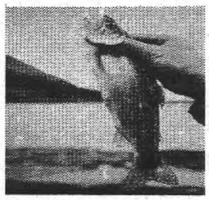
Canada Alberta Northwest Territories

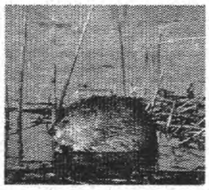
# Northern River Basins Study











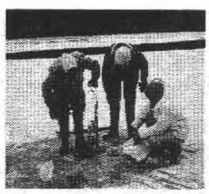


NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 119

# DIET, FOOD WEB AND STRUCTURE OF THE FISH COMMUNITY,

## LOWER SLAVE RIVER, JUNE TO DECEMBER, 1994 AND MAY TO AUGUST, 1995



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Prepared for the
Northern River Basins Study
under Project 3143-D3

by

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NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 119

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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.

F. J. Wrona — 14 May 96

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

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**

P. A. Larkin — 24 May /96

(Dr. P. A. Larkin, Ph.D., Chair) — (Date)

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 — May 29/96

(Lucille Partington, Co-chair) — (Date)

Robert McLeod — May 21/96

(Robert McLeod, Co-chair) — (Date)

# DIET, FOOD WEB AND STRUCTURE OF THE FISH COMMUNITY, LOWER SLAVE RIVER, JUNE TO DECEMBER, 1994 AND MAY TO AUGUST, 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$^{o}$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 diet, food web and seasonal changes in the structure of the fish community of the lower Slave River. Eighteenfish species were collected during the period of study and could be divided into three general groupings depending on their seasonal occupation and use of the river. Similarly, the food web structure was defined.

The results of this project will be combined with the other complementary fish projects dealing with life history (Report #118) and movement (Report # 117) investigations in the form of a synthesis report that will compare current findings with those of the 1980's.

## Report Summary

To determine the diet, food web and seasonal changes in structure of the fish community of the lower Slave River we sampled using gillnets, seines and set lines from late June to December, 1994 and from late May to late August, 1995. Catch per unit effort (CPUE) for each species over two week time periods was calculated as the number of fish per net panel per hour after standardization. The diet was determined by direct examination and classification of dietary items using the percent occurrence method. Eighteen fish species were collected in the Slave River area. The fish community may be characterized by three main types of fish: 1) highly migratory species, such as inconnu and lake whitefish, that spawn in the river in the fall and return to the lake for most of the year; 2) resident species, such as goldeye and flathead chub, that show distinct aggregations in the river in the spring, probably for spawning; and 3) resident species that did not show clear-cut aggregations such as walleye, northern pike, longnose sucker, white sucker and burbot. Based on the CPUE goldeye was the most abundant species by far. Moderately abundant species included the northern pike, walleye, lake whitefish, flathead chub and longnose sucker. White sucker was restricted to the Salt River, a tributary of the Slave River. Inconnu was rare except during the spawning migration. Burbot were also rare but this result may have been because this species was less vulnerable to the gear utilized. The piscine food web is layered into three major types of predator: 1) specialized, fish-only feeders, such as inconnu and burbot; 2) generalized opportunistic predators such as northern pike and walleye that consume both fish and invertebrates; and, 3) invertebrate feeders, such as lake whitefish, goldeye, flathead chub, longnose sucker and white sucker which consume a wide variety of prey items.

## 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 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. Kimberley Howland, Trevor Thera, Fern Saurette and Marc Lange provided professional direction in the field. 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. Fernand Saurette, Jim Reist and George Low of the Department of Fisheries and Oceans provided helpful reviews of earlier versions of the manuscript.

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# 1.0 Introduction

## Background and Rationale

Impacts of development on aquatic systems are often most noticeable, especially to the public, in their effects on fish populations. Many fish are the top predators in aquatic food chains. As such, they can be severely affected by the biomagnification of contaminants in the system (Begon et al. 1990). Compounds such as organochlorines are susceptible to biomagnification (Begon et al. 1990). Biomagnification is an increasing concentration of toxicant at higher trophic levels, as a result of a repeated cycle of concentration of the insecticide in particular tissues in a lower trophic level, consumption by the trophic level above, further concentration, further consumption, and so on, until top predators suffer extraordinarily high doses (Begon et al. 1990). For example, contaminants may be absorbed by aquatic vegetation or be absorbed into detritus. These materials become food for the invertebrate community in the river which, in turn, are food for the forage fish. The smaller invertebrate feeding species are eaten by larger predators such as inconnu or burbot. At each step the toxin is not excreted and accumulates in the tissues.

These same species can also be important as food for humans. Furthermore, the fish community and the inter-relationships, therein, must be understood to determine the pathway that a contaminant takes to arrive in the human population. As well, different fish species will have differing susceptibilities to the effects of aquatic contaminants. These can be at two levels: 1) debilitation of the individual fish which in turn alters the susceptibility to other stressors, and 2) outright lethality. In the former instance, the effects may cause alteration of the vital rates, such as age at maturity, fecundity or growth, and thereby affect population productivity. Therefore, the presence of contaminants may alter the structure of the fish community. 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, thus integration of effects will be most noticeable at this level.

Although the Slave River system has been noted by Katapodis and Yaremchuk (1994) as being highly vulnerable to resource development, the Slave River and its delta has been the least studied of the three watersheds having major deltas in the upper Mackenzie River Basin (Tripp et al. 1981). As many as 23 fish species occur in the lower Slave River proper, and it is also considered to be an important area for spawning of species, such as inconnu (*Stenodus leucichthys*), lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*) and walleye (*Stizostedion vitreum*) (Tripp et al. 1981).

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 (Bodden 1980). 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 (*Esox lucius*) and longnose suckers (*Catostomus catostomus*). Although a few people still fish throughout the year in the Slave River Delta, seasonal fishing is highly evident. Fishing intensity is generally greatest during the fall spawning migrations of the major species, especially lake whitefish, inconnu and burbot. Of an estimated 9715 fish taken in the Slave River Delta during the 1976-77 season, burbot accounted for 45% of the total catch, followed by lake whitefish (26%), longnose sucker (11%), inconnu (9%), northern pike (7%) , and walleye (1%) (Bodden 1980).

A substantial subsistence fishery also exists in the vicinity of Fort Smith during the fall period (McLeod et al. 1985) Inconnu contributed the greatest yield to the domestic catch (44% and 49% of the total catch by weight in 1983 and 1984, respectively); although, lake whitefish was numerically most abundant. In addition, significant subsistence fishery for burbot, taking roughly 4,408 kg in 1984-85, occurred at the Cunningham Landing/Salt River area (McLeod et al. 1985).

MacDonald and Smith (1993) also noted the importance of lake whitefish, inconnu and burbot in the Slave River basin in human subsistence fisheries. They noted that inconnu had the highest harvest, followed by lake whitefish and burbot. They listed eight species as being key species to monitor for changes in abundance, physical condition and contaminants: lake whitefish, inconnu, burbot, northern pike, walleye, goldeye (*Hiodon alosoides*), white sucker (*Catostomus commersoni*) and longnose sucker.

Historically, lake whitefish has been the most important species for commercial harvest in the Great Slave Lake, followed by lake trout (*Salvelinus namaycush*), inconnu, northern pike and walleye (Tripp *et al.* 1981). More recently, the dominant species have been lake whitefish, inconnu, walleye and burbot (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.

As industrial activities expand on the Peace and Athabasca Rivers, concerns are being raised about cumulative impacts of contaminants on fish and water resources downstream, including those in the Slave River. The degree of accumulation and transport of contaminants depend upon their concentrations in the ecosystem, biomagnification effects in the aquatic ecosystem, and the behaviour and biology of the fish species involved. In particular, the patterns of movement and diet of a fish will determine its exposure and the extent to which it is affected by contaminants as well as the extent to which contaminants in its flesh are passed on to higher trophic levels. To understand the effects of ecosystem change on fish one must therefore understand their movement patterns in time and space, their dietary and trophic (food web) relationships, and their population demographics.

Synthesis of dietary information and analysis of the food web of the Slave River aquatic ecosystem are generally absent from previous studies; particularly lacking are studies of seasonal variation in the diets among fish in the lower Slave River. Tripp et al. (1981) recorded gut contents on a number of species but provide no synthesis of this information, whereas McLeod et al. (1985) and Boag and Westworth (1993) did not examine trophic relationships. Therefore, during 1994 and 1995, we investigated the seasonal variation in the diets among fish in the lower Slave River at all levels of the food web.

## 2.0 Materials and Methods

### 2.1 Study Areas

The Slave River is, by far, the largest tributary into Great Slave Lake (Fig. 1.) The Slave River basin in the Northwest Territories drains an area of 2,252 $km^2$. From the Rapids of the Drowned at Fort Smith, NT, the river flows approximately 320 km to the Slave River Delta at Great Slave Lake. Three study areas were chosen for comparison: 1) the Slave River Delta, 2) the Slave River, immediately downstream of the Rapids of the Drowned near Fort Smith, NWT (60°00'N, 111°53'W), and, 3) the lower Salt River.

The Slave River Delta is located midway along the south shore of Great Slave Lake approximately 13 km north-east of Fort Resolution (61°10'N, 113°40'W), where it covers an area of approximately 78 $km^2$ (English 1979). The delta is represented by very diverse habitat types, compared with the main-stem river proper, as a result of the numerous and variably sized channels. Landforms range from large mud flats on the outer edges of the Delta, to cut-bank levees ranging in height from 0.25 m to 3 m (English 1979). Shoreline habitat ranges from heavily vegetated shorelines on gently sloping banks to steeper banks with narrow littoral zones and little vegetation.

The delta consists of four main channels that connect the Slave River to Great Slave Lake: 1) Resdelta, 2) Middle Channel, 3) Old Steamboat Channel and 4) East Channel. Most delta sampling occurred along these channels (Fig. 2). Resdelta Channel is the largest channel through the delta, accounting for 86% of the water flow (Tripp *et al.* 1981), with maximum depths ranging from 12 to 32 m (Tripp *et al.* 1981; per. obs). The other main channels ranged from five to 12 m deep with depths of one to two m in minor channels.

The lower Slave River near Fort Smith (Fig. 3) is a more homogenous system with a maximum width of approximately three km (Vanderburgh and Smith 1988) and is characterized by turbid, fast-flowing water and steep river banks. The cut-bank levees can reach up to 35m high (Vanderburgh and Smith 1988) and, consequently, very narrow littoral zones result, deterring the establishment of aquatic vegetation. This in turn affects the diversity of the fish fauna.

The Salt River, is the largest tributary on the Slave River, located 25 km downstream of Fort Smith (Fig. 4). It is a meandering and narrow river, compared with the Slave River, with an average maximum depth of 1 to 2 m and a maximum width of about 60 m. It also differs from the Slave River by the greater amounts of aquatic vegetation present. The Salt River is a particularly important refuge area for migratory and feeding fishes.

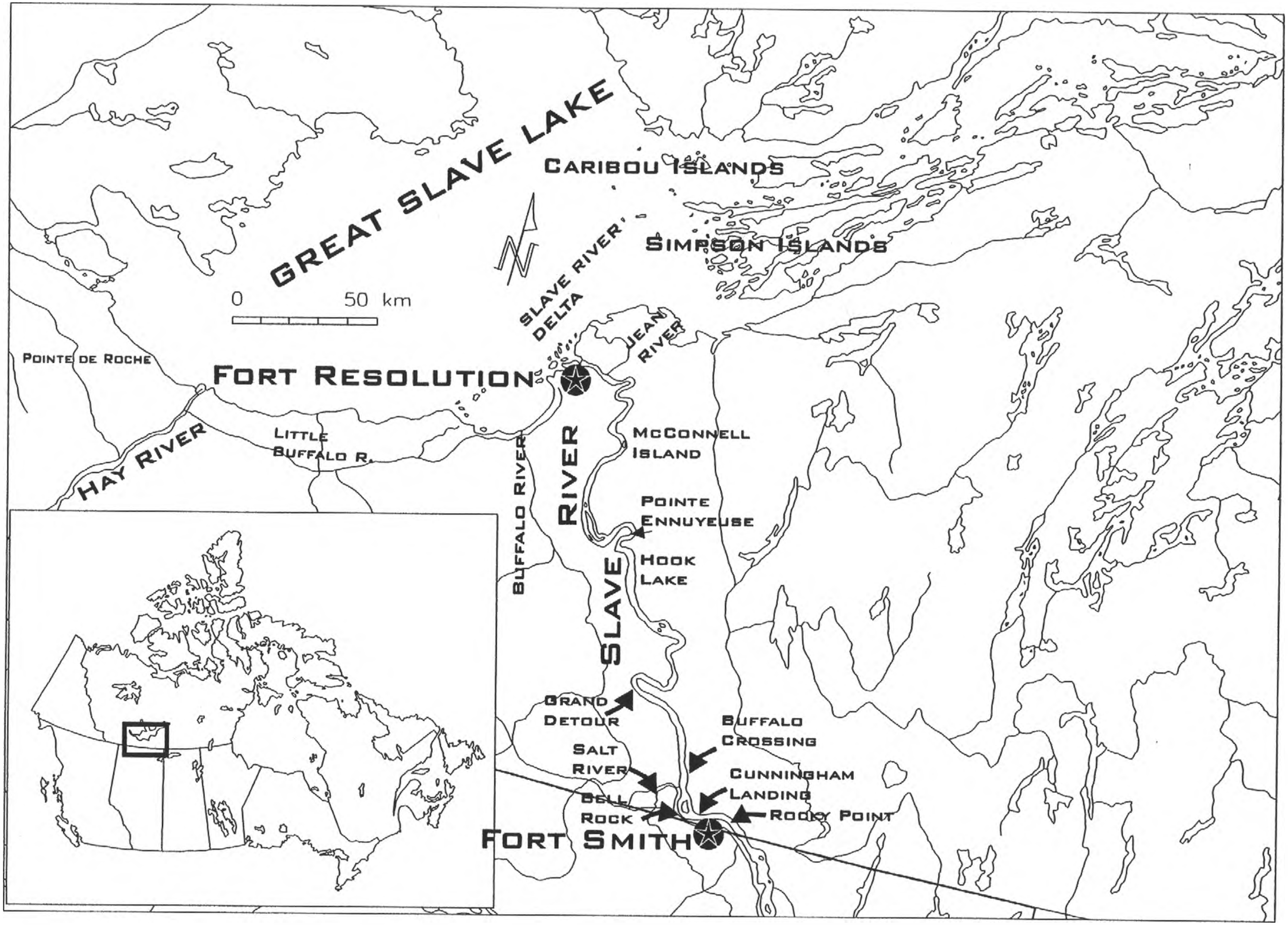


Figure 1. The study area showing the Slave River, Slave River Delta, Great Slave Lake, Fort Resolution and Fort Smith.

# Slave River Delta

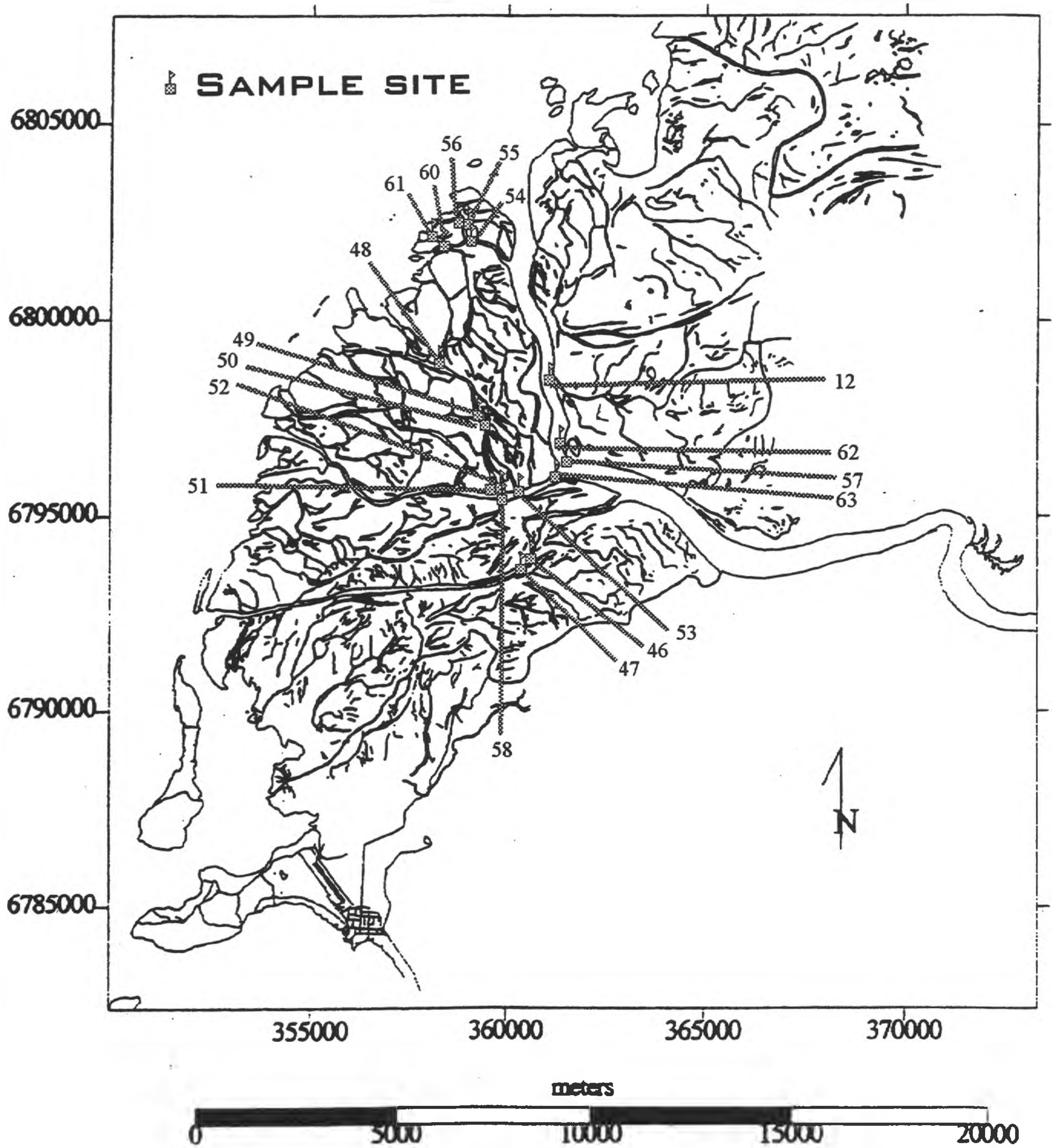


Figure 2 Detailof the Slave River Delta (reprinted with permission of English, Hill, Ormson and Stone. (N.R.B.S. Report, 1996) showing sampling stations.

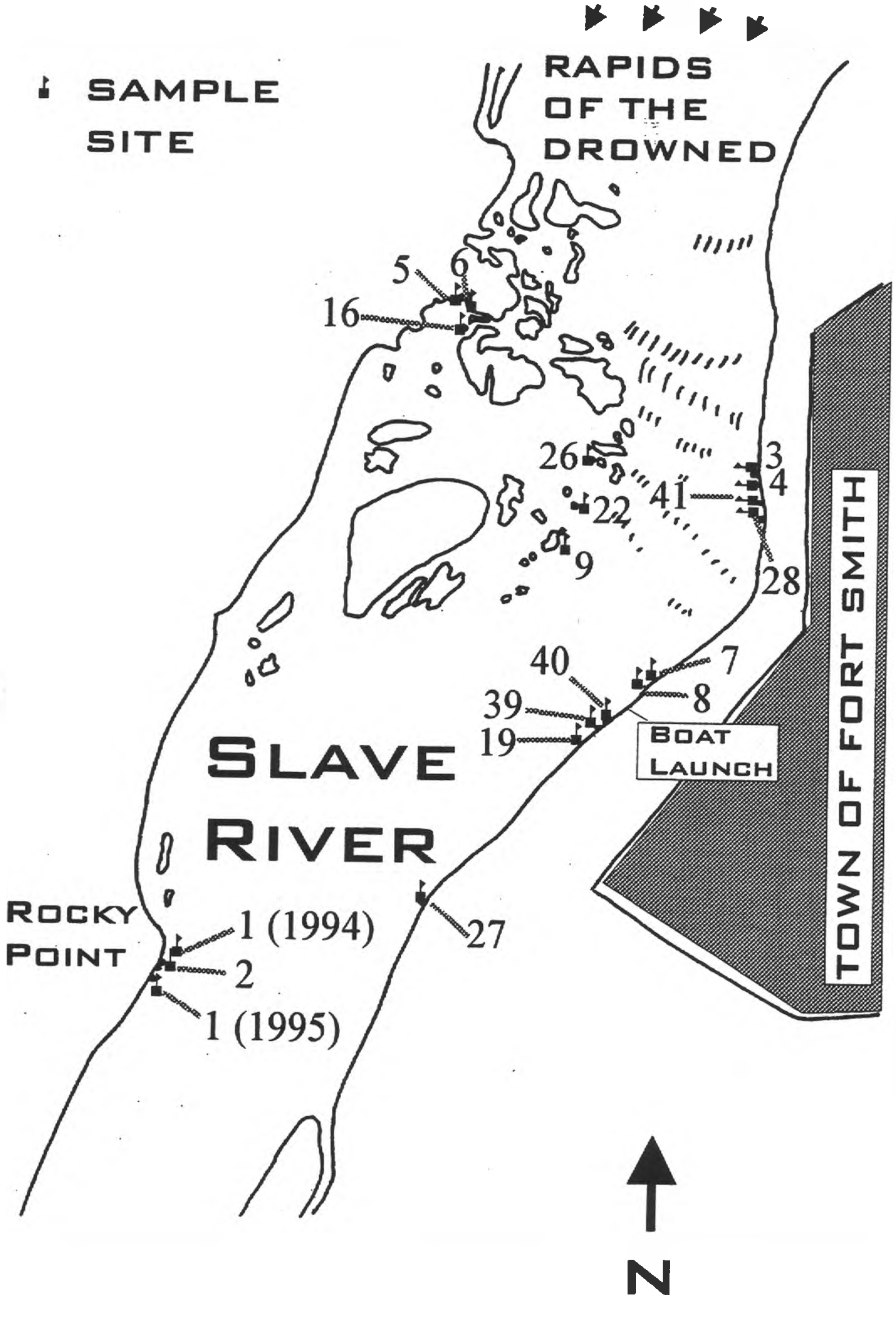


Figure 3. Sampling stations on the lower Slave River at Fort Smith.

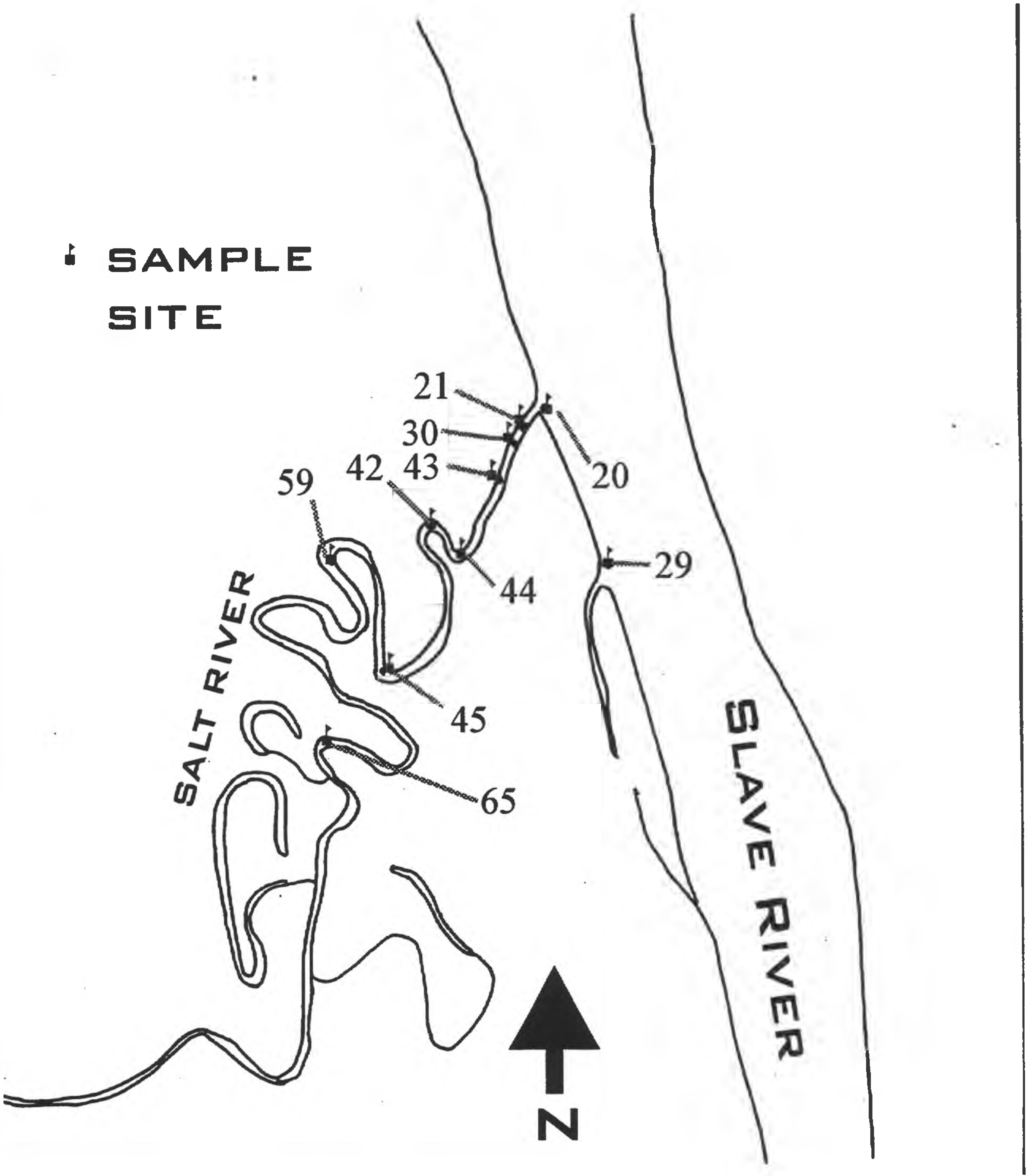


Figure 4. Detail of Salt River and sampling stations.

## 2.2 Collection of fish samples

In the Slave River system, there is a diverse fish community with up to 23 species having been recorded (McLeod et al. 1985; Tripp et al. 1981). Fish were collected during the open-water period every two to four times per week from the lower Slave River site near Fort Smith and the Slave River Delta in 1994 and 1995. Fish species documented during this study are listed in Table 1.

Fish were collected using various sampling techniques to reduce effects of gear selectivity on species and sizes of fish caught. Collecting methods included: 1) two types of experimental multi-mesh gillnets, 1.8 m deep, each made up of three 10m panels of different meshes (38, 51 and 63.5 mm; and 76, 89 and 102 mm stretched mesh), 2) single-mesh gillnets, 25 m in length, 1.8 m and 2.4 m deep (each net of 114 mm or 133 mm stretched mesh); 3) a 16.8 m beach seine, 1.2 m deep with a 5 mm stretch mesh and 4) set lines. Set lines are more effective in catching piscivorous fish, such as burbot, that live mainly at the bottom of the river; due to the strong current, gillnets set at the river bottom would be buried by bottom sediments. Upstream beach seine sweeps were used to capture small fish near shore, such as minnows and young-of-the-year fish, which were too small to be captured by gillnet. However, the main fish collection method was gillnets set in backeddies.

Gillnets were set for 3- to 4-h periods, distributed throughout the 24-h diel cycle. The following habitat parameters were measured at every net check: water current, depth of net set and water flow direction in the back-eddies; as well, water temperature, presence or absence of vegetation and weather conditions were recorded. Water current readings were measured using a Magnetic Flow Meter. River discharge rates and continuous water temperatures were obtained from Water Survey Canada, Fort Smith, NT.

## 2.3 Determination of Catch-per-unit-effort (CPUE)

Results were analyzed using the following variables: 1) netting periods: June16-30, July16-31, 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 in 1994 and May 16-31, June 1-15, June16-30, July 1-15, July16-31, August 1-15, August 16-31 in 1995. Where only a portion of days were covered in the time period (e.g. 16-30 June) the total was extrapolated assuming the sampling days could 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. 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 CPUEwas 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 two meter deep net.

The catch/effort ratio was calculated for each set by dividing the standardized catch for that set by the soak time (in hours).

