A MARK AND RECAPTURE STUDY OF RAINBOW TROUT SPAWNING IN THE UPPER NADINA RIVER MAY, 1988

by

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CONTENTS

ABSTRACT

In May 1988 a mark and recapture study was conducted on spawning rainbow trout in the upper Nadina River, a few hundred meters downstream from Nadina Lake. The objectives were to determine if spawners migrated back to Francois Lake, and to obtain estimates of the spawning population.

A total of 269 fish were tagged and 68 were recaptured during the tagging project.

Various formulae estimated spawning populations of rainbow trout to vary from a minimum of 660 fish to a maximum of 1229 fish (95% confidence interval). Most spawning fish were either six or seven years of age and ranged from 35 cm to 45 cm. Females outnumbered males 3.8 to 1.

A total of 14 tagged fish (5.2%) were later recovered in the sport fishery in Francois Lake, while two (0.7%) were recovered in Tagetochlain Lake.

ACKNOWLEDGEMENTS

D. deLeeuw, G. Schultze and R. Tetreau helped capture and mark the fish. The Department of Fisheries and Oceans (B. Van Horlick and S. Barnetson) provided accommodations at the D.F.O. spawning

channel. D. Bustard aged the trout scale samples and conducted the creel survey on Francois Lake. G. Schultze and M. Beere computed population estimates. P. Stent provided local names of geographic features of Francois Lake. B. Potulicki produced the figures, M. Barnard typed and R. Hooton edited this report.

INTRODUCTION

In 1987 a study was conducted to assess the importance of rainbow trout recruitment from various streams tributary to Francois Lake. It was concluded that the Nadina River accounted for 42% of the total fry and 32% of the total parr production of all tributaries (Bustard, 1988). However, it was noted that a major limitation to trout production in the Nadina was the lack of good quality spawning gravel. Much of the spawning occurred in the Upper Nadina just downstream from Nadina Lake and opposite the sockeye salmon spawning channel operated by the Department of Fisheries and Oceans. It was suspected that spawning fish were attracted to this area by the stable water flows provided by Nadina Lake. However, the gravel in this area was sparse, and generally of poor quality. Consequently, one recommendation of the earlier study was to improve the spawning habitat in the upper Nadina River (Bustard, 1988).

Before proceeding with this gravel enhancement, it was necessary to determine whether the rainbow trout spawning in this location were Francois Lake migrants or Nadina River residents. In spring 1988 a mark and recapture program was conducted to examine this question. The objectives of the project were:

1. Verify the origin of the trout spawning in upper Nadina River.

2. Estimate the population of rainbow trout spawning in upper Nadina through mark and recapture as described by Schnabel, Chapman and Schumacher.

3. Gather biological information about the upper Nadina spawning population and obtain scale samples to determine ages.

DESCRIPTION OF STUDY AREA

The Nadina River flows 42 km from Nadina Lake into the east end of Francois Lake which drains into the Fraser River watershed. The tagging project was conducted on the upper Nadina River, about one kilometer downstream from Nadina Lake. This area is located about 145 km southwest of Houston and is accessible by all weather gravel roads from either Houston or Burns Lake (Fig. 1). An artificial spawning channel was constructed here for sockeye salmon in 1973 and operated by the International Pacific Salmon Fisheries Commission until 1986 when they were integrated with the Department of Fisheries and Oceans (Barnetson, 1990).

Upper Nadina stream gradient was generally less than .5%, the river was about 30 meters wide, and the area utilized by spawning rainbow trout in spring and sockeye salmon in fall was about 250 lineal meters.
Nadina Lake provides a moderating influence to upper Nadina River and results in stable, relatively clear water flow conditions. It

