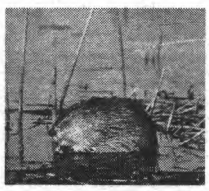
Canada Alberta Northwest Territories

Northern River Basins Study



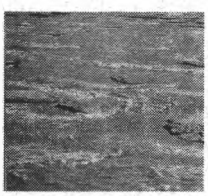


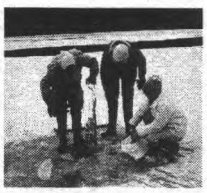





NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 117

MIGRATION OF INCONNU (*Stenodus leucichthys*) AND BURBOT (*Lota lota*), SLAVE RIVER AND GREAT SLAVE LAKE, JUNE, 1994 TO JULY, 1995



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Northern River Basins Study
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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

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Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
this publication be subjected to proper and responsible review and be considered for release to the public.

(Dr. Fred J. Wrona, Science Director) — (Date) 16 May 96

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.
SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [ ] No

(Dr. P. A. Larkin, Ph.D., Chair) — (Date) May 10/96

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[ ] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

(Lucille Partington, Co-chair) — (Date) May 9/96

(Robert McLeod, Co-chair) — (Date) May 21/96

MIGRATION OF INCONNU (*Stenodus leucichthys*) AND BURBOT (*Lota lota*), SLAVE RIVER AND GREAT SLAVE LAKE, JUNE, 1994, TO JULY, 1995

STUDY PERSPECTIVE

To address cumulative environmental effects, the Northern River Basins Study Board identified fish distribution, abundance and movement as areas requiring further scientific investigation. Public input to the Board re-enforced this direction because, in many communities, fish remain peoples' most visible evidence on the health of the rivers. Except for short, isolated reaches of the Peace, Athabasca and Slave rivers, minimal information exists to assess the cumulative impacts of development on the fish community. The lower Slave River is one of these exceptions. In the early 1980's a comprehensive investigation of the fish community in the lower Slave River was completed. This database offered the Study an opportunity to assess possible changes.

The Slave River receives the combined flow of the Athabasca and Peace rivers, including the by-products of development discharged to their waters. The rapids at Fort Smith also serve to separate the fish community of the Slave in two; there is no evidence that fish downstream of the rapids have been able to move upstream into the Alberta portion of the Slave River. The fish community of the river reaches above and below the rapids are different. A number of the fish species are the basis of a domestic and commercial fishery on the Slave River and Great Slave Lake, respectively.

Related Study Questions

6) *What is the distribution and movement of fish species in the watersheds of the Peace, Athabasca and Slave rivers? Where and when are they most likely to be exposed to changes in water quality and where are their important habitats?*

12) *What traditional knowledge exists to enhance the physical science studies in all areas of enquiry?*

13b) *What are the cumulative effects of man-made discharges on the water and aquatic environment?*

14) *What long term monitoring programs and predictive models are required to provide an ongoing assessment of the state of the aquatic ecosystems? These programs must ensure that all stakeholders have the opportunity for input.*

Under the auspices of the Food Chain Component, freshwater scientists developed a multi-faceted investigation into the movement, life history and diet of fish in the Northwest Territories portion of the Slave River, north of the 60°th parallel. The work was undertaken in such a manner that it could be compared to a mid-1980's investigations.

This project report describes the results of an investigation into the migration / movement of two key harvested fish species, inconnu (***Stenodus leucichthys***) and burbot (***Lota lota***). The fish were monitored by radio tags and other tagging techniques, from the fall of 1994 to July, 1995. Despite equipment difficulties that made monitoring of fish in the extreme water depths of the Slave River and Great Slave Lake a challenge, this project's findings were similar to the 1980's field work. Results show inconnu moving into the Slave River from Great Slave Lake from mid-August to mid-October. Large aggegations of inconnu were found below Rapids-of-the-Drowned by mid-October, a site previously identified as an important spawning area. Spawned fish vacated the site and the river by late October. Inconnu movement in Great Slave Lake appear to follow a counter-clockwise direction around the perimeter of the lake. This finding supported earlier

observations from commercial fishing records that such a pattern existed. The limited data gathered on burbot showed these fish moving from Great Slave Lake into the Slave River in late fall close to the formation of ice cover. Concentrations of burbot in the Fort Smith area peaked around the February spawning period. By late Februay there was significant movement downstream.

The results of this project will be combined with the other complementary fish projects dealing with life history (Report # 118) and diet-food web investigations(Report # 119) in the form of a synthesis report that will compare current findings with those of the 1980's.

Report Summary

To determine the timing of movements and relative abundance of burbot, *Lota lota*, and inconnu, *Stenodus leucichthys*, on the lower Slave River north of the 60th parallel, we sampled on a regular basis using gillnets from June to November, 1994. Movement patterns in time and space in the Slave River and Great Slave Lake were determined by radio-tagging 24 inconnu and 16 burbot in the fall of 1994. Tracking was carried through the fall of 1994 through to July 1995.

Inconnu entered the Slave River system from Great Slave Lake in August and attained peak catch-per-unit-effort (CPUE) during the first two weeks of September. By November they had left the system. Burbot CPUE did not increase substantially, therefore, no discernable pattern of movement was recognized from catches. Radio-tagged inconnu stayed in the Fort Smith area of the river until late October when they migrated out of the system into Great Slave Lake. Migrations in Great Slave Lake appeared to be geographically extensive. From January to the end of August 1995, all inconnu were captured or detected by radio telemetry in Great Slave Lake, only. No inconnu were detected or captured in the Slave River. Extensive floy-tagging programs conducted by the Department of Fisheries and Oceans corroborate these observations for inconnu in Great Slave Lake. Burbot appeared to be relatively sedentary and probably escaped detection by residing in deep holes of the river and the river delta. These movement patterns signify that inconnu may transfer contaminants over a large area including Great Slave Lake whereas burbot would concentrate contaminants locally in the lower Slave River and its delta.

Acknowledgements

George Low, Area Biologist and Fred Taptuna, Fisheries Technician, Department of Fisheries and Oceans, Hay River, provided invaluable advice, physical assistance and equipment for the project. They also provided considerable support in terms of acquiring extra flying time for tracking, spending their time doing most of the tracking and in setting up a joint contract with the Fort Smith band to hire local aboriginal assistants. Mr. Dale Archibald, Fishery Officer in charge at Hay River graciously allowed us to use the truck assigned to him for most of the study. The rest of the staff at the Hay River Office provided a base of support that made the study go much more smoothly. Mr. Kevin Antoniak of Arctic College in Fort Smith provided helpful advice and support as well as access to the college facilities. The Salt Plain First Nation of Fort Smith, in particular, Don Lapine, selected local helpers and administered a contract for their pay. The Deninu Kue First Nation of Fort Resolution also selected local helpers and administered a contract for their pay. Fred MacDonald, and Stewart Tourangeau of Fort Smith and Darwin and Tom Unka of Fort Resolution provided able field assistance. DFO research biologist F. Saurette coordinated the acquiring of equipment, ensuring that field equipment was delivered in a timely fashion and kept in good repair, handled financial records, and did just about everything else to ensure that field work and laboratory work went smoothly with continuity. Alison Little, Trevor Thera, Fern Saurette and Marc Lange provided professional direction in the field. Wayne Starling (DIAND) provided us with valuable experience and logistical support during the burbot tagging program. Tom Mill, the food chain component leader provided much needed encouragement at the end of this study. Ken Crutchfield, the associate science director of the NRBS provided helpful feedback and direction regarding client-related issues in Fort Smith as well as good advice regarding record keeping requirements. Glen Hopky, Jim Reist and George Low of the Department of Fisheries and Oceans provided helpful reviews of earlier versions of the manuscript. Melanie Van Guerwen gave a final editorial check of the manuscript.

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1.0 INTRODUCTION

Inconnu, *Stenodus leucichthys*, and burbot, *Lota lota*, are top predators in the fish community of the Slave River, Northwest Territories (Scott and Crossman 1973). Many contaminants, if present in the Slave River, will increase in concentration as they are passed up the food chain. As top predators, inconnu and burbot could potentially accumulate high concentrations of such contaminants in their flesh. In the Slave River, inconnu are the most heavily harvested species for subsistence by aboriginal and non-aboriginal fishermen (Tripp et al. 1981, Bodden 1980, Jalkotsky 1976). In 1994/95, 990 kgs were taken in the aboriginal food fishery (George Low, Department of Fisheries and Oceans, pers. comm.). The Slave River inconnu stock is also thought to be the main source of fish for the second largest commercial fishery on Great Slave Lake (Katapodis and Yaremchuk 1994). In the Slave River, burbot are harvested in subsistence fisheries by aboriginal people, especially for their livers (MacDonald and Smith 1993, Boag and Westworth 1993). Ergo, contamination in these species may have direct impacts on human health (MacDonald and Smith 1993). Inconnu are thought to be highly migratory in other systems such as the lower Mackenzie River (K. Howland, University of Alberta, unpublished data) and in the Buffalo River (George Low, pers. comm.). Two and one half weeks of radio-tracking of fish tagged at the Slave River delta revealed that they migrate to spawning areas upstream (McLeod et al. 1985). In contrast, burbot are thought to be relatively sedentary most of the year with a comparatively short spawning migration during the winter months (Scott and Crossman 1973). While the Department of Fisheries and Oceans has been systematically gathering information for a number of years for fisheries management purposes at present there is little scientific information published on the longer term movements of burbot or inconnu in the lower Slave River. The longer-term movements as well as the magnitude of movements could be important to the transport of contaminants to and from the system. This project uses regular sampling by gillnet and radio-telemetry techniques to investigate the movements of inconnu and burbot in the lower Slave River.

2.0 MATERIALS AND METHODS

2.1 Study Area

The Slave River is the largest tributary flowing into Great Slave Lake (Fig. 1). Approximately, 60 percent of the water entering Great Slave Lake flows through the Slave River. It is connected to the Peace and Athabasca River system to the south. The river is turbid and up to 1 km across. Channel depths vary from less than a meter to 25 meters with many rapids and deep pools. The long series of rapids ending in Rapids of the Drowned near Fort Smith and covering several miles of river are thought to be a barrier to upstream

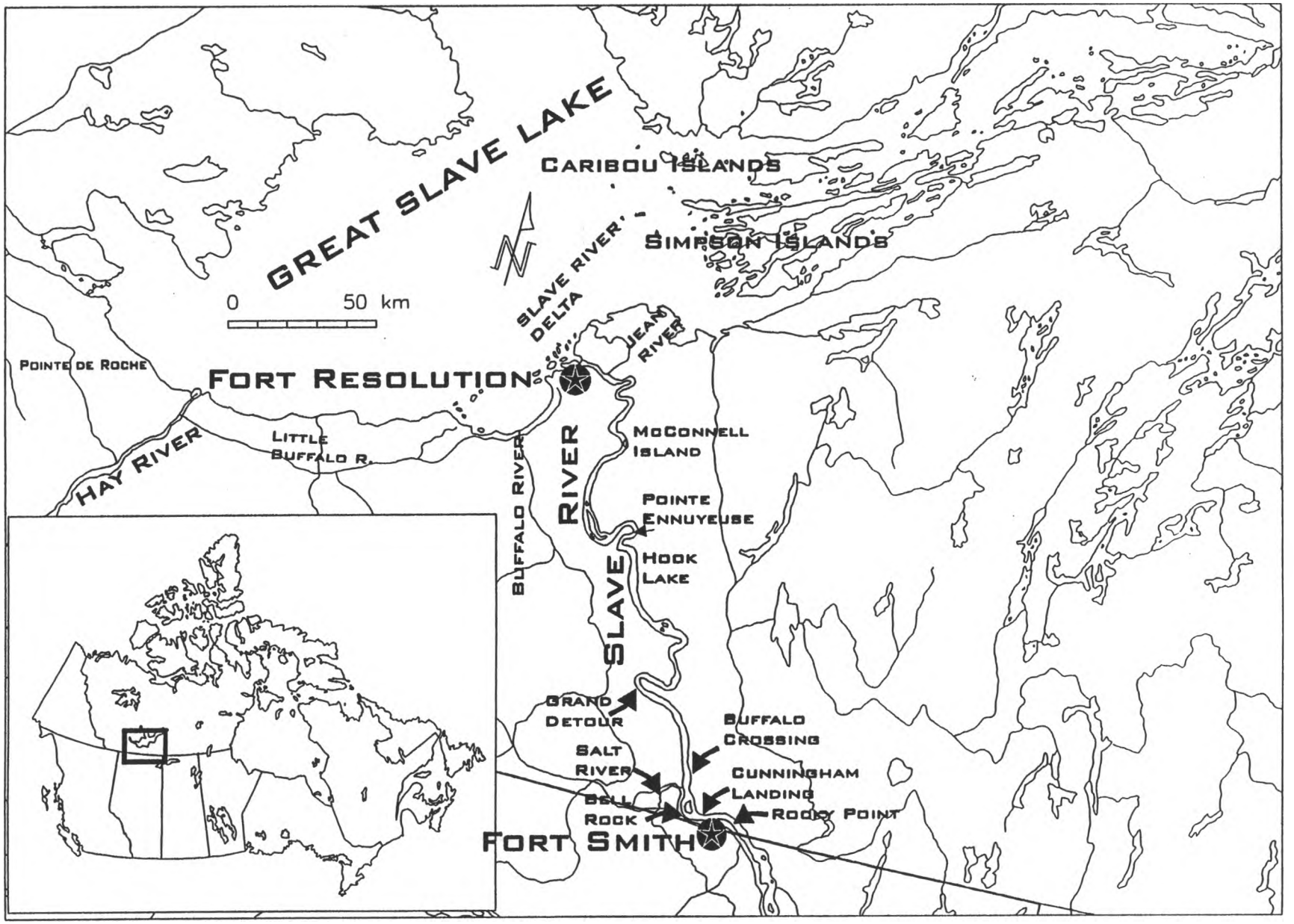

Figure 1. The study area showing the Slave River, Slave River Delta, Great Slave Lake, Fort Resolution and Fort Smith.

movement by fish from the lower Slave River north of the 60th parallel. There is a diverse fish community in the river with up to 30 species having been recorded in the lower Slave River (McLeod et al. 1985, Tripp et al. 1981, Tallman et al. 1996, Tallman 1996).

