RADIO TELEMETRY STUDIES OF SUMMER RUN STEELHEAD TROUT IN THE SKEENA RIVER DRAINAGE, 1979, WITH PARTICULAR REFERENCE TO MORICE, SUSKWA, KISPIOX AND ZYMOETZ RIVER STOCKS

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ABSTRACT

Radio tagging studies were carried out in the Skeena drainage in order to more fully understand the life history of summer run steelhead trout. During the fall of 1978, 24 steelhead were radio tagged on the Morice River, 15 on the Kispiox River, 14 on the Suskwa River and 6 on the Zymoetz River. In the Morice River, tagged fish wintered throughout the mainstem. Spawning locations were identified for 16 tagged fish, of which 9 spawned in side channels and 7 spawned in tributaries to the Morice. Owen, Gosnell and Lamprey Creeks were identified as the most important tributaries, and some enhancement opportunities were identified. In the Suskwa River, tagged fish were found to winter in the section between Km 6 and Km 14 although some were found to winter in the larger Bulkley River before entering the Suskwa during runoff flows and spawning during late May and early June. Spawning sites were identified for 9 tagged fish, of which 5 were in the Suskwa and 4 in Harold Price Creek. Kispiox River fish were found to move very little during the fall and winter. Four of the 5 identified spawning sites were in tributaries to the Kispiox and tagged fish spawned in the mainstem. In the Zymoetz River, one tagged fish wintered beneath the ice in McDonell Lake before spawning at the lake outlet. Management and enhancement options as identified by the study are discussed.

INTRODUCTION

Skeena River steelhead trout *(Salmo gairdneri* Richardson) are declining in numbers under increased pressure from the commercial, Indian and sport fisheries as well as from habitat degradation (Chudyk and Narver, M.S. 1976). In order to take steps to compensate for this recent trend, it is important that the life history of summer steelhead in the Skeena be more fully understood.

Adult steelhead may spend up to 9 months in fresh water after entering the Skeena (Pinsent and Chudyk, M.S. 1973). Prolonged ice cover followed by heavy spring runoff render most Skeena tributaries and their steelhead populations, impossible to monitor and therefore over—wintering and spawning information is often sketchy. Radio telemetry studies were found to be ideally suited to overcome these handicaps (Winter 1976) and in the autumn of 1978, the B.C. Fish and Wildlife Branch began a program of radio tagging summer steelhead in all of the major Skeena tributaries. The Kispiox, Morice, Suskwa and Zymoetz Rivers (Fig. 1) were selected as priority targets because of imminent plans for enhancement projects under the Salmonid Enhancement Program (S.E.P.), and the fact that the steelhead sport fisheries within these rivers are declining.

A variety of previous studies have already been carried out on these major tributaries. Aspects of the sport fishery as well as analysis of age classes for Kispiox steelhead have been described by Whately (1977) and Taylor (M.S. 1968). Inventory of the small tributaries to the Kispiox.

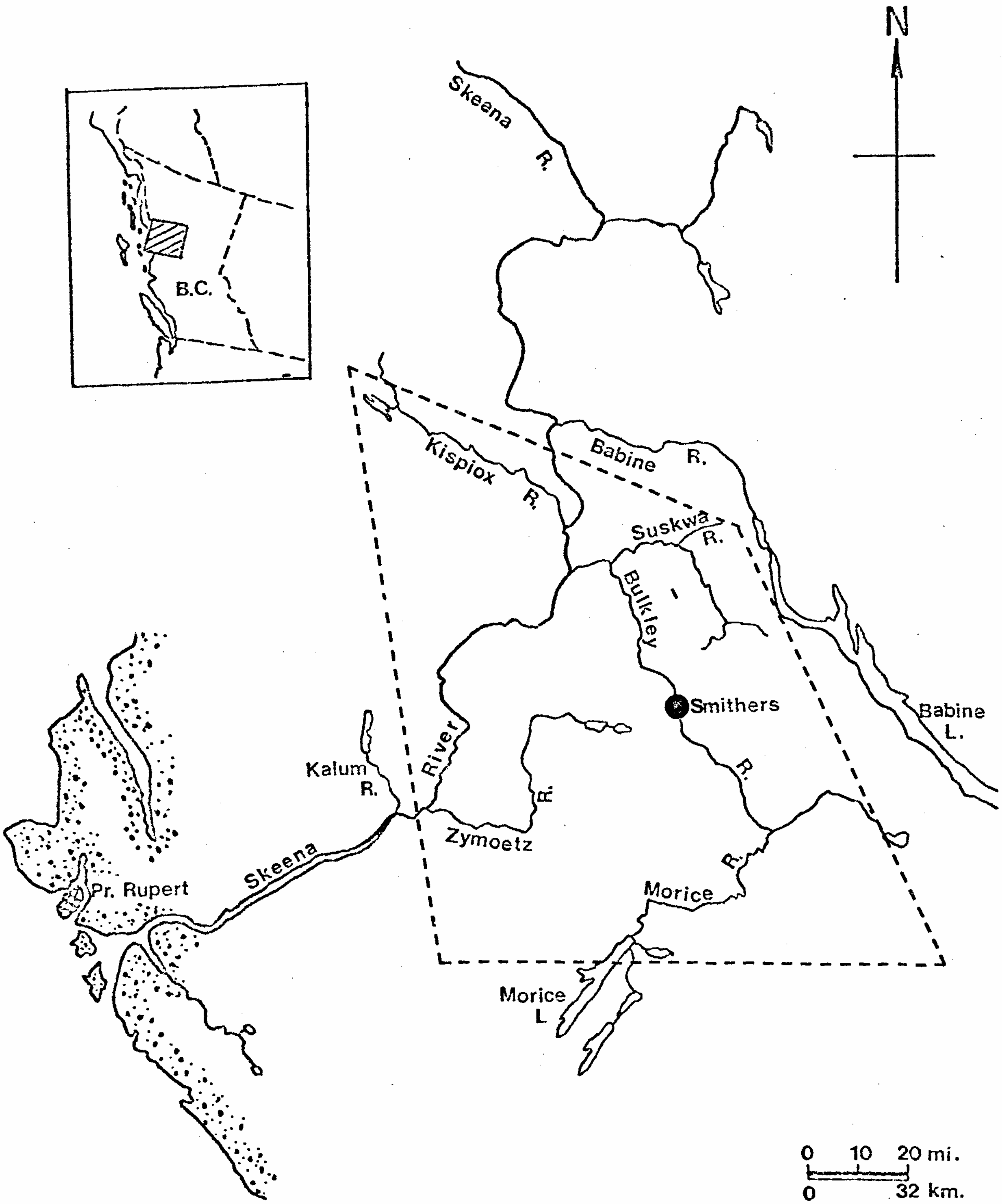


Fig.1. Skeena River drainage study area (1979).

has outlined aspects of both juvenile and adult life histories (Chudyk and Whately, M.S. 1977, and Harding and Erickson, M.S. 1973). On the Morice, steelhead life history characteristics have been investigated by Whately (1978) and many of the larger tributaries have been inventoried with emphasis on juvenile information (Morris and Eccles, M.S. 1976, and Shepard and Algard, M.S. 1977). The Suskwa River has been investigated during preliminary work for the S.E.P. project now underway (Chudyk, M.S. 1978), again with emphasis on life history characteristics and juvenile sampling. Similar surveys have been carried out for the Zymoetz River (Chudyk, M.S. 1979).

A previous radio tagging project provided information on steelhead movements in the Skeena River from the estuary to their natal streams (Lough, M.S. 1978). The primary objective of this study was to provide information on the movements of steelhead within the 4 designated tributaries; their wintering behaviour as well as time and location of spawning.

MATERIALS AND METHODS

TELEMETRY EQUIPMENT

The frequency of telemetry equipment used in this study was 151 Megacycles. This system required a smaller antenna than lower frequency equipment, and therefore was more adaptable to tracking from aircraft, boats and trucks. The radio tags and receivers were purchased from Wildlife Materials Inc. (R.R. #2, Carbondale, Illinois).

Two types of radio tags were used in this study, differing only in size and life of the lithium battery. The larger type was cylindrical in shape, approximately 7.0 cm long and 2.7 cm in diameter, with an expected life of about 400 days. The smaller tags were also cylindrical, but were 5.75 cm long and 1.8 cm in diameter with an expected life of about 200 days. Both types of tags were two—stage subminiature transmitters which emitted a pulsing signal at a rate set between 30 and 70 pulses per minute. They were supplied as a completely self—contained unit encapsulated in several layers of dental acrylic, which waterproofed the unit. Removal of a small external magnet activated the tag, which was designed to be administered internally.

The portable tracking receivers used were tunable radios with a manual channel selector which could be set to cover any of the five frequencies used in this study. Each channel covered a 25 kilocycle band with a 5 kc. overlap between channels. The receivers were powered by an external 12 volt snowmobile battery. Each receiver was equipped with a 3—element yagi antenna (9 decibel gain) and headphone for the operator.

A stationary scanner was designed to be installed semi—permanently beside a stream to detect radio—tagged fish as they passed. Four tributary scanners were used. One was set at the mouth of the Morice River during October 1978. Two were located on the Suskwa River during the spring of 1979, with one at Km 5, and the other at Km 15. The fourth scanner was located at Km 2 of the Zymoetz River from August to November, 1978.

The scanners were pre—set to scan the entire 100 kc. range which covered the five frequencies of tags being used. The centres of the various frequencies were spaced about 20 kc. apart in order to increase discrimination. Each scanner unit was connected to a command print Model 288 Rustrak recorder (Gulton Industries, Rhode Island) which printed out the frequency on a time calibrated strip chart. The entire system was linked to a three (9 db. gain), or an eight element yagi antenna (140 db. gain) and was powered by a 12 volt snowmobile battery. The scanner stations were located on the streams in such a way that they covered shallow riffles, to ensure that the tagged fish produced strong, clear signals as they passed (Fig. 2).

LIVE CAPTURE AND RADIO-TAGGING PROCEDURE

Angling was the most productive method of live capture. A combination of lures and roe with a single hook was generally found to be the most successful.

The steelhead was exhausted by playing on hook and line. The radio tag was pushed down the throat of the fish as far as possible with a finger (Fig. 3) and a stainless steel rod was then used to set the tag down into the stomach. A coating of household margarine on the large 400 day tags allowed them to slip down the throat with ease. After tagging, the fish was held in a recovery tube to ensure that it was healthy at release.

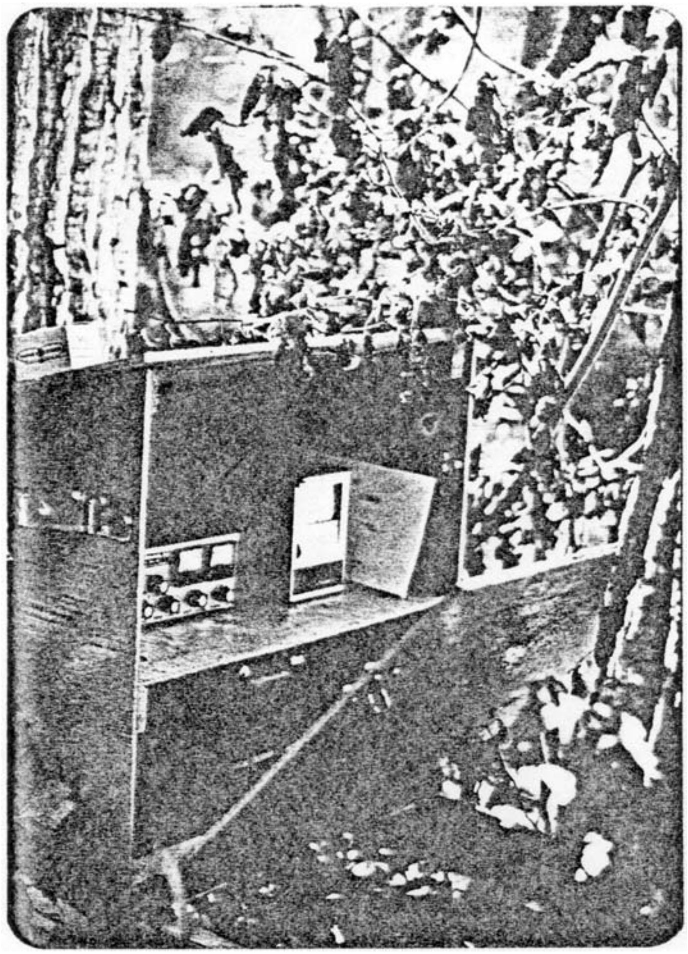


Fig. 2. Automatic scanning station overlooking the river. Time and frequency of radio—tagged fish are recorded as they move past the station.

TRACKING PROCEDURE

Radio tagged fish were identified by characteristic frequencies and pulse rates. The portable tracking receivers were adapted for use in trucks, boats (Fig. 4) and aircraft.

We found that best results in an aircraft were obtained from two portable receivers and operators. An antenna for each radio was mounted on the wing—strut of a Cessna 180 which was usually flown about 140 km/h

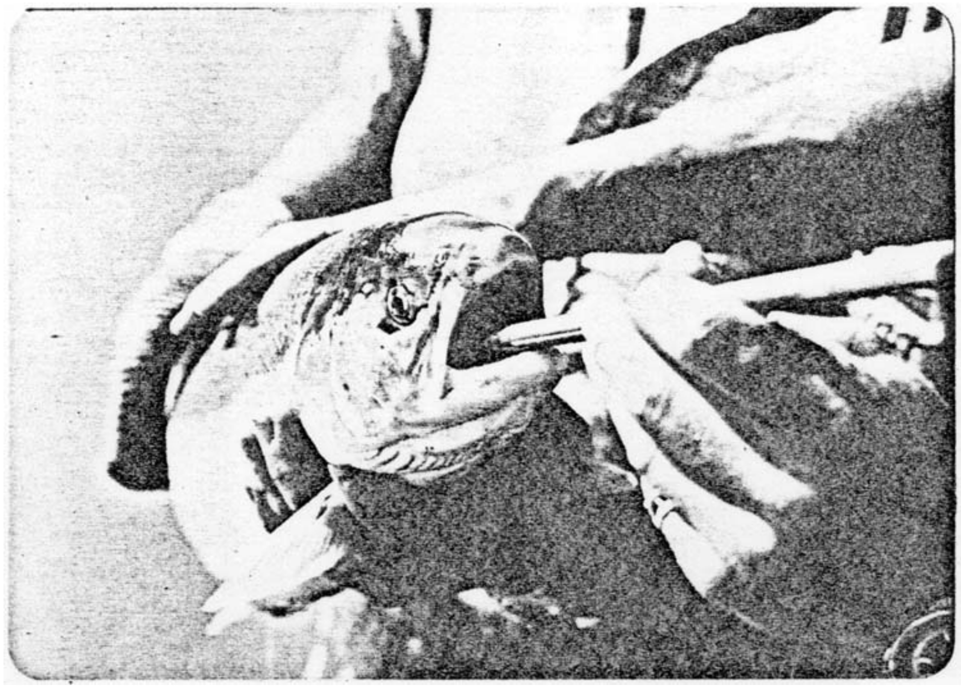


Fig. 3. Radio at an altitude of 100 — 200 m (Fig. 5). When exact locations of fish were needed, a Bell Jet Ranger helicopter was used. The antenna was mounted between the skids with a specially designed attachment to the cargo hook.

RESULTS

LIVE CAPTURE AND RADIO TAGGING

Morice River

A total of 24 steelhead were radio—tagged on the Morice River.

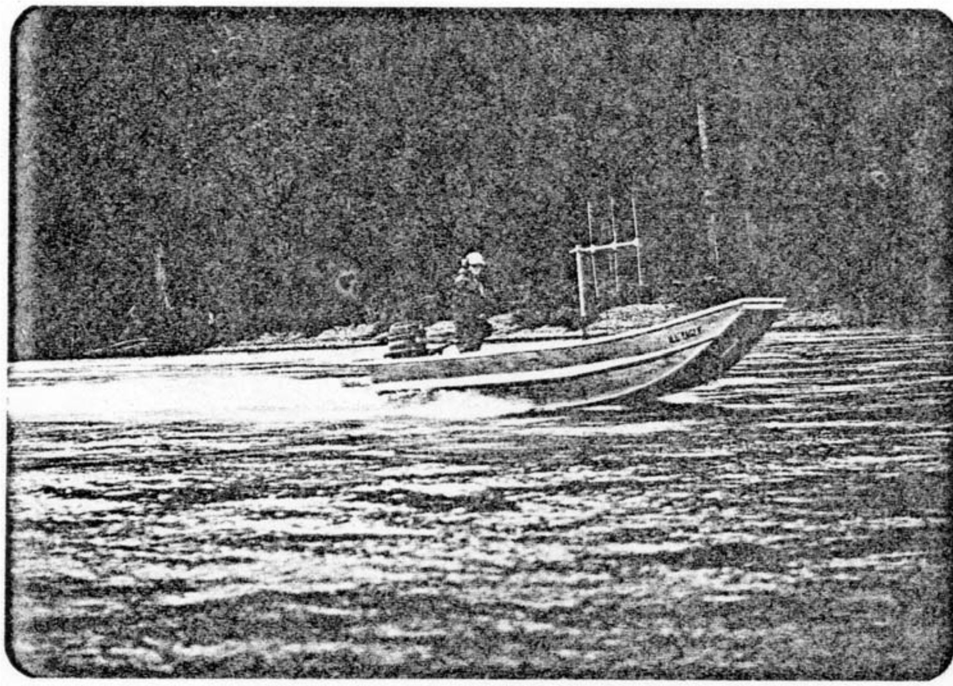


Fig. 4. Tracking radio tagged fish on the Skeena. Portable receivers are readily adaptable for use in river boats, trucks or aircraft.

The radio tagged fish were captured at various points throughout the river in order to sample a cross section of the entire run. The first 14 fish were tagged during October 1978, but in order to increase the sample size, an additional 10 steelhead were tagged during February and March 1979 (Table 1).

Suskwa River

During September and October 1978, 14 steelhead were radio tagged in the Suskwa River (Table 2). Tagging efforts were concentrated on the

Table 1. Steelhead Radio Tagging Data — Morice River 1978—79

Fish No.	Weight (kg.)	Sex	Date Tagged	Location of Tagging (km. on Morice River)[1]
1	5.9	M	Oct. 11/78	73 km
2	3.6	M	Oct. 11/78	73 km
3	4.5	M	Oct. 11/78	73 km
4	4.1	F	Oct. 12/78	71 km
5	5.5	M	Oct. 12/78	70 km
6	5.5	M	Oct. 12/78	70 km
7	4.1	F	Oct. 13/78	53 km
8	6.8	M	Oct. 13/78	36 km
9	4.1	F	Oct. 17/78	3 km
10	4.1	F	Oct. 18/78	0 km
11	3.6	F	Oct. 25/78	28 km
12	4.1	F	Oct. 25/78	28 km
13	5.5	M	Oct. 25/78	28 km
14	5.0	F	Oct. 26/78	31 km
15	3.0	F	Feb. 21/79	75 km
16	3.6	F	Feb. 21/79	75 km
17	5.5	M	Feb. 21/79	75 km
18	4.5	F	Apr. 13/79	36 km
19	5.0	F	Apr. 13/79	35 km
20	7.3	F	Apr. 13/79	32 km
21	5.5	M	Apr. 13/79	32 km
22	5.9	M	Apr. 13/79	32 km
23	3.2	M	Apr. 14/79	23 km
24	5.9	M	Apr. 14/79	11 km

[1]Tagging location taken to nearest river kilometer as measured from Bulkley River/Morice River confluence (0 km) to Morice Lake outlet (88 km).

Table 2. Steelhead Radio Tagging Data — Suskwa River 1978—79

Fish No.	Weight (kg.)	Sex	Date Tagged	Location of Tagging (km. on Suskwa River)
25	4.5	F	Sept. 7/78	1 km
26	4.1	F	Sept. 9/78	0 km
27	6.4	F	Sept. 9/78	0 km
28	5.5	F	Sept. 10/78	0 km
29	6.4	M	Sept. 10/78	0 km
30	5.5	F	Sept. 10/78	0 km
31	5.9	F	Sept. 11/78	0 km
32	6.4	M	Sept. 12/78	9 km
33	5.5	F	Sept. 12/78	11 km
34	4.1	F	Sept. 13/78	14 km
35	4.5	F	Sept. 13/78	14 km
36	4.1	F	Sept. 13/78	14 km
37	3.6	F	Sept. 14/78	16 km
38	4.5	F	Oct. 6/78	11 km

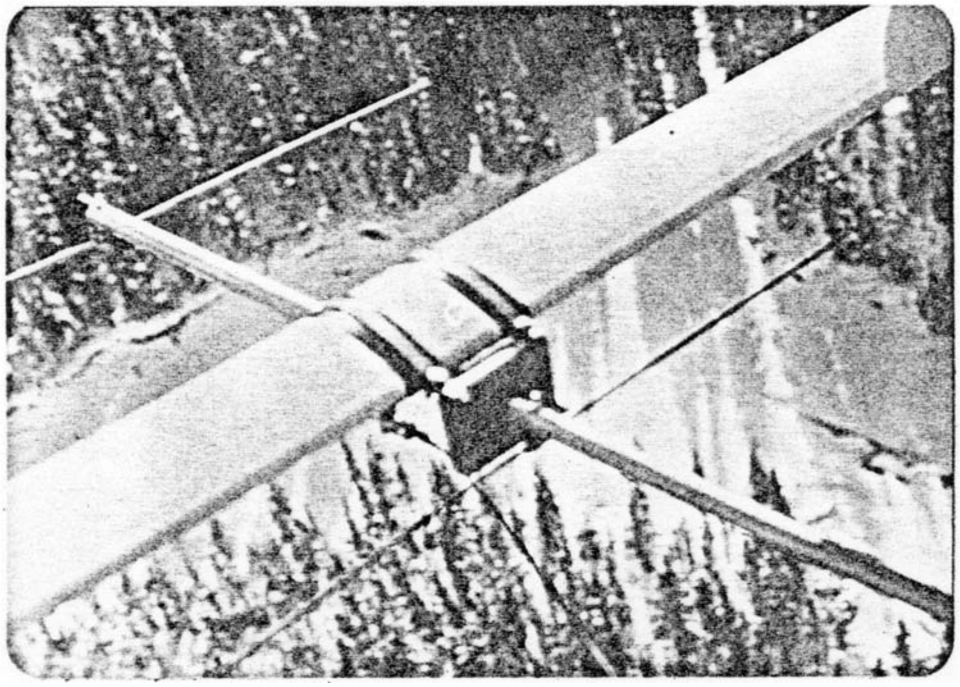


Fig. 5. Strut—mounted antenna on fixed wing aircraft allows tracking in inaccessible areas. Tagged fish beneath the ice were monitored throughout the winter and spring.

lower 15 km of the river because angling produced few fish above this point. Since an intensive sport fishery exists on the Bulkley River at the mouth of the Suskwa, 6 steelhead were radiotagged here to determine whether or not they were Suskwa fish.

Kispiox River

Fifteen steelhead were radio tagged in the Kispiox River during September 1978 (Table 3). All of these fish were tagged in the lower 16 km of the river where the bulk of the sport fishery exists (Whately, 1977).

Table 3. Steelhead Radio Tagging Data — Kispiox River 1978—79

Fish No.	Weight (kg)	Sex	Date Tagged	Location of Tagging (km on Kispiox River)
39	5.4	M	Sept. 12/78	15 km
40	4.5	M	Sept. 19/78	17 km
41	4.1	F	Sept. 19/78	8 km
42	4.5	M	Sept. 20/78	6 km
43	4.1	F	Sept. 20/78	6 km
44	5.0	M	Sept. 20/78	4 km
45	9.5	M	Sept. 21/78	6 km
46	4.1	F	Sept. 21/78	7 km
47	4.5	F	Sept. 21/78	5 km
48	5.4	F	Sept. 21/78	6 km
49	5.4	F	Sept. 21/78	5 km
50	4.5	F	Sept. 25/78	8 km
51	5.4	F	Sept. 25/78	6 km
52	2.6	M	Sept. 25/78	6 km
53	8.1	F	Sept. 25/78	5 km

Zymoetz River

A relatively small preliminary radio tagging study was carried out on the Zymoetz (Copper) River. Six steelhead were radio tagged on August 23, 1978 in several locations between Km 32 and Km 40 (Table 4). These fish represent the early portion of the Zymoetz run (Chudyk, M.S. 1979).

MOVEMENTS OF RADIO TAGGED FISH

Tracking data for each fish was summarized in map form showing the dates that it was located at various points on the river (Appendix). Interpretations were made from these maps regarding the seasonal movements of the fish, watching for any general tendencies which could be applied to that stock of steelhead. Several fish were only monitored a few times before they were lost, so maps were not made for them because they provided little or no useful information.

Morice River

Of 24 steelhead radio tagged on the Morice, 19 were monitored until spawning time, but exact spawning sites were found for only fifteen of these because the rest were lost periodically during spawning time.

Tagged fish dispersed throughout the Morice River during fall and winter. The exception was the upper Morice, from the lake outlet down to Gosnell Creek confluence, which was rarely utilized by radio tagged fish. Three additional fish were later tagged here to clarify this aspect. Snorkel surveys were carried out on the upper Morice during

Table 4. Steelhead Radio Tagging Data — Zymoetz River 1978—79

Fish No.	Weight (kg.)	Sex	Date Tagged	Location of Tagging (km. on Zymoetz River)[1]
54	3.0	F	Aug. 23/78	34 km
55	4.0	F	Aug. 23/78	34 km
56	3.2	M	Aug. 23/78	34 km
57	8.2	M	Aug. 23/78	34 km
58	7.3	F	Aug. 23/78	38 km
59	5.6	M	Aug. 23/78	32 Km

[1]River kilometers measured from the Zymoetz/Skeena confluence to McDonnell Lake.

April and May, to compare with telemetry information. Results show that an estimated 30—40 steelhead wintered in this upper 16 km of the Morice; a small portion of the total run (Hatlevik and Lough, M.S. 1979).

In early November 1978, heavy rains and melting snows brought the Morice to flood stage. A check on locations about one week after peak flows showed that most fish had not moved more than a few km from preflood holding areas. Brush and trees that are usually high and dry were inundated by flood waters, and the radio tagged fish were found holding amongst the trees and brush, well out of the main flows.

Morice fish were observed to have moved as little as 5 km and as much as 72 km during the fall and winter. No fish were observed wintering in tributaries to the Morice or in Morice Lake.

Tagged fish were observed to move upstream and downstream throughout the fall and winter with no obvious pattern as to timing or magnitude of movements. During late April and early May, however, most of the fish began a steady upstream movement which ended at their spawning site. Only two of the fish that were tracked to their spawning location were observed to have any downstream movement in May before they spawned. One of these fish (#16) moved downstream just before heading up a tributary to spawn. Two additional fish (#6 and #13) also showed one downstream movement in May, but it was not clear if these fish spawned before or after this.

The upstream movement appeared to begin as the minimum daily temperature of the Morice mainstem increased above 2°C (Fig. 6). Of 13 fish still being monitored during June, none displayed any upstream movement indicating that the fish had either spawned or had arrived at their

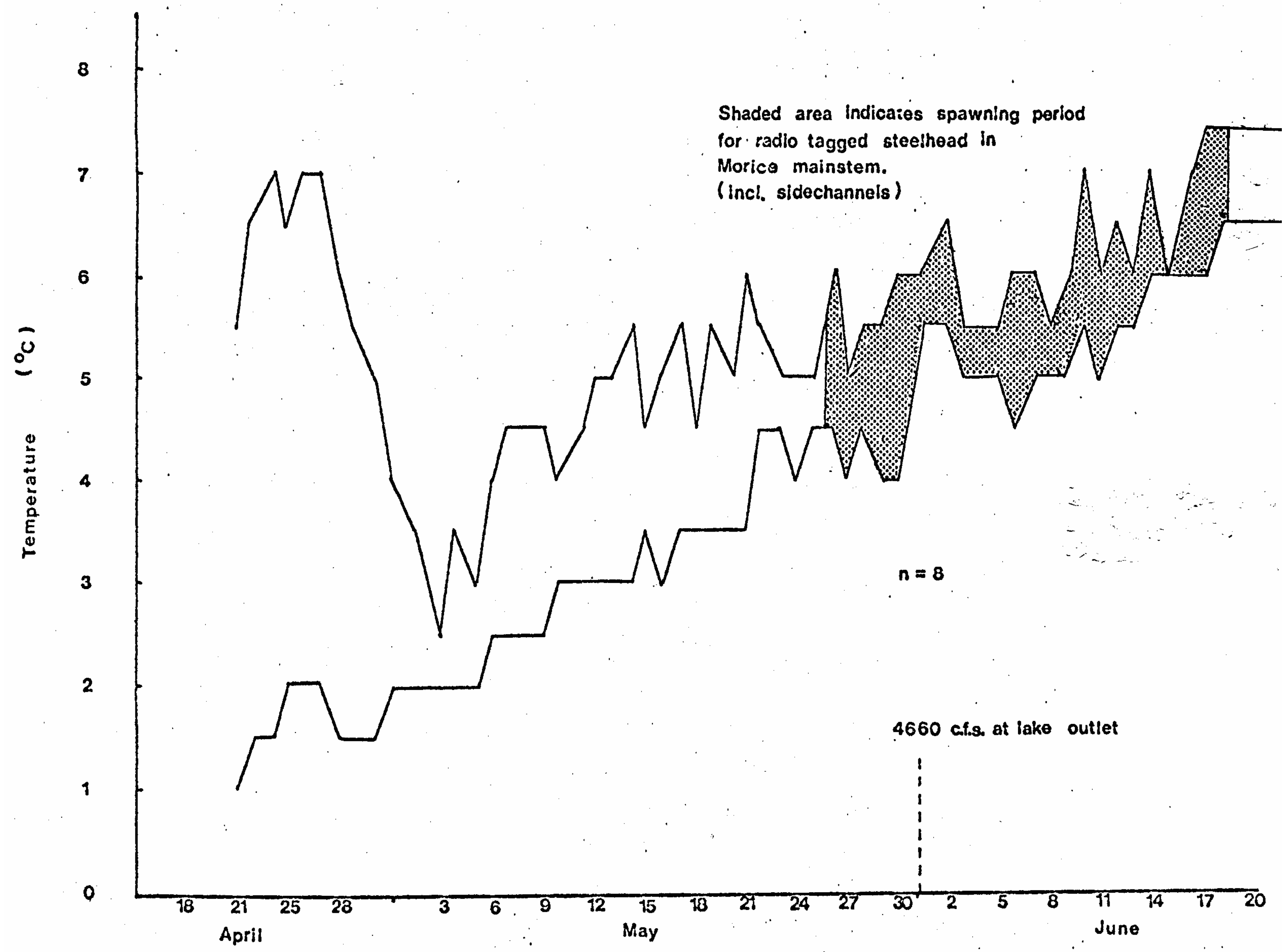


Fig. 6. Daily maximum and minimum water temperature of Morice River, 1979. (Measured at 72 km.)

