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BIOLOGICAL CHARACTERISTICS OF BURBOT IN RIVERS OF INTERIOR ALASKA DURING 1988[1]

By

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ABSTRACT

In an ongoing study of burbot *Lota lota* in rivers of interior Alaska, six sections of the Tanana River, one section of the Yukon River, one section of the Tolovana River, and one section of the Chena River were sampled between 1 July and 21 September, 1989. All sections were 64 kilometers in length, except the Chena River, which was 24 kilometers in length. Sampling in each section was conducted using commercially manufactured hoop traps which were rebaited and moved daily for a period of five days.

Movement information from 526 tag recoveries obtained through sampling efforts and from anglers since the study began in 1983 has shown that burbot in the Tanana River are 76 percent resident (recaptured within eight kilometers of tagging site) to a given area up to a period of 1.5 years. The percentage of burbot remaining resident to an area is lower (48 percent) after a period of 1.5 years, indicating burbot are not completely resident to an area throughout their lifetime. Movements are predominantly upstream. Downstream movements are infrequent and short-ranging. The greatest recorded upstream movement was 264 kilometers, while the greatest recorded downstream movement was 168 kilometers. Ten burbot were documented as moving out of the mainstem Tanana River into tributary streams (Tolovana, Chena, and Goodpaster Rivers), while one burbot has been documented as moving out of a tributary stream (Tolovana River) into the mainstem Tanana River.

Tests to determine burbot passage through two sections of the Tanana River identified two isolated stocks of burbot (lower and upper river), with the boundary lying near the outlet of George Lake (river kilometer 594). Seasonal movements of burbot in the Tanana River based on tag recoveries obtained within one year of tagging indicated that the highest frequencies of movement occurred during the fall (September, October, and November) and winter (December, January, and February) which were interpreted as feeding movements (during fall) and spawning migrations (during winter).

Relative densities of burbot fully recruited to hoop trap gear (greater than 449 millimeters total length) in sample sections of the Tanana River based on catch-per-unit-of-effort statistics (burbot per net-night) ranged from 0.54 to 1.26. Catch-per-unit-of-effort estimates of burbot sampled in the Yukon, Chena, and Tolovana Rivers were 0.59, 0.90, and 1.11, respectively. Mean total lengths of fully recruited burbot in sample sections of the Tanana River varied from 523 to 610 millimeters, while mean total lengths of fully recruited burbot in sample sections of the Yukon, Tolovana, and Chena Rivers were 651, 660, and 557 millimeters respectively.

Eighty-two pairs of otoliths were collected from burbot in the Yukon River from which age data were obtained. Ages ranged from four to 18 years. Mean lengths-at-age of burbot in the Yukon River were similar to those of burbot in the Tanana River.

KEY WORDS: burbot, *Lota lota*, Tanana River, Yukon River, Tolovana River, Chena River, harvest, hoop trap, tagging, movement, catch-per-unit effort, mean length, length frequency, length-at-age, gear selectivity.

INTRODUCTION

The popularity of burbot *Lota lota* sport fishing in the Tanana River drainage has been increasing dramatically over the past 10 years. Harvest has increased approximately 13% annually since 1977, and in 1987 total harvest exceeded 4,000 burbot (Mills 1988). The fishery occurs year-round and throughout the entire system. However, most of the effort occurs in the mainstem Tanana River during the winter and is concentrated near the communities of Fairbanks, Delta Junction, and Tok. Set-lines are the primary gear, although hand-held lines are used as well. Burbot in northern climes are known to be relatively long-lived, slow growing, and late maturing (Chen 1969; Evenson 1988) and are therefore susceptible to overexploitation. Stock assessment studies of burbot in interior Alaska lakes revealed that a number of lake populations were depressed due to overfishing (Peckham 1985; Parker et al. 1988). These findings prompted management actions such as reduction of daily bag limits and closures of some fisheries.