The results were analyzed using a factorial design analysis of variance (Kuttner et al. 1989) with main effects being netting period, net location, and mesh size as well as possible interaction effects as part of the model. The model was :

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

where: CE = Catch/Effort,

$\mu$ = The overall mean CE,

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 variation consisting of variance not explained by model effects and the error variance

To plot the CPUE, the catches were standardized to the most common mesh size - 130mm. Standardization was done by estimating for each mesh size the catchability of inconnu relative to the 130mm mesh size.

## 2.4 Environmental Variables

Physical factors that could potentially influence fish movements were systematically recorded at each study area during the 1994 open-water study period. Water temperature was recorded at each sampling event and location (i.e., each net pull). Information on river levels and discharge for the Fort Smith area was obtained from the Water Survey of Canada Station at Fort Fitzgerald (Station 07NB001). We calculated the Pearson product-moment correlation (Sokal and Rohlf 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.

## 2.5 Fish Processing

The following biological data were collected from individual fish: total length (nearest mm), fork length (nearest mm), standard length (nearest mm) and total weight (nearest g), sex and stage of maturity. Aging structures (scales, pectoral fin rays, and otoliths) and stomachs were removed and preserved for subsequent analysis.

## 2.6 Diet Analysis

For the analysis of stomach contents, the complete digestive tract, from the oesophagus to the anus, was removed and frozen within three h after capture. In the laboratory, stomach contents were sorted into taxonomic categories, weighed and measured. Weight (nearest g), total lengths (nearest mm) and maximum body depths (nearest mm) were measured for fish prey items. The *frequency of occurrence*, and the *percentage composition* of prey categories *by number* and *by weight* of all prey taxa found in fish stomachs were calculated for each fish species to estimate the relative importance of those food taxa in a species' diet (Hyslop 1980). The Relative Importance Index (George and Hadley 1979) was computed. This is essentially a mean of the three diet measures for each food category (Wallace 1981).

Relative Importance Index by George & Hadley (1979) =

$$AI = \%\ \text{frequency occurrence} + \%\ \text{total numbers} + \%\ \text{total weight},$$

$$RI = 100\ AI \Big/ \sum_{1}^{n} AI$$

where $n$ = the number of different food types,

% frequency of occurrence = the percentage of all stomach containing food in which each food category occurred.

% total numbers = the percentage that each food category contributed to the total number of food items in all stomachs.

% total weight = the percentage that each food category contributed to the total weight of food in the stomach.

For stomach contents containing only digested remains of fish prey, diagnostic hard bone structures such as otoliths and pharyngeal arches were used to identify ingested prey items where possible.

Food relationships between species were calculated using the dietary overlap index of Schoener (1974):

$$\alpha = 1 - 0.5 \, (\Sigma \mid p_{xi} - p_{yi} \mid)$$

where $\alpha_{xy}$ is the overlap between species $y$ and species $x$; $p_{yi}$ is the proportion of food taxa $i$ in the diet of species $y$; $p_{xi}$ is the proportion of food taxa $i$ in the diet of species $x$. The index ranges from 0 (no overlap) to 1 (complete overlap); an index value of 0.3 or less indicates little overlap in the diets; an index value of 0.7 or more indicates a high degree of overlap (Keast 1978).

## 3.0 Results

Eighteen fish species were captured in the Slave River and delta during the course of the study (Table 1). A most notable exception were ciscoes (*Coregonus spp.*) observed by Tripp et al. (1981).

## 3.1 Catch Results

### 3.1.1 Inconnu

Inconnu first appeared in the Slave River near the beginning of August, 1994 (Table 2, Fig. 5). The run had two peaks, the first between September 1 and September 15, and the second between October 1 and 15, 1994 and was estimated to have ended in the latter part of October. By October 21, most inconnu appeared to had left the Slave River. However, due to the formation of the ice few sets were made during this period. In 1995, sampling was discontinued by the end of August. Inconnu CPUE in 1995 was low but began increasing in August ( Table 2, Fig. 6).

For 1994 the time period of capture ($p = 0.0454$) had significant effects on the CPUE while meshsize did not ($P = 0.1667$) All interactions were non-significant (e.g., time period by mesh size - $P = 0.7982$). For 1995, time period, mesh size and the interaction between mesh size and time period were all significant ( $P < 0.0001$ for all effects).

Inconnu first entered the system in August when water temperatures were between 19 and 20° C and continued to enter throughout the fall period as temperatures declined to around 10° C (Fig. 7). They exited at much lower temperatures with the last fish leaving when the water temperature was around 5° C. There was a significant negative correlation (Pearson Product Moment Correlation, $r = -0.92893$) between the water temperature and the CPUE of inconnu ($P = 0.0009$).

Inconnu enter the system when discharge levels are beginning to taper off but are still high (around 4000 to 5000 cubic meters per second) (Fig. 8). 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 ($r = -0.009$, $P = 0.9765$).

### 3.1.2 Burbot

Burbot were only occasionally captured in the gillnets, thus, their apparent abundance was quite low (Table 3, Fig. 9). This might have reflected their lack of numbers or their lack of movement during most of the season. Burbot were more readily caught using set lines which is the method employed by local fishermen targeting burbot after freeze-up. The lack of abundance precluded meaningful statistical analyses of CPUE by time period, location and mesh size for this species.

Table 1. List of scientific names, common names, and codes for fish species collected in the lower Slave River, Slave River Delta and Salt River, 1994 to 1995.

| Family and Scientific Name | Common Name | Code | Locations Captured |
|---|---|---|---|
| Petromyzontidae | | | |
| *Lampetra japonica* | arctic lamprey | ARLP | Slave R./ Delta |
| Salmonidae | | | |
| *Salvelinus namaycush* | lake char | LKTR | Delta |
| *Coregonus clupeaformis* | lake whitefish | LKWT | Slave R./Delta/Salt R. |
| *Stenodus leucichthys* | inconnu | INCO | Slave R./Delta |
| Esocidae | | | |
| *Esox lucius* | northern pike | NTPK | Slave R./Delta/Salt R. |
| Hiodontidae | | | |
| *Hiodon alosoides* | goldeye | GOLD | Slave R./Delta/Salt R. |
| Cyprinidae | | | |
| *Couesius plumbeus* | lake chub | LKCB | Delta |
| *Platygobio gracilis* | flathead chub | FHCB | Slave R./Delta/Salt R. |
| *Notropis atherinoides* | emerald shiner | EMSH | Slave R./Delta/Salt R. |
| *Notropis hudsonius* | spottail shiner | SPSH | Slave R./Delta/Salt R. |
| Catostomidae | | | |
| *Catostomus catostomus* | longnose sucker | LNSK | Slave R./Delta/Salt R. |
| *Catostomus commersoni* | white sucker | WTSK | Salt R. |
| Gadidae | | | |
| *Lota lota* | burbot | BRBT | Slave R./Delta/Salt R. |
| Gasterosteidae | | | |
| *Pungitius pungitius* | ninespine stickleback | NSST | Slave R./Delta/Salt R. |
| Percopsidae | | | |
| *Percopsis omiscomaycus* | trout-perch | TRPH | Slave R./Delta/Salt R. |
| Percidae | | | |
| *Stizostedion vitreum vitreum* | walleye | WALL | Slave R./Delta/Salt R. |
| *Perca flavescens* | yellow perch | YWPH | Slave R./Delta* |
| Cottidae | | | |
| *Cottus ricei* | spoonhead sculpin | SPSC | Slave R./Delta/Salt R. |

Table 2. The mean catch-per-unit-effort of inconnu (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0 | 5 | 0 | 0 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.5906 | 42 | 3.0766 | 0.4747 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 3.3676 | 37 | 12.6495 | 2.0796 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 6.0273 | 63 | 19.1550 | 2.4133 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 10.1719 | 49 | 29.8787 | 4.2684 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 7.4523 | 26 | 29.9597 | 5.8756 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 13.5683 | 32 | 36.5826 | 6.4670 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0 | 2 | 0 | 0 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 0 | 6 | 0 | 0 |
| 15 | 1995 | June 1 - June 15 | 0 | 28 | 0 | 0 |
| 16 | 1995 | June 16 - June 30 | 0.1863 | 20 | 0.8330 | 0.1863 |
| 17 | 1995 | July 1 - July 15 | 0 | 26 | 0 | 0 |
| 18 | 1995 | July 16 - July 31 | 0.1547 | 39 | 0.9558 | 0.1547 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 1.8027 | 36 | 5.1515 | 0.8586 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 0.9932 | 5 | 1.0185 | 0.4555 |

Table 3. The mean catch-per-unit-effort of burbot (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0.083 | 5 | 0.186 | 0.083 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.014 | 42 | 0.091 | 0.014 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 0 | 37 | 0 | 0 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 0.0029 | 63 | 0.0178 | 0.002 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 0 | 49 | 0 | 0 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 0 | 26 | 0 | 0 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 0.024 | 32 | 0.0900 | 0.011 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0 | 2 | 0 | 0 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 0 | 6 | 0 | 0 |
| 15 | 1995 | June 1 - June 15 | 0 | 28 | 0 | 0 |
| 16 | 1995 | June 16 - June 30 | 0 | 20 | 0 | 0 |
| 17 | 1995 | July 1 - July 15 | 0 | 26 | 0 | 0 |
| 18 | 1995 | July 16 - July 31 | 0 | 39 | 0 | 0 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0 | 36 | 0 | 0 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 0 | 5 | 0 | 0 |

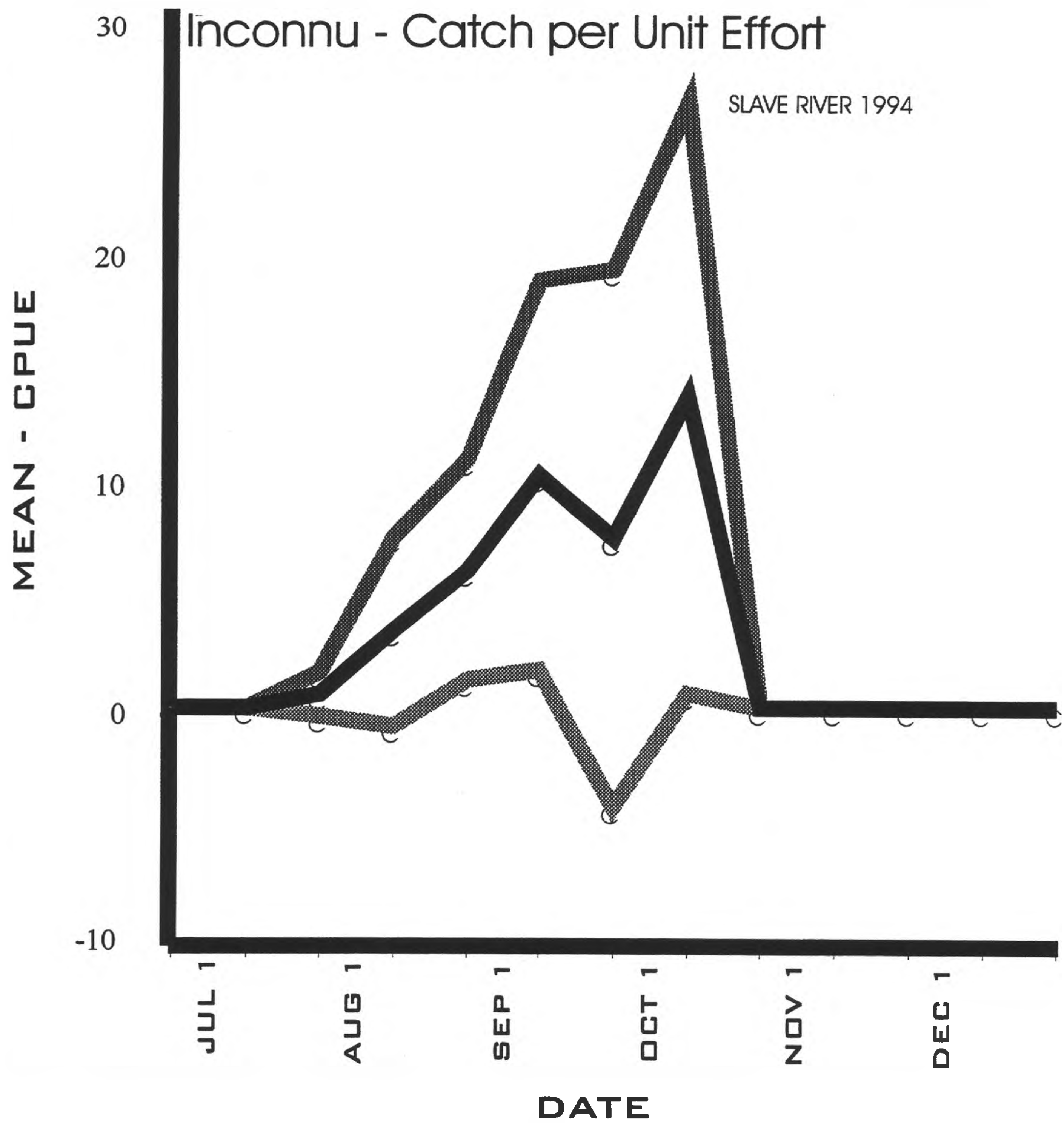


Figure 5 Catch per unit effort (number of fish per hour for standardized net) of inconnu in the Slave River in 1994 against calendar date.

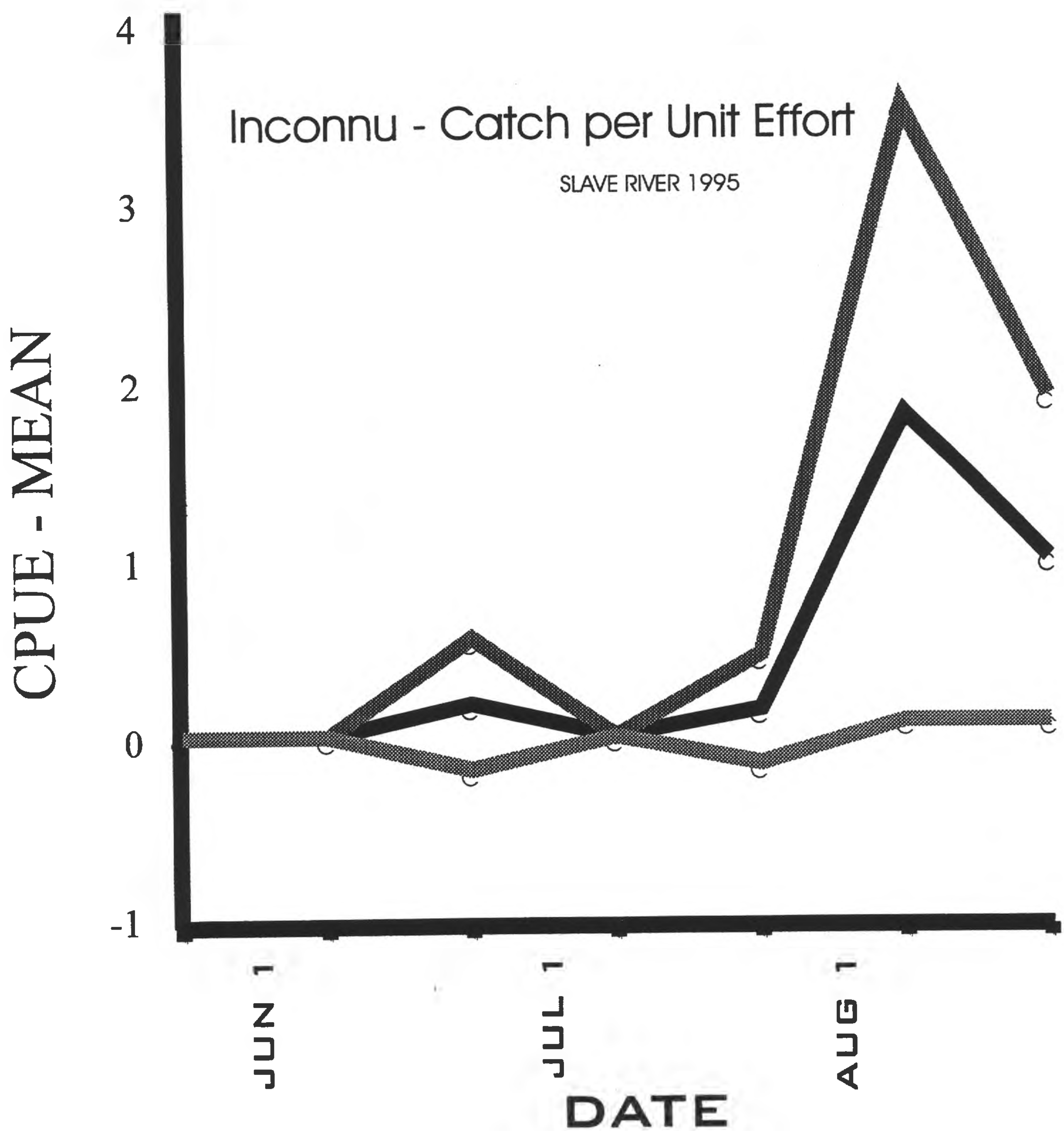


Figure 6 Catch per unit effort (number of fish per hour for standardized net) of inconnu in the Slave River in 1995 against calendar date.

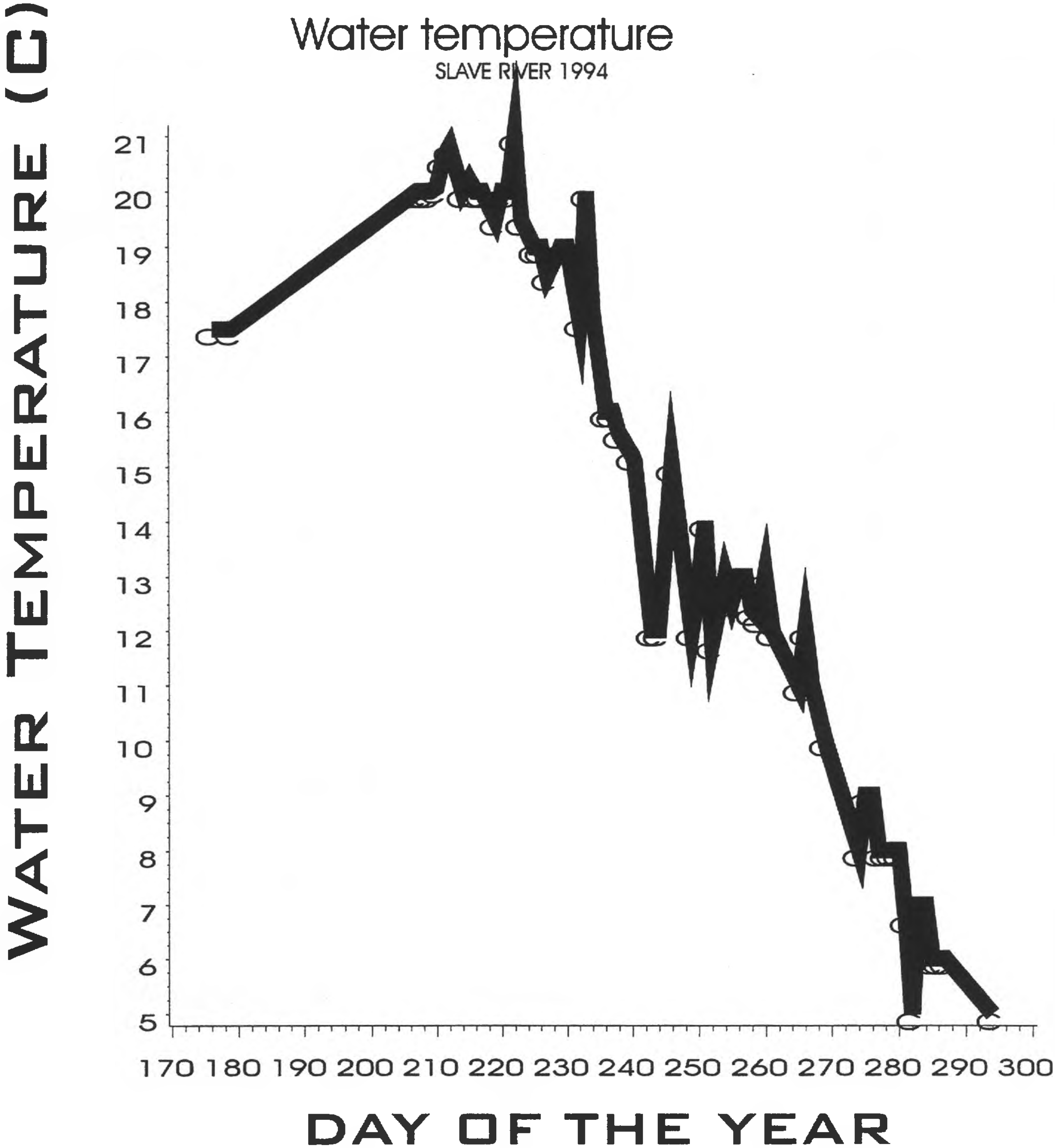


Figure 7. Water temperature (C - degrees Celsius) against calendar date for the Slave River in 1994.

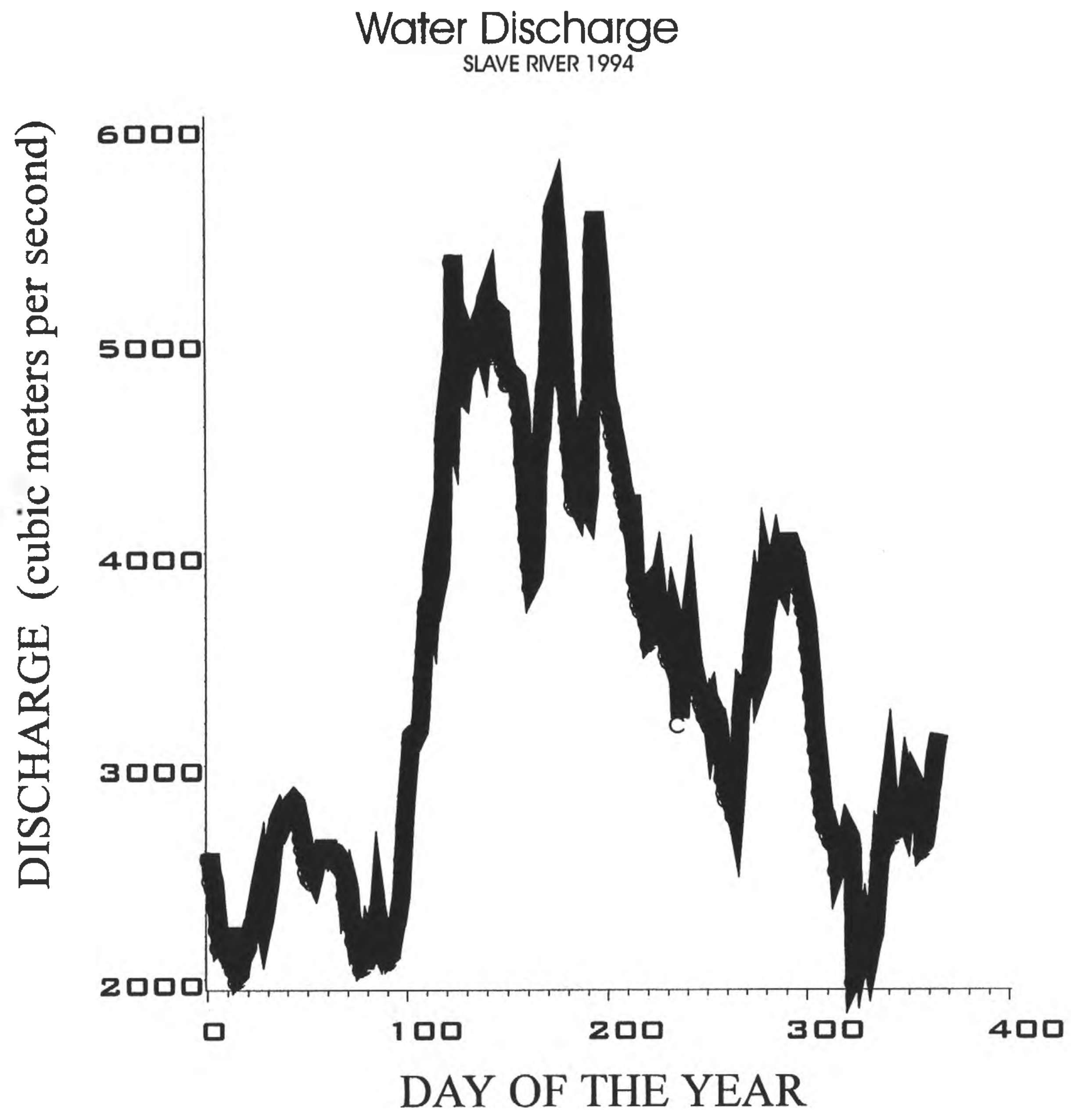


Figure 8. Water discharge in the lower Slave River in 1994.

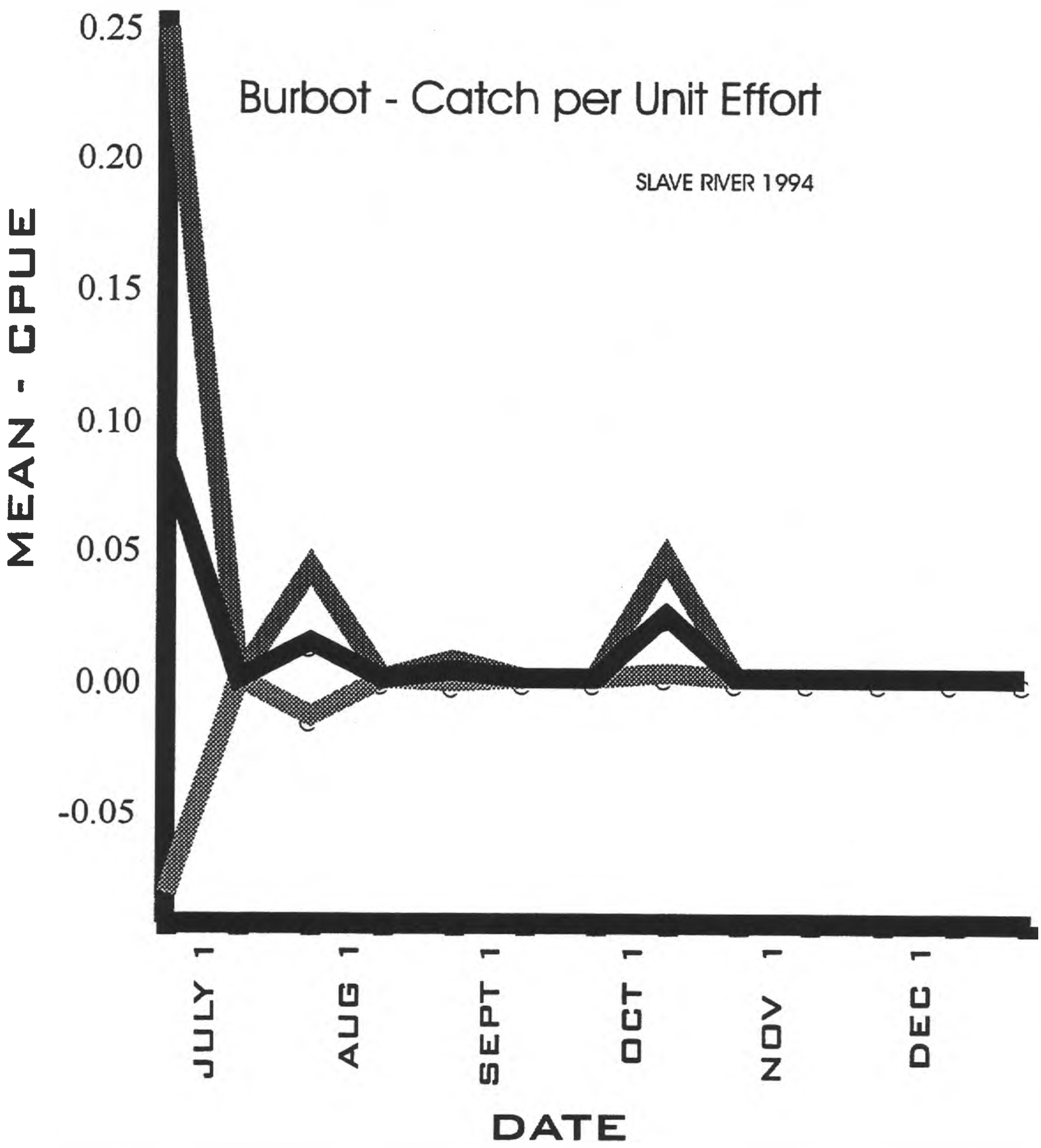


Figure 9. Catch per unit effort (number of fish per hour for standardized net) of burbot in the Slave River in 1994 against calendar date.