2.2 Sampling

To monitor the seasonal abundance and timing of movements of inconnu and burbot in the Slave River, gillnets were set in the Slave River at Rapids of the Drowned near Fort Smith, Cunningham Landing, Salt River and in the Res-Delta Channel of the Slave River delta from June 25, 1994 to November 15, 1994. Sampling was conducted four to seven times per week at Rapids of the Drowned and once per ten days at the Slave River delta. After November 15, sampling was disrupted by the transition to ice-cover on the river. Additional sampling was done through the ice at Fort Smith section of the river during the week of December 7 to December 11, 1994. Sampling was not able to be carried out in Slave River delta at this time because of unstable ice conditions.

Sampling was conducted using gillnets set to the bottom in back-eddies of the river. Nets were 25, 30 and 60 yards (22.86, 27.43 and 54.86m, respectively) in length, 6 feet (1.83m) deep and of five mesh-size patterns: 1) 133mm stretch mesh (25 yards length); 2) 102mm - 89mm - 76mm (3 panels each 10 yards in length); 3) 63.5mm - 51mm - 38mm (3 panels each 10 yards in length); 4) 102mm -89mm - 76mm - 63.5mm - 51mm - 38mm (6 panels each 10 yards in length); 5) 115mm (25 yards in length).

Physical factors which could potentially influence fish movements were systematically recorded at each study area during the 1994 open water study period. These were water temperature was recorded at each sampling event and location (e.g. net pull/set). Information on river levels and discharge for the Fort Smith area was obtained from the Water Survey of Canada Station at Fitzgerald (Station 07NB001). We calculated the Pearson product-moment correlation (Sokal and Rolhf 1981) between each of these environmental variables and the abundance of inconnu in the system. The formula for this calculation is as follows:

$$r_{jk} = \frac{\Sigma\ y_j y_k}{(n - 1)s_j s_k}$$

Where Y_j and Y_k are variables and s_j and s_k are the standard deviations about the mean of variables Y_j and Y_k, respectively and r is the Pearson Statistic.

Results were analyzed using the following variables:

1) Netting periods: June 16-30, July 16-31, August 1-15, August 16-31,September 1-15, September 16-30, October 1-15, October 15-31, November 1-15, November 16-30, December 1-15. Where only a portion of days was covered in the time period (e.g., 16-30

June), the total was extrapolated assuming the sampling days would represent the pattern of variation for the entire time period.

2) Net locations: Area 1, - Fort Smith - Rapids of the Drowned; Area 2, - Cunningham Landing; Area 3, - Salt River; and Area 4, - the Slave River delta.

3) Mesh size and net length (as described above).

The netting periods were selected to permit an unbiased estimate of domestic catch of inconnu which exhibited a defined movement into and out of the area during the survey period. The catch per unit effort was standardized to a 25 meter net length.

Net length was standardized assuming a constant change in effort directly correlated to the net length. Thus, the catch for a set with a 30m net was multiplied by 25/30 to convert to 25m. Net depth was standardized in the same manner to a 1.83m deep net.

The catch/effort (C/E) ratio was calculated for each set by dividing the standardized catch for that set by the soak time (in hours). Because we wished to test quantitatively whether there was an effect of mesh size, the C/E value was used in the following analysis. However, for visual comparison using plots of catch-per-unit-effort between time periods and species we further standardized the CPUE by mesh size (see below for details).

The results for C/E were analyzed using a factorial design analysis of variance (Kuttner et al 1989) with the factors being netting period, net location and mesh size as part of the model. The model was :

$$C/E = \mu + TP + L + MS + TPxL + TPxMS + LxMS + TPxLxMS + E$$

Where: CE = Catch/Effort Ratio

μ = The overall mean C/E

TP = the effect of Time Period

L = the effect of Location

MS = the effect of Mesh Size

TPxL = TP by L interaction

TPxMS = TP by MS interaction

LxMS = L by MS interaction

TPxLxMS = TP by L by MS interaction

E = the residual error and variance not explained by the above effects

To plot the Catch per Unit Effort (CPUE), the catches were standardized to the most common mesh size - 133mm. Standardization was done by estimating for each mesh size the catchability of inconnu relative to the 133mm mesh size.

2.3 Inconnu Tracking

Inconnu were radio-tagged at Fort Smith Marina (Rapids of the Drowned) (N = 12) and at Buffalo Crossing (N = 4) between August 15, 1994 and September 01, 1994. These were thought to be aggregating pre-spawners. Nine more inconnu were tagged as spawners at Fort Smith Landing in the last week of September and first week of October, 1994. The tag used was an external radio-tag, model # 1035 available from Advanced Telemetry Systems (470-1st Ave. N., Box 398 Isanti, Minnesota, 55040). Each tag had a battery lifespan of nine months from the time of activation. Each animal was captured using $5^1/_4$ " (133mm) stretch mesh gill nets. As soon as a fish was snagged in the net, it was removed to minimize tissue damage and trauma. Fish were only tagged if they were undamaged and active. Prior to tagging the fish were anaesthetized using a solution of benzocaine at 25ppm in water. We used a lower than normal dosage of anesthetic because inconnu are very sensitive to oxygen depletion and it was important that their gills did not stop moving at any point. The tag was applied to the left side of the fish (Fig. 2) by using a hypodermic needle to thread two teflon wires attached to the radio tag above the vertebrae and under the dorsal fin and anchoring the wires against the opposite side of the body (the "sub-dorsal fin method" - Winter et al. 1978). All tagging was done while the fish remained anesthetized and immersed in river water. We revived inconnu after tagging by holding them underwater beside the boat in the direction of travel while the boat was being driven at slow speed. Without this treatment inconnu were unlikely to recover.

Inconnu were tracked using a radio-receiver mounted on an aircraft or a hand-held receiver in a boat or on shore. Tracking surveys were conducted by Department of Fisheries and Oceans Hay River area office personnel. The majority of tracking was conducted from a Cessna 185 plane using dual YAGI directional antenna attached to the wing struts (George Low, Pers. Comm.). Tracking was done on a weekly basis after the initial tagging until December 9, 1995 when most of the inconnu had cleared the system. Additional tracking was done January 9, 1995, January 27, 1995, January 31, 1995 and February 15, 1995 to confirm that inconnu had moved out of range into Great Slave Lake. The average altitude of the tracking aircraft was 1500m with two transects being flown per flight, one upstream and

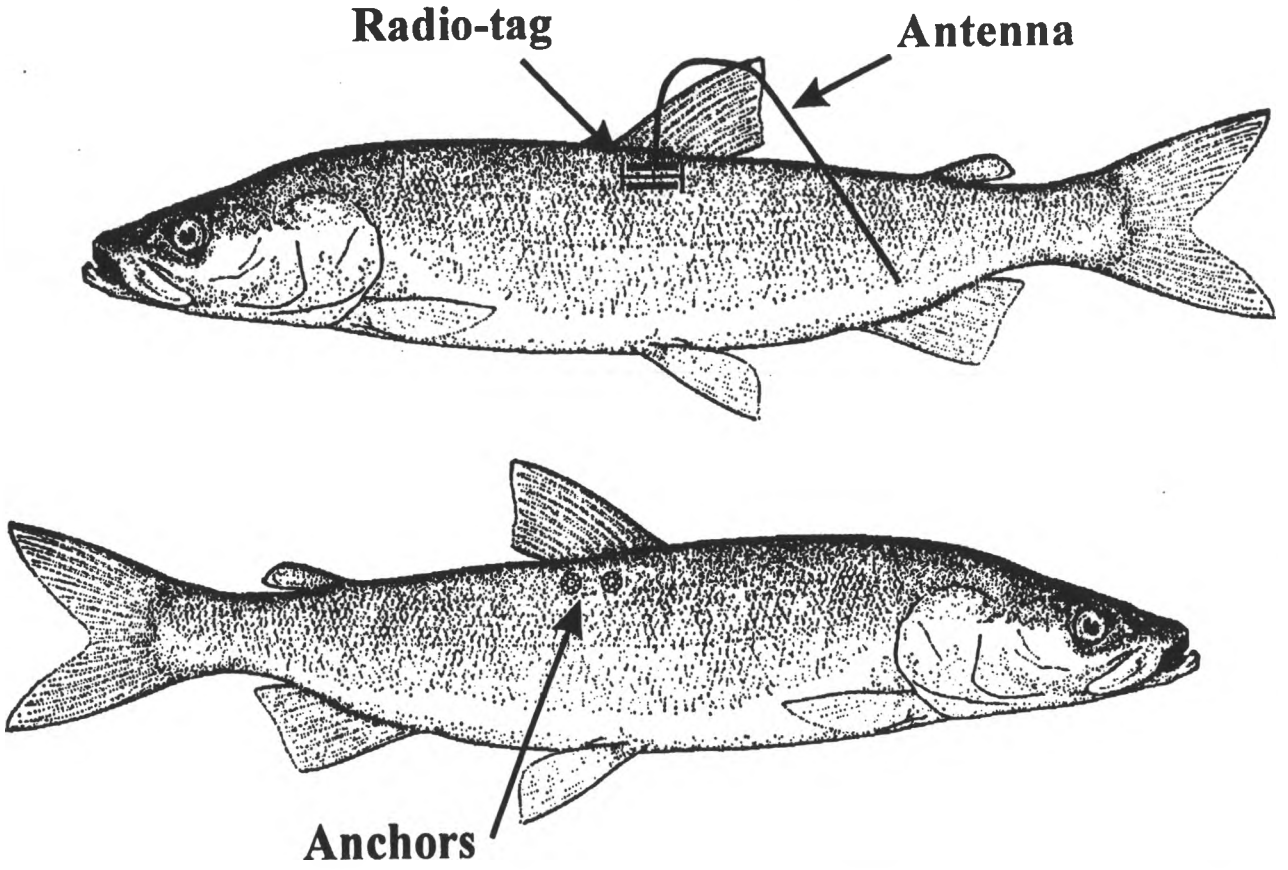

Figure 2. Location of external tag on inconnu.

one downstream. As well, when a detection occurred, circles were flown to confirm the reading. A Smith-Root Incorporated SR-40 search receiver was used; this receiver sequentially monitored 20 channels, thus permitting the pinpointing of individual fish. A reward of $20.00 was offered to domestic and commercial fishermen who captured radio-tagged inconnu and returned the transmitter. Figure 3 shows the normal flight path and area where the inconnu were tracked.

2.4 Burbot Tracking

Sixteen burbot were tagged at Bell Rock between November 25 and December 12, 1994 using the same type of tag as for the inconnu. Each animal was captured using jig lines set on the bottom. As soon as the fish was caught it was removed from the hook to minimize tissue damage and trauma. Only fish that were undamaged and active were tagged. Prior to tagging, the fish were anaesthetized using benzocaine at 25ppm. The tag was applied to left side of the fish by passing wire above the vertebrae and under the dorsal fin. All tagging was done with the fish remaining anaesthetized and immersed in a tub of river water. Fish were tracked using a radio receiver mounted on aircraft or hand-held receiver in a boat. Initial tracking was done after tagging on December 9, 1995. Additional tracking was done January 9, 1995, January 27, 1995, January 31, 1995, February 15, 1995 and twice during June, 1995 to confirm that burbot had moved out of range into Great Slave Lake or into deeper waters in the lower Slave River. The average flying altitude of the tracking aircraft was 1500 m.

3.0 RESULTS

3.1 Movements Inferred by Netting

Inconnu first appeared in the system near the beginning of August, 1994 (Table 1, Fig. 4). The run peaked between September 1 and October 15, 1994. The end of the run was estimated to be in the latter part of October. By October 21 most inconnu had left the Slave River.

Time period had significant effects on the C/E ($P = 0.0454$) while mesh size did not ($P = 0.1667$). All interactions (e.g., time period by mesh size - $P = 0.7982$) were non-significant.

Figure 5 shows the mean daily water temperatures in the Slave River between June and November. Inconnu appeared to first enter the system when water temperatures were near 19 to 20° C and continued to enter throughout the fall period as temperatures declined to around 10° C. They exited at much lower temperatures with the last fish leaving at around 5° C. There was a significant negative correlation ($r = -0.9289$) between the water temperature and the CPUE of inconnu ($P = 0.0009$).