In response to increasing harvests in the Tanana River, and because little published information is available concerning movements and migrations and population dynamics of burbot in riverine systems, the Alaska Department of Fish and Game (ADFG) initiated a stock assessment study in 1983 to investigate migratory behavior, examine life history characteristics, and estimate relative abundance of burbot throughout the Tanana River drainage. The long-term goal of this research is to define sustainable yield of the stock(s) so that rational sport fishery regulations can be developed to maintain the population under increasing fishing pressure. This report summarizes the findings of this study during 1988 and updates information provided by Hallberg et al. (1987). Specific objectives for this investigation in 1988 were to:

1. test the hypothesis that burbot do not migrate past two sections of the Tanana River (river kilometer 144-208 and river kilometer 628-712);

2. estimate an index of abundance (mean catch rate by overnight set of a hoop trap) of all burbot 450 mm TL and longer in each of six sections along the Tanana River, one section of the Tolovana River, one section of the Chena River, and one section of the Yukon River;

3. estimate the mean length of all burbot 450 mm TL and longer in each of six sections of the Tanana River, one section of the Tolovana River, one section of the Chena River, and one section of the Yukon River; and,

4. estimate the mean length-at-age of burbot in the Yukon River.

STUDY AREA

The Tanana River is a large, silt-laden river of glacial origin formed at the confluence of the Chisana and Nebesna Rivers near Northway, Alaska. From its origin, the Tanana River flows northwesterly for 912 km where it drains into the Yukon River, approximately 6 km east of Tanana, Alaska (Figure 1). Tributaries flowing from the south are primarily glacial-fed streams flowing from the Alaska Range and Wrangell Mountains, while northern tributaries are primarily clear runoff streams flowing from the Tanana-Yukon Uplands. Burbot are found throughout the system. During 1983 and 1984 sampling was conducted in one section near Fairbanks. During 1985 sampling was expanded and included seven sections located between Fairbanks and Delta Junction. From 1986 through 1988 sampling was expanded further with sample sections ranging across the entire river (Figure 2).

The Tolovana River is a relatively large clearwater tributary originating in the White Mountains approximately 100 km north of Fairbanks, Alaska. It flows southwesterly through the Minto Flats State Game Refuge and into the Tanana River 168 km above its confluence with the Yukon River (Figure 1). A small fishery for burbot occurs in Minto Flats with the total harvest in 1987 estimated at 132 burbot (Mills 1988). The lower 30 km of the Tolovana River is connected with the Tanana River via Swanneck Slough, and is silty and similar in appearance to the Tanana River. During 1988, a 64 km section of the lower Tolovana River was sampled beginning 37 km above its confluence with the Tanana River and extending upstream to its confluence with the Chatanika River.

The Chena River is also a relatively large clearwater tributary stream with its origin approximately 100 km northeast of Fairbanks. It then flows southwesterly until its confluence with the Tanana River near the community of Fairbanks (Figure 1). Because of its close proximity to Fairbanks, the Chena River supports a relatively large burbot fishery. Harvest in 1986 was an estimated 890 burbot (Mills 1987). During 1988 a subsection of the lower Chena River was sampled beginning at its confluence with the Tanana River extending upstream 25 km.

The Yukon River is Alaska's largest river system flowing southwesterly across the entire state (Figure 1). Due to limited road access and remoteness to large communities, few burbot are harvested by anglers. During 1988, one 64 km subsection was sampled in the vicinity of the Dalton Highway Bridge.

METHODS

Gear Description

Burbot were captured in two different sizes of commercially manufactured hoop traps. The type of trap used during 1983 through 1987 was constructed with knotted nylon netting woven into 25 mm bar mesh attached to seven fiberglass hoops. Traps were 3.66 m long and 0.91 m in diameter. Each trap had a double throat (tied to the first and third hoop) and was kept stretched with two spreader bars made from PVC pipe with snap clips on each end which were attached to the end hoops.

The second type of trap was used experimentally in two subsections during 1987, and was used for all sampling during 1988. The trap was designed as above, but was smaller. These traps were 3.05 m long with seven 6.35 mm steel