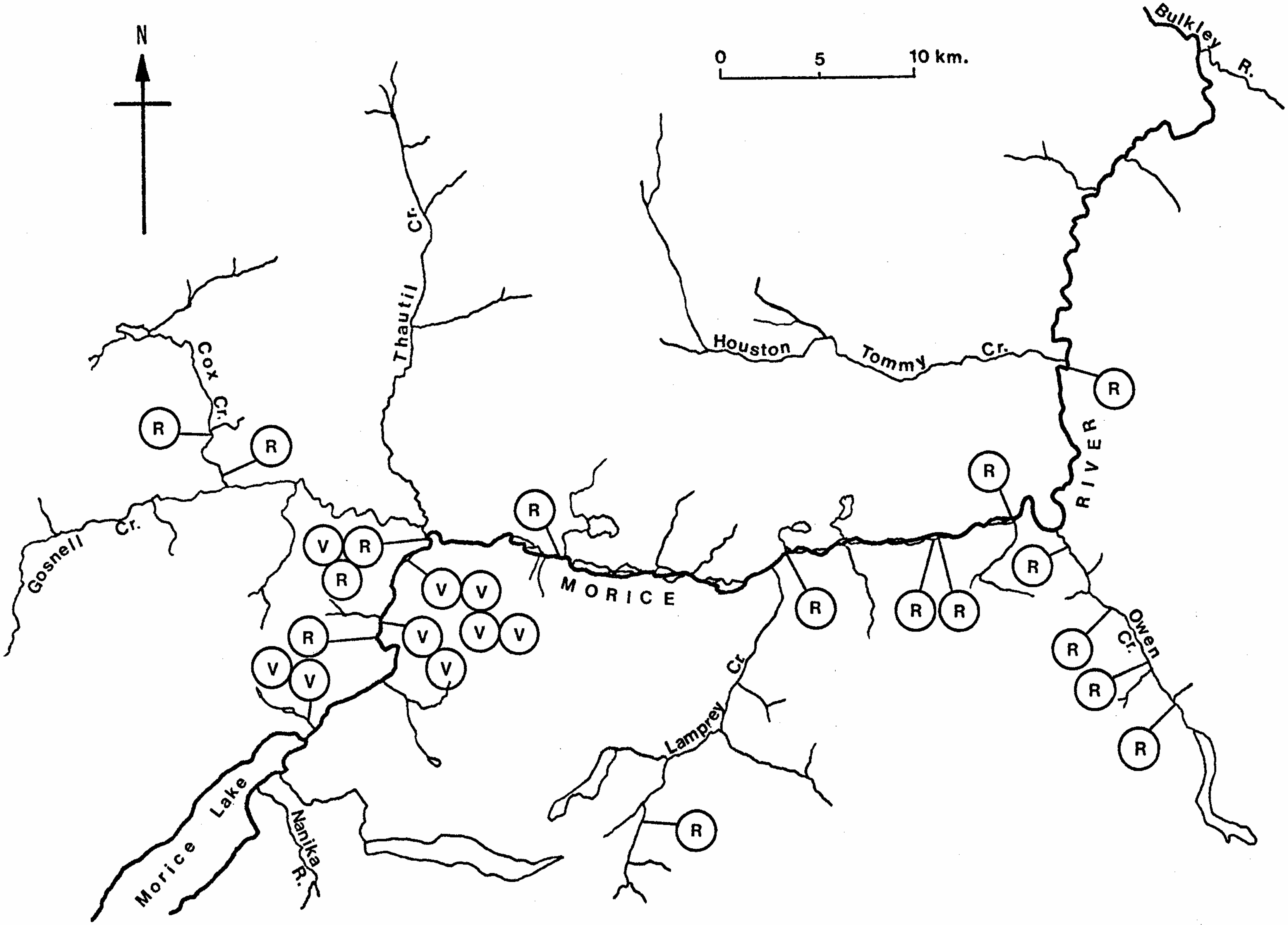
spawning site by June 1.

Nine of the 16 steelhead spawning sites were in the Morice mainstem, between Km 26 and Km 80, and of these, 4 were found to have spawned in side channels in braided sections of the mainstem. Most of the side channel spawning (3 of 4 sites) occurred on the Morice River between Gosnell Creek and Owen Creek, an area that exhibits extensive braiding, and the fourth occurred in a side channel 2 km downstream of the Nado Creek confluence. These eight fish began leaving their spawning sites on May 26, and the last ones left after June 18.

Seven of the 16 located spawning sites were found in tributaries to the Morice River. Four fish spawned in Owen Creek, two in Gosnell Creek and one in Lamprey Creek. All of these fish wintered in the Morice and entered the tributaries between May 11 and June 10. Entry date is defined as the first day the fish was found in the tributary, not necessarily the day it actually entered.

During the course of the study, 9 steelhead that were not tagged were observed at their spawning sites (Fig. 7). One of these spawned in the Morice mainstem, 6 in side channels, and 2 spawned in tributaries (D. Bustard, pers. comm.). The reason most of these fish were observed in the upper Morice is because of the relatively clear water conditions. Lack of visual sightings further downstream does not indicate fish were not spawning there, but only that turbid water conditions made visual observations difficult.

Limited temperature and discharge information was available for



Flg.7. Morice River Study area. Spawning sites located by visual observation (V) and radio telemetry (R) are indicated by circles.

these tributaries. When fish entered, the tributary temperatures were between 4°C and 9°C (Fig. 8). Six of the tributary spawners entered the streams as the water temperatures were increasing. At this time, the tributaries were near peak flows from spring freshet and 2 of the 3 that entered Lamprey and Gosnell did so just after peak flows (Fig. 9).

In some cases, kelts were monitored during their seaward migration. Steelhead #20 (Appendix) was last seen at its spawning site in Owen Creek on June 7. It was tracked on its way down Owen Creek on June 10, and again in the Bulkley River near Smithers (120 km downstream) on June 15, indicating an average downstream migration rate of 25 km/day for the previous 5 days.

Suskwa River

Nine of the 14 radio tagged Suskwa steelhead were monitored for 9 months, until they spawned. Two fish were lost in the fall and three fish in the spring.

Most fish remained active during the fall, but no movements were made upstream of the bridge at Km 16. One fish (#37) was caught and tagged above this point but moved downstream and was lost.

Twelve of the 14 tagged steelhead were monitored throughout the winter. Six of these wintered in the Bulkley River, of which 3 had previously been recorded in the Suskwa, but had come back out for the winter. These fish were found to range as far as 12 km upstream and 2 km downstream of the Suskwa confluence. Two of the 6 Bulkley fish did not move into the Suskwa to spawn.

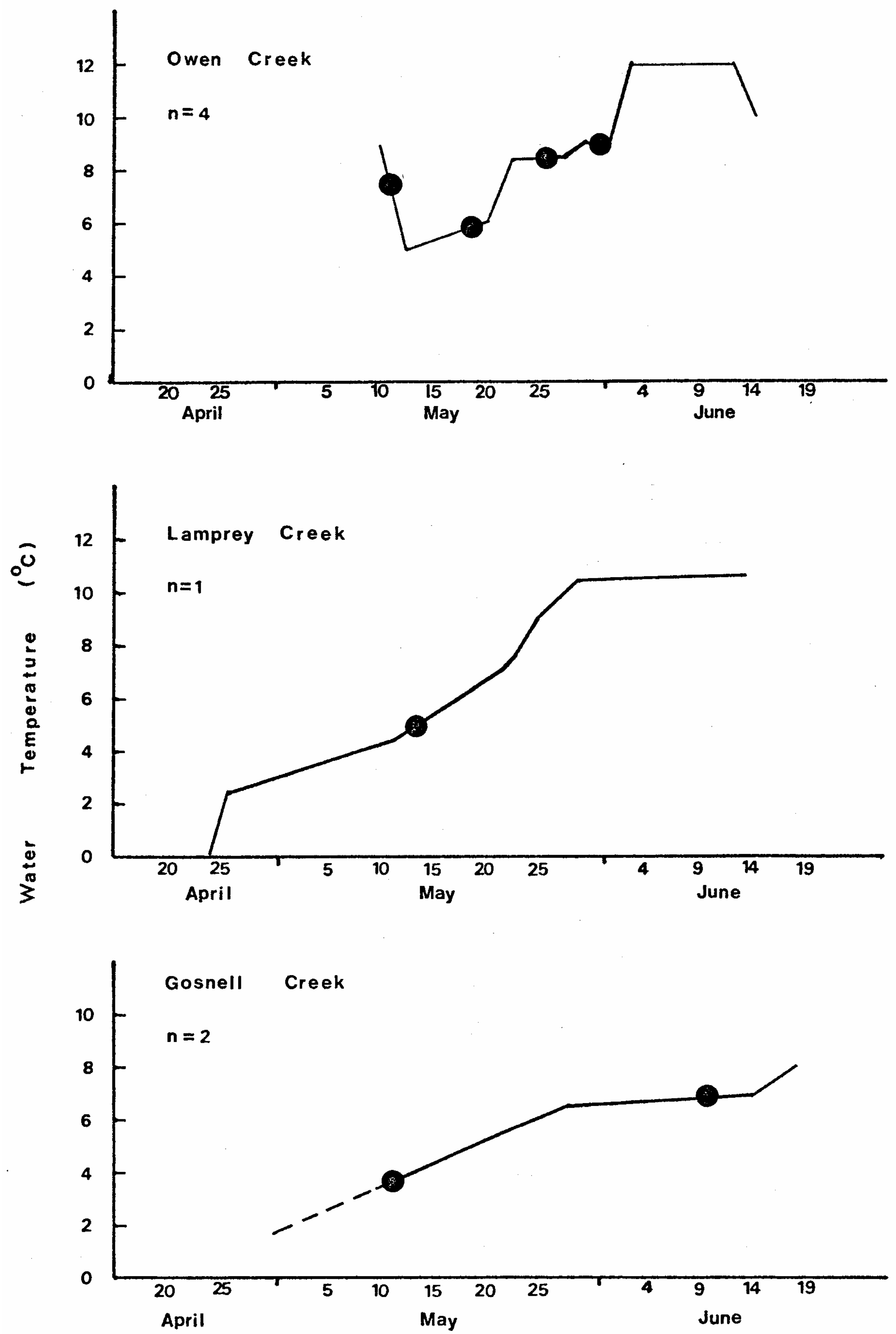


Fig. 8. Spot observations of tributary water temperatures, 1979. Circles indicate dates radio tagged steelhead entered tributary.

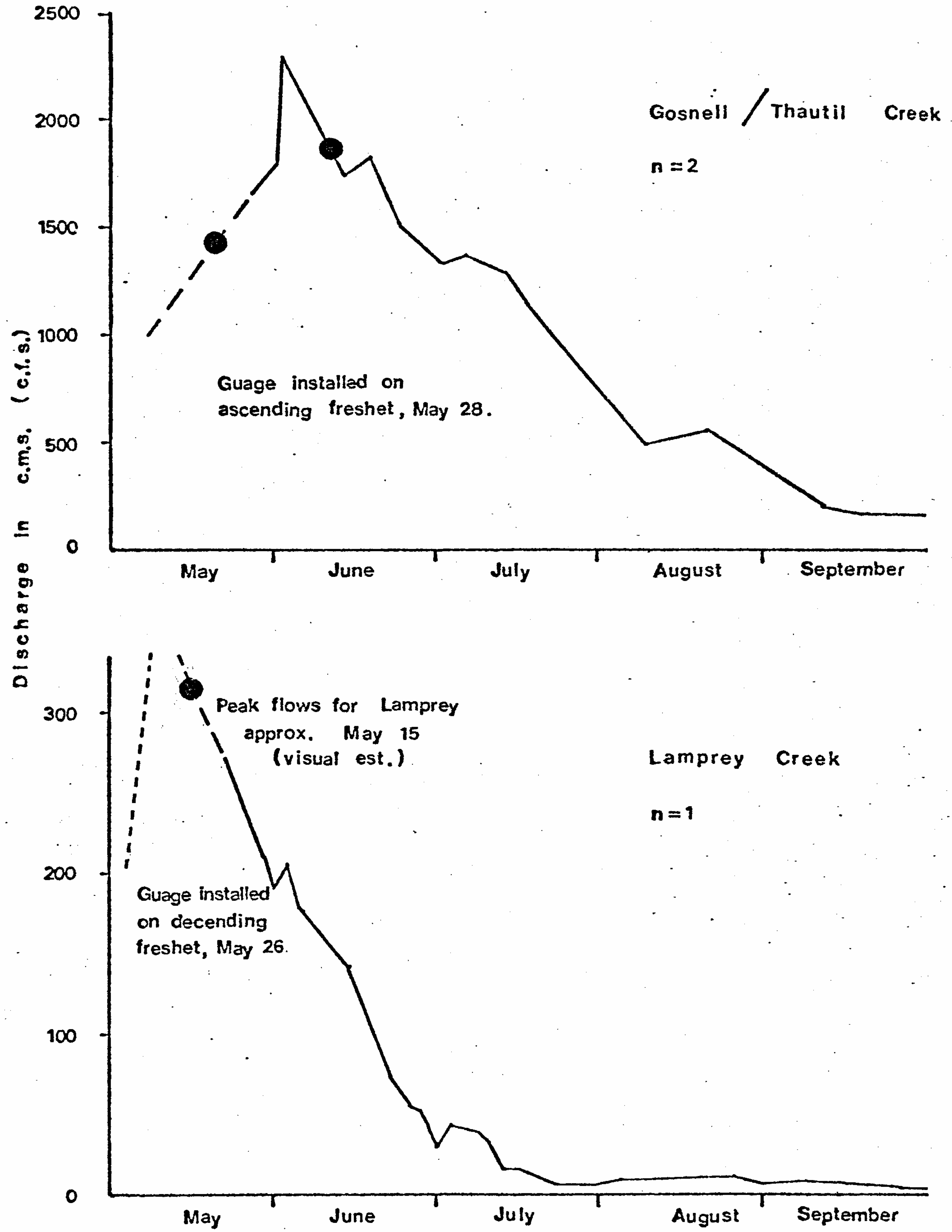


Fig. 9. Discharge recordings for two Morice River tributaries 1979. Circles Indicate dates radio tagged steelhead entered tributary.

Six steelhead wintered in the Suskwa River; all of which remained in the canyon between Km 6 and Km 14. These fish moved very little during the fall and winter. One fish (#33) was tagged at Km 9, and did not move more than 100 m for 6 months.

Data from scanning stations indicated that fish began moving into the Suskwa during the first week of May, and continued to move past the bridge at Km 16 until the third week in May. Water level recordings show that these fish moved as the water was dropping after spring freshet (Fig. 10). Temperature data indicated that the water temperature was climbing, and fish moved when the Suskwa was between 2°C and 5°C (Fig. 11).

Spawning sites were identified for 9 tagged fish (Fig. 12). All of these fish spawned upstream of Km 11 on the Suskwa. Five fish spawned in the Suskwa and four spawned in Harold—Price Creek, which contributes most of the flow to the Suskwa. Six of the 9 fish spawned in side channels, and the remainder (3) spawned in the mainstem of the Suskwa above Harold—Price Creek. Water temperature at the time of spawning was 6°C. In addition, an untagged steelhead was observed spawning in a side channel near Km 21 of the Suskwa on May 17. Water temperature at that time was 5°C.

A set of falls 21 km up Harold—Price Creek is considered to be a barrier to steelhead. There is no indication that steelhead move this far up the system during autumn, but these falls were approached by 3 radio tagged fish in late May, during relatively high spring flows. None of these fish got above the falls, and all spawned in Harold—Price below the falls. A fourth fish (#25) was observed as it approached the falls in mid—May, but was never found again.

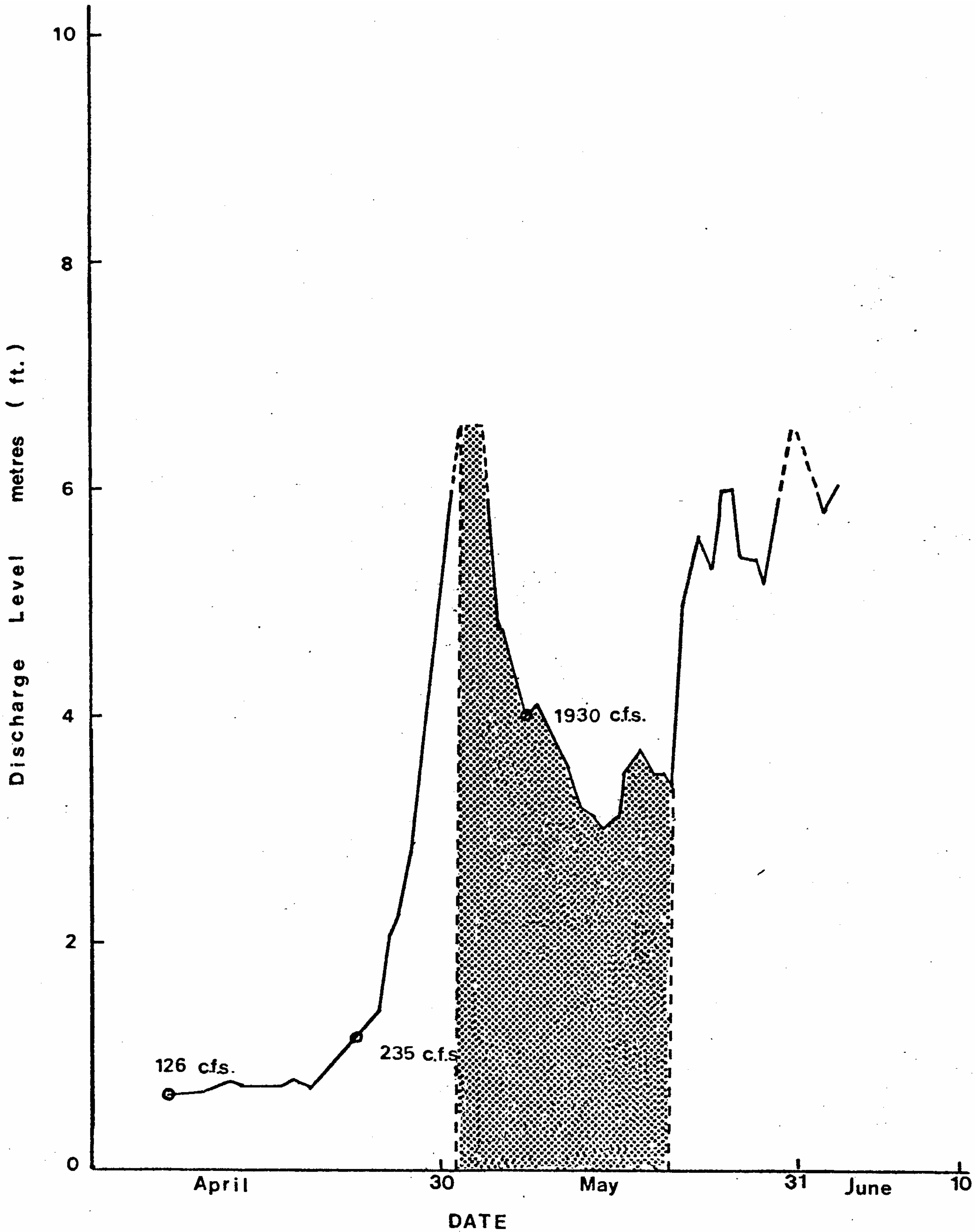


Fig.10. Discharge levels in Suskwa River (13 km.) from April to June 1979. Shaded area indicates period of upstream adult migration

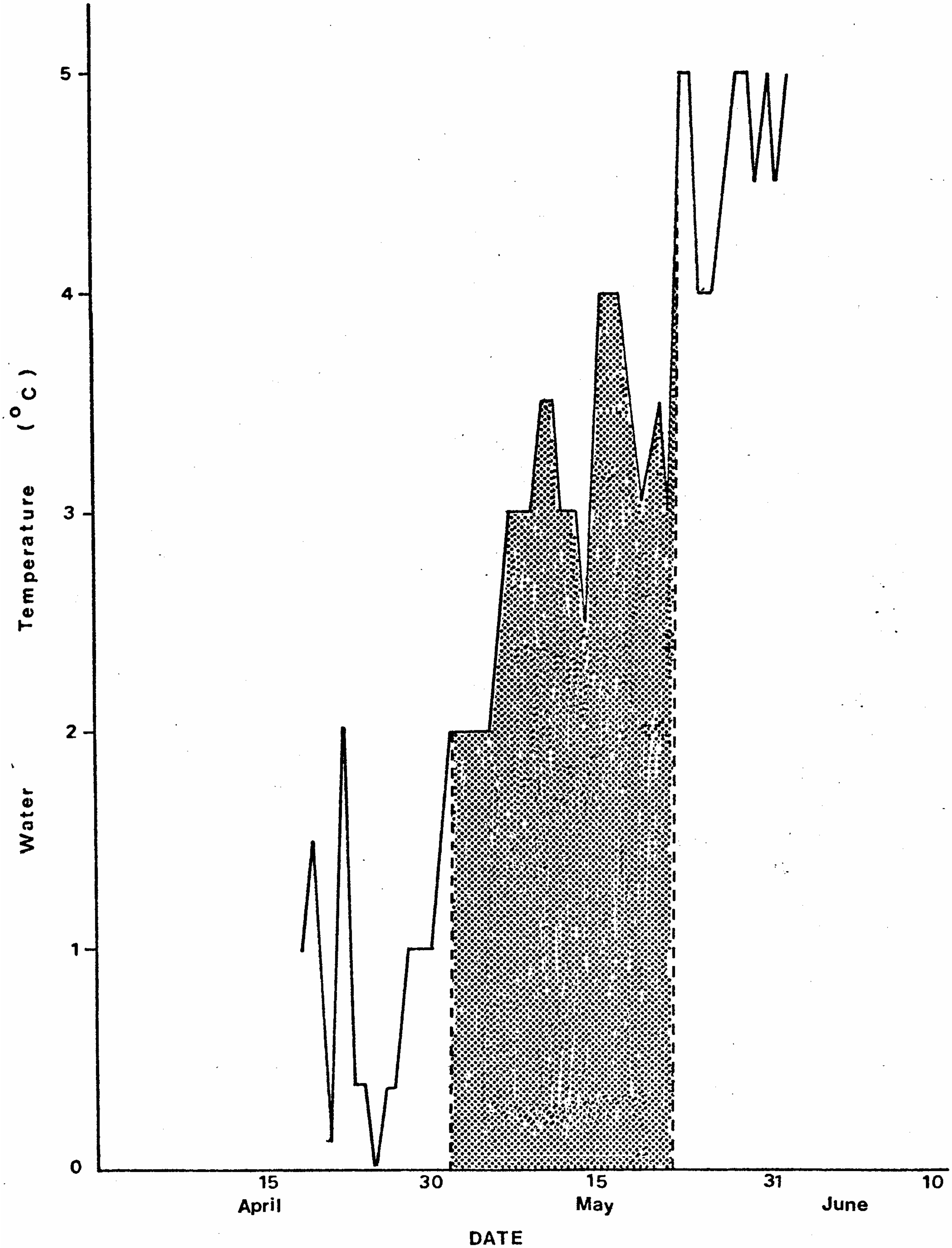


Fig.11. Water temperatures of Suskwa River (13 km.) from April to June, 1979. Shaded area indicates period of upstream adult migration.

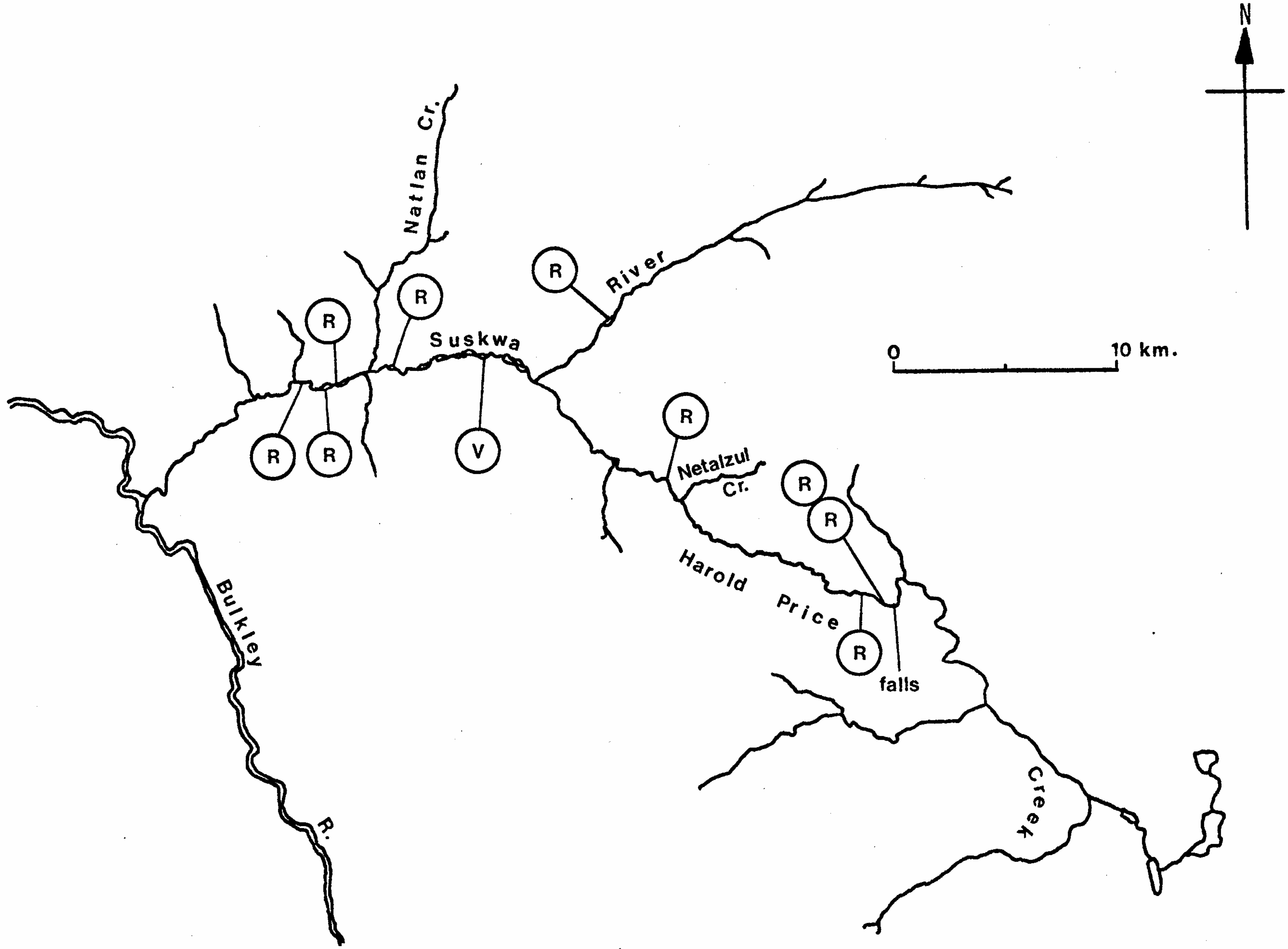


Fig. 12. Suskwa River Study area. Spawning sites located by visual observation (V) and radio telemetry (R) are indicated by circles.

Scanner data indicated that the downstream migration of kelts began May 30, and peaked around June 10. The last tagged fish did not leave the system until June 17.

Kispiox River

Fifteen fish were tagged in the Kispiox, but one fish (#30) was killed in the Indian food fishery, six days after tagging. Spawning sites were identified for only 5 of the remaining 14 fish. Two additional fish were followed until spring time, but spawning sites were not identified. Six of the fish were lost in early fall; perhaps as a result of the extreme flood conditions in November. Winter (1976) found that in flood conditions, steelhead sometimes leave the river and do not return.

All but two of the tagged fish spent the fall and winter downstream of Km 35. One fish (#53) moved 70 km upstream, where it wintered. By late April and early May, the fish in the lower Kispiox began to move up to their spawning sites. Four of the 5 identified spawning sites were in tributaries (Fig. 13). The first fish were found in tributaries on May 16, and some remained in the tributaries until at least May 28.

Two fish spawned in the lower 3 km of Nangeese Creek, in a braided area with instream debris and jams. Another tagged fish spawned in the lower 2 km of Ironside Creek; again in a section with braiding and plenty of instream debris. One steelhead spawned in lower Skunsnat Creek, between the road culvert and the Kispiox mainstem. Steelhead #47 was never actually tracked in Murder Creek, but it was found at the Murder Creek/Kispiox confluence for several days. I suspect this fish entered Murder Creek to

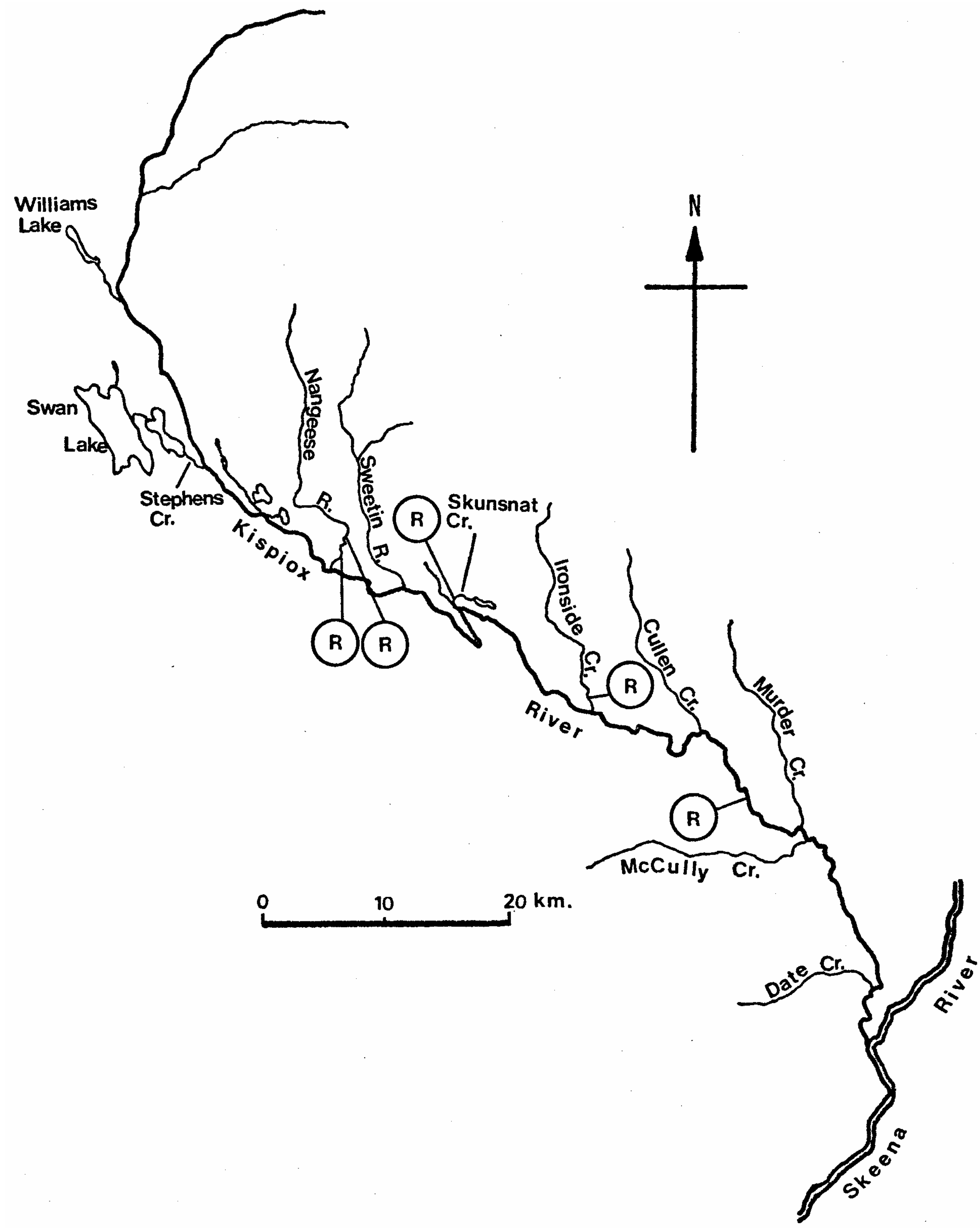


Fig 13. Kispiox River study area. Spawning sites located by radio telemetry (R) are indicated by circles.

spawn and came back out immediately. Winter (1976) found that this behaviour was not unusual with steelhead. Only one fish was found to spawn in the mainstem Kispiox (Km 27).

Tagged fish began leaving the system in late May, and the last fish was found on May 28. One kelt was tracked on its' seaward migration on May 28 in the Skeena, 10 km downstream of the Kispiox.

Zymoetz River

Six steelhead were tagged on the Zymoetz, of which 3 were monitored until spring time. Spawning locations were identified for only 2 of these (Fig. 14).

Two fish were lost during the fall; probably due to extreme flooding conditions during the first week of November. Water levels in some of the lower canyons rose 21m vertical during peak flows. Stationary scanner data from the lower Zymoetz showed that they did not leave before November but floods destroyed the scanner, eliminating any data records during and after the flood event.