### 3.1.3 Flathead Chub

Flathead Chub were present in the system in moderate to low numbers from the end of June to the end of October in 1994 (Table 4, Fig. 10). The absence of flathead chub in catches after the 15th of October may have been due to inactivity on the part of the fish or the lack of sampling effort. Flathead chub CPUE is substantially higher at the end of May and early June in 1995 (Table 4, Fig. 11). By July, 1995 the numbers had returned to levels similar to the 1994 results.

In 1994, mesh size had a significant effect on the CPUE ($P < 0.0001$) whereas time period did not ($P = 0.2422$) All interactions (e.g., time period by mesh size - $P = 0.3723$) were non-significant. In contrast, time period, mesh size and the time period by mesh size interaction were all significant in 1995 ($P < 0.0001$, $P = 0.0058$, and $P = 0.0020$, respectively).

There was no significant correlation ($r = -0.0081$) between the water temperature and the CPUE of flathead chub ($p = 0.9849$). There was no significant correlation between flathead chub CPUE and discharge level in the system ($r = 0.1496$, $p = 0.6257$, Fig. 8).

### 3.1.4 Goldeye

Goldeye were abundant in the system with peak catches occurring first between August 1 and August 15 and and again between October 15 and October 31, 1994 (Table 5, Fig. 12). They were undoubtably the most dominant fish in the Slave River system. The low catches in the November to December period was likely a result of limited sampling. Goldeye CPUE was at its highest at the end of May and early June, 1995 (Table 5, Fig. 13). By July, 1995, the numbers had returned to levels similar to the 1994 results.

In 1994, mesh size had significant effects ($P < 0.0001$) on the CPUE while time period did not ($P = 0.1702$) All interactions (eg. time period by mesh size - $P = 0.2093$) were non-significant. Contrastingly, time period was significant in 1995 ($P < 0.0001$) while mesh size and interactions were not significant ( $P = 0.2420$, and $P = 0.9243$, respectively).

Correlation between the water temperature and the CPUE of goldeye was not significant ($r = 0.0410$ $P = 0.9232$, Fig. 7). There was no significant correlation between goldeye CPUE and discharge level in the system ($r = 0.2725$, $P = 0.3678$, Fig. 8).

Table 4. The mean catch-per-unit-effort of flathead chub (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0.1667 | 5 | 0.3727 | 0.1667 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.1303 | 42 | 0.4660 | 0.0719 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 0.5985 | 37 | 1.7169 | 0.2823 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 0.1433 | 63 | 0.7048 | 0.0888 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 0.5775 | 49 | 2.6472 | 0.3782 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 0.1282 | 26 | 0.6537 | 0.1282 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 0.0343 | 32 | 0.1943 | 0.0343 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0 | 2 | 0 | 0 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 13.3333 | 6 | 25.5821 | 10.4439 |
| 15 | 1995 | June 1 - June 15 | 4.7499 | 28 | 11.8651 | 2.2423 |
| 16 | 1995 | June 16 - June 30 | 0 | 20 | 0 | 0 |
| 17 | 1995 | July 1 - July 15 | 0.1357 | 26 | 0.4032 | 0.0791 |
| 18 | 1995 | July 16 - July 31 | 0.3718 | 39 | 1.5246 | 0.2441 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0.0579 | 36 | 0.2470 | 0.0412 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 0.9932 | 5 | 1.0185 | 0.4555 |

Table 5. The mean CPUE of goldeye (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 1.1333 | 5 | 1.7575 | 0.7599 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 6.7262 | 42 | 9.2742 | 1.4310 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 24.9315 | 37 | 72.2862 | 11.8838 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 7.7156 | 64 | 31.4412 | 3.9302 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 0.9629 | 48 | 2.6544 | 0.3831 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 1.7405 | 26 | 4.5131 | 0.8851 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 5.9697 | 32 | 11.5922 | 2.0492 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 10.5982 | 2 | 2.4175 | 1.7094 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 4 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 2 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 89.6136 | 6 | 116.825 | 47.6936 |
| 15 | 1995 | June 1 - June 15 | 56.9072 | 28 | 90.7637 | 17.1527 |
| 16 | 1995 | June 16 - June 30 | 5.2228 | 20 | 7.9946 | 1.7876 |
| 17 | 1995 | July 1 - July 15 | 3.0925 | 26 | 6.2607 | 1.2278 |
| 18 | 1995 | July 16 - July 31 | 4.5068 | 39 | 8.0106 | 1.2827 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 4.9309 | 36 | 9.4803 | 1.5801 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 3.4179 | 5 | 5.1652 | 2.3099 |

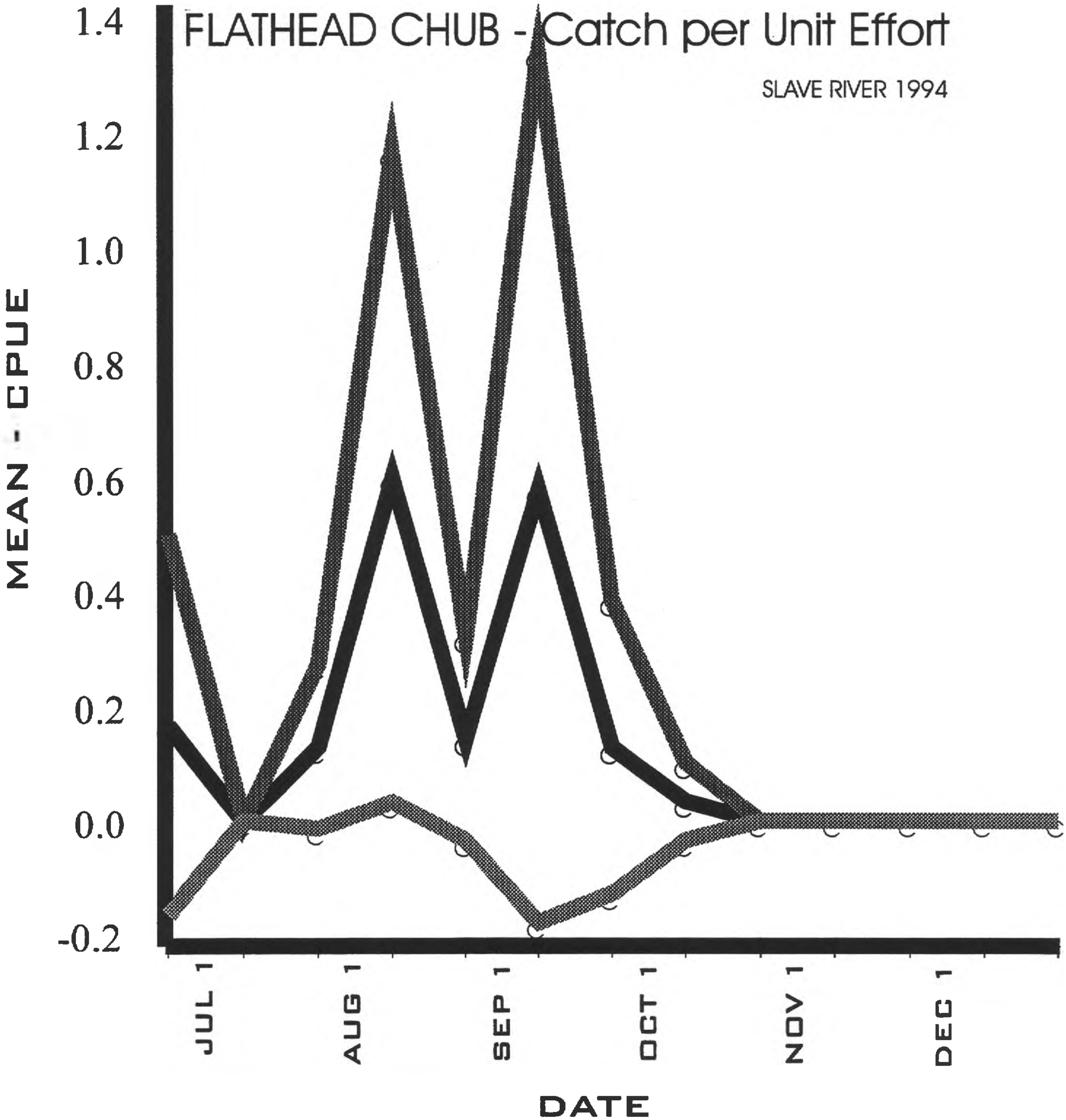


Figure 10. Catch per unit effort (number of fish per hour for standardized net) of flathead chub in the Slave River in 1994 against calendar date.

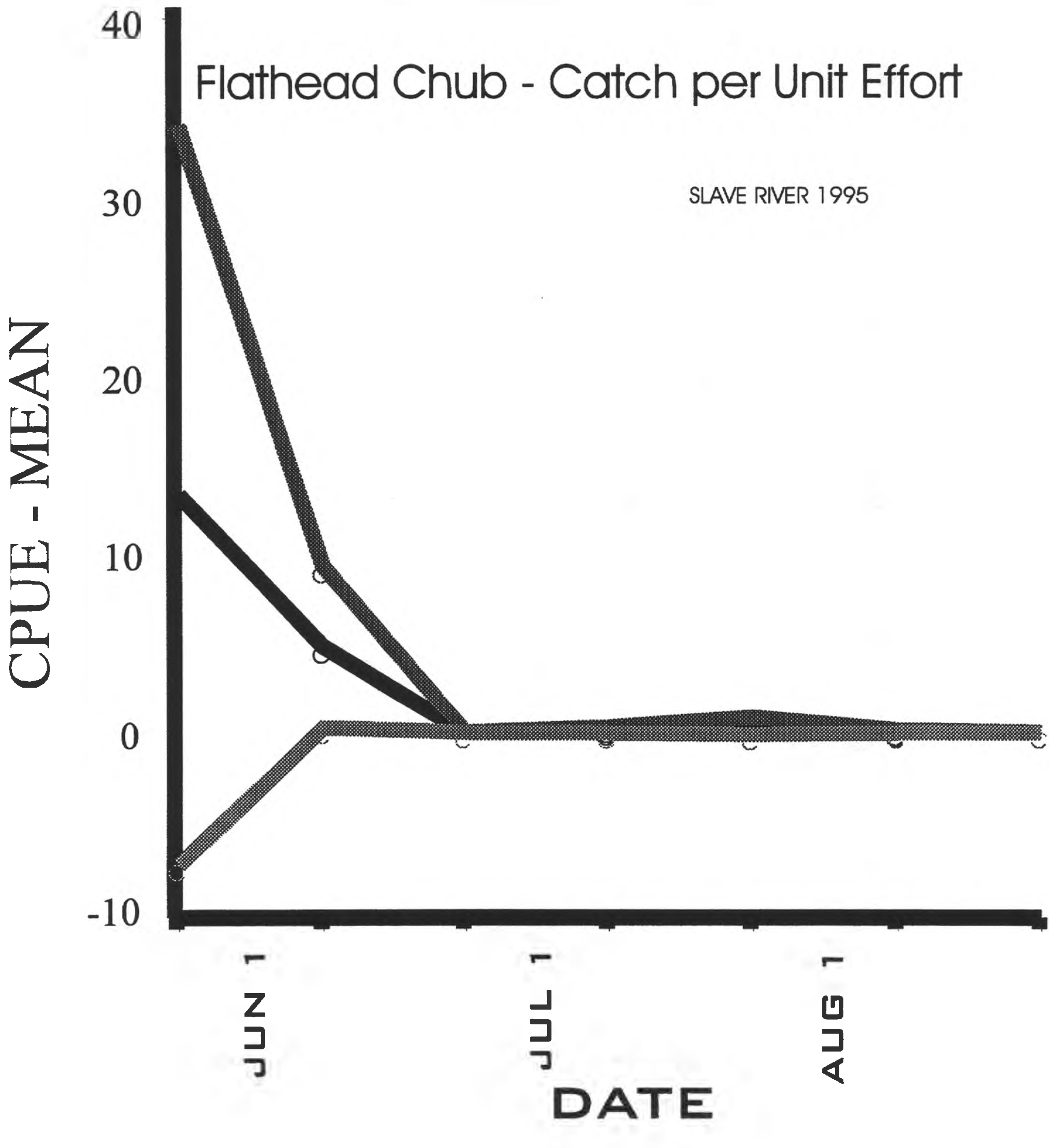


Figure 11. Catch per unit effort (number of fish per hour for standardized net) of flathead chub in the Slave River in 1995 against calendar date.

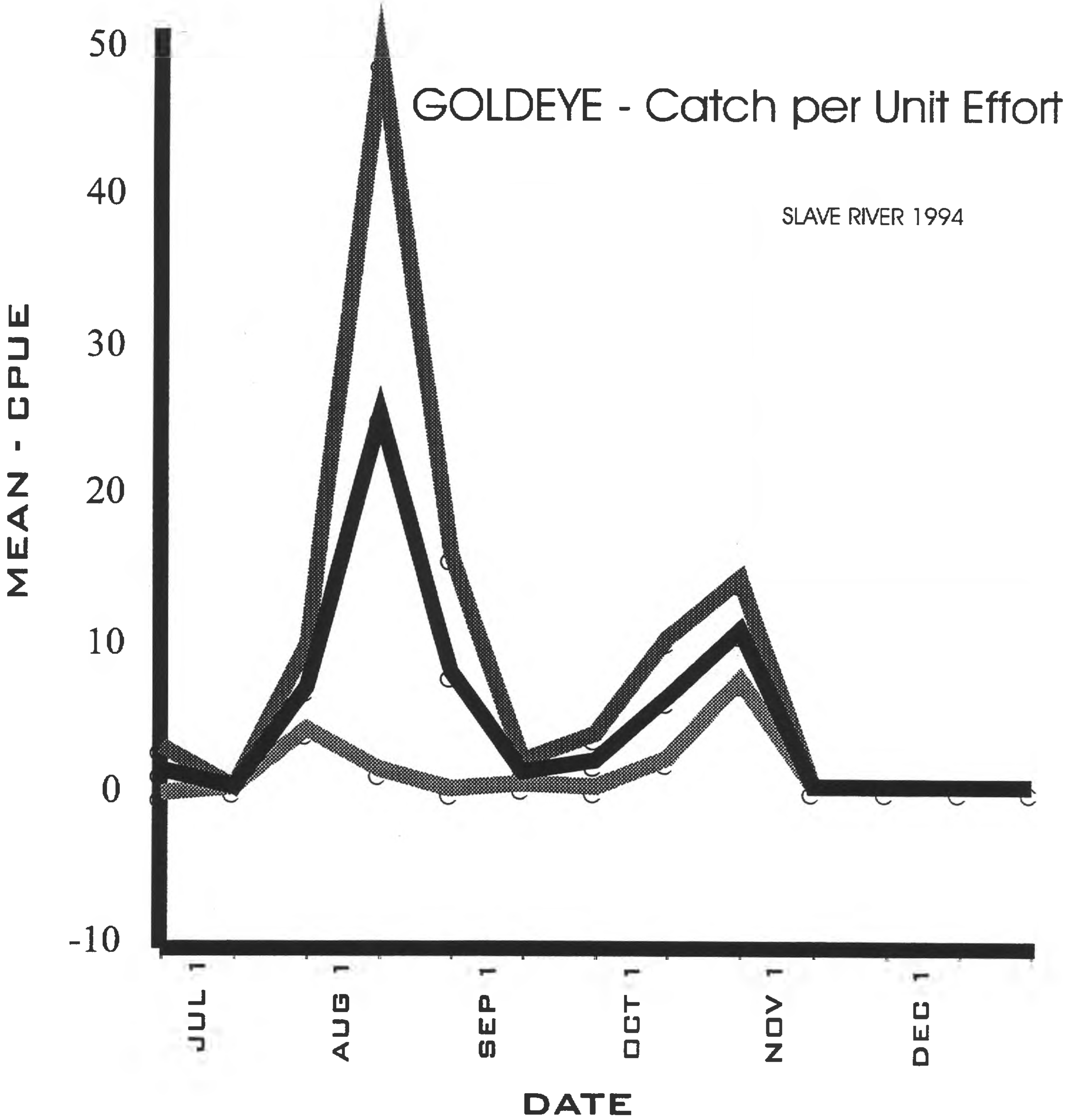


Figure 12. Catch per unit effort (number of fish per hour for standardized net) of goldeye in the Slave River in 1994 against calendar date.

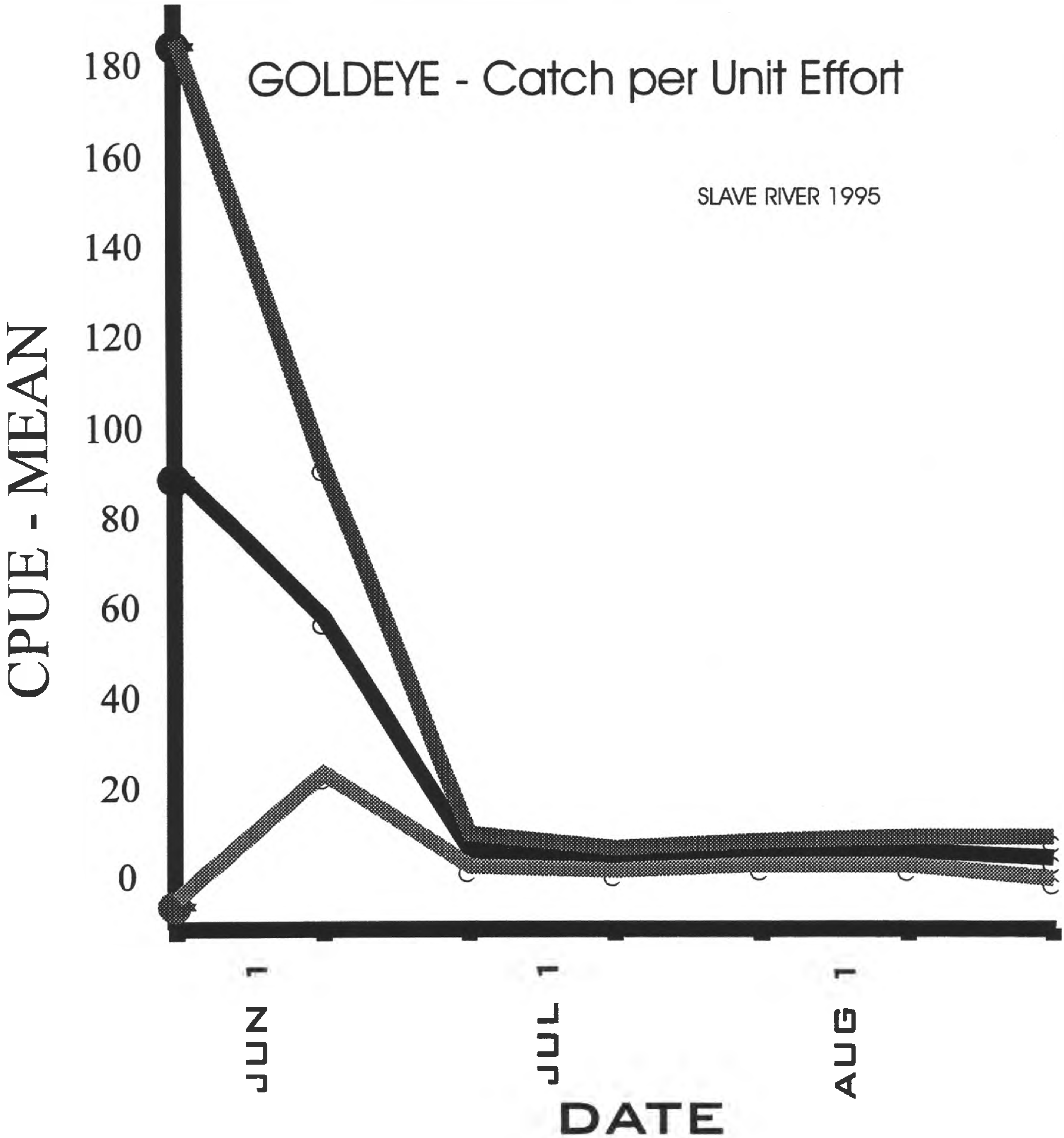


Figure 13. Catch per unit effort (number of fish per hour for standardized net) of goldeye in the Slave River in 1995 against calendar date.

### 3.1.5 Lake Whitefish

Lake whitefish became abundant in August and the CPUE steadily climbed to a peak in the first two weeks of October, 1994 (Table 6, Fig. 14). By the beginning of November lake whitefish appeared to have left the Slave River. However, due to the formation of the ice few sets were made during this period. In 1995, sampling was discontinued by the end of August. Lake whitefish CPUE in 1995 was high early in June and then showed a similar pattern to that of 1995 (Table 6, Fig. 15). The early high CPUE was due to the capture of large numbers of juveniles in the Salt River which was sampled more intensively than in the previous year. The Salt River appears to be a nursery area for lake whitefish.

For 1994 and 1995 the time period ($P = 0.0479$, $P < 0.0001$, respectively) and mesh size ($P < 0.0001$, $P = 0.0199$, respectively) had significant effects on the CPUE while interactions (eg. time period by mesh size - $P = 0.1117$, $P = 0.3417$) were non-significant.

Lake whitefish CPUE began increasing in August when water temperatures were between 19 and 20° C. Whitefish continued to enter throughout the fall period as temperatures declined to around 10° C (Fig. 7). They exited at much lower temperatures with the last fish leaving when the water temperature was around 5° C. There was a significant negative correlation ($r = -0.8668$) between the water temperature and the CPUE of lake whitefish ($P = 0.0053$).

Lake whitefish entered the system when discharge levels were beginning to taper off but were still high (around 4000 to 5000 cubic meters per second) (Fig. 8). The discharge level fell steadily throughout the fall to a level of 2000 cubic meters per second. There was no significant correlation between lake whitefish abundance and discharge level in the system ($r = .1246$, $P = 0.6850$).

### 3.1.6 Longnose sucker

Longnose suckers were present in low numbers during the open water sampling period in 1994 (Table 7, Fig. 16). In 1995, longnose sucker showed substantial numbers in late May, but after this showed levels close to those of 1994 (Table 7, Fig. 17).

For 1994 the time period by mesh size interaction ($P = 0.0361$) was significant while time period and mesh size were not ($P = 0.1449$, $P = 0.7688$, respectively). For the 1995 CPUE, time period was significant ($P < 0.0001$) while mesh size and the mesh by time period interaction were not ($P = 0.4705$, $P = 0.7470$).

Longnose sucker were present all the time and therefore there was no significant correlations between their CPUE and water temperature or discharge (Pearson Product Moment Correlations = -0.5966, -0.0142, respectively; $P = 0.1184$ and $P = 0.9632$, respectively for 1994 and 1995).

Table 6. The mean CPUE of lake whitefish (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0.0667 | 5 | 0.1491 | 0.0667 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.6741 | 42 | 1.5025 | 0.2318 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 1.9191 | 37 | 8.0351 | 1.2318 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 1.4480 | 63 | 3.4221 | 0.4311 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 2.0678 | 49 | 7.8676 | 1.1239 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 1.9883 | 26 | 3.7575 | 0.7369 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 5.5053 | 32 | 8.0619 | 1.4251 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 1.5384 | 2 | 2.1757 | 1.5384 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 1.2053 | 6 | 1.0465 | 0.4272 |
| 15 | 1995 | June 1 - June 15 | 4.7148 | 28 | 6.1259 | 1.1577 |
| 16 | 1995 | June 16 - June 30 | 0.7904 | 20 | 2.1093 | 0.4716 |
| 17 | 1995 | July 1 - July 15 | 0.7226 | 26 | 1.8682 | 0.3664 |
| 18 | 1995 | July 16 - July 31 | 0.5206 | 39 | 1.2713 | 1.2036 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0.6956 | 36 | 1.5314 | 0.2552 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 2.6310 | 5 | 2.8744 | 1.2855 |

Table 7. The mean catch-per-unit-effort of longnose sucker (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0 | 5 | 0 | 0 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.0423 | 42 | 0.2381 | 0.0367 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 0.3378 | 37 | 1.5146 | 0.2490 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 0.1589 | 63 | 1.1282 | 0.1410 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 0.0105 | 49 | 0.0355 | 0.0051 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 0.5292 | 26 | 1.7570 | 0.3446 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 0.2066 | 32 | 0.6322 | 0.1118 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0 | 2 | 0 | 0 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 3.1111 | 6 | 3.1301 | 1.2779 |
| 15 | 1995 | June 1 - June 15 | 0.4609 | 28 | 1.1442 | 0.2162 |
| 16 | 1995 | June 16 - June 30 | 0.0400 | 20 | 0.1789 | 0.0400 |
| 17 | 1995 | July 1 - July 15 | 0.0540 | 26 | 0.1908 | 0.0374 |
| 18 | 1995 | July 16 - July 31 | 0.0250 | 39 | 0.1561 | 0.0250 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0.0884 | 36 | 0.5303 | 0.0884 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 0 | 5 | 0 | 0 |

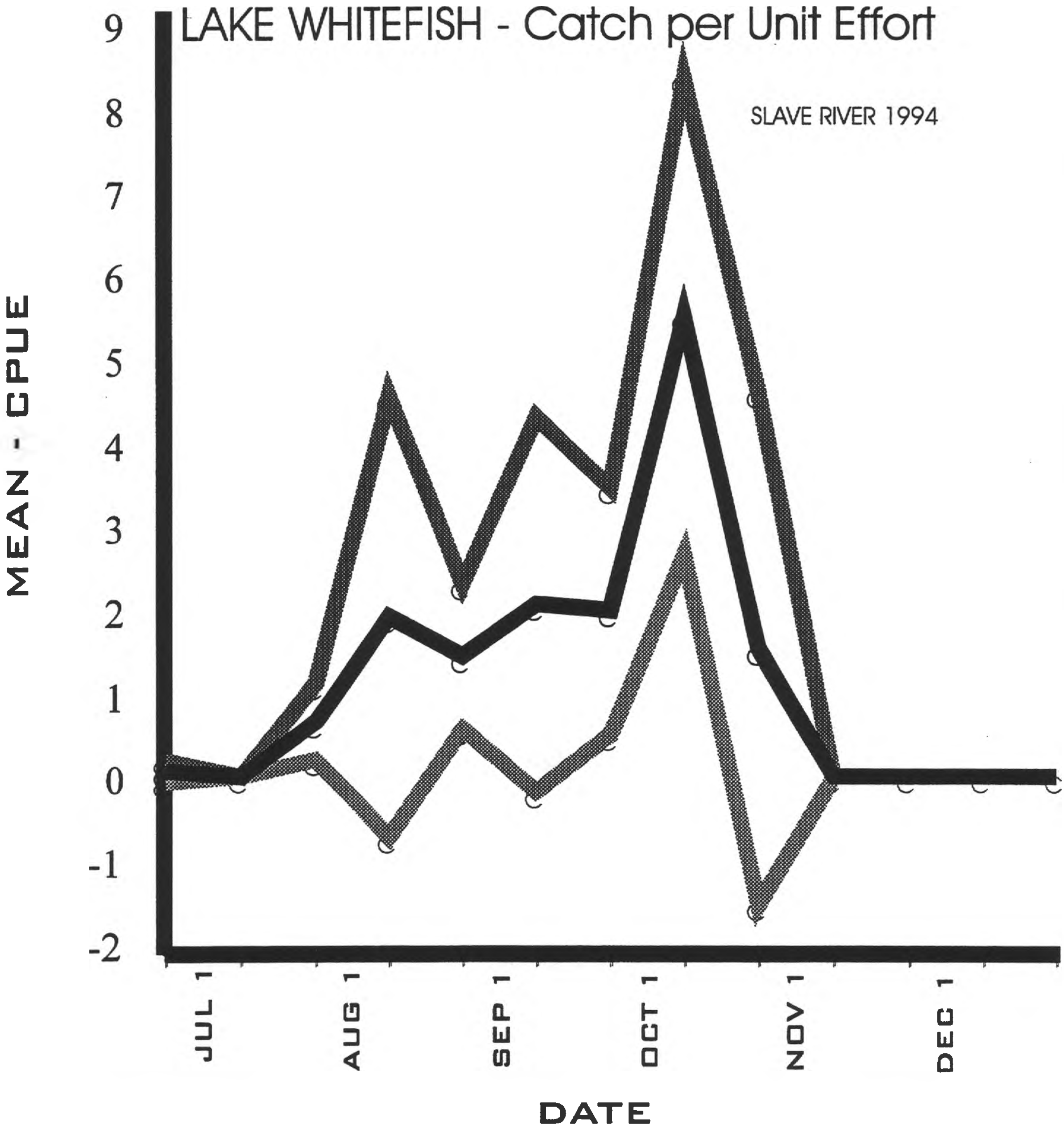


Figure 14. Catch per unit effort (number of fish per hour for standardized net) of lake whitefish in the Slave River in 1994 against calendar date.