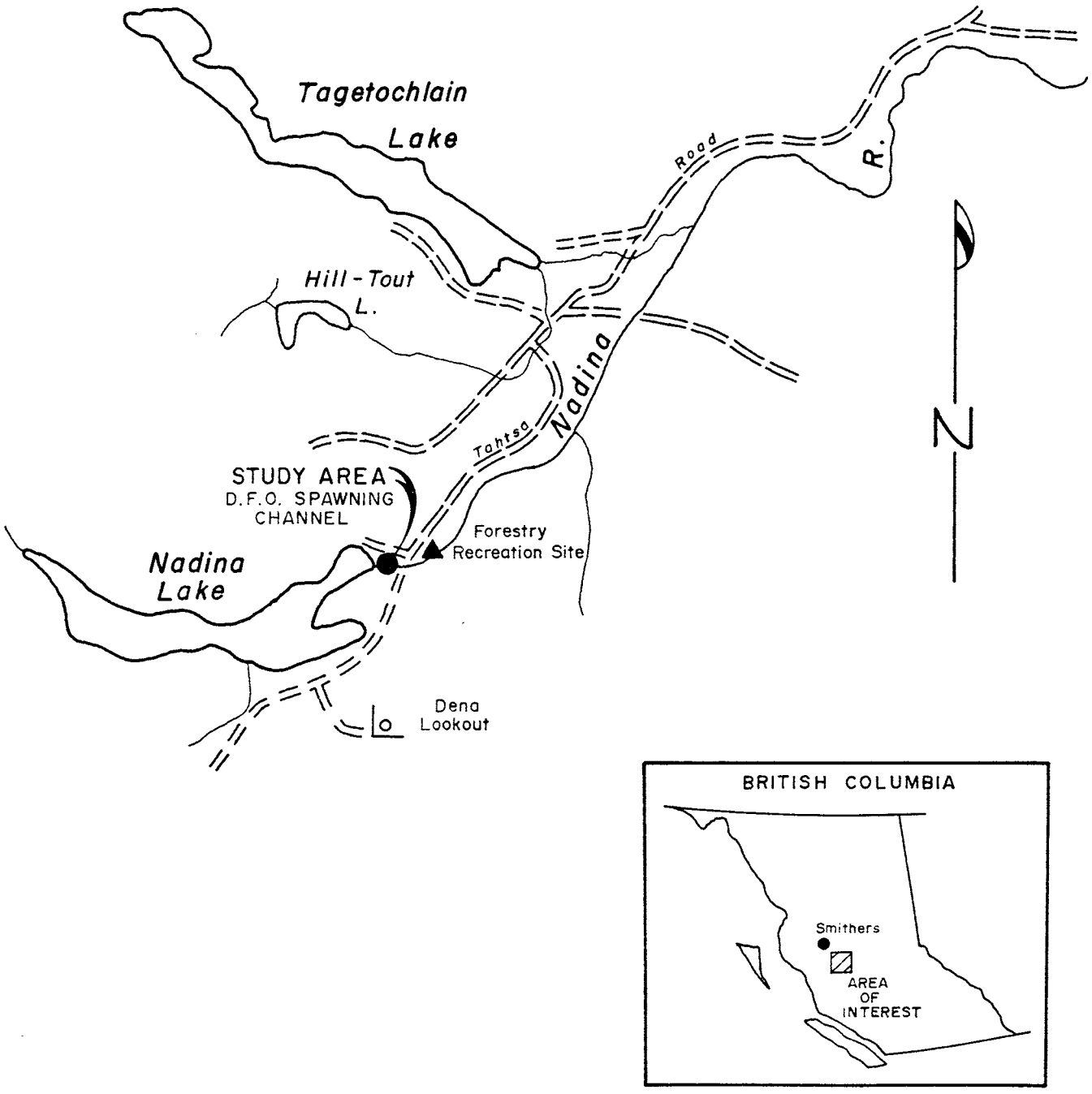


Fig. 1 . Location of Upper Nadina River

was suspected that this is the primary reason rainbow trout are attracted to this area to spawn. However, the quality of spawning gravel is poor and scattered in small patches throughout this section. Upstream, the river banks are primarily bedrock affording no gravel recruitment to the spawning area. A series of waterfalls and chutes immediately downstream from Nadina Lake restricts upstream fish movement during certain flow conditions (Barnetson, 1990).

There are Ministry of Forests campsites at the Nadina River bridge crossing, and at Nadina Lake. A fishing camp (Nadina Lake Lodge) has operated on the lake for more than 20 years.

Fish species common to Nadina River include rainbow trout *(Oncorhynchus mykiss),* Dolly Varden char *(Salvelinus malma)* and sockeye salmon *(O.nerka).* Occasionally chinook salmon *(O.tshawytscha),* have been observed in the Nadina River, adjacent to the spawning channel (Van Horlick, 1988).

Nadina Lake contains rainbow trout, kokanee salmon *(O.nerka),* mountain whitefish *(Prosopium williamsoni)* and longnose sucker *(Catostomus catostomus)* (Burns and Tredger, 1974).

METHODS

Project staff caught and tagged rainbow trout by angling from shore. Dennison Mark II and Monarch Marking 3030 tagging guns were used to apply numbered blue Hallprint anchor tags (no.T198) to all fish landed. All tags were inserted and anchored obliquely into the back of the fish immediately below the dorsal fin. Where feasible a fish tagging stand (see photographs) was used to facilitate easier handling of the fish.

Date, tag number, fork length of fish, maturity, and sex of each fish captured was recorded. Tag numbers and maturity of previously marked fish were recorded. Scales were taken from the preferred area behind the dorsal fin above the lateral line. (All fish caught were released alive immediately following tagging.)

Approximately 20 scales per fish were mounted between glass slides and projected using a Leitz Neo—Promor projection microscope at either x25 or x40 magnification. The scales were aged independently by two experienced technicians, and where ages differed, consensus was reached by collaboration.

Spawning population estimates were calculated on an AST micro computer using Lotus 1—2—3 software and based on the formulae developed by Schnabel, Chapman and Schumacher as described by Ricker (1975)

Information posters explaining the Nadina tagging project were placed at various Forestry Recreation sites and fishing lodges around Francois Lake. Anglers were asked to record tag number, date and location of capture of tagged fish and forward this information either to the Fish and Wildlife Branch or to any of the roving creel survey personnel.

RESULTS AND DISCUSSION

A. MARK AND RECAPTURE

Fish tagging began May 11 and continued until May 26. A total of 269 rainbow trout were caught and tagged. Sixty—one were recaptured once, six fish were recaptured twice, and one individual was recaptured three times. Angler effort varied from one rod per day to four rods per day (Table 1).

Terminal tackle used was roe, roe—paste, worms, flies, spinners and spoons. Roe—paste, was very effective, as were worms, while spoons and spinners were generally the least effective.

During the first few days of tagging, Nadina River was relatively high and turbid and fish were not visible unless they surfaced. Fish were readily and consistently caught in specific areas of the river. As the water level dropped and visibility improved, it became evident they were concentrated on the few patches of gravel which appeared suitable for spawning. In fact, angling anywhere else, even in deep pools nearby, was generally not productive throughout the study.

Table 1 Number of rainbow trout tagged and recaptured and angler effort in Nadina River opposite D.F.O. sockeye spawning channel in May, 1988.

Date	No. of Untagged Fish Caught	No. of first Recaptures During Period	No. of second Recaptures During Period	No. of third Recaptures During Period	Cum. no of Untagged and Tagged Fish	No. of Rods
May 11					12	1
16	14				26	1
17	49	3			78	3
18	89	12	1		180	4
19	22	10			212	4
25	62	26	4	1	305	3
26	21	10	1	_	337	3
Totals	269	61	6	1		18

Rainbow trout were concentrated in the area immediately downstream from the spawning channel outlet. Fish activity increased toward evening, as evidenced by surface display. The spawning channel operator indicated sockeye fry emigration peaked in the evening (Van Horlick, 1988), and it appeared the rainbow trout were actively feeding on the sockeye fry as they were leaving the channel.

