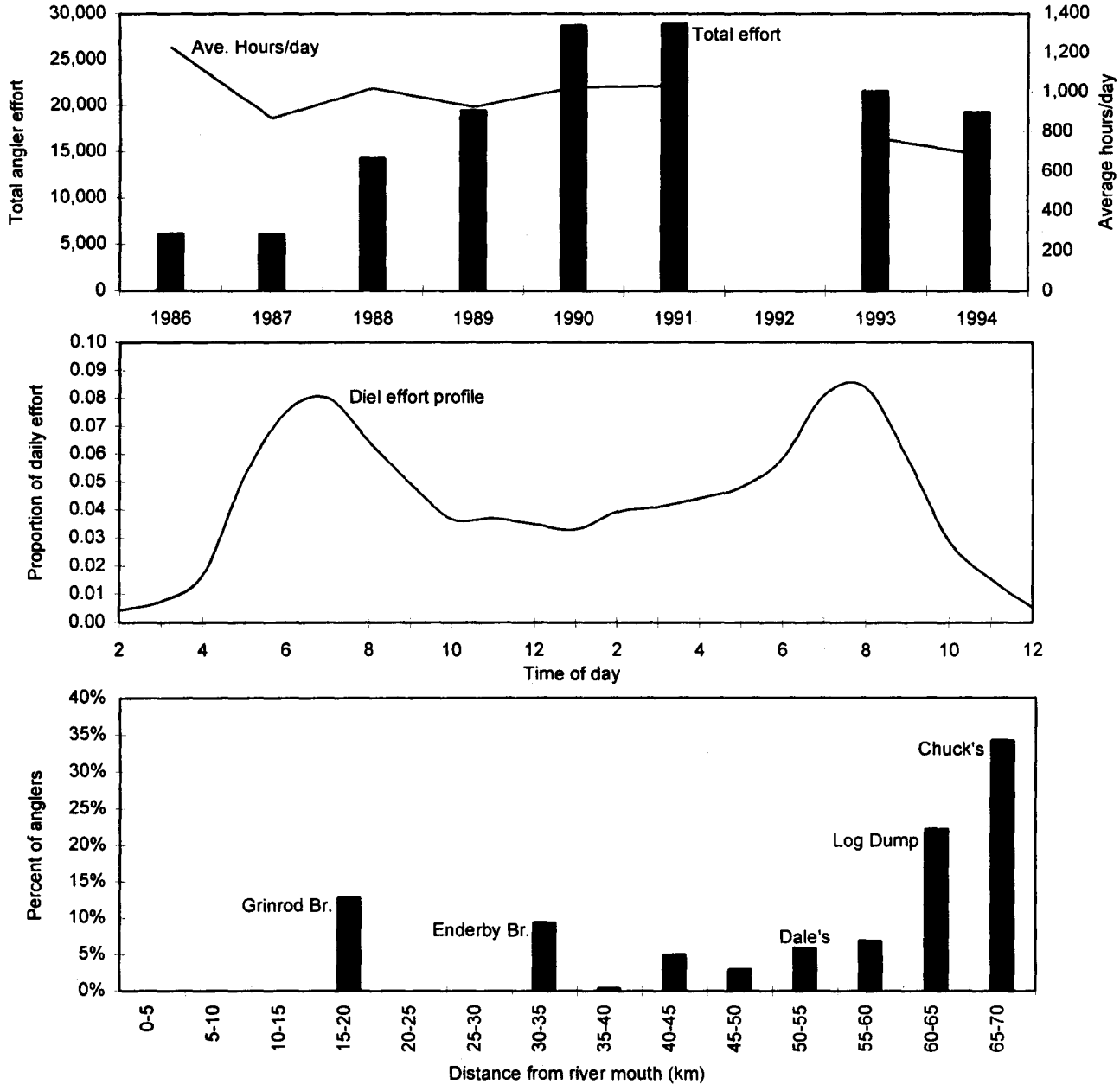


Fig. 10. Lower Shuswap River angler effort: annual total and average per day; average diel profile; and average spatial distribution of anglers.

HPUE was low in the lower 40 km where effort was sparse, and high in the upper 25 km where effort was high. The highest HPUE was downstream from the largest angler concentrations, where gear interactions may have reduced individual effectiveness. This suggests that anglers who probe areas away from the angler clusters may improve their fishing success.

Most anglers accessed the river by road, although some used boats or crossed private property. Boat access was restricted to a few launch sites in the river because Skookumchuck Rapids prevented the movement of boats downstream from Mabel Lake. Because boat anglers were not always visible from the road access sites, boat-based effort was estimated by counting trailers at the boat launch areas and assuming that the party size was the same as among the shore-based anglers. Anglers who accessed the river by crossing private property have never constituted a large proportion of the effort, and

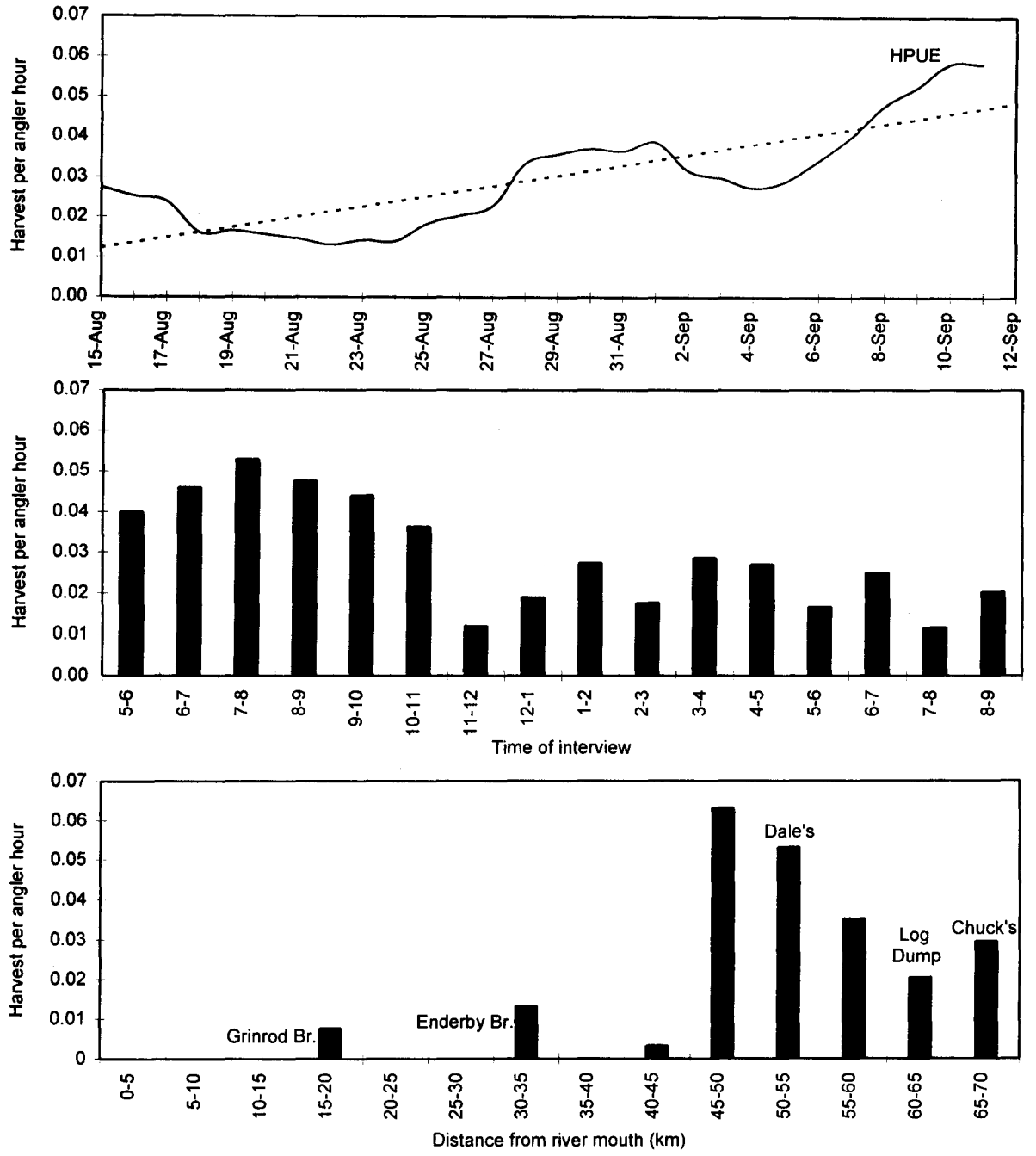


Fig. 11. Lower Shuswap River harvest per angler hour (HPUE): average daily HPUE; average HPUE by time of interview; and average spatial distribution.

that proportion is declining because more land owners are refusing anglers access to the river. Because the creel survey rod counts were conducted only at road access points, the above factors suggest that effort was estimated with a small negative bias. Future studies should evaluate this bias by conducting at least some angler counts simultaneously by road and aircraft.

Virtually all of the lower Shuswap anglers fished for chinook salmon, and most intended to harvest, rather than catch and release, a fish. Up to half of the anglers used lures, and a quarter each used bait or baited lures; catch rate was consistently higher among those using bait. Less than 10% of the interviewed anglers had harvested a chinook adult during their trip. In compar-

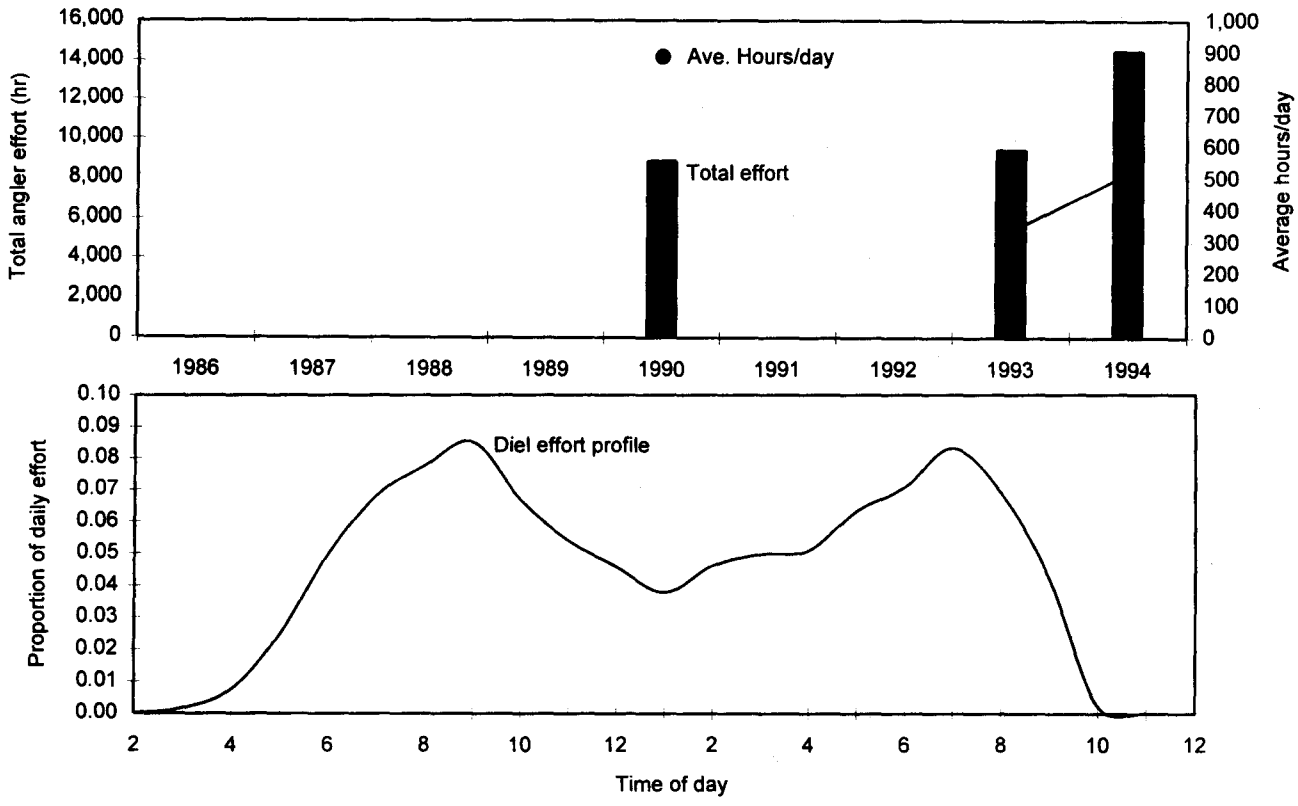


Fig. 12. Mabel Lake angler effort: annual total and average per day; and average diel profile

ison, 14% of the lower Fraser anglers harvested at least one fish per trip (Schubert 1992b). When interviewed in the last week of the fishery, however, 40% of the lower Shuswap anglers had harvested at least one chinook adult during the season. This was high despite the relatively poor catch rate because the majority of the anglers were from the local area and fished the river frequently. Two-thirds of the interviewed anglers had fished within two weeks of the interview.

Angler success in the lower Shuswap fishery was normally high at the start of the season, declined for the next ten days, and then slowly increased through the remainder of the season (Fig. 11). The early season success probably reflected the limited exposure of the fish to angling. Lower Shuswap chinook appear less likely to strike after a prolonged exposure to continuous angling effort. For example, HPUE was high in 1986-1987 (Table 5) when the fishery opened only two days per week (Table 4) because the fish could recover from angling related stress during the weekly closed periods. In contrast, HPUE was about two-thirds lower in 1988 when the change to a seven day per week fishery removed that recovery period. Increasing success later in the season may have reflected either greater fish aggressiveness as the spawning time approached or higher abundance. Chinook arrive in the river from July to September and hold in the deep river pools or migrate through the river and hold in Mabel Lake. As the season progresses, abundance in the river increases as a result of new arrivals and fish moving from the lake to the spawning grounds.

Mabel Lake

The Mabel Lake fishery reopened in 1990, but it was not until 1993 that it was assessed by a structured creel survey (Table 4). The fishery targets on lower Shuswap chinook which hold in the lake before dropping back into the river to spawn. Annual angler effort averaged 10,900 hours or 580 hours per open day (Table 5), with rod counts of up to 98 during the peak activity period. Angler effort was stable between 1990 and 1993, but increased to about 14,500 hours in 1994 (Fig. 12). Harvest averaged 212 chinook

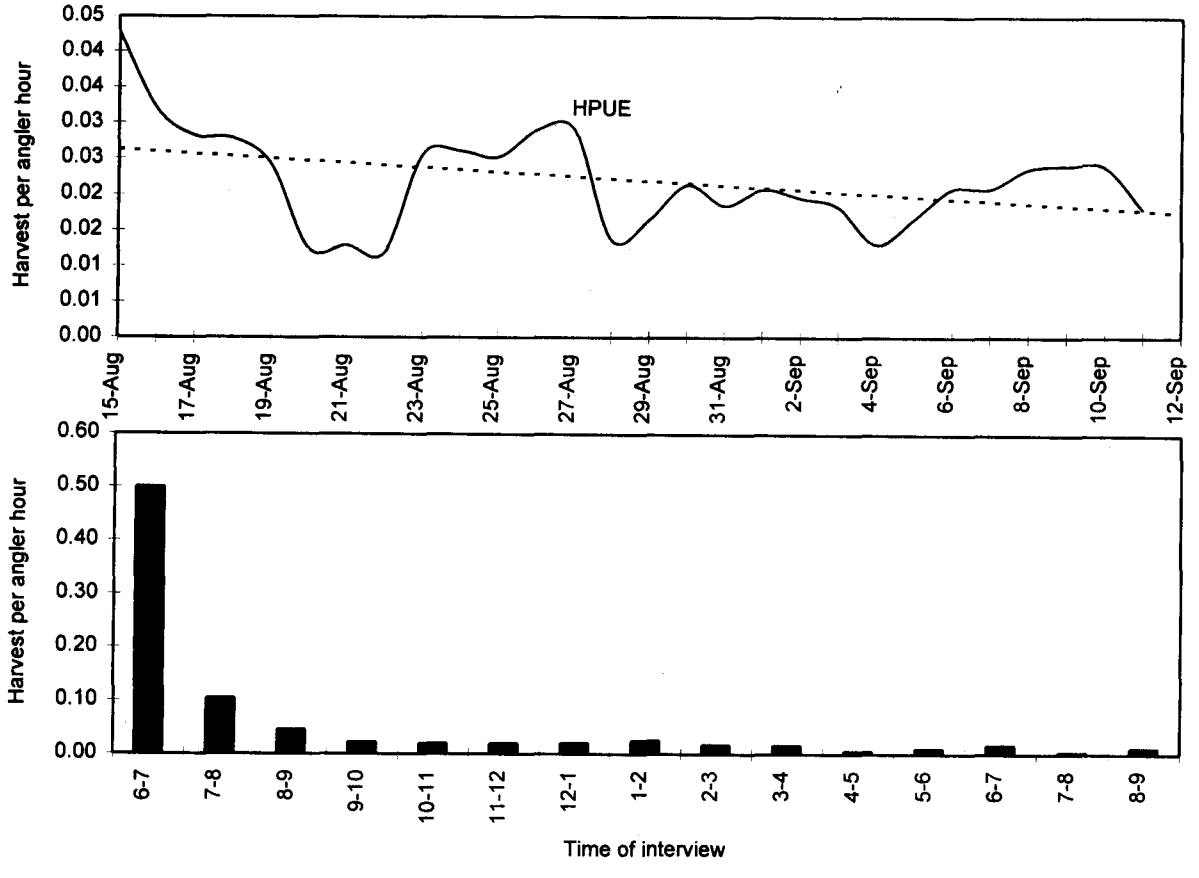


Fig. 13. Mabel Lake harvest per angler hour (HPUE): average daily HPUE; and average HPUE by time time of interview.

adults, with a much higher harvest of 468 in 1994. The higher estimates in 1994 may have reflected high water temperatures in the lower Shuswap River which caused fish to delay in the lake; consequently, higher abundance may have attracted more angler effort.

The diel effort pattern in Mabel Lake was bimodal with morning (9 a.m.) and evening (7 p.m.) peaks (Fig. 12). Unlike the river fishery, however, effort peaked two hours later in the morning, did not occur 24-hours per day and was low during the hours of darkness, probably due to boat safety concerns. The most effective time of the day to fish (approximated by an hourly stratification of HPUE by time of interview) was in the early morning before 9 a.m. (Fig. 13). Success was low and relatively constant for the remainder of the day.

Mabel Lake anglers fished entirely from boats, most of which fished within 2 km of the lake outlet where hydroacoustic readings indicated that chinook abundance was highest; about 10% of the anglers fished in other parts of the lake. Because these anglers were not included in the boat counts, effort was estimated with a negative bias. Anecdotal reports suggest that angler success in other parts of the lake was poor; therefore, this bias was unlikely to have introduced a similar bias in the harvest estimate.

Anglers accessed the fishery from boat launch ramps at the lake outlet and at a resort north of the lake outlet (Fig. 2), and from cabins along the lake shore. Most of the anglers fished for chinook, although the proportion which fished for other species (10%) was higher than in the lower Shuswap River. The species composition of the catch was more diverse than in the river; kokanee, Dolly Varden and lake trout were harvested exclusively in the lake. Over 98% of the anglers used lures, and all intended to harvest, rather than catch and release, a chinook.

Less than 10% of the interviewed anglers had harvested a chinook adult during their trip, and less than 30% had harvested at least one chinook adult during the season. Despite the presence of tourists at the resort, about 70% of the anglers had fished the lake within two weeks of the interview. This suggests that the nonlocal anglers stayed for extended periods and, like the locals, fished frequently. The catch rate was lower at the resort that at the river landing, however, suggesting that they were less knowledgable of the fishery.