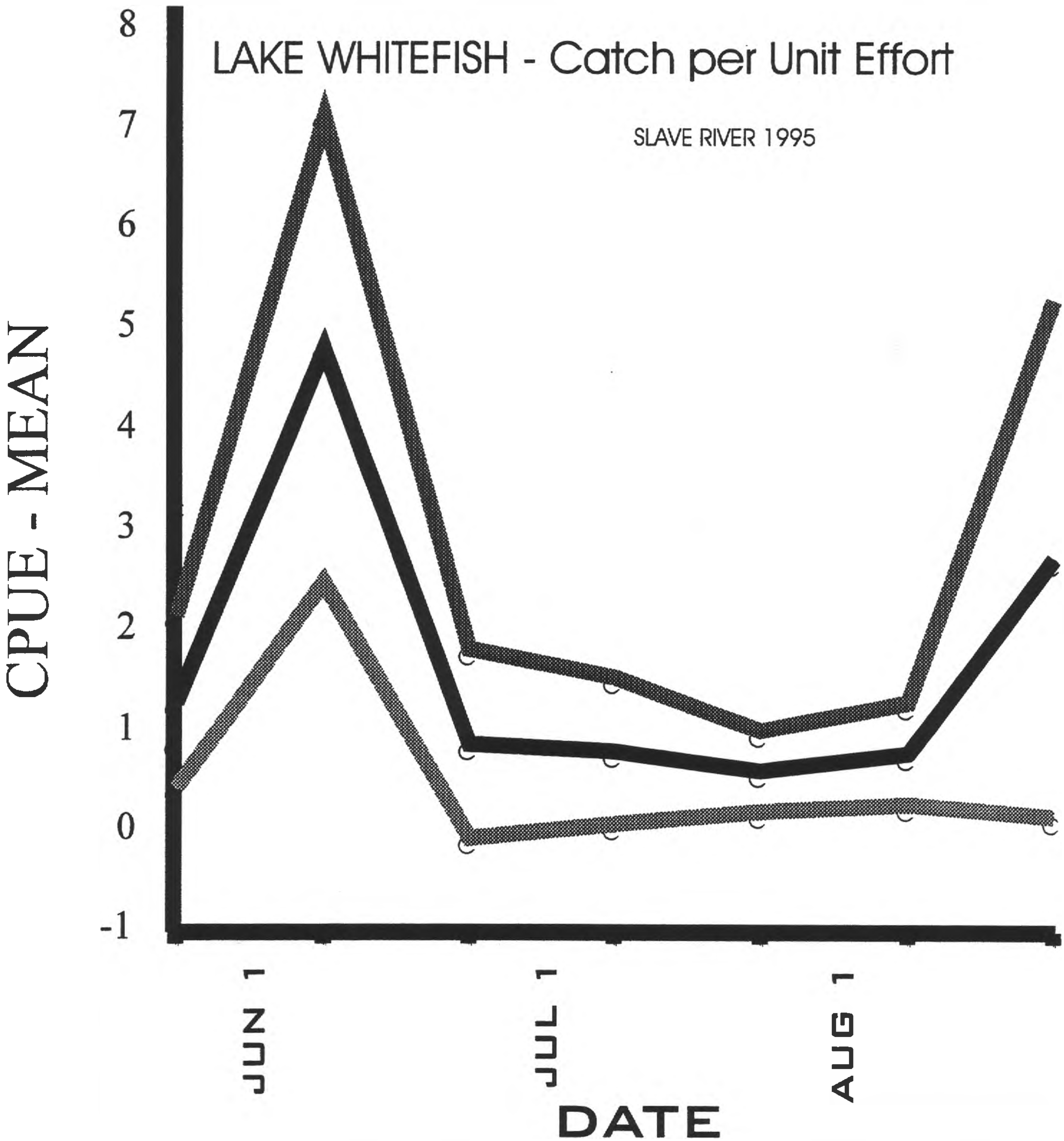


Figure 15. Catch per unit effort (number of fish per hour for standardized net) of lake whitefish in the Slave River in 1995 against calendar date.

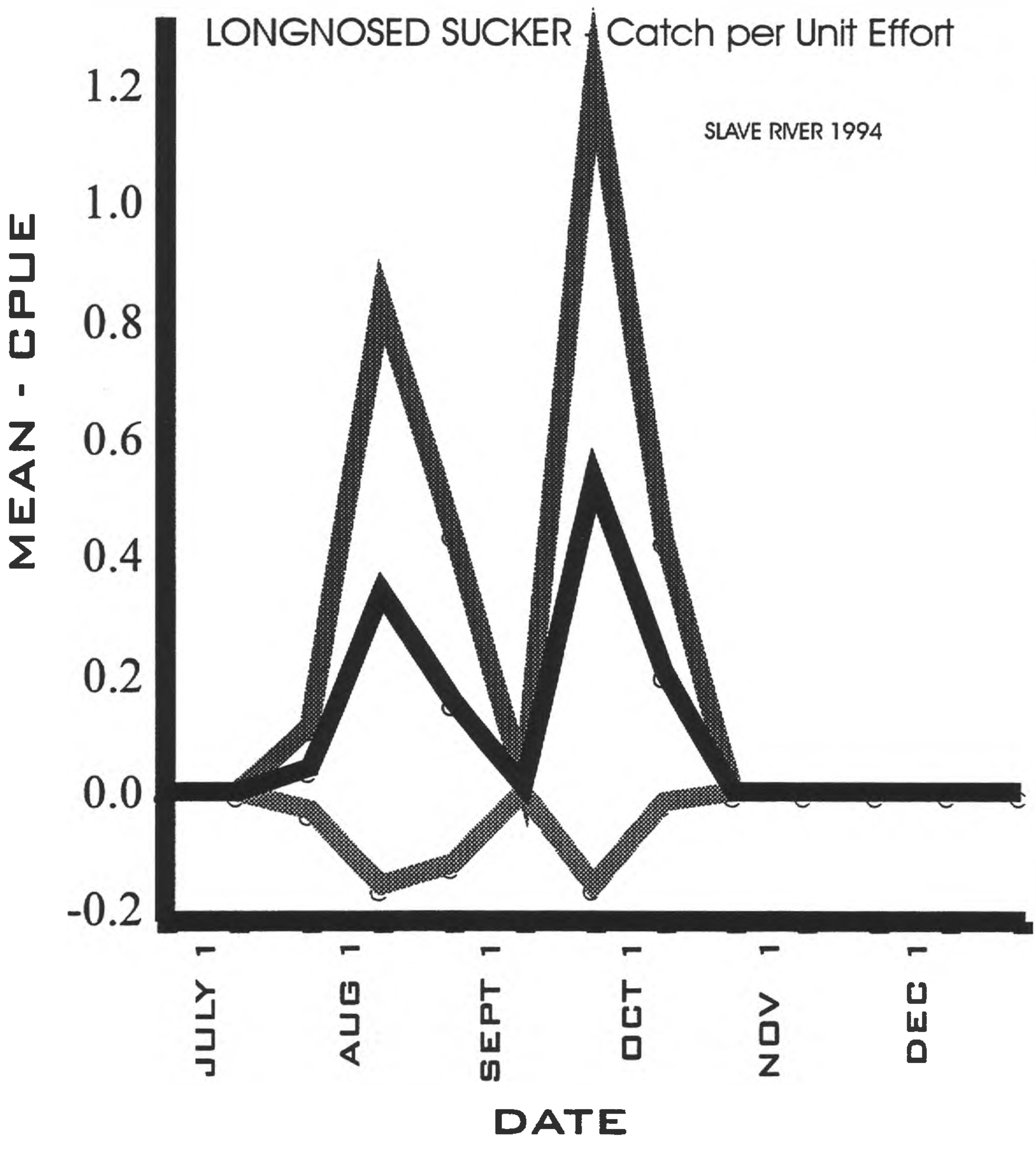


Figure 16. Catch per unit effort (number of fish per hour for standardized net) of longnose sucker in the Slave River in 1994 against calendar date.

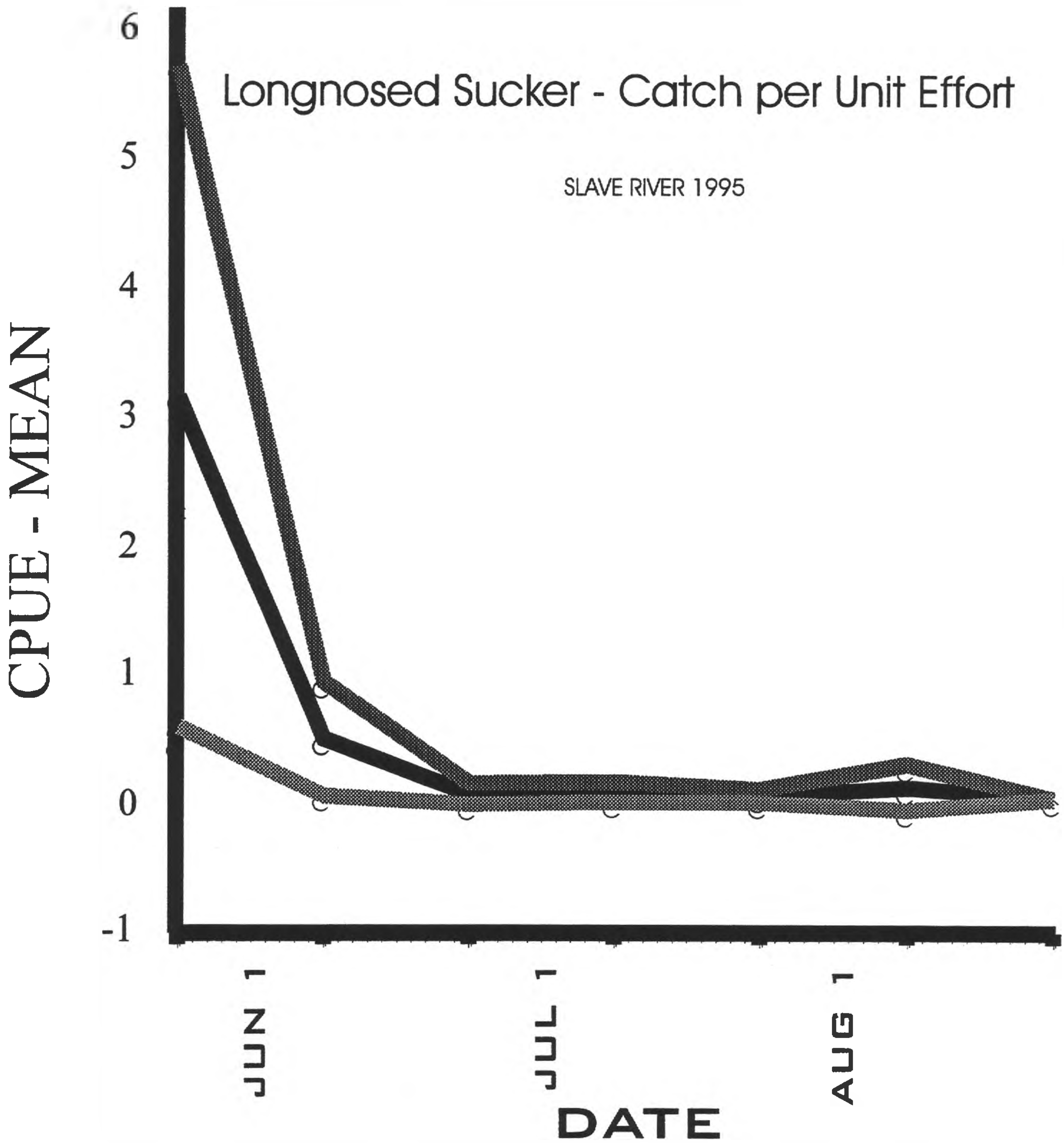


Figure 17. Catch per unit effort (number of fish per hour for standardized net) of longnose sucker in the Slave River in 1995 against calendar date.

### 3.1.7 Northern Pike

Northern pike were present in moderate abundance throughout the open water sampling period in 1994 (Table 8, Fig. 18). In 1995 they were present in consistently higher numbers throughout the sampling period with substantial abundance recorded in the first two weeks of June and the last two weeks of August (Table 8, Fig. 19). The increase in 1995 was probably due to better sampling coverage of the juvenile pike population in the area because more sampling was done in the Salt River area where juvenile pike were abundant.

Mesh size had a significant influence on the CPUE of northern pike in both years ($p < 0.0001$, and $P = 0.0186$, respectively) Time period was significant in 1995 ($p < 0.0001$) and nearly so in 1994 ($P = 0.0759$). The interaction between mesh size and time period was not significant in 1994 ( $P = 0.2018$) but was for the 1995 CPUE ($P = 0.0009$)

Pike CPUE was highest when water temperatures were warmest in July (around 20° C). However, there was no correlation between water temperature and abundance ($r = -0.0224$, $P = 0.9580$). There was also no relationship between CPUE and discharge ( $r = 0.2362$, $P = 0.4371$).

### 3.1.8 Walleye

Walleye were present in moderate to high abundance throughout the open water sampling period for both 1994 and 1995 (Table 9, Fig.s 20 and 21). The points of high abundance were in early August and early October in 1994, and in late May and early June, 1995.

Time period and mesh size had a significant influence on the CPUE in both years (time period - $P = 0.0350$, and $p < 0.0001$, respectively: mesh size - $p < 0.001$, and $P = 0.0445$, respectively) The interaction between mesh size and time period was not significant in 1994 ( $P = 0.1820$) but was for the 1995 CPUE ($P = 0.0014$). All other interaction effects were non-significant.

Judging from the overall pattern from the two years walleye abundance fluctuated May though to the end of October. Not surprisingly, the CPUE was not significantly correlated with water temperature or discharge ( Pearson Product Moment Correlation = -0.4283, $P = 0.2898$ and Correlation = 0.2839, $P = 0.3472$, respectively).

Table 8. The mean catch-per-unit-effort of northern pike (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0.1333 | 5 | 0.2984 | 0.1333 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 0.9807 | 42 | 1.6736 | 0.2582 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 3.3301 | 37 | 5.8989 | 0.9698 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 1.3821 | 63 | 4.9248 | 0.6205 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 0.3534 | 49 | 4.1215 | 0.5888 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 0.8323 | 26 | 1.9887 | 0.3516 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 0.7692 | 32 | 1.0879 | 0.7692 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0 | 2 | 0 | 0 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 5.9855 | 6 | 5.5919 | 2.2829 |
| 15 | 1995 | June 1 - June 15 | 13.0979 | 28 | 21.2114 | 4.0086 |
| 16 | 1995 | June 16 - June 30 | 4.8163 | 20 | 5.8044 | 1.2979 |
| 17 | 1995 | July 1 - July 15 | 5.0989 | 26 | 5.7078 | 0.9140 |
| 18 | 1995 | July 16 - July 31 | 5.5693 | 39 | 11.6514 | 2.2850 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 5.0060 | 36 | 5.7078 | 0.9140 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 39.0742 | 5 | 84.3018 | 37.7009 |

Table 9. The mean catch-per-unit-effort of walleye (CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 1 | 1994 | June 16 -June 30 | 0.4667 | 5 | 0.7303 | 0.3266 |
| 2 | 1994 | July 1 - July 15 | 0 | 4 | 0 | 0 |
| 3 | 1994 | July 16 - July 31 | 5.9717 | 42 | 22.2597 | 3.4347 |
| 4 | 1994 | Aug. 1 - Aug. 15 | 10.2595 | 37 | 34.4782 | 5.6682 |
| 5 | 1994 | Aug. 16 - Aug. 31 | 3.3641 | 64 | 15.4723 | 1.9340 |
| 6 | 1994 | Sept. 1 - Sept. 15 | 1.8372 | 48 | 7.6437 | 1.1033 |
| 7 | 1994 | Sept. 16 - Sept. 30 | 4.4416 | 26 | 13.7479 | 2.6962 |
| 8 | 1994 | Oct. 1 - Oct. 15 | 9.5987 | 32 | 18.1523 | 3.2089 |
| 9 | 1994 | Oct. 16 - Oct. 31 | 0.7906 | 2 | 0.3324 | 0.2350 |
| 10 | 1994 | Nov. 1 - Nov. 15 | 0 | 2 | 0 | 0 |
| 11 | 1994 | Nov. 16 - Nov. 30 | 0 | 4 | 0 | 0 |
| 12 | 1994 | Dec. 1 - Dec. 15 | 0 | 4 | 0 | 0 |
| 13 | 1994 | Dec. 16 - Dec. 30 | 0 | 4 | 0 | 0 |
| 14 | 1995 | May 16 - May 31 | 15.5617 | 6 | 6.2383 | 2.5468 |
| 15 | 1995 | June 1 - June 15 | 9.6955 | 28 | 12.8209 | 2.4229 |
| 16 | 1995 | June 16 - June 30 | 0.8153 | 20 | 1.9068 | 0.4264 |
| 17 | 1995 | July 1 - July 15 | 2.1602 | 26 | 2.0052 | 0.3933 |
| 18 | 1995 | July 16 - July 31 | 1.7502 | 39 | 2.6839 | 0.4298 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0.3139 | 36 | 0.9629 | 0.1605 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 3.2351 | 5 | 5.8331 | 2.6086 |

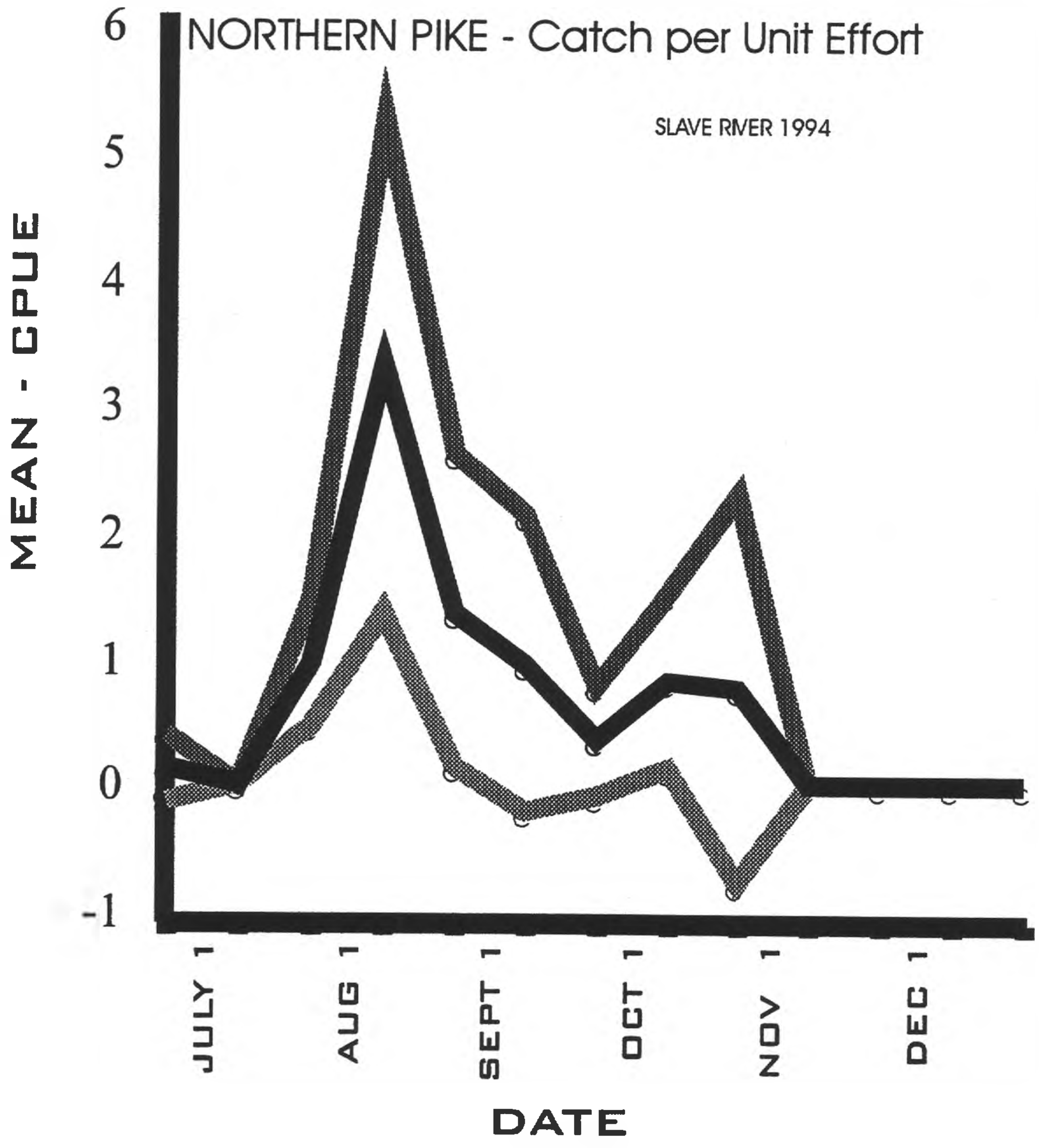


Figure 18. Catch per unit effort (number of fish per hour for standardized net) of northern pike in the Slave River in 1994 against calendar date.

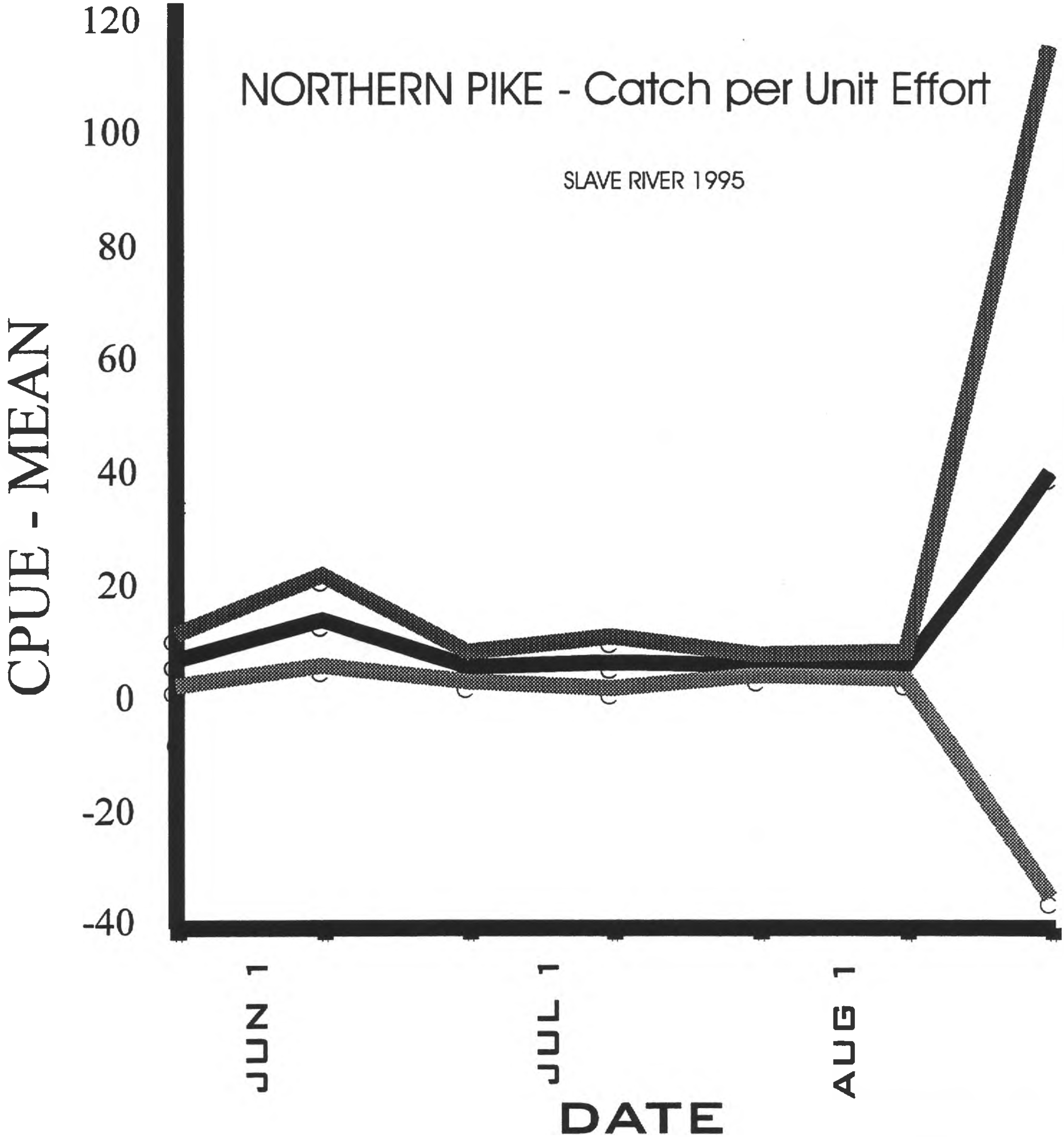


Figure 19. Catch per unit effort (number of fish per hour for standardized net) of northern pike in the Slave River in 1995 against calendar date.

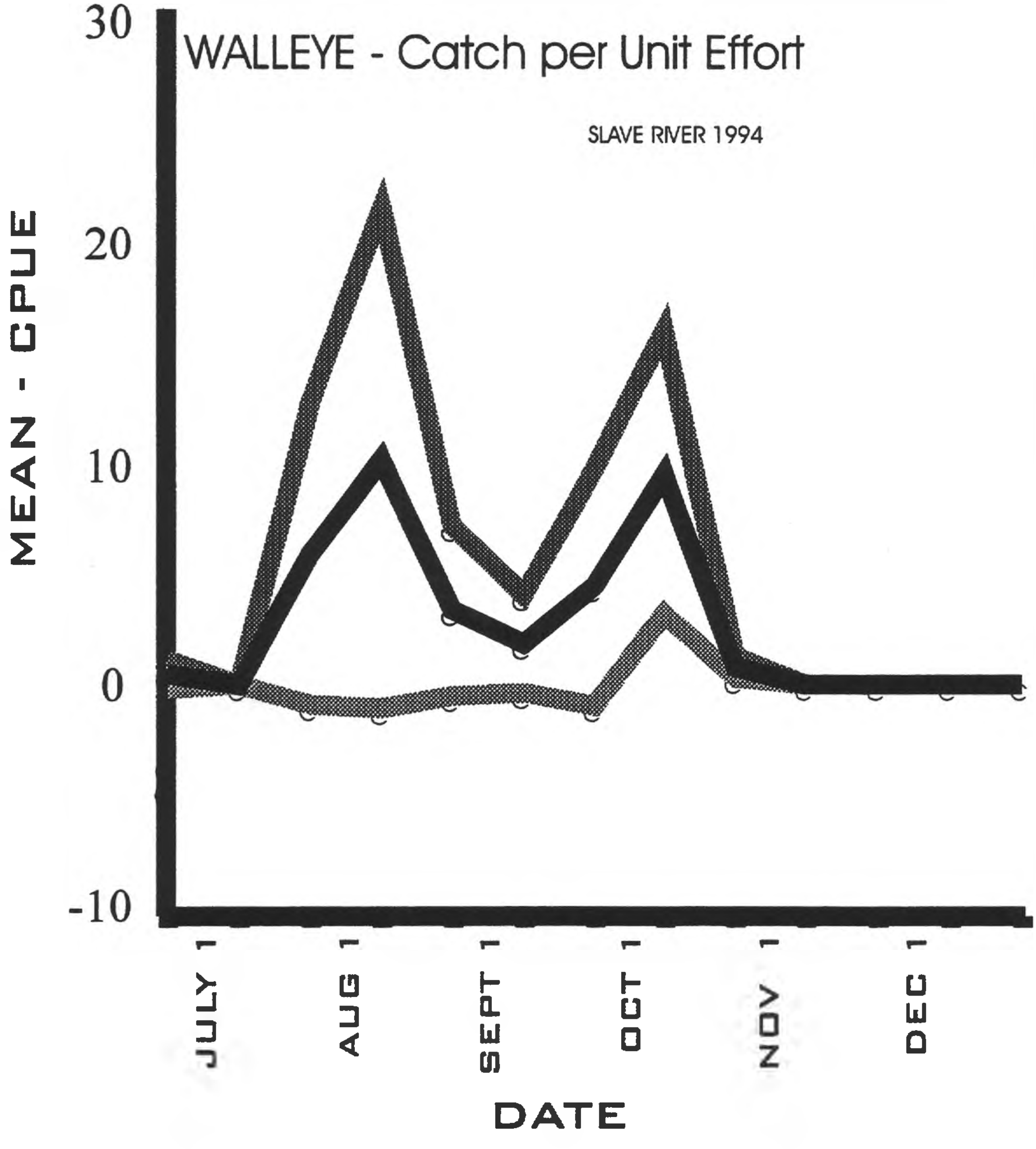


Figure 20. Catch per unit effort (number of fish per hour for standardized net) of walleye in the Slave River in 1994 against calendar date.