The tagging project was terminated on May 26. By that date the ratio of marked to unmarked fish increased abruptly and kelts began to dominate the catch.

These factors suggested peak spawning was past, and the population was declining as kelts left the area.

B. SPAWNING POPULATION ESTIMATION

Table 2 presents estimates of the rainbow trout population spawning in the study area. The Schumacher formula provided the lowest estimate of 820 fish, with confidence limits at 95 percent level of 667 to 1062 fish. The Schnabel formula produced the highest estimate of 864 fish with a range of 682 to 1095 fish (Poisson) or 666 to 1229 (normal). Details of the calculations are presented in the appendix.

Table 2 Multiple census population estimates of rainbow trout spawning in upper Nadina River in May, 1988.

METHOD	Estimated Population	95 Percent confidence Interval
Schnabel	864	666 — 1229(Normal) 682 — 1095(Poisson)
Chapman	852	660 — 1200(Normal) 668 — 1078(Poisson)
Schumacher	820	668 — 1062

Ricker (1975) suggested that the validity of a population estimate, based upon a mark and recapture study, related to the following assumptions:

1. That natural mortality for marked fish is the same as for unmarked.
2. That marked fish are as catchable as unmarked fish.
3. That marked fish do not lose their mark.
4. That the marked fish become randomly mixed with the unmarked.
5. That all marked recoveries are recognized and reported.

6. That recruitment into the study population during mark and recovery is negligible.

It was felt that most of these conditions were satisfied. The fisheries crew was very experienced in catching and tagging fish and was reasonably certain of negligible mortalities. In fact, no mortalities for marked (or unmarked) fish were observed. The river was closed to angling, so sport fishermen did not remove any fish. Some mortality may have occurred from ospreys which were present for the duration of the study. However, it is difficult to speculate whether they would have selected marked fish over unmarked ones. The number of recaptures (61), second recaptures (6), and even a third recapture suggests that marked fish were as readily catchable as unmarked fish. The tagging study was of short duration (16 days) so it was believed that the marked fish did not lose their tags.

Because these fish were attracted to this area to spawn it seemed reasonable to assume that they would remain after being marked and would randomly mix with unmarked fish on the gravel patches until completion of spawning.

At the start of tagging (May 11) it was possible that not all fish had arrived. Consequently, there may have been some initial recruitment. However, only 4.5% of the fish were tagged on this day, and there was a five day interval to the second day of tagging

on May 16. By May 19, angling at several sites downstream from this area was unsuccessful. It was therefore speculated that all fish had completed migration to the spawning area.

C. LIFE HISTORY

a. Age

Ages were determined for 87 fish randomly selected during tagging operations. Ages ranged from four years to nine years, with 40.2% age six, followed by 32.2% age seven. Only one fish was four years, while just three fish were nine years (Table 3).

Table 3 Age and Length of spawning rainbow trout caught in Upper Nadina River in May, 1988.

Age	Fork Lengths (cm)			No. of Fish	Percent Total Sample
	Mm	Max	Mean		
4	—	—	27.0	1	1.1
5	35.0	39.0	37.1	8	9.2
6	36.0	44.0	39.7	35	40.2
7	39.0	46.5	42.4	28	32.2
8	39.5	48.0	45.9	12	13.8
9	47.0	49.0	48.0	3	3.4
				87	99.9

Of particular interest was that about 72% of the spawners were either age six or seven. Lengths for these two age classes varied from 36 cm to 46.5 cm. These data could be of some significance in developing future regulations for Francois Lake. For example, if a minimum size restriction is being considered to conserve spawning

fish, those less than 35—40 cm should not be harvested.

b. Growth

Figure 2 presents length frequency distributions for the 269 unmarked rainbow trout caught and tagged in upper Nadina River. About 75% were between 35 cm and 45 cm. Figure 3 was developed to compare length frequencies of the 87 aged fish with all 269 fish caught to determine if the lengths of the aged fish were representative of all fish tagged. The length frequency of aged fish was similar to the tagged population (Fig. 3).

Table 4 illustrates average annual growth increments, based on fork length. From age five to age eight, average annual growth increased by about 2.9 cm or 7.4% per year. Sample sizes of fish in age class four years and nine years were insufficient for the data to provide any meaningful information.
Scale patterns suggested initial slow growth followed by consistent, relatively rapid growth.

Thirty-three of 88 fish sampled (37%) exhibited two years of slow growth while 55 fish (62%) indicated three years of slow growth. This could suggest that Nadina fish remained in the river for either two or three years before emigrating to Francois Lake where more rapid growth is assumed to occur.