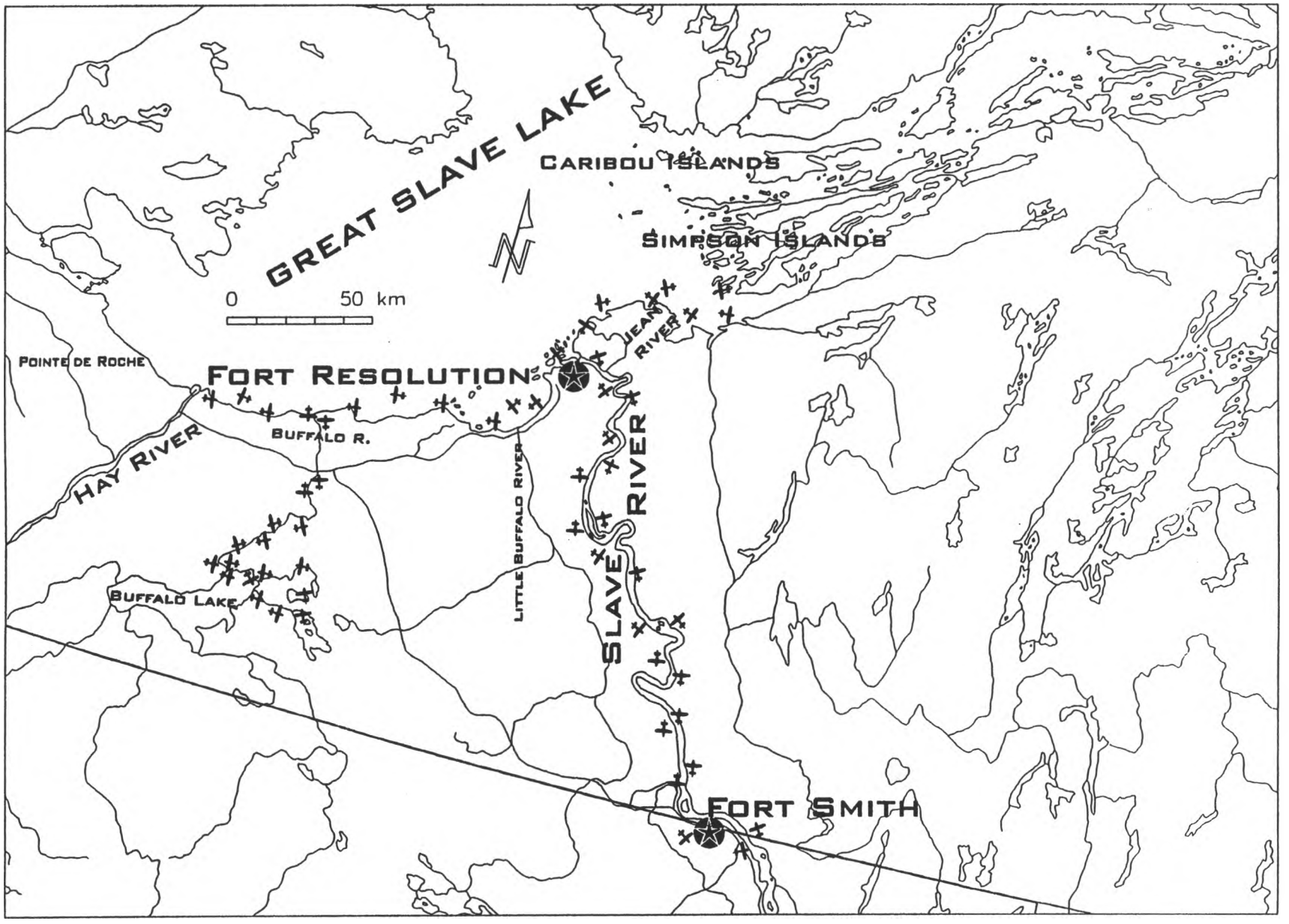

Figure 3. Flight path of tracking plane.

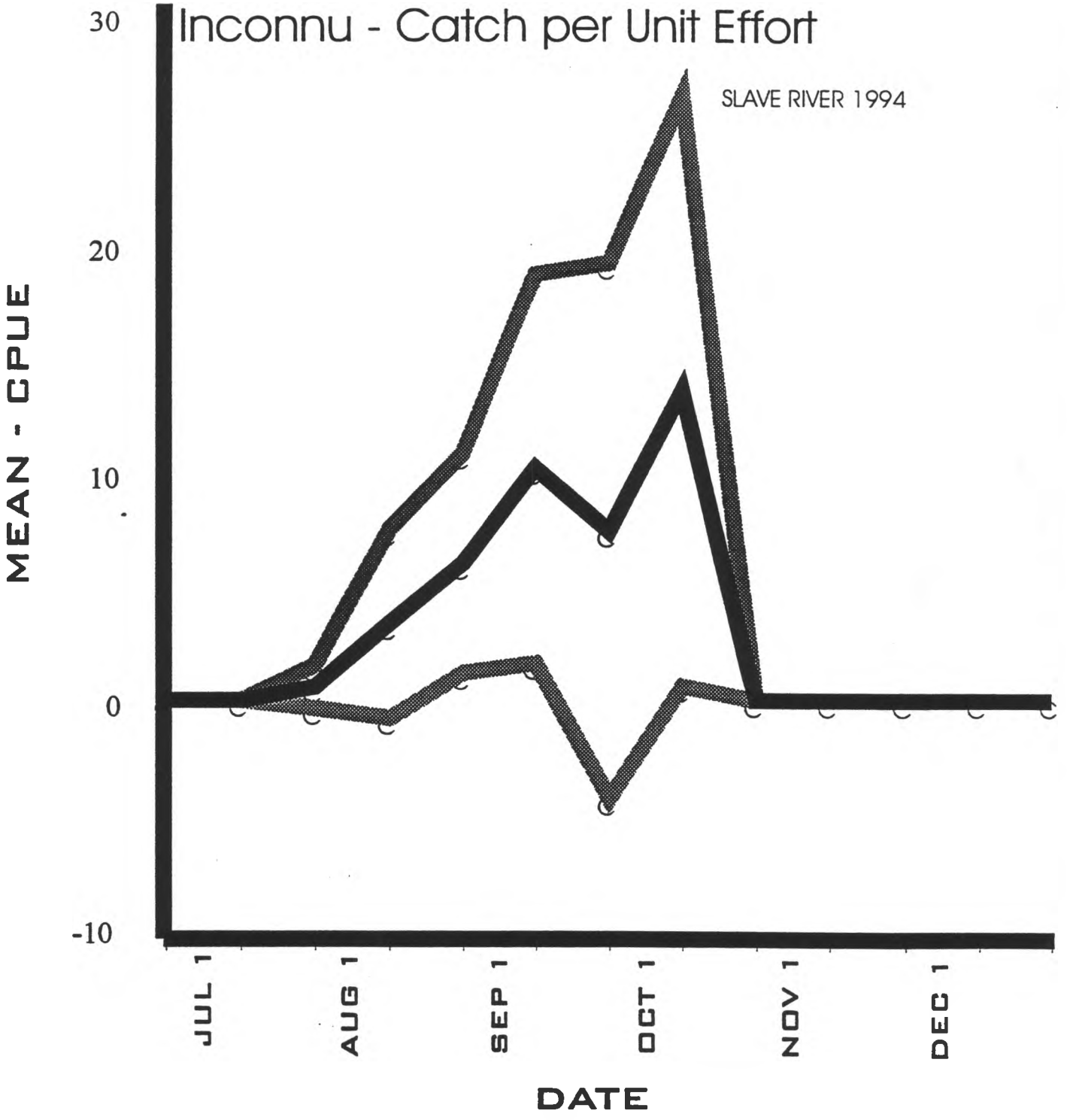

Figure 4. Catch-per-unit-effort (CPUE) (number of fish per hour for standardized net) of inconnu in the lower Slave River in 1994 against calendar date - Solid dark line is the mean CPUE - outside lighter lines are 2 standard errors from the mean.

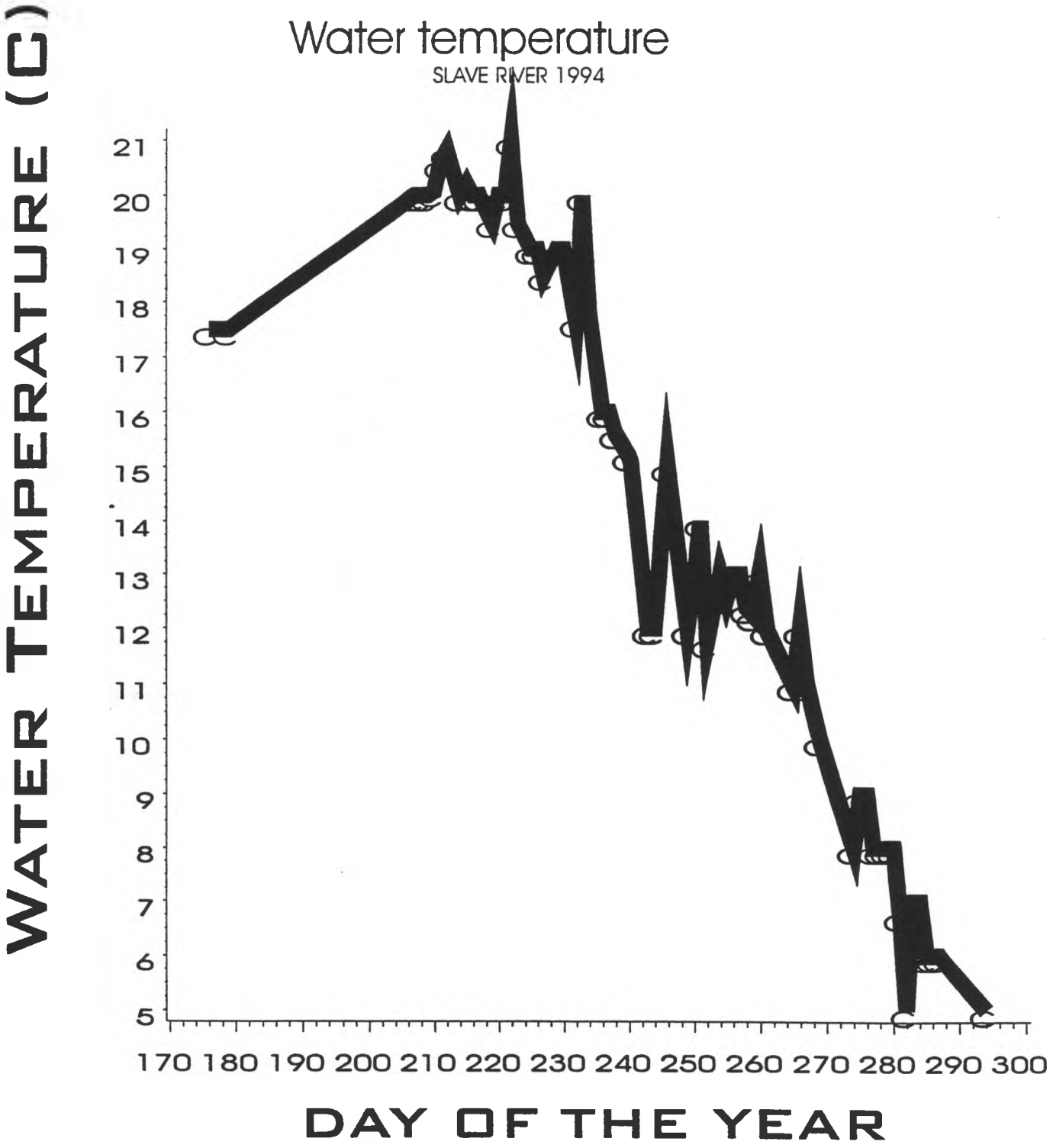

Figure 5. Water temperature (C - degrees Celsuis) against calendar date for the Slave River in 1994.

Table 1. The mean catch per unit effort of inconnu (CPUE - number of fish per hour per 25m length, 2m deep net) by time period for all areas sampled on the Slave River. N = number of sets, STE = standard error.

Time Period	Year	DATES	Mean CPUE	N	STE
1	1994	June 16 -June 30	0	5	0
2	1994	July 1 - July 15	0	4	0
3	1994	July 16 - July 31	0.5906	42	0.4747
4	1994	Aug. 1 - Aug. 15	3.3676	37	2.0796
5	1994	Aug. 16 - Aug. 31	6.0273	63	2.4133
6	1994	Sept. 1 - Sept. 15	10.1719	49	4.2684
7	1994	Sept. 16 - Sept. 30	7.4523	26	5.8756
8	1994	Oct. 1 - Oct. 15	13.5683	32	6.4670
9	1994	Oct. 16 - Oct. 31	0	2	0
10	1994	Nov. 1 - Nov. 15	0	2	0
11	1994	Nov. 16 - Nov. 30	0	4	0
12	1994	Dec. 1 - Dec. 15	0	4	0
13	1994	Dec. 16 - Dec. 30	0	4	0
14	1995	May 16 - May 31	0	6	0
15	1995	June 1 - June 15	0	28	0
16	1995	June 16 - June 30	0.1863	20	0.1863
17	1995	July 1 - July 15	0	26	0
18	1995	July 16 - July 31	0.1547	39	0.1547
19	1995	Aug. 1 - Aug. 15	1.8027	36	0.8586
20	1995	Aug. 16 - Aug. 31	0.9932	5	0.4555

Figure 6 shows the mean daily water discharge level in the Slave River between May and December, 1994. Inconnu entered the system when discharge levels were beginning to taper off but are still high (around 4000 to 5000 cubic meters per second). The discharge level fell steadily throughout the fall to a level of 2000 cubic meters per second. There was no significant correlation between inconnu abundance and discharge level in the system ($r = -0.009$, $P = 0.9765$).

Burbot were not readily captured in the gillnets and thus their apparent abundance was quite low (Fig. 7). The occasional captures of burbot in the area may have reflected their lack of numbers or their lack of active movement during most of the season. They were more readily caught using set lines or trap nets (Hopky and Ratynski 1984). The set line method is employed by local fishermen when they target burbot. The lack of abundance precluded meaningful statistical analyses for this species.