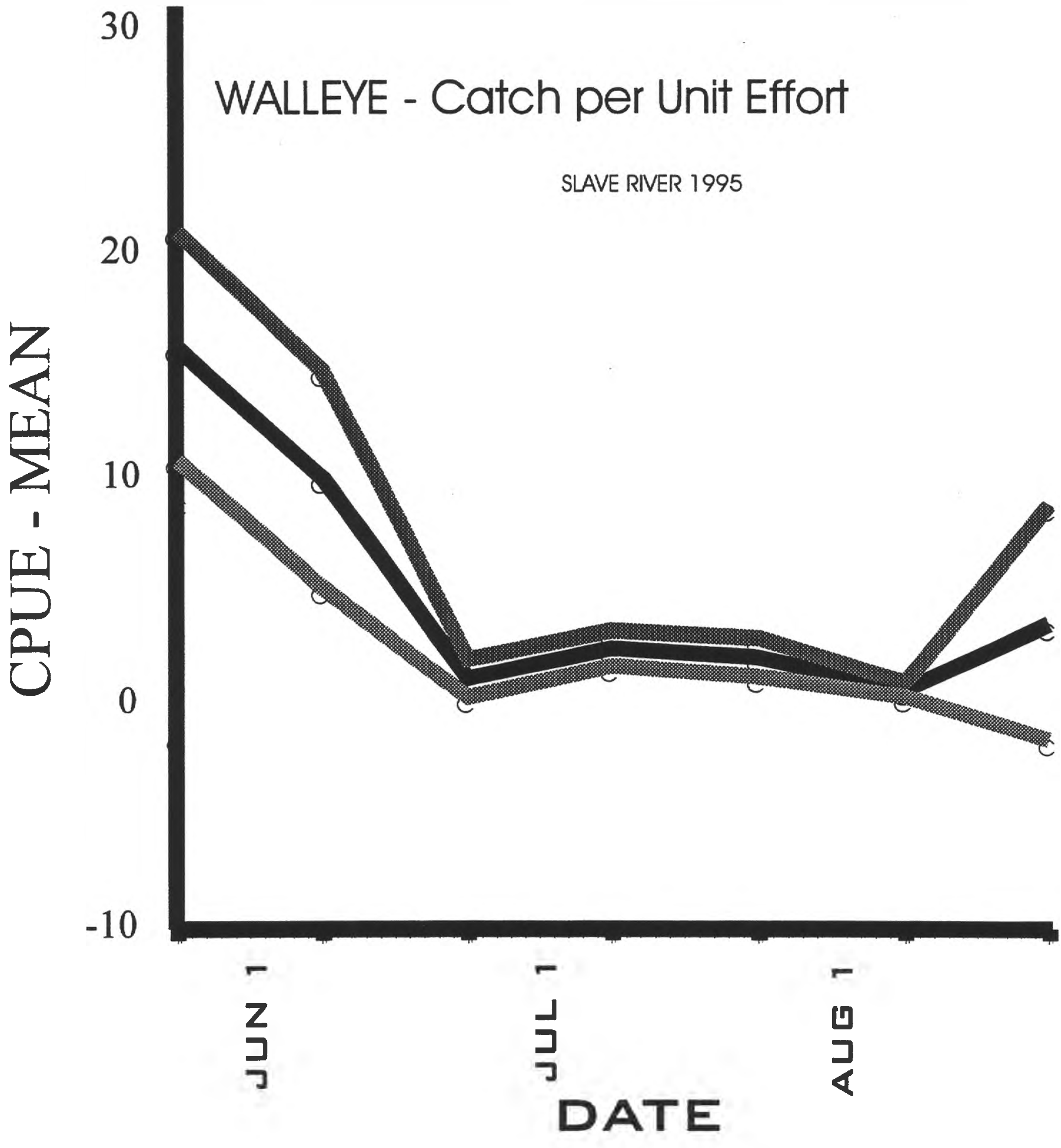


Figure 21. Catch per unit effort (number of fish per hour for standardized net) of walleye in the Slave River in 1995 against calendar date.

### 3.1.9 White Sucker

White sucker were not captured in 1994. In 1995 , white suckers were present in low to moderate abundance but only in the Salt River during June and July (Table 10, Fig. 22).

Time period had a significant effect on the CPUE of white sucker (P = 0.0053) whereas mesh size did not (P = 0.7655). The interaction between mesh size and time period was not significant (P = 0.9936). No other interactions were significant.

Table 10. The mean catch-per-unit-effort of white sucker(CPUE - number of fish per hour per 25m length, 2 m deep net) by time period. N = number of sets, STD = standard deviation, STE = standard error.

| Time Period | Year | DATES | Mean CPUE | N | STD | STE |
|---|---|---|---|---|---|---|
| 14 | 1995 | May 16 - May 31 | 0 | 6 | 0 | 0 |
| 15 | 1995 | June 1 - June 15 | 0.7051 | 28 | 1.6407 | 0.3101 |
| 16 | 1995 | June 16 - June 30 | 0.3696 | 20 | 1.1761 | 0.2630 |
| 17 | 1995 | July 1 - July 15 | 0.3807 | 26 | 1.0325 | 0.2025 |
| 18 | 1995 | July 16 - July 31 | 0.0787 | 39 | 0.3506 | 0.0561 |
| 19 | 1995 | Aug. 1 - Aug. 15 | 0 | 36 | 0 | 0 |
| 20 | 1995 | Aug. 16 - Aug. 31 | 0 | 5 | 0 | 0 |

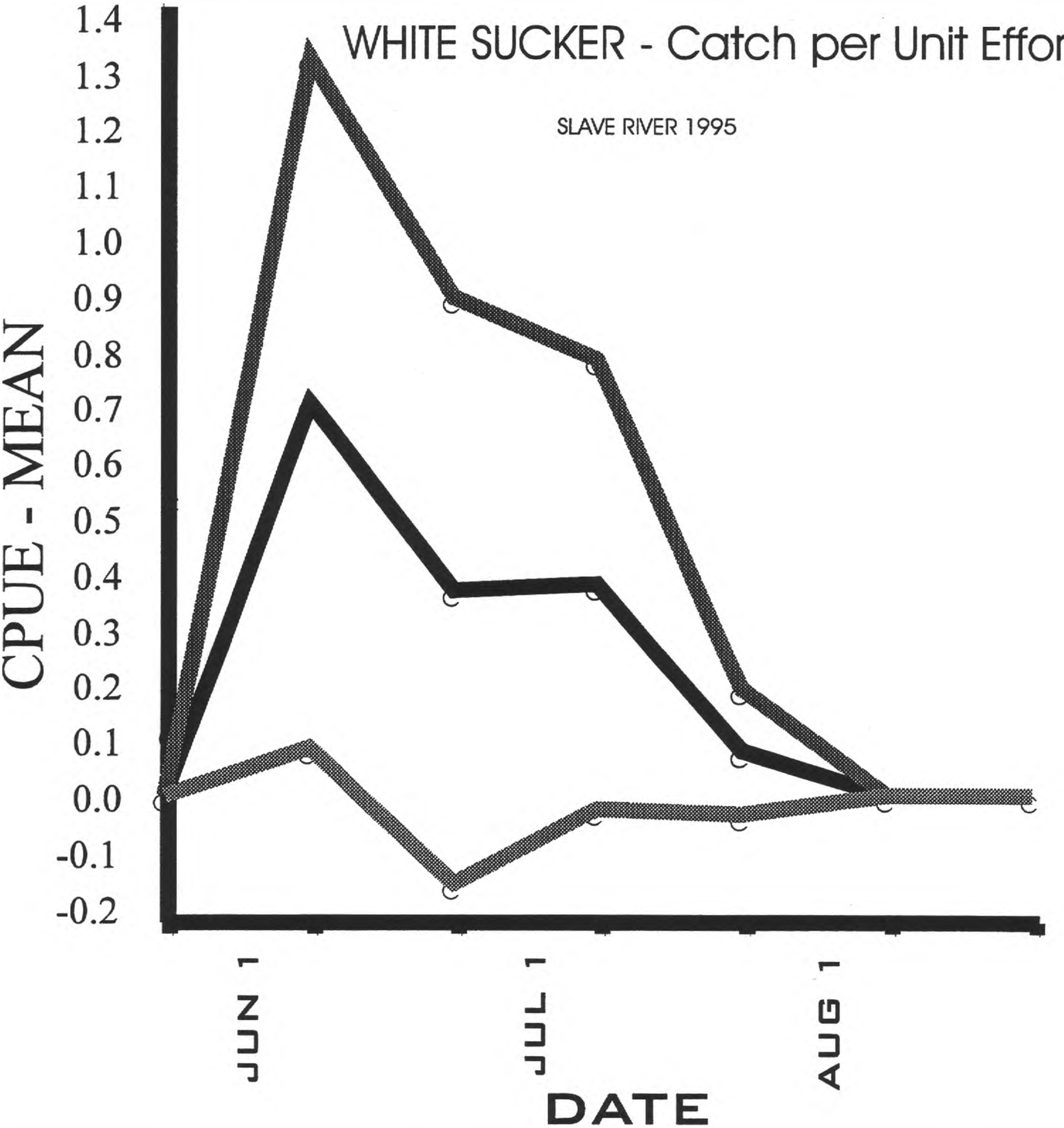


Figure 22. Catch per unit effort (number of fish per hour for standardized net) of white sucker in the Slave River in 1995 against calendar date.

### 3.2 Dietary Analysis

#### 3.2.1 Northern Pike

Stomach content analysis was determined for 290 northern pike stomachs in 1994 and 1995. Of these only 102 stomachs (42%) were found to contain prey items. Northern pike were widespread geographically and available in all seasons for capture. They were caught in sufficient numbers to analyze their diet by sampling location, season and by size class. In most cases the catch of the other species did not allow as comprehensive an analysis.

General Description of Northern Pike diet: A general summary of prey items found is in Table 11. A total of 21 different prey items were documented, 14 of which were fish species (37.5% total), four were invertebrate orders (3.3%) and three were terrestrial vertebrate species (1.2%). The most common fish found in the stomachs were ninespine stickleback (6.7%), northern pike (4.6%), flathead chub (3.0%), Arctic lamprey (3.0%), burbot (3.0%) and lake whitefish (3.0%) based on percent by absolute numbers of all prey items found in the diet (Fig. 23). Overall, the top five prey items ranked by percent-by-weight and percent-by-frequency-of-occurrence were flathead chub (24%), lake whitefish (21%), burbot (17%), longnose sucker (12%), and northern pike (10%) and flathead chub (14%), burbot (14%), northern pike (12%), Arctic lamprey (9%) and lake whitefish (9%), respectively (Table 12). The Relative Importance Index (RII) (George and Hadley 1979) was calculated for each prey item to reduce the biases of ranking by absolute numbers, by weight or by frequency of occurrence. The most important prey types as ranked by the RII were flathead chub, burbot, lake whitefish and northern pike, respectively (Table 12).

##### 3.2.1.1 Northern pike diet by sampling location

The stomach content data were separated according to the three sampling locations, the Slave Delta, the lower Slave River at Fort Smith and the Salt River (Fig. 24). These three sampling locations were originally chosen since they are representive of three different types of habitat, and fish species composition varied among these sampling locations.

For 1995, 15 different prey items found in northern pike stomachsfrom the Salt River, in comparison to ten prey items in the Slave River and five in the Slave Delta. The diets of northern pike caught in the Salt River included 9 different fish species, accounting for 46% of the total diet, three invertebrate orders (9%), and three vertebrate species (3%). Ninespine sticklebacks and small lake whitefish were the most common prey items found.

Of the northern pike caught in the Slave River, eight of the ten prey items found were fish species (38%) and two were invertebrate orders (3.5%). Arctic lamprey and flathead chub were by far the most common prey types found in adult pike stomachs from the Slave River near Fort Smith, accounting for 11.8% and 9.4% respectively.

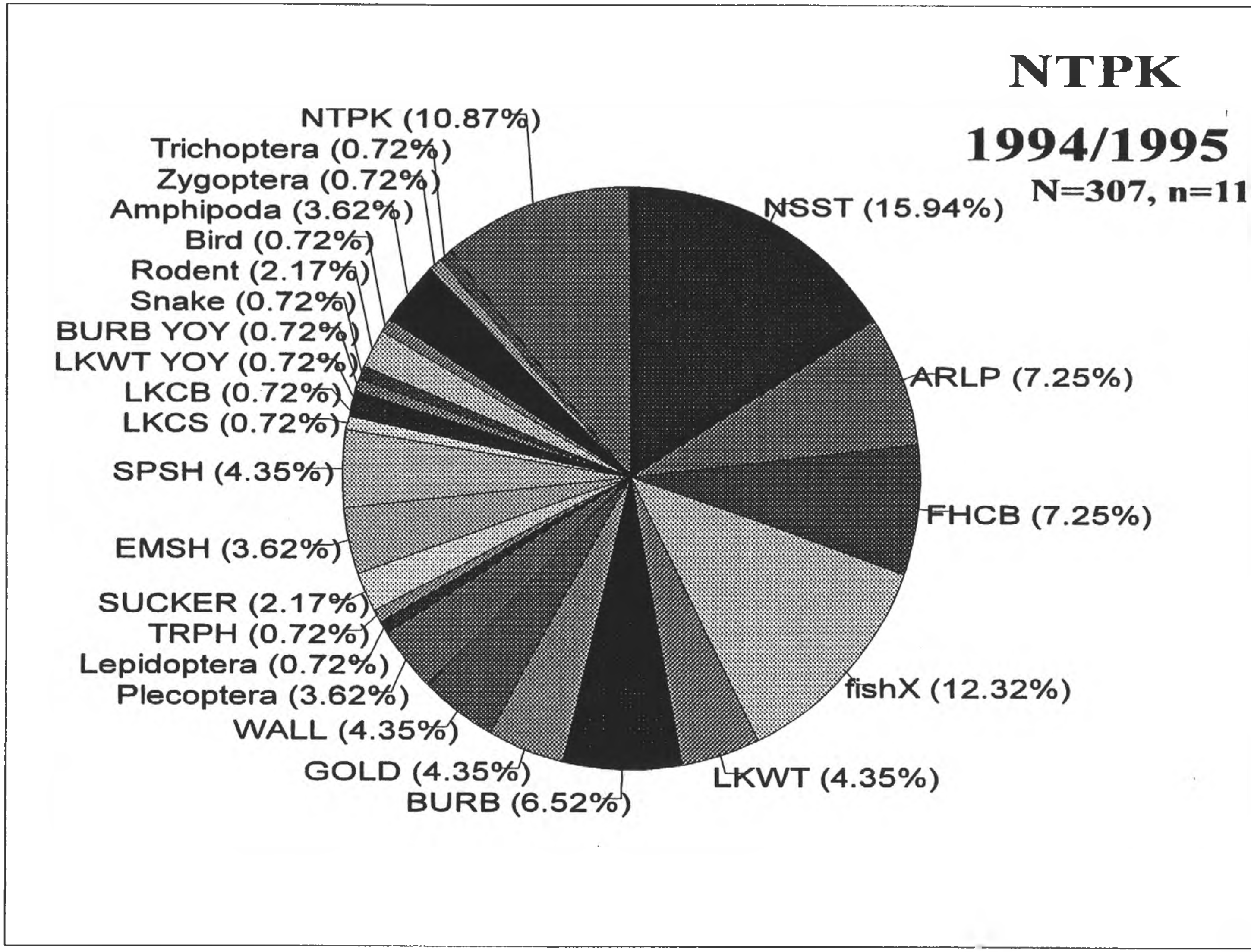


Figure 23. Percent occurrence of food items examined in the stomachs of northern pike in the Slave River area in 1994 and 1995.

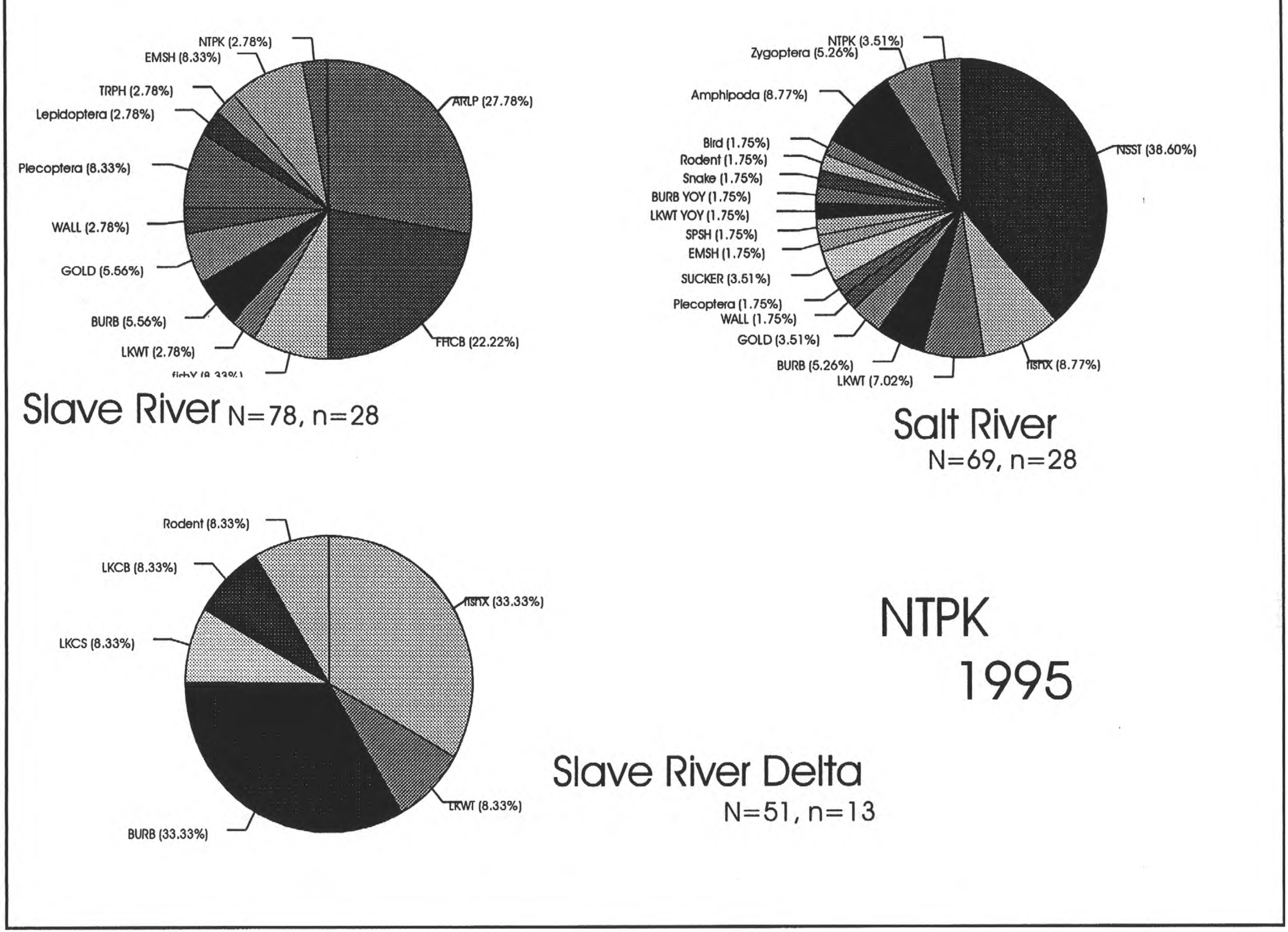


Figure 24. The distribution (percent occurrence) of food items in northern pike from the Slave River area divided into the Slave River, Salt River and Slave River Delta.

Table 11. Prey items found in stomach contents of fish in the lower Slave River, NT.

| | PREDATORS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Prey Items | NTPK | WALL | INCO | BRBT | LKWT | GOLD | FHCB | LNSK | WTSK |
| FISH | | | | | | | | | |
| FHCB | X | X | X | | | | | | |
| NTPK | X | X | X | | | | | | |
| ARLP | X | X | | | | | | | |
| BRBT | X | | | | | | | | |
| LKWT | X | | X | X | | | | | |
| GOLD | X | | | X | | | | | |
| NSST | X | X | | | X | | | | |
| WALL | X | X | X | | | | | | |
| EMSH | X | X | | | | | | | |
| SPSH | X | X | | | | | | | |
| TRPH | X | X | X | | | | | | |
| LKCB | X | | | | | | | | |
| LKSC | X | | | | | | | | |
| SUCKER | X | X | X | | | | | | |
| Rodents | X | | | | | X | | | |
| Snakes | X | | | | | | | | |
| Birds | X | | | | | | | | |
| Amphipoda | X | | | | X | X | | | |
| Gastropoda | | | | | X | | X | | |
| Ostracoda | | | | | X | | | | |
| Ephemeroptera | | X | | | X | X | | | |
| Odonata | X | X | | | X | X | | | |
| Plecoptera | X | X | | | | X | | | |
| Trichoptera | | X | | | X | X | | | |

Table 11.(CONT.) Prey items found in stomach contents of fish in the lower Slave River, NT.

| | PREDATORS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Prey Items | NTPK | WALL | INCO | BRBT | LKWT | GOLD | FHCB | LNSK | WTSK |
| Coleoptera | | | | | | X | X | | |
| Dytiscidae | | X | | | | X | X | | |
| Corixidae | | | | | X | X | X | | |
| Orthoptera | | | | | | | X | | |
| Hymenoptera | X | X | | | | X | X | | |
| Diptera | | | | | | | | | |
| Chironomidae | | | | | X | X | X | | |
| Tabanidae | | | | | X | | | | |
| Ceratopogonidae | | | | | X | | X | | |
| Vegetation | | | | | X | | | | |
| Oligochaeta | | | | | X | | | | |
| Nematoda | | | | | | X | | | |

Table 12. Relative Importance Index (George and Hadley, 1979) for Northern Pike. The numbers in paratheses represent the relative ranking of the taxa in terms of their importance in the diet. See Table 1 for fish species abbreviations, - YOY = young-of-the-year.

| Prey Items | % Number | % Weight | % Frequency of Occurrence | Absolute Importance (AI) | Relative Importance (RII) |
|---|---|---|---|---|---|
| FHCB | 0.0857 (2) | 0.2433 (1) | 0.1385 (1) | 0.4674 | 14.89 |
| BRBT | 0.0857 (2) | 0.1676 (3) | 0.1385 (1) | 0.3918 | 12.48 |
| LKWT | 0.0571 (3) | 0.2134 (2) | 0.0923 (3) | 0.3629 | 11.56 |
| NTPK | 0.0857 (2) | 0.1004 (5) | 0.1231 (2) | 0.3092 | 9.85 |
| NSST | 0.2095 (1) | 0.0024 (9) | 0.0154 (8) | 0.2273 | 7.24 |
| ARLP | 0.0857 (2) | 0.0378 (7) | 0.0923 (3) | 0.2158 | 6.88 |
| Sucker | 0.0286 (5) | 0.1150 (4) | 0.0462 (6) | 0.1897 | 6.05 |
| GOLD | 0.0476 (4) | 0.0291 (8) | 0.0769 (4) | 0.1536 | 4.90 |
| Amphipod | 0.0571 (3) | 7.5 x 10-5 (17) | 0.0615 (5) | 0.1188 | 3.78 |
| EMSH | 0.0476 (4) | 0.0002 (16) | 0.0615 (5) | 0.1109 | 3.53 |
| SPSH | 0.0571 (3) | 0.0026 (15) | 0.0462 (6) | 0.1059 | 3.37 |
| WALL | 0.0190 (6) | 0.0382 (6) | 0.0308 (7) | 0.0880 | 2.80 |
| Plecoptera | 0.0286 (5) | $3.3 \times 10^{-5}$(19) | 0.0462 (6) | 0.0748 | 2.38 |
| Snake | 0.0095 (7) | 0.0314 (10) | 0.0154 (8) | 0.0563 | 1.80 |
| Rodent | 0.0190 (6) | 0.0063 (11) | 0.0308 (7) | 0.0561 | 1.79 |
| Damselfly L. | 0.0190 (6) | $1.4 \times 10^{-5}$(20) | 0.0308 (7) | 0.0498 | 1.59 |
| LKCS | 0.0095 (7) | 0.0052 (12) | 0.0154 (8) | 0.0301 | 0.96 |
| Bird | 0.0095 (7) | 0.0041 (13) | 0.0154 (8) | 0.0290 | 0.93 |
| TRPH | 0.0095 (7) | 0.0004 (14) | 0.0154 (8) | 0.0253 | 0.81 |
| LKWT YOY | 0.0095 (7) | 0.0004 (14) | 0.0154 (8) | 0.0253 | 0.81 |
| BRBT YOY | 0.0095 (7) | 0.0002 (16) | 0.0154 (8) | 0.0251 | 0.80 |
| Flying Insect | 0.0095 (7) | $3.6 \times 10^{-5}$(18) | 0.0154 (8) | 0.0249 | 0.79 |

Note: ( ) = order in ranking scale.

Results from the Slave Delta showed a total of five different prey types, four of which were fish (22%) and 1 vertebrate species, a rodent (2%). Burbot were the most common prey item eaten (8%), followed by lake whitefish (2%), lake cisco (2%) and lake chub (2%), while 76% of the stomachs analyzed were empty.

### 3.2.1.2 Northern pike diet by season

The stomach content data obtained for each of the three sampling locations, were divided into two seasonal time periods - May/June and July/August (Figs. 25 and 26). The significance of dividing the data in this manner is that there are different species present in relatively higher abundance at different times of the year depending on their life histories. Consequently, prey items found northern pike diets are liekly to be linked to the abundance and availability of prey in the environment (Christiansen 1976 Scott and Crossman 1973).

Stomach contents of northern pike caught in the Salt River during May and June (Fig. 25) showed that seven different prey items were found; three fish species (17%), two invertebrate orders (15%) and two vertebrate species (5%). Damselfly larvae, amphipods and smaller northern pike were the most common prey items. A YOY burbot was also found in the stomach contents. For the Slave River, stomachs contained seven different prey items, five of which were fish species (45%) and two were invertebrate orders (7%). Arctic lamprey and flathead chub were by far the dominant prey types, each comprising 17%. Twenty-eight stomach samples were analyzed from the Delta, 21 of which were empty. Prey items found were burbot, lake whitefish, lake cisco, lake chub and rodent remains. For the July and August sampling period, there were 11 different prey items found in the northern pike stomachs caught in the Salt River; eight fish species (67%), two invertebrate orders (5%), and one terrestrial vertebrate (2%). Ninespine sticklebacks, lake whitefish and burbot were the most common prey types. Also found in the stomach contents was a YOY lake whitefish. The stomach content data for the Slave River in Figure 26 showed a decrease in arctic lamprey, flathead chub and goldeye and an increase in smaller northern pike and walleye compared to the May/June period (Fig. 25). The diversity in diet composition of fish caught in the Slave River during July and August increased compared to the May/June stomach contents. However, fish species found in the diet accounted for 35% in July/August compared to 45% in May/June.