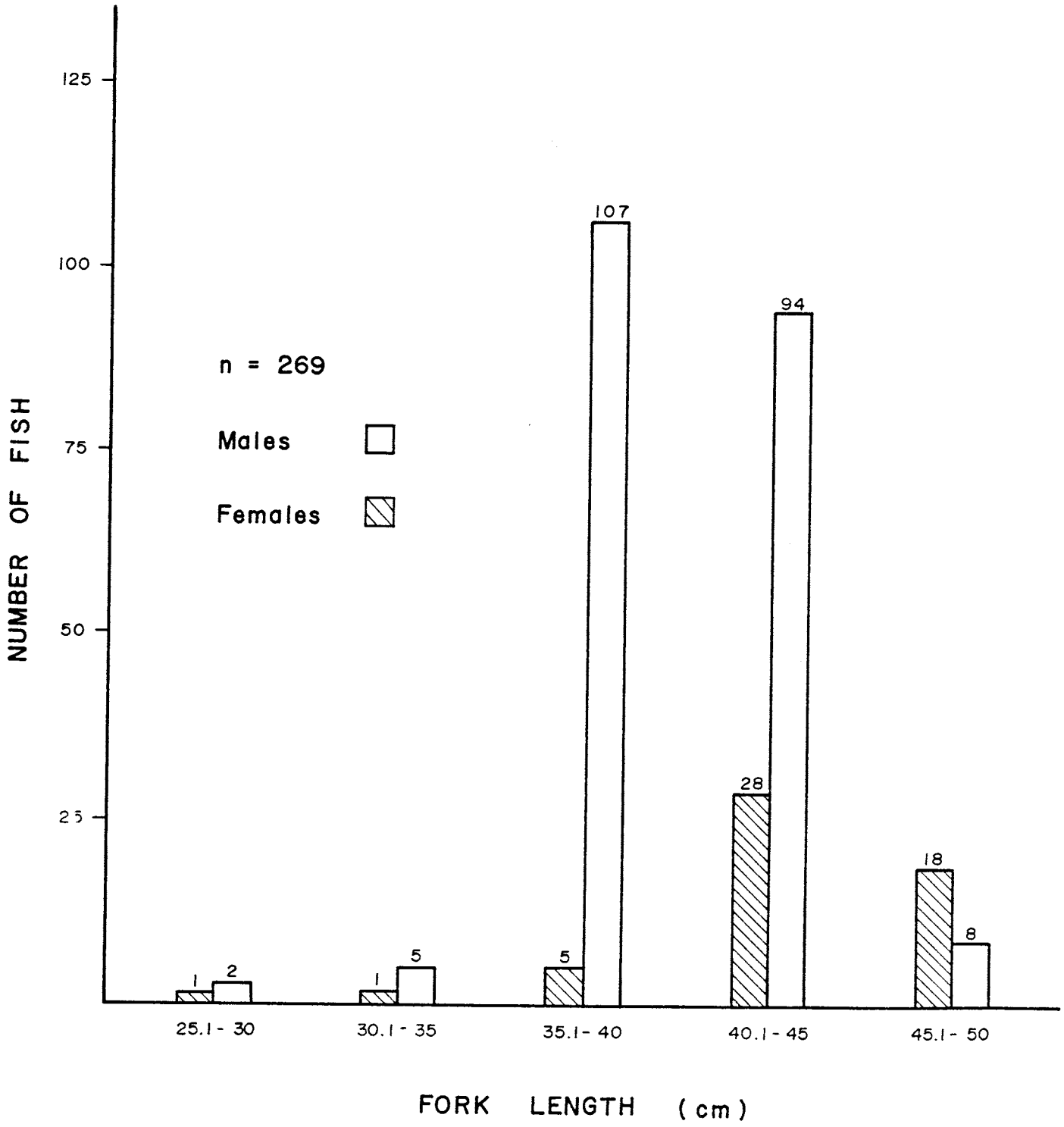


Fig. 2. Length frequency distribution of rainbow trout caught in Nadina River , May , 1988