One tagged steelhead was found wintering beneath the ice in McDonell Lake, at the headwaters of the Zymoetz. This fish was tracked in the east end of the lake, 0.5 km from the lake outlet. By March 19, it had moved out of the lake and back into the river, just upstream of the Serb Creek confluence. It spawned in that area in late May, and left between May 25 and June 7. One other tagged steelhead spawned in this area, but it wintered in the canyon above Red Canyon Creek confluence. The third tagged fish was last monitored just below Red Canyon Creek, but was lost just

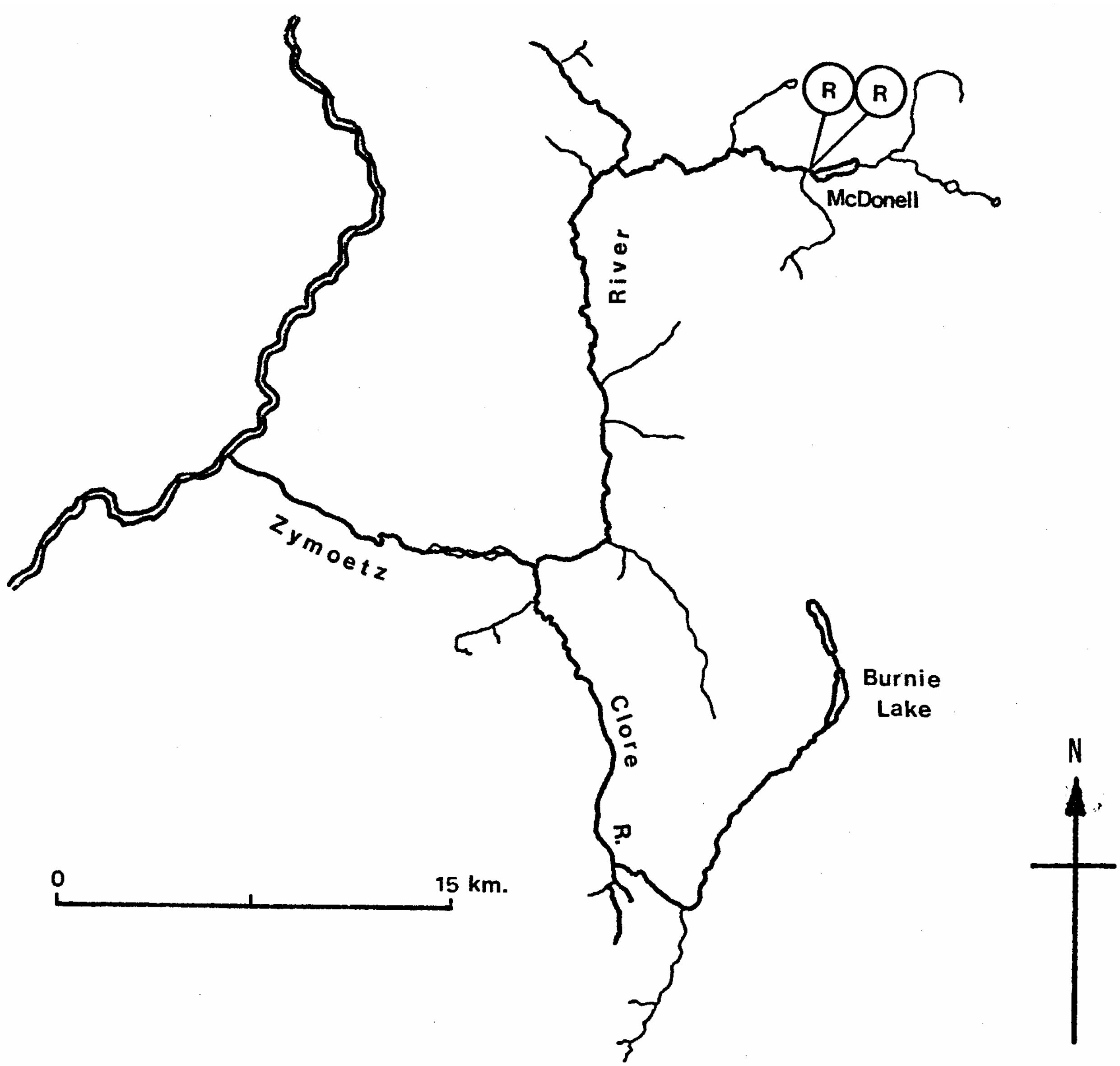


Fig.14. Zymoetz River study area. Spawning sites located by radio telemetry (R) are indicated by circles.

before spawning time. Red Canyon Creek was never flown, but I suspect this fish may have spawned there because the rest of the Zymoetz headwaters were flown several times with no results.

DISCUSSION

Not all fish captured by angling were radio tagged. Many of the steelhead were too small to be tagged, and some fish were fatally hooked during capture. On the Morice River, a total of 136 steelhead were captured, of which 5 were killed. The Suskwa and Kispiox Rivers both had a total of 19 fish captured, and each had one fatality. Six steelhead were captured and tagged on the Zymoetz River, with no hooking mortality (Table 5).

Radio tagged fish were identified through characteristic frequencies and pulse rates. Fish with the most unique combinations were the ones most easily identified, but in a few cases, transmitters were found to be similar in these respects. In this situation, the fish were monitored as usual, but it was difficult to differentiate the 2 fish with similar signals, and hence their tagging sites.

Field data from radio tracking have been summarized for each fish on individual maps, indicating the dates it was found at various locations (Appendix). Inspection of these maps show that there is more data for some fish than for others. This is due to the accessibility of the stream; those near a road were monitored more often than those which could only be monitored by aircraft. This project however, was not geared to a study of daily movements of fish, but rather to seasonal movements with hopes of

Table 5. Hooking mortality of steelhead trout during capture by angling with single hook on sport gear. Autumn, Winter, 1978—79.

River	Number Captured by angling	Hooking mortality (%)	Radio tagged (%)
Morice	136	5 (3.7)	24 (17.6)
Suskwa	19	1 (6.0)	14 (73.6)
Kispiox	19	1 (6.0)	15 (78.9)
Zymoetz	6	0 (0)	6 (100)
Totals:	181	7 (3.9)	59 (32.6)

finding general tendencies to be applied to steelhead of that river.

Data on spawning locations were more complete for some fish than for others, and I occasionally had to make a judgement about spawning locations on what appeared to be incomplete data. In this study, I identified the spawning site through a combination of several factors. If a fish was located after an upstream movement in May, in suitable spawning habitat and water temperature as outlined in "The Probability of Use Criteria for Salmonidae" (Bovee, 1978), then it was considered to have spawned at that site. An example of this is steelhead #12 on the Morice River (Appendix). Although this fish was only found in Owen Creek once, it was located at a site that had substrate and flows suitable for spawning. In addition, this was found to be the upstream limit of its movements during May, and the water temperature was within the limits for spawning at 9°C. I therefore concluded that this fish spawned at this location.

Results of this study indicate that it is difficult to make generalizations which apply to all tributaries in the Skeena. Steelhead in various rivers appear to have evolved a life strategy that is suitable to the characteristics of that system. For this reason, results from each river will be examined individually.

Morice River

Steelhead begin to appear in the Morice during mid—August, but continue to enter during the fall, dispersing throughout the length of the mainstem (Whately, 1978). Telemetry data indicates that these fish remain active throughout the fall, within a range that appears to vary in size from fish to fish. This should be considered when interpreting population estimates for steelhead because a fish may be counted several times when moving past one point (i.e., the Alcan Aluminum Company's fish counting platform at Km 33).

After freeze—up, the only section of river to remain open was the 16 kilometers directly below the lake outlet. Steelhead were found to winter throughout the entire length of the mainstem, but only a small percentage were found to utilize this upper portion. Snorkel survey estimates indicate a wintering population of not more than 40 steelhead for this upper section. It is possible that some of the fish from this area moved into Morice Lake to winter, although this has not been documented. Steelhead destined to spawn in the Nanika River must go through Morice Lake, but it is unclear if these fish hold in the lake for the entire winter, or if they winter in the river. No steelhead were found to winter in the tributaries; probably because of the hazards caused by low or intermittent winter flows. Those that spawned in the tributaries were found to winter in the mainstem either upstream or downstream of their spawning tributary.

Steelhead started to move upstream to their eventual spawning locations in late April and early May. By mid—May, some fish were found holding near the mouths of tributaries such as Owen, Gosnell and Lamprey Creeks. This coincides with spring freshet, and at this time tributary flows were peaking. Steelhead entered during high water, usually as levels began to drop, which allowed the fish to handle obstacles which could be a barrier at low water. Beaver dams, log jams or culverts can often be formidable obstacles during low flows, but at high water many of these can be negotiated by upstream migrants. Fish were found to enter the tributaries when water temperatures were between 4°C and 9°C, and increasing. In 1979, this was between May 11 and June 10.

Spawning in tributaries occurred from mid—May to mid—June, although it appeared to peak between the last week of May and the first week of June. Gosnell Creek was colder than Owen and Lamprey Creeks (more glacial in origin) and as a result spawning seemed to occur towards mid—June.

Spawning in the Morice mainstem and side channels occurred mostly in the section between Gosnell Creek and Owen Creek. These fish began leaving their spawning sites on May 26, and the last ones left after June 18. Winter (1976) found that female steelhead from Lake Superior remained near their redds for an average of 3.1 days after spawning, while Everest (1973) found that Rogue River females stayed near the redds for 4 to 7 days. Information is lacking for males, but Everest found that it is longer than the females. This information indicates that spawning probably started around the third week in May and may have continued until mid—June. Daily water temperatures for that time would therefore have been between 4°C and 7°C (Fig. 6), a slightly wider range than the 5.5°C to 6.5°C derived from visual spawning observations of Pinsent and Chudyk (M.S. 1973). It seems that cooler temperatures in the mainstem Morice once again delay spawning slightly because the last two fish found in the entire Morice drainage were still holding in a side channel on June 18.

Steelhead spawned throughout the Morice system. Although the furthest downstream spawning site located was near Houston Tommy Creek (Fig. 7), I suspect at least one tagged fish (#3) spawned in the Bulkley River above the Morice confluence. This widely distributed spawning clarifies one aspect of previous juvenile sampling throughout the system. Shepard and Algard (M.S. 1977) found juvenile rainbow of all age classes rearing in tributaries and side channels of the Morice. Although this information suggests that these areas were utilized for spawning, it was generally believed that most spawning occurred in the upper Morice mainstem, near the lake outlet.

Of the 16 radio tagged fish followed during the spawning period, 7 spawned in Morice tributaries including 4 in Owen Creek, 2 in a tributary of Gosnell Creek and 1 in upper Lamprey Creek. The remaining 9 spawned in the Morice River, including 4 mainchannel spawners, 4 side channel spawners, and 1 indistinguishable which could have spawned either in a side channel or the Morice River mainstem (Fig. 15).

Several management implications can be derived from these findings. Priorities as outlined by the Salmonid Enhancement Program (S.E.P.) have indicated that the first step in enhancement is to reduce declines in steelhead stocks where possible. Habitat degradation is one mechanism which can be manipulated to a certain degree. Specifically, results from this and other studies show that the critical spawning and rearing habitats are the tributaries and side channels of the Morice. Owen, Gosnell and Lamprey Creeks are the most important tributaries in the system, and all have extensive road construction and/or logging proposed over the next

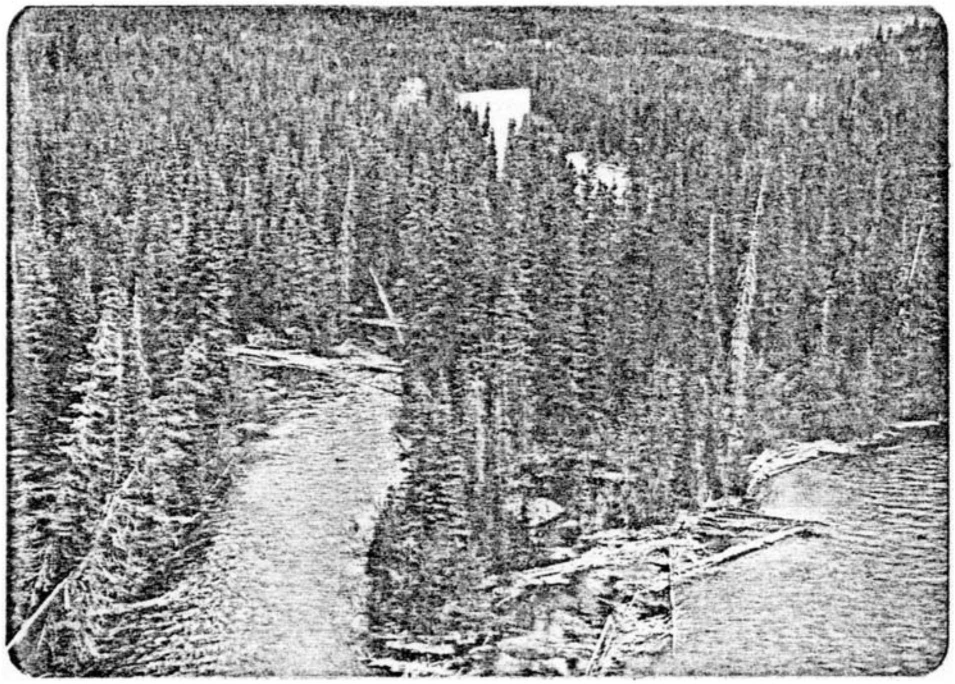


Fig. 15. Morice River side channel. Spawning site for tagged steelhead was located in the channel at the left of the picture.

several years. These systems must be protected with vigor, with emphasis placed on maintenance of spawning gravel (water quality during disturbance of the drainage) and adequate precautions to ensure upstream or downstream migration of adults and juveniles throughout the year.

Another threat to steelhead on the Morice is the proposed Kemano II development. If lower flows reduce the side channel habitat between Gosnell and Owen Creek a major spawning and rearing area for the Morice will be seriously affected.

In the future, it may be necessary to obtain adult brood stock for a variety of enhancement techniques. There are two opportunities for obtaining gravid adults. One is to angle in the mainstem Morice before the river becomes too muddy (in 1979, this happened on April 25). The other is to angle in the designated tributaries in mid—May; after they clear, but before steelhead spawn in late May. Capture of adults with an upstream fence and trap would be difficult because fish enter the tributaries during high water levels, and temporary structures would be a problem to operate.

Winters (1976) suggests that steelhead can be induced to establish a new population in a stream following removal of a barrier. Cox Creek, a tributary of Gosnell Creek has a set of falls which are apparently impassable, but telemetry results show that steelhead spawn in this tributary below the falls. Removal of this barrier appears to be an attractive enhancement opportunity, and deserves closer inspection.

Suskwa River

Steelhead began to move into the Suskwa by mid—August and continued to enter throughout the fall. It is possible that the earliest fish to enter, moved directly to the upper reaches of the system, but no evidence was found to support this. Steelhead tagged in the lower 16 km of the river during early September did not continue upstream, but instead remained downstream for the duration of the fall and winter. All of the tagged fish that wintered in the Suskwa utilized the area between Km 6 and Km 14, which is largely composed of canyon—type water with extensive rock outcroppings and deep pools. During the winter freeze, the Suskwa flows are substantially reduced, and other sections of the river do not have as much deep water for wintering. One fish moved downstream and wintered in the Bulkley River before returning to spawn in the spring.

Four of the 6 steelhead tagged off the mouth of the Suskwa proved to be Suskwa fish. Although they wintered in the Bulkley, they were observed to enter the Suskwa briefly during the fall before dropping back to the Bulkley River. Winters (1976) also found that steelhead may enter a river, but leave the system and return again during more favourable flow conditions, such as spring freshet.

This information may be useful as a basis for an additional management tool for the Suskwa. As previously mentioned, a substantial sport fishery exists at the mouth of the Suskwa River during the fall. Telemetry results indicated that 4 of the 6 steelhead tagged in this fishery were Suskwa River fish. Current regulations allow a 1 and 2 limit for these fish, with no bait restrictions. This is in contrast to the Suskwa River regulations which allow for only a 1 and 1 limit with a roe ban. The rationale behind the Suskwa regulations is to reduce the harvest of Suskwa steelhead in order to allow depleted stocks to recover, but it now appears that much (if not most) of the Suskwa steelhead harvest occurs during the fall fishery at the mouth. If it appears that an additional relief from harvest pressure is required, I recommend that Suskwa River regulations be extended to include the Bulkley River for at least 5 km upstream and downstream of the Suskwa confluence.

By late April and early May, the upstream move to the spawning sites had started. This coincided with high water and increasing water temperatures during spring runoff. The fish were found to move upstream when water temperatures were between 2°C and 5°C.

All of the 9 spawning sites identified were in the Suskwa (5) and Harold—Price Creek (4). Six of the 9 fish spawned in side channels and the remaining 3 fish spawned in the main channel of Suskwa or Harold-Price (Fig. 16). These results differ from those in other rivers such as the Morice mainly because no fish were found to spawn in the minor tributaries of the system. This is probably due to the fact that the Suskwa River for the most part runs through a V—notch type valley, and tributaries climb rapidly from the flood plain leaving only lower reaches accessible to fish. It is possible that some steelhead may utilize these lower reaches of small creeks for spawning, but move quickly in and out of them. Natlan Creek differs from most tributaries because it seems to offer good spawning and rearing habitat for steelhead. Although no tagged fish entered Natlan, it is difficult to believe that this system is not utilized.

Three radio tagged steelhead were observed to approach the Harold-Price falls during May. Recent surveys after the blasting of the falls (Chudyk, M.S. 1979) have shown that coho salmon are able to get above them. It must be noted that coho salmon ascend the falls during relatively low flows in the autumn, and whether steelhead can do the same at high flows during runoff, remains to be seen. Additional telemetry work may be required in the future to determine if more work is needed on the falls, since removal of this barrier is crucial to colonization of the upper Harold—Price.

Fig. 16. An example of spawning habitat in the Suskwa River. A radio tagged steelhead was observed spawning in the side channel at the left of the picture.

Kispiox River

The first steelhead appear in the Kispiox during mid—August, but continue to enter throughout the fall (Whately, 1977). Steelhead were radio tagged on the lower Kispiox in late September, when the sport fishery there was in full swing. Information was required about the movements of steelhead in this part of the Kispiox throughout the sport fishing season (August 15 to November 30). Rather than continuing their upstream migration, most of these fish were found to remain in the lower Kispiox throughout the fall and winter. From this, it appears that anglers are fishing the same group of fish repeatedly throughout the season, rather than fishing them as they go by on their way upstream. This evidence is supported by the fact that 3 tagged fish were recaptured during the season; of which 2 were released and one was killed. In terms of steelhead management, this is sound evidence that the current catch and release regulations on the Kispiox during September are not only justified, but most likely crucial to the current status of those steelhead and the Kispiox sportfishery.

By late April and early May, the fish began to move to their spawning areas. Four of the 5 identified spawning sites were in tributaries to the Kispiox. Fish entered their spawning tributaries in mid to late May, once again as temperatures began to increase, and flows started to drop after spring runoff. This is slightly earlier than higher systems because the earlier runoff at low elevation advances the flow patterns of the Kispiox. Two fish were found to have spawned in the lower 3 km of Nangese Creek and one fish spawned in the lower 2 km of Ironside Creek (Fig. 17). One steelhead spawned in Skunsnat Creek, downstream of the road culvert, and an additional fish is suspected to have spawned in Murder Creek.

These tributaries have all been previously found to have either juvenile or adult steelhead populations (Chudyk and Whately, M.S. 1977 and Harding and Erikson, M.S. 1973), so it was not surprising to find tagged fish spawning in them. No tagged steelhead were found in upper Kispiox tributaries such as Stephens, Club or Williams Creek; areas where most of the Kispiox run was considered to spawn (Pinsent and Chudyk, M.S. 1973).

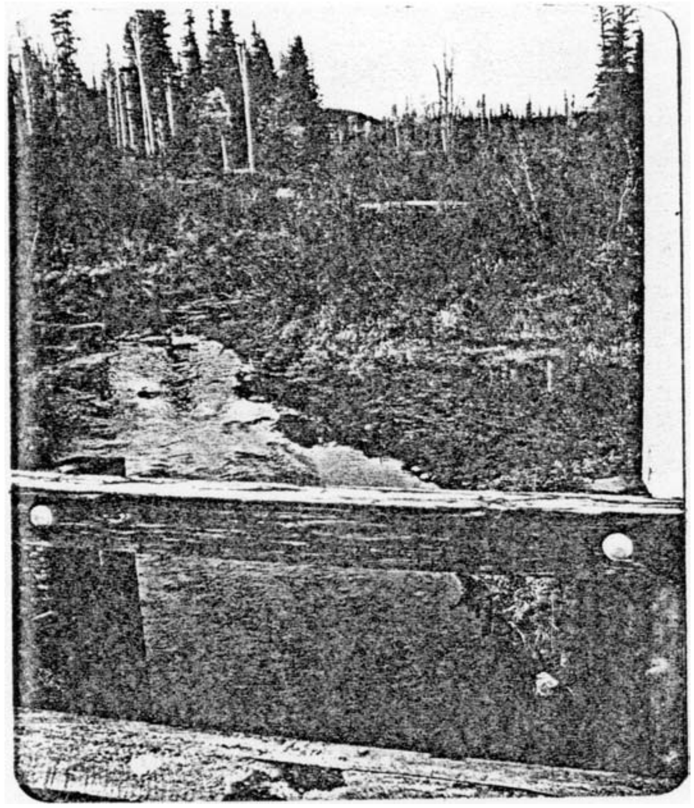


Fig. 17. Ironside Creek, a tributary to the Kispiox River, was one of the tributaries utilized by radio tagged steelhead for spawning.

Steelhead first moved into the Kispiox in mid—August, but the fish were not radio tagged until late September, indicating that the earlier fish may not have been tagged. Everest (1973) found that the time of entry and seasonal positioning of steelhead is largely hereditary, and that the earliest fish to enter tend to locate furthest up the river. If this is the case on the Kispiox, it is likely that the early part of the run moves through the lower Kispiox and spends the fall and winter in the upper Kispiox, and are likely the fish that spawn in the upper tributaries. This would help explain why no tagged fish were found to spawn in the upper river even though a spawning population is known to exist there (M. Whately, pers. comm.).

If present studies support this, there are potential management implications for upcoming S.E.P. projects, specifically in the choice of tributaries to be enhanced. It appears that fish which spawn in the lower Kispiox tributaries are the ones that receive the brunt of the sportfishing pressure. Semi—natural enhancement of parent stock for a variety of potential projects should originate from these lower tributaries since these are the fish that seem to provide the greatest fishery benefits to the sport angler.

There is little mainstem spawning on the Kispiox even though suitable substrate exists throughout the lower river. One aspect that is apparent at all spawning sites is the availability of nearby cover for spawning fish, and consequently for rearing juveniles. Much of the lower Kispiox has been cleared to the edge of the river, and natural cover is now lacking or absent. It may be difficult to hold any artificial cover structure in the mainstem of a highly fluctuating river like the Kispiox, but it may be worthwhile to do so in side channels with hopes of providing cover for adult spawners as well as the resulting fry.

Zymoetz River

Although steelhead begin to enter the Zymoetz by mid—July, the first major run does not usually occur until the third or fourth week of August, with fish continuing to enter through the fall (Chydyk, M.S. 1979). Steelhead were tagged on August 23, during the first part of the Zymoetz run. During the fall, however, one tagged fish was recaptured and killed, and an additional 2 fish were lost after the extreme flooding in early November. Peak flows during the flood were incredible and it is possible that these fish were killed, but previous studies (Winter, 1976) show that steelhead may leave the system and eventually spawn in another river with more favourable flows, such as the nearby Kalum River.

One tagged fish was found to have moved into McDonell Lake and remain there throughout the winter. Subsequent information (L. O'Neill, pers. comm.) indicates that these fish are extremely vulnerable to sportfishing in the lake, but fishing pressure is presently low and does not seem to warrant immediate changes in regulations to protect these fish. Steelhead angling pressure on the lake may increase however, and closure of this fishery should be considered as added protection to these upper river fish to ensure an adequate spawning stock.

Although I suspect one fish spawned in Red Canyon Creek, the only sites positively identified were at the outlet of McDonell Lake, above the Serb Creek confluence. This section has been previously identified as a major spawning area (Humphreys and Morely, M.S. 1978) and underlines the importance of maintaining or improving it with projects such as the Serb Creek stabilization and gravel improvement which are currently in progress.

SUMMARY AND CONCLUSIONS

1. 24 steelhead were radio tagged on the Morice River, 15 on the Kispiox River, 14 on the Suskwa River, and 6 on the Zymoetz River.

2. All fish were live captured by angling with an average hooking mortality of 3.9%.

3. <u>Morice River</u>

   — tagged fish remained active during the fall, moving both upstream and downstream within a range that seems to vary in size from fish to fish.

   — steelhead wintered throughout the Morice River, but only a small percentage utilized the 16 km below Morice Lake outlet. Spawning locations were identified for 16 tagged fish. Of these, 7 spawned in Morice tributaries, and 9 spawned in the mainstem and its side channels.

   - the steelhead that spawned in Morice tributaries were found to have wintered in the mainstem and entered the tributaries between May 11 and June 10 when flows were high, and water temperatures were between 4°C and 9°C.

   — tagged fish spawned in the Morice River mainstem when water temperatures were between 4°C and 7°C.

— Owen, Gosnell and Lamprey Creeks are the most important tributaries in the Morice, and all have extensive road construction and/or logging proposed over the next several years. During development, emphasis must be placed on maintenance of water quality and adequate precautions to ensure upstream or downstream migration of adults and juveniles throughout the year.

— if the proposed Kemano II development reduces the flows and side channel habitat between Gosnell Creek and Owen Creek, a major steelhead spawning and rearing area will be reduced.

— there are two opportunities for obtaining gravid adults for brood stocks in the Morice. One is to angle the mainstem before the river becomes too muddy in the spring, the other is to angle the designated tributaries in mid—May.

— removal of the falls on Cox Creek appears to be an attractive enhancement opportunity and deserves more study.

4. Suskwa River

— tagged steelhead in the Suskwa remained in the lower 16 km during fall and winter.

— all of the tagged fish that wintered in the Suskwa utilized the area between 6 km and 14 km. One fish was found to leave the Suskwa and winter in the Bulkley River before returning to spawn in the spring.

—Four of the 6 steelhead tagged in the Bulkley at the mouth of the Suskwa proved to be Suskwa River fish. These fish wintered in the larger Bulkley River before moving into the Suskwa to spawn in the spring.

—Suskwa River regulations should be extended to include the Bulkley River for at least 5 km upstream and downstream of the Suskwa River confluence.

—spawning sites were identified for 9 steelhead, 5 of which were in the Suskwa and 4 in Harold—Price Creek.

—additional radio tagging may be required to determine if steelhead are able to get above the Harold—Price falls during high flows in the spring.

5. <u>Kispiox River</u>

—fish tagged in the lower Kispiox remained in the lower river throughout the fall, which is evidence to support the current catch and release regulations on the Kispiox.

—four of the 5 identified spawning sites were in tributaries to the Kispiox.

—two fish were found to spawn in lower Nangese Creek, one in lower Ironside Creek and one in Skunsnat Creek. An additional fish is suspected to have spawned in Murder Creek.

— instream improvement of side channels, possibly in conjunction with incubation boxes, appears to be one enhancement opportunity for the Kispiox mainstem.

6. Zymoetz River

— spawning sites were identified for 2 tagged fish which were both found to have spawned between the Serb confluence and McDonell Lake.

— one tagged fish was found to have moved into McDonell Lake, and remain there throughout the winter before spawning in the lake outlet.

REFERENCES

Bovee, K.D. 1978. Probability of use criteria for the family Salmonidae. Cooperative Instream Flow Service Group, Fish and Wildlife Service, U.S. Department of the Interior. 81 pp.

Chudyk, W.E. M.S. 1978. Suskwa River steelhead trout: The 1977 inventory, creel survey and life history characteristics study leading to the removal of a barrier on Harold—Price Creek. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 34 pp.

Chudyk, W.E. M.S. 1979. Zymoetz River steelhead trout: A preliminary report of the 1978 sport fishery and some aspects of their history. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 28 pp.

Chudyk, W.E. M.S. 1979. Suskwa River steelhead trout: The colonization of Harold Price Creek with hatchery reared steelhead. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 15 pp.

Chudyk, W.E. and D.W. Narver. M.S. 1976. Commercial interceptions of steelhead trout in the Skeena River. A preliminary review. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 27 pp.

Chudyk, W.E. and M.R. Whately. 1977. Some notes on the habits and habitat of steelhead trout in the Kispiox River with particular reference to Cullen Creek. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 15 pp.

Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission. Fishery report #7. 48 pp.

Harding, T. and L. Erickson. M.S. 1973. A survey of lower Kispiox River streams. File report. Fish and Wildlife Branch, Smithers, B.C. 12 pp.

Hatlevik, S.P. and M. Lough. 1979. Morice River steelhead snorkel survey. File report. Fish and Wildlife Branch, Smithers, B.C. 4 pp.

Humphries, D.H. and C. Morely. M.S. 1978. A fisheries survey of the upper Zymoetz River system (headwaters to Red Canyon Creek) with particular reference to steelhead and cutthroat trout habitat and enhancement opportunities. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 157 pp.

Lough, M.J. 1978. Radio telemetry studies of summer run steel— head trout in the Skeena River, 1978, with particular reference to equipment and capture methods. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 17 pp.

Pinsent, M.E. and W.E. Chudyk. M.S. 1973. An outlined of the steel— head of the Skeena River System. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 138 pp.

Shepard, C. and J. Algard. M.S. 1976. A preliminary survey of juvenile steelhead and rainbow trout distribution and rearing habitat in the Morice River system, 1976. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 49 pp.

Taylor, G.D. M.S. 1968. Report on the preliminary survey of the Skeena River drainage tributaries. Unpubl. M.S. Fish and Wildlife Branch, Smithers, B.C. 42 pp.

Whately, M.R. 1977. Kispiox River steelhead trout: The 1975 sport fishery and life history characteristics from angler catches. B.C. Fish and Wildlife Branch, Fish. Tech. Circ. No. 30, 22 pp. and appendices.

Whately, M.R. 1978. Morice River steelhead trout: The 1976 and 1977 sport fishery and life history characteristics from angler catches. B.C. Fish and Wildlife Branch, Fish. Tech. Circ. No. 36, 22 pp.

Winter, J.E. 1976. Movement and behavior of largemouth bass *(Micropterus salmoides)* and steelhead *(Salmo gairdneri)* determined by radio telemetry. Ph.D. thesis. Univ. Minnesota. 195 pp.