Angler success in the Mabel Lake fishery, although variable (Fig. 13), was generally high when the fishery opened and declined for the balance of the season. The high early season success may have resulted from the limited initial exposure of the fish to angling effort, as was observed in the lower Shuswap fishery. It also may reflect the presence in the fishing area of late migrant middle Shuswap chinook. The subsequent pattern of declining HPUE complements the increasing HPUE observed later in the season in the lower Shuswap fishery. Both were caused by the progressive movement of fish from the lake holding areas to the river spawning grounds.

Middle Shuswap River

The middle Shuswap fishery initially reopened in 1986, but was again closed when that year's assessment showed that the fishery had a capacity in excess of that which the stock could support. Between 1986 and 1990, enhancement was used to accelerate the rebuilding of this stock to a fishable level. Escapement increased five-fold (Table 5; Appendix 15, page 90), permitting the reopening of the fishery in 1991. Subsequent annual angler effort averaged 6,600 hours or about 570 hours per open day (Fig. 14), with rod counts of up to 114 during the peak activity period. Harvest was variable, averaging 293 chinook adults per year. These estimates are from a roving survey in 1986 and hybrid surveys in 1991-1994. With the exception of 1986, therefore, comparable assessment methods were used each year.

Angler effort has been stable at about 5,500 hours per year in three of the last four years. Interestingly, the average effort per day declined over this period, from about 800 hours in 1991 to 450 hours in 1994 (Fig. 14). This may reflect the effect on a stable angler pool of a doubling of the length of the open period.

As in the lower Shuswap fishery, middle Shuswap anglers fished at all hours of the day (Fig. 14). The diel effort profile was somewhat bimodal, with a large peak in the early morning (6 a.m.) and a smaller peak in the early evening (7-8 p.m.). This pattern reflected an angler preference to fish before and after work, to avoid the heat of the day, and to leave the river before mid-day when the catch rate was low. The absence of a distinct evening peak probably reflected the low HPUE after 4 p.m. (Fig. 15). The most effective fishing time was before 11 a.m. This suggests that a significant proportion of the harvest occurred early in the morning; however, the critical period could not be identified more precisely because the actual time of harvest was not recorded and some anglers may have continued fishing after they had harvested a chinook.

Middle Shuswap anglers tended to cluster at a small number of sites in the upper river; the canyon accounted for about one-third of the effort. There was virtually no angling in the lower 13 km (Fig. 14) where the river is slow and moves through a series of tortuous meanders. The spatial distribution of harvest was similar to that of the anglers (Figs. 14, 15), although the highest HPUE occurred well downstream from the concentrated effort in the canyon. These patterns reflected the tendency of returning chinook to migrate to the upper river where they held in pools before moving onto the spawning grounds. Although this pattern was observed in most years, it was dependent on river conditions. In 1992 and 1994, for example, most of the run remained in Mabel Lake during extended periods of hot weather because river water temperatures were high and water levels were low.

Most middle Shuswap anglers accessed the river by road, although there was also limited use of boats. Virtually all of the anglers fished for chinook salmon, and most intended to harvest, rather than catch and release, a fish. About 40% of the anglers used bait, a quarter used lures and a third used baited lures; catch rate was generally higher among those using bait, then lures. About 15% of the interviewed anglers had harvested a chinook adult during their trip and, when interviewed in the last week of the fishery,

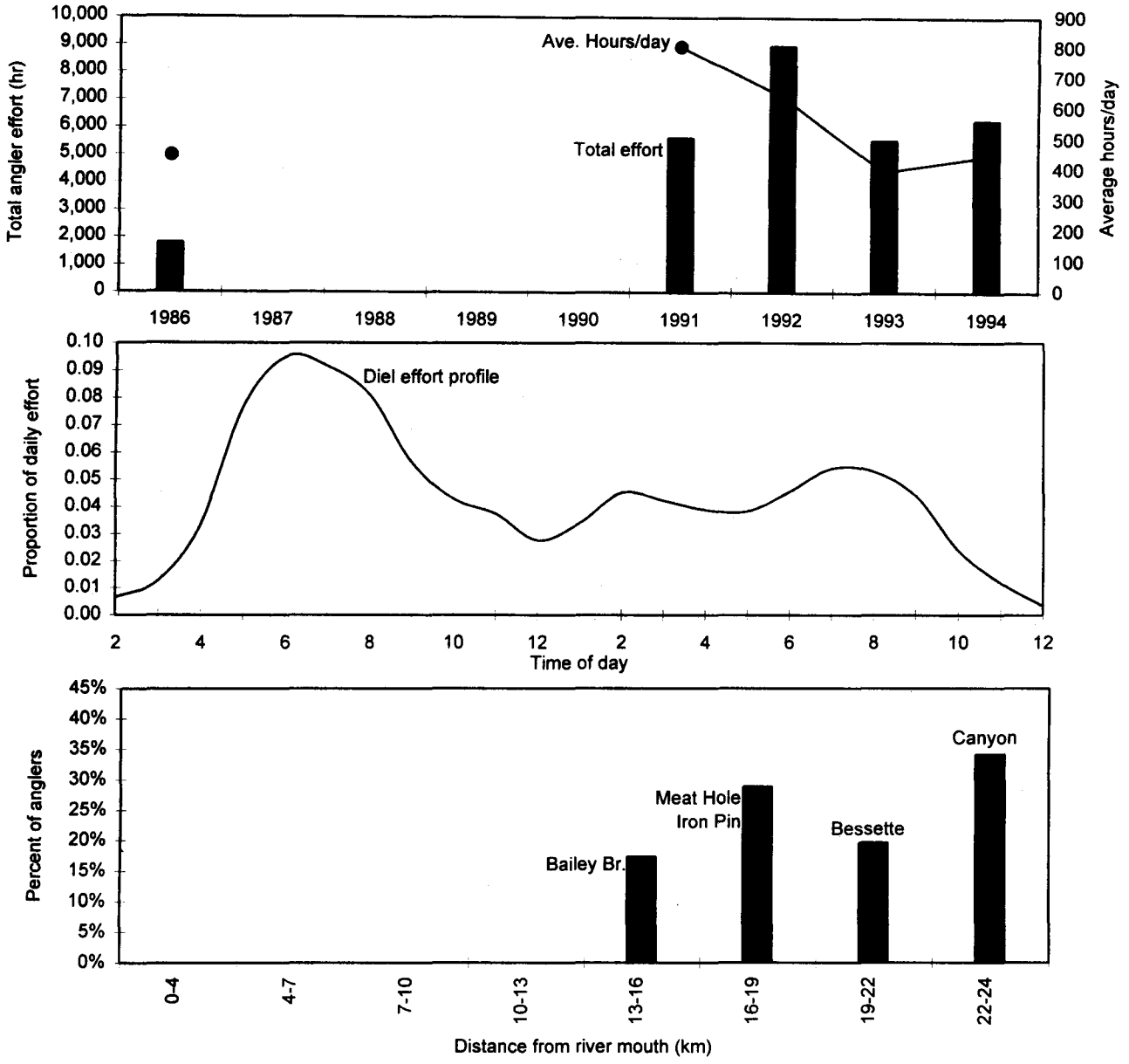


Fig. 14. Middle Shuswap River angler effort: annual total and average per day; average diel profile; and average spatial distribution of anglers.

26% had harvested at least one during the season. The similarity between the daily and seasonal responses reflects the short duration of the fishery. About half of the anglers fished the river more than once during the season, i.e. on at least a weekly basis.

Middle Shuswap chinook were highly catchable, as indicated by the average HPUE, harvest rate and catchability coefficients (Table 5). In fact, in the years when cool river temperatures permitted the entire stock to hold in the river, catchability rivalled that of the Thompson fishery, the most effective of the upper Fraser fisheries. Variable environmental conditions in the smaller middle Shuswap River, however, caused wide fluctuations in the annual catchability of this stock. Despite the environmental factors, there is evidence to suggest that high catchability is an inherent trait of this stock. In 1986, fisheries were opened on middle Shuswap chinook in both the lower and middle Shuswap rivers. Although catchability was lower in the former, it was much higher than that observed in a fishery on the

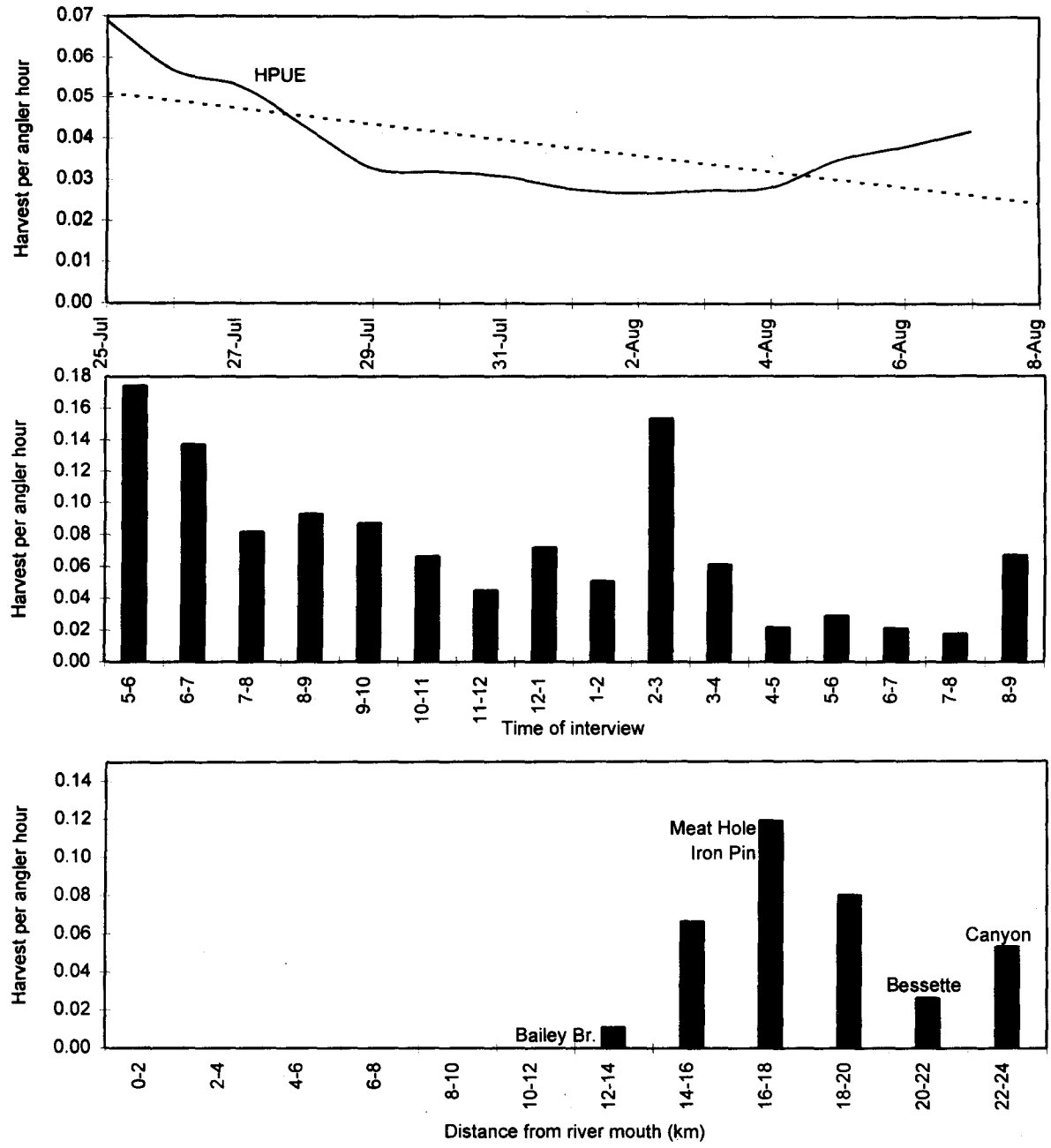


Fig. 15. Middle Shuswap River harvest per angler hour (HPUE): average daily HPUE; average HPUE by time of interview; and average spatial distribution.

lower Shuswap stock conducted later that year (Schubert 1988). Angler success in the middle Shuswap fishery was initially high, declined for two weeks, then increased at the end of the season (Fig. 15). As in the lower Shuswap, the decline in success following the opening may have reflected the cumulative impact of the prolonged exposure of the fish to continuous angling effort. These fish may be more susceptible to such stress because fish densities can be high in the relatively short section of the upper river where they appear to hold before moving to the spawning grounds.

Thompson River

The Thompson River chinook sport fishery reopened in 1988 and, although small in terms of

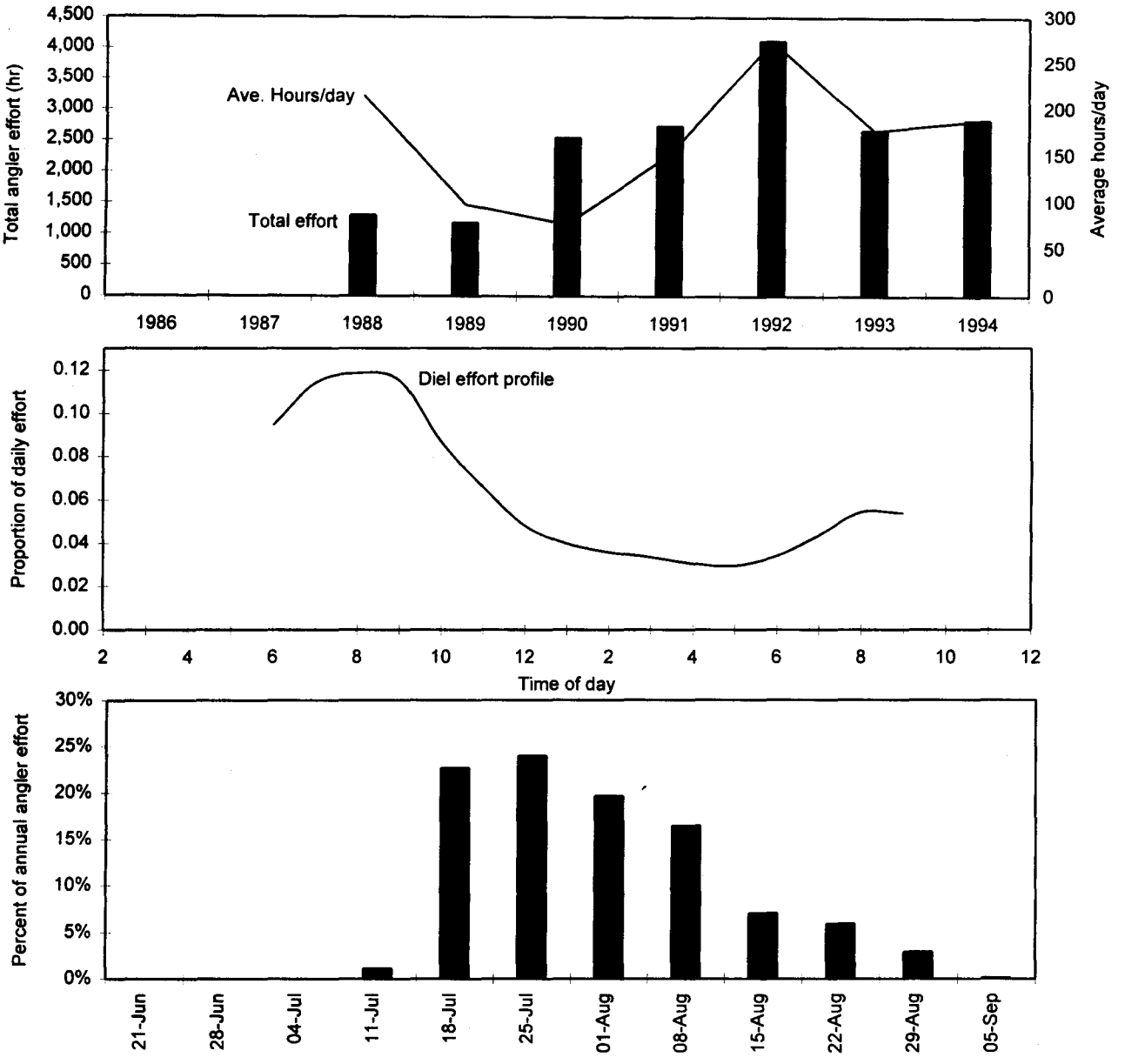


Fig. 16. Thompson River (Spences Bridge) angler effort: annual total and average per day; average diel profile; and weekly proportion of the annual total.

total angler effort, has been consistently among the most effective of the upper Fraser fisheries in harvest rate, harvest per angler hour and catchability (Table 5). Annual angler effort averaged 2,500 hours or about 170 hours per open day (Fig. 16), with rod counts of up to 75 during the peak activity period. Harvest averaged 200 chinook adults, and has tended to increase since the fishery opened (Table 5; Appendix 15, page 82). All of these figures are complete counts from a full census of the fishery.

Although a number of Thompson River system stocks are present in the open area during the fishery, coded wire tag recoveries and fish age and morphology samples indicate that the harvest consisted almost entirely of Nicola chinook. Nicola chinook return to the Fraser River in May and June and migrate to the Thompson River where they hold until August. While holding in the Thompson River, these fish are considerably more vulnerable to harvest than other Thompson stocks which actively migrate through

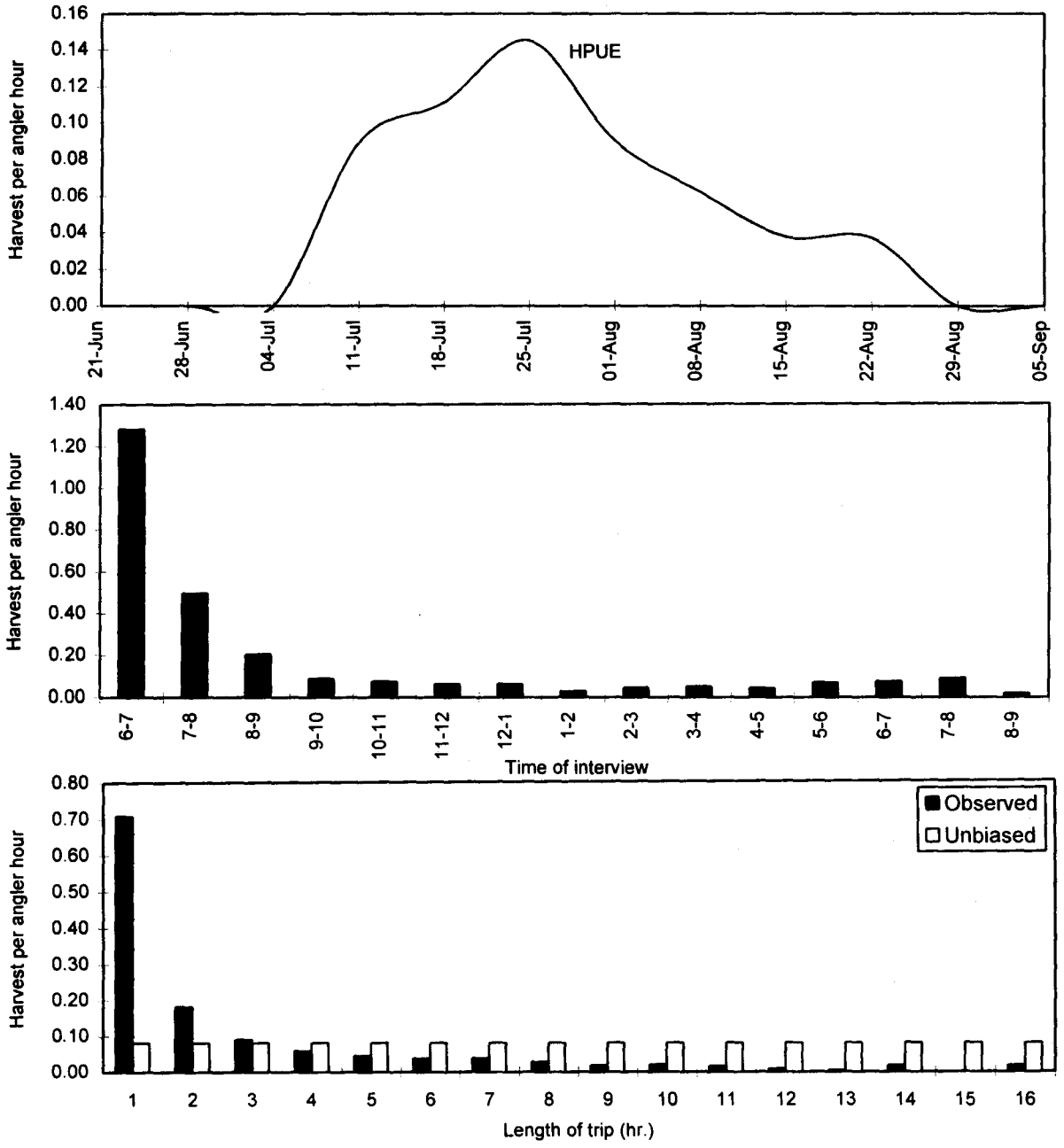


Fig. 17. Thompson River (Spences Bridge) harvest per angler hour (HPUE): average daily HPUE; average HPUE by time of interview; and average HPUE by trip duration.

the open area. In August, Nicola chinook migrate from the Thompson to the Nicola River spawning grounds. This migration is largely complete by early September.