3.2 Radio-tagging Results - Inconnu

Table 2 shows the initial tagging date, re-capture dates and locations for all inconnu tagged. Figure 8 shows the locations of tagging of inconnu in 1994. Figures 9, 10 and 11 show the geographic locations of re-captures of inconnu between August 15 and October 15, 1994, October 15 and October 30, 1994, November 1, 1994 and July, 1995, respectively. Inconnu were detected in the Slave River up to October 25, 1994. After this date it was presumed that all fish were in Great Slave Lake. For example, tracking on January 9, 1995 revealed no inconnu in the river even though all burbot radio-tagged in December were detected. Inconnu numbers 3, 12, 13, 14, 23 and 24 were not seen again after initial tagging. Assuming that they did not expire they probably proceeded directly to Great Slave Lake. This seems reasonable because several inconnu were seen only as re-captures or detections in the Great Slave Lake between February and late June, 1995 (fish numbers 9, 10, 11, 15, 18, 20, 21, 25). These results suggest that inconnu could return to the lake as early as August 22 (fish number 3), but see Discussion for alternative interpretations of this pattern of detection. Other inconnu were detected several times proceeding down the river after tagging and release (fish numbers 1, 2, 4, 5, 6, 8, 10, 11, and 16-22). For example, fish number 5 was tagged on August 25, 1994 at Fort Smith Landing. The fish was then detected at: Cunningham Landing on October 9, 1994, Salt River on October 11, Cunningham Landing on October 15, Bell Rock on October 18 and downstream of Pointe Ennuyeuse on October 25. Another example, fish number 8, which was tagged at Fort Smith Landing on August 30, 1994, was detected upstream of Cunningham Landing on October 11, at Cunningham Landing on October 15, upstream of Grand Detour on October 18 (twice), downstream of Pointe Ennuyeuse on October 25, and then not detected after this point. Fish 10 was tagged August 31, 1994, moved to Cunningham Landing by October 6, Pointe Ennuyeuse by October 18 (twice) and was detected at MacConnell Island just west of Old Steamboat Channel on June 9, 1995. Another fish (number 25) was detected close by Steamboat Channel on June 9, 1995. Two other fish (18 and 21) were detected near the mouth of the nearby Jean River on June 9, 1995, also. The others were probably out of

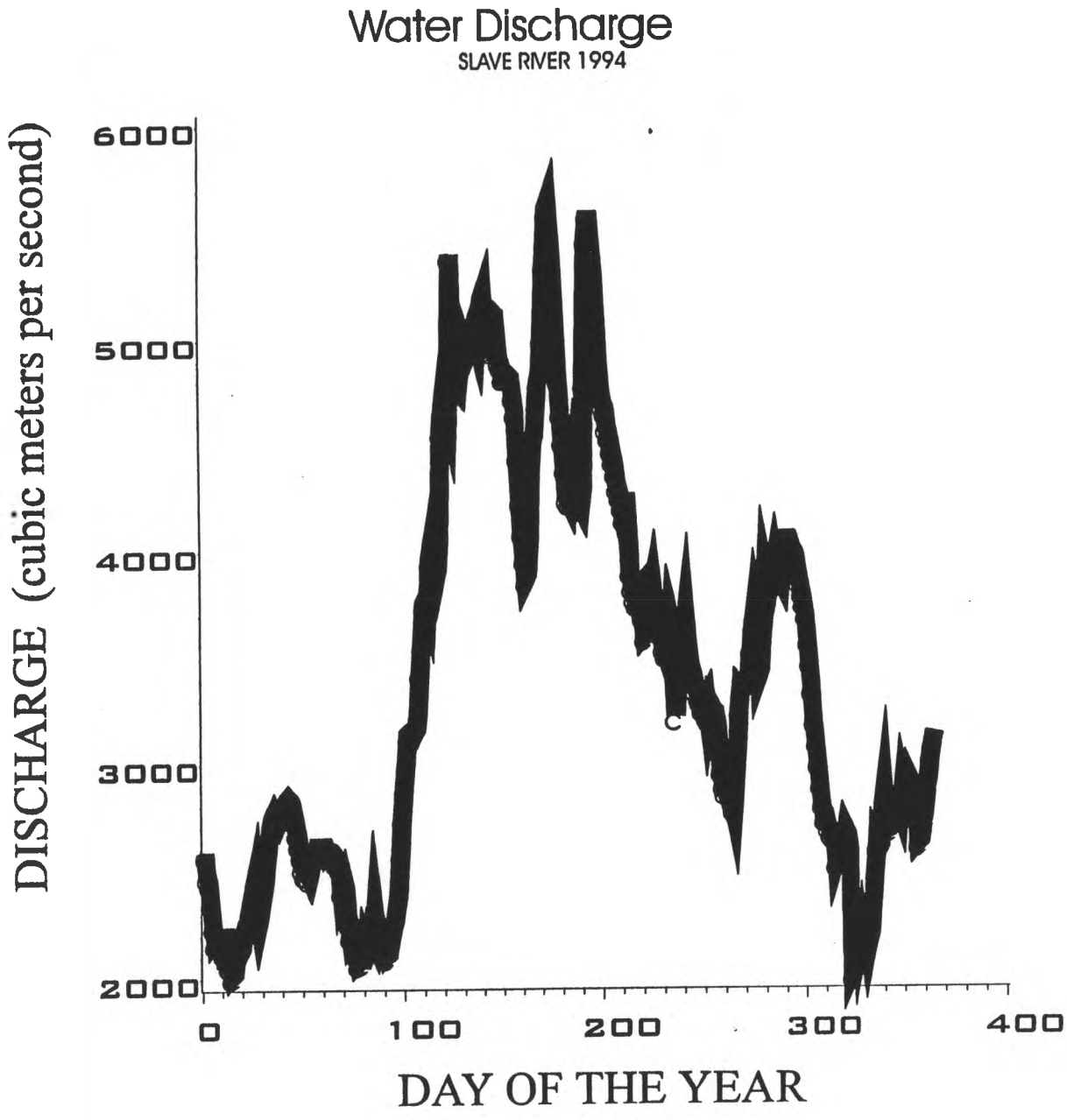

Figure 6. Water discharge in the lower Slave River in 1994.

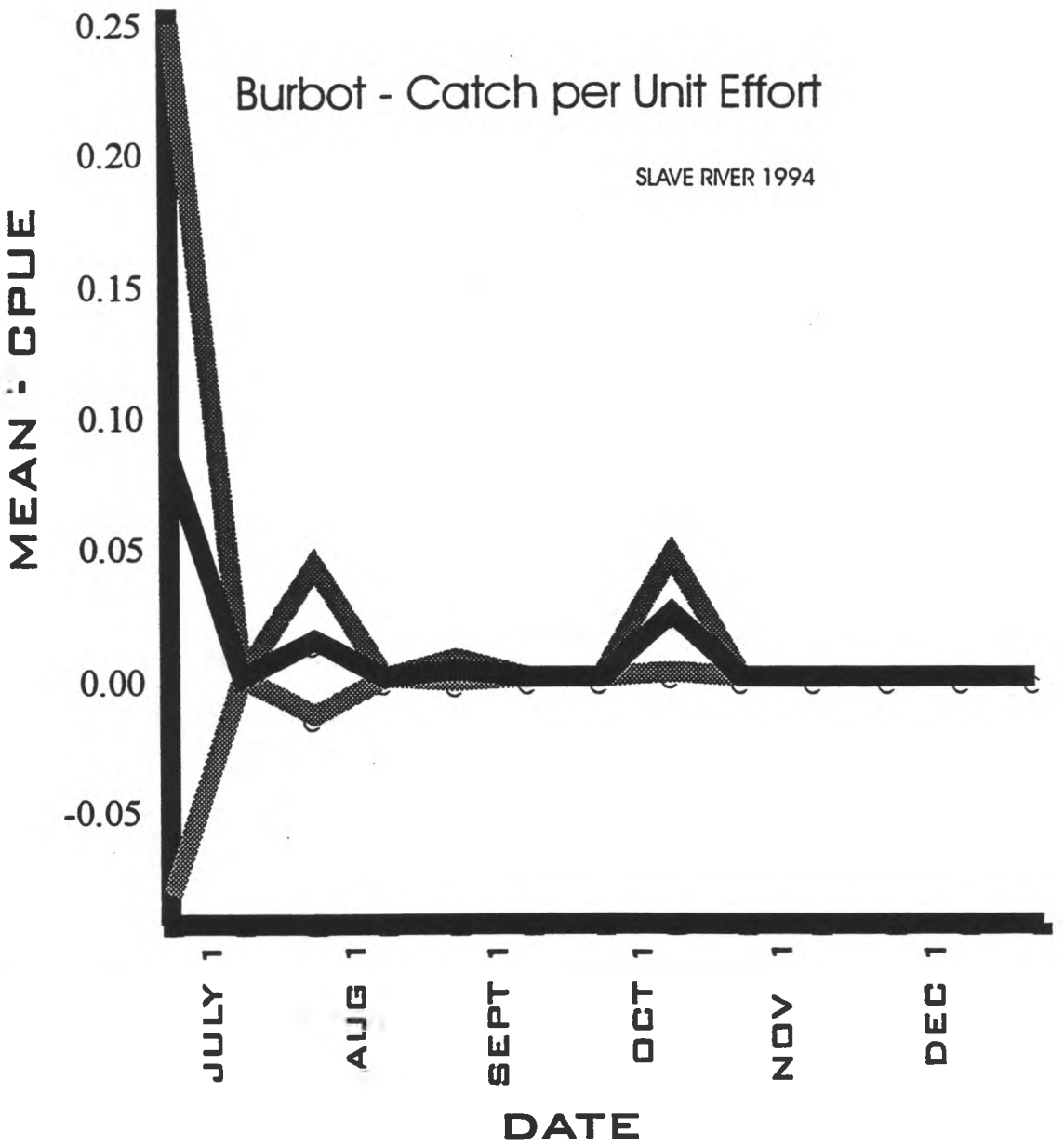

Figure 7. CPUE of burbot in the lower Slave River in 1994 against calendar date.

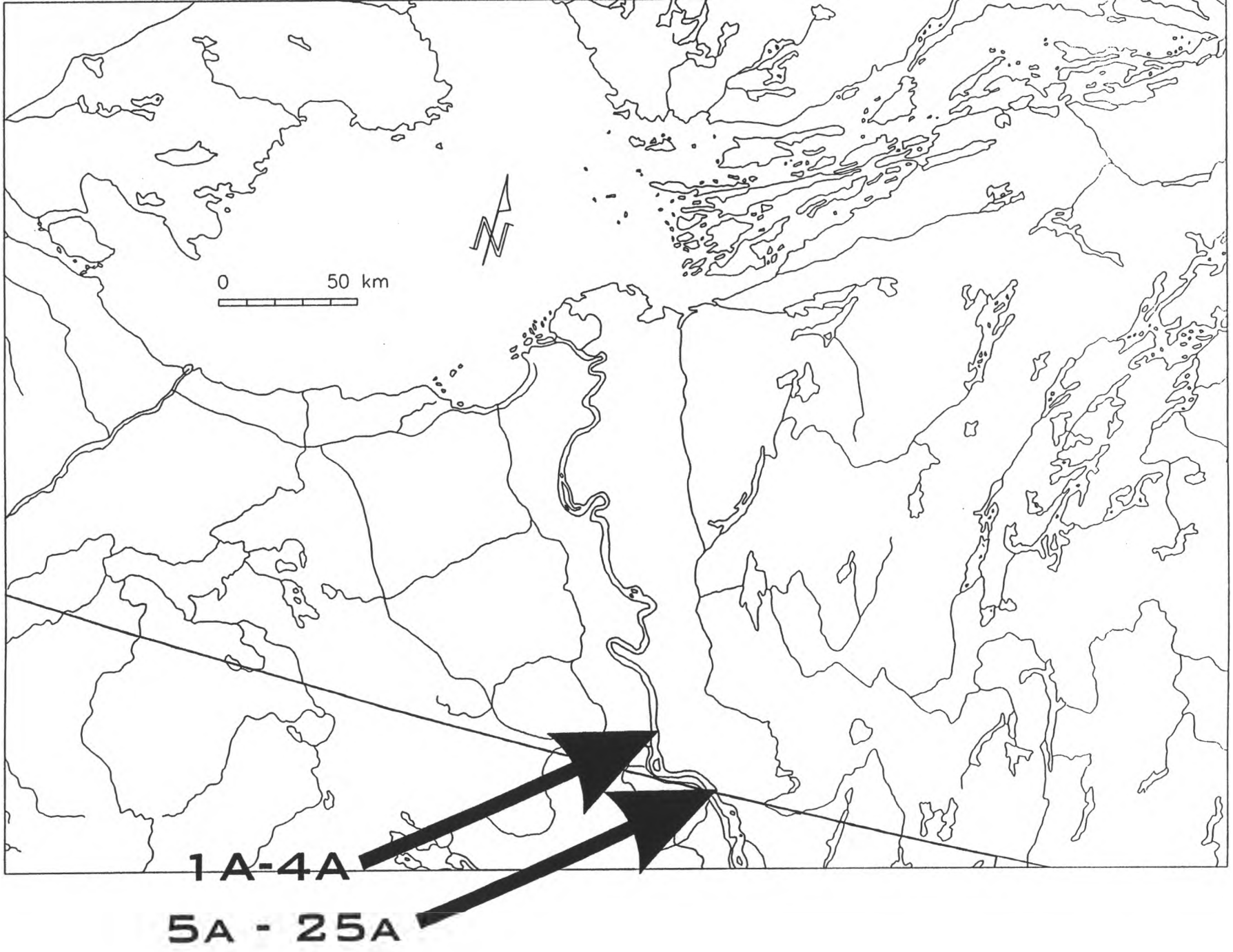

Figure 8. Tagging locations of inconnu in Slave River in 1994 during August and October. Letter-number codes correspond to individual fish and times. (See Table 2 for precise times and locations per fish).