### 3.2.1.3 Diet of two size classes of Northern Pike

Finally, Figure 27 illustrates the differences found between two size-classes of northern pike . The criterion for determining the different size-classes of pike was based on the average length of prey found in the diet: 1) less than 400mm fork length (<400mm) and 2) greater than and equal to 400mm fork length (>400mm). Twenty-two samples were analyzed for the pike <400mm category. Lengths of fish prey ranged from 26mm to100mm. For the >400mm pike size-class, prey lengths ranged from 30mm(EMSH) to 363mm (LKWT); a snake with a total length of

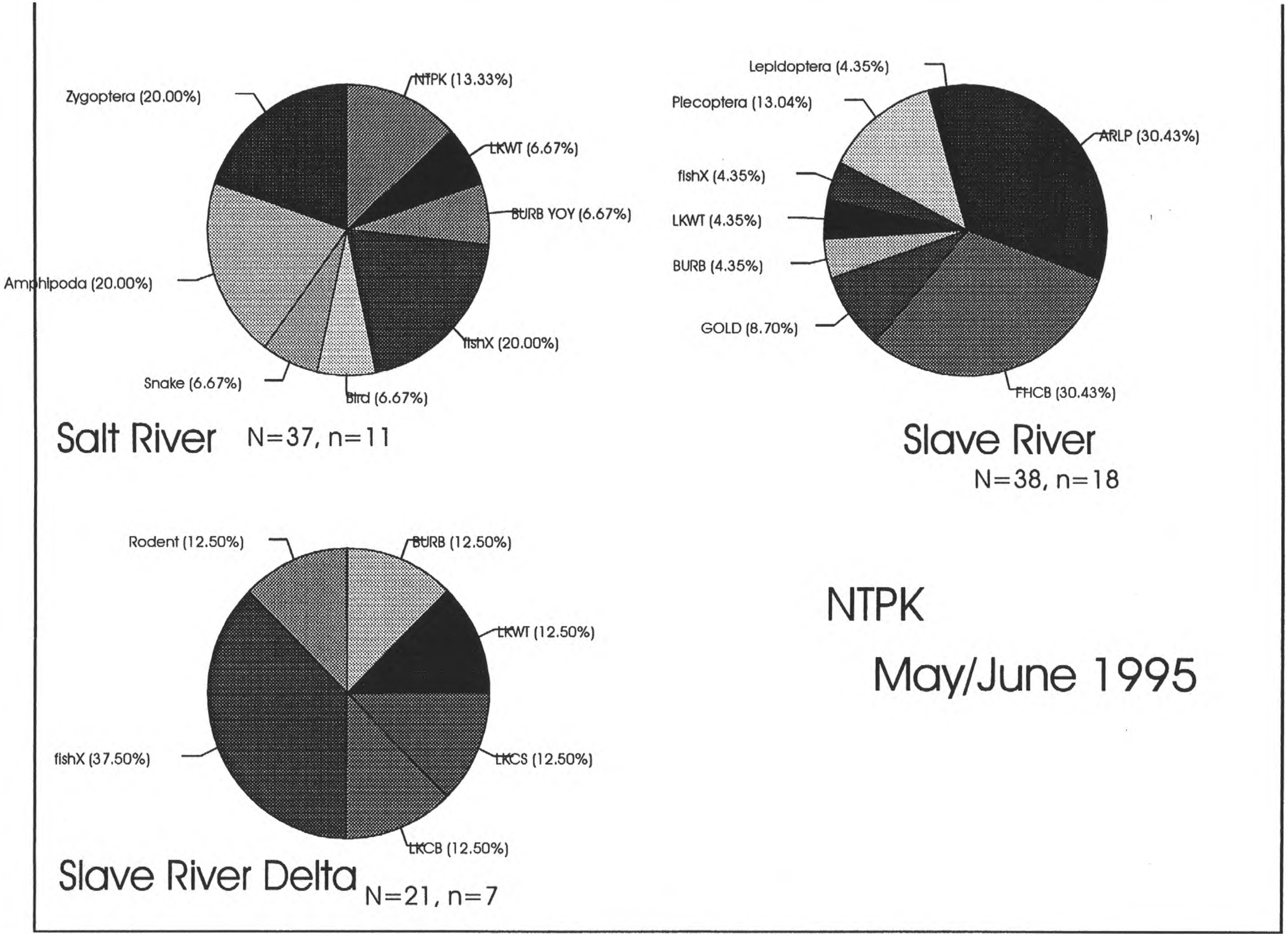


Figure 25. The distribution (percent occurrence) of food items in northern pike from the Slave River area divided into the Slave River, Salt River and Slave River Delta during May and June, 1995.

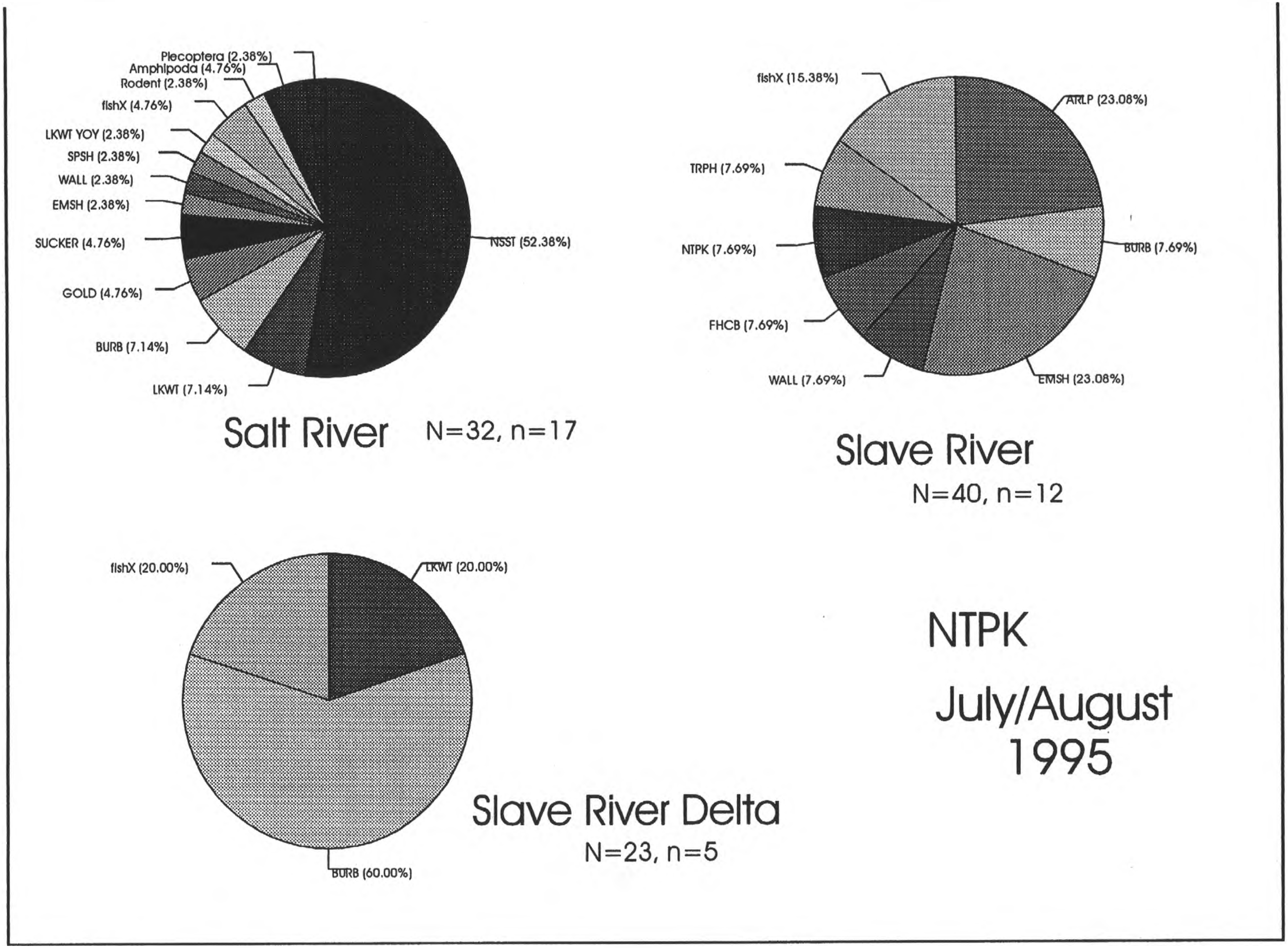


Figure 26. The distribution (percent occurrence) of food items in northern pike from the Slave River area divided into the Slave River, Salt River and Slave River Delta during July and August, 1995.

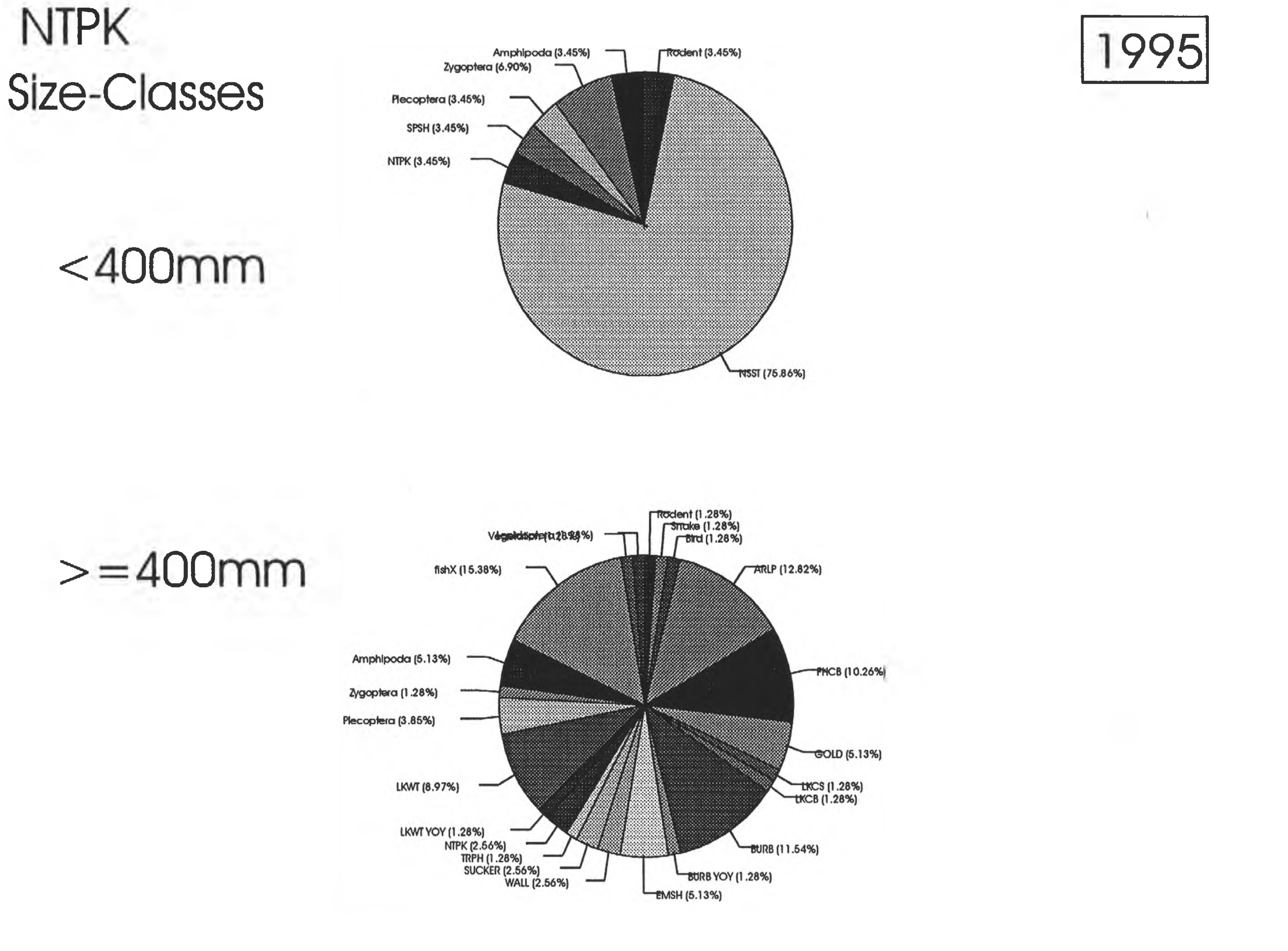


Figure 27. Relative importance of taxa in the diet of northern pike in the lower Slave River in 1995 - length classes < 400mm and >= 400mm.

930mm was found in a 545 mm northern pike. Prey length varied from 7% to 43% of total predator length. Both assigned size-classes had invertebrates present.

### 3.2.2 Walleye

Stomach content analysis was determined for 197 walleye stomachs in 1994 and 1995. Only 59 stomachs (38%) were found to contain prey items. Walleye were noted to occasionally regurgitate their stomach contents when caught in gillnets.

General Description of Walleye diet: Prey items found are listed in Table 11. A total of 14 different prey items were documented, eight of which were fish species (26%) and six of which were invertebrate categories (12%). The most common fish prey types were northern pike (5%), walleye (3%) and longnose sucker (3%) based on percent by absolute numbers of prey items found in the diet (Fig. 28). It should be noted that using absolute numbers may over-emphasize the importance of invertebrates since more invertebrates can be consumed at a given time. Prey items were also ranked by percent-by-weight and percent-by-frequency-of-occurrence in Table 13. The RII was calculated for each prey item to reduce the biases of ranking by absolute numbers, by weight, or by frequency of occurrence. The most important prey types as ranked by the RII were northern pike, arctic lamprey, plecopterans and ephemeropterans, respectively (Table 13). Aquatic invertebrates were found in a wide range of lengths of predators, the largest being a 372mm walleye.

#### 3.2.2.1 Walleye diet by sampling location

The stomach content data obtained for each of the three sampling locations were divided into two seasonal time periods, May/June and July/August ( Fig. 29 and 30). The Salt River during May/June (Fig. 29) had seven different prey items present, two of which were fish (9%). Plecopterans were the most commonly eaten prey item, accounting for 13% of total stomach contents. Figure 30 shows the diet composition of walleye caught in the Salt River during July and August as mostly fish prey (69%). For the walleye caught in the Slave River, the diversity of prey items was much lower in May/June compared to the July/August sampling period. Northern pike were the most common prey type in the July/August sampling period, accounting for 8% of the stomachs dissected. (for discussion: spawning, little feeding in May/early June). During the June sampling in the Slave Delta, only four walleye were caught, all with empty stomachs.

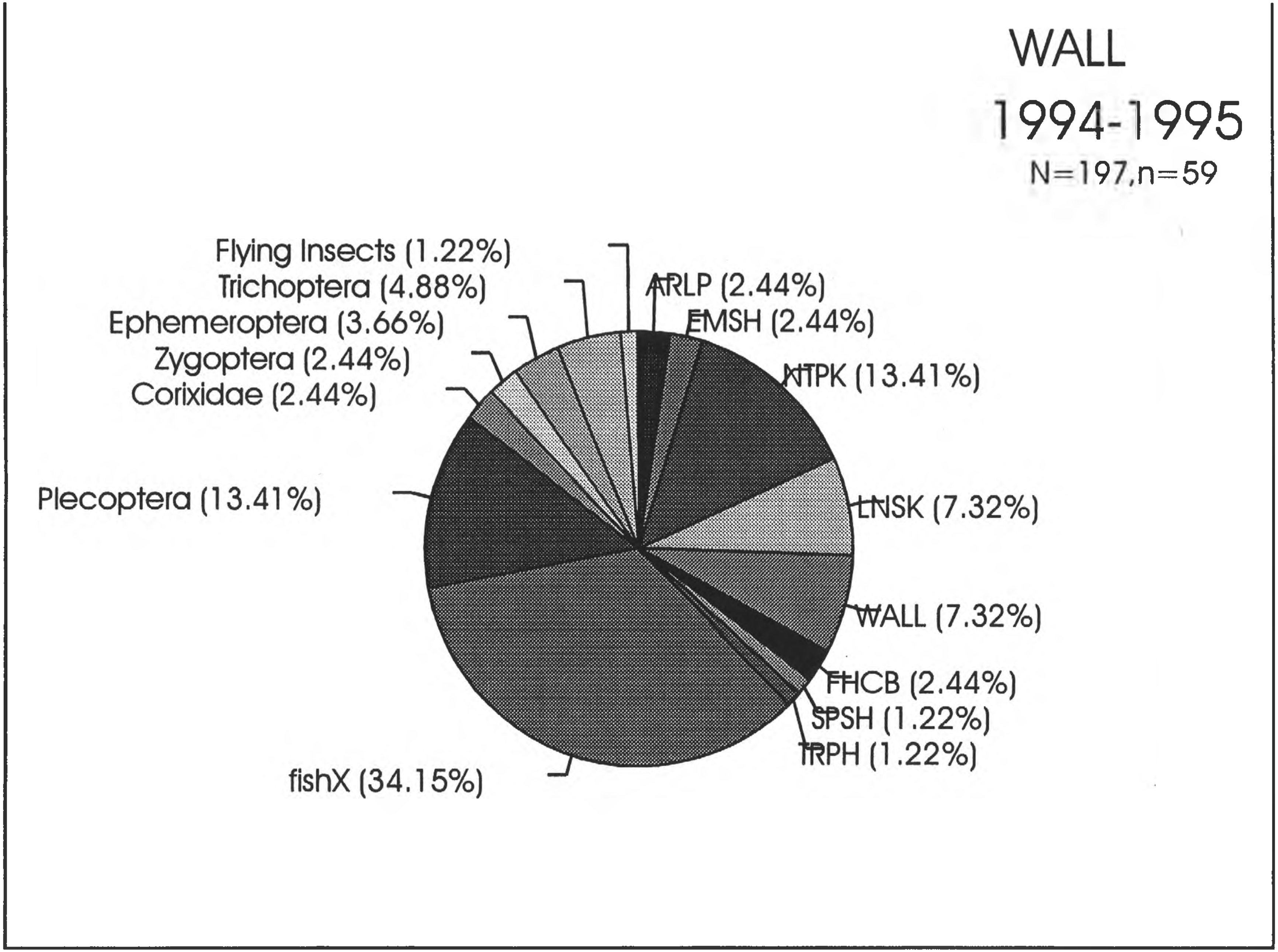


Figure 28. Relative importance of taxa in the diet of walleye in the lower Slave River during 1994 and 1995.

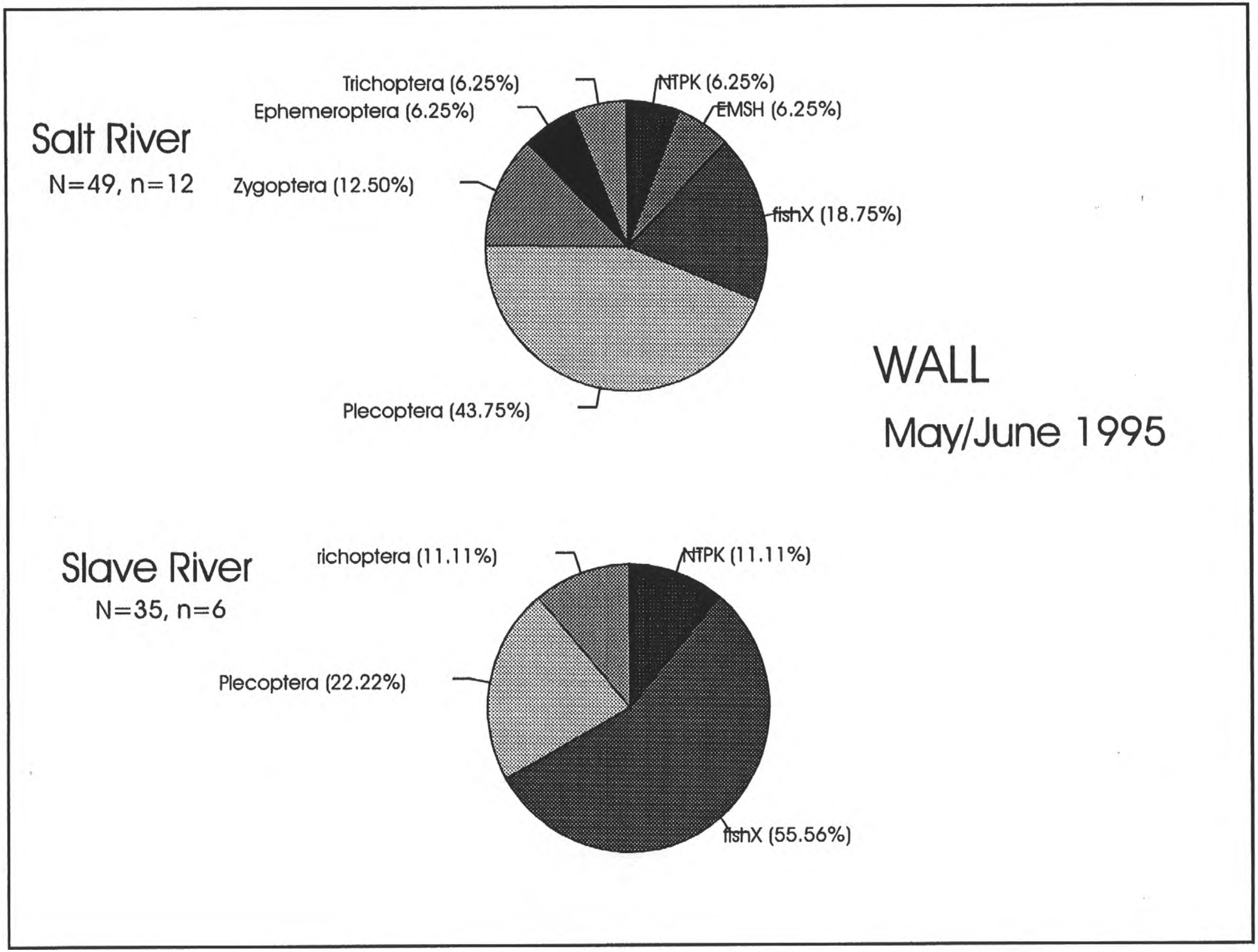


Figure 29. The distribution (percent occurrence) of food items in walleye from the Slave River area divided into the Slave River and Salt River during May and June, 1995.

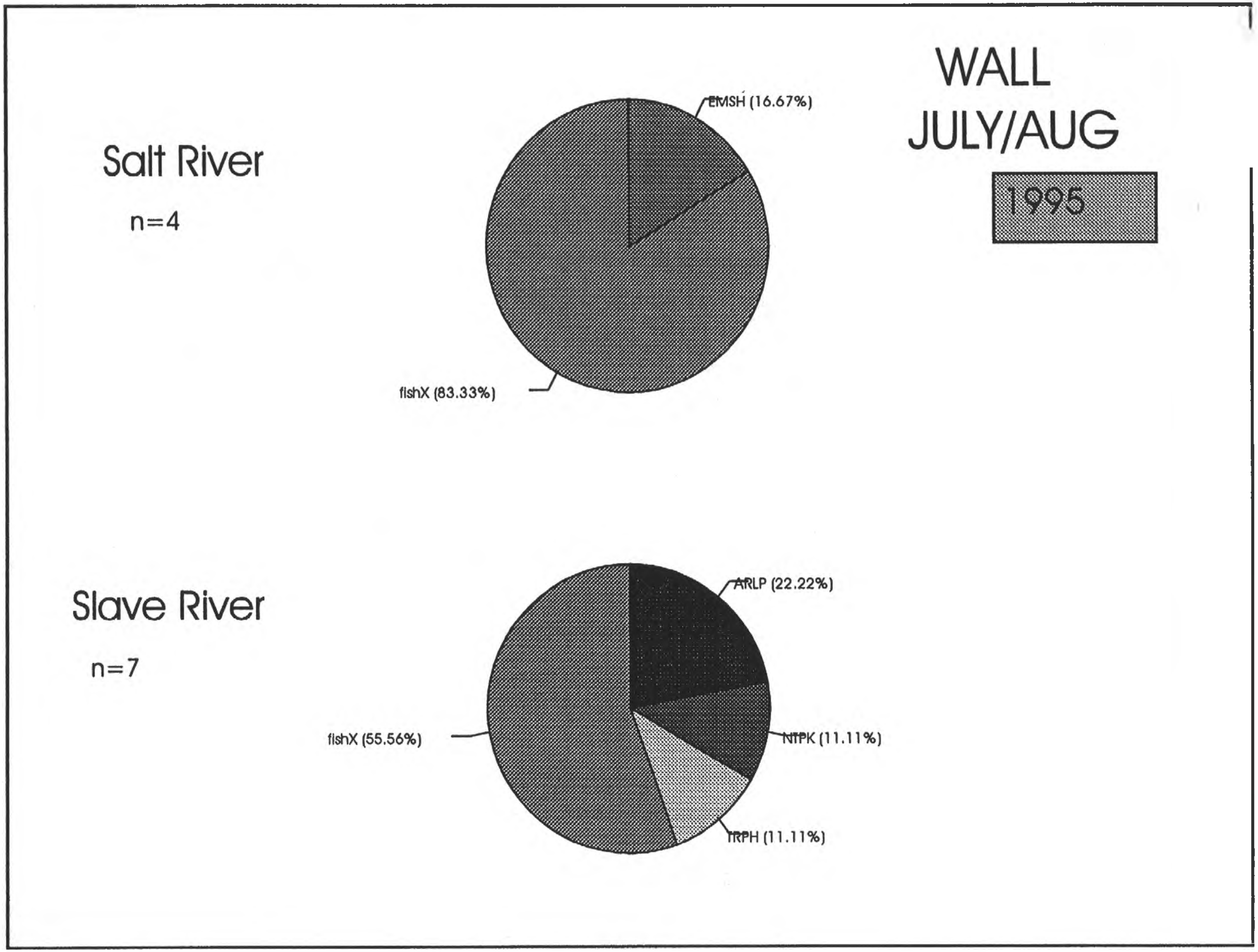


Figure 30. The distribution (percent occurrence) of food items in walleye from the Slave River area divided into the Slave River and Salt River during July and August, 1995.

Table 13. Relative Importance Index (George and Hadley 1979) for Walleye. The numbers in paratheses represent the relative ranking of the taxa in terms of their importance in the diet. See Table 1 for fish species abbreviations, - YOY = young-of-the-year.

| Prey Items | % Number | % Weight | % Freq. of Occurrence | Absolute Importance (AI) | Relative Importance (RII) |
|---|---|---|---|---|---|
| NTPK | 0.1961 (2) | 0.3338 (2) | 0.1714 (1) | 0.7013 | 23.16 |
| ARLP | 0.0392 (5) | 0.3820 (1) | 0.0571 (4) | 0.4784 | 15.79 |
| Plecopteran | 0.1765 (3) | 0.0017 (10) | 0.1714 (1) | 0.3496 | 11.54 |
| Ephemeropteran | 0.2157 (1) | 0.0021 (9) | 0.1143 (2) | 0.3321 | 10.96 |
| EMSH | 0.0392 (5) | 0.0611 (4) | 0.0571 (4) | 0.1575 | 5.20 |
| Damselfly L. | 0.0392 (5) | 0.0007 (12) | 0.0571 (4) | 0.0971 | 3.21 |
| TRPH | 0.0196 (6) | 0.0152 (8) | 0.0286 (6) | 0.0635 | 2.10 |
| NSST | 0.0196 (6) | 0.0013 (11) | 0.0288 (5) | 0.0494 | 1.63 |
| FHCB | 0.0392 (5) | 0.0419 (6) | 0.0571 (4) | 0.1382 | 4.56 |
| LNSK | 0.0588 (4) | 0.0522 (5) | 0.0857 (3) | 0.1968 | 6.50 |
| Corixidae | 0.0392 (5) | 9.2 x 10-5 (14) | 0.0286 (6) | 0.0679 | 2.24 |
| WALL | 0.0392 (5) | 0.0340 (7) | 0.0571 (4) | 0.1303 | 4.30 |
| SPSH | 0.0196 (6) | 0.0736 (3) | 0.0286 (6) | 0.1218 | 4.02 |
| Trichopteran | 0.0588 (4) | 0.0002 (13) | 0.0857 (3) | 0.1448 | 4.78 |

Note: ( ) = order in ranking scale.

### 3.2.3 Inconnu

Stomach content analysis was determined for 110 inconnu stomachs in 1994 and 1995. Only 26 stomachs (24%) were found to contain prey items.

General Description of Inconnu diet: Prey items found are listed in Table 11 and Figure 31. A total of six fish species were documented in the stomach contents - northern pike, trout-perch, longnose sucker, flathead chub, walleye and lake whitefish. The RII was calculated only for those prey items that a suitable weight could be obtained from. The results from the RII are shown below in Table 14. Trout-perch were ranked first, followed by northern pike, then longnose suckers. Although flathead chub, lake whitefish and walleye could not be included in this ranking because their weights could not be properly determined, the resulting ranking shown in Figure 31 would be the most appropriate order of importance, regardless.

### 3.2.4 Burbot

Stomach content analysis was determined for 65 burbot stomachs in 1994 and 1995. We separated the burbot stomach content data into two categories, those collected during the spawning season and those not collected during the spawning season.

General Description of Burbot diet: Prey items found are listed in Table 11 and shown in Figure 32. Stomachs contents analyzed from the spawning period (beginning of December), showed that 69.5% were empty. Only 41 stomachs of a total of 60 were found to contain prey items. Of the prey items documented, only one goldeye and one lake whitefish was found. The most common item in the stomachs was bait (25%). We suggest two possible explanations for these results: first, burbot were collected using set lines. This is apparently the best way for catching burbot, however it can also be assumed that burbot caught on a set line probably had an empty stomach before being caught. Therefore, collecting fish for diet analysis using the set line method, may have biased results. Secondly, diet analysis completed on spawning fish may not give a full representation of diet composition since most fish species do not feed during this period of their life history. However, some additional diet information was derived from burbot found in the stomachs of other piscivores. A total of five burbot stomachs were analyzedthis way; three were found to be empty or have only unidentifiable digestive matter present; one stomach had a ninespine stickleback present, and one stomach contained a young longnose sucker.