Annual angler effort in the Thompson River fishery was mediated by restrictions to the size of the open area and the duration of the season. These regulations were intended to facilitate a complete census and to limit harvest to the harvest ceiling (Table 4). The area restriction effectively controlled the maximum daily effort because the open area included only two major fishing sites, immediately downstream from the Nicola River and on the shore opposite the Nicola confluence. Despite crowding at these sites, very few anglers fished in the short section downstream, or upstream when the river was

opened as far as Martel in 1992 (Fig. 3). Site availability, therefore, will likely constrain the maximum angler effort to about 400 hours per day unless additional sites are opened well downstream from the present area. Because virtually all of the sites were occupied during the openings, the restriction of the number of days open each week was highly effective in controlling annual effort, especially during the most effective fishing period between early July and early August (Fig. 17). Angler effort would likely increase in direct proportion to the number of open days if this regulation was relaxed.

The diel effort profile in the Thompson was unique among the upper Fraser fisheries because angling was restricted by regulation to 6 a.m. to 9 p.m. (Fig. 16). The profile was somewhat bimodal, with a large peak in the morning (7-9 a.m.) and a smaller peak in the evening (8 p.m.). Although this pattern may have reflected an angler preference to fish before and after work and to avoid the heat of the day, the overriding motivation was the very high catch rate shortly after the daily opening at 6 a.m. (Fig. 17). This also resulted in significantly higher catch rates among anglers fishing for short trips because successful anglers tended to leave the fishery after filling their daily bag limit. The bottom graph in Figure 17, which stratifies HPUE by trip length, demonstrates the pattern observed every year in this fishery (black bars) relative to the unbiased pattern (white bars) which occurs when catch rate is independent of trip length. That this basic assumption was consistently violated means that the Thompson fishery cannot be assessed using a roving survey. Future assessments must be based on information provided by complete fishing trip interviews.

Angling in the Thompson River was ineffective until river flows receded in early July and water clarity improved. Effort increased sharply in mid July (Fig. 16), with about a quarter of the seasonal effort occurring in each of the subsequent three weeks. Catch rates showed a coincidental pattern (Fig. 17), with both declining through August as the fish migrated into the Nicola River.

All of the anglers accessed the river by road, and virtually all fished for chinook salmon. Unlike other upper Fraser fisheries, there was a substantial number of catch and release anglers, with an average release of over 20% of the landed catch. This was especially true in 1994 when an adipose-clip-only fishery was implemented to reduce the catch rate after the harvest ceiling was reached in the first week of the fishery. In other years, it reflected the very high catch rate in this fishery, especially early in the morning. Some anglers who had harvested a chinook adult shortly after the daily opening did not wish to quit fishing for the day; rather, they continued catch and release fishing for several hours. About 80% of the anglers used bait, and 10% each used lures or baited lures. Catch rate was similar among anglers using bait and lures, but tended to be higher among the latter. About a third of the interviewed anglers had harvested a chinook adult during their trip, the highest success rate among the upper Fraser fisheries. In comparison, less than 10% of the lower Shuswap and Mabel Lake anglers and 15% of the middle Shuswap anglers had harvested at least one chinook per trip. When interviewed in the last week of the fishery, 45% of the Thompson anglers had harvested at least one chinook adult during the season. The similarity between the daily and seasonal responses suggests that the proportion of nonlocal anglers may have been higher in this fishery than in other upper Fraser fisheries. That there was an infusion of new anglers into the fishery as the season progressed is supported by two other observations. First, the weekly proportion of the anglers who had not yet harvested a chinook adult actually increased during the season (Fig. 5). This pattern was observed most years and was unique to the Thompson fishery. Second, only about a half of the anglers had fished within two weeks of the interview, which was among the lowest average proportion of repeat anglers in the upper Fraser fisheries.

RECOMMENDATIONS

1. In 1986, the Fraser River Division (FRD) developed a set of realistic and attainable management objectives for the upper Fraser River chinook sport fisheries. These objectives were addressed by a set of rules which determined when a fishery could open and how it would be controlled. More recently, however, the management of these fisheries has become less risk averse and the rules under which they are managed have become less well defined. It is recommended, therefore, that the FRD prepare an explicit statement of objectives which update the 1986 criteria

and incorporate the following five points identified in this report:

- The rebuilding status of each stock must be reevaluated annually, and the results of this evaluation must then play a preeminent role in determining whether the fishery on that stock will open the following year. If fisheries continue on stocks classified as *Not Rebuilding*, then the rationale for this decision must be explicitly described in an FRD policy statement;
- The terminal chinook fisheries (sport or other) should be limited to a maximum harvest rate of 5% until the management of downstream fisheries changes from the *status quo*. Under *status quo* management, terminal harvest rates in excess of 5% could have a cumulative impact which would be detrimental to the rebuilding status of most stocks;
- Mangers must avoid inseason adjustments to the harvest ceilings if harvest rates in excess of 5% are to be avoided. If greater management flexibility is required, then reliable inseason abundance indicators must be developed on a fishery specific basis;
- Managers should avoid opening new fisheries on stocks with highly variable escapements. If such fisheries are opened, either an inseason estimate of abundance must be available or the ceiling must be set at a level which will protect the stock at its weakest level of abundance;
- Enhancement is recommended for stocks where the incremental enhanced return will measurably improve stock status, and for stocks subject to intensive terminal fisheries if the incremental return will reduce management risk.

2. In 1986, the FRD developed an assessment policy to help determine whether the management objectives for the upper Fraser chinook sport fisheries had been achieved. The Department should reaffirm its commitment (including identifying a budget) to the three components of that policy:

- All new fisheries must be assessed in their first year, and until effort and catch rates stabilize;
- There must be ongoing creel surveys in the largest and most effective fisheries;
- The less effective fisheries with low, stable effort and harvest can be assessed in most years by fishery officers using subjective techniques; however, creel surveys should be conducted every three to five years to document fishery changes.

3. Creel surveys additional to the four currently conducted in the lower and middle Shuswap and Thompson rivers and Mabel Lake are recommended in the following areas:

- Fishery performance data should be updated in three fisheries which have not been surveyed for up to eight years: in the Bowron, Clearwater and South Thompson rivers;
- Additional funds are required for the middle Shuswap River survey to permit the fishery to expand from two to four weeks. This recommendation is based on three points identified in this report: surplus returns are available for harvest; an expanded open period would improve the precision of the catch and effort estimates; and increased harvest in the middle Shuswap fishery would make the monthly bag limit more effective in regulating harvest in the lower Shuswap fishery.

It is further recommended that funds be identified to permit the assessment on a rotational basis of all of the upper Fraser fisheries every three to five years.

4. The investigation of alternate creel survey methods such as the access-intercept technique is encouraged, especially for use as an alternative to roving surveys; however, the four ongoing hybrid or access point surveys or censuses should be continued because these study types: a) address the need for continuity in the established catch and effort data base; and b) are amenable to the generation of the inseason harvest estimates required by the managers.

5. Estimation precision is at or near acceptable levels in most of the upper Fraser studies; however, additional improvements may be possible through a modification of the sampling effort allocation and stratification strategies. Simulation studies are recommended to determine the most appropriate strategy for each fishery.

6. Fishing effort should continue to be estimated in angler hour units. Angler day or trip units should be avoided for two reasons: a) this unit

represents an amount of effort which is inherently variable, making difficult any realistic comparison of effort among fisheries, or areas or periods within a fishery; and b) there remain unresolved problems in the derivation of unbiased trip length estimates.

7. A monthly bag limit implemented in the Shuswap system in 1991-1994 was ineffective in controlling total harvest or the distribution of harvest among anglers. The utility of this regulation can be improved by: a) reducing the bag limit or expanding its effective period to cover the entire duration the three Shuswap fisheries; b) expanding the middle Shuswap opening to increase the monthly bags in that fishery, thereby reducing effort in the lower Shuswap; or c) improving angler compliance by redirecting enforcement effort in years when the catch rate is high. The monthly bag limits in the North and South Thompson systems were also unlikely to have been effective because catch rates in those fisheries were low. Similar recommendations apply in those areas.

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Appendices

Appendix 1a. Interview responses by week at Chuck's Pool in the 1994 lower Shuswap River chinook sport fishery.

	Week ending				
	21-Aug	28-Aug	4-Sep	11-Sep	Total
Number of Interviews	132	100	132	120	484
Mean Angler Day Length (hr.)					
- All anglers	4.4	4.3	4.2	5.0	4.5
- Complete trip interviews					
Number	54	54	88	73	269
Hours	3.1	2.9	3.5	4.1	3.5
- Incomplete trip interviews					
Number	78	46	44	47	215
Hours	5.3	6.0	5.7	6.5	5.8
Mean number of anglers per party	2.1	1.9	2.7	2.1	2.1
Target Species					
- Chinook	130	97	131	113	471
- Rainbow	2	0	0	3	5
Harvested Catch					
- Chinook adult	8	9	14	22	53
- Chinook jack	2	0	0	0	2
- Rainbow	1	0	0	0	1
Released Catch					
- Chinook adult	1	2	0	9	12
Inspection of Catch					
- Number	1	1	0	2	4
- Number correct	1	1	-	2	4
Gear					
- Bait	36	22	33	48	139
- Lure	46	49	48	34	177
- Bait/Lure	46	29	51	37	163
- Fly	4	0	0	0	4
Previous lower Shuswap River Angling a					
- Had not fished chinook previously	71	27	26	26	150
- Fished chinook previously	61	73	106	94	334
- Mean angler day length	4.5	4.9	4.3	5.0	4.7
- Chinook adult harvest:	12	14	22	15	63
Harvest to Date; Number of Anglers who had harvested:					
- 0 Chinook adults	111	64	70	61	-
- 1 Chinook adult	16	22	28	18	-
- 2 Chinook adults	1	8	10	13	-
- 3 Chinook adults	3	1	6	5	-
- 4 Chinook adults	1	5	5	5	-
- 5 Chinook adults	0	0	5	2	-
- 6 Chinook adults	0	0	5	7	-
- 7 Chinook adults	0	0	1	3	-
- 8 Chinook adults	0	0	0	2	-
- 9 Chinook adults	0	0	1	2	-
- 10 Chinook adults	0	0	1	2	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 1b. Interview responses by week at Log Dump Pool in the 1994 lower Shuswap River chinook sport fishery.

	Week ending				
	21-Aug	28-Aug	4-Sep	11-Sep	Total
Number of Interviews	84	54	50	29	217
Mean Angler Day Length (hr.)					
- All anglers	3.4	5.3	4.6	5.7	4.8
- Complete trip interviews					
Number	39	15	27	23	104
Hours	3.8	2.9	4.3	4.8	4.0
- Incomplete trip interviews					
Number	45	39	23	6	113
Hours	4.9	6.4	5.0	9.9	5.8
Mean number of anglers per party	2.3	2.1	2.2	1.9	2.2
Target Species					
- Chinook	81	54	50	29	214
Harvested Catch					
- Chinook adult	1	1	9	2	13
Released Catch					
- Chinook adult	0	1	4	1	6
Inspection of Catch					
- Number	1	0	3	1	5
- Number correct	1	-	3	1	5
Gear					
- Bait	49	20	23	6	98
- Lure	26	25	18	20	89
- Bait/Lure	0	5	7	2	14
- Fly	0	0	0	0	0
Previous lower Shuswap River Angling a					
- Had not fished chinook previously	23	29	18	14	84
- Fished chinook previously	0	25	32	15	72
- Mean angler day length	-	6.9	5.5	6.8	6.0
- Chinook adult harvest:	-	2	5	3	10
Harvest to Date; Number of Anglers who had harvested:					
- 0 Chinook adults	82	48	38	26	-
- 1 Chinook adult	2	4	8	1	-
- 2 Chinook adults	0	0	3	1	-
- 3 Chinook adults	0	0	1	0	-
- 4 Chinook adults	0	2	0	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 1c. Interview responses by week in the roving survey of the 1994 lower Shuswap River chinook sport fishery.

	Week ending				
	21-Aug	28-Aug	4-Sep	11-Sep	Total
Number of Interviews	131	130	179	147	587
Mean Angler Day Length (hr.)					
- All anglers	5.8	5.9	6.2	6.8	6.2
- Complete trip interviews					
Number	22	17	8	18	65
Hours	4.0	5.0	1.6	4.1	4.0
- Incomplete trip interviews					
Number	109	113	171	129	522
Hours	6.1	6.0	6.4	7.1	6.4
Mean number of anglers per party	2.1	1.9	1.7	1.6	1.8
Target Species					
- Chinook	127	125	179	146	577
- Rainbow	3	3	0	0	6
Harvested Catch					
- Chinook adult	12	10	12	31	65
- Chinook adult, AFC	1	0	0	0	1
- Squawfish	4	0	0	0	4
Released Catch					
- Chinook adult	1	0	1	1	3
- Rainbow	1	0	0	0	1
- Squawfish	0	0	2	0	2
Inspection of Catch					
- Number	0	5	3	29	37
- Number correct	-	5	3	29	37
Gear					
- Bait	52	45	70	70	237
- Lure	72	75	106	69	322
- Bait/Lure	3	10	0	5	18
- Fly	3	0	0	0	3
Previous middle Shuswap River Angling a					
- Had not fished chinook previously	70	20	29	16	135
- Fished chinook previously	61	110	150	131	452
- Mean angler day length	5.7	5.4	5.3	5.3	5.4
- Chinook adult harvest:	11	17	37	29	94
Harvest to Date; Number of Anglers who had harvested:					
- 0 Chinook adults	110	105	104	85	-
- 1 Chinook adult	16	10	30	25	-
- 2 Chinook adults	2	5	20	9	-
- 3 Chinook adults	2	7	9	9	-
- 4 Chinook adults	1	3	5	9	-
- 5 Chinook adults	0	0	6	3	-
- 6 Chinook adults	0	0	3	2	-
- 7 Chinook adults	0	0	2	3	-
- 8 Chinook adults	0	0	0	1	-
- 9 Chinook adults	0	0	0	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 2. Daily angler counts by area in the 1994 lower Shuswap River chinook sport fishery.

Date	Day of week	Time	Grinrod Bridge to Ashton Creek Bridge a				Ashton Creek Bridge to Mabel Lake b						Lower Shuswap River total
			2	3	4	Total	1	2	3	4	5	Total	
15-Aug	Mon	1835 to 2012	11	15	0	26	8	13	3	0	26	50	76
16-Aug	Tue	1830 to 1930	5	17	0	22	1	3	0	0	20	24	46
17-Aug	Wed	627 to 815	2	1	0	3	10	10	1	2	21	44	47
20-Aug	Sat	637 to 800	7	1	2	10	7	11	2	3	39	62	72
21-Aug	Sun	1838 to 1959	12	18	9	39	3	24	2	0	14	43	82
22-Aug	Mon	1830 to 2016	4	3	0	7	2	16	0	0	18	36	43
23-Aug	Tue	629 to 804	5	3	0	8	2	9	0	1	25	37	45
26-Aug	Fri	635 to 758	4	4	3	11	4	3	1	4	19	31	42
27-Aug	Sat	1832 to 1945	30	18	8	56	9	17	1	0	32	59	115
28-Aug	Sun	634 to 745	9	1	3	13	7	23	4	0	26	60	73
31-Aug	Wed	1835 to 2012	25	17	4	46	10	12	5	5	26	58	104
1-Sep	Thu	632 to 825	5	2	0	7	12	5	4	1	18	40	47
2-Sep	Fri	1830 to 1947	17	26	17	60	4	10	0	3	21	38	98
3-Sep	Sat	633 to 805	6	3	2	11	4	8	3	0	34	49	60
4-Sep	Sun	1827 to 2005	24	26	20	70	7	14	3	2	34	60	130
5-Sep	Mon c	625 to 805	4	1	2	7	4	9	6	1	46	66	73
8-Sep	Thu	631 to 810	1	3	1	5	5	11	4	2	25	47	52
9-Sep	Fri	1821 to 1920	13	8	2	23	5	4	3	0	12	24	47
10-Sep	Sat	626 to 802	8	5	1	14	5	9	4	0	24	42	56
11-Sep	Sun	1831 to 2000	25	17	5	47	7	10	2	0	14	33	80
Weekday:		Mean (a.m.)	3	3	1	7	7	8	2	2	22	40	47
		Mean (p.m.)	13	14	4	31	5	10	2	1	21	38	69
Weekend/holiday		Mean (a.m.)	7	2	2	11	5	12	4	1	34	56	67
		Mean (p.m.)	23	20	11	53	7	16	2	1	24	49	102

a. Areas are:
- 2 - above Mara Bridge to Grinrod Bridge;
- 3 - above Grinrod Bridge to Enderby Bridge;
- 4 - above Enderby Bridge to Ashton Creek (Trinity Valley) Bridge.

b. Areas are:
- 1 - above Ashton Creek (Trinity Valley) Bridge to Fall Creek;
- 2 - above Fall Creek to Cooke Creek;
- 3 - above Cooke Creek to Delorne Creek;
- 4 - above Delorne Creek to 300 m below Skookumchuck;
- 5 - below Skookumchuck to Mabel Lake.

c. Statutory holiday.

Appendix 3. Mean proportion of the daily angler effort per hour in the 1994 sport fisheries in the lower and middle Shuswap and Thompson rivers and Mabel Lake.

							Thompson River Chinook Fishery			
	Lower Shuswap River		Mabel Lake		Middle Shuswap River		Nicola River side		CNR side	
Hour	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
100	0.002	0.000	0.000	0.001	0.004	0.000				
200	0.003	0.001	0.000	0.001	0.004	0.000				
300	0.011	0.005	0.003	0.002	0.020	0.003				
400	0.033	0.025	0.010	0.006	0.052	0.027				
500	0.066	0.053	0.021	0.023	0.087	0.101				
600	0.075	0.083	0.040	0.058	0.094	0.123	0.082	0.102	0.109	0.136
700	0.091	0.079	0.057	0.071	0.072	0.080	0.099	0.113	0.147	0.151
800	0.053	0.063	0.053	0.083	0.038	0.058	0.133	0.106	0.192	0.113
900	0.039	0.048	0.080	0.097	0.031	0.045	0.116	0.093	0.179	0.104
1000	0.032	0.041	0.072	0.065	0.028	0.025	0.084	0.085	0.096	0.062
1100	0.030	0.042	0.061	0.049	0.018	0.029	0.073	0.080	0.032	0.037
1200	0.031	0.041	0.045	0.040	0.013	0.025	0.045	0.046	0.032	0.035
1300	0.033	0.032	0.029	0.040	0.035	0.031	0.045	0.040	0.013	0.021
1400	0.053	0.035	0.051	0.045	0.056	0.062	0.036	0.040	0.013	0.028
1500	0.052	0.034	0.047	0.051	0.056	0.059	0.025	0.043	0.032	0.023
1600	0.040	0.043	0.055	0.060	0.034	0.028	0.027	0.032	0.045	0.019
1700	0.040	0.043	0.076	0.064	0.056	0.028	0.029	0.036	0.026	0.033
1800	0.056	0.063	0.090	0.069	0.061	0.046	0.032	0.039	0.026	0.049
1900	0.064	0.081	0.098	0.092	0.068	0.043	0.057	0.038	0.032	0.060
2000	0.071	0.082	0.075	0.058	0.068	0.046	0.056	0.055	0.013	0.057
2100	0.062	0.059	0.036	0.017	0.054	0.065	0.061	0.050	0.013	0.072
2200	0.035	0.028	0.000	0.003	0.030	0.040				
2300	0.021	0.014	0.000	0.001	0.016	0.025				
2400	0.007	0.004	0.000	0.000	0.004	0.012				

Appendix 4. Daily catch (harvest and release) per angler hour, by species, in the 1994 lower Shuswap River chinook sport fishery.