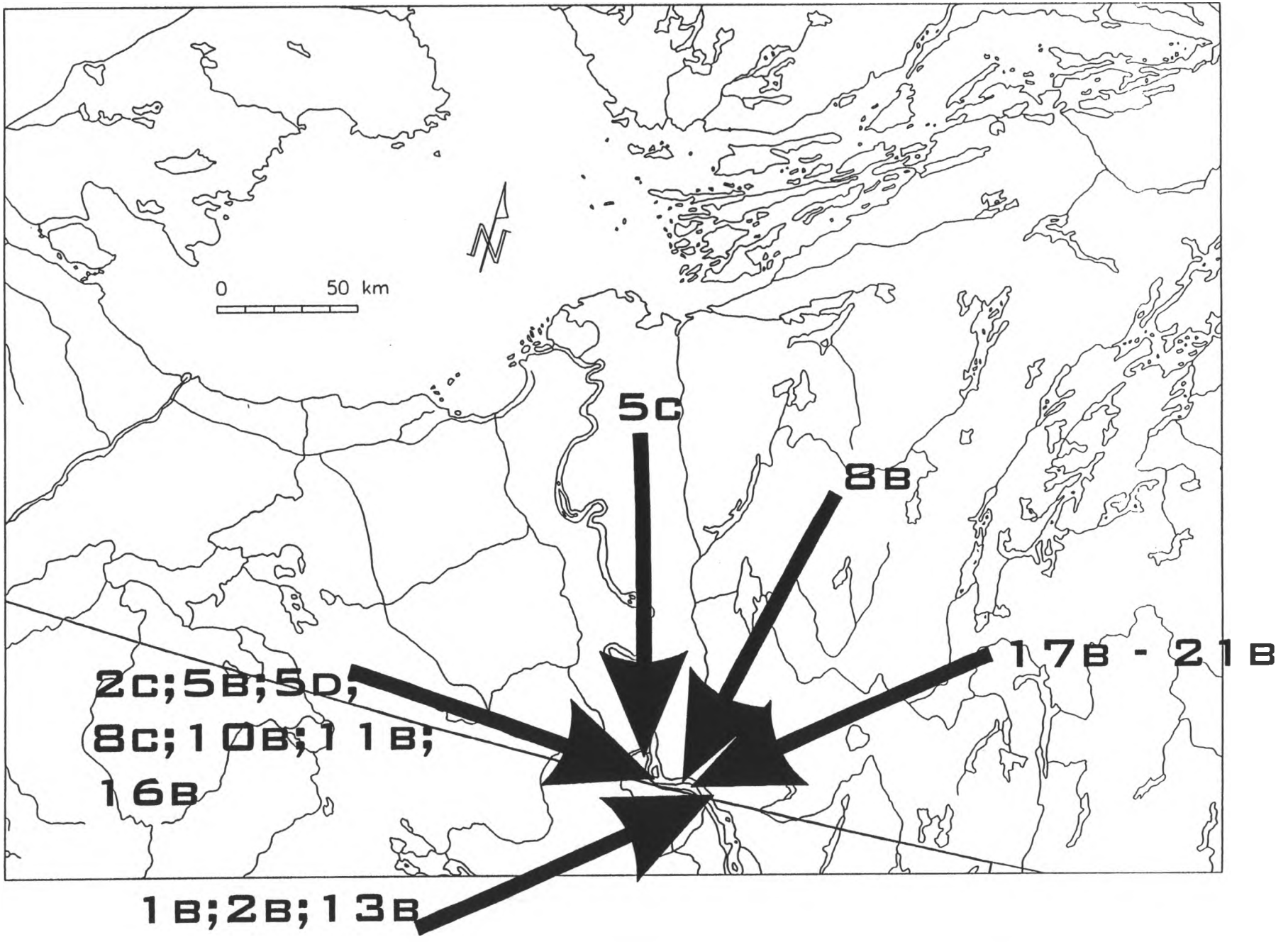

Figure 9. Re-capture and detection locations of inconnu in the Slave River and Great Slave Lake between August and October 15, 1994. Letter-number codes correspond to individual fish and times. (See Table 2 for precise times and locations per fish).

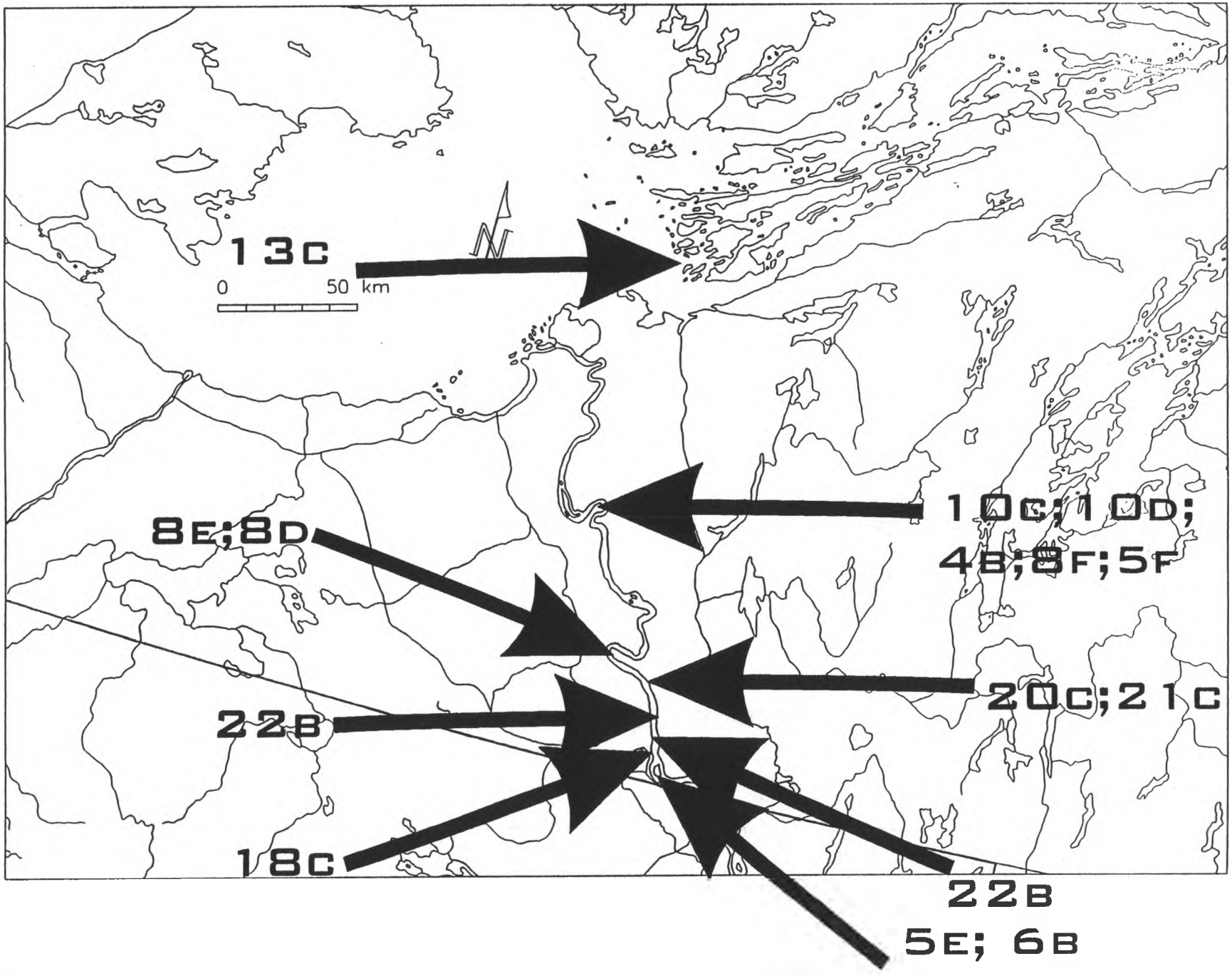

Figure 10. Re-capture and detection locations of inconnu in the Slave River and in Great Slave Lake between October 15 and Octoober 30, 1994. Letter-number codes correspond to individual fish and times. (See Table 2 for precise times and locations per fish).

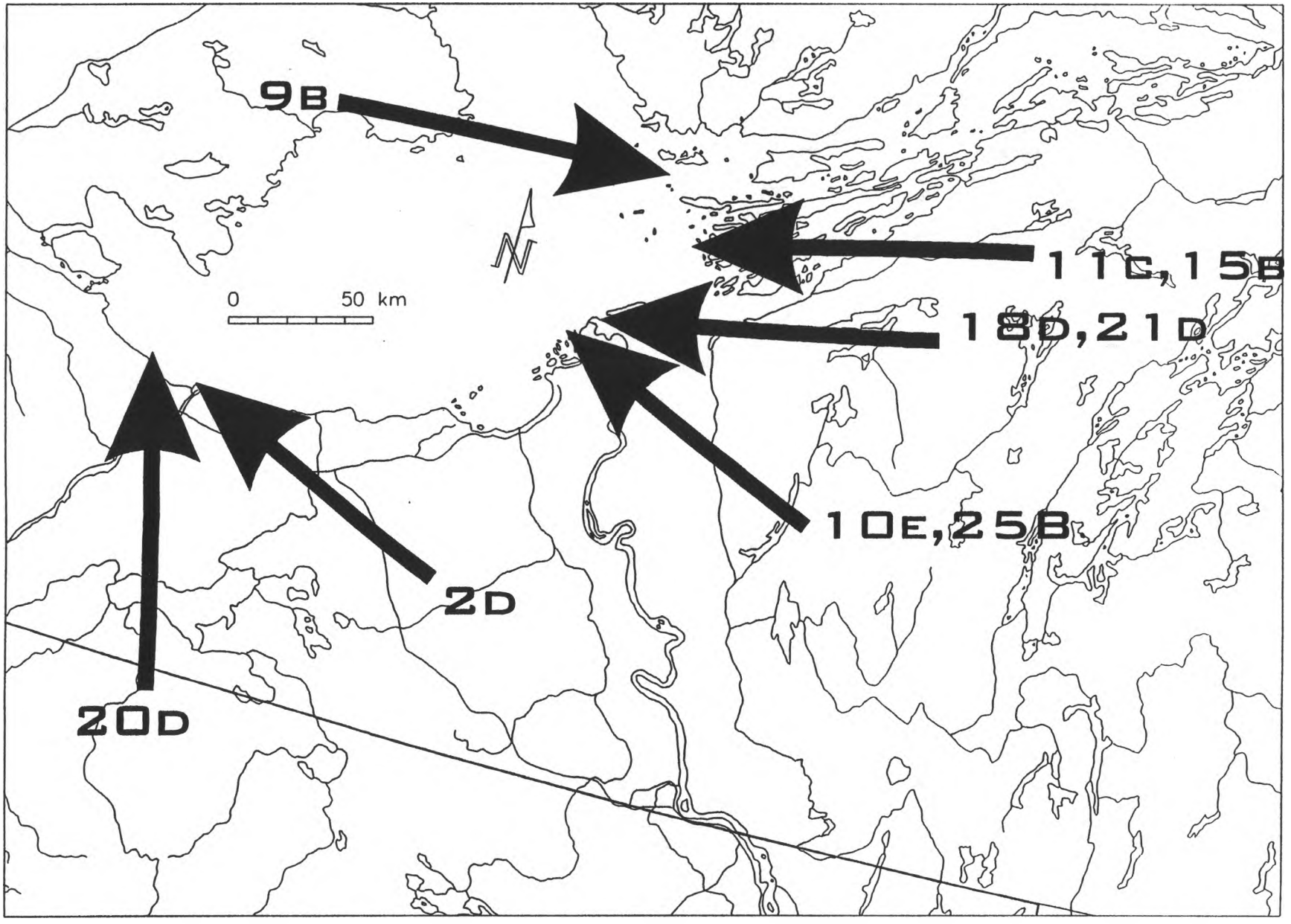

Figure 11. Re-capture and detection locations of inconnu in the Slave River and Great Slave Lake between November, 1994 and July, 1995. Letter-number codes correspond to individual fish and times. (See Table 2 for precise times and locations per fish).

range at this point. G. Low (DFO area biologist, pers. comm.) has tracked inconnu from the Buffalo River into Great Slave Lake and suggested that once in the lake the inconnu swim at depths too deep for the signal to reach the receiver (See Discussion for further interpretation on this point). We suspect that this was the case with radio tagged inconnu in the Slave River, also.

All inconnu that were detected or re-captured in 1995 were found in Great Slave Lake (Fig. 11). Fish number 10 was detected at McConnell Island off Old Steamboat Channel on June 9, 1995. Fish number 2 was captured near the mouth of Hay River, on the south shore of the lake well to the west of the Slave River, on July 11, 1995. Fish number 9 was captured on June 26, 1995 at Caribou Islands, in the northern part of the lake. Fish 11 was captured on February 1, 1995 at the Simpson Islands at the edge of the east arm of Great Slave Lake. Fish number 15 was captured on March 31, 1995 in the Simpson Islands, also. On June 9, fish 18 and 21 were detected one km north of the mouth of the Jean River and fish 25 was detected three km north of Steamboat Channel. The patterns of movement observed by these re-captures were consistent with the results obtained from radio-tracking. Three radio-tagged fish were re-captured in the river during the month of October. Two fish (numbers 11 and 15) were re-captured at Simpson Island on March 31, 1995. Fish numbers 18 and 21 were detected one km north of the mouth of the Jean River on June 9, 1995. Fish 20 was re-captured on June 21, 1995 at Pointe de Roche. Fish 25 was re-captured on June 9, 1995, three km north of Steamboat Channel. With the exception of fish number 9, all fish re-captured or detected in the summer months were close to the shore or in the channels of river deltas. The fish detected or re-captured in the winter were in the deeper part of the lake.