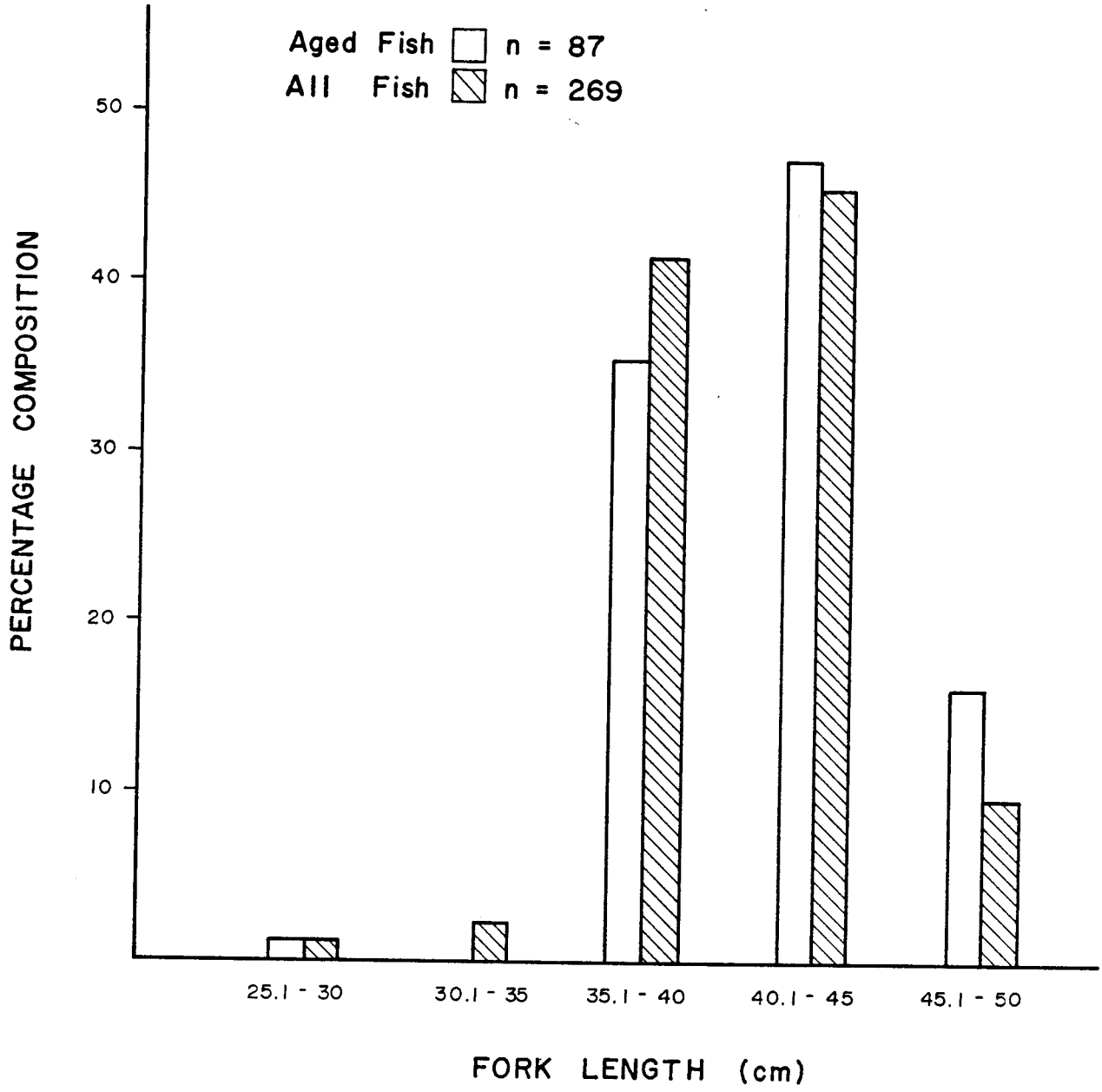


Fig. 3 A comparison of length frequency distribution of aged rainbow trout tagged in Nadina River , May ,1988.

Table 4 Average annual growth increase of aged rainbow trout from upper Nadina River, May, 1988.

Age (years)	No. of Fish	Mean Length (cm)	Annual growth increment	
			cm	%
5	8	37.1		
6	35	39.7	2.6	7
7	28	42.4	2.7	6.8
8	12	45.9	3.5	8.3
9	3	48.0	2.1	4.6

C. Sex Ratio

Of the 269 unmarked rainbow trout caught, only 56 (20.8%) were males, and the sex ratio was 3.8 females: 1 male. This suggested either that sampling was biased toward females or that females dominated the spawning population. The similarity of recapture rates for males and females (23.2% and 22.5% respectively) implied sampling was not biased and that females were in fact more abundant.

Among the 87 aged fish, males were not represented until age six, and females were not older than eight years (Table 5). There was a noticeable absence of precocious males in the sample.

It was difficult to determine whether the 87 aged fish were a representative sample of the population age structure and sex

ratio. However, the sex ratios of aged fish (3.1:1) versus all fish sampled (3.8:1) were similar.

Table 5 Age frequency of male and female rainbow trout caught in upper Nadina River, May, 1988

Age (years)	No. of Males	No. of Females	Total	% Males
4	0	1	1	0
5	0	8	8	0
6	5	30	35	14
7	4	24	28	14
8	9	3	12	75
9	3	0	3	100
	21	66	87	24

Sex ratio: 3.1 females: 1.0 male

d. Spawning

Rainbow trout were first observed spawning on May 9 (Barnetson, 1988) and were still present on May 26. Onsite staff indicated that for most years rainbow spawners arrived in this area in the first week of May and by the second week in June the fish had completed spawning and emigrated. In the current study, over 50% of the fish caught were kelts on May 25 and May 26. This suggested that the peak of spawning had occurred near these dates (Table 6).

Table 6 Number of unmarked fish and kelts caught in upper Nadina River, May, 1988

Date	No. of Unmarked Fish Caught	No. of Kelts	% Kelts
May 11	12		
16	14		
17	49	1	2.0
18	89	9	10.1
19	22	1	4.5
25	62	32	51.6
26	21	11	52.4
Total	269	54	

D. MARKED FISH RECOVERIES IN SPORT FISHERIES

A total of 14 marked fish were recaptured by anglers on Francois Lake and two were caught in Tagetochlain (Poplar) Lake (Table 7). The first tagged fish was recovered on June 12 near the Nadina River. The last reported recapture occurred at the east end of Francois Lake on October 31. Generally, most tagged fish were recovered from the central portion of Francois Lake (Table 7) (Fig. 4). This was interesting because the creel survey indicated that this area (Zone 2) received only 29.1% of the angler effort compared to 24.3% and 46.6% for Zones 1 and 3 (east end) respectively. However CPUE was 0.41 for Zone 2 while only 0.32 and 0.22 for Zones 1 and 3 respectively (Bustard, 1989).

Table 7 Summary of rainbow trout tagged in upper Nadina River and recaptured in Francois and Tagetochlain (Poplar) lakes — 1988