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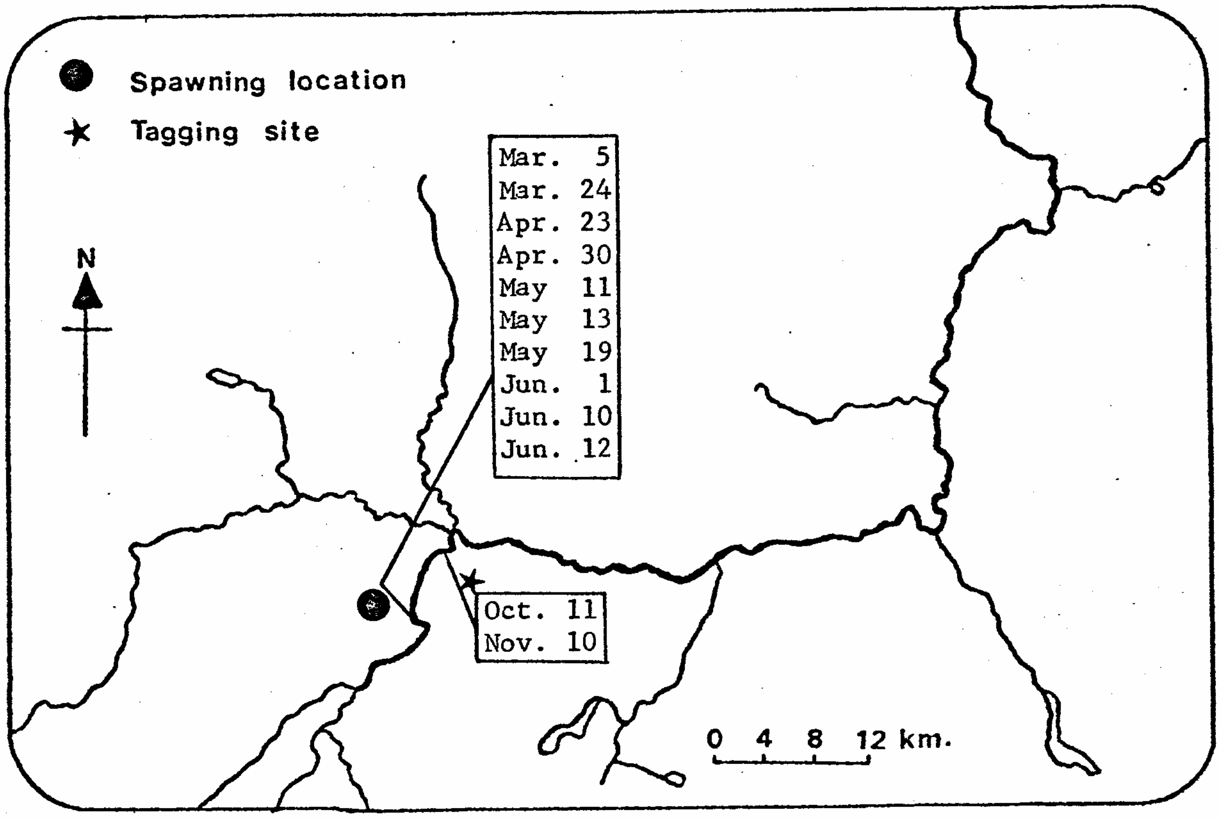
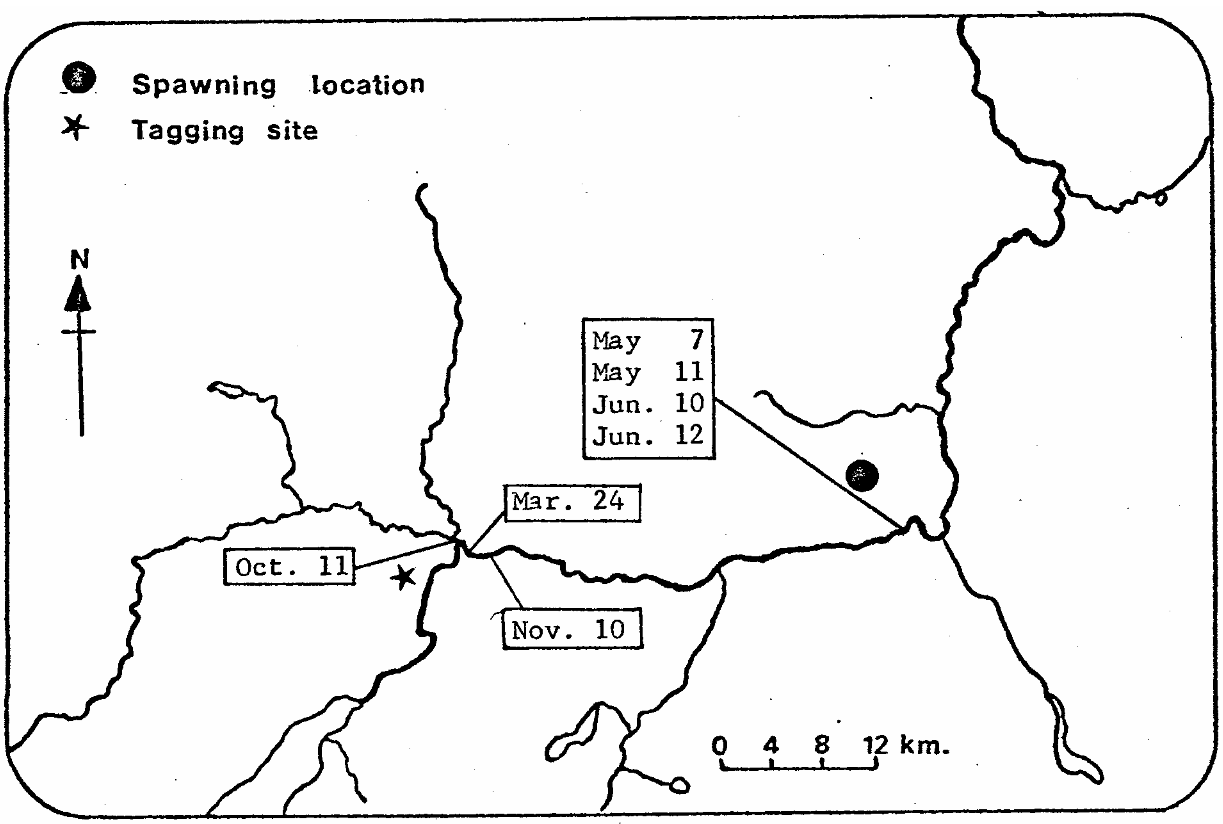
APPENDIX

MORICE RIVER

The following charts indicate the dates that each fish was located at various points on the Morice River. For the sake of clarity, the names of locations have been omitted from these charts, but may be found in Figure 7.



Appendix. Location and dates for tagging and tracking steelhead no.1.



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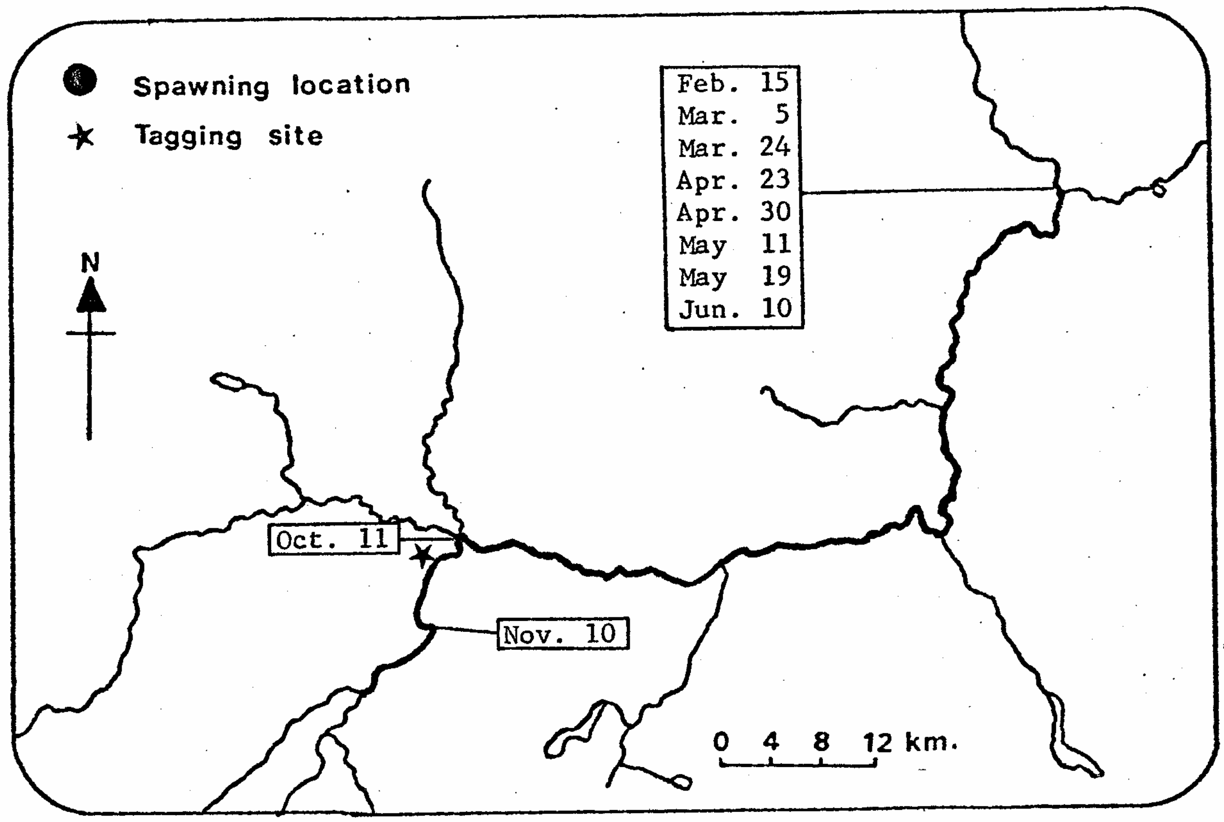

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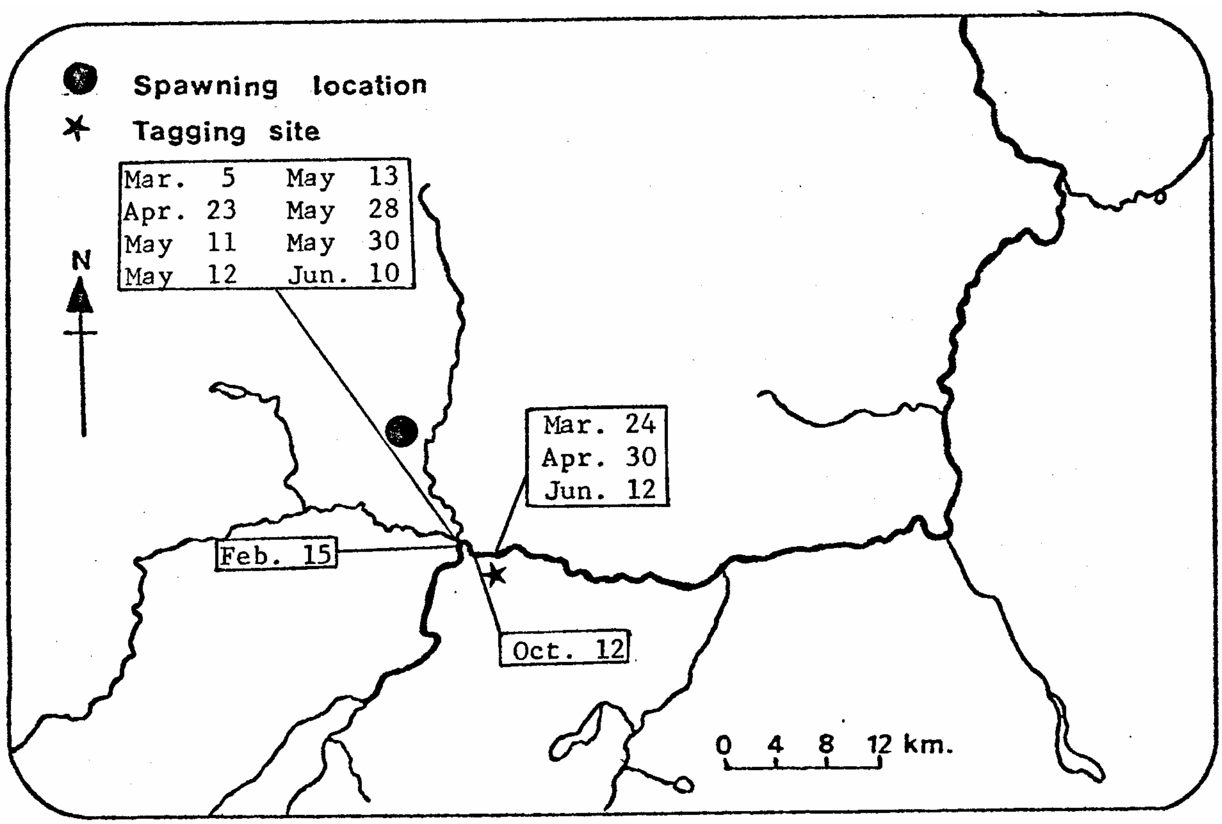

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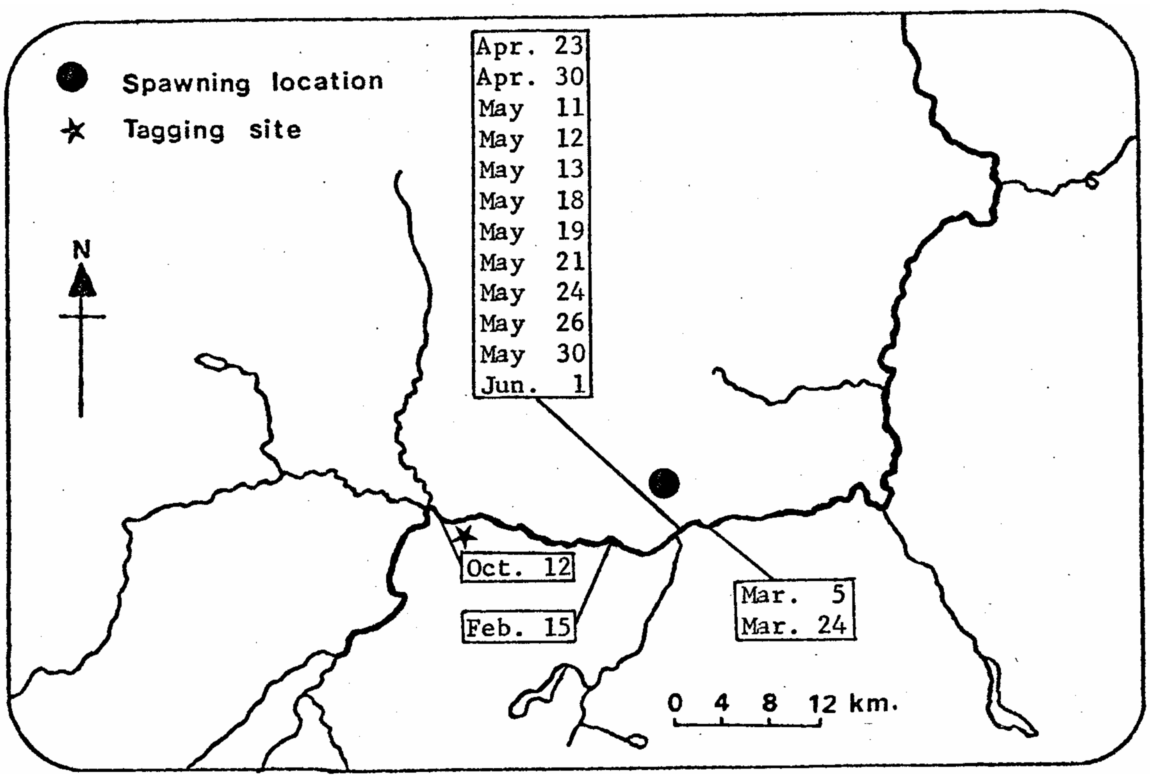

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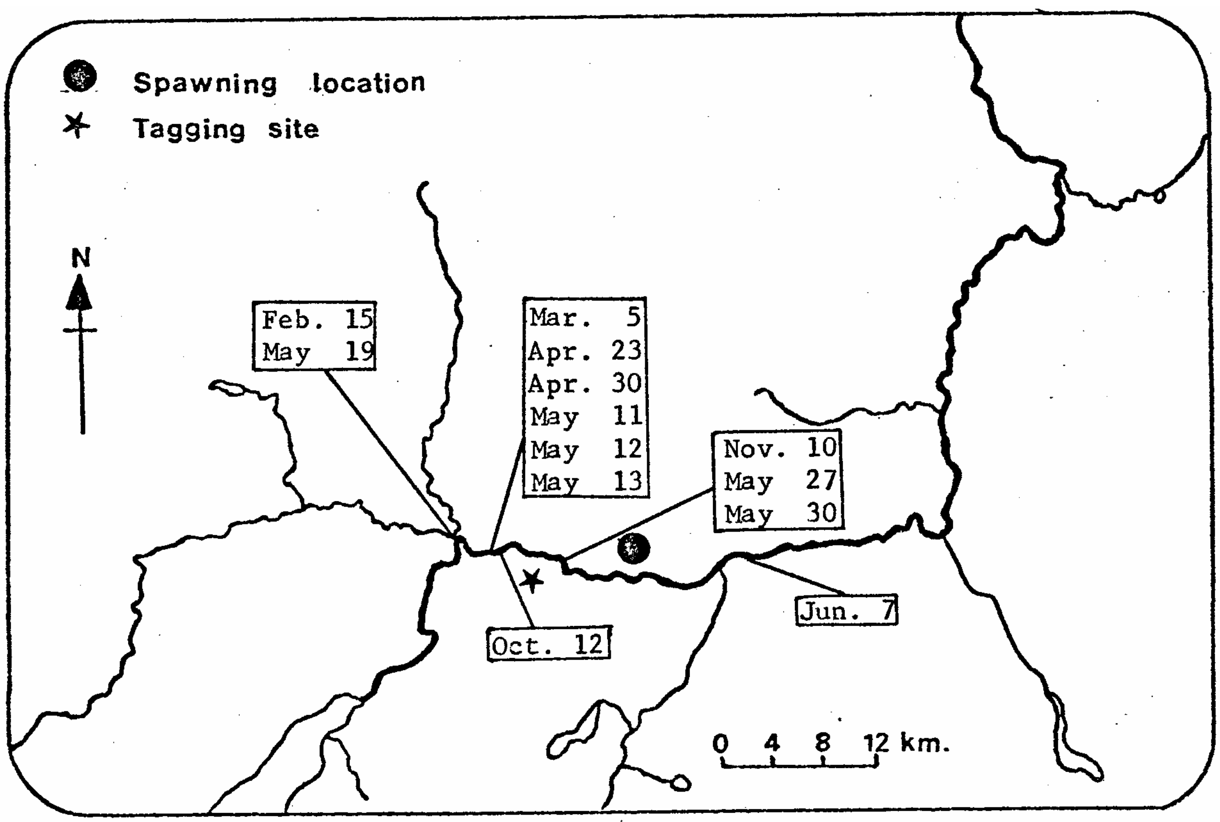

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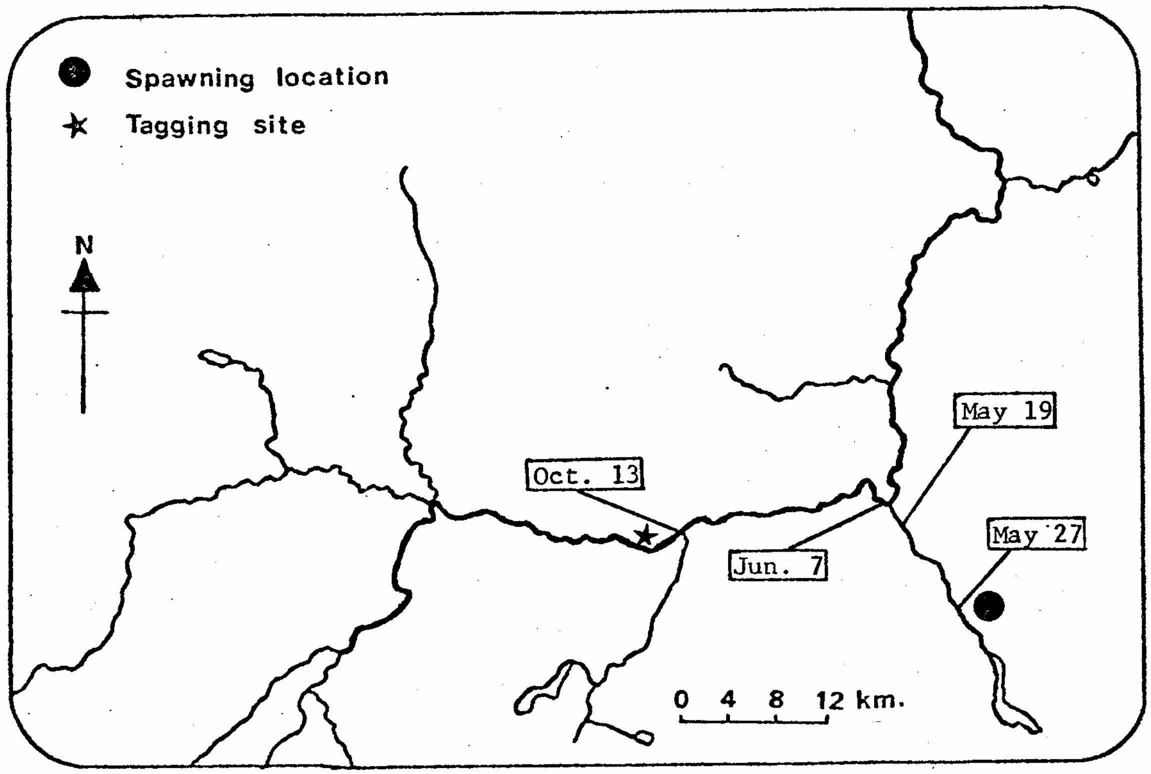

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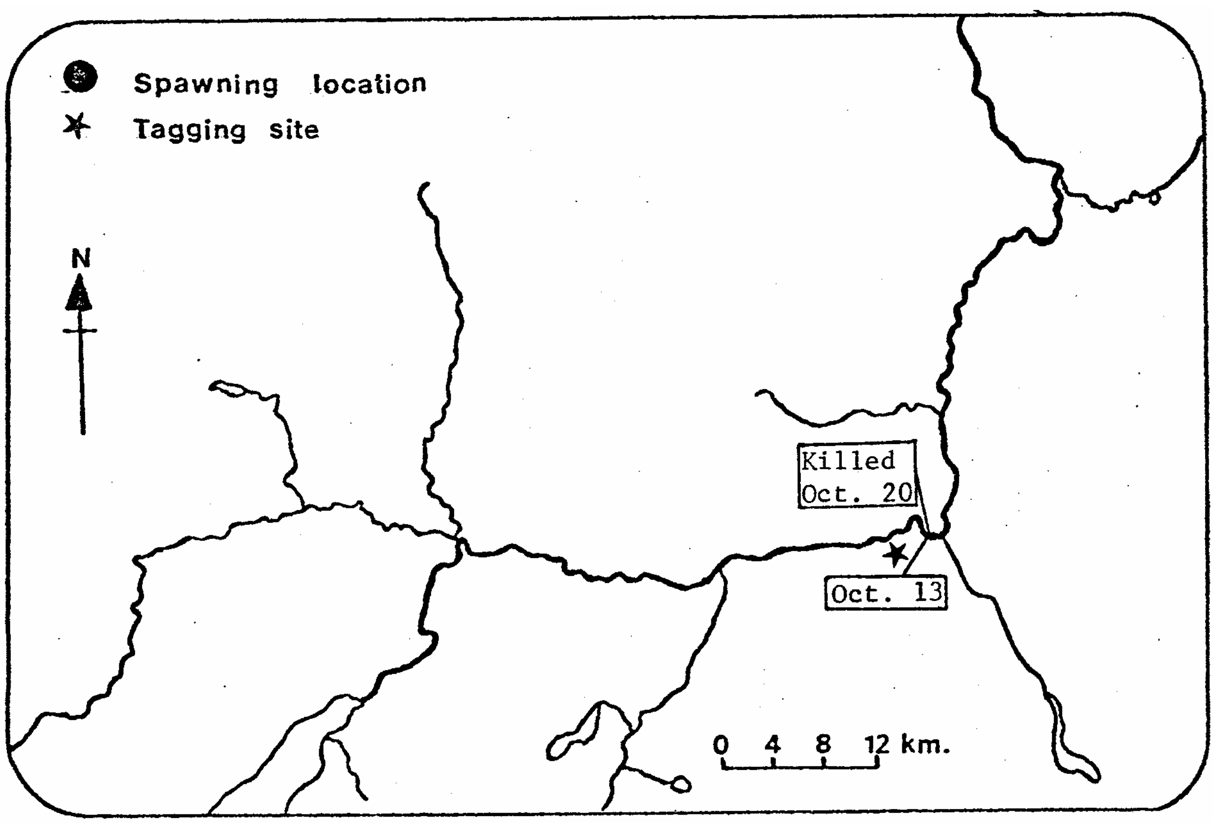

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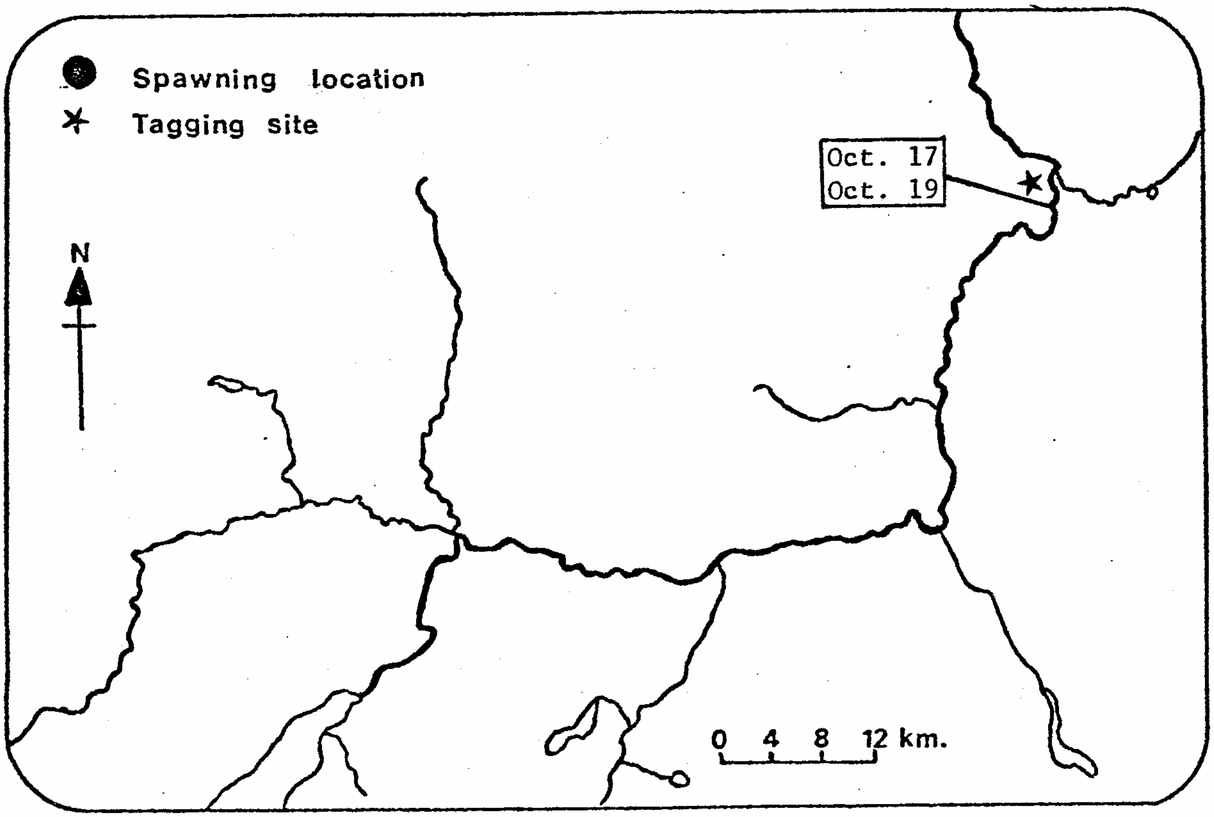
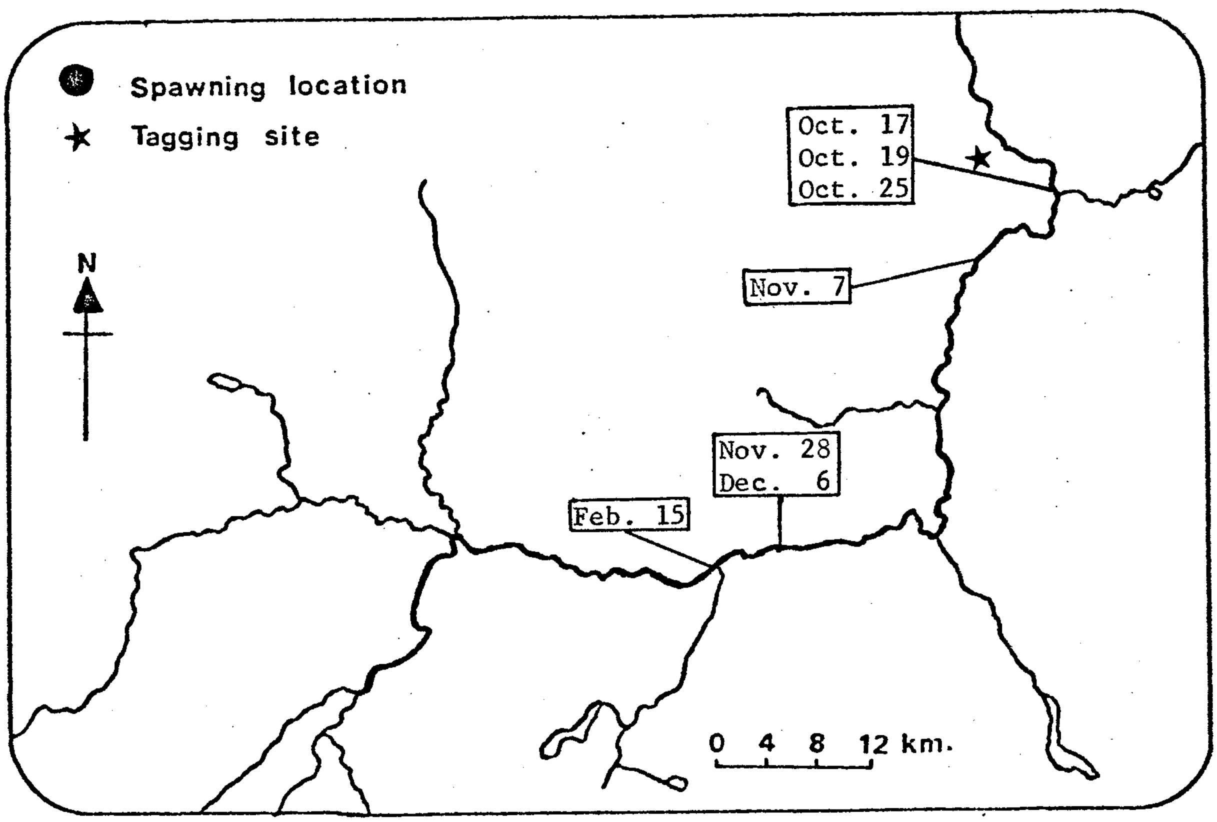


Appendix. Location and dates for tagging and tracking steelhead no.9.