Table 14. Relative Importance Index (George and Hadley 1979) for Inconnu. The numbers in paratheses represent the relative ranking of the taxa in terms of their importance in the diet. See Table 1 for fish species abbreviations, - YOY = young-of-the-year.

| Prey Items | % Number | % Weight | % Freq. | AI | RI |
|---|---|---|---|---|---|
| TRPH | 0.5 (1) | 0.484 (1) | 0.5 (1) | 1.484 (1) | 49.47 |
| NTPK | 0.333 (2) | 0.480 (2) | 0.333 (2) | 1.146 (2) | 38.2 |
| LNSK | 0.167 (3) | 0.036 (3) | 0.167 (3) | 0.37 (3) | 12.33 |

Note: ( ) = order in ranking scale.

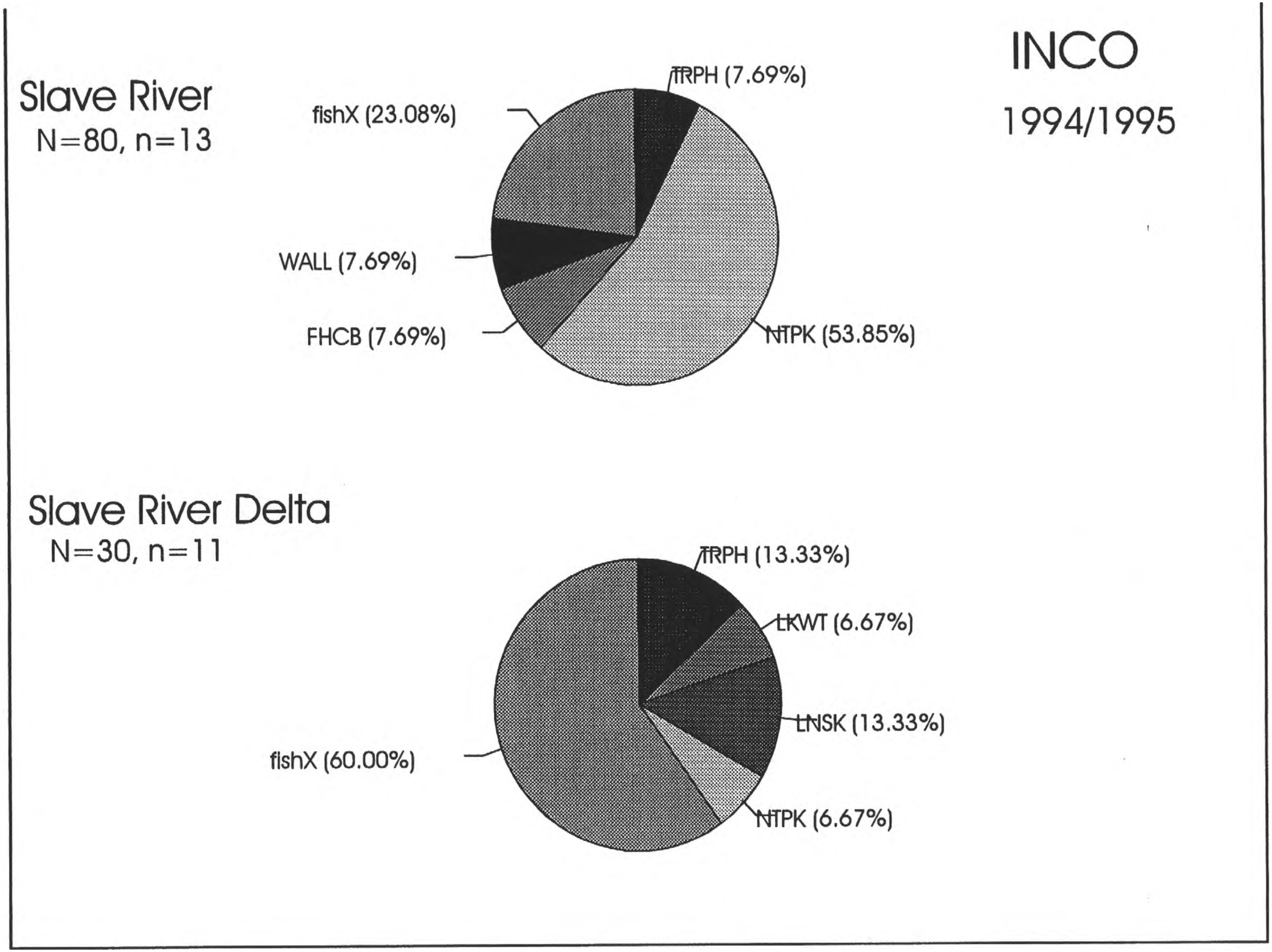


Figure 31. Percent occurrence of food items examined in the stomachs of inconnu in the Slave River area in 1994 and 1995.

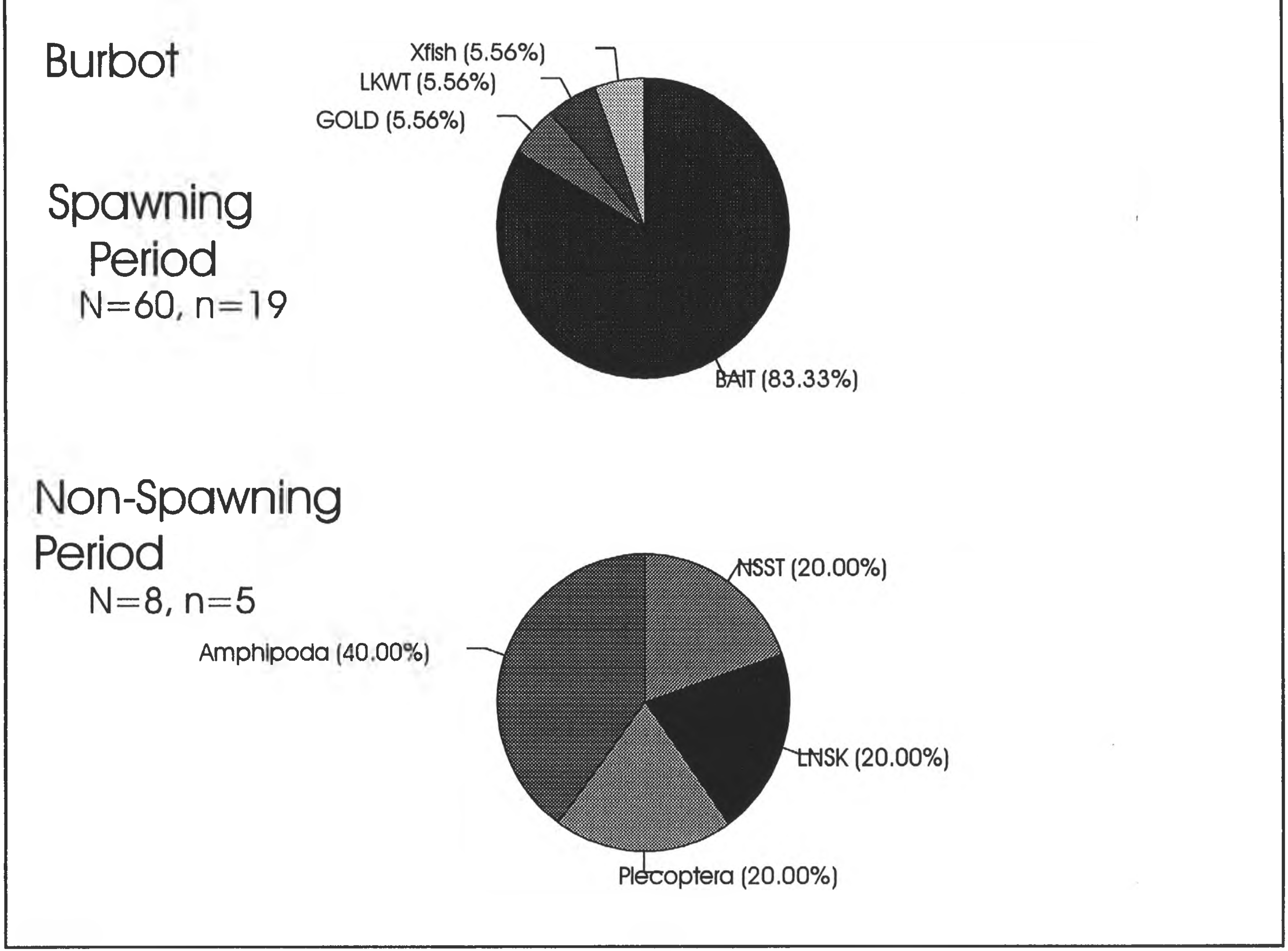


Figure 32. Percent occurrence of food items examined in the stomachs of burbot in the Slave River area in 1994 and 1995.

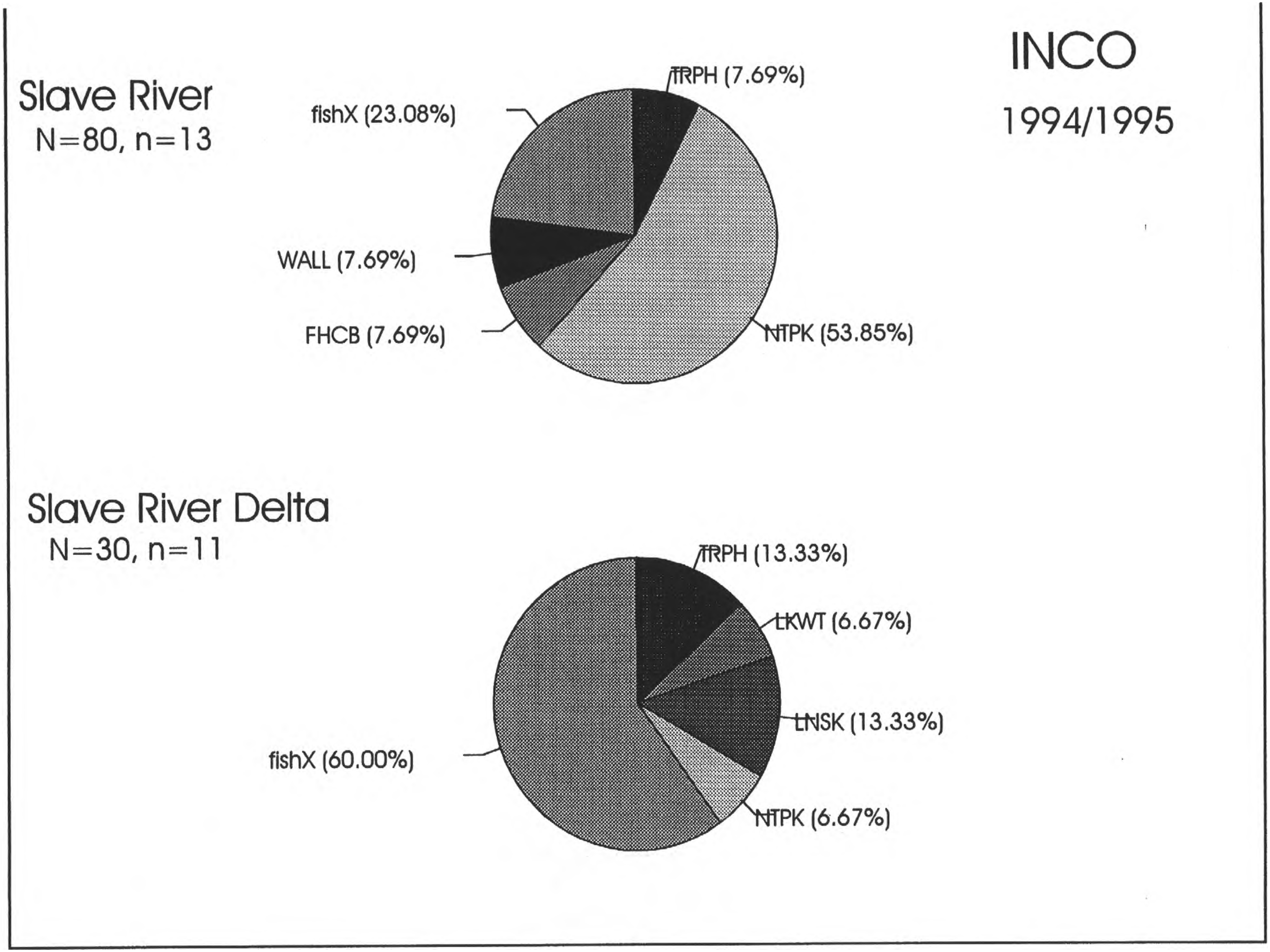


Figure 31. Percent occurrence of food items examined in the stomachs of inconnu in the Slave River area in 1994 and 1995.

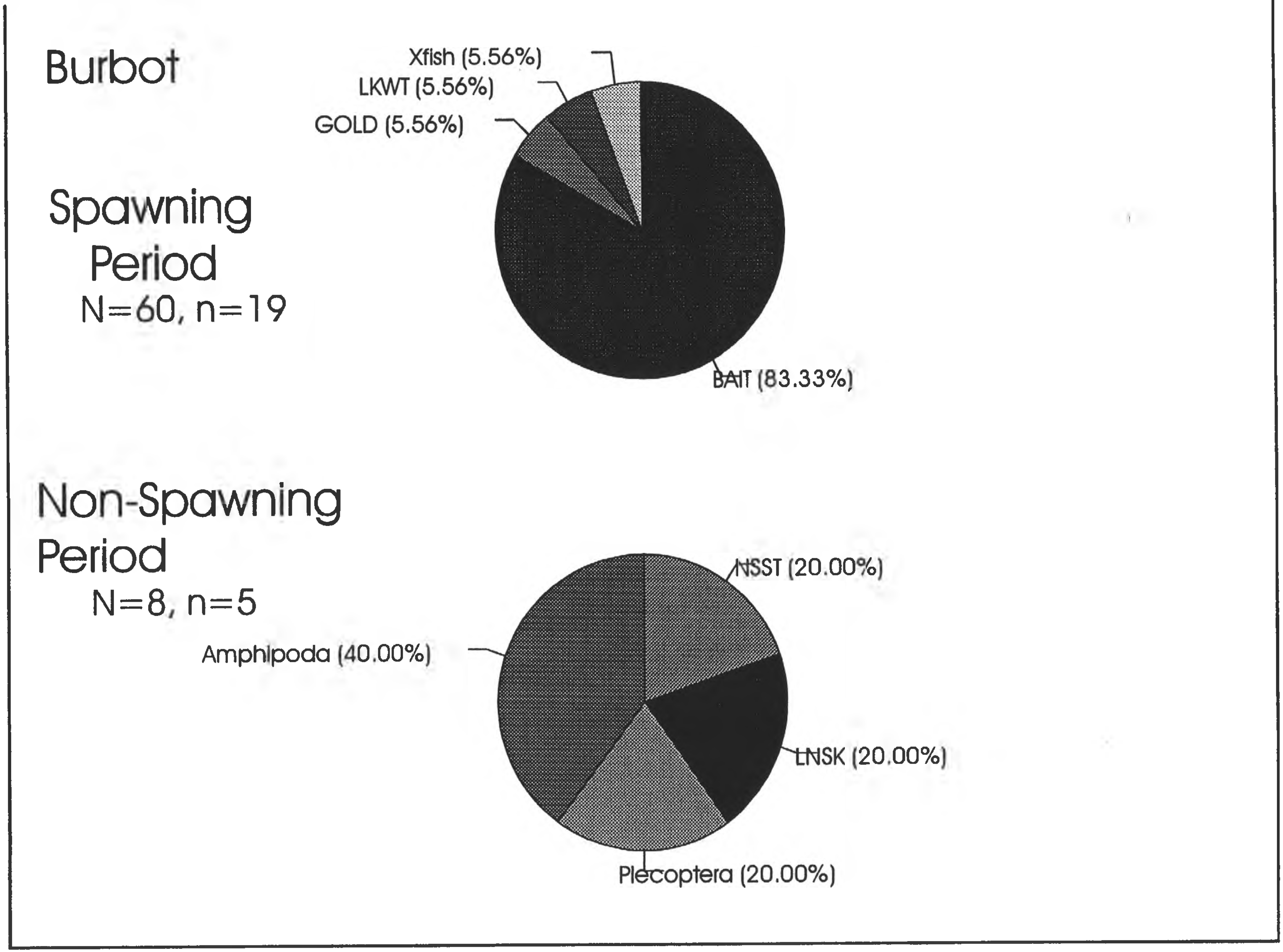


Figure 32. Percent occurrence of food items examined in the stomachs of burbot in the Slave River area in 1994 and 1995.

### 3.2.5 Lake Whitefish

Stomach content analysis was determined for 69 lake whitefish stomachs in 1994 and 1995. Thirty-three stomachs, representing 98.6% of total stomach contents were found to contain prey items.

General Description of Lake Whitefish diet: Prey items found are listed in Table 11 and Figure 33. A total of 14 different prey items were documented, 12 of which were invertebrate orders (98% total); fish in the diet represented 0.12% and vegetation represented 0.3% of the total diet. The most common items found in the stomachs were ostracods (75%) followed by corixids (12%) and trichopterans (6%) based on percent by absolute numbers of prey items found in the diet (Fig. 33). Prey items were also ranked by percent-by-weight and percent-by-frequency-of-occurrence in Table 15. The RII was calculated for each prey item (Table 15). The RII accounted for the numbers of items found, the weight and the frequency of occurrence; based on those three measures ostracods were ranked first in the diet of lake whitefish, followed by trichopteran larvae, and corixids.

Most of the lake whitefish stomach content data used above were from fish caught in the Salt River because throughout the 1995 spring and summer sampling periods, most lake whitefish were caught in the Salt River. Figure 33 best represents the diet of lake whitefish in the Salt River. A total of 111 lake whitefish were caught in 1995, 85 of which were caught in the Salt River, 22 were from the Slave River caught in mid-August and four were caught in the Slave Delta. For lake whitefish caught in the Slave River, a total of 25 stomachs were analyzed for 1994 and 1995 and all of those analyzed from mid-August onwards were empty or contained minimal unidentifiable digestive matter.

### 3.2.6 Goldeye

Stomach content analysis was determined for 43 goldeye stomachs in 1995. Thirty stomachs, representing 92.5% of total stomach contents were found to contain prey items.

General Description of Goldeye diet: Prey items found are listed in Table 11. A total of 14 different prey items were documented; invertebrate orders represented 89.6% total contents, vegetation represented 1.7% and rodent remains represented 0.5% of total stomach contents analyzed (Fig. 33). Results from the RII are shown in Table 16. The top four ranked prey items were as follows: plecoptera (31%), rodent remains (20.8%), Corixidae (14.4%), and Dytiscidae (11%).

Table 15. Relative Importance Index (George and Hadley 1979) for Lake Whitefish. The numbers in paratheses represent the relative ranking of the taxa in terms of their importance in the diet. See Table 1 for fish species abbreviations, - YOY = young-of-the-year.

| Prey Items | % Number | % Weight | % Freq. of Occurrence | Absolute Importance (AI) | Relative Importance (RII) |
|---|---|---|---|---|---|
| Ostracoda | 0.7553 (1) | 0.0452 (5) | 0.4412 (3) | 1.2416 | 27.06 |
| Trichoptera | 0.0581 (3) | 0.3872 (1) | 0.5 (2) | 0.9454 | 20.60 |
| Hemiptera | | | | | |
| Corixidae | 0.1171 (2) | 0.2217 (2) | 0.5589 (1) | 0.8976 | 19.56 |
| Gastropoda | 0.0117 (6) | 0.1693 (3) | 0.1765 (5) | 0.3575 | 7.79 |
| Amphipoda | 0.0181 (5) | 0.0560 (4) | 0.2059 (4) | 0.2800 | 6.10 |
| Coleoptera | | | | | |
| Dytiscidae | 0.0091 (7) | 0.0357 (7) | 0.1765 (6) | 0.2212 | 4.82 |
| Plant Material | 0.0026 (9) | 0.0145 (8) | 0.1471 (7) | 0.1642 | 3.58 |
| Diptera | | | | | |
| Chironomidae | 0.0219 (4) | 0.0093 (11) | 0.1176 (8) | 0.1488 | 3.24 |
| Ceratopogonidae | 0.0004(11) | 0.0002 (13) | 0.0294 (11) | 0.0300 | 0.65 |
| Tabanidae | 0.0038 (8) | 0.0361 (6) | 0.0882 (9) | 0.1281 | 2.79 |
| NSST | 0.0008(10) | 0.0115 (9) | 0.0588 (10) | 0.0711 | 1.55 |
| Damselfly L | 0.0004(11) | 0.0108 (10) | 0.0294 (11) | 0.0406 | 0.89 |
| Ephemeroptera | 0.0004(11) | 0.0025 (12) | 0.0294 (11) | 0.0323 | 0.70 |
| Oligochaeta | 0.0004(11) | 0.0000 (14) | 0.0294 (11) | 0.0298 | 0.65 |

Note: ( ) = order in ranking scale.

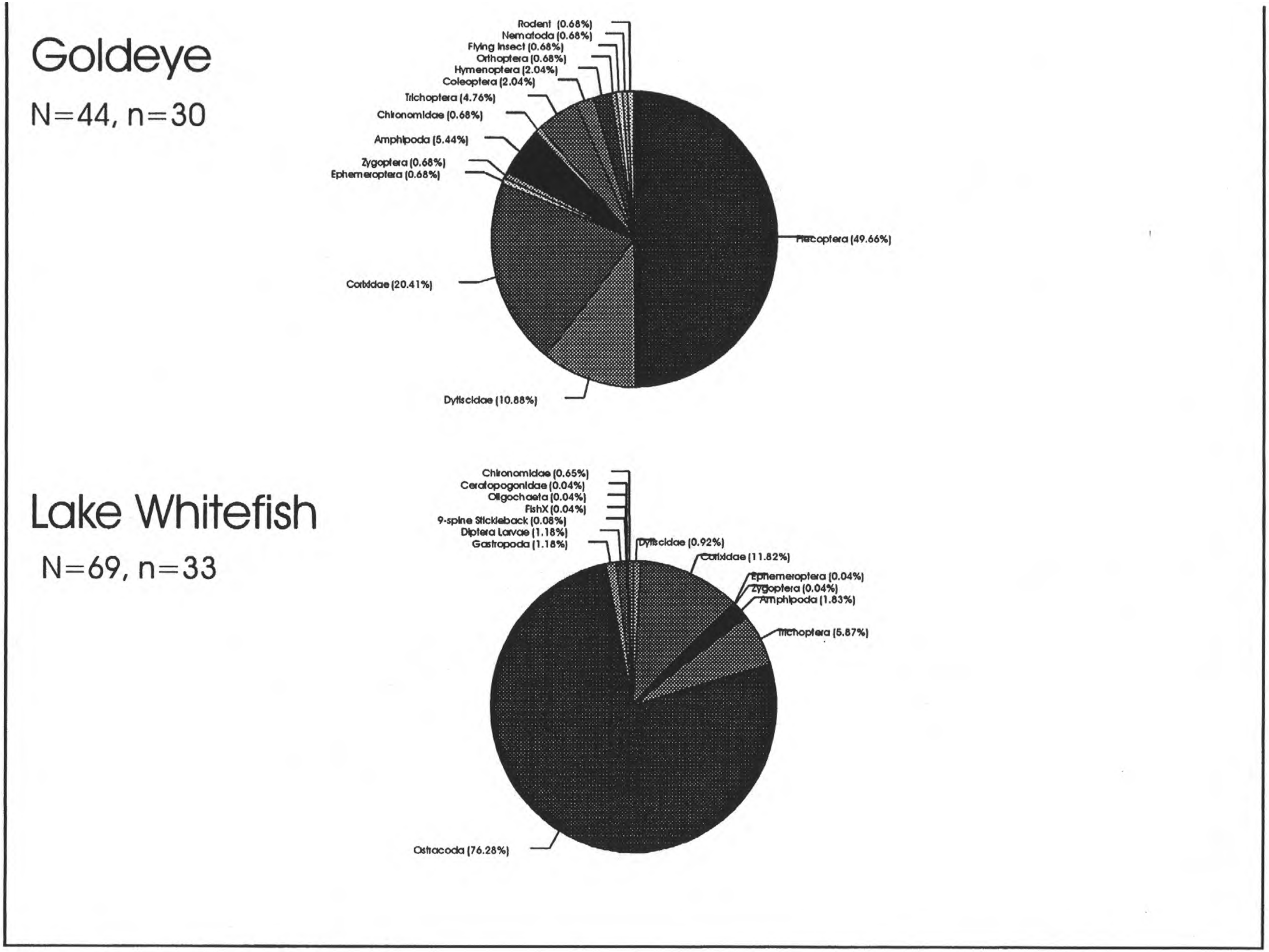


Figure 33. Percent occurrence of food items examined in the stomachs of goldeye and lake whitefish in the Slave River area in 1994 and 1995.

Table 16. Relative Importance Index (George and Hadley 1979) for Goldeye. The numbers in paratheses represent the relative ranking of the taxa in terms of their importance in the diet. See Table 1 for fish species abbreviations, - YOY = young-of-the-year.

| Prey Items | % Number | % Weight | % Frequency of Occurrence | Absolute Importance (AI) | Relative Importance (RII) |
|---|---|---|---|---|---|
| Plecoptera | 0.4654 (1) | 0.1010 (3) | 0.5667 (1) | 1.1334 | 31.19 |
| Rodent | 0.0063 (8) | 0.7163 (1) | 0.0333 (7) | 0.7560 | 20.80 |
| Corixidae | 0.2327 (2) | 0.0236 (4) | 0.2667 (2) | 0.5230 | 14.39 |
| Dytiscidae | 0.1132 (3) | 0.1223 (2) | 0.1667 (3) | 0.4022 | 11.07 |
| Trichoptera | 0.0440 (5) | 0.0080 (6) | 0.1333 (4) | 0.1854 | 5.10 |
| Plant Material | 0.0314 (6) | 0.0070 (7) | 0.1333 (4) | 0.1718 | 4.73 |
| Amphipoda | 0.0566 (4) | 0.0152 (5) | 0.0667 (6) | 0.1385 | 3.81 |
| Hymenoptera | 0.0189 (7) | 0.0014 (9) | 0.1000 (5) | 0.1203 | 3.31 |
| Flying Insects | 0.0063 (8) | 0.0016 (8) | 0.0333 (7) | 0.0411 | 1.13 |
| Damselfly L. | 0.0063 (8) | 0.0012 (10) | 0.0333 (7) | 0.0408 | 1.12 |
| Driftwood | 0.0063 (8) | 0.0012 (10) | 0.0333 (7) | 0.0408 | 1.12 |
| Ephemeroptera | 0.0063 (8) | 0.0005 (11) | 0.0333 (7) | 0.0401 | 1.10 |
| Chironomidae | 0.0063 (8) | 0.0003 (12) | 0.0333 (7) | 0.0400 | 1.10 |
| | | | | | 100 |

### 3.2.7 Flathead Chub

Stomach content analysis was determined for 26 flathead chub stomachs in 1995, of which eight contained prey items.

General Description of Flathead Chub diet: Prey items found are listed in Table 11. A total of nine different prey items were documented; invertebrate orders represented 65%, and vegetation represented 1.85% of total stomach contents analyzed (Fig. 34). Gastropods and corixids were by far the most common prey item, representing 20.8% and 18.9% respectively. Chironomids represented 7.4% of the stomachs analyzed; also found were items belonging to the orders Hymenoptera, Coleoptera, Orthoptera, and the family Dytiscidae.

### 3.2.8 Longnose Sucker

Stomach content analysis was determined for ten longnose sucker stomachs in 1995, of which nine contained prey items.

General Description of Longnose sucker diet: Prey items found are listed in Table 11. A total of eight different prey items were documented; invertebrate orders represented 57% and vegetation represented 4% of total stomach contents analyzed (Fig. 35). Ostracods, plecopteran and trichopteran larvae were the most common prey item, representing 21.74%, 17.39% and 13.04% of the stomach contents, respectively. Amphipods represented 4.35% of the stomachs analyzed.

### 3.2.9 White Sucker

Stomach content analysis was determined for ten white sucker stomachs in 1995, of which all ten contained prey items.

General Description of white sucker diet: Prey items found are listed in Table 11. Their diet was much broader than the longnose sucker with a total of 15 different prey items being documented; invertebrate orders represented 98% of total stomach contents analyzed (Fig. 35). Chironomids and corixiidae were the primary prey items, representing 38% and 43% of the stomach contents, respectively.