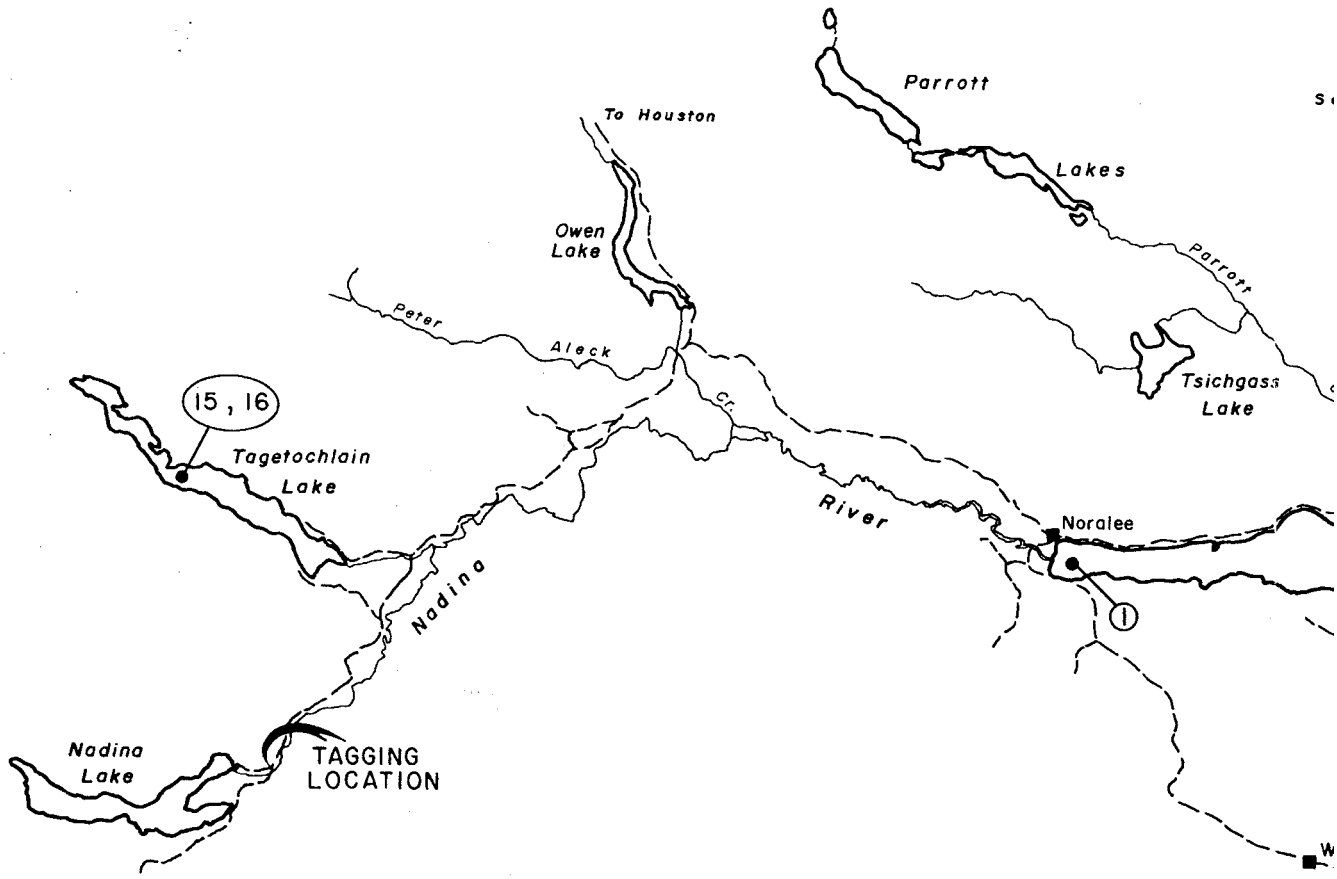
A. Francois Lake

Fish No. (Fig.4)	Tag No.	Date Tagged	Date Recaptured	Recapture Location
1	02109	May 18	June 12	Off mouth of Nadina River
2	02223	May 25	June 21	Pierce Point
3	02256	May 25	June 21	Pierce Bay area
4	02152	May 18	June 24	4 mi. west of Sandy's Resort
5	02014	May 16	June 26	Near Sandy's Resort
6	02028	May 17	June 26	Near Francois Ferry
7	02066	May 17	July 3	Near Sandy's Resort
8	02078	May 17	July 3	2km West of Sandy's Resort
9	02211	May 25	July 3	Across from Francois Lk. Resort
10	02087	May 17	Aug. 1	John's Island
11	02132	May 25	Aug. 19	Big Bay (near Sandy's Resort)
12	02269	May 25	Aug. 20	not site specific
13	02266	May 25	Aug. 25	Cabin Bay, near Sandy's Resort
14	02073	May 17	Oct. 31	East end Francois Lake