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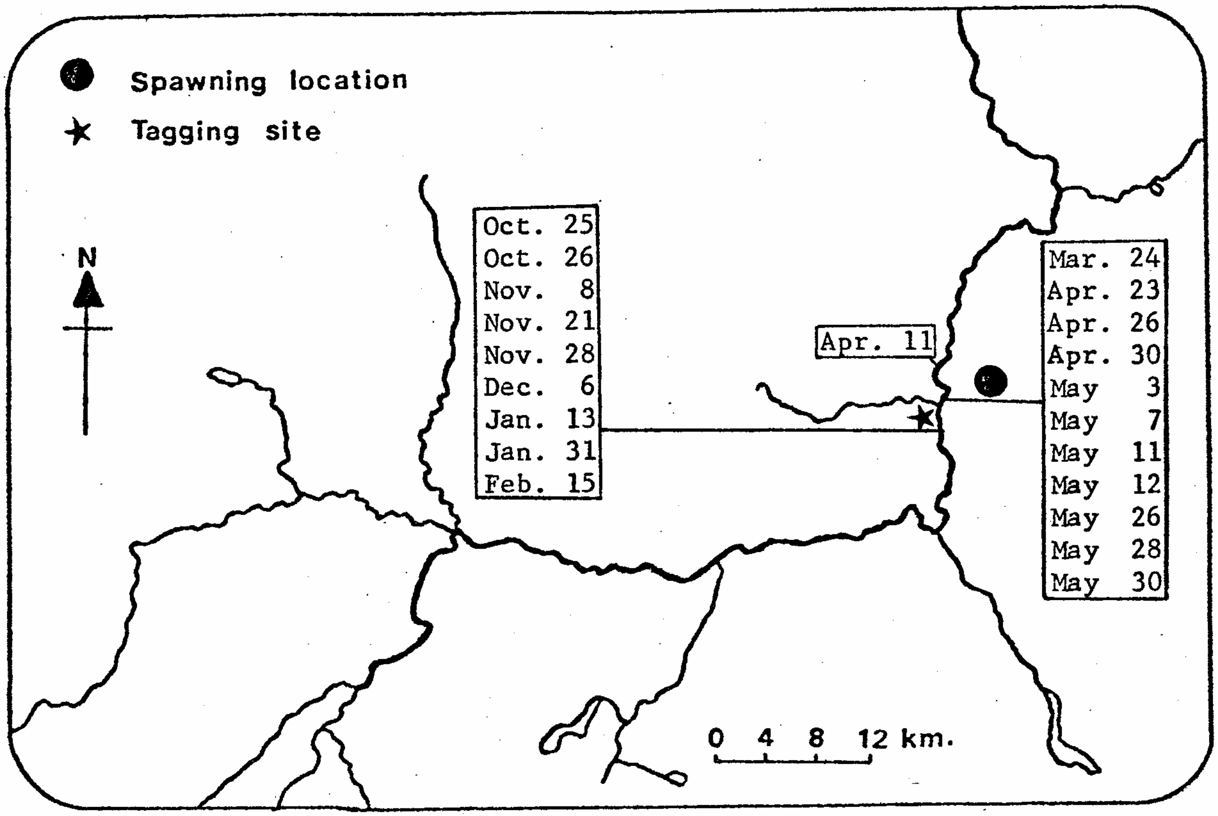
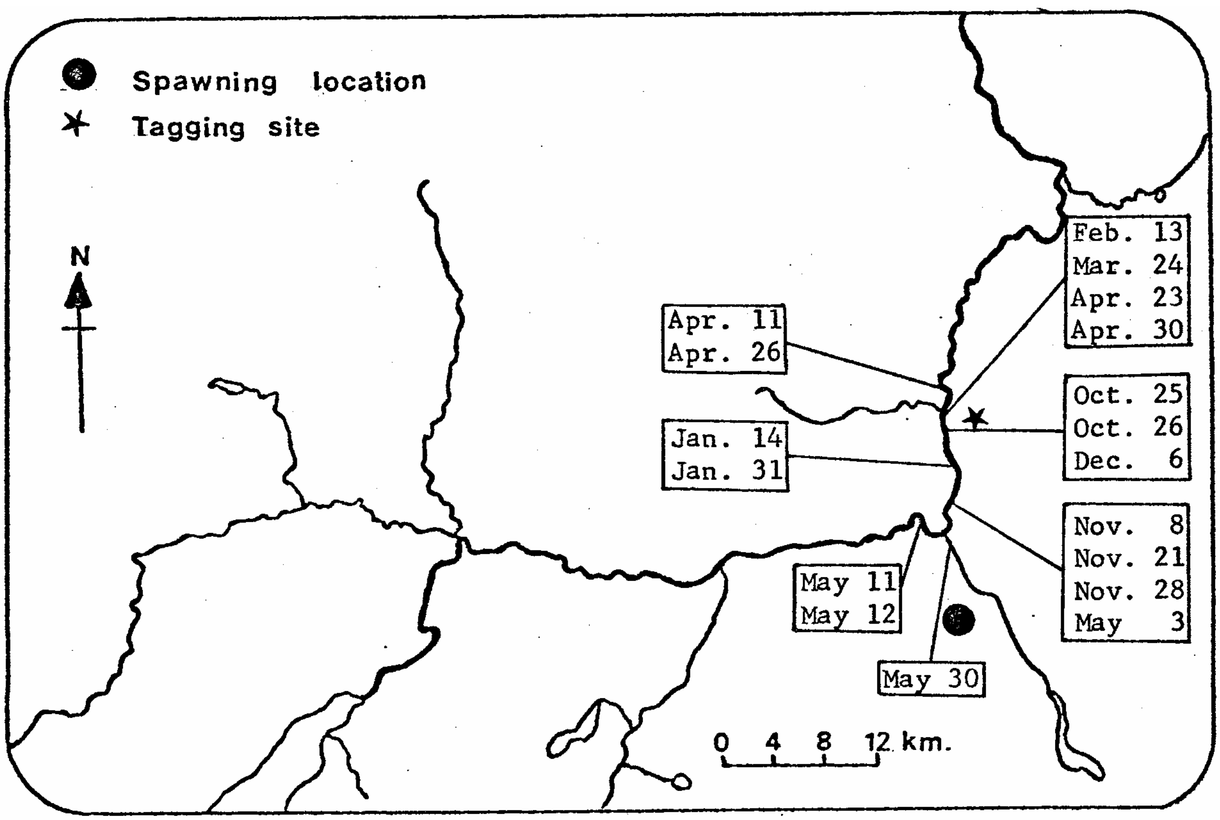
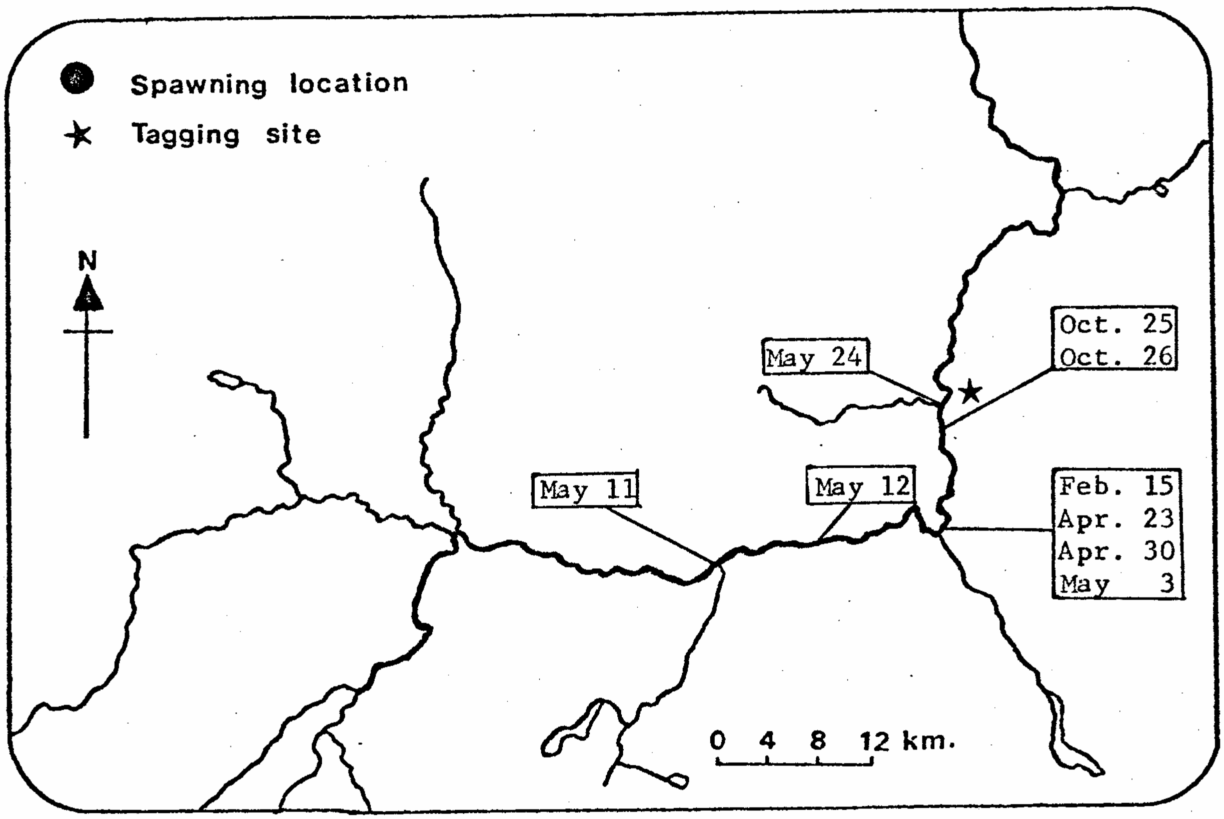


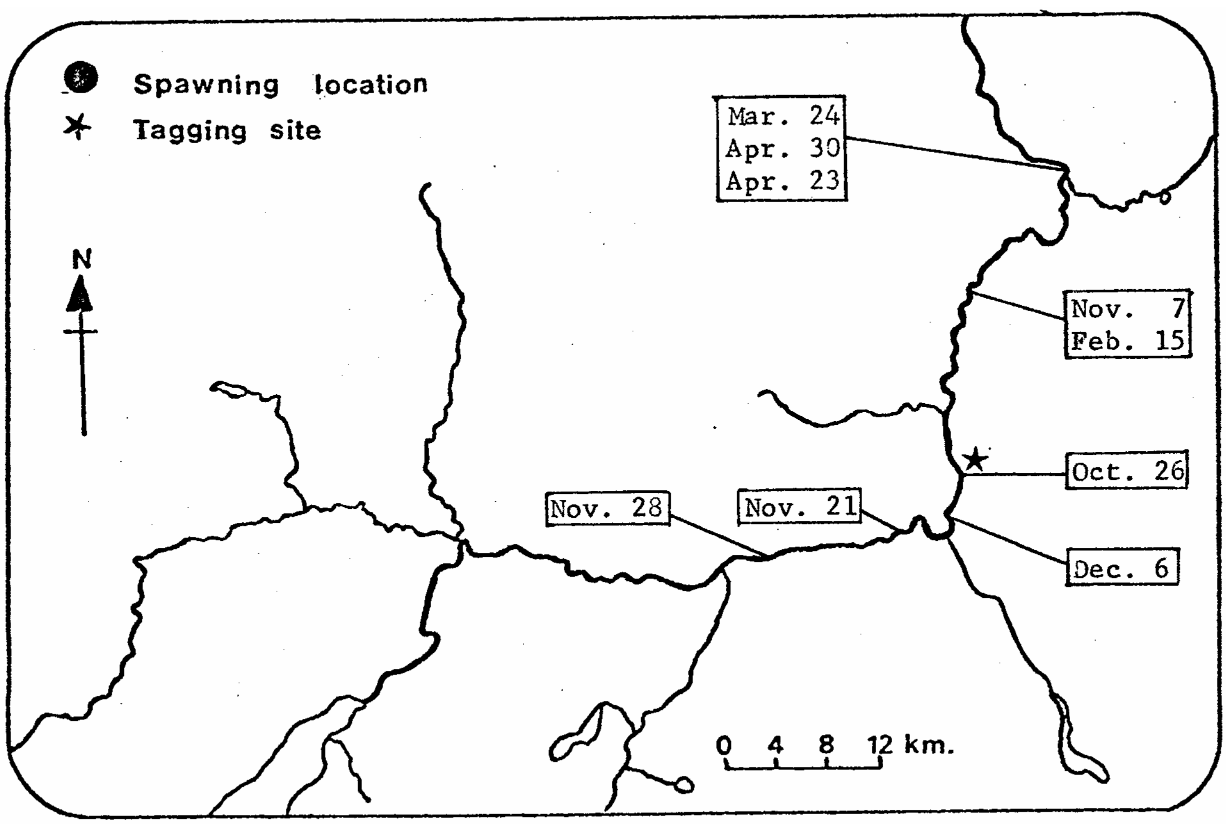
Appendix. Location and dates for tagging and tracking steelhead no.11.



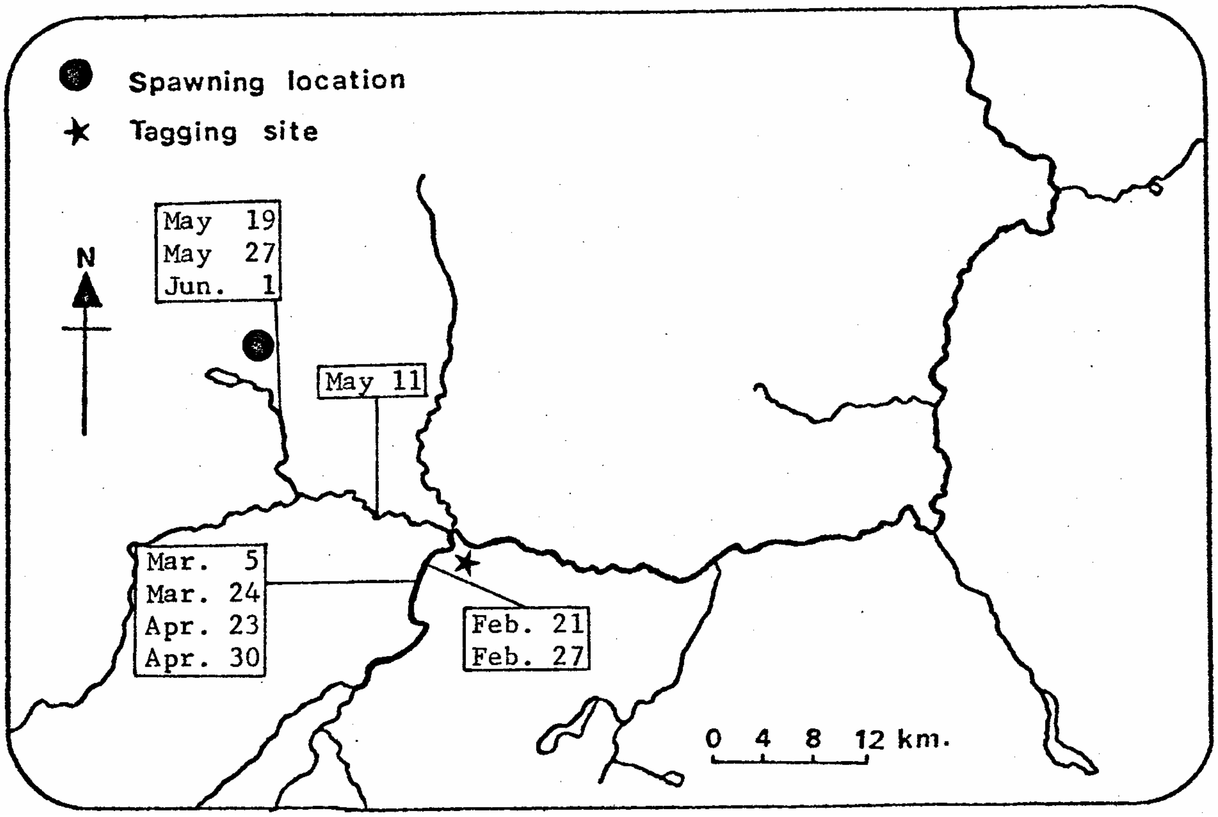
Appendix. Location and dates for tagging and tracking steelhead no.12.



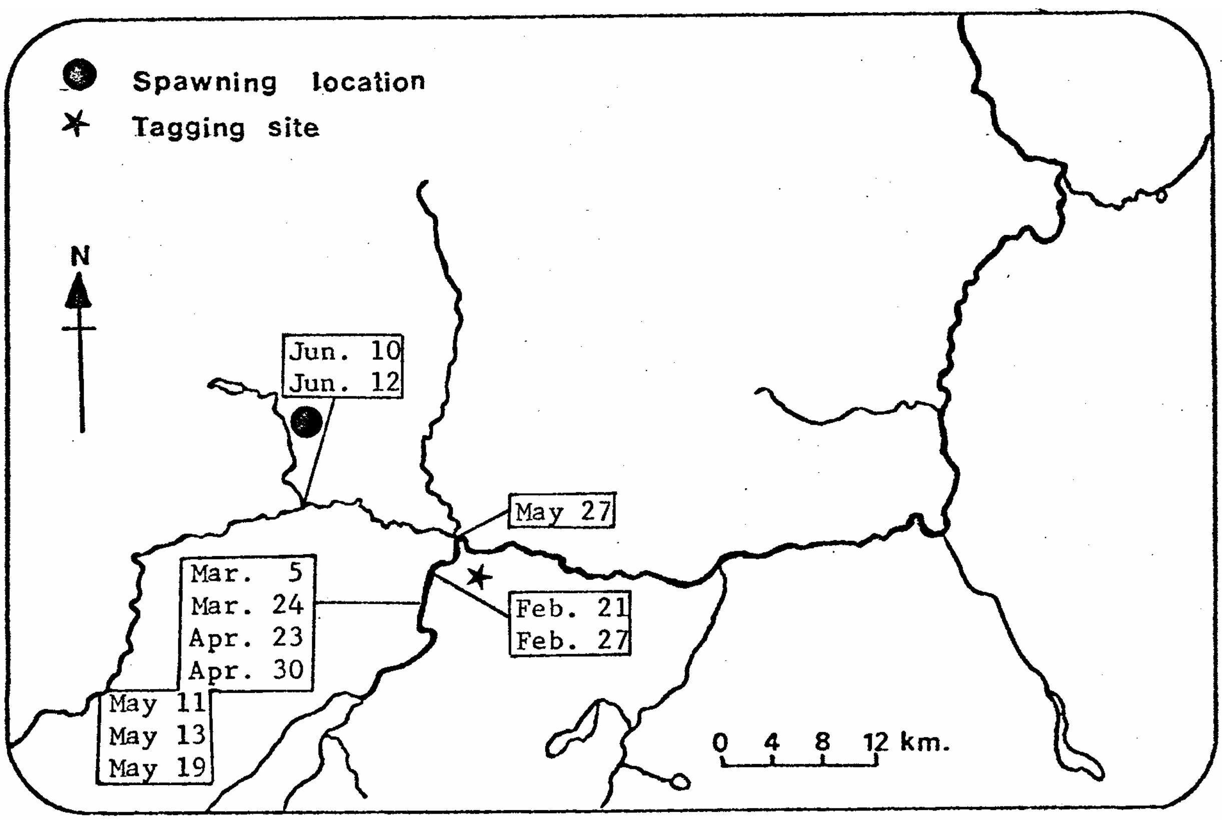
Appendix. Location and dates for tagging and tracking steelhead no.13.



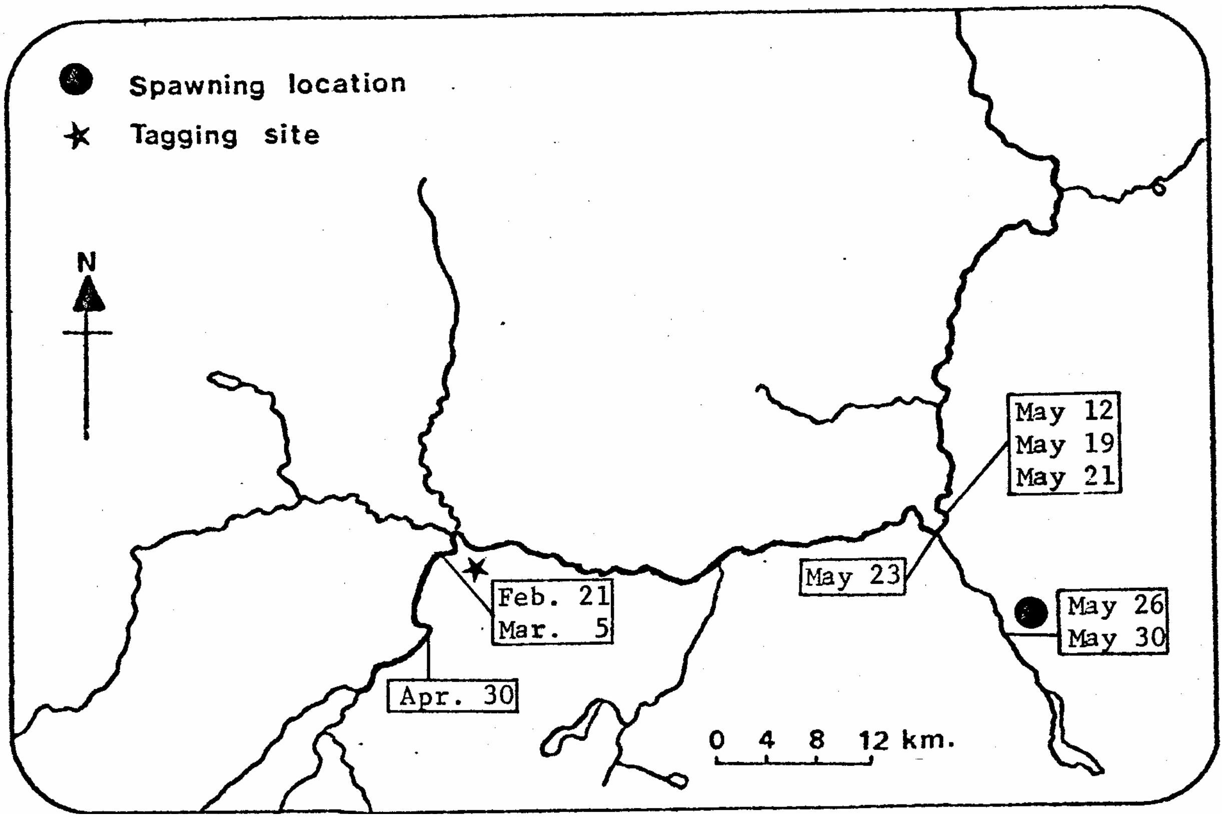
Appendix. Location and dates for tagging and tracking steelhead no.14.



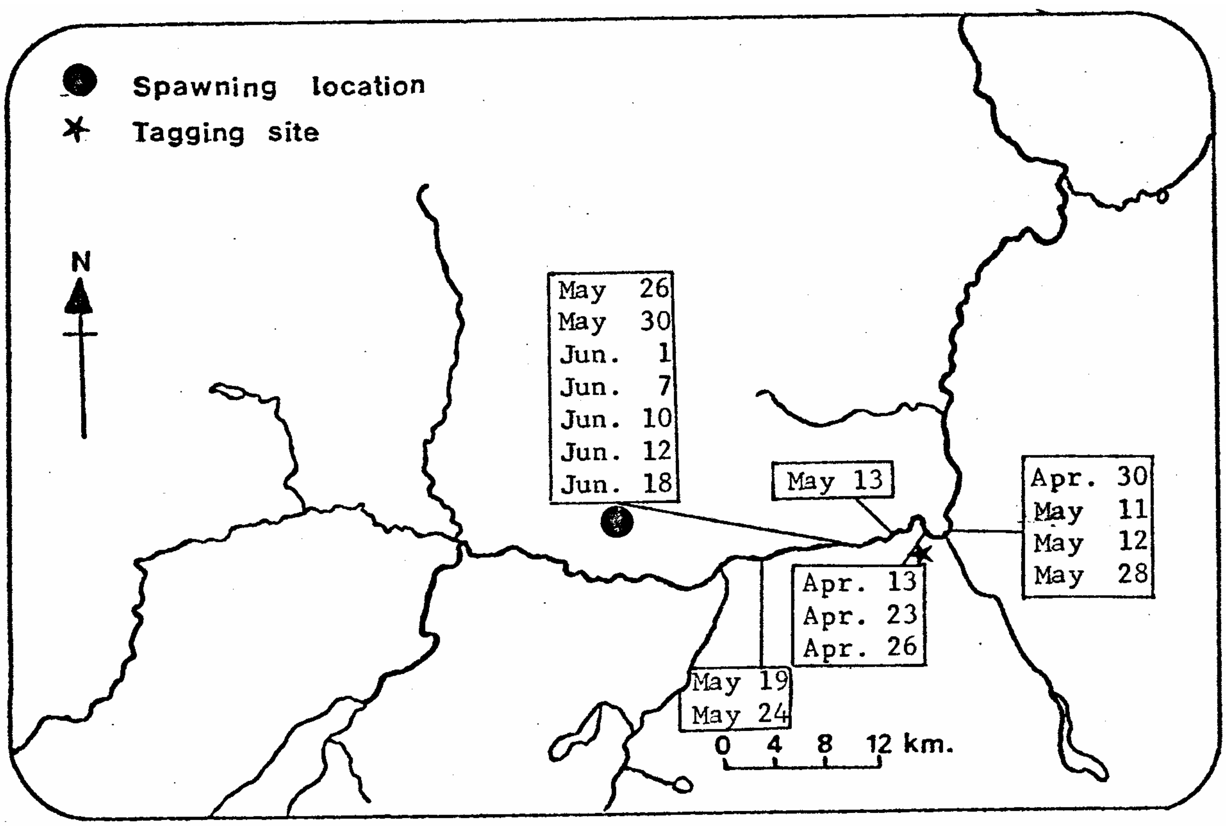
Appendix. Location and dates for tagging and tracking steelhead no.15.



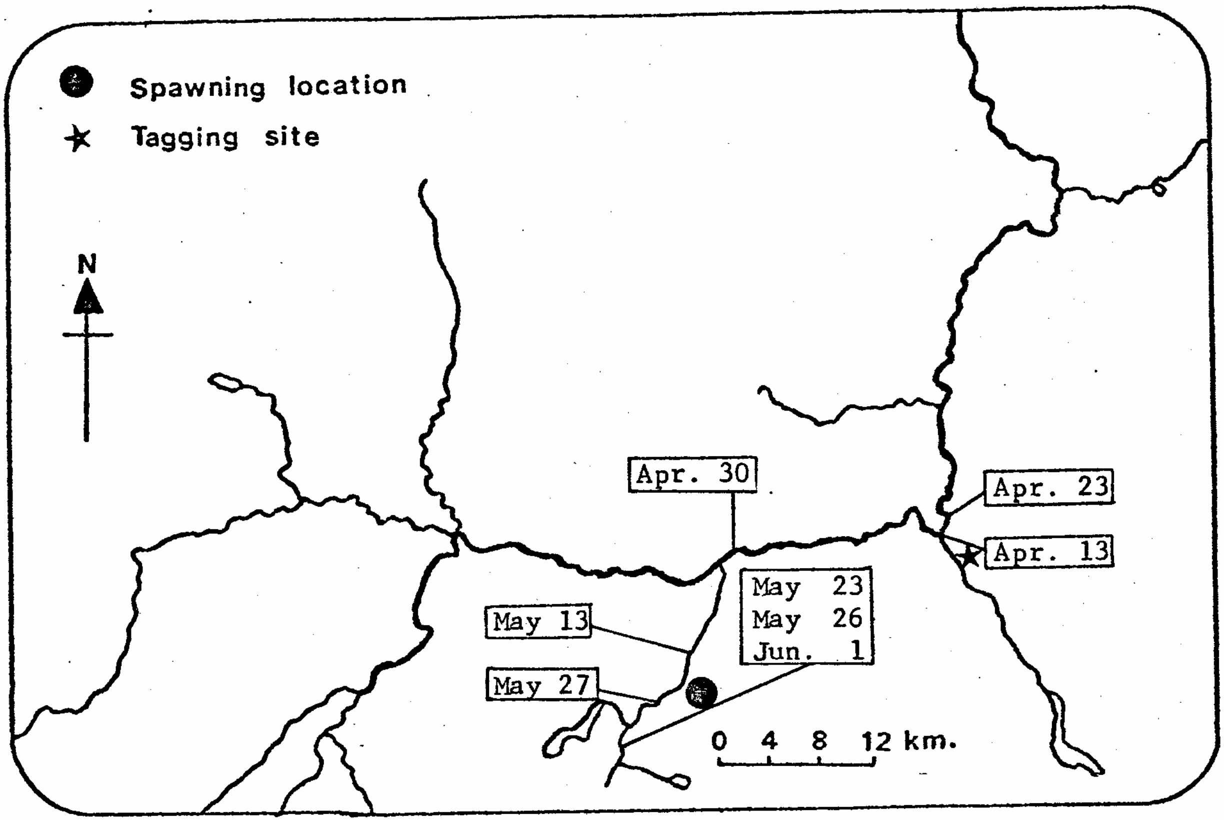
Appendix. Location and dates for tagging and tracking steelhead no.16.



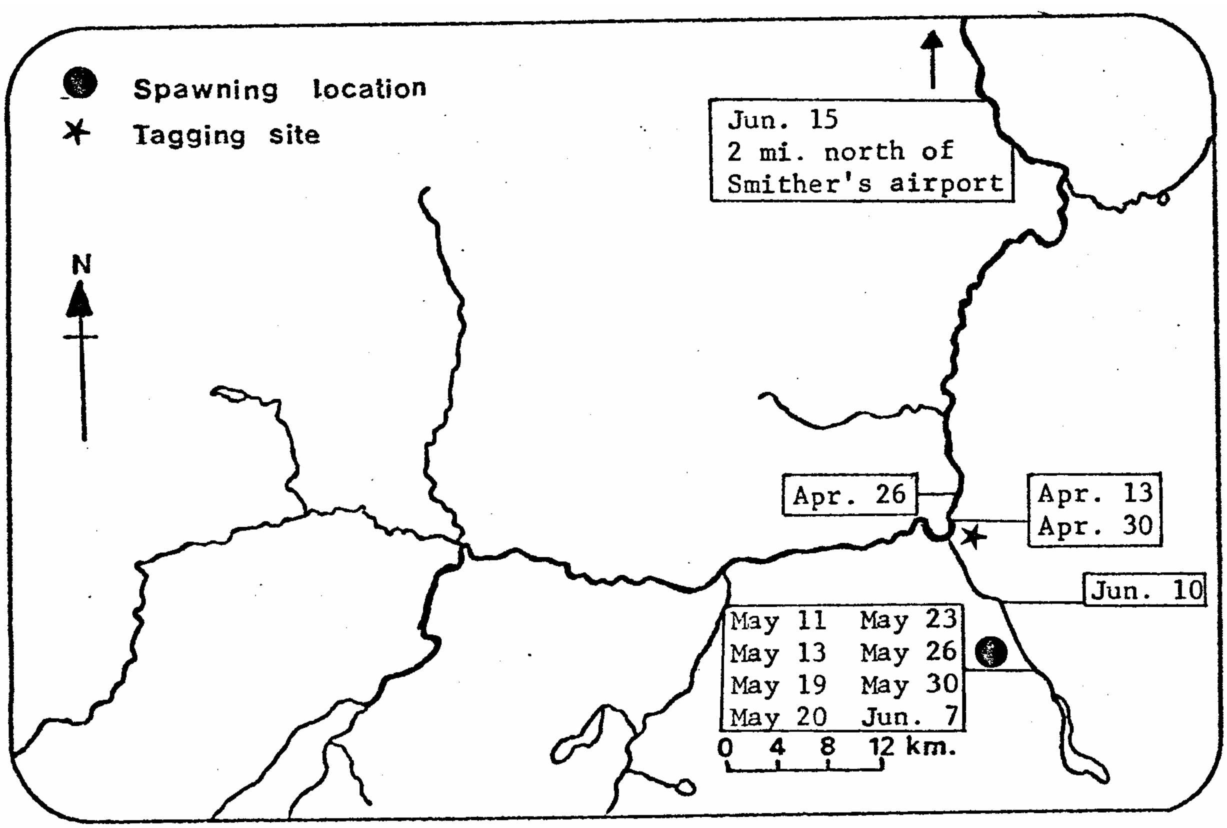
Appendix. Location and dates for tagging and tracking steelhead no.17.



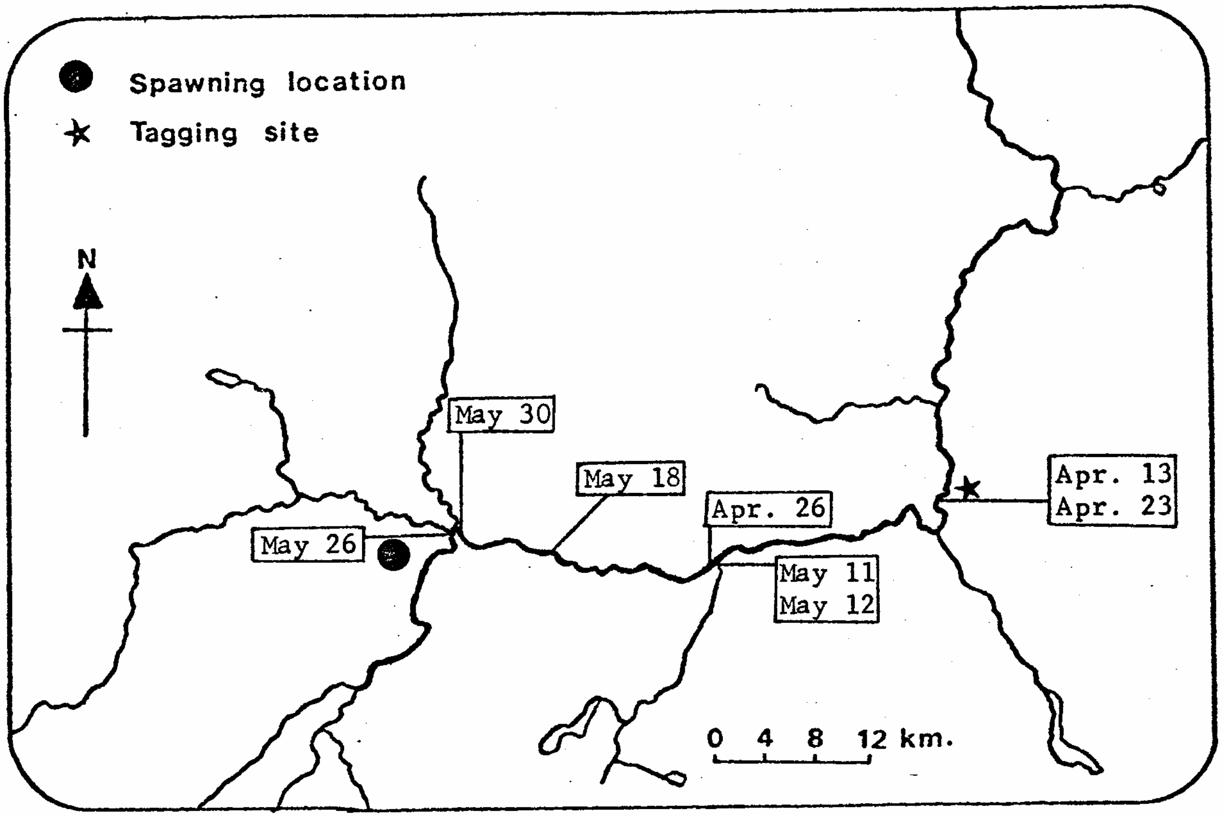
Appendix. Location and dates for tagging and tracking steelhead no.18.