	Chuck's Pool			Log Dump Pool	Roving survey		
Date	Chinook adult	Chinook jack	Rainbow	Chinook adult	Chinook adult	Rainbow	Squaw-fish
15-Aug	0.056	0.000	0.007	0.000	0.017	0.017	0.000
16-Aug	0.000	0.016	0.000	0.000	0.019	0.000	0.000
17-Aug	0.013	0.013	0.000	0.061	0.035	0.000	0.035
20-Aug	0.000	0.000	0.000	0.000	0.053	0.000	0.000
21-Aug	0.000	0.000	0.000	0.000	0.039	0.000	0.013
22-Aug	0.000	0.000	0.000	0.026	0.000	0.000	0.000
23-Aug	0.033	0.000	0.000	0.000	0.000	0.000	0.000
26-Aug	0.059	0.000	0.000	0.069	0.042	0.000	0.000
27-Aug	0.056	0.000	0.000	0.000	0.015	0.000	0.000
28-Aug	0.000	0.000	0.000	0.000	0.052	0.000	0.000
31-Aug	0.000	0.000	0.000	0.089	0.038	0.000	0.000
1-Sep	0.053	0.000	0.000	0.000	0.039	0.000	0.000
2-Sep	0.000	0.000	0.000	0.034	0.000	0.000	0.023
3-Sep	0.040	0.000	0.000	0.074	0.000	0.000	0.000
4-Sep	0.027	0.000	0.000	0.111	0.028	0.000	0.000
5-Sep	0.049	0.000	0.000	0.000	0.013	0.000	0.000
8-Sep	0.091	0.000	0.000	0.000	0.126	0.000	0.000
9-Sep	0.119	0.000	0.000	0.148	0.047	0.000	0.000
10-Sep	0.076	0.000	0.000	0.000	0.035	0.000	0.000
11-Sep	0.018	0.000	0.000	0.017	0.043	0.000	0.000
Total HPUE	0.0342	0.0013	0.0006	0.0182	0.0341	0.0000	0.0021
Total RPUE	0.0077	0.0000	0.0000	0.0084	0.0016	0.0005	0.0010

Appendix 5a. Interview responses by week at the Mabel Lake outlet in the 1994 Mabel Lake chinook sport fishery.

	Week ending				
	21-Aug	28-Aug	4-Sep	11-Sep	Total
Number of Interviews	163	129	159	102	553
Mean Angler Day Length (hr.)					
- All anglers	5.3	4.9	5.4	5.0	5.2
- Complete trip interviews					
Number	113	102	97	77	389
Hours	4.8	4.5	4.5	4.6	4.6
- Incomplete trip interviews					
Number	50	27	62	25	164
Hours	6.3	6.7	6.8	6.3	6.6
Mean number of anglers per party	1.9	2.0	2.0	1.6	1.9
Target Species					
- Chinook	158	123	148	102	531
- Rainbow	3	3	9	0	15
- Kokanee	0	0	1	0	1
Harvested Catch					
- Chinook adult	45	9	27	16	97
- Chinook jack	0	1	0	0	1
- Kokanee	0	1	0	0	1
- Rainbow	1	3	5	0	9
Released Catch					
- Chinook jack	2	0	0	0	2
- Rainbow	0	0	3	0	3
Inspection of Catch					
- Number	6	6	8	7	27
- Number correct	6	6	8	7	27
Gear					
- Bait	1	1	1	0	3
- Lure	155	120	150	102	527
- Bait/Lure	2	0	5	0	7
- Fly	0	0	0	0	0
Previous Mabel Lake Angling a					
- Had not fished chinook previously	95	34	40	23	192
- Fished chinook previously	67	95	119	79	360
- Mean angler day length	4.3	4.7	4.7	4.4	4.6
- Chinook adult harvest:	3.0	0	2	2	7
Harvest to Date; Number of Anglers who had harvested:					
- 0 Chinook adults	117	100	115	55	-
- 1 Chinook adult	21	14	16	11	-
- 2 Chinook adults	16	8	12	11	-
- 3 Chinook adults	6	5	5	11	-
- 4 Chinook adults	3	1	4	7	-
- 5 Chinook adults	0	0	0	5	-
- 6 Chinook adults	0	1	1	2	-
- 7 Chinook adults	0	0	3	0	-
- 8 Chinook adults	0	0	3	0	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 5b. Interview responses by week at the Mabel Lake Resort in the 1994 Mabel Lake chinook sport fishery.

	Week ending				
	21-Aug	28-Aug	4-Sep	11-Sep	Total
Number of Interviews	256	169	196	148	769
Mean Angler Day Length (hr.)					
- All anglers	5.0	5.7	5.1	5.6	5.3
- Complete trip interviews					
Number	127	62	158	89	436
Hours	3.8	4.4	4.4	4.7	4.3
- Incomplete trip interviews					
Number	129	107	38	59	333
Hours	6.2	6.5	8.2	7.1	6.7
Mean number of anglers per party	2.1	1.9	1.9	1.9	2.0
Target Species					
- Chinook	161	136	171	123	591
- Kokanee	0	0	5	0	5
- Anything	70	30	18	22	140
Harvested Catch					
- Chinook	25	10	16	19	70
- Rainbow	1	0	0	1	2
- Kokanee	1	2	6	2	11
- Dolly Varden	1	0	0	0	1
Released Catch					
- Coho	1	0	0	0	1
- Rainbow	0	0	0	1	1
- Kokanee	0	0	0	2	2
Inspection of Catch					
- Number	7	0	0	0	7
- Number correct	6	-	-	-	6
Gear					
- Bait	0	0	0	0	0
- Lure	234	165	191	145	735
- Bait/Lure	1	0	1	0	2
- Fly	1	1	1	2	5
Previous Mabel Lake Angling a					
- Had not fished chinook previously	75	25	43	26	169
- Fished chinook previously	70	144	153	120	487
- Mean angler day length	4.7	4.9	5.4	5.6	5.2
- Chinook adult harvest:	1	6	3	2	12
Harvest to Date; Number of Anglers who had harvested:					
- 0 Chinook adults	224	138	161	109	-
- 1 Chinook adult	23	19	15	17	-
- 2 Chinook adults	6	3	4	4	-
- 3 Chinook adults	1	3	3	6	-
- 4 Chinook adults	2	5	5	6	-
- 5 Chinook adults	0	1	6	4	-
- 6 Chinook adults	0	0	2	0	-
- 7 Chinook adults	0	0	0	0	-
- 8 Chinook adults	0	0	0	0	-
- 9 Chinook adults	0	0	0	1	-
- 10 Chinook adults	0	0	0	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 6. Daily boat counts and angler estimates in the 1994 Mabel Lake chinook sport fishery.

Date	Day of week	Time	Boat count a	Estimated number of rods b
15-Aug	Mon	7 p.m.	39	78
16-Aug	Tue	7 p.m.	19	38
17-Aug	Wed	9 a.m.	29	58
20-Aug	Sat	9 a.m.	49	98
21-Aug	Sun	7 p.m.	35	70
22-Aug	Mon	7 p.m.	27	54
23-Aug	Tue	9 a.m.	23	46
26-Aug	Fri	9 a.m.	9	18
27-Aug	Sat	7 p.m.	38	76
28-Aug	Sun	9 a.m.	28	56
31-Aug	Wed	7 p.m.	17	34
1-Sep	Thu	9 a.m.	6	12
2-Sep	Fri	7 p.m.	13	26
3-Sep	Sat	9 a.m.	23	46
4-Sep	Sun	7 p.m.	19	38
5-Sep	Mon c	9 a.m.	36	72
8-Sep	Thu	9 a.m.	18	36
9-Sep	Fri	7 p.m.	19	38
10-Sep	Sat	9 a.m.	26	52
11-Sep	Sun	7 p.m.	17	34
Mean	Weekday:	9 a.m.	17	34
		7 p.m.	22	45
	Weekend/holiday:	9 a.m.	32	65
		7 p.m.	27	55

a. Boats visible from shore; a small proportion of the boats were not visible.
b. From the average number of anglers per party (see Appendix 5).
c. Statutory holiday.

Appendix 7. Daily catch (harvest and release) per angler hour, by species, in the 1994 Mabel Lake chinook sport fishery.

	Mabel Lake outlet				Mabel Lake Resort				
Date	Chinook adult	Chinook jack	Rainbow	Kokanee	Chinook adult	Coho	Rainbow	Kokanee	Dolly Varden
15-Aug	0.040	0.006	0.006	0.000	0.051	0.000	0.005	0.005	0.000
16-Aug	0.149	0.021	0.000	0.000	0.014	0.007	0.000	0.000	0.000
17-Aug	0.244	0.000	0.000	0.000	0.058	0.000	0.000	0.000	0.000
20-Aug	0.028	0.000	0.000	0.000	0.024	0.000	0.000	0.000	0.000
21-Aug	0.028	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.004
22-Aug	0.048	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000
23-Aug	0.000	0.000	0.010	0.000	0.008	0.000	0.000	0.000	0.000
26-Aug	0.000	0.000	0.000	0.000	0.021	0.000	0.000	0.000	0.000
27-Aug	0.009	0.004	0.009	0.004	0.004	0.000	0.000	0.008	0.000
28-Aug	0.033	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000
31-Aug	0.022	0.000	0.077	0.000	0.028	0.000	0.000	0.000	0.000
1-Sep	0.072	0.000	0.000	0.000	0.045	0.000	0.000	0.000	0.000
2-Sep	0.037	0.000	0.000	0.000	0.004	0.000	0.000	0.009	0.000
3-Sep	0.047	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000
4-Sep	0.021	0.000	0.005	0.000	0.007	0.000	0.000	0.015	0.000
5-Sep	0.043	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000
8-Sep	0.031	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000
9-Sep	0.000	0.000	0.000	0.000	0.006	0.000	0.012	0.018	0.000
10-Sep	0.073	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.000
11-Sep	0.011	0.000	0.000	0.000	0.022	0.000	0.000	0.006	0.000
Total HPUE	0.0406	0.0004	0.0038	0.0004	0.0227	0.0000	0.0006	0.0036	0.0003
Total RPUE	0.0000	0.0008	0.0013	0.0013	0.0000	0.0003	0.0003	0.0006	0.0000

Appendix 8a. Interview responses by week at the Canyon Pool in the 1994 middle Shuswap River chinook sport fishery.

	Week ending		
	31-Jul	7-Aug	Total
Number of Interviews	50	91	141
Mean Angler Day Length (hr.)			
- All anglers	5.1	4.6	4.8
- Complete trip interviews			
Number	25	54	79
Hours	3.3	4.0	3.8
- Incomplete trip interviews			
Number	25	37	62
Hours	7.1	5.6	6.2
Mean number of anglers per party	2.2	2.6	2.4
Target Species			
- Chinook	50	89	139
Harvested Catch			
- Chinook adult	6	11	17
Released Catch			
- Chinook adult	1	0	1
Inspection of Catch			
- Number	6	10	16
- Number correct	6	10	16
Gear			
- Bait	15	24	39
- Lure	3	38	41
- Bait/Lure	32	24	56
- Fly	0	0	0
Previous middle Shuswap River Angling a			
- Had not fished chinook previously	31	36	67
- Fished chinook previously	19	55	74
- Mean angler day length	4.4	4.8	4.7
- Chinook adult harvest:	1	22	23
Harvest to Date; Number of Anglers who had harvested:			
- 0 Chinook adults	44	66	-
- 1 Chinook adult	5	18	-
- 2 Chinook adults	1	5	-
- 3 Chinook adults	0	1	-
- 4 Chinook adults	0	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 8b. Interview responses by week in the roving survey of the 1994 middle Shuswap River chinook sport fishery.

	Week ending		
	31-Jul	7-Aug	Total
Number of Interviews	101	53	154
Mean Angler Day Length (hr.)			
- All anglers	6.0	5.4	5.8
- Complete trip interviews			
Number	7	8	15
Hours	3.3	3.9	3.6
- Incomplete trip interviews			
Number	94	45	139
Hours	6.2	5.7	6.1
Mean number of anglers per party	2.2	2.5	2.3
Target Species			
- Chinook	96	50	146
- Rainbow	3	2	5
Harvested Catch			
- Chinook adult	4	1	5
- Chinook adult, AFC	1	1	2
Released Catch	0	0	0
Inspection of Catch			
- Number	5	0	5
- Number correct	5	-	5
Gear			
- Bait	29	11	40
- Lure	13	5	18
- Bait/Lure	56	34	90
- Fly	2	1	3
Previous middle Shuswap River Angling a			
- Had not fished chinook previously	69	10	79
- Fished chinook previously	32	43	75
- Mean angler day length	4.4	4.3	4.4
- Chinook adult harvest:	1	3	4
Harvest to Date; Number of Anglers who had harvested:			
- 0 Chinook adults	96	45	-
- 1 Chinook adult	5	7	-
- 2 Chinook adults	0	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 9. Daily angler counts by area in the 1994 middle Shuswap River chinook sport fishery.

Date	Day of week	Rod count start time	Below Bailey Bridge to above Poacher's Rock	Poacher's Rock to above the Iron Pin	Above the Iron Pin to the Canyon a	Total
25-Jul	Mon	7 p.m.	14	17	33	64
26-Jul	Tue	7 a.m.	8	15	21	44
27-Jul	Wed	7 p.m.	12	10	10	32
30-Jul	Sat	7 a.m.	1	7	15	23
31-Jul	Sun	7 p.m.	1	7	5	13
1-Aug	Mon b	7 a.m.	3	5	12	20
2-Aug	Tue	7 a.m.	0	0	10	10
5-Aug	Fri	7 p.m.	2	9	18	29
6-Aug	Sat	7 p.m.	7	8	10	25
7-Aug	Sun	7 a.m.	4	11	33	48
Weekdays:		Mean (a.m.)	4	8	16	27
		Mean (p.m.)	9	12	20	42
Weekends/holidays:		Mean (a.m.)	3	8	20	30
		Mean (p.m.)	4	8	8	19

a. Includes the Canyon Pool.
b. Statutory holiday.

Appendix 10. Daily catch (harvest and release) per angler hour, by species, in the 1994 middle Shuswap River chinook sport fishery.

Date	Canyon Pool chinook adult	Roving survey chinook adult
25-Jul	0.0380	0.0395
26-Jul	0.0174	0.0000
27-Jul	0.0000	0.0000
28-Jul	0.0816	0.0000
29-Jul	0.0488	0.0000
1-Aug	0.0465	0.0000
2-Aug	0.0364	0.0000
3-Aug	0.0000	0.0000
6-Aug	0.0326	0.0000
7-Aug	0.0625	0.0263
Total HPUE	0.0320	0.0199
Total RPUE	0.0019	0.0000

Appendix 11a. Interview responses by week on the east bank (Nicola River mouth) in the 1994 Thompson River (Spences Bridge) chinook sport fishery.

	Week ending					
	18-Jul	25-Jul	1-Aug	8-Aug	15-Aug	Total
Number of Interviews	165	110	84	87	47	493
Mean Angler Day Length (hr.)						
- All anglers	4.3	3.0	3.6	4.4	3.3	3.8
- Complete trip interviews						
Number	131	108	84	87	47	457
Hours	3.8	2.9	3.6	4.4	3.3	3.6
- Incomplete trip interviews						
Number	34	2	0	0	0	36
Hours	6.4	12.5	-	-	-	6.8
Mean number of anglers per party	2.3	2.3	2.3	2.4	2.0	2.3
Target Species						
- Chinook	160	110	84	87	47	488
- Steelhead	3	0	0	0	0	3
- Rainbow	1	0	0	0	0	1
Harvested Catch						
- Chinook adult	91	0	0	0	0	91
- Chinook adult, AFC	23	80	28	16	4	151
Released Catch						
- Chinook adult	6	182	1	1	0	190
Inspection of Catch						
- Number	114	79	84	16	4	297
- Number correct	113	79	84	16	4	296
Gear						
- Bait	134	100	77	79	40	430
- Lure	7	8	6	3	6	30
- Bait/Lure	10	2	0	5	1	18
- Fly	0	0	0	0	0	0
Fished Thompson R. in the last 2 weeks: a						
- No	81	28	34	58	20	221
- Yes	84	82	50	29	27	272
- Mean angler day length (hrs)	6.7	5.3	6.9	6.6	10.1	6.7
- Chinook adult harvest	30	17	9	5	5	66
Harvest to Date; Number of Anglers who had harvested:						
- 0 Chinook Adults	34	22	46	64	26	-
- 1 Chinook Adult	90	37	13	8	7	-
- 2 Chinook Adults	32	21	12	5	4	-
- 3 Chinook Adults	9	13	1	2	4	-
- 4 Chinook Adults	0	12	3	3	1	-
- 5 Chinook Adults	0	3	0	1	0	-
- 6 Chinook Adults	0	2	4	0	1	-
- 7 Chinook Adults	0	0	2	0	2	-
- 8 Chinook Adults	0	0	2	2	0	-
- 9 Chinook Adults	0	0	1	0	1	-
- 10 Chinook Adults	0	0	0	2	1	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 11b. Interview responses by week on the west bank in the 1994 Thompson River (Spences Bridge) chinook sport fishery.

	Week ending					
	18-Jul	25-Jul	1-Aug	8-Aug	15-Aug	Total
Number of Interviews	111	72	61	46	12	302
Mean Angler Day Length (hr.)						
- All anglers	3.1	3.8	3.7	3.3	3.8	3.5
- Complete trip interviews						
Number	110	72	61	46	12	301
Hours	3.1	3.8	3.7	3.3	3.8	3.4
- Incomplete trip interviews						
Number	1	0	0	0	0	1
Hours	6.0	-	-	-	-	6.0
Mean number of anglers per party	2.8	2.5	2.7	2.7	1.7	2.6
Target Species						
- Chinook	111	72	61	46	12	302
Harvested Catch						
- Chinook adult	54	0	0	0	0	54
- Chinook adult, AFC	14	26	15	3	0	58
Released Catch						
- Chinook adult	15	14	5	3	0	37
Inspection of Catch						
- Number	68	26	15	3	0	112
- Number correct	67	26	15	3	-	111
Gear						
- Bait	96	68	59	46	12	281
- Lure	6	4	2	0	0	12
- Bait/Lure	6	0	0	0	0	6
- Fly	1	0	0	0	0	1
Fished Thompson R. in the last 2 weeks: a						
- No	60	17	13	9	2	101
- Yes	51	55	48	37	10	201
- Mean angler day length (hrs)	5.1	11.0	12.2	7.0	9.3	7.7
- Chinook adult harvest	31	11	4	0	0	46
Harvest to Date; Number of Anglers who had harvested:						
- 0 Chinook Adults	30	23	19	18	8	-
- 1 Chinook Adult	55	8	5	3	0	-
- 2 Chinook Adults	22	19	9	4	1	-
- 3 Chinook Adults	4	8	9	8	1	-
- 4 Chinook Adults	0	9	5	6	0	-
- 5 Chinook Adults	0	5	4	0	0	-
- 6 Chinook Adults	0	0	8	1	0	-
- 7 Chinook Adults	0	0	2	5	2	-
- 8 Chinook Adults	0	0	0	1	0	-

a. Within 2 weeks of the interview; data are specific to the most recent trip.