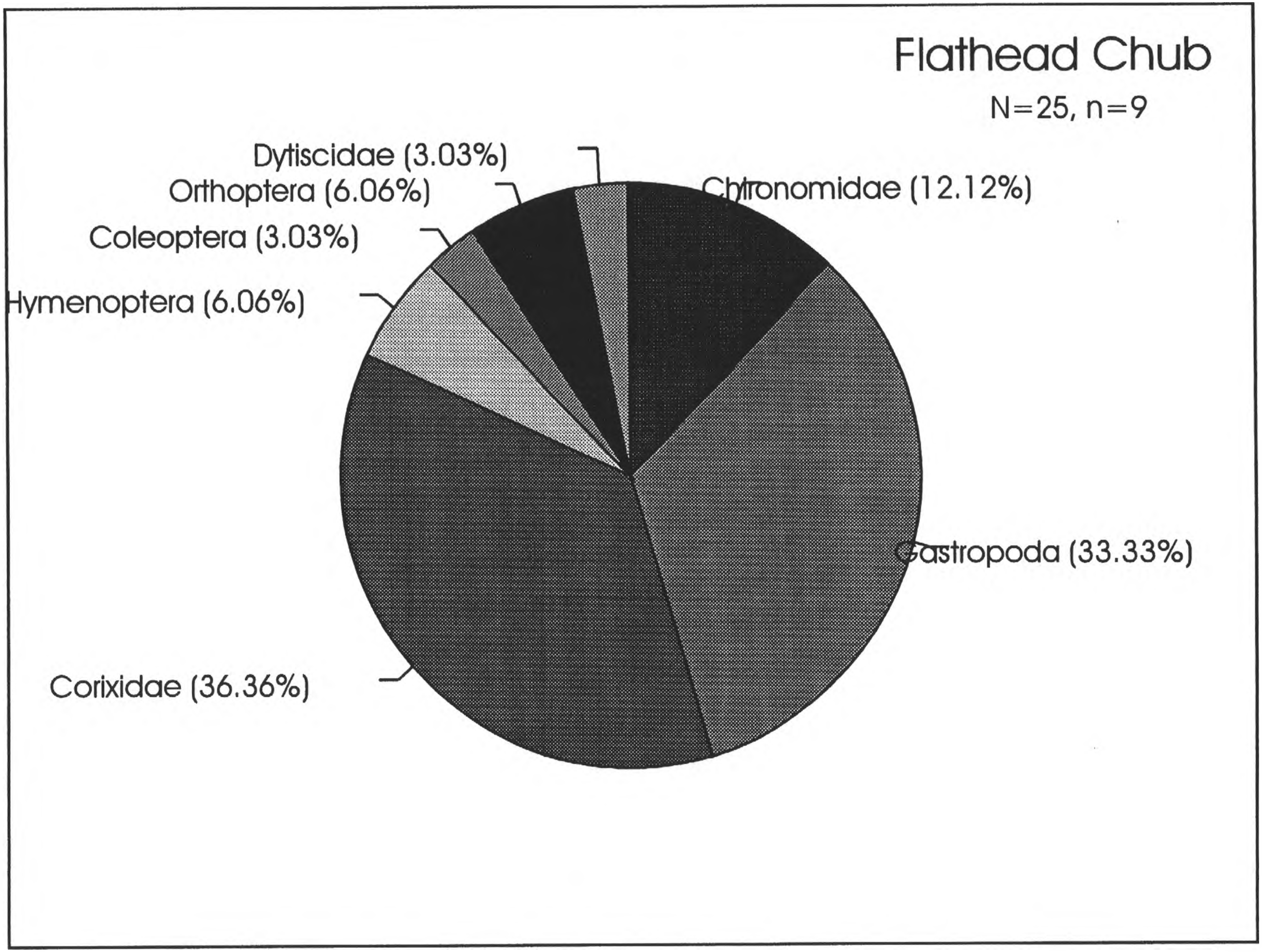


Figure 34. Percent occurrence of food items examined in the stomachs of flathead chub in the Slave River area in 1994 and 1995.

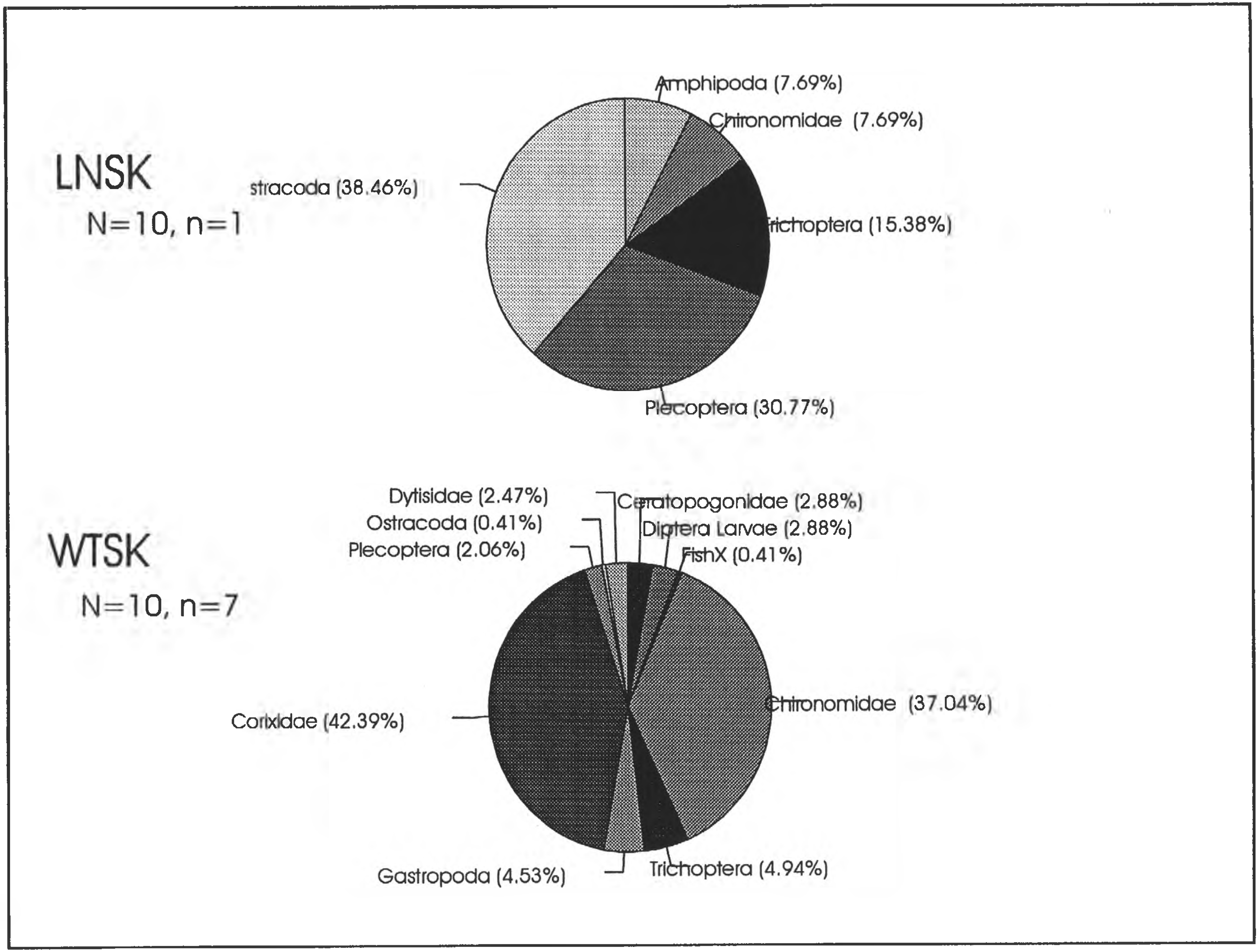


Figure 35. Percent occurrence of food items examined in the stomachs of longnose sucker and white sucker in the Slave River area in 1994 and 1995.

## 4.0 DISCUSSION

### 4.1 Life Cycle Summary

The life cycle, particularly whether the species in question is migrating or spawning has relevance to the seasonal and geographic feeding patterns and structure of the fish community in the lower Slave River. When fish are migrating or spawning they often do not feed heavily. For example, inconnu rarely feed during the final stages of their spawning migration (Howland and Tallman, unpublished data). Similarly, life cycle patterns influence the structure of the fish community. At certain times of the year the community may be dominated by one or more species that have migrated into the river from Great Slave Lake.

#### 4.1.1 Inconnu Life Cycle

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,cisco, (*Coregonus* spp.), 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 between August 23 1983 and November 10, 1983 and between August 6, 1984 and December 11, 1984. They were able to radio track inconnu for about six weeks 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 results they observed a large increase of inconnu in the system around mid to late August and continuing into October. Their radio-telemetry work revealed that inconnu have a rapid initial rate of upstream migration between mid-August and early September, followed by a holding pattern near the final point of upstream migration or fall back to downstream locations in the Slave River. Based on gillnetting and more precisely on their radio telemetry results, they estimated time of spawning to be between early and mid-October. Radio-tagging results from other studies that we have conducted (Tallman et al. 1996a) are quite similar to those of McLeod et al. (1985) and complement their findings well. Our findings suggest that spawning probably occurs around mid-October. Our results showed that inconnu only use the Slave River seasonally - 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. Statistical analysis suggests that falling temperatures appear to play some part in the maturation of inconnu. In 1995, field workers observed that the early drop in temperatures in the system coincided with a slightly earlier spawning readiness in the inconnu than in 1994. Other authors (Alt 1987, Nikol'skii 1961) believe inconnu to have specific temperature requirements for spawning. The abundance of inconnu in the system was independent of water flow but inconnu may require an upper maximum discharge level in order to migrate efficiently. Alterations to the system that might increase or charge the temperature and discharge patterns in the system would presumably have detrimental effects on the inconnu reproduction.

Our results show that inconnu mainly utilize the Slave River for spawning, entering the river in mid-August and leaving by late October. These results corroborate those of McLeod *et al.* (1985) and Tripp *et al.* (1981) who indicated that the Slave was an important spawning river for species such as inconnu

### 4.1.2 Burbot Life Cycle

The studies of Tripp et al. (1981) and McLeod et al. (1985) did not examine the migration and spawning of burbot. From our results we are confident that burbot make few if any directed movements in the Slave River between June and November (Tallman et al 1996a, 1996b). Judging from the state of the gonads in December we suggest that spawning probably occurs around February. Most burbot were around 10-15% GSI. Normally, GSI's must reach close to 25% at spawning. In this respect Slave River burbot would spawn at a similar time as most other Canadian populations (Scott and Crossman 1973).

We suspect that during most of the warmer months burbot hold in small feeding territories along the river, delta and Great Slave Lake. Our lack of success in capturing burbot using gillnets during the summer months would corroborate this. On the other hand, it is possible that burbot are able to avoid capture by gillnets. Burbot are chiefly nocturnal animals and are well equipped to find their prey in the absence of visual stimuli (McCrimmon and Devitt 1954). Perhaps they can feel the gillnet and thereby avoid it.

### Flathead Chub Life Cycle

Flathead chub were present in low abundance except during late May and early June when we recorded statistically significant increases in CPUE. We suspect that the high catches are due aggregations of flathead chub, probably for the purpose of spawning. If so, the timing of spawning of this species is in early spring shortly after river break-up. According to Scott and Crossman (1973) details of the spawning habits of flathead chub are unknown but available information indicates that spawning takes place in summer. Olund and Cross (1961) reported collections of males and females in spawning condition, taken in the Milk River in August 1955. However, McPhail and Lindsey (1970) reported the capture of females with large ovaries of almost free eggs, and one spent female in the Mackenzie River at 64° N, on June 27. Oland and Cross (1961) suggested that spawning occurred when water levels receded to the seasonal low during mid-summer. However, the seasonal low in the Slave River would be in fall. The nature of the Slave River may encourage spring spawning in this system.

The abundance of flathead chub may be important to monitor in the future because flathead chub are susceptible to flow changes in river systems. They are considered to be a specialized species for systems, such as the Slave River, characterized by high turbidity, wide seasonal fluctuations in flow and a wide channel that is in a constant state of change (Pflieger and Grace 1987) Traditionally, the Slave delta showed about four-year cycles of flooding and drying (Tom Unka, Fort Resolution Native Band Environmental Council, pers. comm.). Since the construction of the W.A.C. Bennett Dam in the upper Peace River these cycles have been destroyed. Pflieger and Grace (1987) found that flathead chub declined in abundance to the point of extirpation after extensive man-made alterations to the Missouri River that restricted the river such that the turbidity and sediment load were reduced and the natural-flow regimen modified.

### 4.1.4 Goldeye Life Cycle

Goldeye were the most abundant species in the Slave River over the entire sampling season. Similar to the flathead chub there were exceedingly high numbers present in late May and early June. The analysis of variance confirms that goldeye had a strong seasonal effect in their abundance. The biology of goldeye is well studied in Canada. In most locales, spawning occurs in the spring from May to the first week of June starting just after the ice breaks and continuing over a period of 3-6 weeks (McPhail and Lindsey 1970, Battle and Sprules 1960, Kennedy and Sprules 1967, Pankhurst et al. 1986). Thus, we interpret the high CPUE in late May and early June as indicative of spawning aggregations. We suppose that spawning must take place during May shortly after ice break-up.

The constant high abundance of goldeye suggests that it is an important species in the Slave River. Changes to the goldeye community from environmental changes would probably impact on the entire community of the Slave River both Aquatic and terrestrial. On the other hand, Sandheinrich and Atchison (1986) have shown in the Missouri River that anthropogenic changes could result in greater habitat for goldeye.

### 4.1.5 Lake Whitefish Life Cycle

Lake whitefish adults aggregated in the fall and likely spawn around the end of September. This is consistent with most literature reports for this species (Scott and Crossman 1973). The statistical analysis confirmed that time period was important. The capture of large numbers of juveniles on the Salt River is indicative that this area is a nursery area for this species. Abundance was correlated with temperature changes and therefore we conclude that the falling temperature is important in stimulating the spawning migration. The high CPUE in late May and early June is mainly due to the capture of large numbers of juveniles.

### 4.1.6 Longnose sucker life cycle

Longnose sucker were present in low numbers except during late May when a significantly higher CPUE was recorded. Since longnose suckers spawn in the spring as soon as the water temperature exceeds 5° C (Harris 1962, Geen et al. 1966), we would expect that spawning had occurred around mid-May. The high CPUE represented the tail end of the spawning aggregation. Longnose sucker are usually associated with clear waters and therefore may not be as successful in the turbid Slave River as elsewhere. Nevertheless, they appear to be a relatively constant presence in the system. The lack of correlations with seasonally changing environmental variables suggest that they are resident fish rather than transient migrants.

### 4.1.7 Northern pike life cycle

Similarly, northern pike appear to be resident fish in the Slave River system. The higher abundance overall in 1995 is difficult to interpret and as yet we have no explanation for it. The additional sampling in the Salt River is likely responsible for the higher catches of pike. Both young pike and adults occupy this area. The slow moving character of this river and the presence of lake whitefish juveniles make it suitable for pike. Pike are early spring spawners - probably so early here that there was no distinct evidence of a spawning aggregation. As a resident fish, the abundance of pike did not co-vary seasonally with environmental variables.

### 4.1.8 Walleye life cycle

Considering that walleye are a predator of other fishes and therefore high on the food chain they are present in substantial numbers. The highest abundance was in late May and we conclude that this is the likely time of spawning for this population. According to Scott and Crossman (1973) spawning occurs in spring or early summer depending on the latitude and water temperature (early April in southwestern Ontario to the end of June in the far north) . However, in our results we could not correlate water temperature with abundance. Normally, spawning begins shortly after the ice breaks up. Spawning grounds are the rocky area in white water below impassable falls in rivers. Based on these criteria, we suspect that the Rapids of the Drowned is the spawning area for walleye in the lower Slave River.

### 4.1.9 White sucker life cycle

White sucker were only found in the Salt River in 1995. They are moderately abundant in this river during June and July but were not captured after the beginning of August.

### 4.1.10 General Life Cycle Summary

Overall, the Slave River appears to be home to four different migratory types of fish. 1) There are highly migratory species such as inconnu and perhaps lake whitefish that are chiefly lake dwellers but use the Slave River for spawning in the fall. 2) There are other species that are spring or early summer spawners such as goldeye, flathead chub and walleye and pike that are moderately to highly abundant residents of the system. 3) There are species such as the longnose and white suckers that are in low abundance and never aggregate and therefore it is not clear if they spawn in the system. 4) Finally, burbot are very low in apparent abundance yet can be readily caught using set lines during the winter. They are also winter spawners. These life cycles and general patterns of seasonal and spatial occurrence significnatly affect the diet of the individual and thus the food web of the aquatic ecosystem of the lower Slave River.

## 4.2 Food Web

Northern pike consumed 21 distinct taxa. Of these, 14 are fish species, three were terrestrial vertebrates, and four were aquatic invertebrates. Pike, as generalist feeders, therefore, have a wide impact on the community and are a key component in the food web. Pike not only take aquatic animals but also large terrestrial vertebrates such as snakes, rodents and birds. Their versatility as predators is further emphasized when one considers the range of prey size against predator size. Prey ranged from seven to 60% of the length of the pike predator body length. To some extent, the pike diet can be used as an indicator of what is available in the system. For example, the stomachs of pike from the Salt River contained damselfly larvae whereas those from the Slave River proper and the Slave River delta did not. There were few flathead chub available in the Salt River and no Arctic lamprey. No white sucker were captured by pike in the Slave River. In general, the diet was quite different in pike captured in the Salt River, Slave River or Slave River delta (Fig. 24).

Northern pike diet varied seasonally. In May and June Slave River pike from the Slave River concentrated on flathead chub (17% of stomachs examined) and Arctic lamprey (17%). Pike in the Salt River ate mainly amphipods and a variety of fish species; whereas while those from the delta consumed fish species associated with Great Slave Lake such as lake chub, lake cisco, lake whitefish and burbot. During July and August, the Slave River pike diet shifted such that a wide variety of fish species made up the diet with northern pike (9% of stomachs sampled) being dominant. The change in species composition of ther prey probably reflected greater availability of migratory species such as lake whitefish in the latter part of the summer. Salt River pike also shifted more to fish species during the latter part of the summer. Fish were found in 67% of the stomachs examined. The dominant food item was the nine-spined stickleback (39%). The diet of pike from the delta remained focussed on lake dwelling species especially lake whitefish and burbot.

The larger size of pike greater than 400mm allowed them to prey upon a much wider variety of organisms. For example, one larger pike comsumed a snake nearly one m in length. Smaller pike appeared to be limited to invertebrates and the smaller fish species (e.g. chironomids and cyprinid fishes).

The large number of empty stomachs found forof walleye may be due to the tendency of walleye to regurgitate when caught in the net. Walleye consumed 14 different prey taxa and appeared to be an opportunistic generalist feeder similar to pike. Walleye relied about equally on invertebrates and fish species as prey with the most important prey being plecoptera and pike. Eight fish and six invertebrate species were noted.

Inconnu and burbot were exclusively piscivorous. In the Slave River, inconnu concentrated on walleye, flathead chub, northern pike and trout perch as prey. In the delta, they consumed pike, longnose sucker, lake whitefish and trout perch. The diet of burbot did not overlap with inconnu in the Slave River where they consumed lake whitefish and goldeye. In the delta, they consumed longnose sucker and nine-spined stickleback.

Goldeye, lake whitefish, flathead chub, longnose sucker and white sucker were almost exclusively invertebrate feeders consuming a wide variety of prey items. Goldeye concentrated on plecopteran larvae, dytiscids and corixids (42%, 9% and 17% of stomachs examined, respectively). Lake whitefish ate mainly ostracods (75%). Flathead chub concentrated on chironomid larvae, gastropods and corixidae (8%, 21% and 19%, respectively). Longnose sucker focussed on trichopteran larvae, plecopteran larvae, and ostracods (13%, 17% and 22%, respectively). White sucker focussed on corixidae and chironomid larvae (43% and 38%, respectively) Thus, there were no predators that focussed on exactly the same prey species although there were several cases of overlap in preferred prey items among the invertebrate feeders.

In conclusion, the piscine food web is layered into three major types of predator: 1) specialized fish only feeders such as inconnu and burbot; 2) generalized opportunistic predators such as pike and walleye that will take fish and invertebrates; and, 3) invertebrate feeders such as lake whitefish, goldeye, flathead chub, longnose sucker and white sucker which consume a wide variety of prey items.

These patterns suggest that several species are top predators and hence potential risks for biomagnification effects. These are northern pike, burbot, inconnu and walleye. A schematic of the Slave River food web shows that three fish species, northern pike, goldeye and lake whitefish have the greatest number of interactions with others (Fig. 36). Northern pike sample from most of the fish species available while goldeye and lake whitefish prey upon a great range of invertebrate taxa. Certain species such as goldeye, trout-perch and flathead chub serve as energy conduits between the lower trophic levels and the harvested fishes.

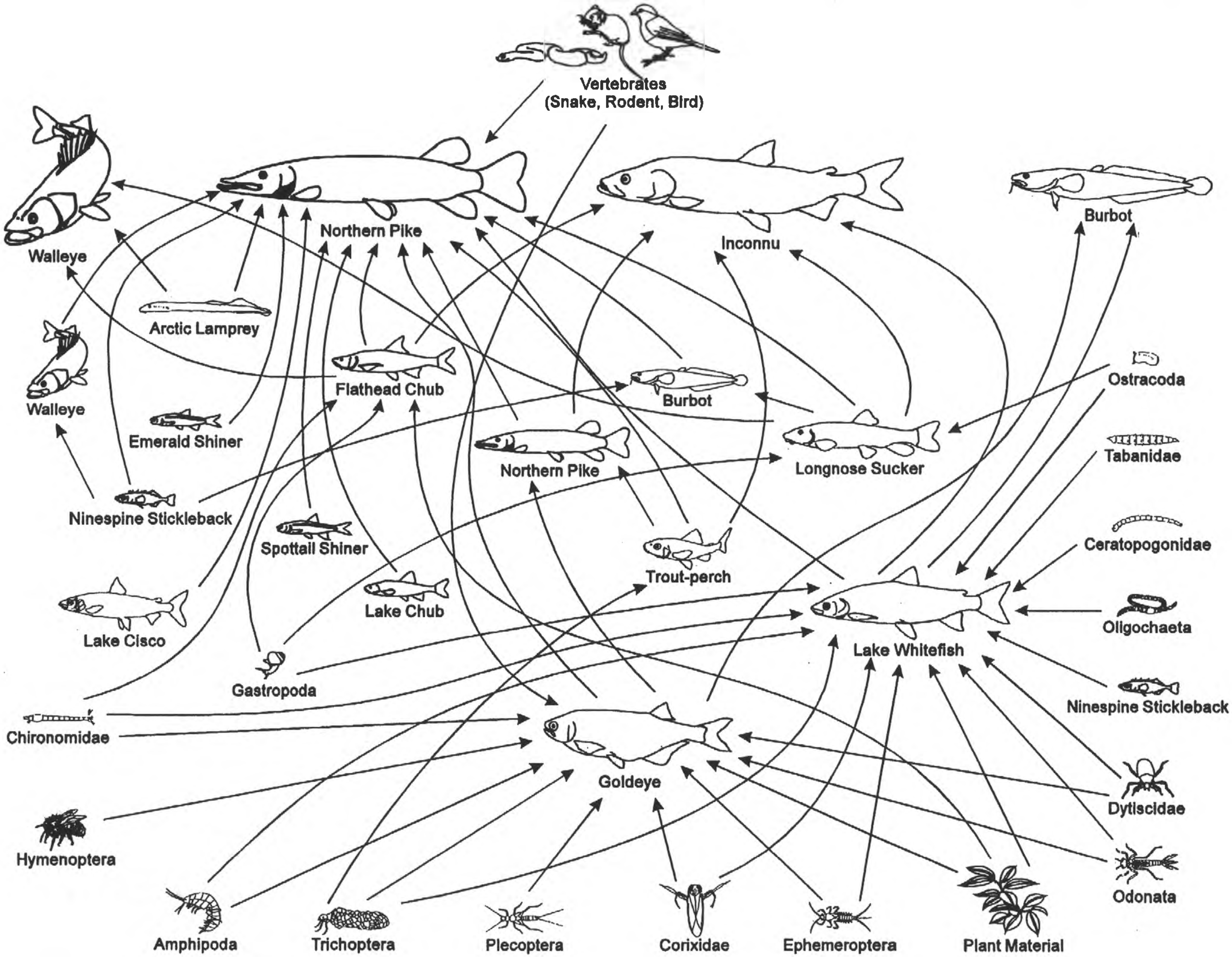


Figure 36. Slave River food web - arrows indicate the direction of predation.

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# APPENDIX A

# TERMS OF REFERENCE

# NORTHERN RIVER BASINS STUDY

# SCHEDULE A - TERMS OF REFERENCE

**Project: 3143-D3 DIET OF FISHES AND FOOD WEB**

## 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. Forty-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 sport fishing. 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 focused 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 complements 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 composition of the diet of fishes in the Slave River, N.W.T. with the aim of characterizing the inter-specific and intra- specific partitioning of resources and constructing a trophic web for the ichthyological community. The elucidation of the trophic positions of different species and size or age classes within species will reveal the potential pathways for bio-magnification of contaminants into species consumed by humans such as inconnu, Stenodus leucichthys, walleye, Stizostedion vitreum, and burbot, Lota lota. The information gathered should compliment the findings of studies of the food web conducted by other means such as with stable isotope analysis. As well, valuable information on the basic bio- diversity in the fish community of the Slave River will be obtained.

## III. TERMS OF REFERENCE

1. The contractor is required to obtain samples through a regular monitoring program on the Slave River from June to November, 1994 and if necessary in additional samples up to August in 1995.

    a. Samples (in 1994) will be acquired from the LIFE HISTORY VARIATION OF HARVESTED FISH program. Thus sampling will be from June to November on a bi-weekly or monthly basis. Two and possibly three sampling sites will be determined. If the logistical problems can be solved it is expected that there will be at site near the town of Fort Smith, and a site upstream and downstream from this location.

    b. Sampling will commence by mid-June, 1994 with samples taken every two to four weeks until the end of November using large mesh ( 4-5.5 " stretch mesh) gillnets and multi-mesh (1.5 - 4.5 ") gangs of gillnets.

    c. For each fish caught the length of time that the net was set, the net mesh size, environmental conditions, fish species, fish length, both fork length and total length, fish weight, and sex will be recorded. The fish will be dissected to determine the sexual maturity stage and gonad weight, and the gonads, otoliths, a pelvic fin ray, scales and stomach removed and preserved. Additional tissues will be removed as requested by other investigations such as the determination of stable isotope patterns, contaminant loading, bioenergetic investigation and genetic variation. Some fish will be sent to the FWISL laboratory for more detailed analysis.

    d. Gonads will be analyzed at the FWISL to verify the stage of sexual maturity and to estimate female fecundity. The otoliths, scales and finrays will be processed at the

FWISL and used to determine fish age. The stomach contents will be analyzed to determine if the fish were feeding in the river and to determine the diet

e. The data will be analyzed to determine the diet at size and age for each species. Ages will be determined from the most reliable structure (Otolith, scale, fin ray or operculum) or, if no suitable structure exists, analytically, using the technique of MacDonald (1980). An index of importance of each dietary item will be calculated and index of competitive overlap, such as Morisita's index of overlap will be calculated. The trophic interactions will be mapped to produce the food web for the Slave River.

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 for 1994 is anticipated by December 1994. Laboratory processing and analysis of samples is anticipated by March 31, 1995. Field work in 1995 is anticipated to be completed by August 1995. Data entry and analysis of the data will be completed and a final report will be prepared on all results and submitted to the Study office by September 30, 1995.

2. The final report will include:

   a. a description of the methods utilized in the study including method of dietary analysis, food types found and the details of gillnetting procedures, mesh sizes of nets, sampling times and locations.

   b. a determination of the importance of dietary items for each species by size class and age and measurement of the competitive overlap between size classes and species in diet. Development of a food web model for the fish of the Slave River.

   c. a brief interpretation of the meaning of the results, particularly in terms of the pathways of bio-magnification of contaminants within the fish community.

3. The raw data relating to field sampling and dietary analysis 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.

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 Appendix with the Terms of Reference for this project.

   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 E00, 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. 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
Fax: (403) 422-3055

This project is under the Food Chain Component of the NRBS led by:

Dr. Ray Hesslein
Research Scientist
Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Phone: (204) 983-5251
Fax: (204) 984-2404

Questions of a scientific nature should be directed to him.

## VI. 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.

## VII. PROJECT MANAGEMENT PLAN - DFO/Winnipeg laboratory

1. Field sampling during June to November 1994 on the Slave River. Laboratory analysis of samples will be from December, 1994 to May, 1995. Field sampling during June to August 1995 on the Slave River. Laboratory analysis of samples will be from August, 1995 to September, 1996. Data analysis and write-up by September 30, 1995 All permits for the netting of fish and the transport of samples 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 acquiring fish or other unforeseen problems.

## VIII. LITERATURE CITED/REFERENCES

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