3.3 Radio-tagging Results - Burbot

Table 2 shows the initial tagging dates, re-capture dates and locations for all burbot tagged. Figure 12 shows the geographic locations and times of re-captures. Fish were detected January 5, 1995 and January 31, 1995. Beyond this point there was no further detection and it was presumed that all fish were residing in deep portions of the river. Interestingly, no fish were detected with land-based reconnaissance on January 27, 1995 which was only three weeks post-tagging. Fish number 29 was the only fish detected on January 31, 1995. Although tracking included the nearshore southern Great Slave Lake area from Hay River to the tip of the Slave Peninsula, no fish were detected. We presume that the benthic dwelling habit of the burbot meant that they were out of range for our receiver. Fish that move in water deeper than 10 ft. are thought to be less detectable (George Low, Pers. Comm.). It is possible that the tags did not function well given that the fish were tagged under very cold conditions, but signals were detected in mid-winter from tags frozen to the bottom. We do not think that there was mortality or the tags failed because on January 9, 1995 we detected nearly all the fish and if the fish expired we might expect tags to continue transmitting from one fixed location. Similarly, from the inconnu work we know that if the tags worked initially as confirmed by the January 9 detections then they should not be affected by the temperature of the water. Assuming that the tags worked well, it appears that

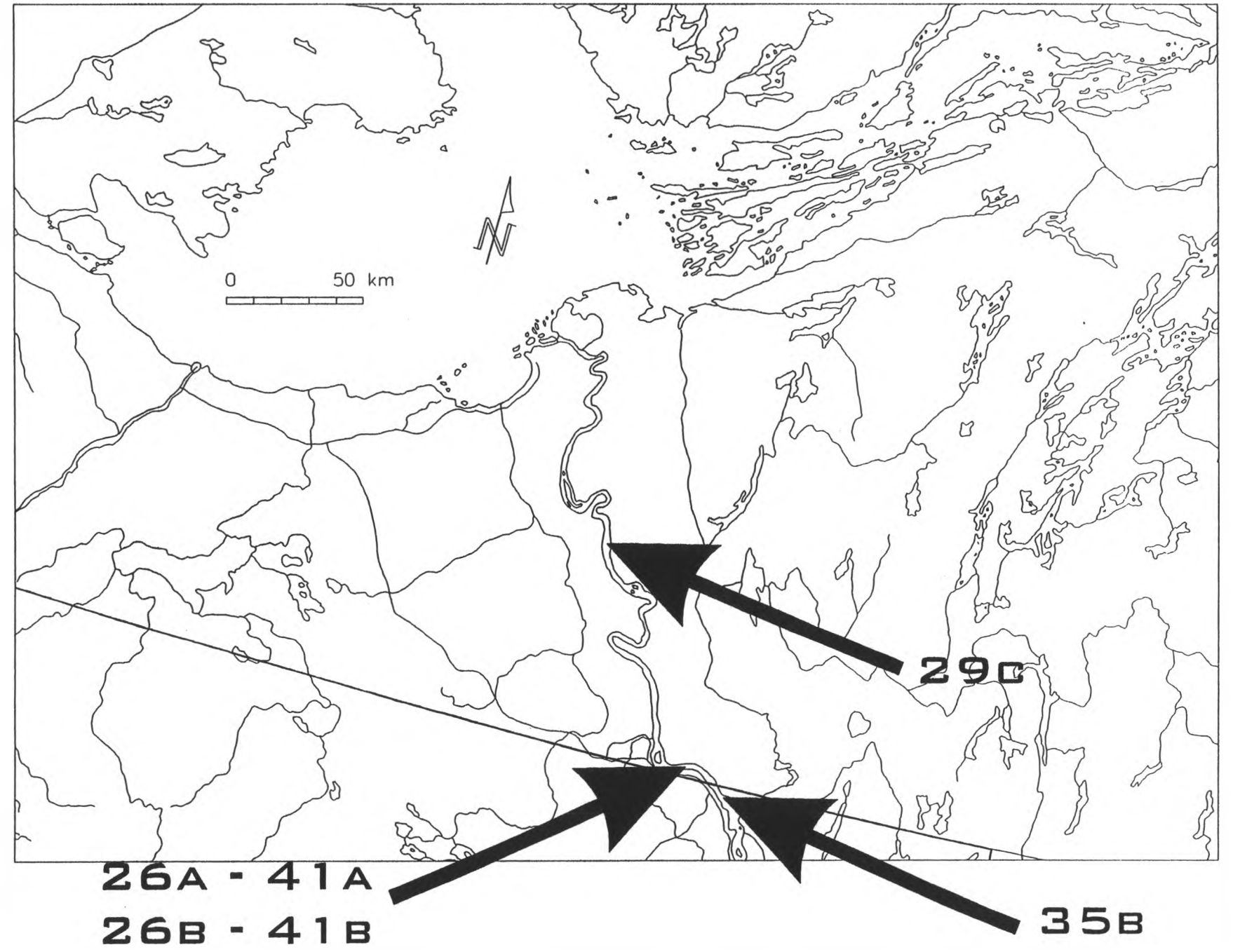

Figure 12. Tagging, re-capture and detection locations of burbot in the Slave River and Great Slave Lake between December, 1994 and July, 1995. Letter-number codes correspond to individual fish and times. (See Table 2 for precise times and locations per fish).

there were only slight movements of burbot from the initial site of capture. Although it is possible that the burbot moved into Great Slave Lake, the most plausible explanation is that they had moved into deeper sections of the river, thereby escaping detection and that they remained in the local vicinity where they were tagged. Alternatively, they may have moved into the Slave River Delta.

Table 2. Tagging, tracking and re-capture dates and locations for radio-tagged inconnu and burbot on the lower Slave River and Great Slave Lake, 1994-1995. Sequential letters under 'Fish #' refer to successive events for that fish.

Fish #	Species	Sex	Freq	Event	Date Tagged	Location	Coordinates	Tracking Mode
1A	Inconnu	M	49.170	Tagged	20-Aug-94	Buffalo Crossing	60-06-34N 112-14-04W	
-B				Detected	9-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	Water
2A	Inconnu	F	49.350	Tagged	20-Aug-94	Buffalo Crossing	60-06-34N 112-14-04W	
-B				Detected	5-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	Land
-C				Detected	15-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Water
-D				Captured*	11-Jul-95	Hay River	60-02-00N 115-45-00W	
3A	Inconnu	.	49.270	Tagged	22-Aug-94	Buffalo Crossing	60-06-34N 112-14-04W	
4A	Inconnu	.	49.230	Tagged	22-Aug-94	Buffalo Crossing	60-06-34N 112-14-04W	
-B				Detected	18-Oct-94	Pointe Ennuyeuse	60-49-00N 113-02-00W	Air
5A	Inconnu	.	49.190	Tagged	25-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	9-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Water
-C				Detected	11-Oct-94	Salt River	60-06-13N 112-13-29W	Air
-D				Detected	15-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Water
-E				Detected	18-Oct-94	Bell Rock	60-01-20N 112-05-00W	Air
-F				Detected	25-Oct-94	Down Pte. Ennuyeuse	60-44-00N 112-10-00W	Air
6A	Inconnu	.	49.290	Tagged	28-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	18-Oct-94	Up Cunningham Landing	60-02-30N 112-01-00W	Air
7A	Inconnu	M	49.210	Tagged	30-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Captured*	3-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
8A	Inconnu	M	49.330	Tagged	30-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	11-Oct-94	Up Cunningham Landing	60-02-30N 112-01-00W	Air
-C				Detected	15-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Water
-D				Detected	18-Oct-94	Up Grand Detour	60-20-00N 112-34-00W	Air
-E				Detected	18-Oct-94	Up Grand Detour	60-21-00N 112-38-00W	Air
-F				Detected	25-Oct-94	Down Pte. Ennuyeuse	60-47-00N 113-49-00W	Air
9A	Inconnu	F	49.250	Tagged	30-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Captured*	26-June-95	Caribou Island	62-07-25N 113-49-00W	
10A	Inconnu	F	49.470	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	6-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Land
-C				Detected	18-Oct-94	Up Pointe Ennuyeuse	60-45-00N 112-58-30W	Air
-D				Detected	18-Oct-94	Up Pointe Ennuyeuse	60-45-00N 112-58-30W	Air
-E				Detected	9-June-1995	McConnell Island	60-48-00N 112-56-00W	Air
11A	Inconnu	M	49.120	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	9-Oct-94	Cunningham Landing	60-01-40N 112-07-33W	Water
-C				Captured*	1-Feb-95	Simpson Island (G.S.L.)	61-45-00N 113-00-00W	
12A	Inconnu	M	49.100	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
13A	Inconnu	M	49.140	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	5-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	Land
14A	Inconnu	F	49.570	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
15A	Inconnu	M	49.550	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Captured*	31-Mar-95	Simpson Island (G.S.L.)	61-45-00N 113-00-00W	
16A	Inconnu	F	49.590	Tagged	31-Aug-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Captured*	15--Oct-94	Cunningham Landing	60-01-05N 111-53-32W	
17A	Inconnu	M	49.750	Tagged-	12-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	15-Oct-94	Rocky Point	60-02-14N 111-54-33W	Air
18A	Inconnu	M	49.630	Tagged	12-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	15-Oct-94	Rocky Point	60-02-14N 111-54-33W	Water
-C				Detected	18-Oct-94	Up Salt R.	60-05-00N 112-14-00W	Air
-D				Detected	9-Jun-95	1km N. of mouth-Jean R.	61-25-00N 113-35-00W	Air
19A	Inconnu	M	49.910	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	15-Oct-94	Rocky Point	60-02-14N 111-54-33W	Air
20A	Inconnu	M	49.870	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	15-Oct-94	Rocky Point	60-02-14N 111-54-33W	Water
-C				Detected	18-Oct-94	Up Grand Detour	60-18-30N 112-25-00	Air
-D				Captured*	21-Jun-95	Point de Roche	60-54-00N 116-09-00W	
21A	Inconnu	M	49.790	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	15-Oct-94	Rocky Point	60-02-14N 111-54-33W	Water
-C				Detected	18-Oct-94	Up Grand Detour	60-16-00N 112-22-00W	Air
-D				Detected	9-Jun-95	1km N. of mouth-Jean R.	61-25-00N 113-35-00W	Air
22A	Inconnu	M	49.610	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	18-Oct-94	Buffalo Crossing	60-10-30N 112-16-04W	Air
23A	Inconnu	F	49.770	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
24A	Inconnu	F	49.390	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
25A	Inconnu	F	49.370	Tagged	13-Oct-94	Ft. Smith Landing	60-01-05N 111-53-32W	
-B				Detected	9-Jun-95	3km N of Steamboat Ch.	61-20-00N 113-45-00W	Air
26A	Burbot	.	49.490	Tagged	13-Dec-94	Bell Rock	60-01-20N 112-05-00W	
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-35N 112-06-33W	Air
27A	Burbot	.	49.410	Tagged	13-Dec-94	Bell Rock	60-01-20N 112-05-00W	
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-35N 112-02-55W	Air
28A	Burbot	.	49.080	Tagged	14-Dec-94	Bell Rock	60-01-20N 112-05-00W	

-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-08N	111-51-37W	Air	
29A	Burbot	.	49.430	Tagged	14-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-49N	111-54-34W	Air	
-C				Detected	31-Jan-95	Hook Lake	60-42-65N	112-52-67W	Air	
30A	Burbot	.	49.810	Tagged	14-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-02-16N	112-00-02W	Air	
31A	Burbot	.	49.890	Tagged	14-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock	60-01-20N	112-05-00W	Air	
32A	Burbot	.	49.830	Tagged	14-Dec-94	Bell Rock	60-01-35N	112-06-33W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-02-47N	112-01-49W	Air	
33A	Burbot	.	49.020	Tagged	15-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-20N	112-04-12W	Air	
34A	Burbot	.	49.510	Tagged	15-Dec-94	Bell Rock	60-01-20N	112-05-00W		
35A	Burbot	.	49.450	Tagged	15-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	31-Jan-95	Up Fort Smith Landing	59-54.00N	111-43.50W	Air	
36A	Burbot	.	49.040	Tagged	15-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-58N	111-55-04W	Air	
37A	Burbot	.	49.670	Tagged	16-Dec-94	Bell Rock	60-01-20N	112-05-00W		
38A	Burbot	.	49.710	Tagged	16-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-49N	112-08-44W	Air	
39A	Burbot	.	49.730	Tagged	16-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock	60-02-09N	111-54-54W	Air	
40A	Burbot	.	49.650	Tagged	16-Dec-94	Bell Rock	60-01-20N	112-05-00W		
-B				Detected	9-Jan-95	Bell Rock/Salt River	60-01-50N	111-54-02W	Air	
41A	Burbot	.	49.690	Tagged	16-Dec-94	Bell Rock	60-01-20N	112-05-00W		
42	-	.	49.530	not used	-	-			42	49.530
43	-	.	49.060	not used	-	-			43	49.060
44	-	.	49.310	not used	-	-			44	49.310
45	-	.	49.850	not used	-	-			45	49.850

N.B. Tracking via aircraft on 01-Nov-94, via land on 27-Jan-95, but no hits recorded
* Commercial catch of Inconnu radio tag within Great Slave Lake.

4.0 DISCUSSION

The Slave River may be divided into two major sections: the river above the series of rapids located between Fort Fitzgerald and Fort Smith ending in the Rapids of the Drowned and the lower Slave River. This division might be good one biologically since the rapids are probably a barrier to the passage of fish species. For example, the Rapids of the Drowned located near Fort Smith, are the farthest upstream occurrence of inconnu - a decidedly Arctic fish.