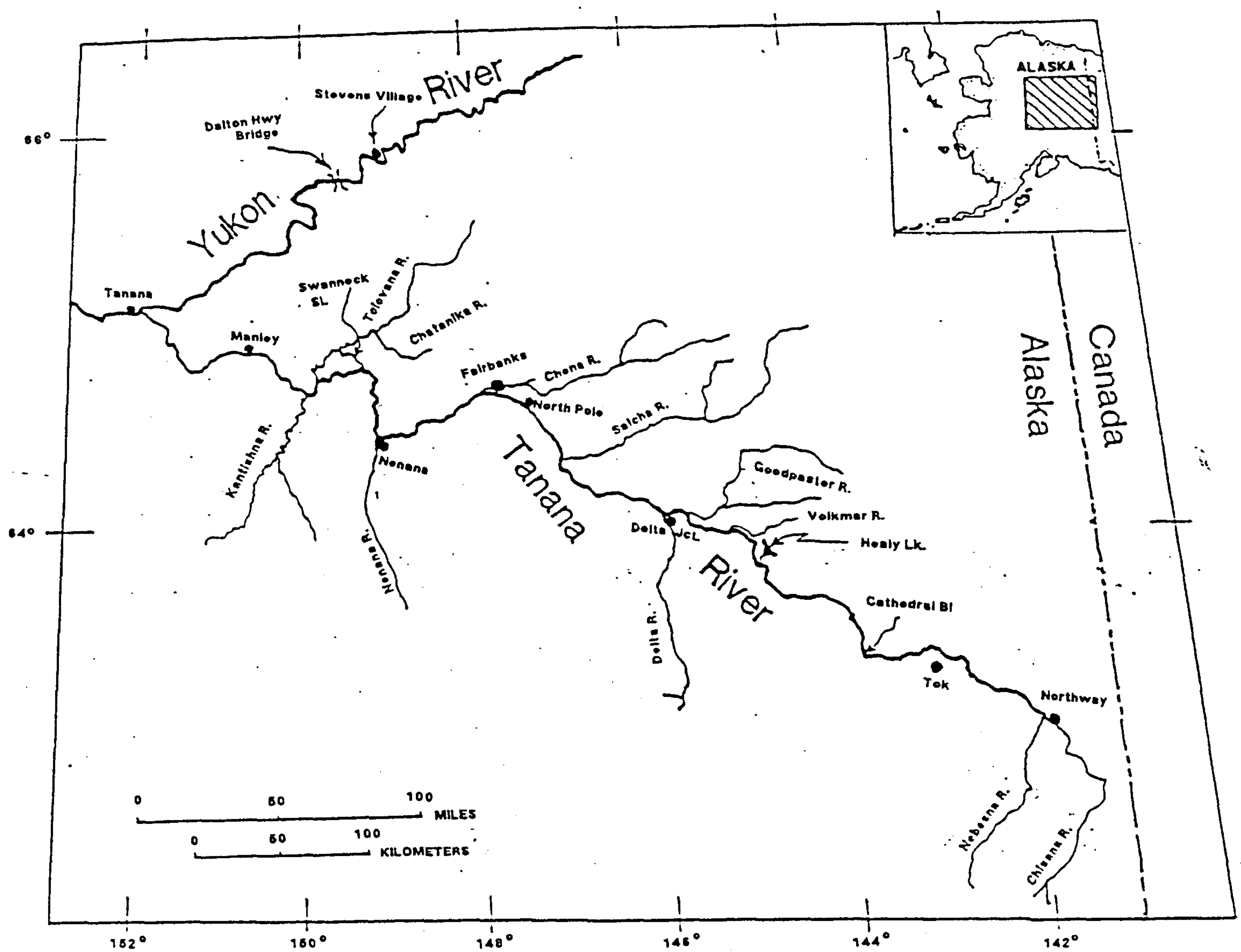

Figure 1. Map of the Tanana River drainage.