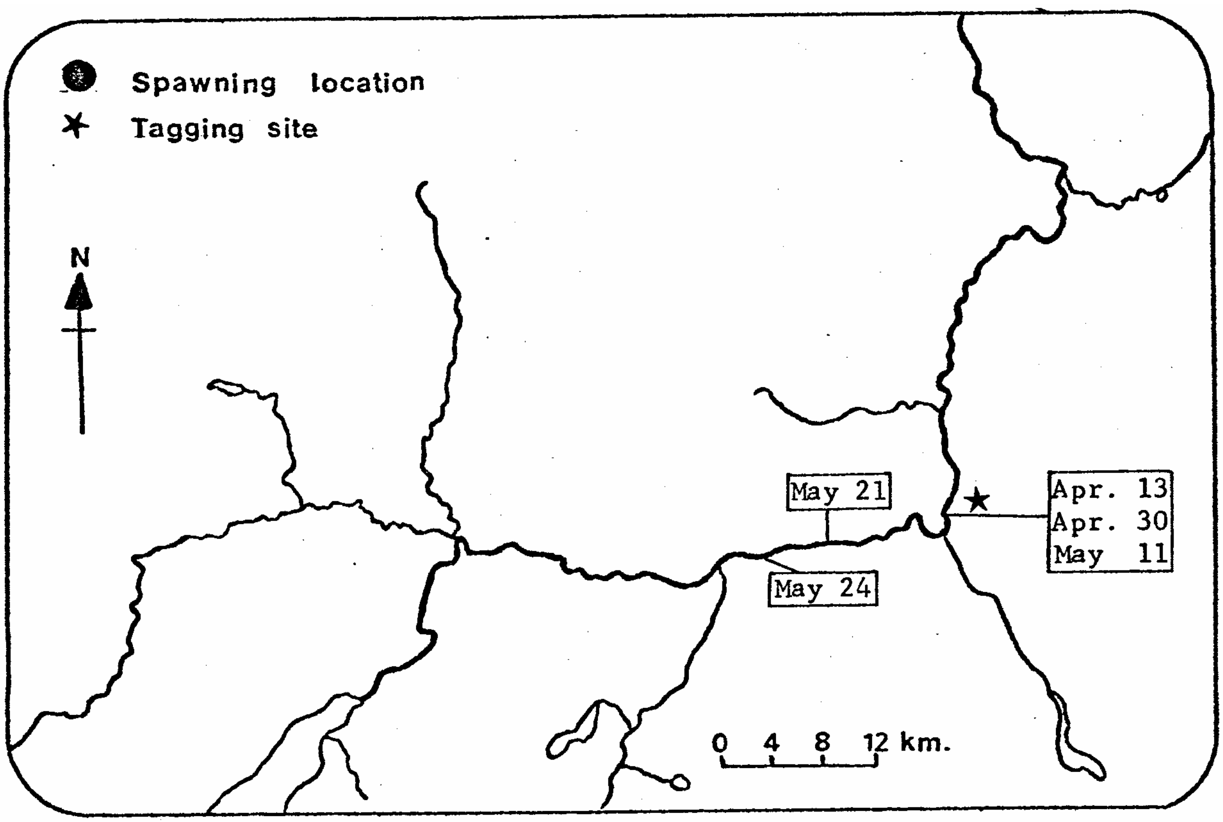
Appendix. Location and dates for tagging and tracking steelhead no.19.



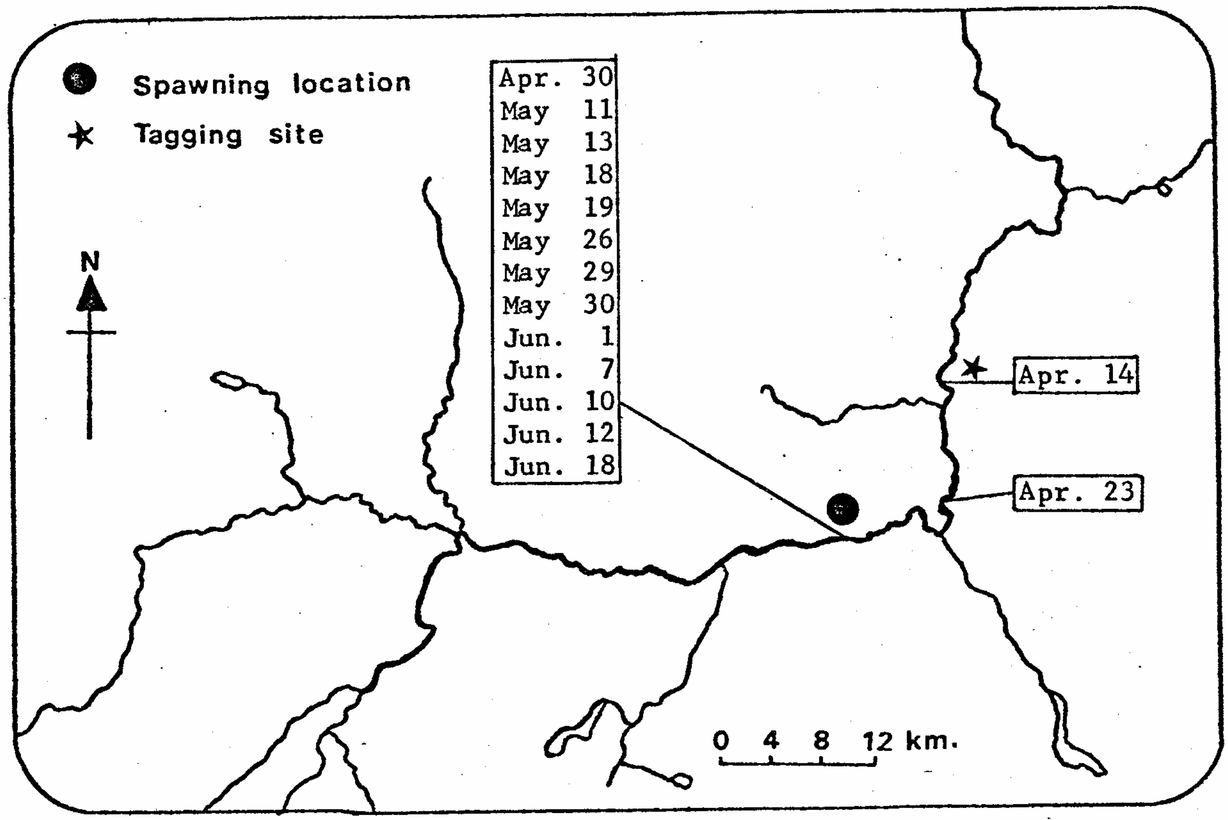
Appendix. Location and dates for tagging and tracking steelhead no.20.



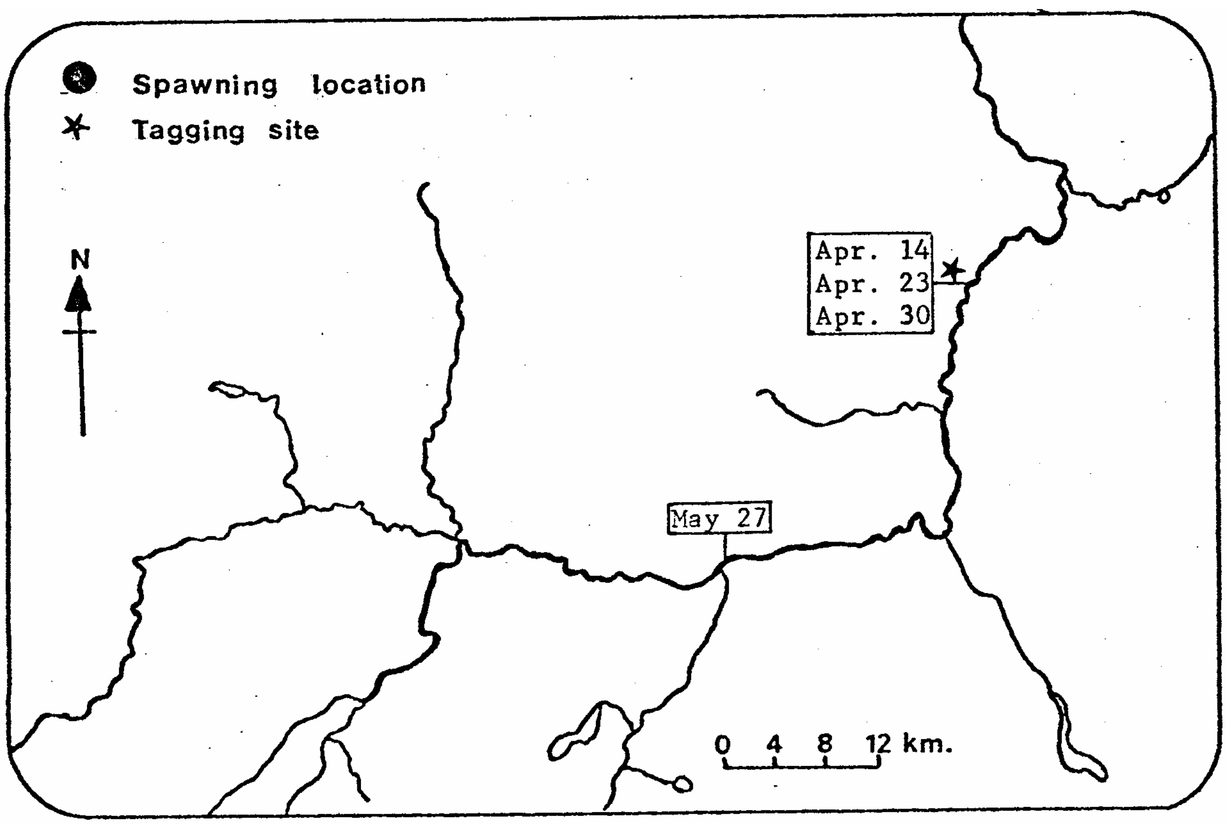
Appendix. Location and dates for tagging and tracking steelhead no.21.



Appendix. Location and dates for tagging and tracking steelhead no.22.



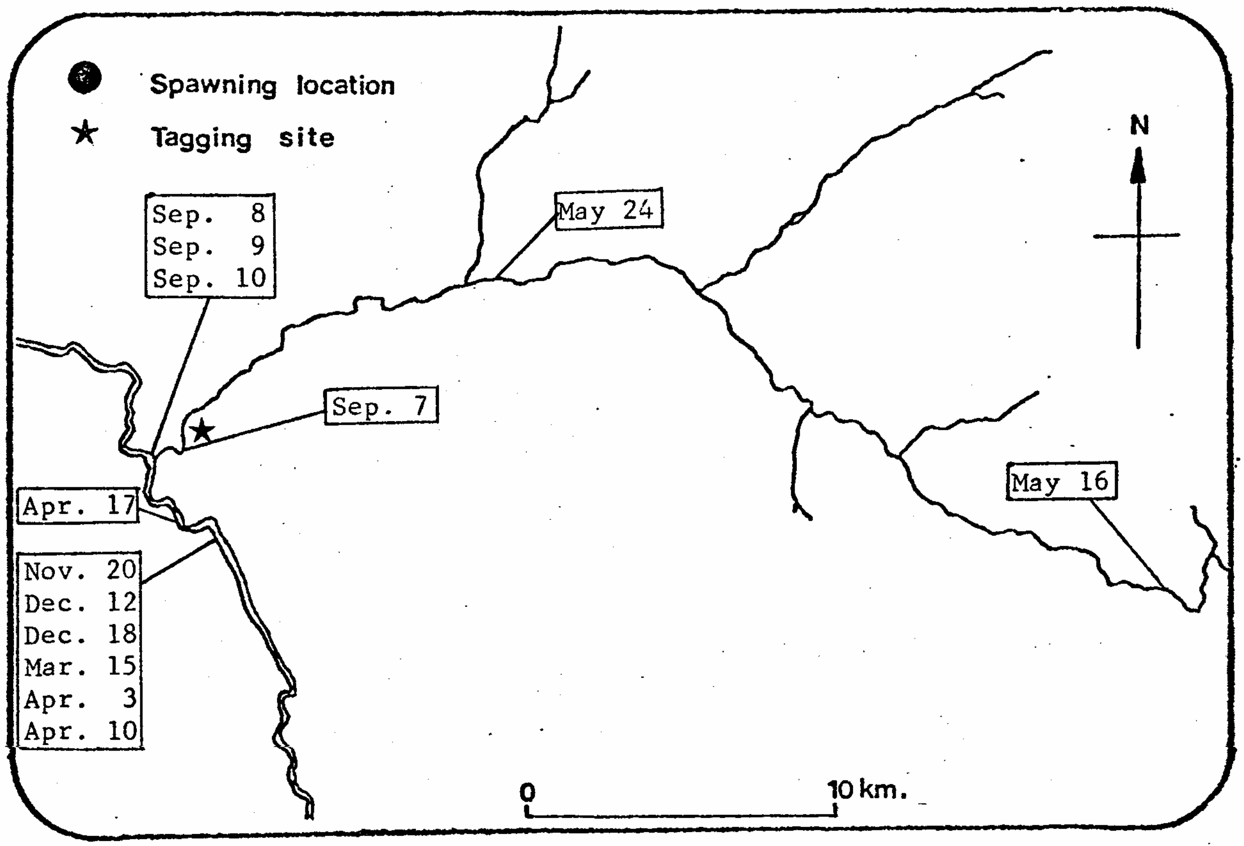
Appendix. Location and dates for tagging and tracking steelhead no.23.



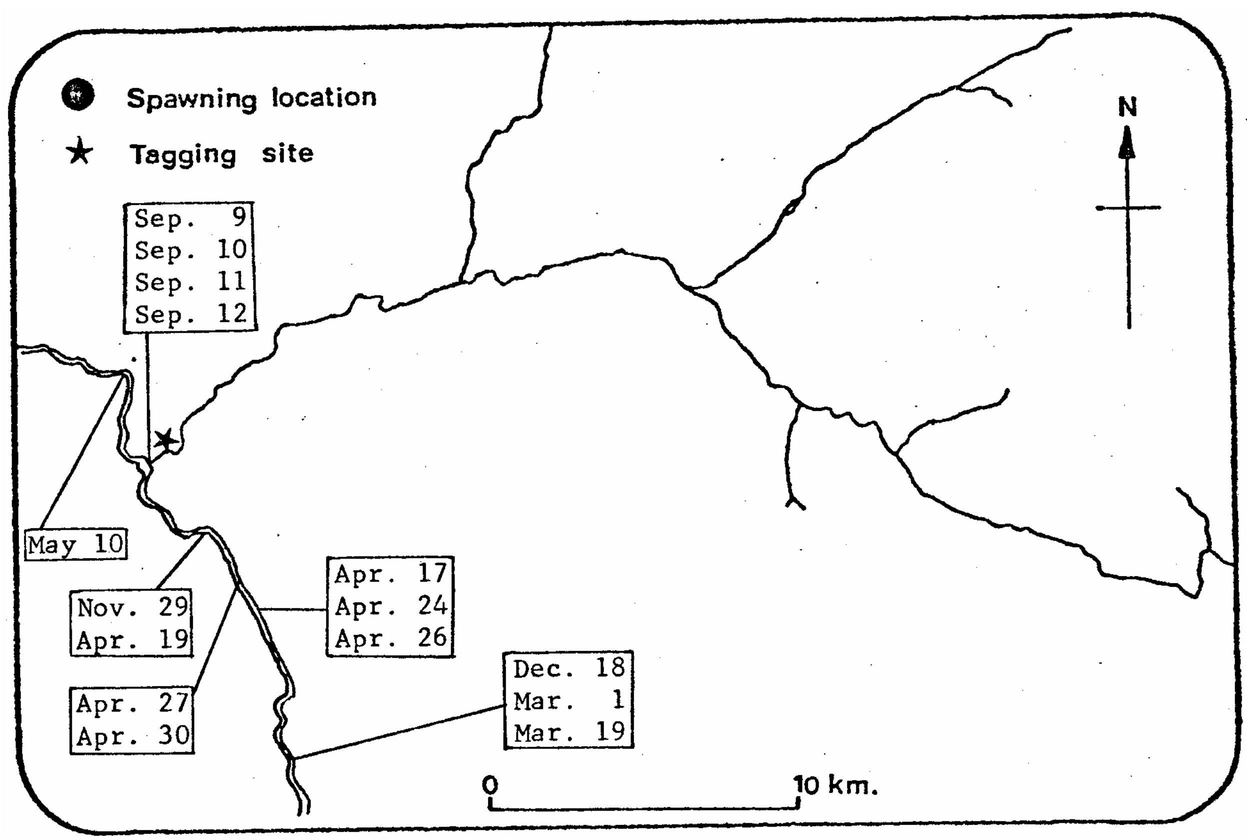
Appendix. Location and dates for tagging and tracking steelhead no.24.

SUSKWA RIVER

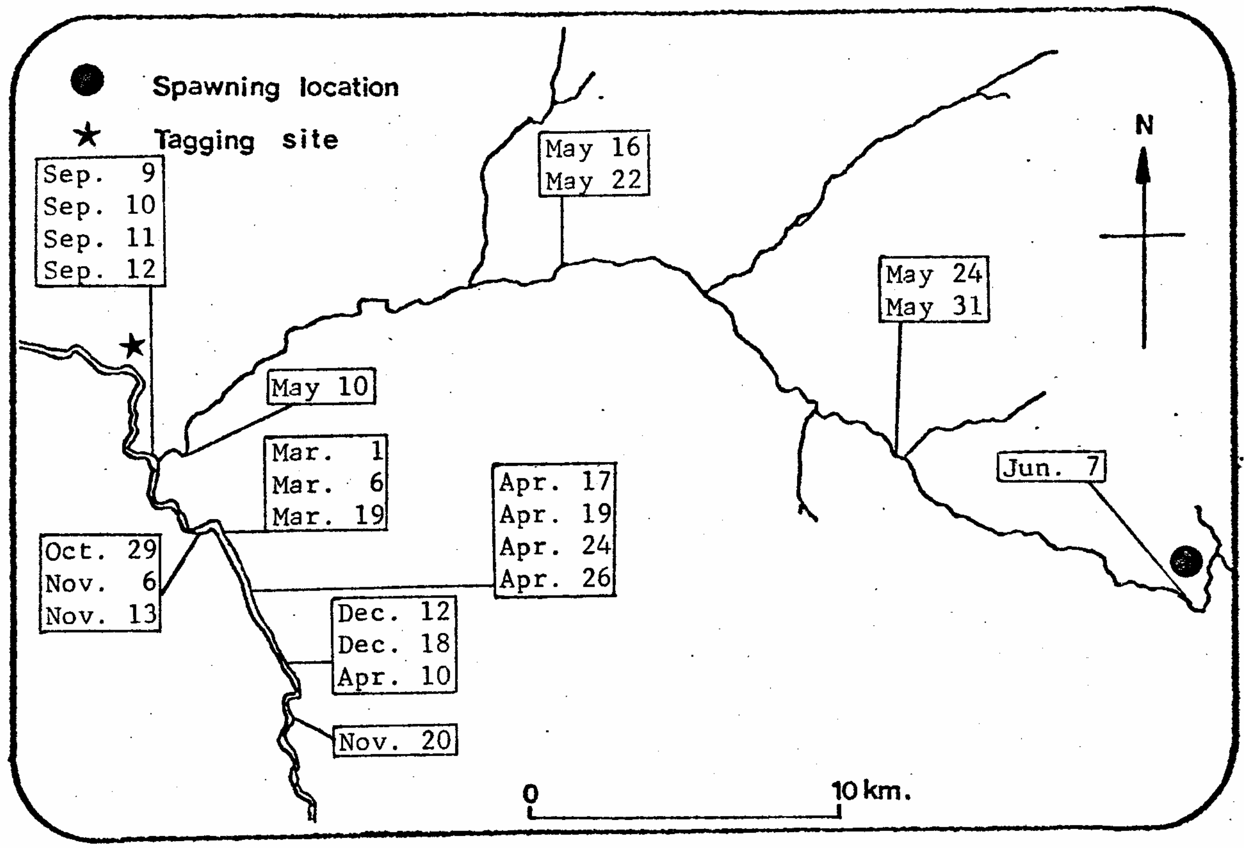
The following charts indicate movements of those fish with the best tracking data on the Suskwa River. Dates that each fish was located at various points on the river are indicated. Names of tributaries have been omitted, but may be found in Figure 12.



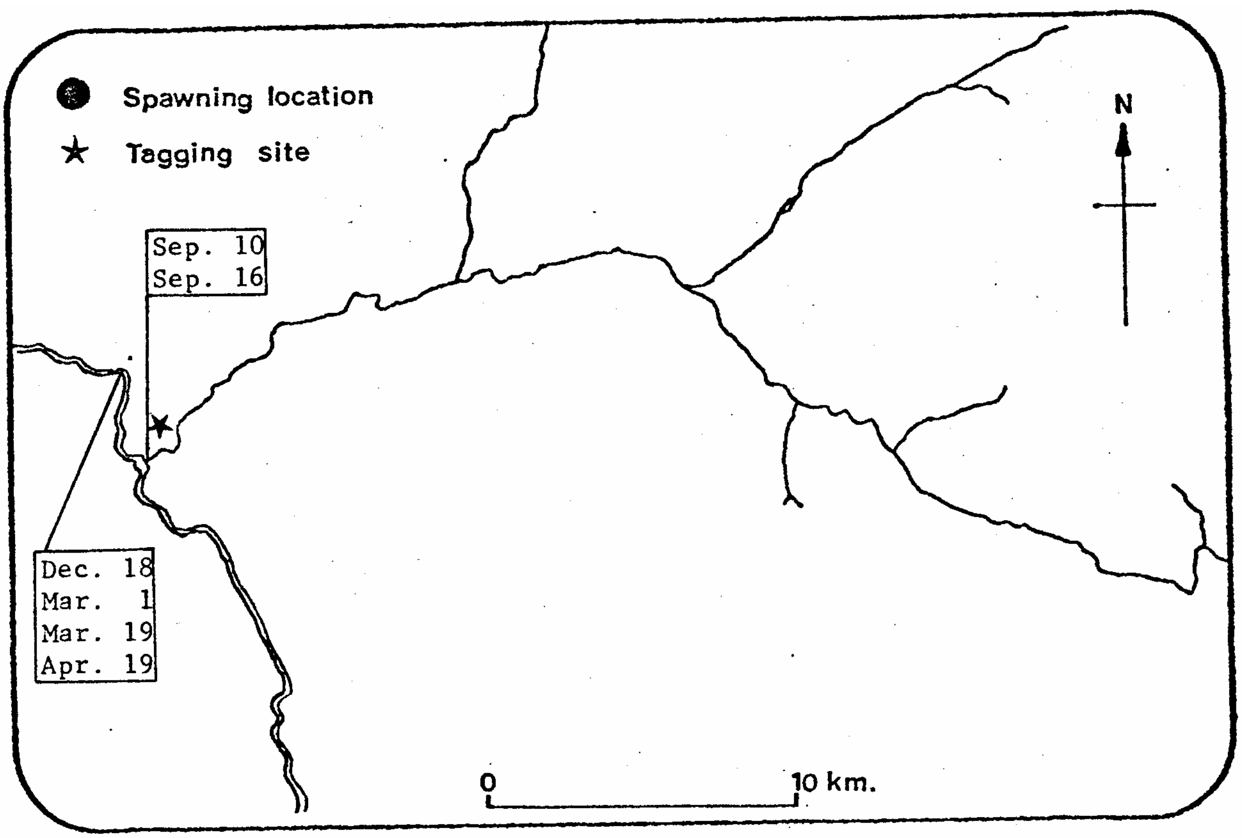
Appendix. Location and dates for tagging and tracking steelhead No.25.



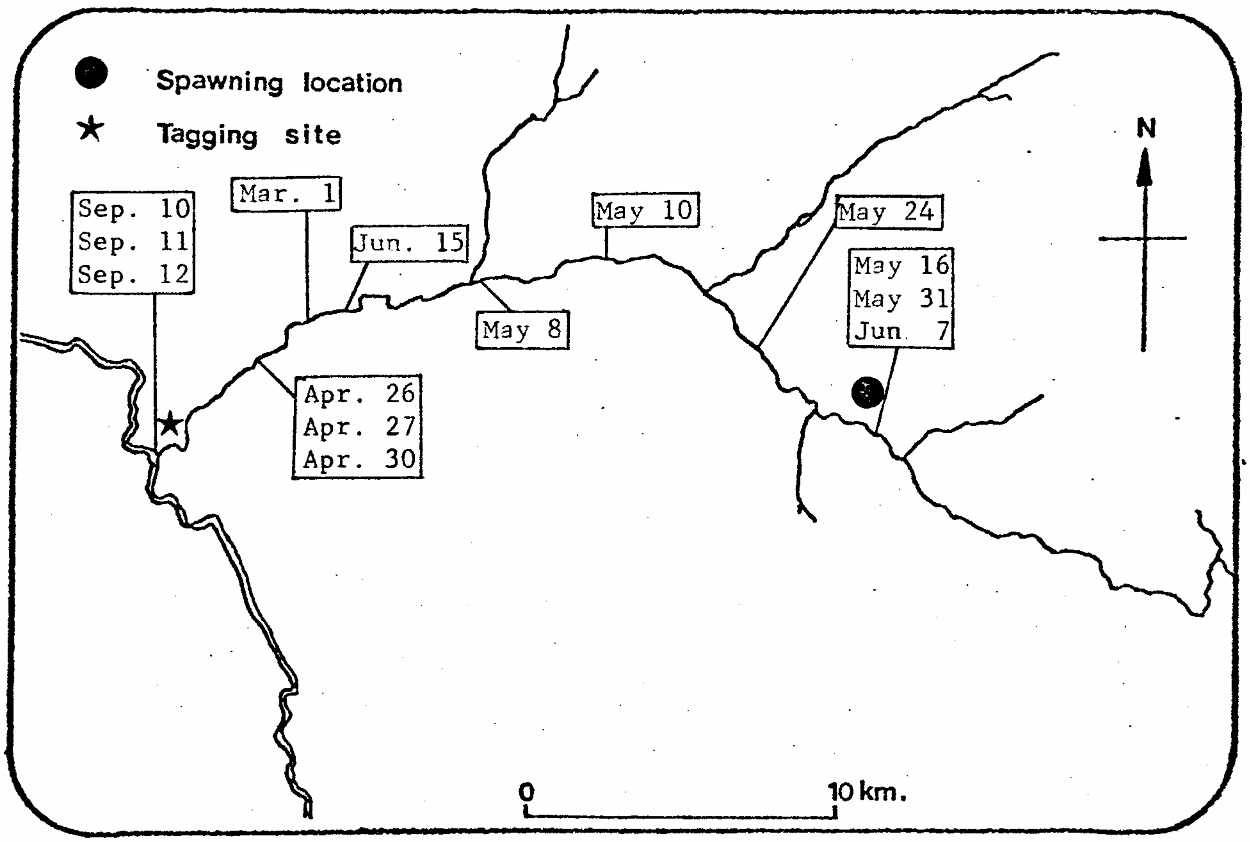
Appendix. Location and dates for tagging and tracking steelhead No.26.



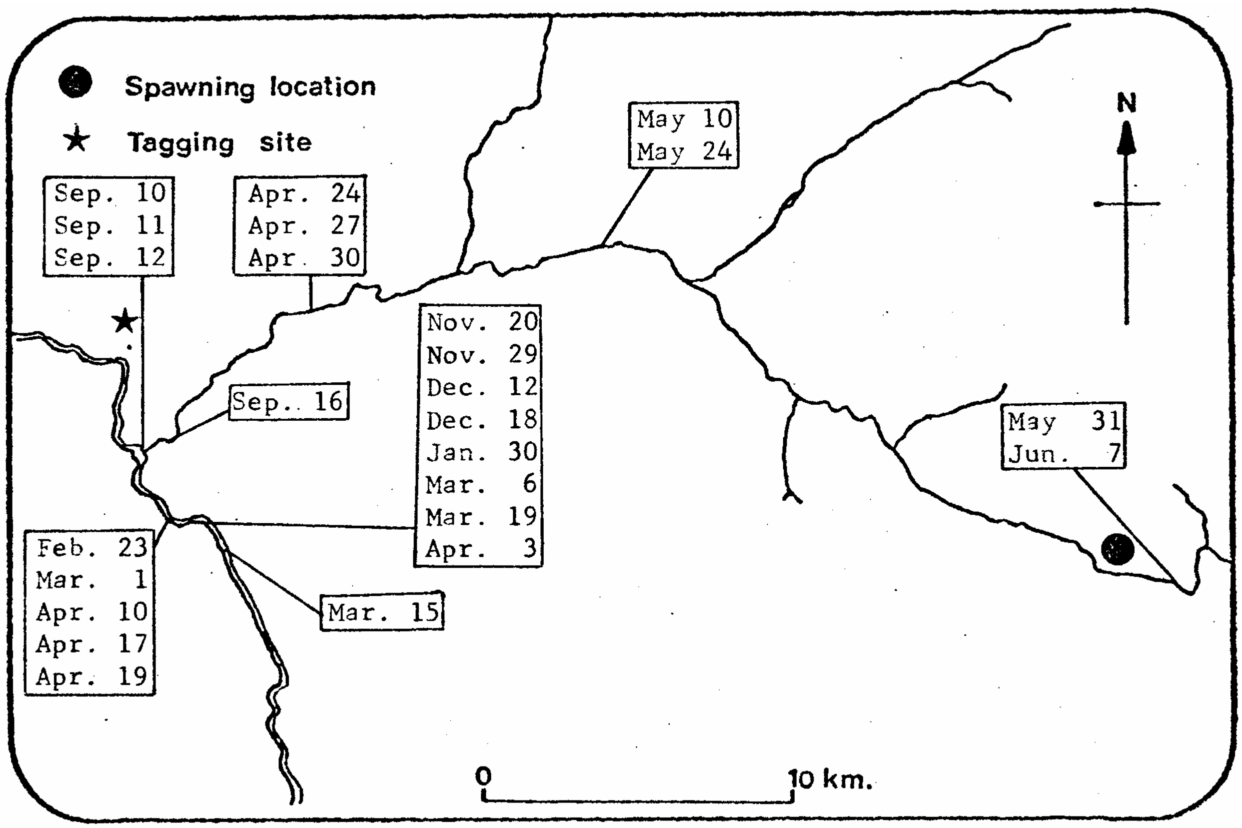
Appendix. Location and dates for tagging and tracking steelhead No.27.



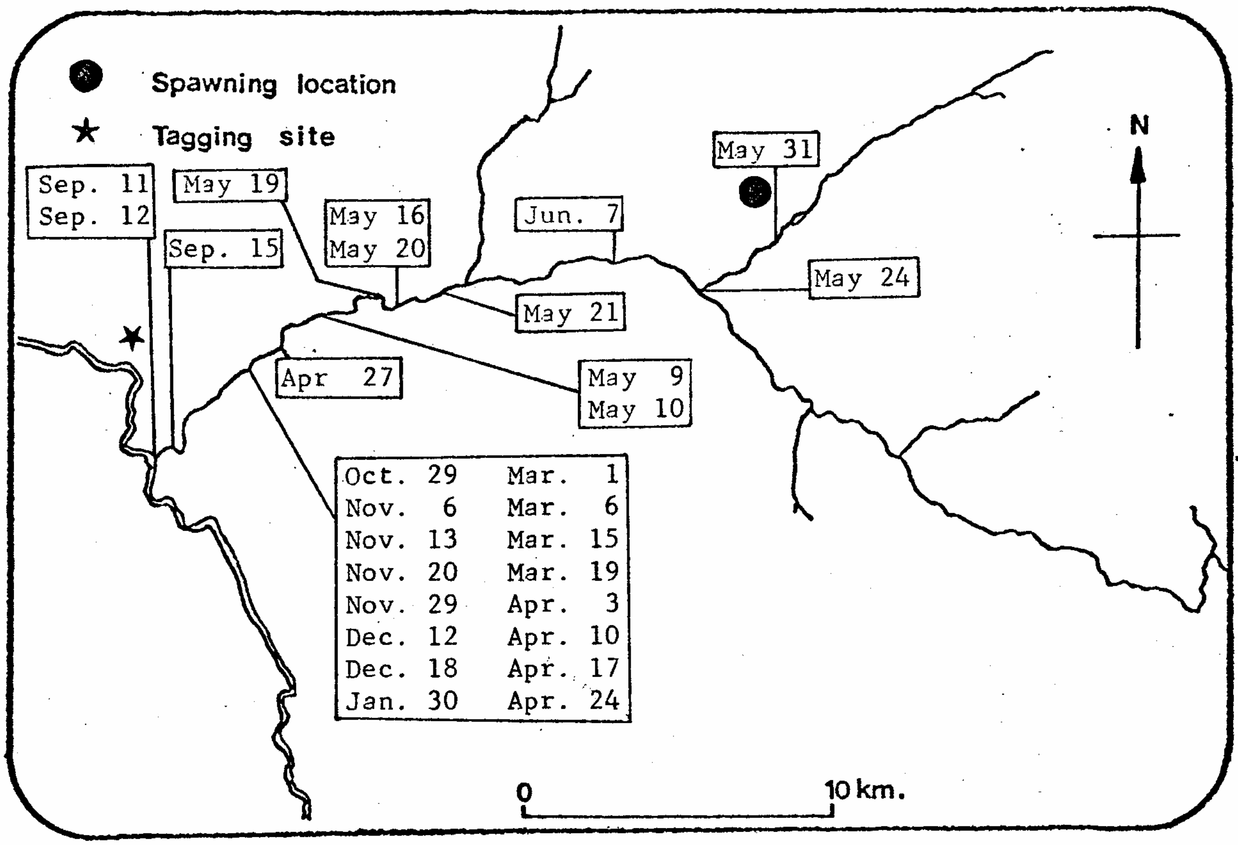
Appendix. Location and dates for tagging and tracking steelhead No.28.