Appendix 12. Daily catch (harvest and release) per angler hour, by species, in the 1994 Thompson River chinook sport fishery.

	East Bank (Nicola River Mouth)	West Bank (CNR Side)
Date	Chinook adult	Chinook adult
16-Jul	0.1670	0.3274
17-Jul	0.1832	0.2256
18-Jul	0.2538	0.1406
23-Jul a	1.1918	0.0775
24-Jul	0.5181	0.2574
25-Jul	0.4551	0.0899
30-Jul	0.1236	0.1443
31-Jul	0.0800	0.0800
1-Aug b	0.0707	0.0000
6-Aug	0.0783	0.0319
7-Aug	0.0273	0.0519
8-Aug	0.0215	0.0526
13-Aug	0.0198	0.0000
14-Aug	0.0460	0.0000
15-Aug	0.0000	0.0000
Total HPUE	0.1354	0.1076
Total RPUE	0.1064	0.0356

a. First day of nonretention of unmarked fish.
b. Statutory holiday.

Appendix 13. Mean nose-fork length and weight, by flesh colour, age and sex, of chinook salmon harvested in the 1994 Thompson River (Spences Bridge) chinook sport fishery.

			Male				Female				Total			
Week ending	Flesh colour	Age	No.	%	Mean length (cm)	Mean weight (kg)	No.	%	Mean length (cm)	Mean weight (kg)	No.	%	Mean length (cm)	Mean weight (kg)
18-Jul	Red	5/2	4	6%	81.5	5.8	1	1%	76.0	4.5	5	3%	80.4	5.5
		4/2	35	56%		4.1	69	75%	70.4	3.8	104	67%	70.9	3.9
		4/1	4	6%	80.8	6.5	2	2%	79.5	5.9	6	4%	80.3	6.3
		3/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/1	14	22%	69.2	3.6	15	16%	65.2	3.5	29	19%	67.1	3.5
		Unknown	5	-	66.4	3.6	19	-	70.7	4.0	24	-	69.8	3.9
		Total	62	-	71.9	4.2	106	-	70.0	3.8	168	-	70.7	4.0
	White	4/2	5	8%	73.8	4.3	5	5%	72.8	3.9	10	6%	73.3	4.1
		3/1	1	2%	79.0	5.0	0	0%	-	-	1	1%	79.0	5.0
		Unknown	1	-	75.0	4.1	2	-	72.0	4.1	3	-	73.0	4.1
		Total	7	-	74.7	4.4	7	-	72.6	4.0	14	-	73.6	4.2
25-Jul	Red	5/2	1	4%	78.0	5.0	1	1%	67.0	3.6	2	2%	72.5	4.3
		4/2	11	44%	71.0	4.4	58	82%	71.1	4.1	69	72%	71.1	4.1
		4/1	0	0%	-	-	2	3%	79.0	6.1	2	2%	79.0	6.1
		3/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/1	10	40%	67.0	3.4	9	13%	67.1	3.5	19	20%	67.1	3.5
		Unknown	6	-	72.3	4.3	4	-	74.0	4.5	10	-	73.0	4.4
		Total	28	-	70.1	4.0	74	-	70.9	4.1	102	-	70.7	4.1
	White	4/2	2	8%	77.0	5.0	1	1%	72.0	3.6	3	3%	75.0	4.6
		3/1	1	4%	68.0	2.7	0	0%	-	-	1	1%	68.0	2.7
		Unknown	0	-	-	-	0	-	-	-	0	-	-	-
		Total	3	-	73.0	4.1	1	-	72.0	3.6	4	-	72.7	4.0
01-Aug	Red	5/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		4/2	8	89%	73.9	4.5	21	75%	72.0	3.9	29	78%	72.5	4.0
		4/1	0	0%	-	-	3	11%	76.7	4.5	3	8%	76.7	4.5
		3/2	1	11%	75.0	4.1	0	0%	-	-	1	3%	75.0	4.1
		3/1	0	0%	-	-	4	14%	69.0	3.4	4	11%	69.0	3.4
		Unknown	0	-	-	-	5	-	75.0	4.8	5	-	75.0	4.8
		Total	9	-	74.0	4.4	33	-	72.5	4.0	42	-	72.8	4.1
08-Aug	Red	5/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		4/2	3	75%	72.7	4.1	8	67%	69.5	3.4	11	69%	70.4	3.6
		4/1	0	0%	-	-	2	17%	83.0	5.7	2	13%	83.0	5.7
		3/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/1	1	25%	70.0	3.6	2	17%	66.5	2.7	3	19%	67.7	3.0
		Unknown	0	-	-	-	3	-	72.7	3.6	3	-	72.7	3.6
		Total	4	-	72.0	4.0	15	-	71.5	3.6	19	-	71.6	3.7
15-Aug	Red	5/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		4/2	0	0%	-	-	2	50%	67.5	3.4	2	40%	67.5	3.4
		4/1	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/1	1	100%	70.0	3.6	2	50%	67.0	2.5	3	60%	68.0	2.9
		Unknown	0	-	-	-	0	-	-	-	0	-	-	-
		Total	1	-	70.0	3.6	4	-	67.3	3.0	5	-	67.8	3.1

Continued

Appendix 13. Mean nose-fork length and weight, by flesh colour, age and sex, of chinook salmon harvested in the 1994 Thompson River (Spences Bridge) chinook sport fishery, continued.

			Male				Female				Total			
Week ending	Flesh colour	Age	No.	%	Mean length (cm)	Mean weight (kg)	No.	%	Mean length (cm)	Mean weight (kg)	No.	%	Mean length (cm)	Mean weight (kg)
Total	Red	5/2	5	5%	80.8	5.6	2	1%	71.5	4.1	7	2%	78.1	5.2
		4/2	57	56%	71.9	4.2	158	76%	70.8	3.9	215	70%	71.1	4.0
		4/1	4	4%	80.8	6.5	9	4%	79.2	5.5	13	4%	79.7	5.8
		3/2	1	1%	75.0	4.1	0	0%	-	-	1	0%	75.0	4.1
		3/1	26	25%	68.4	3.5	32	15%	66.4	3.4	58	19%	67.3	3.5
		Unknown	11	-	69.6	4.0	31	-	72.0	4.1	42	-	71.4	4.1
		Total	104	-	71.6	4.2	232	-	70.7	3.9	336	-	71.0	4.0
	White	4/2	7	7%	74.7	4.5	6	3%	72.7	3.9	13	4%	73.8	4.2
		3/1	2	2%	73.5	3.9	0	0%	-	-	2	1%	73.5	3.9
		Unknown	1	-	75.0	4.1	2	-	72.0	4.1	3	-	73.0	4.1
		Total	10	-	74.5	4.4	8	-	72.5	3.9	18	-	73.6	4.1
	No AFC	5/2	4	8%	81.5	5.8	1	1%	75.0	4.5	5	4%	80.4	5.5
		4/2	32	64%	71.4	4.1	58	82%	70.3	3.8	90	74%	70.7	3.9
		4/1	1	2%	86.0	8.2	2	3%	79.5	5.9	3	2%	81.7	6.7
		3/2	0	0%	-	-	0	0%	-	-	0	0%	-	-
		3/1	13	26%	70.1	3.7	10	14%	67.3	3.4	23	19%	68.9	3.6
		Unknown	5	-	66.4	3.6	18	-	71.2	4.0	23	-	70.1	4.0
		Total	55	-	71.7	4.2	89	-	70.4	3.8	144	-	70.9	4.0
	AFC	5/2	1	2%	78.0	5.0	1	1%	67.0	3.6	2	1%	72.5	4.3
		4/2	32	62%	73.1	4.5	106	78%	71.1	4.0	138	73%	71.6	4.0
		4/1	3	6%	79.0	5.9	7	5%	79.1	5.3	10	5%	79.1	5.5
		3/2	1	2%	75.0	4.1	0	0%	-	-	1	1%	75.0	4.1
		3/1	15	29%	67.7	3.5	22	16%	66.0	3.4	37	20%	66.7	3.4
		Unknown	7	-	72.7	4.3	15	-	73.0	4.2	22	-	72.9	4.2
		Total	59	-	72.1	4.2	151	-	70.9	4.0	210	-	71.2	4.0

Appendix 14. Variance estimation procedure for hybrid and access point surveys (adapted from DPA Group Inc. (MS 1985a)).

CATCH (C)

$$(1) \qquad Var(C) = \bar{c}^2 E^2 \left[\frac{Var(E)}{E^2} + \frac{Var(\bar{c})}{\bar{c}^2} + \frac{Var(E)\,Var(\bar{c})}{\bar{c}^2\,E^2} \right]$$

where: E = estimate study period effort (hours);
$Var(E)$ = variance of the estimated study period effort (Equation 2)
$\bar{c}$ = estimated study period catch per angler hour;
$Var(\bar{c})$ = variance of the estimated study period catch per angler hour (Equation 3).

EFFORT (E)

$$(2) \qquad Var(E) = N^2 \left[\frac{\bar{y}_j^*}{\bar{p}_j^*} \right]^2 \left[\frac{Var(\bar{y}_j^*)}{\bar{y}_j^{*2}} + \frac{Var(\bar{p}_j^*)}{\bar{p}_j^{*2}} - \frac{2Cov(\bar{y}_j^*, \bar{p}_j^*)}{(\bar{y}_j^*)\,(\bar{p}_j^*)} \right]$$

where: N = total days in the study period;
$\bar{y}_j^*$ = mean instantaneous rod count (hour j^*);
$Var\ \bar{y}_j^*$ = variance of the mean rod count at hour j^* (Equation 4);
$\bar{p}_j^*$ = proportion of daily angler hours occurring at the time of the instantaneous rod count;
$Var\ \bar{p}_j^*$ = variance of the proportion of daily angler hours occurring at the time of the instantaneous rod count (Equation 5).

CATCH PER UNIT EFFORT ($\bar{c}$)

Because $\bar{c}$ is a ratio of catch to time of interview ($\hat{X}$) and time fished to time of interview ($\hat{T}$), a Taylor series approximation to the variance of the ratio of random variables was used. Because we expected to interview a relatively large proportion of the anglers the greatest variance was expected to occur at the stint level; consequently, the following estimate embodies only that sampling stage.

$$(3) \qquad Var(\bar{c}) = \left[\frac{\hat{X}}{\hat{T}} \right]^2 \left[\frac{Var(\hat{X})}{\hat{X}^2} + \frac{Var(\hat{T})}{\hat{T}^2} - \frac{2Cov(\hat{X}, \hat{T})}{(\hat{X})\,(\hat{T})} \right]$$

where:
$$Cov(\hat{X}, \hat{T}) = \sum_i \sum_l N^2\ (1/n_{ij} - 1/N) \sum_f \left[\frac{(\hat{X}_{ilf}\,\hat{T}_{ilf}) - 1/n_{ij} \sum_f \hat{X}_{ilf} \sum_i \hat{T}_{ilf}}{n_{ij} - 1} \right]$$

$$Var(\hat{X}) = \sum_i \sum_l N^2\ (1/n_{ij} - 1/N) \sum_f \left[\frac{(\hat{X}_{ilf} - (1/n_{if} \sum_f \hat{X}_{ilf}))^2}{n_{ij} - 1} \right]$$

$Var(\hat{T})$ is analogous to above.

$\hat{X}_{ilf}$ = estimated total catch for the f^{th} stint of the l^{th} stint type at the i^{th} site;

$\hat{T}_{i1f}$ = estimated total angler hours for the f^{th} stint of the 1^{th} stint type at the i^{th} site;

n_{ij} = number of interview sample days at site i on hour j.

MEAN INSTANTANEOUS ROD COUNT $(\bar{y}_j^*)$

$$(4) \qquad Var(\bar{y}_j^*) = (1/n_j^* - 1/N) \sum_k \left[\frac{(y_j^* k - \bar{y}^*)^2}{n_j^* - 1} \right]$$

where: $\bar{n}_j^*$ = number of instantaneous rod counts at hour j^*;

$y_j^*{}_k$ = instantaneous rod count on day k;

$\bar{y}_j^*{}_k$ = estimated mean rod count at hour j^*.

PROPORTION OF DAILY EFFORT AT TIME OF INSTANTANEOUS ROD COUNT $(\bar{p}_j^*)$.

Because $\bar{p}_j^*$ is a ratio of $\hat{R}_j$ and ΣR_j the following Taylor Series approximation to the variance of the ratio of random variables was used:

$$(5) \qquad Var(\bar{p}_j^*) = \left[\frac{\hat{R}_j^*}{\sum_j \hat{R}_j} \right]^2 \left[\frac{Var(\hat{R}_j^*)}{\hat{R}_j^{*2}} + \frac{Var \sum_j \hat{R}_j}{\sum_j \hat{R}_j^2} - \frac{2Cov(\hat{R}_j^*, \sum_j \hat{R}_j)}{(\hat{R}_j^*)(\sum_j \hat{R}_j)} \right]$$

where:

$$Cov(\hat{R}_j^*, \sum_j \hat{R}_j) = \sum_i N^2 \ (1/n_{ij}^* - 1/N) \sum_k \left[\frac{(r_{ij}^* k \sum_j r_{ijk}) - (1/n_{ij}^* \sum_k r_{ij}^* k \sum_{ij} \sum r_{ijk})}{n_{ij}^* - 1} \right]$$

$$Var(\hat{R}_j^*) = \sum_i N^2 \ (1/n_{ij}^* - 1/N) \sum_k \left[\frac{(r_{ij}^* k - (1/n_{ij}^* \sum_k r_j^* k))^2}{n_{ij}^* - 1} \right]$$

Var $\sum_j \hat{R}_j$ is analogous to above.

N = number of days in stratum;

n_{ij}^* = number of interview sample days at site i;

r_{ijk} = rod count at site i at hour j on day k;

$r_{ij}^* k$ = rod count at site i on day k at the hour of the instantaneous effort count;

$\hat{R}_j^*$ = estimated total effort (hours) during the instantaneous rod count time block;

$\sum_j \hat{R}_j$ = estimated total effort over all hours and days at the sites surveyed.

Appendix 15. Synoptic summaries of eleven sport fisheries on nine upper Fraser River chinook stocks. Data are from the following sources:

Angler Effort: Angler effort is presented only for fisheries which were assessed by creel surveys or censuses. Less structured surveys either did not attempt to estimate effort, or the estimates were considered unreliable based on comparisons with creel survey estimates in previous years.

Chinook Adult Harvest: Harvest estimates were from creel surveys, censuses or unstructured surveys. The later were included to provide an indication of trends in fishery performance in non-survey years.

Chinook Adult Escapement: In most cases, escapement was estimated by fishery officers using visual techniques.

Escapement Goal: Interim escapement goals for British Columbia chinook stocks were established by the Chinook Technical Committee (Anon. 1986b) and later declared regional policy by the Director General. The goals were intended as initial targets to guide joint management actions under the Pacific Salmon Treaty. Goals for natural and enhanced stocks were double the base period average escapement. The base period was 1979-1982, except 1984 was used if estimation techniques improved in the early 1980's.

Base to Goal Line: A line joining the average escapement during the stock's base period to its escapement goal. This line provides an *approximation of the expected rebuilding pattern*, but should not be confused with the *projected* rebuilding pattern. The latter is not estimated because of inadequate stock specific data.

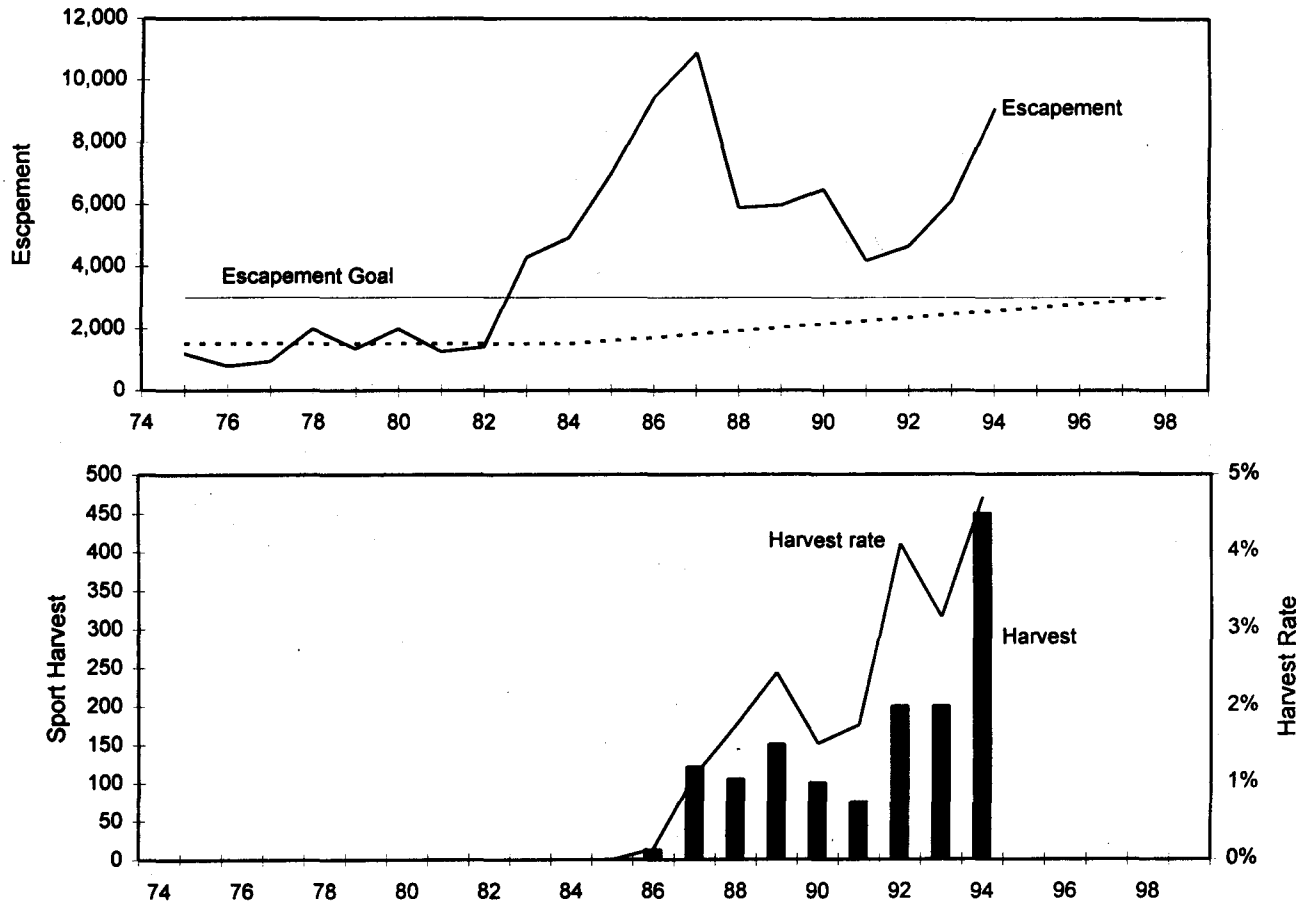
Enhancement: Enhancement was defined as the expected return of adults from at least two brood years of hatchery production.