The detection of inconnu in July of 1995 indicated that the experiment was successful meaning that inconnu could live extended periods with an external radio-tag attached and that the tags continued to work for the expected time period.

McLeod et al. (1985) conducted an environmental feasibility study related to hydroelectric development of the Slave River. The major objective of the study program was to survey fall-spawning fish populations and describe spawning habitat utilization. Studies focused on inconnu, lake whitefish (*Coregonus clupeaformis*), cisco (*Coregonus* sp.), and chum salmon (*Oncorhynchus keta*). The sub-objectives of the program were: 1) identification and mapping of spawning areas; 2) quantification of late summer and fall fishery resource use; and 3) fish movement and tracking. The study was conducted in 1983 between August 23 and November 10 and in 1984 between August 6 and December 11. They were able to track inconnu for about three weeks during each of these two years.

McLeod et al. (1985) concluded from their radio-telemetry studies that inconnu used the Slave River north of Fort Smith as a spawning area. From gillnetting data they determined that inconnu began to move into the Slave River during mid-August with peak movements occurring near the end of August or early September. Radio telemetry studies indicated a rapid initial rate of upstream migration, followed by a holding pattern near the final point of upstream migration or fallback to downstream locations. They inferred from the telemetry that the population could be separated into upper-river spawners (Cunningham Landing to Rapids of the Drowned) and mid-river spawners (Pointe Ennuyeuse to below Grand Detour). Based on gillnetting and more precisely on their radio-telemetry results they proposed that spawning occurred in early and mid-October.

Our gillnetting results are quite similar to those of McLeod et al. (1985), who observed a large increase of inconnu in the system around mid to late August and continuing into October. Our findings suggest that most spawning probably occurs around mid-October.

Our radio-telemetry results indicate that until mid-October the inconnu were still in close proximity to the tagging sites near Fort Smith. This evidence corroborates that of McLeod et al. (1985), who suggested that there are important spawning sites near Fort Smith below the Rapids of the Drowned. The general pattern of detections and re-captures from our study indicates that between October 15th and 30th the fish begin to migrate downstream.

Individually, fish that were tagged but not detected again may have migrated directly back into Great Slave Lake or may have been in deep pools in the river. For example, fish 23 and 24 were tagged in October and might have been post-spawners. On the other hand it seems less likely that fish 3, 12, 13, and 14, which were tagged in August, would necessarily return to the lake as part of their natural behaviour. Based on our knowledge of the temporal pattern of gonadal maturation it is probably too early in the season for spawning. These fish may have made a "false migration" and were not ready to spawn. More likely, they may have fallen back to the lake or into deep pools to recover from the tagging procedure. In using these techniques on inconnu at the Arctic Red River we observed that fish tend to drift downstream following tagging (initially), especially if the spawning date is somewhat distant in the future. McLeod et al. (1985) also found that most inconnu wandered downstream due to the handling stress of tagging and that some individuals dropped back to Great Slave Lake after tagging (see page 43 in McLeod et al. 1985). In 1995 all fish that were detected or re-captured were outside the river within Great Slave Lake. Thus, the radio-tracking catch per unit effort results suggest that the upstream migration of inconnu to their spawning sites probably occurs during August and September. Inconnu may initially swim upstream until they reach a barrier (i.e Rapids of The Drowned). Some may spawn there but others move about in the reaches of the river just downstream of the rapids in search of suitable spawning sites. Examining the graphs of movement in McLeod et al. (1985) we observed similar behaviour in the initial period following tagging. From our results we believe that the downstream post-spawning migration occurs during a brief period of probably less than two weeks in late October. After this period all inconnu are in Great Slave Lake, probably in off-shore areas (since tracking along the south shore and in the river did not reveal any tagged inconnu). After the winter period the inconnu became available in the areas closer to shore. The inconnu appeared to utilize a large part of the lake basin in the course of a year. This was confirmed by the capture and detection of inconnu in 1995. In other systems, such as the Arctic Red River, N.W.T., the fish leave the system shortly after spawning. So, spawning in the Slave River is most likely to occur between early and mid-October, after which the inconnu leave the system for Great Slave Lake.

Inconnu use the lower Slave River seasonally, only - spending the rest of their time in Great Slave Lake. The migration in and out of the system creates fishing opportunities for local aboriginal fishermen in the Fort Resolution, Salt River and Fort Smith areas. Temperature appears to be highly correlated with the abundance of inconnu in the system. The majority of inconnu were present in the weeks just before freeze-up. The lower temperature may reduce the metabolic stress on the inconnu when they are spawning. There may be upper temperature limits for successful rearing of their eggs, also. The abundance of inconnu in the system was independent of water discharge but inconnu may require an upper maximum discharge level in order to migrate efficiently and are thought to have specific requirements for spawning (Alt 1987, Nikolskii 1961). Alterations to the system that might change the temperature and discharge patterns in the system would presumably have detrimental effects on the inconnu reproduction.

Re-captures are consistent with the radio-tracking. McLeod et al. (1985) followed inconnu using radio-telemetry for about 3 weeks during their upstream migration from the Slave River Delta to spawning sites at Rapids of the Drowned and Cunningham Landing. They were unable to successfully attach external radio-tags but rather inserted the radio-tag into the gut through the mouth of the fish. After a few weeks the most of the fish regurgitated the tag or died (Tom Unka, Fort Resolution pers. comm.). A likely explanation for this is that the tag obstructed the passage of food once the inconnu resumed feeding after spawning.

We were successful at following tagged inconnu into July, 1995. The following movements were observed for post-spawning inconnu. A number of captures and detections of inconnu in 1995 were well to the west of the Slave River. The pattern in time and space of captures and detections in Great Slave Lake suggests that fish migrate throughout most of the lake basin and that there is a progressive movement in a counter-clockwise direction throughout the winter to the next summer. This pattern follows the direction of current movement around the lake, which proceeds in a large anti-clockwise gyre. George Low (pers. comm.) has interpreted tag returns and other fishery observations as indications that inconnu undergo extensive migrations in Great Slave Lake during the winter months. In the spring (May and June), current year spawners, along with immatures and resting individuals congregate at the mouth of the Slave River. By July, non-spawning fish disperse back into deep water until the following spring. Spawners hold at the mouth through July and begin migration into the river during August. The wide dispersal of Slave River fish into the lake could mean that any contaminants absorbed while in the river would be transported throughout Great Slave Lake and into commercially sold fishes.

McLeod et al. (1985) were not able to describe the movements of fish at the base of the Rapids of the Drowned because they were immediately intercepted by the intense subsistence fishery prosecuted at that time. We were fortunate (scientifically) that there was only one fisherman operating in the area near the rapids in 1994 and therefore we were able to observe movements near Fort Smith Landing and Rapids of the Drowned more closely.

We did not observe any inconnu travelling upstream of the Fort Smith area. Therefore, we would presume that contaminants could only be transmitted downstream into Great Slave Lake by water or by forage fish that might migrate past the Rapids of the Drowned. Since inconnu are probably the most powerful swimmers in the system and they appear to be blocked by the rapids it seems unlikely that smaller animals could undertake migrations between the upper Slave, Peace or Athabasca Rivers and the lower Slave.

Our radio-tracking results for burbot are consistent with the model that this species remains relatively sedentary until individuals begin their winter spawning migration. In conversations with the local fisherman it appears that the spawning migration occurs in February, which according to Scott and Crossman (1973), is a time that is similar to most burbot populations. In the process of tagging during December, 1994 we found no evidence that the fish were close to spawning. None had ripe eggs or running milt, for example. After this period all burbot may return to Great Slave Lake perhaps to reside in off-shore areas or more likely

rest deep in the Slave River delta (since tracking along the south shore and in the river in 1995 did not reveal any tagged burbot).

Radio-tracking of a bottom dwelling species such as burbot will not be very effective if the fish migrate to water greater than 5 meters in depth. Below this depth it is thought that the radio signal attenuates and becomes hard to detect when tracking. In the Slave River and its delta there are many places of depths up to 25 meters. Great Slave Lake, of course, has waters of great profundity. Thus, it was difficult to determine the exact fate of the radio-tagged burbot, especially since they are bottom feeders. Future studies could use tags with stronger batteries for multi-year tracking.

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APPENDIX A

TERMS OF REFERENCE

NORTHERN RIVER BASINS STUDY

SCHEDULE A - TERMS OF REFERENCE

Project: 3143-D1: MOVEMENT OF HARVESTED FISH

I. INTRODUCTION

A. Background

Impacts of development on aquatic systems are often most noticeable, especially to the public, in their effects on fish populations. Many fishes are top predators in the aquatic food chain. As such, they can be most severely affected by the bio-magnification of toxicants in the system. These same species can also be important as food for humans. There have been numerous cases of human tragedy as a result of unknowing consumption of tainted fish. Through fishing the public will monitor the health of a system by making personal observations on changes in numerical abundance, average size and condition of the animals that they catch. Because of their size and value fish are the most visible aquatic animals to the public. Fish kills are noticed.

The degree of accumulation and transport of toxicants in fish depend upon their concentration in the ecosystem and the behaviour and biology of the fish species. In particular, the patterns of movement and diet of a fish species will determine the extent to which it is affected. The life history traits of each species, such as size at age , age at maturity, age structure, fecundity, and egg size are considered to be optimized by evolution. These traits integrate the effects of cumulative impacts of ecosystem changes on the species in question. To understand the effects of ecosystem change on fish one must understand their movements patterns in time and space, their dietary and trophic (foodweb) relationships and their demographics.

The Slave River and its delta has been the least studied of the three watersheds with major deltas in the Mackenzie River Basin (Tripp et al. 1981). McLeod et al. (1985) noted that 25 species occurred in the Slave River proper, with all except chum salmon (Oncorhynchus keta) and emerald shiner (Notropis atherinoides) also present in the delta. The river is considered to be an important area for spawning of species such as inconnu (Stenodus leuichthys), lake whitefish (Coregonus clupeaformis), burbot (Lota lota) and walleye (Stizostedion vitreum) (Tripp et al. 1981). The Slave River system has been noted by Katapodis and Yaremchuk (1994) as being highly vulnerable to resource development.

Tripp et al (1981) employed floy tags to mark 4044 fish which included 334 lake whitefish, 495 burbot, 413 walleye but only 18 inconnu. From their results, Tripp et al. (1981) proposed that inconnu and lake whitefish migrate through the delta in late summer and

early fall to spawn upstream. Large concentrations of both species have been observed in the vicinity of the rapids at Fort Smith during late fall. Tripp et al. (1981) also suggested that walleye move through the delta to spawn in the Slave River during the spring. Some return to feed in the delta shortly after spawning while others return in early fall to feed before continuing on to overwintering areas in Great Slave Lake. Burbot were reported to move into the delta area to spawn from late freeze-up to late December. Although it is likely that most return to Great Slave Lake, some burbot apparently move upstream as far as Fort Smith after spawning. Burbot, walleye and inconnu thus represent a range in expected migratory tendency from least migratory to most migratory, respectively. These piscivorous predators are all important for subsistence fishing with the best subsistence fishing areas located in the upper Slave River near Fort Smith (Tripp et al. 1981). These authors recommended that the movements in time and space of the inconnu and lake whitefish in the upper Slave River were the most important areas for further study. Such studies would provide the best opportunity to tag fish to assess the importance of the Slave River to commercial and subsistence fisheries in Great Slave Lake.

Floy tagging studies by Tripp et al (1980, 1981) and Fuller (1947, 1955) indicated that inconnu began rapid upstream movement into the Slave River during mid-August with peak movements occurring near the end of August or early September. Radio-telemetry studies by McLeod et al. (1985) showed that the inconnu separated into upper river spawners (Cunningham Landing to Rapids of the Drowned) and mid-river spawners (Pointe Ennuyeuse to below Grand Detour). Rapid downstream (post-spawning) movement was recorded in mid-October. Fourty-six inconnu were fitted with radio-transmitters and movements followed by aerial surveys. However, their studies did not commence until the spawning run was well underway and therefore could characterize the earliest seasonal period of the migration. As well, since tags were inserted into the intestinal tract the inconnu could migrations could only be tracked during the period just prior to spawning when they were not feeding. In 1983, 16 inconnu were successfully tracked. Five inconnu were tracked for 38 days with rest being tracked for lesser periods down to one day, only. In 1984, 24 inconnu were tracked. One fish was followed for 47 days with the rest being followed for lesser time periods down to one day. Post-spawning and longer term movements would not have been possible to follow since the tags would prevent normal feeding activities.

McLeod et al. (1985), also, observed a well defined run of burbot in the Slave River delta after November 1, prior to freeze-up. However, radio-tagged fish movements did not follow a definable pattern. Most fish showed little movement. This may have been due to the effect of the tags on feeding.

Tripp et al. (1981) provide some information on the life cycles of various species in the Slave River delta area. However, the samples taken were limited. For lake whitefish a full analysis of life history traits (size at age, age specific fecundity, egg size and maturity) was only achieved on 12 fish. For inconnu age and growth characteristics were achieved on only 26 fish with a full analysis on only 9 fish. There was growth information on 143 burbot but

only 20 fish analyzed fully. These traits are the keys to understanding population growth and mortality rates and thus stock productivity. Usually, minimum sample sizes of 200 or more fish per stock per species are considered necessary for this type of analysis.

McLeod et al. (1985) provided some data but no analysis in their appendices on the growth rate, and age at maturity of inconnu, lake whitefish and burbot but did no work on age-specific fecundity or egg size.