B. Tagetochlain (Poplar) Lake

15	02006	May 16	July 3	Unknown
16	02119	May 18	Sept. 4	Unknown

Given that 5% of the fish tagged at upper Nadina River were later recovered in Francois Lake it is reasonable to assume that the Nadina spawning population was comprised mainly of fish which originated from Francois Lake. The two recoveries in Tagetochlain Lake suggested that some Nadina spawners originated there. Straying could not be discounted however nor could the possibility that Tagetochlain residence was temporary.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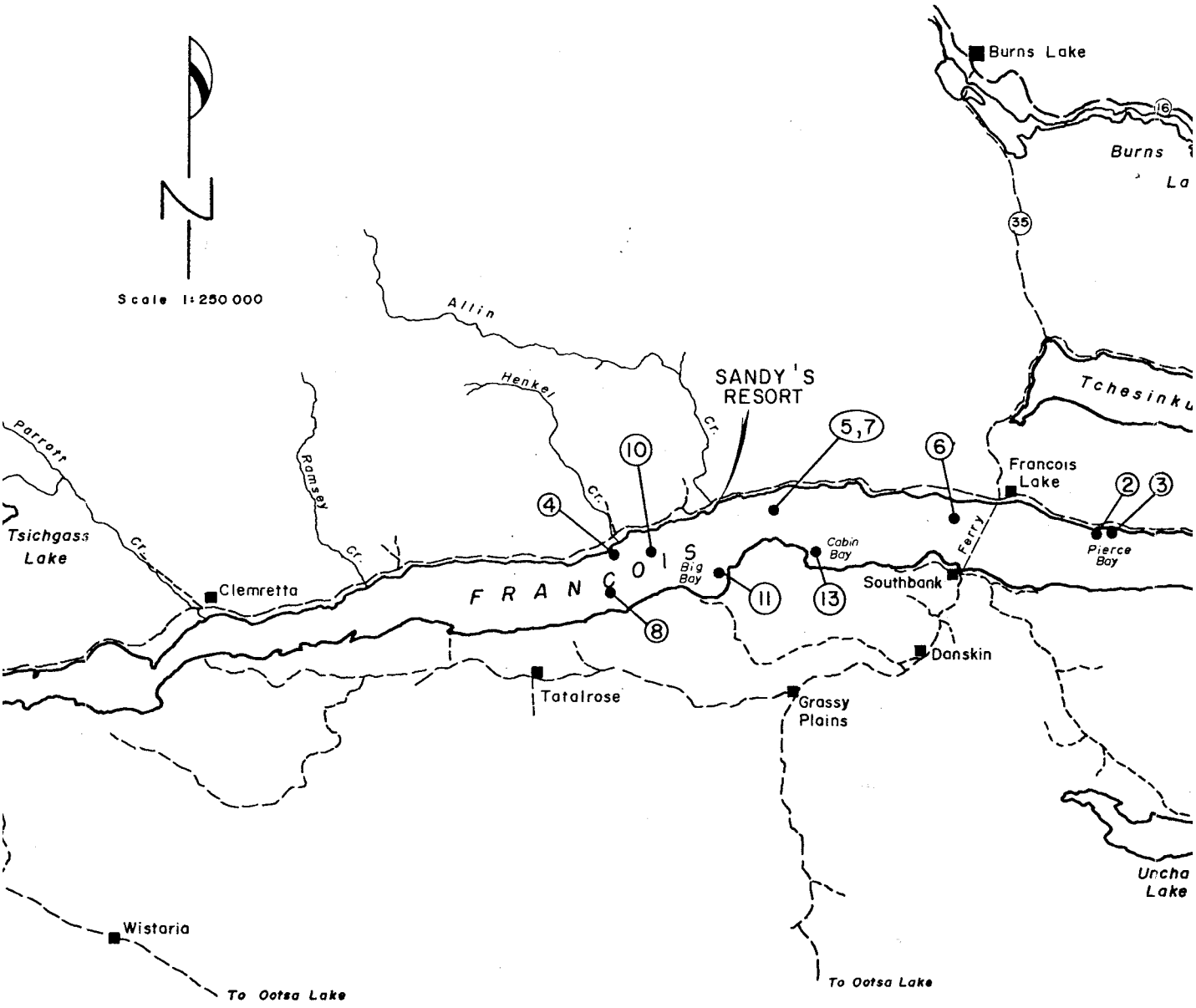
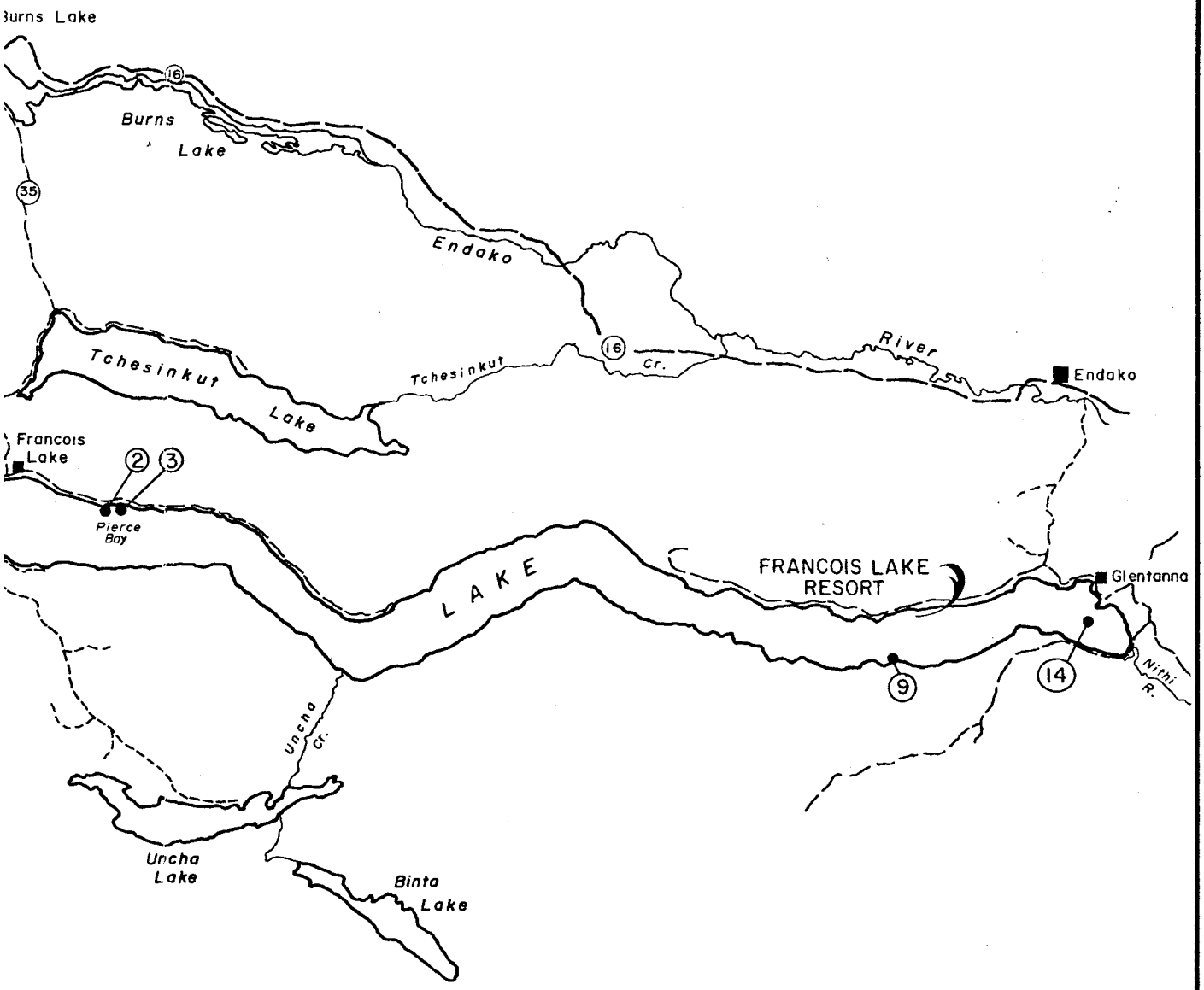


Fig. 4. Locations of tagged fish recovered in the sport fisheries in Tagetochlain (Poplar) and Francois Lakes during summer and fall, 1988.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SUMMARY

Between May 11 and May 26, 1988, 269 rainbow trout were angled and marked in the upper Nadina River opposite the D.F.O. sockeye spawning channel. Fish were concentrated on the few available gravel patches and spawning habitat was considered to be of marginal quality. Spawning population estimates varied from a low of 660 fish to a high of 1229 fish. Scale samples from 87 fish were analyzed and their ages ranged from four years to nine years, with about 72% either six or seven years. Fork lengths of all fish caught varied from 27 cm to 50 cm, with 75% measured between 35 cm and 45 cm. The sex ratio of all fish caught was 3.8 females to 1.0 male. Rainbow trout appear to spawn in the upper Nadina River commencing in early May and concluding about mid—June.