Rebuilding Status: Stock rebuilding status was evaluated using the criteria developed by the Canada-U.S. Chinook Technical Committee. Descriptions of the evaluation criteria are extracted from the Chinook Technical Committee's 1993 Annual Report (Anon. 1994), except the tests were updated to include the 1994 escapement estimate:

> **Modified Mean Criterion:** A test value was calculated as the average of the 1990-1994 data points from the stock's base to goal line. This test value was then compared to the average observed escapement for the last five years. If the observed average was greater than or equal to the test value, then a score of +1 was assigned. Otherwise, a score of -1 was assigned.
>
> **Modified Line Criterion:** Observed escapements were compared with the base to goal line. If, in three or more of the last five years, the actual escapements were on or above the base to goal line, then a score of +1 was assigned. Otherwise, a score of -1 was assigned.
>
> **Short Term Trend Criterion:** If in at least four of the last five years an escapement exceeded the previous year's escapement, then a score of +1 was assigned. If in at least four of the last five years an escapement was equal to or below the previous year's escapement, then a score of -1 was assigned. Otherwise, a score of 0 was assigned.

These three scores were then summed, resulting in a total score ranging from +3 to -3. Stocks with scores of +3 and +2 were classified as *Rebuilding*, +1 and 0 as *Indeterminate*, and -1, -2, and -3 as *Not Rebuilding*.

Bowron River



SYNOPSIS

Rebuilding Criterion: In 1986, Bowron River chinook were responding well to the rebuilding program. Escapement had increased to levels above the interim escapement goal for four consecutive years and, consequently, the stock was classified as *Above Goal.* Since 1986, the escapements peaked and declined sharply before increasing for the last three years. Escapements remained above the interim goal for the last 11 years, however, and the rebuilding classification remains as *Above Goal.*

Manageability Criterion: The fishery harvest exceeded the 300 ceiling once (1994) in nine years. Because the 1994 abundance was also high, harvest rates remained below 5%.

Assessment Criterion: Creel surveys were conducted in 1986-1988. Subsequent estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: Enhancement contributed to the return in 1985-1992. No further enhanced returns are expected following the closure of the Quesnel River Hatchery.

BOWRON RIVER CHINOOK

A. Annual fishery performance and stock status.

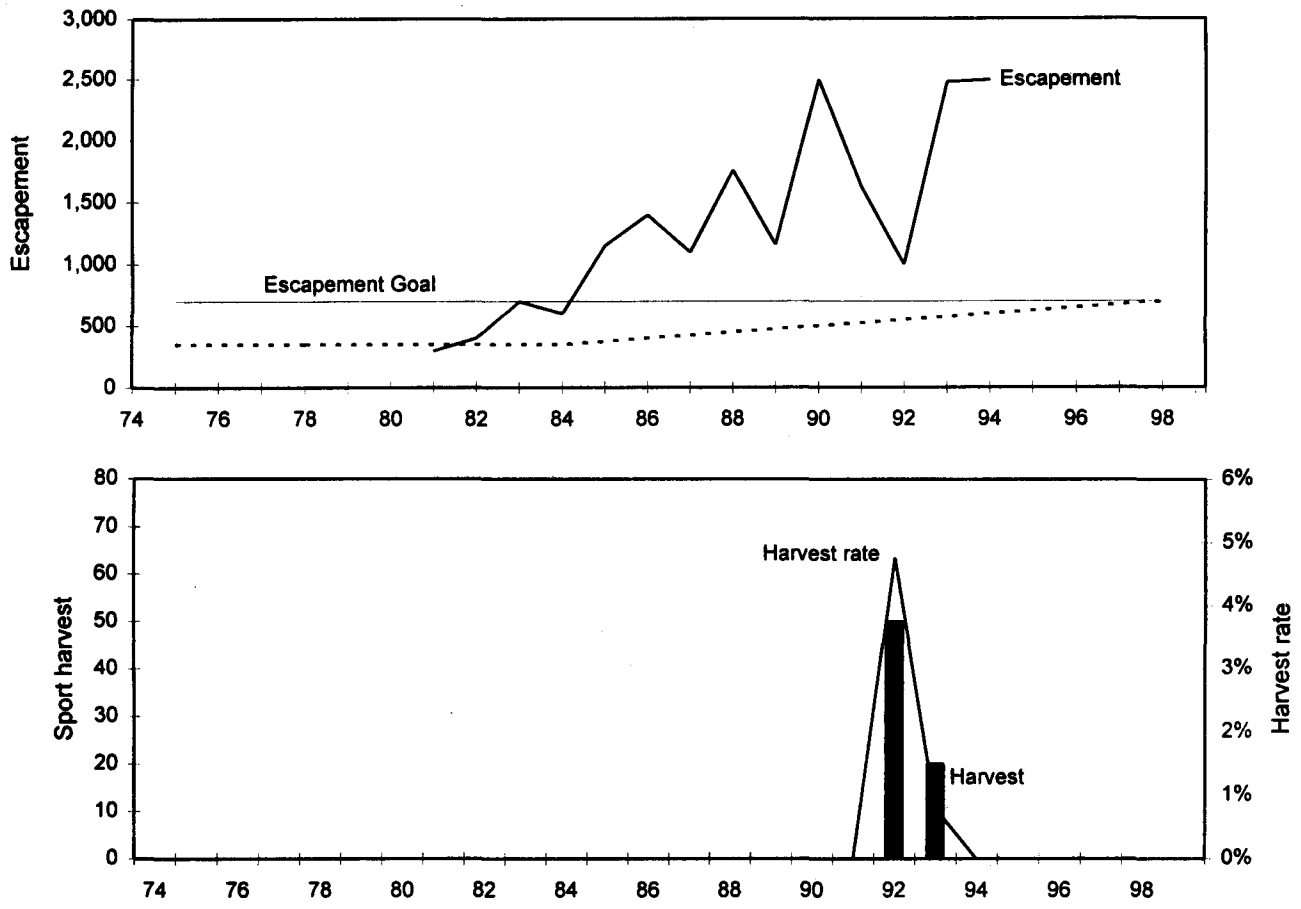
Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	n/a	n/a	n/a	n/a	1,200	n/a	-
1976	n/a	n/a	n/a	n/a	800	n/a	-
1977	n/a	n/a	n/a	n/a	950	n/a	-
1978	n/a	n/a	n/a	n/a	2,000	n/a	-
1979	n/a	n/a	n/a	n/a	1,350	n/a	-
1980	Closed	0	0	n/a	2,000	0.0%	-
1981	Closed	0	0	n/a	1,260	0.0%	-
1982	Closed	0	0	n/a	1,400	0.0%	-
1983	Closed	0	0	n/a	4,300	0.0%	-
1984	Closed	0	0	n/a	4,922	0.0%	-
1985	Closed	0	0	n/a	7,002	0.0%	-
1986	Hybrid	3,179	13	7	9,465	0.1%	Above Goal
1987	Hybrid	4,769	121	0	10,900	1.1%	Above Goal
1988	Hybrid	5,804	105	12	5,908	1.7%	Above Goal
1989	a	n/a	150	n/a	6,000	2.4%	Above Goal
1990	a	n/a	100	n/a	6,500	1.5%	Above Goal
1991	a	n/a	75	n/a	4,200	1.8%	Above Goal
1992	a	n/a	200	n/a	4,670	4.1%	Above Goal
1993	a	n/a	200	n/a	6,140	3.2%	Above Goal
1994	a	n/a	450	n/a	9,104	4.7%	Above Goal

a. Estimated by local enforcement staff using a variety of subjective techniques.

B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly	Annual			
1986	15-Jul to 15-Aug	1	none	10	2	10	300
1987	25-Jul to 09-Aug	1	none	10	7	16	300
1988	23-Jul to 07-Aug	2	none	10	7	16	300
1989	22-Jul to 06-Aug	2	none	10	7	16	300
1990	21-Jul to 05-Aug	2	none	10	7	16	300
1991	20-Jul to 12-Aug	2	none	10	7	24	300
1992	20-Jul to 15-Aug	2	none	10	7	27	300
1993	20-Jul to 15-Aug	2	none	10	7	27	300
1994	20-Jul to 15-Aug	2	none	10	7	27	300

Cariboo River



SYNOPSIS

Rebuilding Criterion: Cariboo River chinook escapements have increased over the period of record, from an average 350 during the base period (1981-1982) to 1,570 during the rebuilding period (1984-1994). The escapements have been above the interim goal for the last ten years; consequently, the stock has been classified as *Above Goal* since the fishery opened in 1992. The escapement trends should be interpreted with two points in mind: a) pre-1981 escapements were unavailable due to either a lack of survey effort or their inclusion in the Quesnel River estimate; and b) enumeration intensity changed over the period of record, initially through increased efforts by Quesnel Hatchery staff and later through the installation of a counting facility in the Cariboo River fishway. The rebuilding trend, therefore, may be overstated because the interim escapement goal (calculated from the base period average) may be low.

Manageability Criterion: This fishery is not managed to a harvest ceiling because angler effort has been low. Harvest rates have never exceeded 5%; however, because the stock is relatively small, the harvest rate approached 5% in 1992.

Assessment Criterion: A creel survey was conducted in 1994; however, low angler effort prevented the collection of useable data.

Enhancement Criterion: Enhancement contributed to the return from 1985 to the present. Due to the closure of the Quesnel River Hatchery, the last significant enhanced production will return in 1995.

CARIBOO RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	n/a	n/a	n/a	n/a	b	n/a	-
1976	n/a	n/a	n/a	n/a	b	n/a	-
1977	n/a	n/a	n/a	n/a	b	n/a	-
1978	n/a	n/a	n/a	n/a	b	n/a	-
1979	n/a	n/a	n/a	n/a	b	n/a	-
1980	Closed	0	0	n/a	b	0.0%	-
1981	Closed	0	0	n/a	300	0.0%	-
1982	Closed	0	0	n/a	400	0.0%	-
1983	Closed	0	0	n/a	700	0.0%	-
1984	Closed	0	0	n/a	600	0.0%	-
1985	Closed	0	0	n/a	1,150	0.0%	-
1986	Closed	0	0	n/a	1,400	0.0%	Rebuilding
1987	Closed	0	0	n/a	1,100	0.0%	Rebuilding
1988	Closed	0	0	n/a	1,760	0.0%	Above Goal
1989	Closed	0	0	n/a	1,160	0.0%	Above Goal
1990	Closed	0	0	n/a	2,500	0.0%	Above Goal
1991	Closed	0	0	n/a	1,625	0.0%	Above Goal
1992	a	n/a	50	n/a	1,000	4.8%	Above Goal
1993	a	n/a	20	n/a	2,480	0.8%	Above Goal
1994	Roving	c	0	0	2,500	0.0%	Above Goal

a. Estimated by local enforcement staff using a variety of subjective techniques.

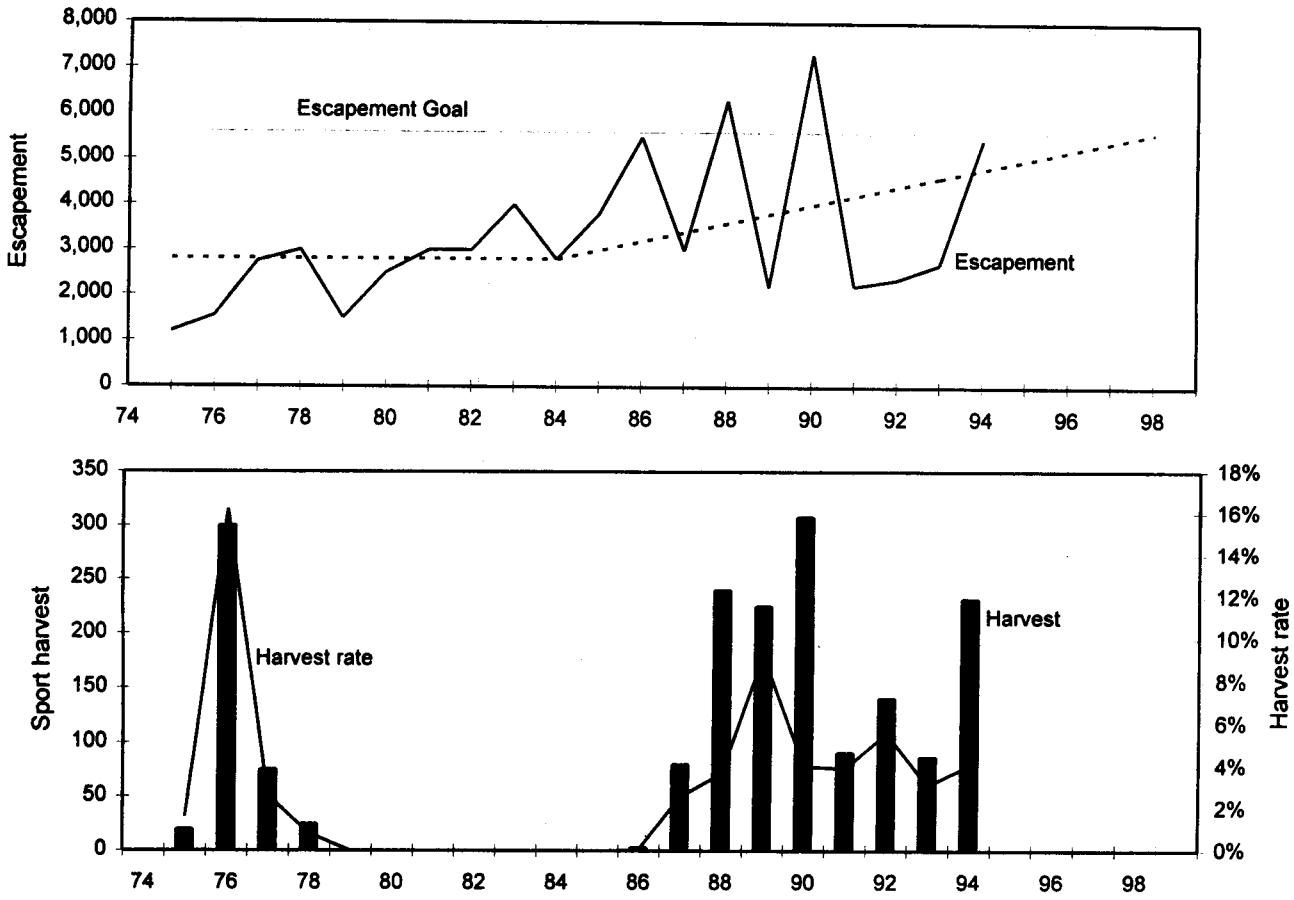
b. Not estimated separately from Quesnel River.

c. Unable to estimate due to very limited angler effort.

B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly	Annual			
1992	03-Aug to 07-Aug	2	none	10	7	5	none
1993	02-Aug to 08-Aug	2	none	10	7	7	none
1994	01-Aug to 07-Aug	2	none	10	7	7	none

Clearwater River



SYNOPSIS

Rebuilding Criterion: In 1986, the Clearwater River stock was responding well to the rebuilding program. Escapement had gradually increased since the early 1970's and approached the interim goal in 1986; consequently, the stock was classified as *Rebuilding*. Since 1986, the escapements have fluctuated trendlessly, exceeding the interim goal in two years but below the base period average in four years. As a result, the rebuilding classification changed to *Indeterminate* in 1991-1992, and to *Not Rebuilding* in 1993-1994.

Manageability Criterion: The fishery harvest exceeded the 300 ceiling for the combined Clearwater and Thompson harvest twice (1990, 1994) in nine years. Because of variable abundance, the harvest rates exceeded 5% in two other years (1989, 1992).

Assessment Criterion: A creel survey was conducted only in 1986 when fishery performance was poor. Subsequent estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: Enhancement contributed to the returns in 1987-1994. No further enhanced returns are expected following the closure of the Clearwater River Hatchery.

CLEARWATER RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	a	n/a	20	n/a	1,200	1.6%	-
1976	a	n/a	300	n/a	1,550	16.2%	-
1977	a	n/a	75	n/a	2,750	2.7%	-
1978	a	n/a	25	n/a	3,000	0.8%	-
1979	Closed	0	0	n/a	1,500	0.0%	-
1980	Closed	0	0	n/a	2,500	0.0%	-
1981	Closed	0	0	n/a	3,000	0.0%	-
1982	Closed	0	0	n/a	3,000	0.0%	-
1983	Closed	0	0	n/a	4,000	0.0%	-
1984	Closed	0	0	n/a	2,800	0.0%	-
1985	Closed	0	0	n/a	3,800	0.0%	-
1986	Roving	626	3	0	5,500	0.1%	Rebuilding
1987	a	n/a	80	n/a	3,000	2.6%	Rebuilding
1988	a	n/a	240	n/a	6,300	3.7%	Rebuilding
1989	a	n/a	225	n/a	2,200	9.3%	Rebuilding
1990	a	n/a	308	n/a	7,320	4.0%	Rebuilding
1991	a	n/a	91	n/a	2,219	3.9%	Indeterminate
1992	a	n/a	141	n/a	2,370	5.6%	Indeterminate
1993	a	n/a	87	n/a	2,700	3.1%	Not rebuilding
1994	a	n/a	232	n/a	5,450	4.1%	Not rebuilding

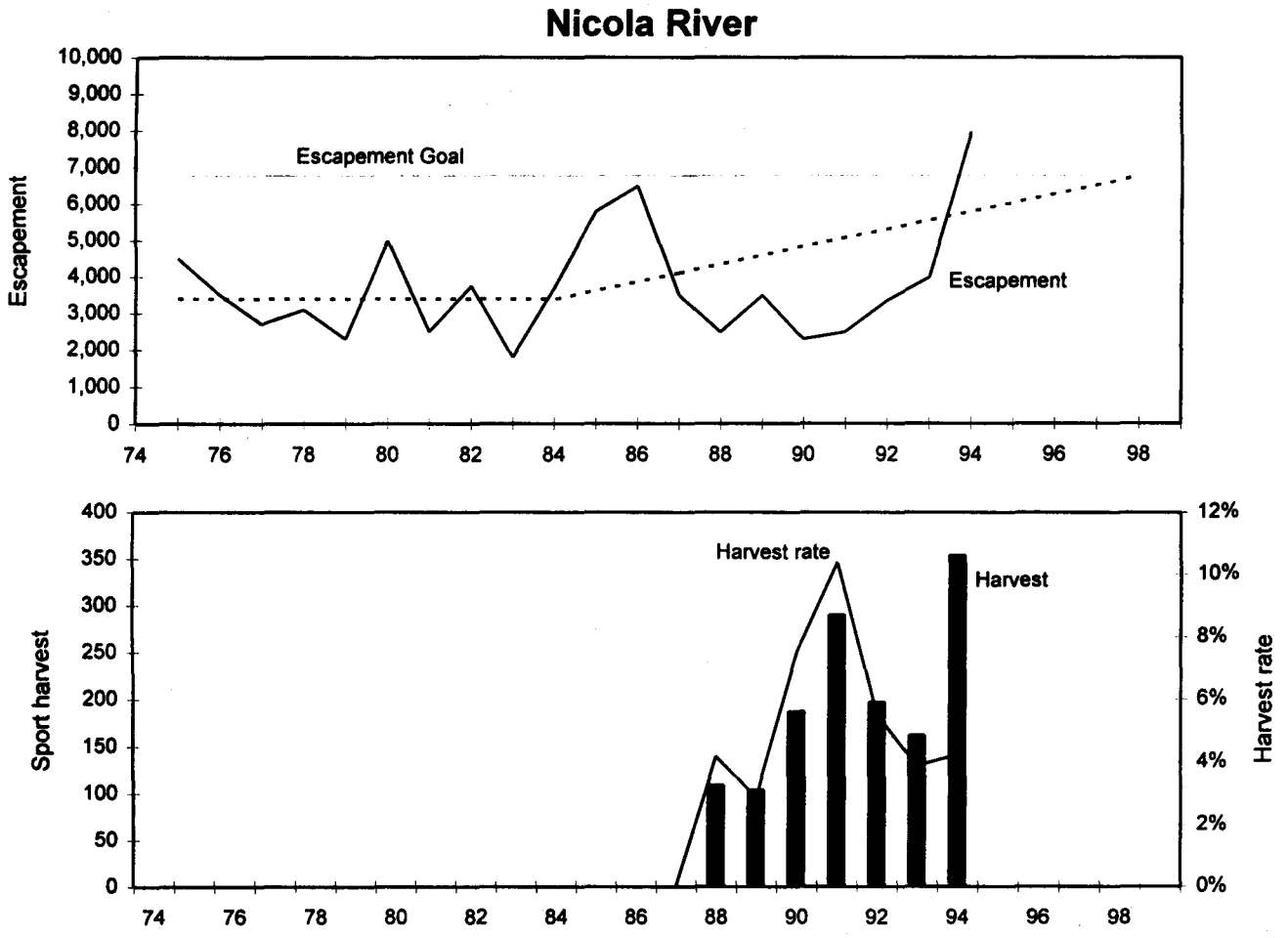
a. Estimated by local enforcement staff using a variety of subjective techniques.