Boag and Westworth (1993) studied the Slave River south of the Northwest Territorial Boundary focussing on species considered important to sportfishing. They noted that the sportfish catch in this southern section of the Slave river consisted of northern pike, (Esox lucius) goldeye, (Hiodon alosoides) walleye and burbot (most important to least important, respectively). No age specific information was generated in the study. Results of tagging in terms of movements were not noted in the report. The report focussed on fish inventory.

Analysis of dietary information and food web from diet is generally lacking. Tripp et al. (1981) record gut contents on a number of species but provide no synthesis of this information. There is no mention of it in the executive summary of their document. McLeod et al. (1985) and Boag and Westworth (1993) did not examine trophic relationships.

According to Bodden (1980), fish have traditionally been an important source of food for the people of Fort Resolution, providing up to 40% of their own and 100% of their dogs' food supply. Lake whitefish and inconnu are the most highly prized fish for both humans and dogs, followed by burbot, walleye and to a lesser extent by northern pike and longnose suckers (Catostomus catostomus). A few people fish throughout the year in the Slave River delta. Fishing intensity is generally greatest during the fall spawning migrations of the major species in the Slave Delta, especially lake whitefish, inconnu and burbot. Of an estimated total of 9715 fish taken in the Slave River delta during the 1976-77 season burbot were estimated to account for 45.3% of the total catch, followed by lake whitefish (25.7%), longnose sucker (10.8%), inconnu (9.4%), pike (7.9%) , and walleye (0.9%) (Bodden 1980).

McLeod et al. (1985) recorded a substantial subsistence fishery in the vicinity of Fort Smith during the fall period. Inconnu contributed the greatest yield to the domestic catch (43.8% and 49.1% of the total catch by weight in 1983 and 1984, respectively), although, lake whitefish was numerically most abundant. A significant subsistence fishery for burbot, taking roughly 4408 kg in 1984-85 occurred at the Cunningham Landing/Salt River area (McLeod et al. 1985)

MacDonald and Smith (MS, 1993) also noted the importance for subsistence of lake whitefish, inconnu and burbot in the Slave River basin. They noted that inconnu had the highest harvest followed by lake whitefish and burbot. They listed eight species as being key species to monitor: lake whitefish, inconnu, burbot, northern pike, walleye, goldeye, white sucker (Catostomus commersoni) and longnosed sucker.

Historically, the lake whitefish has been the most important species for commercial harvest in the Great Slave Lake followed by lake trout, inconnu, northern pike and walleye (Tripp et al 1981). More recently, the dominant species have been lake whitefish, pike, lake trout, inconnu, and walleye (C. Day Dept of Fisheries and Oceans, Pers. Comm.). Although they do not use the delta extensively, large concentrations of lake whitefish are found in the Slave River near Fort Smith in the fall. However, because lake whitefish is not a piscivore, they would be less vulnerable to accumulations of toxic materials. Among the others, lake trout does not occur in the Slave River and pike are less preferred for eating than the other species. Thus, inconnu, and burbot are most suitable for detailed study because they are piscivores throughout most of their lives, they are abundant in the Slave River and they important for both commercial and aboriginal subsistence harvest. Of these the least is known regarding the movements and life history variation of inconnu.

While there has been useful work on the fish populations of the Slave River work on movements is based on floy tagging studies with one study using radio-tracking. The number of fish floy tagged has not generally been sufficient for inconnu. The radio-telemetry study is thorough but represented only a short season effort - missing the early part of the migration and the longer term movements. Only very limited information exists to understand and characterize the demographics and life history traits important to stock productivity of key species for human consumption. There is only spotty dietary information with no integration and synthesis nor is there any inter-annual comparisons of diet and trophic positions. Therefore, we propose to investigate the migration of two species, the inconnu and burbot using radio- telemetry techniques employing external tags. We will also examine the variation in life history traits important to productivity in these species - specifically size at age, age at maturity, age-specific fecundity and egg size by collecting fish and analyzing appropriate samples. Finally, we will conduct a thorough examination of the diets of species at all levels of the fish food web.

Study Board Concerns Considered:

Distribution and movement of fish species
- compile life histories of important species

When and where are fish "exposed" and where are important habitats
- Describe fish food-chain relationships

B. The Program

The program for the Slave River is a collaborative effort between the University of Alberta, the Department of Fisheries and Oceans and the Northern Rivers Basin Study Office. The project involves four components which that comprise an integrated whole to determine the movements and demographics of key harvested fish species and a description of the fish food

web in the lower Slave River. It relates to the objectives (concerns) of the Northern Rivers Basin Study Board that deal with

1) Distribution and movement of fish species
   - compile life histories of important species

2) When and where are fish "exposed" and where are important habitats
   - Describe fish food-chain relationships

The four components are :

1) Movement of Harvested Fish

2) Life History Variation of Harvested Fishes

3) Diet of Fishes and Food Web

4) Fish Processing

The four components are inter-related so that each one supports and compliments the other. Two harvested fish species, the inconnu, Stenodus leucichthys, and the burbot, Lota lota are the focus. These are top predators, harvested heavily, with a body composition susceptible to the concentration of contaminants. Inconnu is highly important both in the commercial and aboriginal subsistence economy. Burbot is also important and is a focal species for studies basin wide including the Peace and Athabasca Rivers. They represent the extremes in migratory movement with burbot rather sedentary and inconnu highly migratory. The acquisition of samples will be rationalized for all programs by taking specimens for life history (demographic) and food web analysis while tagging fish. The life history component will serve to do the field specimen collection for both life history and food web. (There will, of course, be some requirement to make special collections for single a single purpose). Fish processing will support the life history and food web by sampling the largest suite of relevant variables possible per fish under ideal sampling conditions. This approach will minimize the costs while maximizing the information content.

The results of the study will put into ecological context the findings of some of the other components of the Northern Rivers Basin Study and other programs such as the Slave River Monitoring Program. The sampling may reduce some of the sample collection costs or enhance the volume of data available to other studies such as those on contaminant in fishes. Finally, the information gathered will be synthesized with other available information from parallel studies and from the historical studies in the Slave River area. The synthesis will allow a more comprehensive interpretation of the longer term events in the system and the significance of the results to the objectives of the Northern Rivers Basin Study.

II. PROJECT DESCRIPTION

The Northern Rivers Basins Study requires the contract laboratory to determine the movements of fish harvested for human consumption such as inconnu, Stenodus leucichthys. and burbot, Lota lota in terms of their distance and timing along the Slave River during the calender year. These species represent a dichotomy of movement patterns from long distance migrators like inconnu, to relatively sedentary species like burbot. These species are likely at the highest level of the food chain where toxicants such as 2,4,5-trichlorophenol can be concentrated before human consumption. Highly migratory species may therefore be exposed to and transport these substances over long distances from sources compared with sedentary species.

III. TERMS OF REFERENCE

1. The contractor is required to track inconnu, and burbot movements along the Slave River using radio-telemetry techniques between June, 1994 and March, 1995.

    a. Radio tags with the capacity to function for up to six months will be attached to 25 inconnu and 20 burbot during the summer and fall months of 1994.

    b. Tracking by radio-telemetry techniques using fixed wing aircraft will be undertaken biweekly or monthly flights over the Slave River south to 60 degrees north latitude and north over the western portion of Great Slave Lake.

2. The contractor is requested to explore and implement, where practical, opportunities for community association/involvement with the project, e.g., South Slave Research Centre.

IV. REPORTING REQUIREMENTS

1. A progress report of field results to date will be submitted to the Northern River Basins Study office by March 31, 1995. Completion of the field work is anticipated by March 31, 1995. Analysis of the data will be completed by April 30, 1995. A final report will be prepared on all results and submitted to the Study office by June 30, 1995.

2. The final report will include:

    a. a description of the methods and tags utilized in the study.
    b. a description of the movements in time and space including maps of movements for each tagged fish in the study area. Maps will show the distance from the mouth, pathway for calculating that distance and the U.T.M. for each fish tagged.
    c. a brief interpretation of the meaning of the results, particularly with respect to possible transport of toxicants in the study area.

3. Identify to species and enumerate all fish capture. Record the general conditions of "abnormal" fish using the Gross Pathology Form (Appendix 1). Compile a properly labelled colour photographic record of caught fish exhibiting "abnormalities". Labelling should permit cross referencing with fish data collection records.

   a. sample number,
   b. species,
   c. reach,
   d. date of capture,
   e. kilometres from river mouth,
   f. Universal Transverse Mercator coordinates for Zone 11,
   g. capture method
   h. abnormality

   In addition to the above tagged fish are to have the following data obtained:

   i. total and fork length (mm.), weight (gms.),
   j. life stage
   k. tag number.

   The raw data relating to tagging and tracking records will be maintained in a data-base retained by the FWISL laboratory but will be made available to the Northern River Basins Study upon request. Fish tagging and recovery data tables will be included as an appendix in the report.

4. The Contractor is to provide draft and final reports in the style and format outlined in the NRBS Style Manual. A copy of the Style Manual entitled "A Guide for the Preparation of Reports" will be supplied to the contractor by the NRBS.

5. Ten copies of the Draft Report along with an electronic disk copy are to be submitted to the Project Liaison Officer by September 30, 1995.

   Three weeks after the receipt of review comments on the draft report, the Contractor is to provide the Project Liaison Officer with two unbound, camera ready copies and ten cerlox bound copies of the final report along with an electronic version.

6. The final report is to include the following: an acknowledgement section that indicates any local involvement in the project, Project Summary, Table of Contents, List of Tables, List of Figures and an Appendices of the Project Terms of Reference, fish tagging data.

   Text for the report should be set up in the following format:

   a) Times Roman 12 point (Pro) or New Times Roman (WPWIN60) font.

b) margins; are 1" at top and bottom, 7/8" on left and right.
c) Headings; in the report body are labelled with hierarchical decimal Arabic numbers.
d) Text; is presented with full justification; that is, the text aligns on both left and right margins.
e) Page numbers; are Arabic numerals for the body of the report, centred at the bottom of each page and bold.

- If photographs are to be included in the report text they should be high contrast black and white.
- All tables and figures in the report should be clearly reproducible by a black and white photocopier.
- Along with copies of the final report, the Contractor is to supply an electronic version of the report in Word Perfect 5.1 or Word Perfect for Windows Version 6.0 format.
- Electronic copies of tables, figures and data appendices in the report are also to be submitted to the Project Liaison Officer along with the final report. These should be submitted in a spreadsheet (Quattro Pro preferred, but also Excel or Lotus) or database (dBase IV) format. Where appropriate, data in tables, figures and appendices should be geo-referenced.

7. All figures and maps are to be delivered in both hard copy (paper) and digital formats. Acceptable formats include: DXF, uncompressed Eøø, VEC/VEH, Atlas and ISIF. All digital maps must be properly geo-referenced.

8. All sampling locations presented in report and electronic format should be geo-referenced. This is to include decimal latitudes and longitudes (to six decimal places) and UTM coordinates. The first field for decimal latitudes / longitudes should be latitudes (10 spaces wide). The second field should be longitude (11 spaces wide).

V. INTELLECTUAL PROPERTY

Upon completion or termination of this project, all data, documents, and materials which are acquired or produced under this project shall become the sole property of the Northern River Basins Study.

VI. PROJECT MANAGEMENT PLAN - DFO/Winnipeg laboratory

1. Radio-transmitters will be attached to inconnu and burbot during June, July and September of 1994 in the Fort Smith area. All permits for the netting of fish and handling and attaching of radio- transmitters will be obtained by the Contractor.

2. The Northern Rivers Basins Study office will be informed at the earliest possible date of any impediments to the execution of this investigation such as difficulty in acquiring fish attaching transmitters or post-tagging mortality.

VII. CONTRACT ADMINISTRATION

The Project Liaison Officer for this project is:

Ken Crutchfield
Associate Science Director
Northern River Basins Study
690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4
Bus. Phone: (403) 427-1742
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This project is under by the Food Chain Component of the NRBS led by:

Dr. Ray Hesslein
Research Scientist
Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
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Phone: (204) 983-5251
Fax: (204) 984-2404

Questions of a scientific nature should be directed to him.

VIII. LITERATURE CITED/REFERENCES

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NORTHERN RIVER BASINS STUDY
Appendix 1

EXAMINATION SHEETS
GROSS PATHOLOGY

DATE: _____

SAMPLE NO.: _____ **U.T.M. LOCATION:** _____

SPECIES: _____ **CAPTURE METHOD:** _____

CAPTURE TIME: _____ **EXAMINATION TIME:** _____

GROSS EXTERNAL EXAMINATION

Skin: ( ) Normal ( ) Excessive mucus ( ) Abnormal Colour _____

( ) Lesions ( ) Single ( ) Multiple ( ) Closed

( ) Open ( ) Haemorrhagic ( ) Necrotic ( ) Ulcer

( ) Blister ( ) Tumour ( ) Lost Scales ( )Abrasions

Body Location: _____

Eyes: ( ) Normal ( ) Exophthalmia ( ) Cataract ( ) Haemorrhagic

( ) Opaque cornea ( ) Lens lost ( ) Parasites ( ) Bilateral

Fins: ( ) Normal ( ) Frayed_____ ( ) Haemorrhagic

( ) Eroded _____ ( ) Deformed _____

Gills: ( ) Normal ( ) Pale ( ) Mottled ( ) Haemorrhagic

( ) Necrotic ( ) Excessive mucus ( ) Hyperplasia

( ) Telangiectasia ( ) Gas emboli ( ) Cysts

( ) Large Parasites _____ ( ) Fungus Visible

OTHER: _____

N.B. In the event that a significant number of specimens at any site have abnormalities, the contractor is asked to immediately notify the Project Liaison Officer.
Phone: 427-1742 or fab to 422-3055