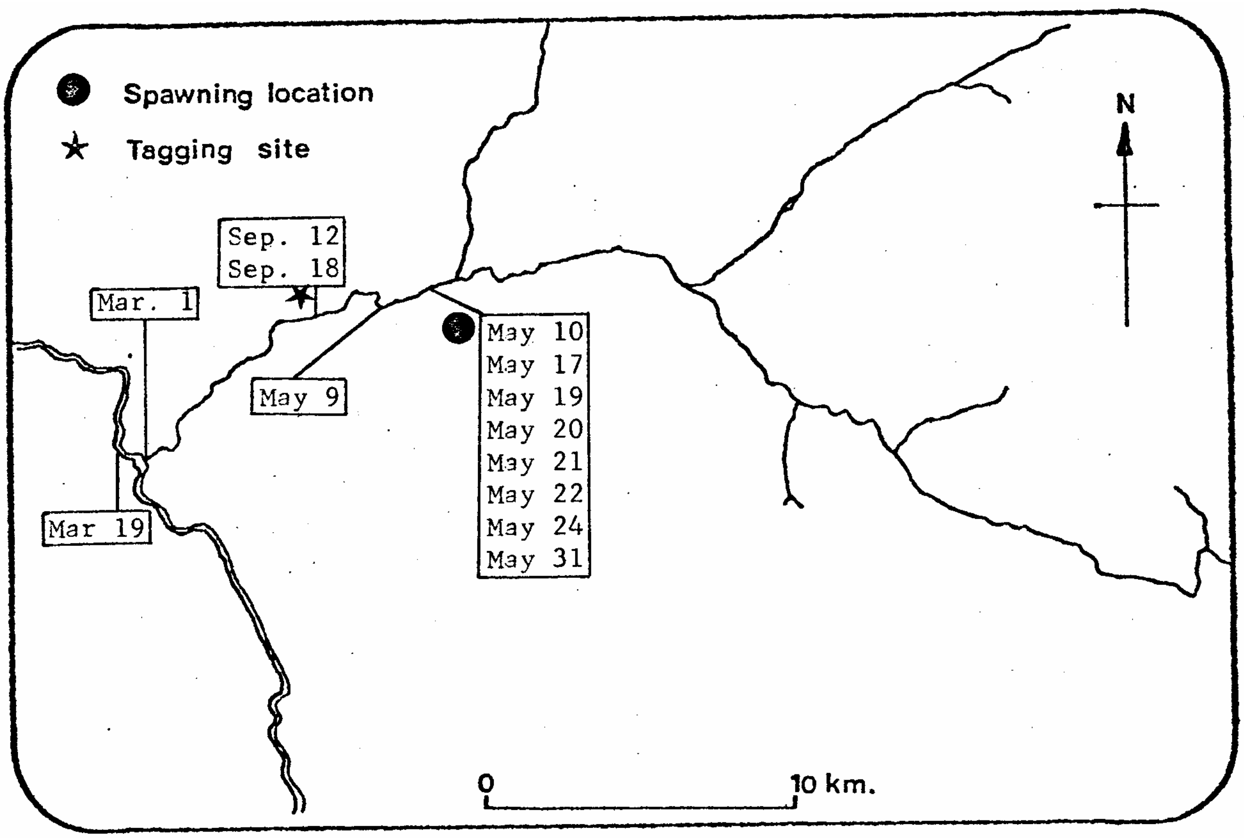
Appendix. Location and dates for tagging and tracking steelhead No.29.



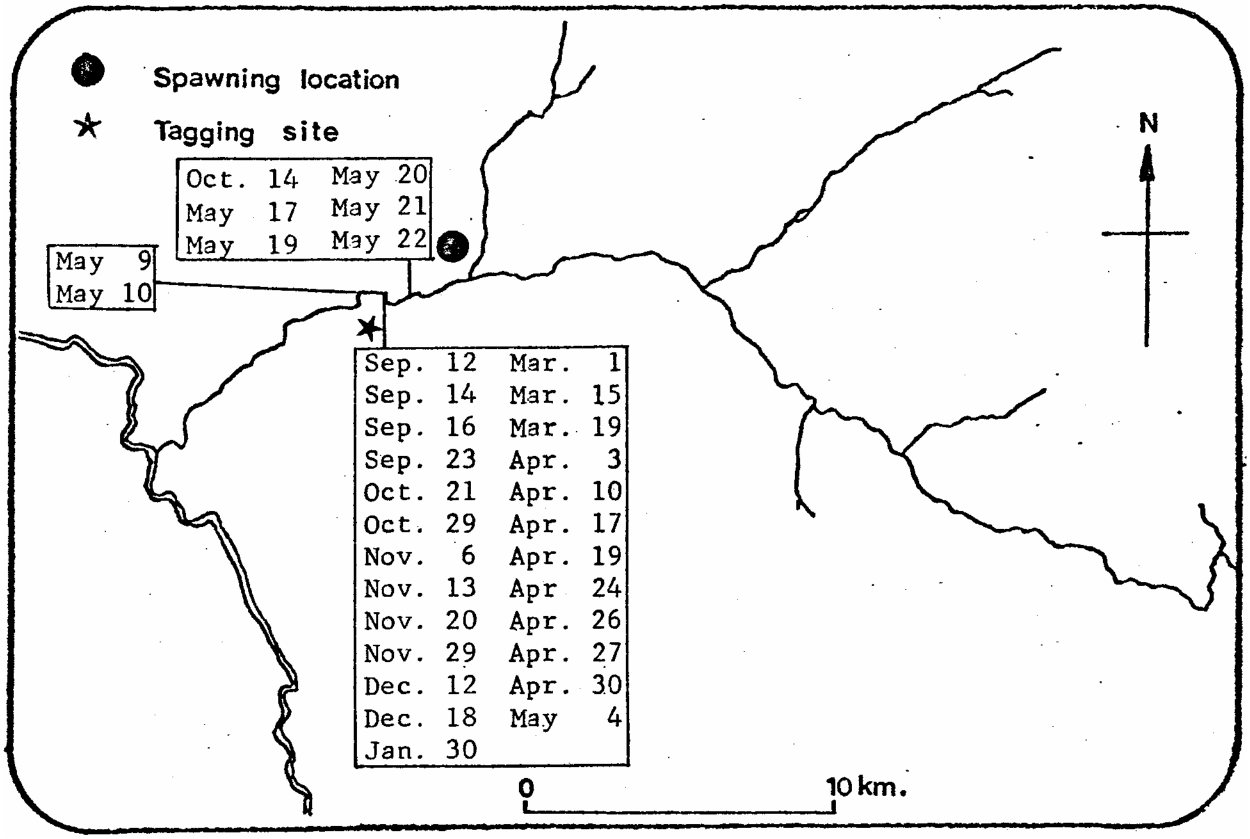
Appendix. Location and dates for tagging and tracking steelhead No.30.



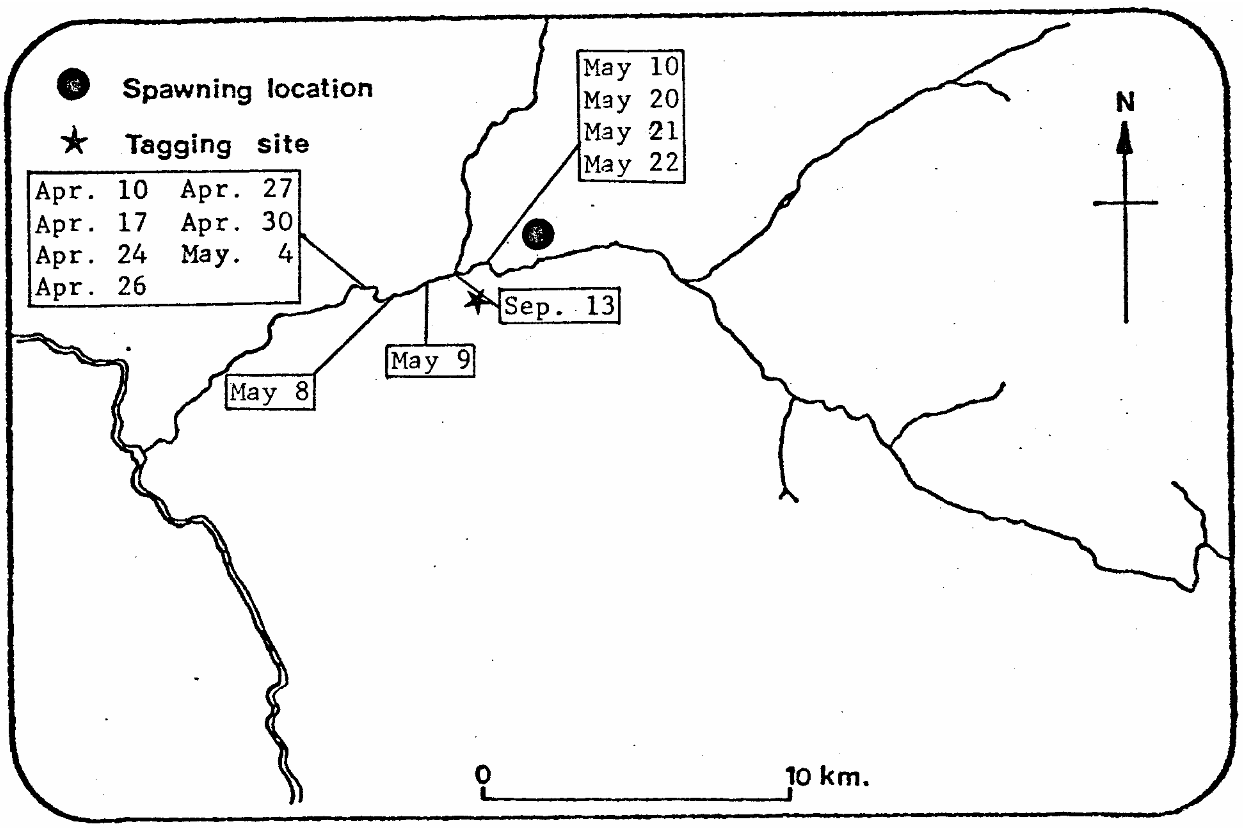
Appendix. Location and dates for tagging and tracking steelhead No.31.



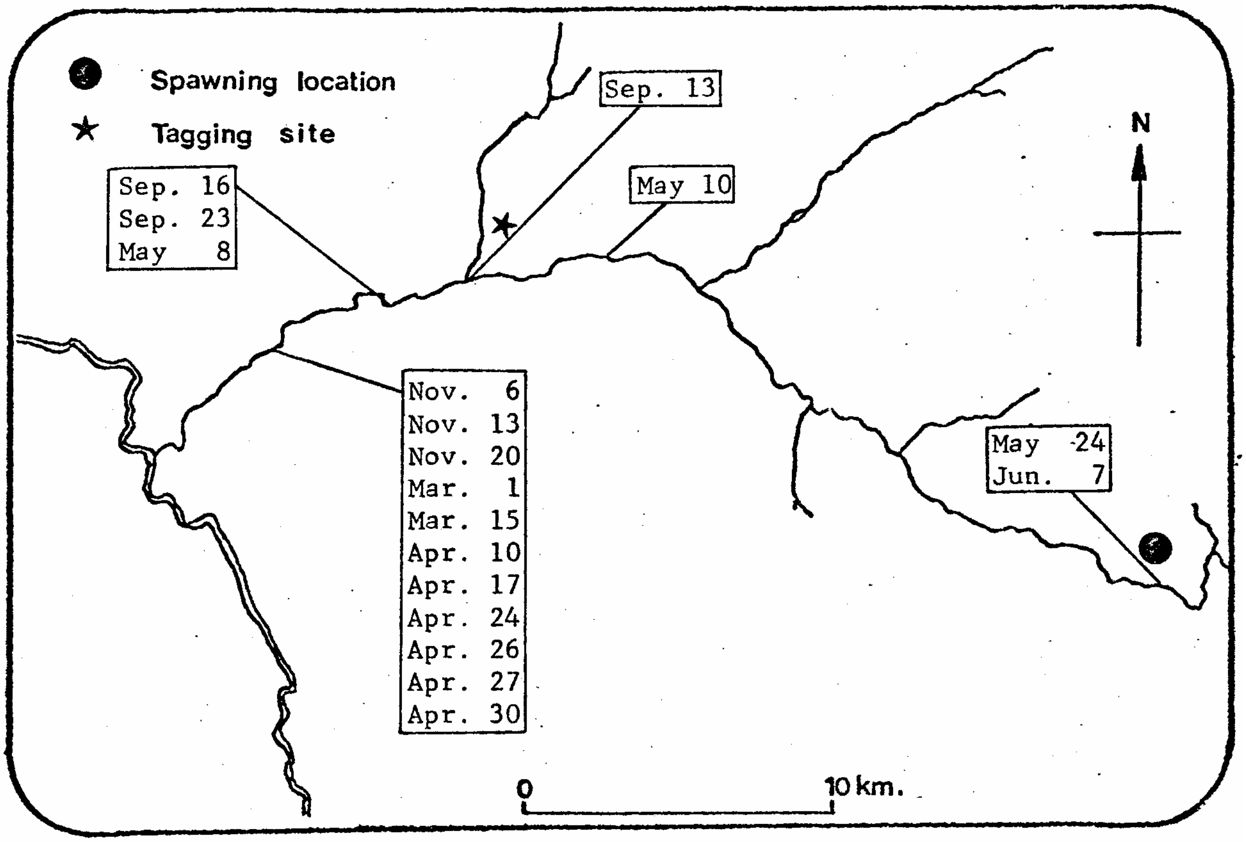
Appendix. Location and dates for tagging and tracking steelhead No.32.



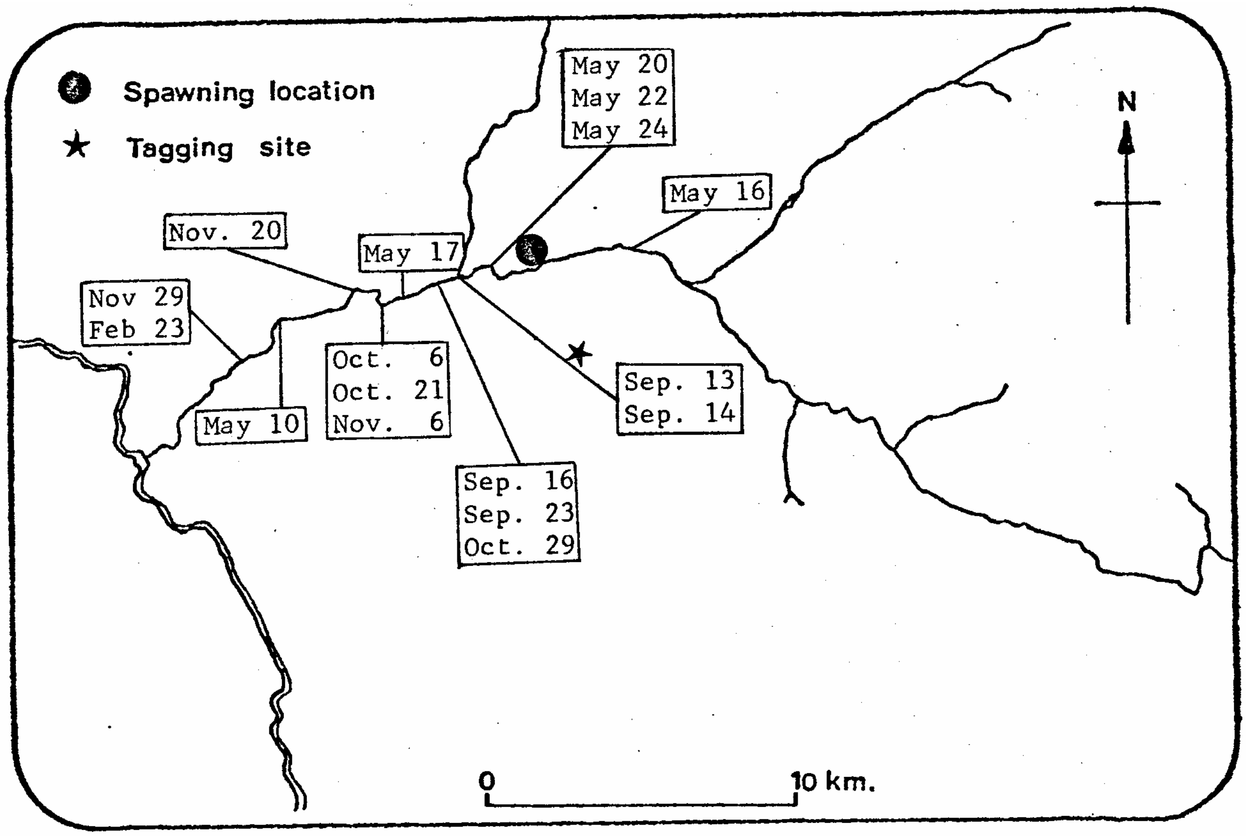
Appendix. Location and dates for tagging and tracking steelhead No.33.



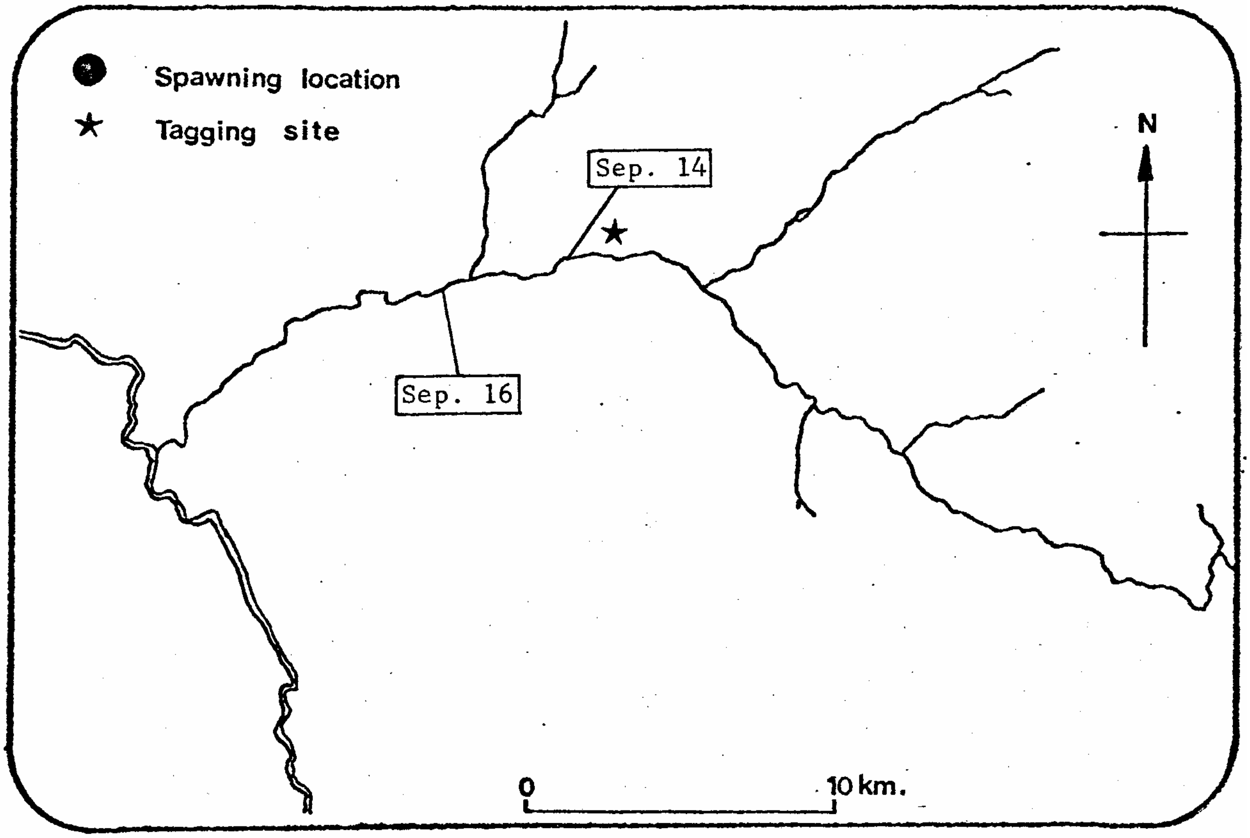
Appendix. Location and dates for tagging and tracking steelhead No.34.



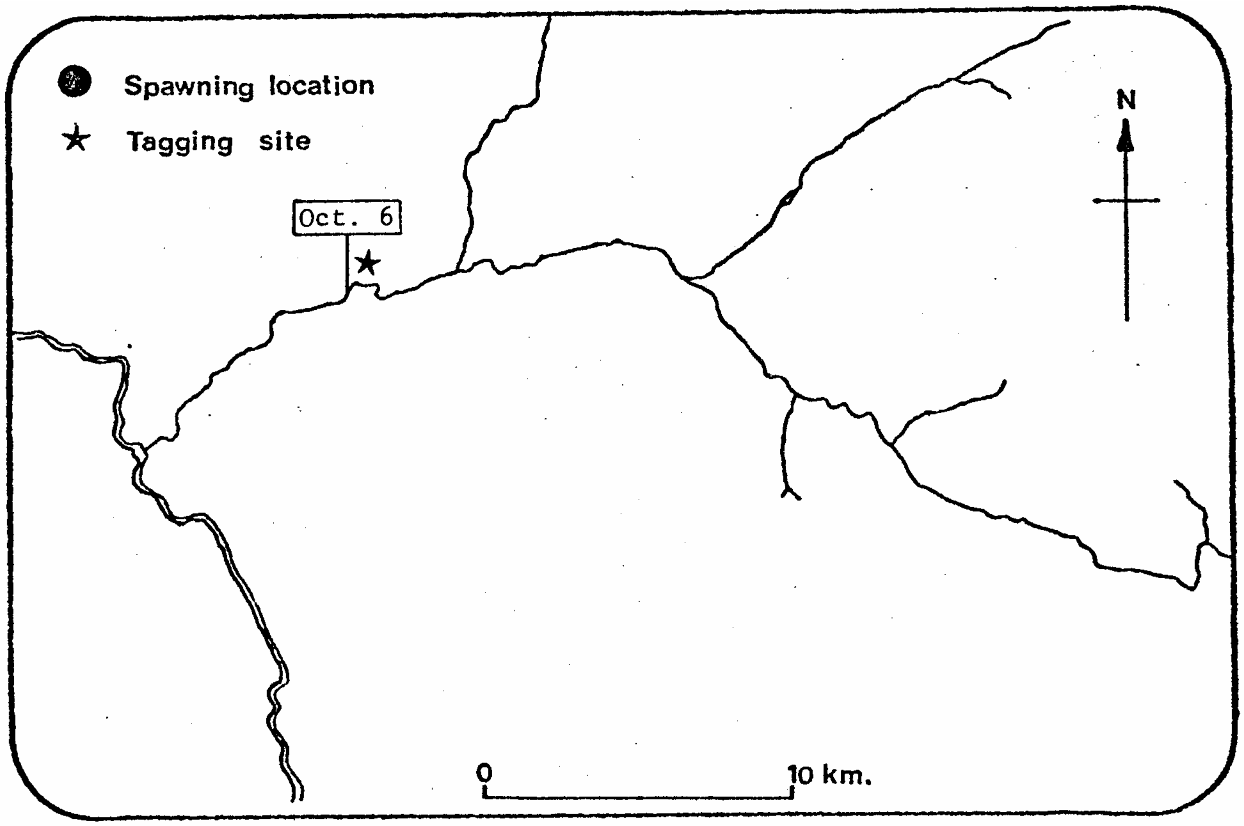
Appendix. Location and dates for tagging and tracking steelhead No.35.



Appendix. Location and dates for tagging and tracking steelhead No.36.



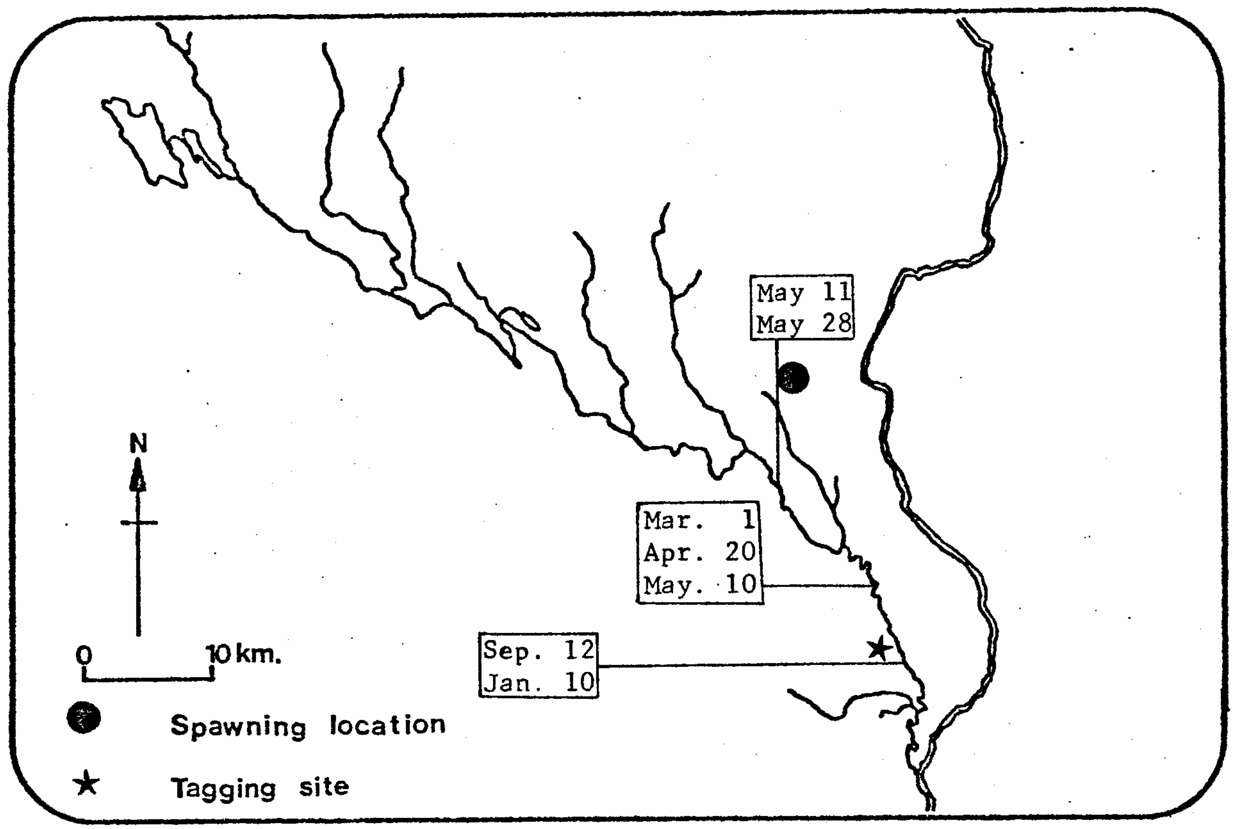
Appendix. Location and dates for tagging and tracking steelhead No.37.



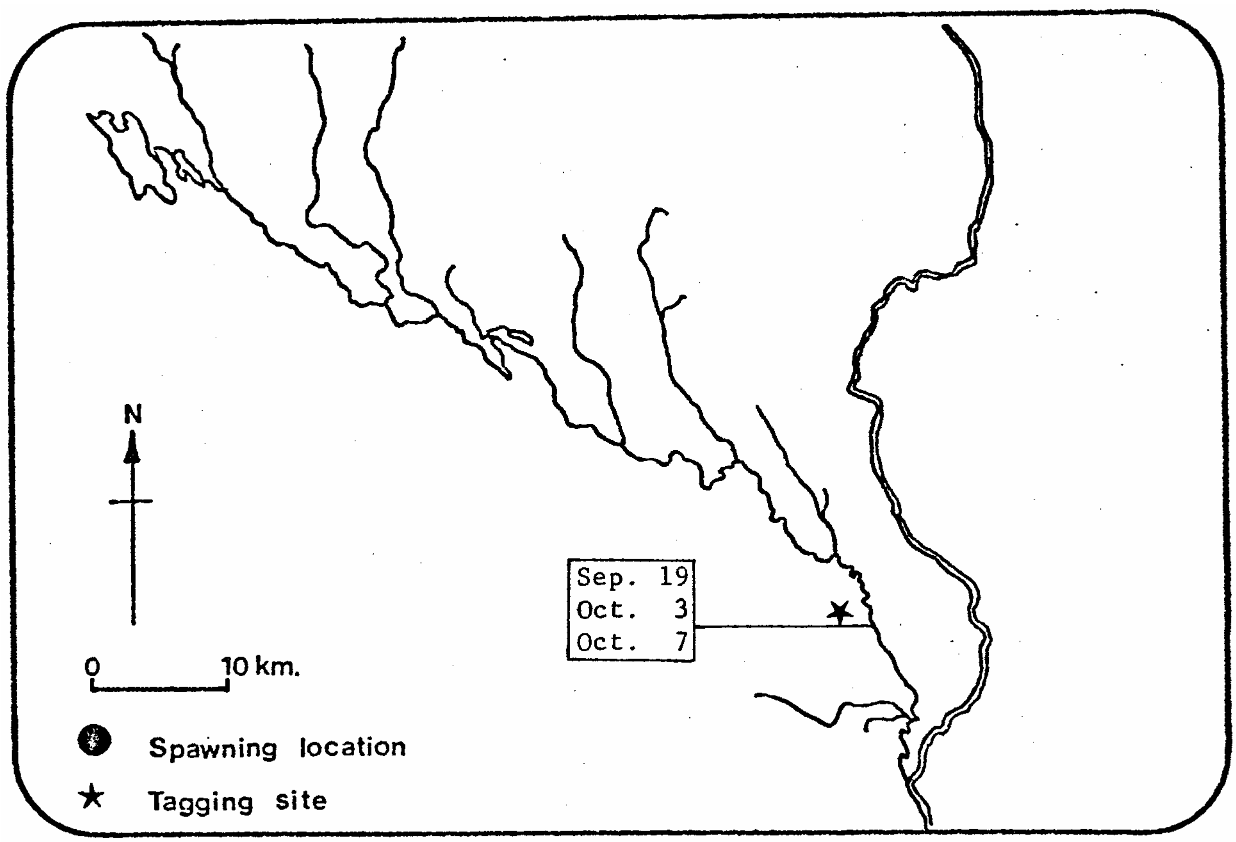
Appendix. Location and dates for tagging and tracking steelhead No.38.