B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly a	Annual			
1986	15-Jul to 15-Aug	1	none	10	2	10	300
1987	31-Jul to 30-Aug	1	none	10	3	15	300
1988	05-Aug to 04-Sep	2	none	10	3	15	300
1989	04-Aug to 03-Sep	2	none	10	3	15	300
1990	03-Aug to 02-Sep	2	none	10	3	15	300
1991	02-Aug to 01-Sep	2	6	10	3	15	300
1992 b	01-Aug to 31-Aug	2	6	10	7	31	300
1993 b	01-Aug to 31-Aug	2	6	10	7	31	300
1994 b	01-Aug to 31-Aug	2	6	10	7	31	300

a. Monthly ceiling applied to Clearwater and North Thompson rivers.

b. Ceiling includes harvest in the North Thompson River fishery.



SYNOPSIS

Rebuilding Criterion: In 1986, Nicola River chinook appeared to be responding to the rebuilding program, with increased escapements in three consecutive years; consequently, the stock was classified as *Rebuilding*. Since 1986, the escapement declined and has been below the base period average in five of the last eight years. As a result, the rebuilding classification changed to *Indeterminate* in 1989 and to *Not Rebuilding* in 1990-1994.

Manageability Criterion: Fishery harvest exceeded the ceiling five times in seven years. Harvest rates exceeded 5% in three years (1990, 1991, 1992).

Assessment Criterion: This fishery has been assessed by a complete census every year since it opened in 1988.

Enhancement Criterion: Enhancement has contributed to the return every year since 1987.

NICOLA RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	a	n/a	n/a	n/a	4,500	n/a	-
1976	a	n/a	n/a	n/a	3,500	n/a	-
1977	a	n/a	n/a	n/a	2,700	n/a	-
1978	a	n/a	n/a	n/a	3,100	n/a	-
1979	a	n/a	n/a	n/a	2,300	n/a	-
1980	Closed	0	0	n/a	5,000	0.0%	-
1981	Closed	0	0	n/a	2,500	0.0%	-
1982	Closed	0	0	n/a	3,750	0.0%	-
1983	Closed	0	0	n/a	1,800	0.0%	-
1984	Closed	0	0	n/a	3,700	0.0%	-
1985	Closed	0	0	n/a	5,800	0.0%	-
1986	Closed	0	0	n/a	6,500	0.0%	Rebuilding
1987	Closed	0	0	n/a	3,500	0.0%	Rebuilding
1988	Census	1,289	109	53	2,490	4.2%	Rebuilding
1989	Census	1,174	104	40	3,500	2.9%	Indeterminate
1990	Census	2,537	187	37	2,300	7.5%	Not rebuilding
1991	Census	2,729	290	53	2,500	10.4%	Not rebuilding
1992	Census	4,117	197	50	3,368 b	5.5%	Not rebuilding
1993	Census	2,659	162	21	4,000	3.9%	Not rebuilding
1994	Census	2,828	354	227	7,970	4.3%	Not rebuilding

a. Estimated by local enforcement staff using subjective techniques.

b. B.C. 16 corrected by C. Cross (SEP Biologist, pers. comm.).

B. Annual sport fishery regulations.

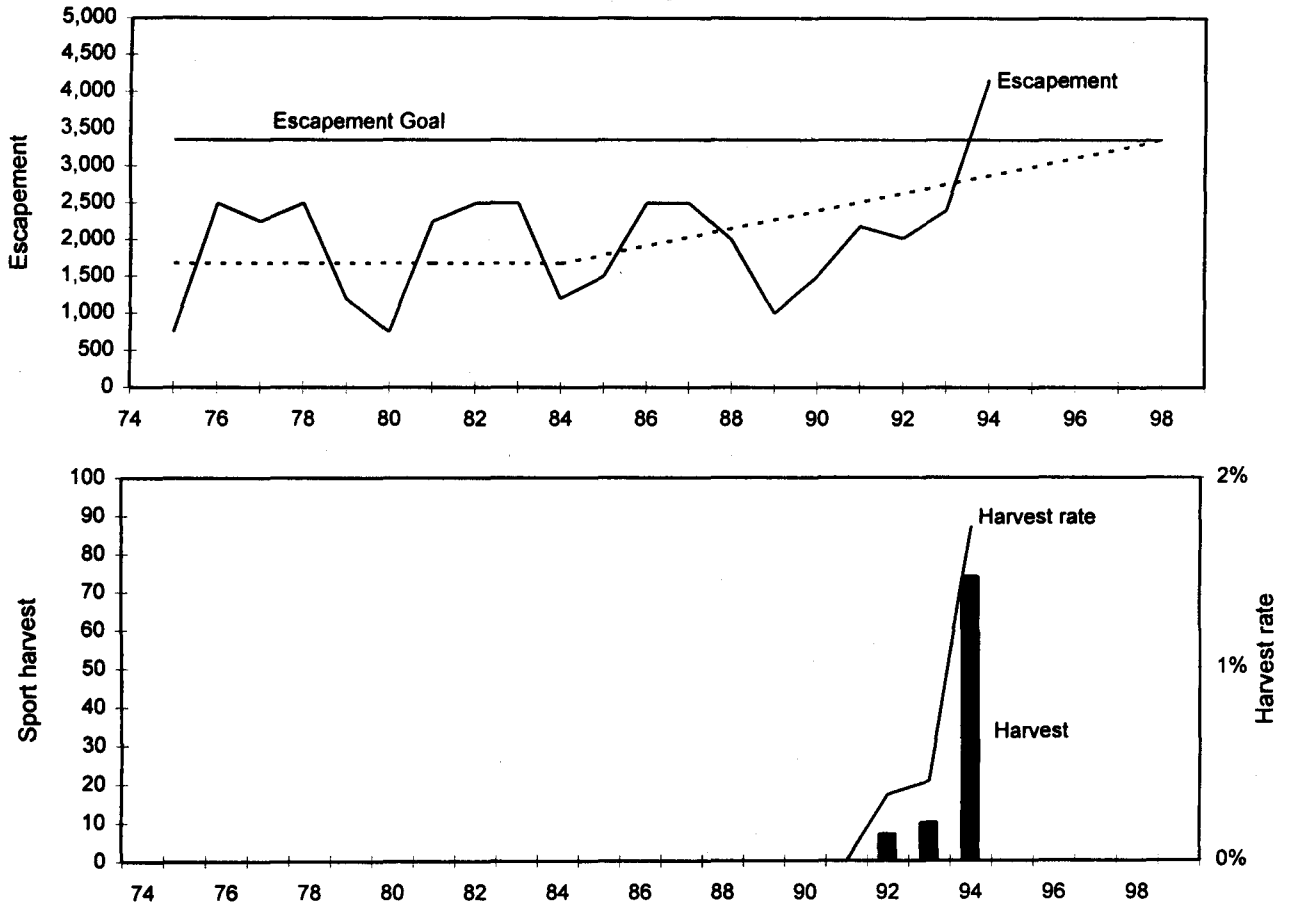
Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly	Annual			
1988	22-Jul to 26-Aug a	1	none	10	1	6	150
1989	08-Jul to 27-Aug b	1	none	10	1-2	12	100
1990	23-Jun to 03-Sep c	1	none	10	3	33	300
1991	13-Jul to 19-Aug c	1	none	10	3	18	150
1992	18-Jul to 17-Aug c	1	none	10	3	15	150
1993	17-Jul to 16-Aug c	1	none	10	3	15	150
1994	16-Jul to 15-Aug c	1	none	10	3	15	150

a. Open between 8 a.m. and 8 p.m. daily.

b. Initially open 6 a.m. to 2 p.m. daily, but was extended to 6 a.m. to 9 p.m. after July 30.

c. Open between 6 a.m. and 9 p.m. daily.

North Thompson River



SYNOPSIS

Rebuilding Criterion: North Thompson River chinook escapements have been trendless over the period of record. Overall, escapements increased from an average of 1,675 in the base period (1979-1982) to 2,088 in the rebuilding period (1984-1994). The interim escapement goal for this stock was achieved only once (1994); the escapements were below the base-to-goal line in six of the last seven years and were below the base period average in two of those years. This stock has been classified as *Not Rebuilding* since the sport fishery opened in 1992.

Manageability Criterion: The fishery harvest is included in the Clearwater fishery ceiling. The combined harvests exceeded the ceiling in 1994; however, harvest rates in this fishery have never approached 5%.

Assessment Criterion: This fishery has never been assessed by a creel survey. All available harvest estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: Enhancement contributed to the return in 1989-1993. No further enhanced returns are expected following the closure of the Clearwater River Hatchery.

NORTH THOMPSON RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	n/a	n/a	n/a	n/a	750	n/a	-
1976	n/a	n/a	n/a	n/a	2,500	n/a	-
1977	n/a	n/a	n/a	n/a	2,250	n/a	-
1978	n/a	n/a	n/a	n/a	2,500	n/a	-
1979	n/a	n/a	n/a	n/a	1,200	n/a	-
1980	Closed	0	0	n/a	750	0.0%	-
1981	Closed	0	0	n/a	2,250	0.0%	-
1982	Closed	0	0	n/a	2,500	0.0%	-
1983	Closed	0	0	n/a	2,500	0.0%	-
1984	Closed	0	0	n/a	1,200	0.0%	-
1985	Closed	0	0	n/a	1,500	0.0%	-
1986	Closed	0	0	n/a	2,500	0.0%	Rebuilding
1987	Closed	0	0	n/a	2,500	0.0%	Rebuilding
1988	Closed	0	0	n/a	2,000	0.0%	Indeterminate
1989	Closed	0	0	n/a	1,000	0.0%	Not rebuilding
1990	Closed	0	0	n/a	1,500	0.0%	Not rebuilding
1991	Closed	0	0	n/a	2,183	0.0%	Not rebuilding
1992	a	n/a	7	n/a	2,020	0.3%	Not rebuilding
1993	a	n/a	10	n/a	2,400	0.4%	Not rebuilding
1994	a	n/a	74	n/a	4,164	1.7%	Not rebuilding

a. Estimated by local enforcement staff using a variety of subjective techniques.

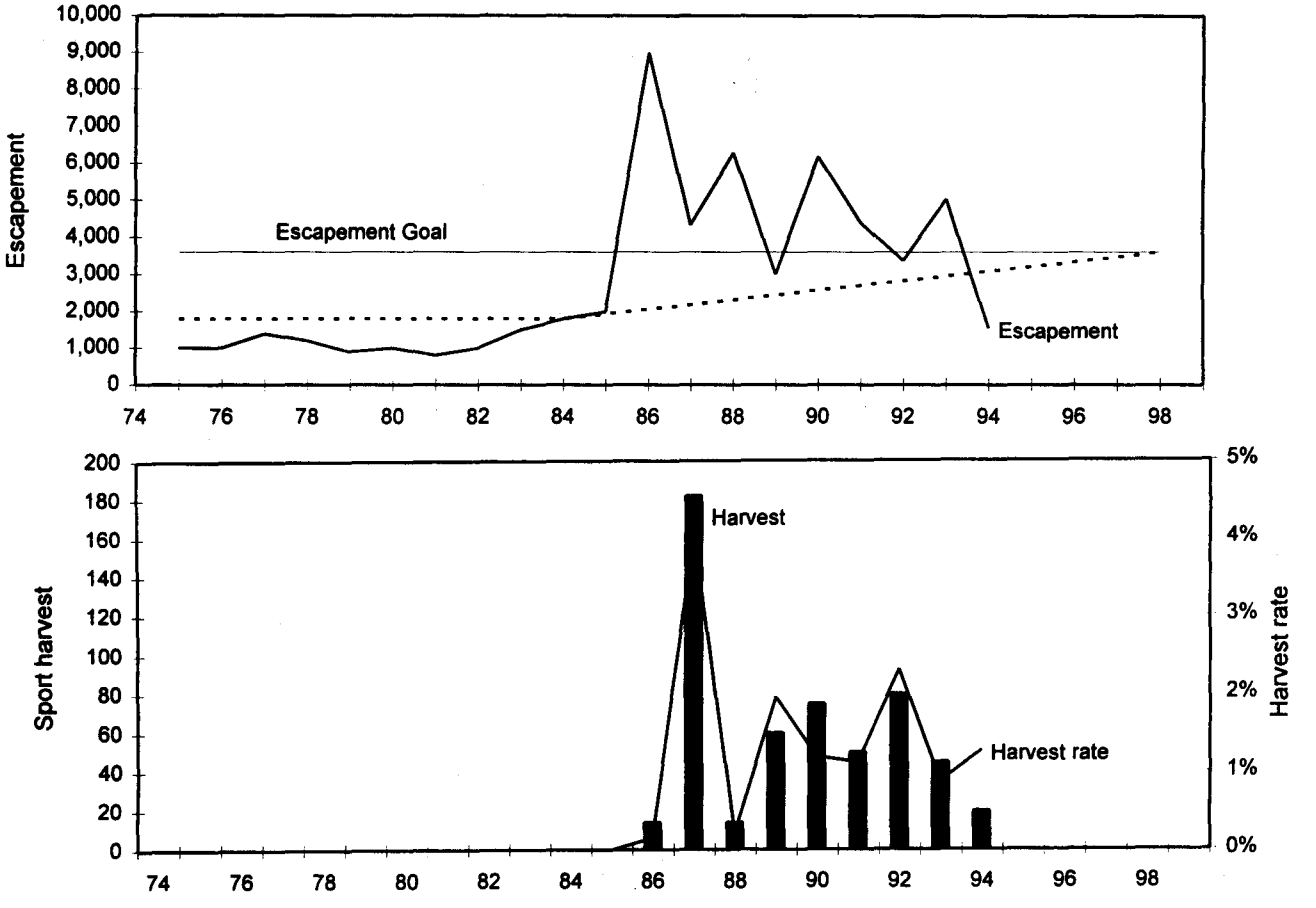
B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly a	Annual			
1992	01-Aug to 07-Aug	2	6	10	7	7	b
1993	01-Aug to 14-Aug	2	6	10	7	14	b
1994	01-Aug to 31-Aug	2	6	10	7	31	b

a. Monthly ceiling applied to Clearwater and North Thompson rivers.

b. Ceiling included harvest in the Clearwater River fishery.

Quesnel River



SYNOPSIS

Rebuilding Criterion: In 1986, Quesnel River chinook had shown a response to the rebuilding program in only one year; consequently, the stock was classified as *Indeterminate*. A strong escapement in 1986, and escapements above the interim goal in 6 of the last 11 years, however, resulted in a change in the rebuilding classification to *Rebuilding* in 1987-1994.

Manageability Criterion: The fishery harvest has never exceeded the 300 ceiling, and harvest rates have never approached 5%.

Assessment Criterion: Creel surveys were conducted in the upper Quesnel River in 1986, 1988 and 1989, and in the lower Quesnel River in 1987. All other estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: Enhancement contributed to the return in 1984-1994. The return of enhanced production is expected to be complete in 1998; further enhancement of this stock is unlikely following the closure of the Quesnel River Hatchery.

QUESNEL RIVER CHINOOK

A. Annual fishery performance (includes both lower and upper fisheries) and stock status.

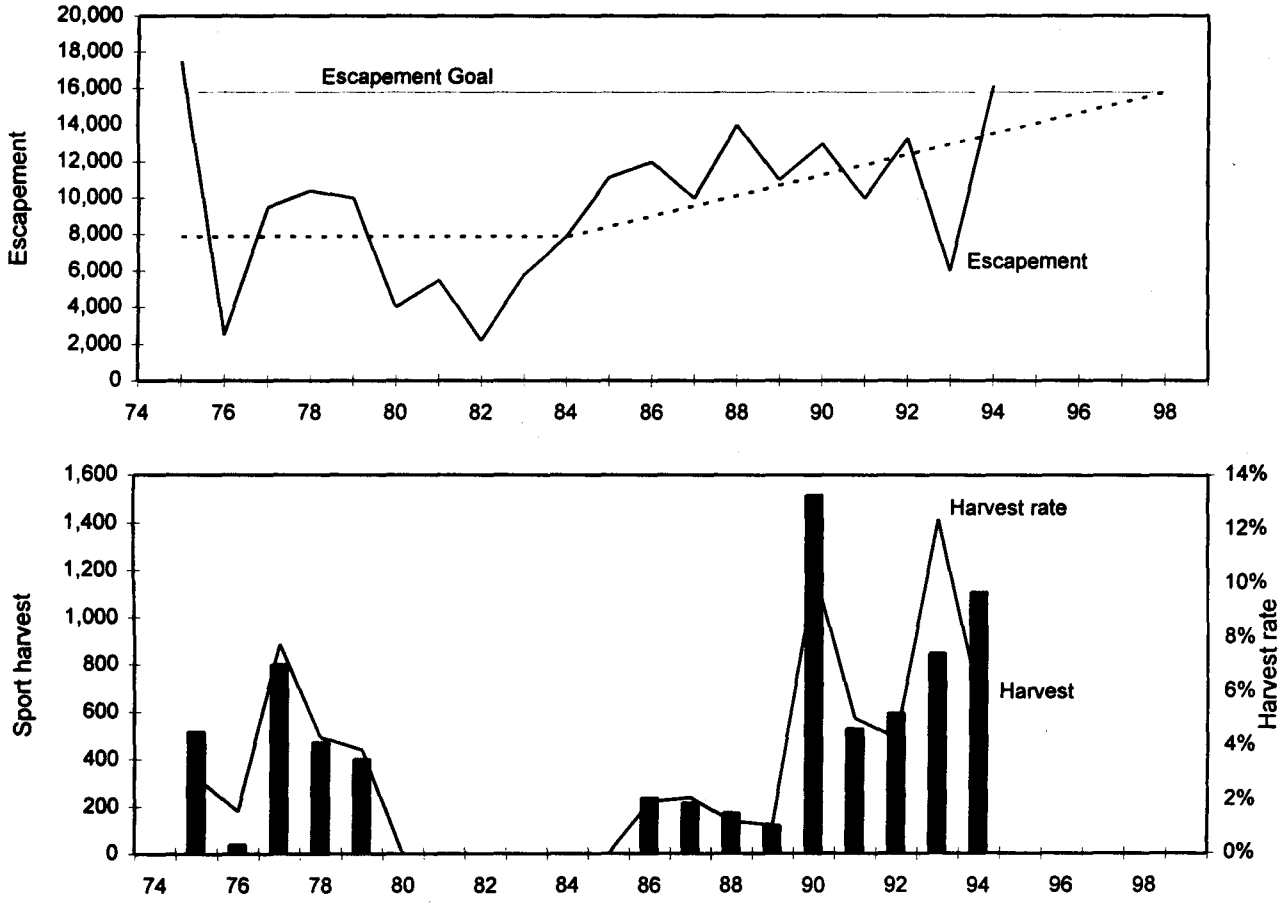
Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	n/a	n/a	n/a	n/a	1,000	n/a	-
1976	n/a	n/a	n/a	n/a	1,000	n/a	-
1977	n/a	n/a	n/a	n/a	1,400	n/a	-
1978	n/a	n/a	n/a	n/a	1,200	n/a	-
1979	n/a	n/a	n/a	n/a	900	n/a	-
1980	Closed	0	0	n/a	1,000	0.0%	-
1981	Closed	0	0	n/a	800	0.0%	-
1982	Closed	0	0	n/a	1,000	0.0%	-
1983	Closed	0	0	n/a	1,500	0.0%	-
1984	Closed	0	0	n/a	1,800	0.0%	-
1985	Closed	0	0	n/a	2,000	0.0%	-
1986	Roving	1,484 b	14	3	9,000	0.2%	Indeterminate
1987	Roving	1,211 c	182	0	4,331	4.0%	Rebuilding
1988	Roving	1,164 b	14	0	6,300	0.2%	Rebuilding
1989	Roving	1,832 b	60	0	3,000	2.0%	Rebuilding
1990	a	n/a	75	n/a	6,195	1.2%	Rebuilding
1991	a	n/a	50	n/a	4,400	1.1%	Rebuilding
1992	a	n/a	80	n/a	3,375	2.3%	Rebuilding
1993	a	n/a	45	n/a	5,028	0.9%	Rebuilding
1994	a	n/a	20	n/a	1,549	1.3%	Rebuilding

a. Estimated by local enforcement staff using a variety of subjective techniques.
b. Effort data are from the upper river fishery only.
c. Effort data are from the lower river fishery only.