A total of 14 marked fish were later recovered in the sport fishery in Francois Lake and, surprisingly, two were caught in Tagetochlain Lake. Recovery dates varied from June 12 to October 31, while locations were scattered throughout the entire length of Francois Lake, with some concentration in the central area.

CONCLUSIONS

The upper Nadina River, adjacent to the sockeye spawning channel just downstream from Nadina Lake, is an important spawning area for rainbow trout. However, the spawning gravel is patchy, and the

quality is marginal. Significant numbers of rainbow trout migrate from Francois Lake to spawn in this area. Additionally, rainbow trout from Tagetochlain Lake may spawn here. This could suggest a lack of adequate spawning habitat in the Tagetochlain watershed.

RECOMMENDATIONS

1. The quality and quantity of rainbow trout spawning habitat in the upper Nadina River should be enhanced.

2. Mark and recapture studies, similar to this one, should be conducted periodically on the upper Nadina River to monitor the spawning population. This would be of particular importance if a spawning habitat enhancement is undertaken.

3. The entire Nadina River should be examined in May to determine if rainbow trout spawn other than in the spawning channel vicinity.

4. The entire Nadina River should be examined in late summer or early fall to assess stream residency.

5. The Tagetochlain Lake watershed should be investigated to determine if there is adequate spawning gravel for rainbow trout.

6. Tributaries to the Nadina River should be examined to identify spawning habitat and utilization.

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PHOTOGRAPHS (All were taken in May, 1988)

Photo 1. Sign at entrance to Nadina River sockeye salmon spawning channel operated by Department of Fisheries and Oceans.

Photo 2. The sockeye salmon spawning channel.

Photo 3. The area in upper Nadina River where spawning rainbow trout were tagged.

Photo 4. Ron Tetreau tagging a rainbow trout.

Photo 5. Ministry of Environment Fisheries staff Ron Tetreau and George Schultze, and D.F.O. channel operator Bruce Van Horlick (left to right).

Photo 6. The study area opposite the spawning channel.

APPENDIX

Population estimates of spawning rainbow trout in the Nadina River, opposite the Department of Fisheries and Oceans Spawning Channel for May, 1988, using Schnabel, Chapman, and Schumacher formulae as described by Ricker (1975).

POPULATION ESTIMATION USING SCHNABEL, CHAPMAN AED SCHUMACHER - Version I

SYSTEM: Nadina River
STOCK/BRYR: Rainbow Trout
TIME OF SURVEY: May 1988

PERIOD	CT	RT	RT*RT	NEW TAGS	MT	MT*MT	CT*MT	MT*RT	CT(MT*MT)	(RT*RT)/CT	FISH REMOVED
1	12	0	0	12	12	144	144	0	1728	0	
2	14	0	0	14	26	676	364	0	9464	0	
3	52	3	9	49	75	5625	3900	225	292500	0.173076923	
4	102	13	169	89	164	26896	16728	2132	2743392	1.656862745	
5	32	10	100	22	186	34596	5952	1860	1107072	3.125	
6	93	31	961	62	248	61504	23064	7688	5719872	10.33333333	
7	32	11	121	21	269	72361	8608	2959	2315552	3.78125	
7	337	68	1360	269	980	201802	58760	14864	12189580	19.06952300	0

POPULATION ESTIMATES

1.SCHNABEL: N=SUM(CT*MT)/SUM(RT)
N= 864.1176

2. CHAPMAN: N=SUME(CT*MT)/SUM(RT)+1
N= 851.5942

3. SCHUMACHER: 1/N=SUM(MT*RT)/SUM(CT(MT*MT))
1/N=0.001219
N=820.0740

WHERE: CT=NUMBER FISH CAUGHT DURING PERIOD (USUALLY A DAY)
RT=NUMBER RECAPTURES DURING PERIOD INCLUDING SAME DAY RECAPTURES
MT=NUMBER MARKS AT LARGE

T=STUDENT'S T DISTRIBUTION
D.F.=DEGREES OF FREEDOM (NO. OF OBSERVATIONS MINUS 1)

CONFIDENCE LIMITS OF POPULATION ESTIMATES (95%, 2-TAILED)

1.SCHNABEL AND CHAPMAN: NORMAL DISTRIBUTION:

SCHNABEL: V(1/N)=(R)/((SUM CT*MT)(SUM CT*MT))
V(1/N)=2.0E-08

S= 0.000140
T= 2.447 D.F.= 6
(1/N)= 0.001157
S(1/N)= 0.000343

C.L.= 666.3757 TO 1228.735

CHAPMAN: V(1/N)=(R-1)/(SUM CT*MT)(SUM CT*MT))
V(1/N)= 1.9E-08

S= 0.000139
T= 2.447 D.F.= 6
(1/N)= 0.001174
S(1/N)= 0.000340

C.L.= 660.0055 TO 1199.907

2. SCHNABEL AND CHAPMAN; POISSON DISTRIBUTION:

SCHNABEL: RT= 68 VALUES (X) FROM APDX. II (RICKER,1975):

C.L.=SUM(CT*MT)/POISSON RT
= 681.6627 TO 1095.471

CHAPMAN: RT+1= 69 VALUES (X) FROM APDX. II (RICKER, 1975):

C.L.=SUM(CT*MT)/POISSON RT
= 672.9384 TO 1077.740

3. SCHUMACHER: S(S)= 0.157388
S= 0.396721
T= 2.447 D.F.= 6
S(1/N)= 0.000113

C.L.= 667.8001 TO 1062.303