KISPIOX RIVER

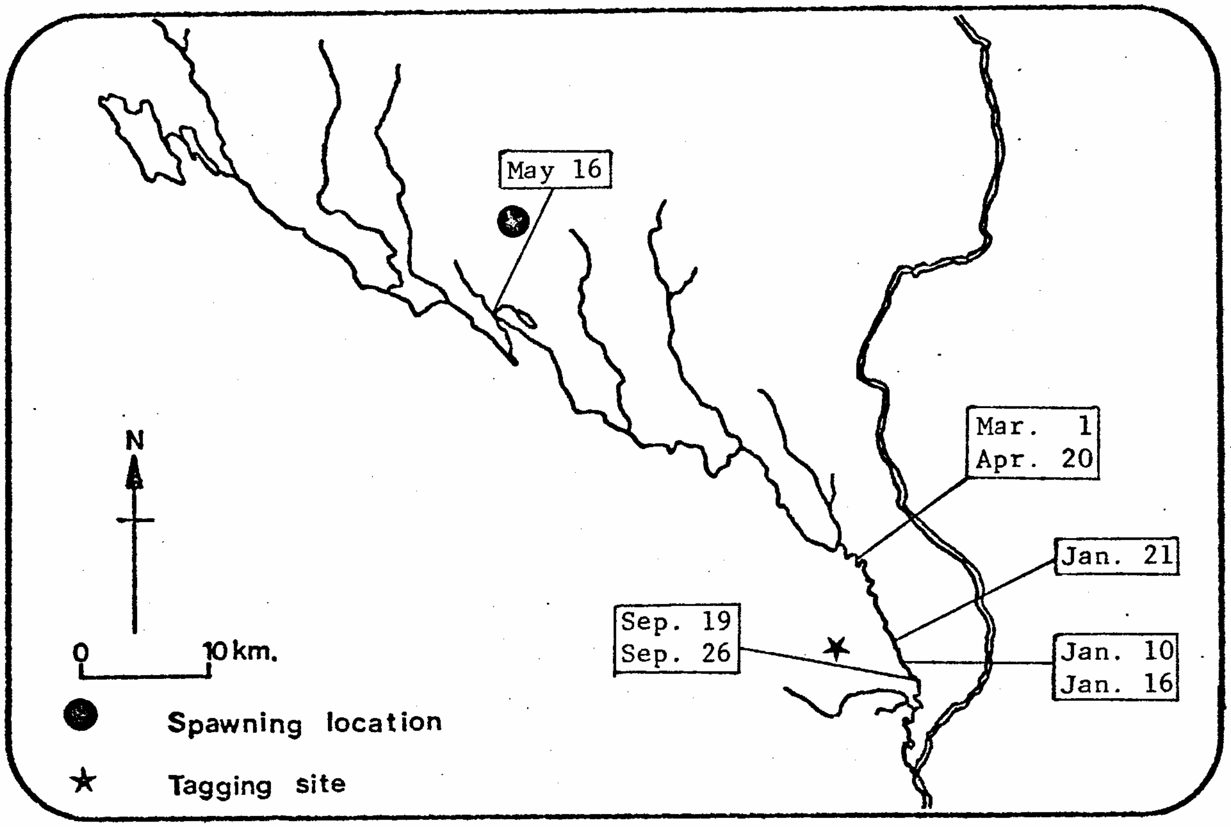
The following charts indicate movements of those fish with the best tracking data on the Kispiox River. Dates that each fish was located at various points on the river are indicated. Names of tributaries have been omitted, but may be found in Figure 13.



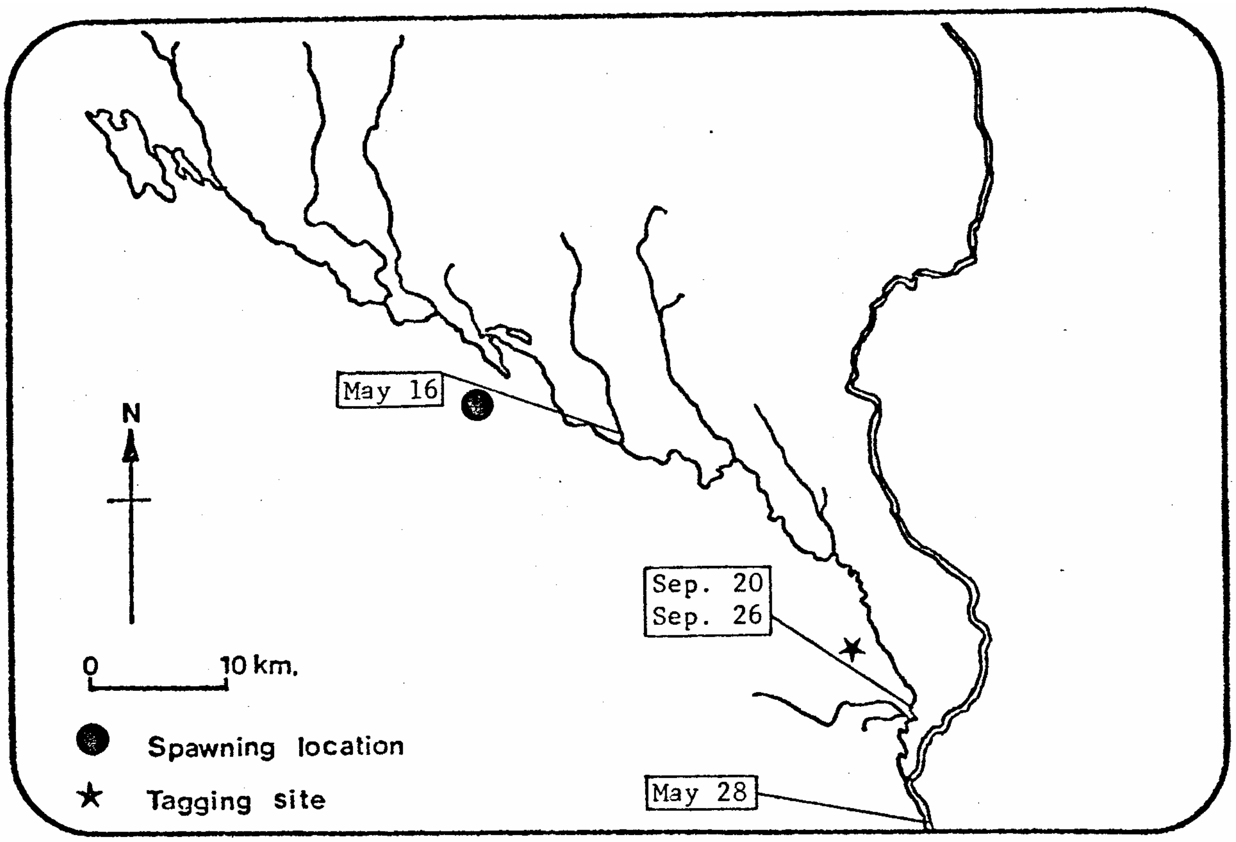
Appendix. Location and dates for tagging and tracking steelhead No.39.



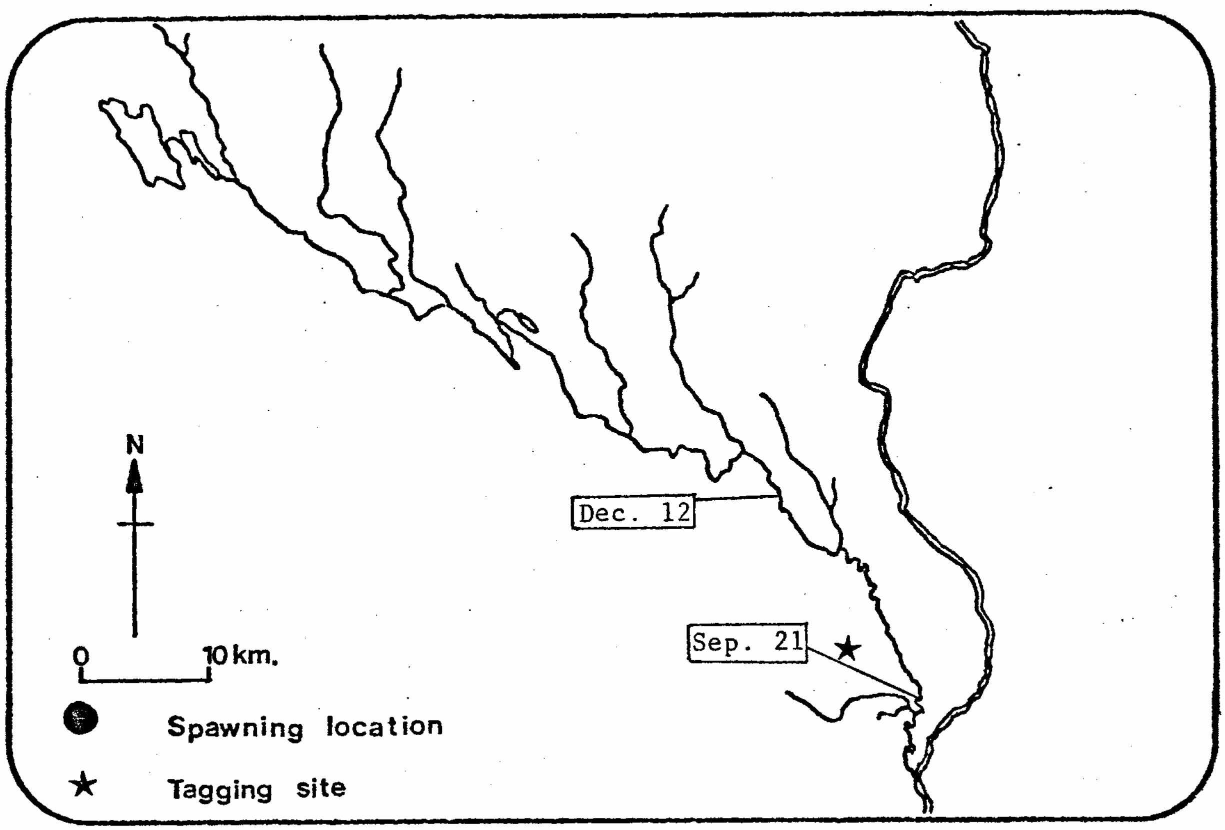
Appendix. Location and dates for tagging and tracking steelhead No.40.



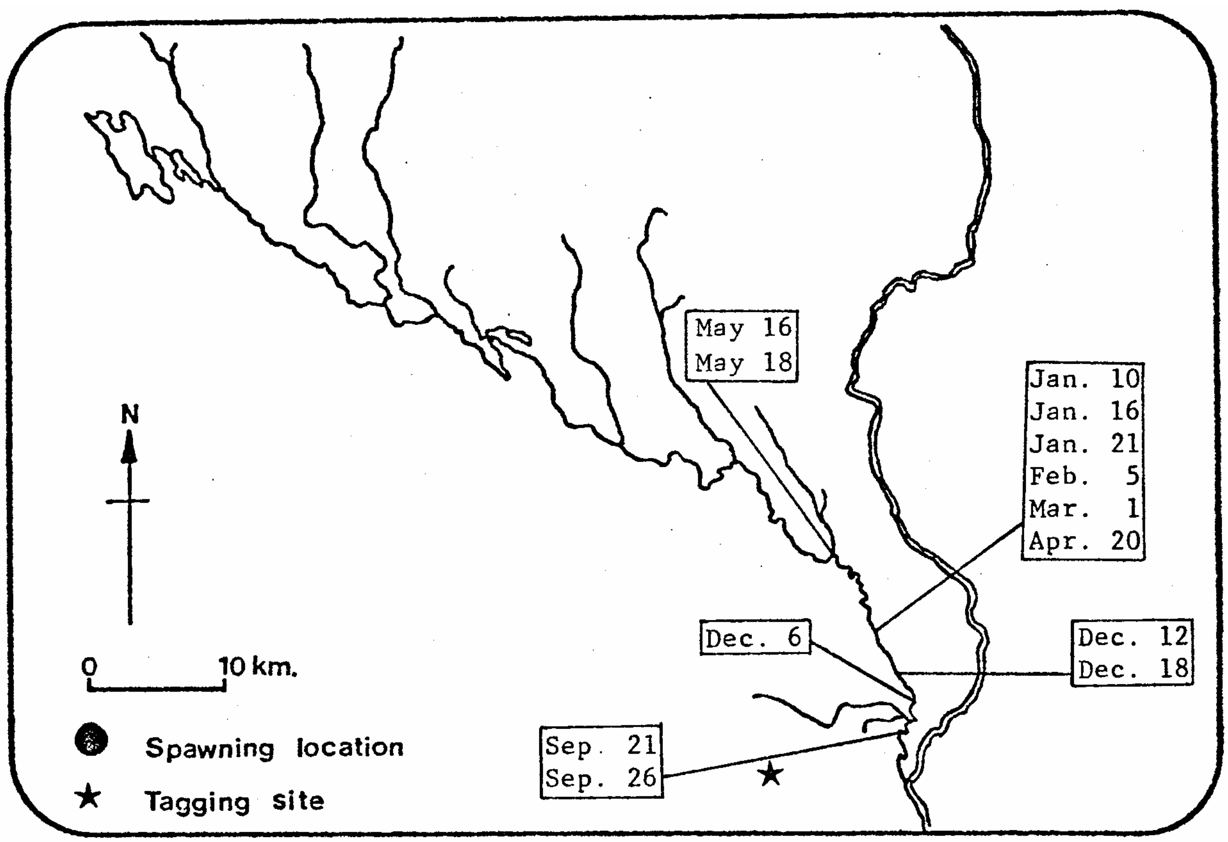
Appendix. Location and dates for tagging and tracking steelhead No.41.



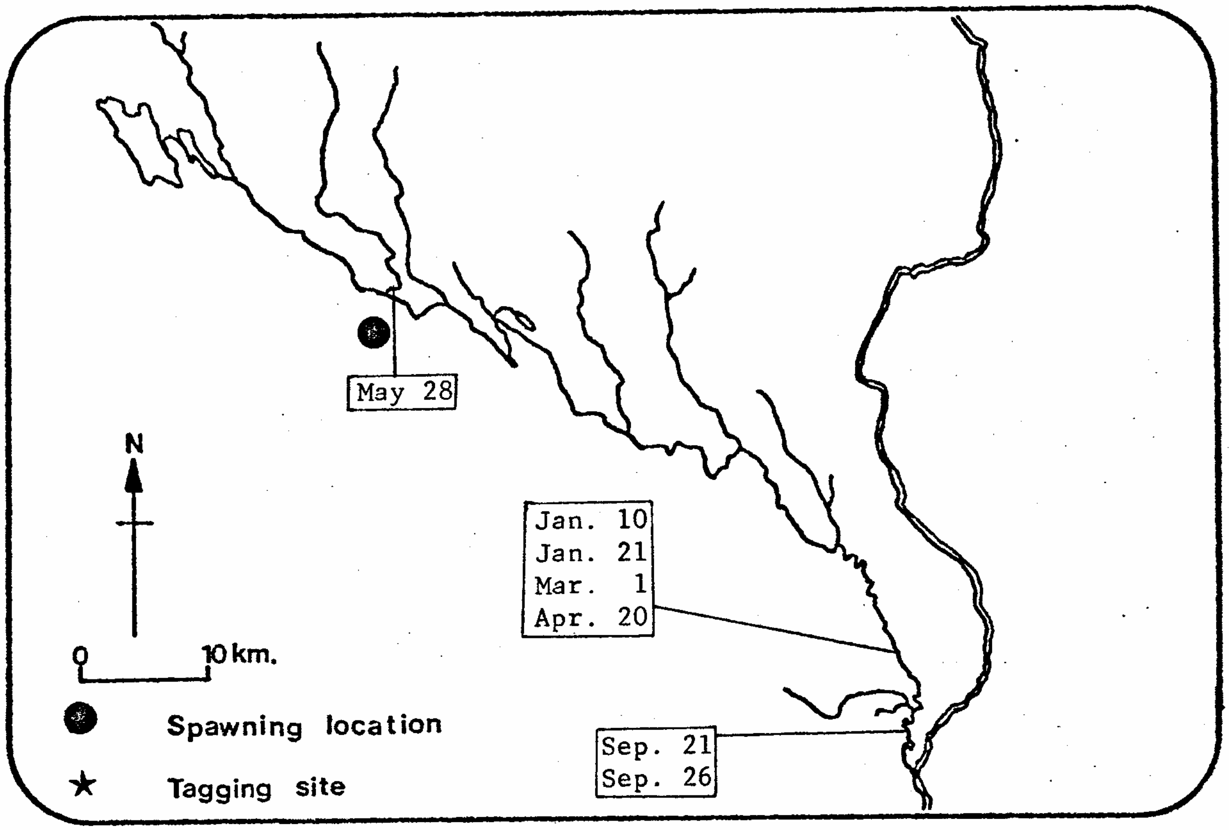
Appendix. Location and dates for tagging and tracking steelhead No.43.



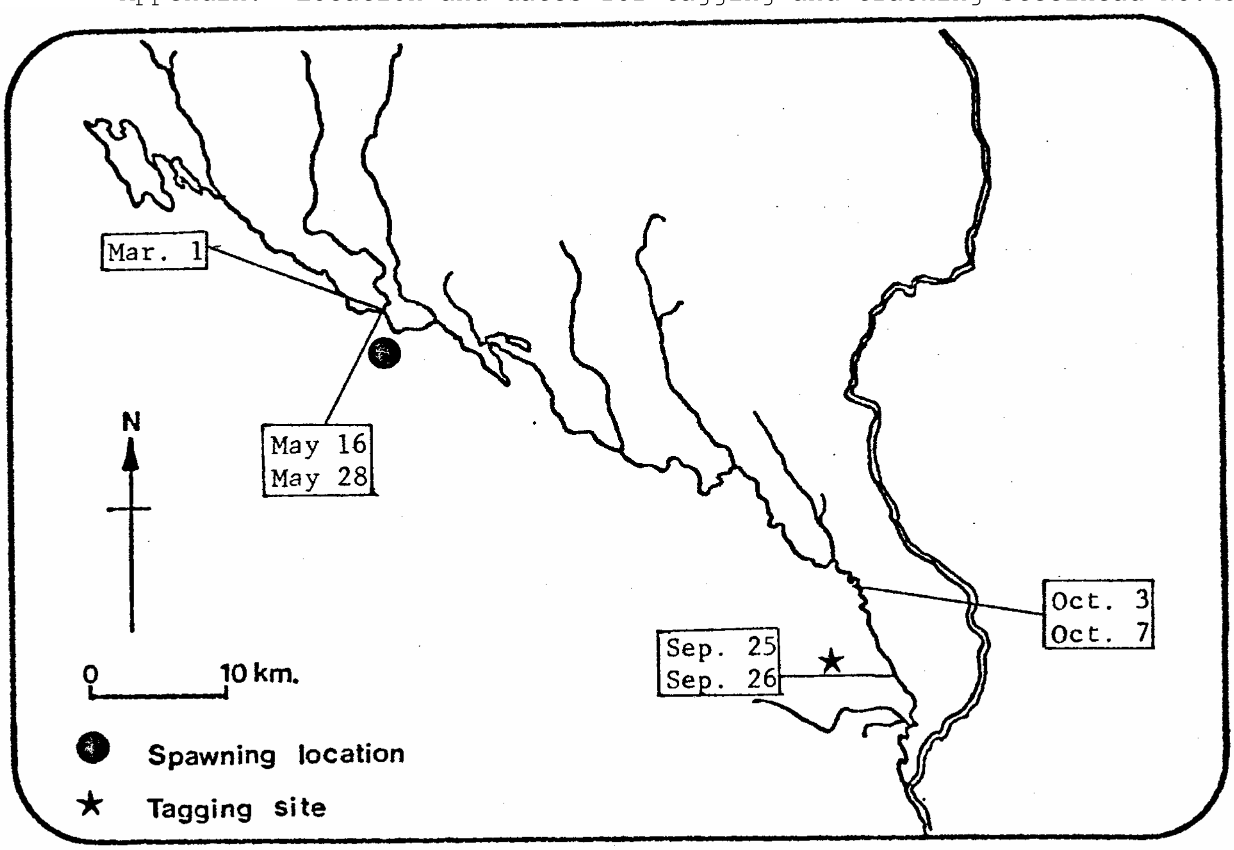
Appendix. Location and dates for tagging and tracking steelhead No.45.



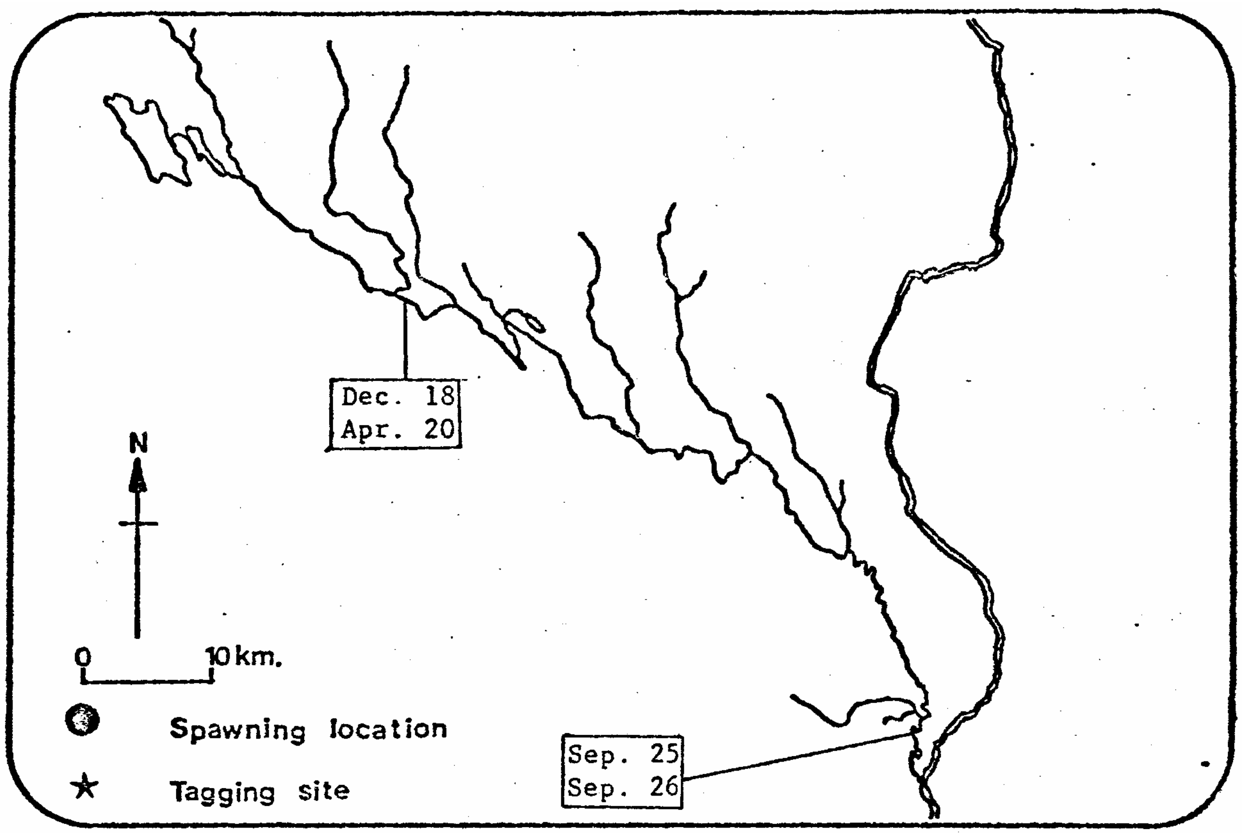
Appendix. Location and dates for tagging and tracking steelhead No.47.



Appendix. Location and dates for tagging and tracking steelhead No.49.



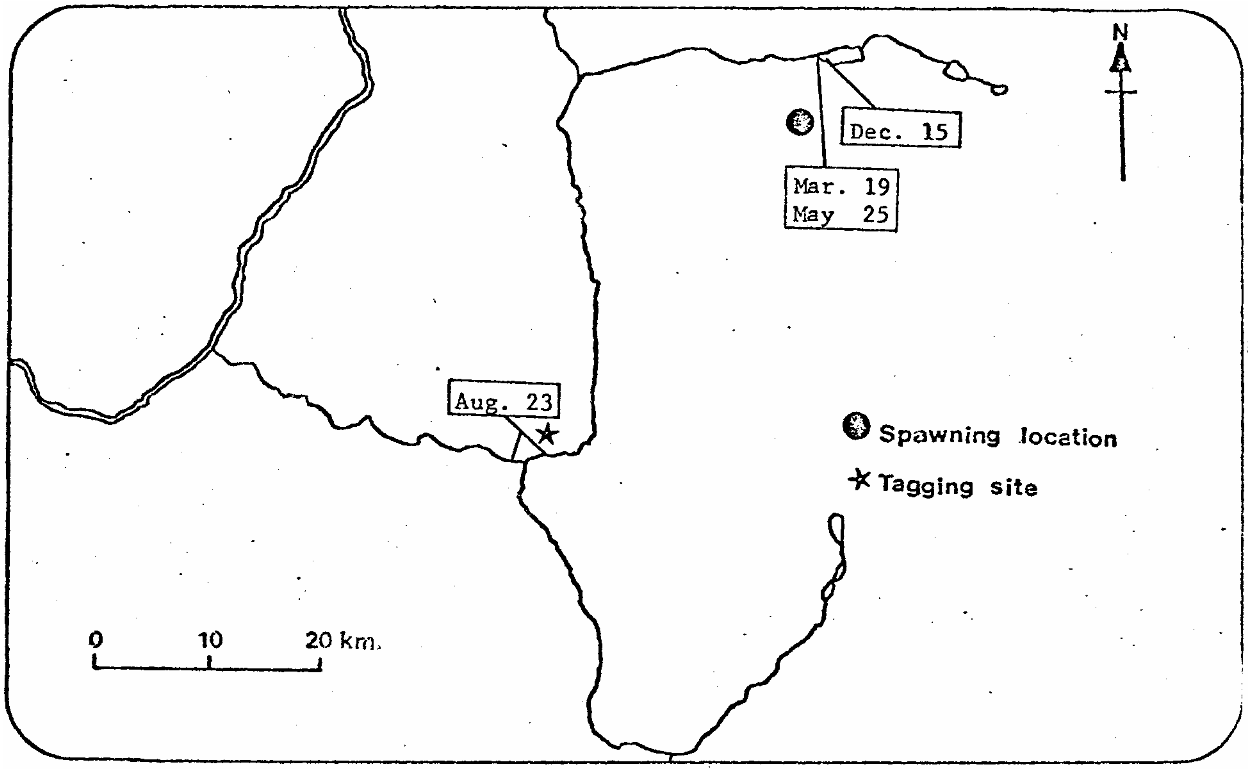
Appendix. Location and dates for tagging and tracking steelhead No.50.



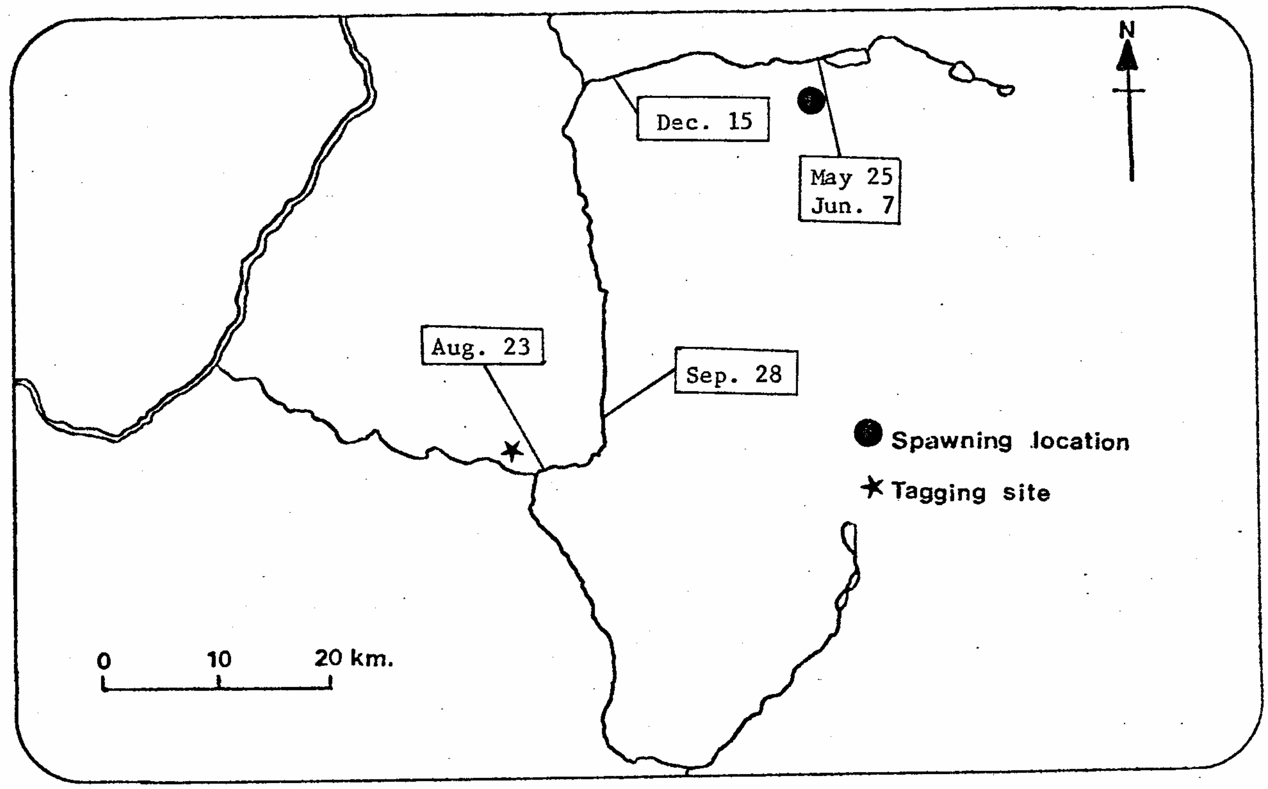
Appendix. Location and dates for tagging and tracking steelhead No.53.

ZYMOETZ RIVER

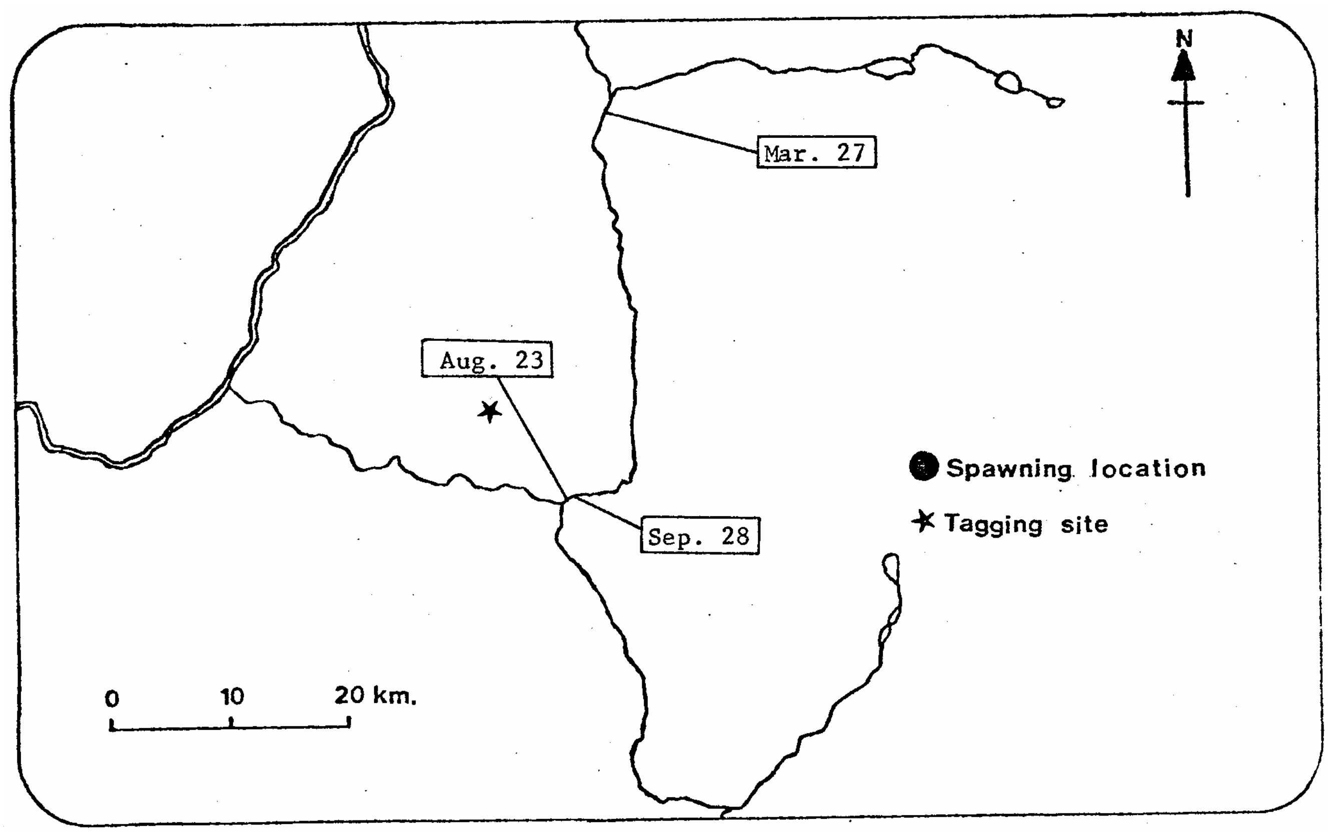
The following charts indicate movements of those fish with the best tracking data on the Zymoetz River. Dates that each fish was located at various points on the river are indicated. Names of tributaries have been omitted, but may be found in Figure 14.



Appendix. Location and dates for tagging and tracking steelhead no.55 or 56.



Appendix. Location and dates for tagging and tracking steelhead no.55 or 56.



Appendix. Location and dates for tagging and tracking steelhead no.54, 57, 58 or 59.