B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly a	Annual			
			Lower River Fishery				
1987	14-Jul to 15-Aug	1	none	10	2	10	200
1988	16-Jul to 16-Aug	2	none	10	2	10	200
1989	04-Aug to 10-Sep	2	none	10	3	18	200
1990	03-Aug to 09-Sep	2	none	10	3	18	200
1991	02-Aug to 08-Sep	2	none	10	3	18	200
1992	17-Jul to 06-Sep	2	none	10	3	24	200
1993	16-Jul to 05-Sep	2	none	10	3	24	200
1994	15-Jul to 04-Sep	2	none	10	3	24	200
			Upper River Fishery				
1986	01-Aug to 29-Aug	1	none	10	2	9	200
1987	04-Aug to 08-Sep	1	none	10	2	11	200
1988	06-Aug to 10-Sep	2	none	10	2	11	200
1989	04-Aug to 10-Sep	2	none	10	2	12	200
1990	04-Aug to 09-Sep	2	none	10	2	12	200
1991	02-Aug to 08-Sep	2	none	10	3	18	200
1992	16-Aug to 06-Sep	2	none	10	7	22	200
1993	16-Aug to 06-Sep	2	none	10	7	22	200
1994	16-Aug to 05-Sep	2	none	10	7	21	200

Lower Shuswap River



SYNOPSIS

Rebuilding Criterion: In 1986, lower Shuswap River chinook were responding well to the rebuilding program, with escapement increases in four consecutive years; consequently, the stock was classified as *Rebuilding*. Since 1986, the escapements have been relatively trendless at a level below the interim escapement goal. As a result, the rebuilding classification changed to *Indeterminate* in 1993-1994.

Manageability Criterion: The harvest in the lower Shuswap River and Mabel Lake fisheries exceeded the 700 ceiling three times (1990, 1993, 1994) in nine years. Harvest rates exceeded 5% in the same years.

Assessment Criterion: Creel surveys have been conducted in the lower Shuswap River every year except 1992, and in Mabel Lake in 1993 and 1994. All other estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: Enhancement has contributed to the return in every year since 1987 and is expected to continue for the foreseeable future.

LOWER SHUSWAP RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	a	n/a	515	n/a	17,500	2.9%	-
1976	a	n/a	40	n/a	2,500	1.6%	-
1977	a	n/a	800	n/a	9,500	7.8%	-
1978	a	n/a	470	n/a	10,400	4.3%	-
1979	a	n/a	400	n/a	10,000	3.8%	-
1980	Closed	0	0	n/a	4,000	0.0%	-
1981	Closed	0	0	n/a	5,500	0.0%	-
1982	Closed	0	0	n/a	2,200	0.0%	-
1983	Closed	0	0	n/a	5,800	0.0%	-
1984	Closed	0	0	n/a	7,892	0.0%	-
1985	Closed	0	0	n/a	11,125	0.0%	-
1986	Hybrid	6,145	237	0	12,000	1.9%	Rebuilding
1987	Hybrid	6,071	215	8	10,000	2.1%	Rebuilding
1988	Hybrid	14,288	174	0	14,000	1.2%	Rebuilding
1989	Hybrid	19,449	120	0	11,000	1.1%	Rebuilding
1990	Hybrid	28,708	1,515 b	20	13,000	10.4%	Rebuilding
1991	Roving	28,891	528 b	0	10,000	5.0%	Rebuilding
1992	a	n/a	595 b	n/a	13,300	4.3%	Rebuilding
1993	Hybrid	30,992 b	847 b	167	6,000	12.4%	Indeterminate
1994	Hybrid	33,754 b	1,107 b	100	16,150	6.4%	Indeterminate

a. Estimated by local enforcement staff using subjective techniques.

b. Includes estimates from the Mabel Lake fishery.

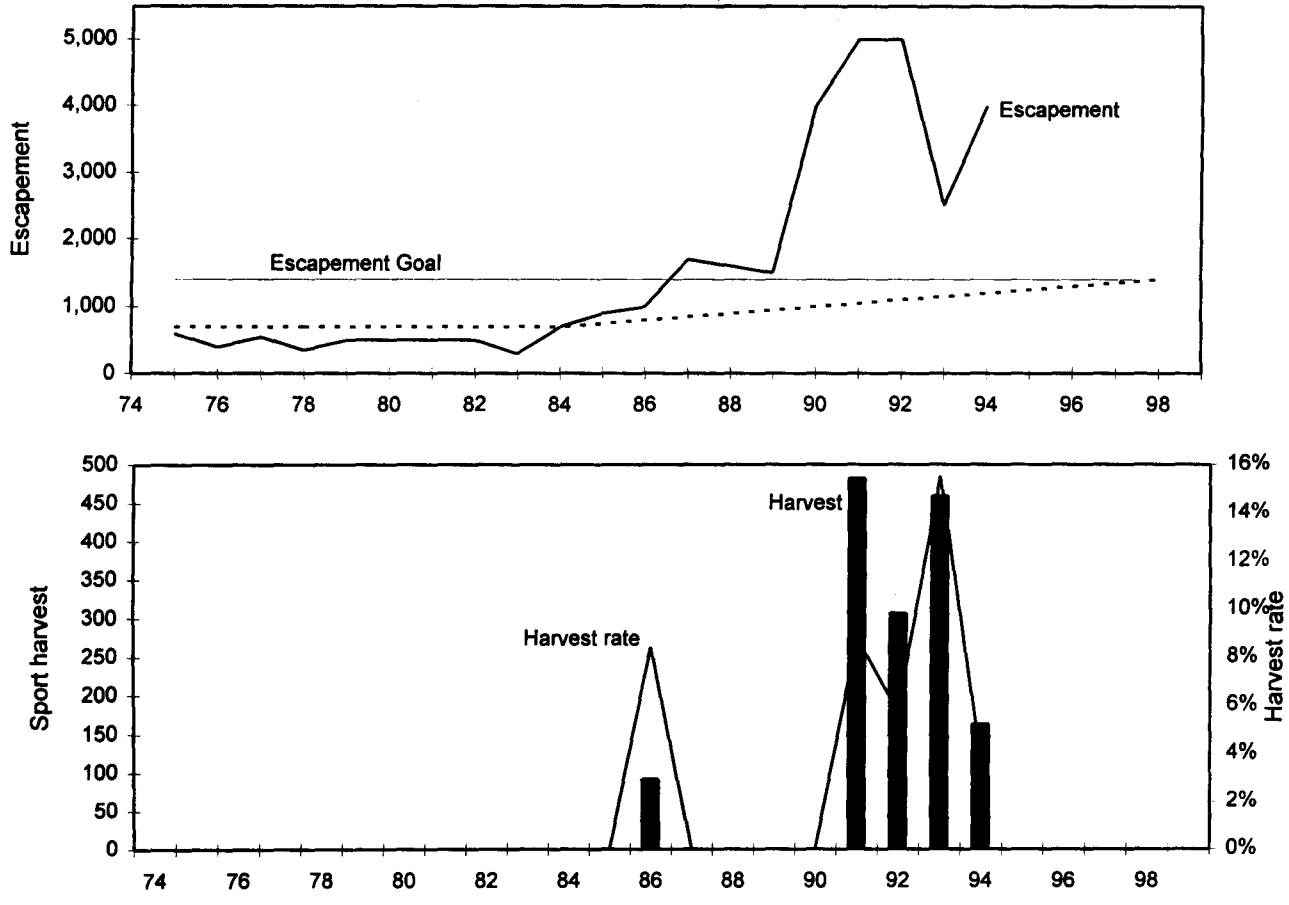
B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly a	Annual			
			Lower Shuswap River				
1986	29-Jul to 08-Aug	1	none	10	2	4	50
1986	09-Sep to 23-Sep	1	none	10	2	5	450
1987	01-Sep to 22-Sep	1	none	10	2	7	500
1988	24-Aug to 07-Sep b	2	none	10	7	14	500
1989	16-Aug to 06-Sep b	2	none	10	7	21	500
1990	15-Aug to 12-Sep b	2	none	10	7	28	500
1991	15-Aug to 12-Sep b	2	6	10	7	28	500
1992	15-Aug to 12-Sep b	2	6	10	7	28	500
1993	15-Aug to 12-Sep b	2	6	10	7	28	500
1994	15-Aug to 12-Sep b	2	6	10	7	28	500
			Mabel Lake				
1990	29-Aug to 08-Sep b	2	none	10	7	10	100
1991	29-Aug to 12-Sep b	2	6	10	7	10	200
1992	15-Aug to 12-Sep b	2	6	10	7	28	200
1993	15-Aug to 12-Sep b	2	6	10	7	28	200
1994	15-Aug to 12-Sep b	2	6	10	7	28	200

a. Monthly limit included the entire Shuswap River system.

b. Fisheries opened and closed at noon.

Middle Shuswap River



SYNOPSIS

Rebuilding Criterion: The middle Shuswap River chinook escapements reflect an initially positive response to the rebuilding program, followed by a dramatic increase resulting from enhancement measures intended to provide increased returns for terminal harvest. The rebuilding progress of this stock has clearly exceeded all other stocks in the Thompson group, with escapements in excess of the interim goal in every year since 1987. This stock was classified as *Rebuilding* in 1986-1989, and as *Above Goal* in 1990-1994.

Manageability Criterion: This fishery is not regulated by a ceiling and, although harvest rates commonly exceed 5%, the middle Shuswap is a special case because current escapements are well above the interim target of 1,400. High terminal harvest rates reflect a harvest of fish which are surplus to the interim escapement goal and do not, therefore, impact the rebuilding program.

Assessment Criterion: Creel surveys were conducted each year this fishery has been open.

Enhancement Criterion: Enhancement has contributed to the return in every year since 1987 and is expected to continue for the foreseeable future.

MIDDLE SHUSWAP RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	n/a	n/a	n/a	n/a	600	n/a	-
1976	n/a	n/a	n/a	n/a	400	n/a	-
1977	n/a	n/a	n/a	n/a	550	n/a	-
1978	n/a	n/a	n/a	n/a	350	n/a	-
1979	n/a	n/a	n/a	n/a	500	n/a	-
1980	Closed	0	0	n/a	500	0.0%	-
1981	Closed	0	0	n/a	500	0.0%	-
1982	Closed	0	0	n/a	500	0.0%	-
1983	Closed	0	0	n/a	300	0.0%	-
1984	Closed	0	0	n/a	700	0.0%	-
1985	Closed	0	0	n/a	900	0.0%	-
1986	Roving	3,808	92	0	1,000	8.4%	Rebuilding
1987	Closed	0	0	n/a	1,700	0.0%	Rebuilding
1988	Closed	0	0	n/a	1,600	0.0%	Rebuilding
1989	Closed	0	0	n/a	1,500	0.0%	Rebuilding
1990	Closed	0	0	n/a	4,000	0.0%	Above goal
1991	Hybrid	5,622	482	4	5,000	8.8%	Above goal
1992	Hybrid	8,964	307	0	5,000	5.8%	Above goal
1993	Hybrid	5,542	459	70	2,500	15.5%	Above goal
1994	Hybrid	6,255	163	7	4,000	3.9%	Above goal

a. Includes effort and harvest in the lower Shuswap River fishery targetting on middle Shuswap River chinook.

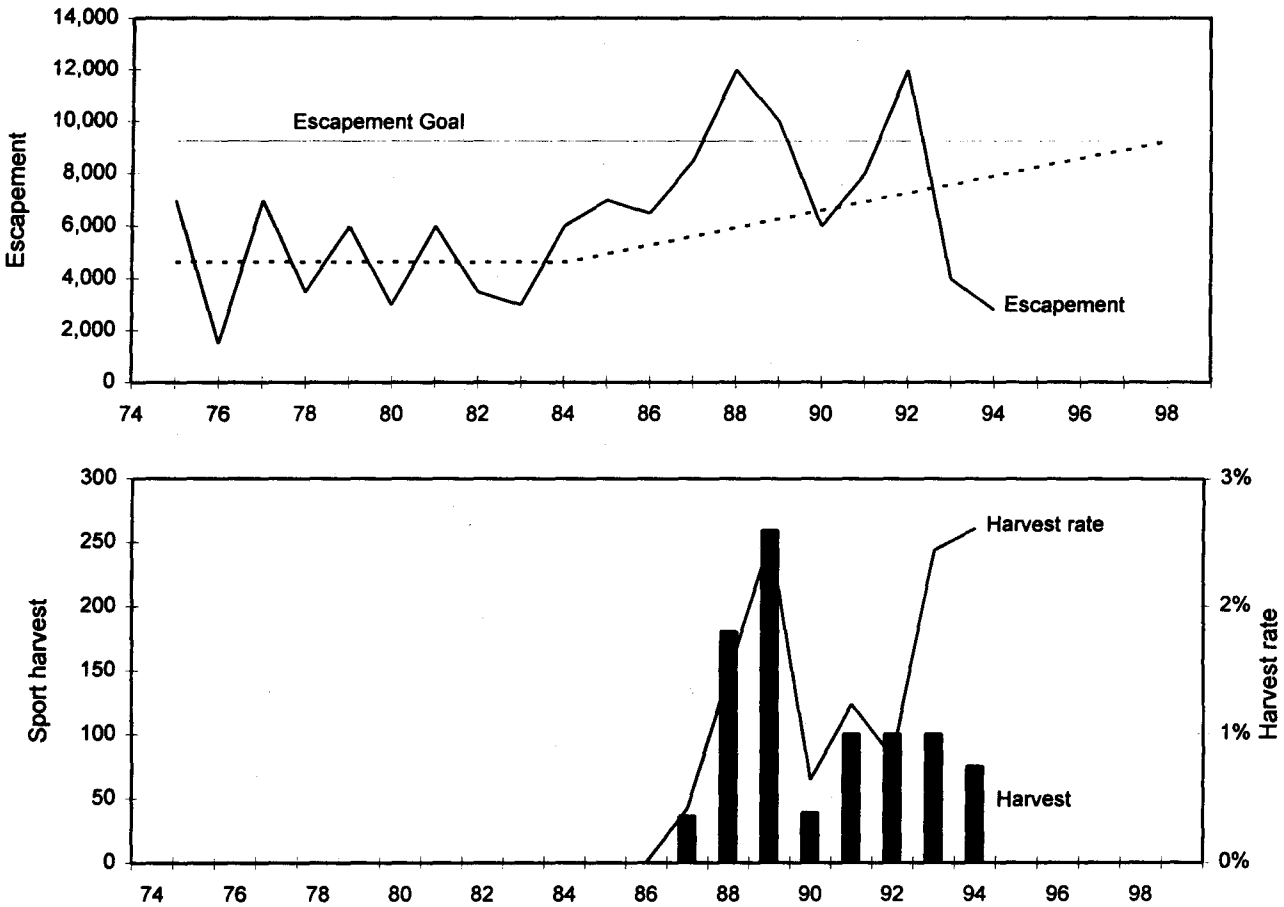
B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly a	Annual			
1986	29-Jul to 08-Aug	1	none	10	2	4	50
1991	01-Aug to 08-Aug b	2	6	10	7	7	100
1992	25-Jul to 08-Aug b	2	6	10	7	14	none
1993	25-Jul to 08-Aug b	2	6	10	7	14	none
1994	25-Jul to 08-Aug b	2	6	10	7	14	none

a. Monthly limit included the entire Shuswap River system.

b. Fishery opened and closed at noon.

South Thompson River



SYNOPSIS

Rebuilding Criterion: In 1987, South Thompson River chinook were responding well to the rebuilding program. The escapements had gradually increased since the early 1980's and were well above the base period average; consequently, the stock was classified as *Rebuilding*. Rebuilding performance since 1987 has been variable. The escapements were above the interim goal in three of the last seven years; however, they were below the base-to-goal line in three of those years and below the base period average in the last two years. As a result, the rebuilding classification changed to *Not Rebuilding* in 1994.

Manageability Criterion: The fishery harvest exceeded the ceiling once (1989) in eight years; however, harvest rates were below 5% each year.

Assessment Criterion: Creel surveys were conducted in 1987, 1989 and 1990. All other estimates were provided by fishery officers and were derived using less structured techniques.

Enhancement Criterion: This stock has never been enhanced.

SOUTH THOMPSON RIVER CHINOOK

A. Annual fishery performance and stock status.

Year	Fishery estimation technique	Angler effort (hour)	Chinook adult catch		Chinook adult escapement	Harvest rate (%)	Rebuilding status
			Harvest	Release			
1975	a	n/a	b	n/a	7,000	n/a	-
1976	a	n/a	b	n/a	1,500	n/a	-
1977	a	n/a	b	n/a	7,000	n/a	-
1978	a	n/a	b	n/a	3,500	n/a	-
1979	a	n/a	b	n/a	6,000	n/a	-
1980	Closed	0	0	n/a	3,000	0.0%	-
1981	Closed	0	0	n/a	6,000	0.0%	-
1982	Closed	0	0	n/a	3,500	0.0%	-
1983	Closed	0	0	n/a	3,000	0.0%	-
1984	Closed	0	0	n/a	6,000	0.0%	-
1985	Closed	0	0	n/a	7,000	0.0%	-
1986	Closed	0	0	n/a	6,500	0.0%	Rebuilding
1987	Hybrid	5,671	36	0	8,500	0.4%	Rebuilding
1988	a	n/a	180	n/a	12,000	1.5%	Rebuilding
1989	Hybrid	12,118	259	3	10,000	2.5%	Rebuilding
1990	Hybrid	4,227	39	8	6,000	0.6%	Rebuilding
1991	a	n/a	100	n/a	8,000	1.2%	Rebuilding
1992	a	n/a	100	n/a	12,000	0.8%	Rebuilding
1993	a	n/a	100	n/a	4,000	2.4%	Rebuilding
1994	a	n/a	75	n/a	2,800	2.6%	Not rebuilding

a. Estimated by local enforcement staff using subjective techniques.

b. Included in the lower Shuswap River.

B. Annual sport fishery regulations.

Year	Open Period	Angler harvest limits			Days open per week	Total days open	Harvest ceiling
		Daily	Monthly	Annual			
1987	11-Sep to 25-Sep	1	none	10	2	5	200
1988	07-Sep to 16-Sep a	2	none	10	7	9	200
1989	30-Aug to 13-Sep a	2	none	10	7	14	200
1990	29-Aug to 19-Sep a	2	none	10	7	21	300
1991	29-Aug to 26-Sep a	2	6	10	7	28	300
1992	29-Aug to 26-Sep a	2	6	10	7	28	300
1993	29-Aug to 26-Sep a	2	6	10	7	28	300
1994	29-Aug to 26-Sep a	2	6	10	7	28	300

a. Fishery opened and closed at noon.