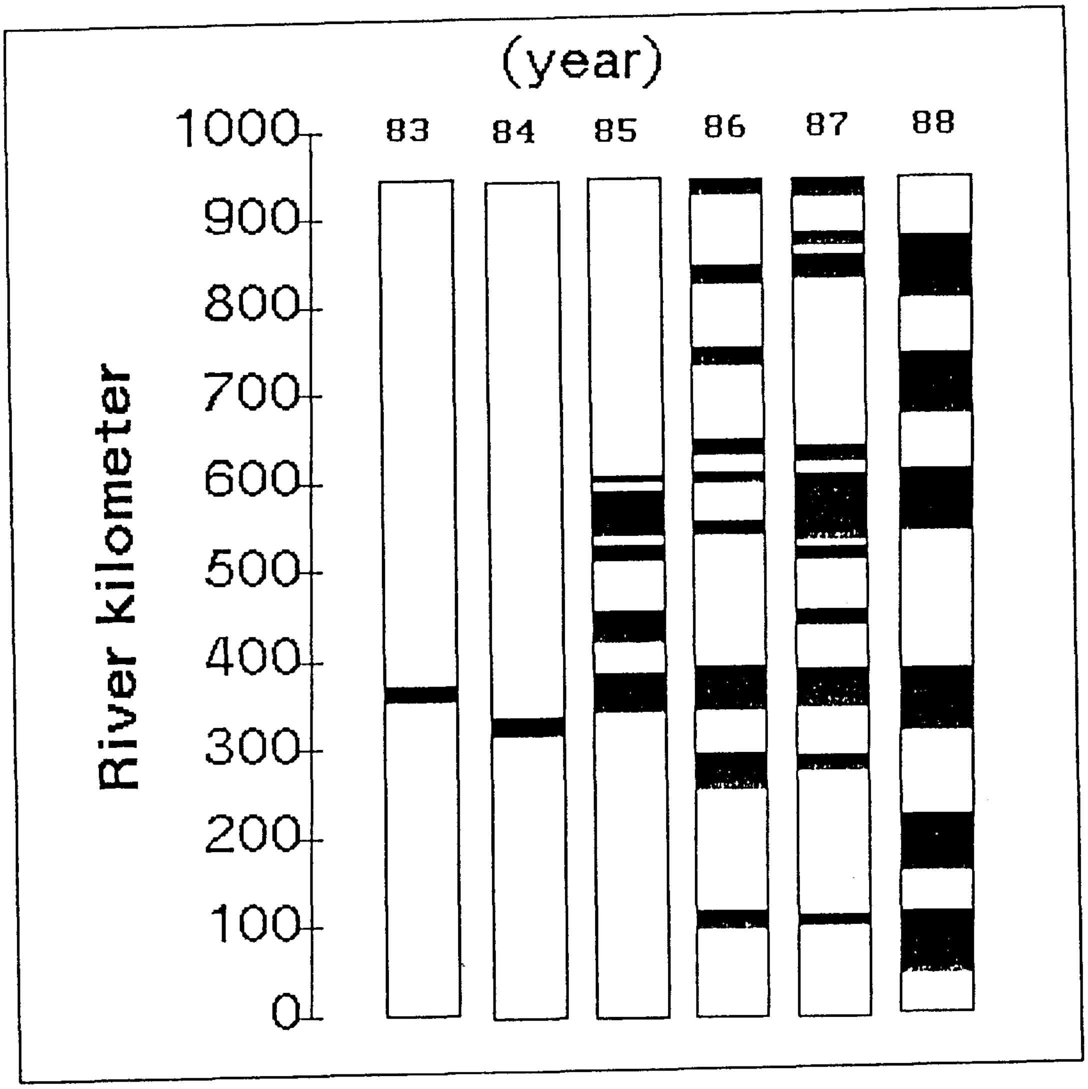

Figure 2. Relative locations of sample areas in the mainstem Tanana River from 1983 through 1988 (sample areas are in black).

hoops tapering from 0.61 m diameter at the entrance to 0.46 m at the cod end. Spreader bars were constructed of 12 mm galvanized steel conduit (Figure 3).

The hoop traps were baited with cut Pacific herring *Clupea harengus* placed in perforated plastic containers. One end of a five to 10 m section of polypropolene rope was tied to the cod end of each trap, while the other end was tied off to shore. The traps then fished on the river bottom near shore with the opening facing downstream. An outboard-powered riverboat was used to set, move, and retrieve the traps.

Study Design

All sampling of burbot from 1983 through 1987 was conducted in the mainstem Tanana River. Subsections typically were 16 km in length. In 1988 six larger subsections (64 km) were sampled in the mainstem Tanana River. In addition, two tributary streams (Chena and Tolovana Rivers) were sampled during 1988, as well as a section of the Yukon River. Sample sections in the Tolovana and Yukon Rivers were 64 km in length. Due to time constraints, only 24 km of the Chena River were sampled. All sampling was conducted during open water periods between 1 June and 15 October.

For each of the subsections sampled during 1983 through 1988, traps were typically set for a period of 24 hours at a density of three to six traps per kilometer. Traps were set at near equal intervals along both shores depending on availability of suitable setting locations and were moved each day to a new location within the subsection. All trap locations were marked on 1:63,360 USGS maps and were recorded to the nearest river kilometer (kilometer 0 located at the mouth of the river and kilometer 915 located at the headwaters). All burbot captured were measured to the nearest millimeter, tagged using individually numbered Floy internal anchor tags, finclipped (right and left pelvic clips were alternated from one year to the next) and released at the capture sight. Recaptured burbot were obtained through subsequent sampling and from anglers.

Data Analysis

Burbot movement data was analyzed for relative mixing rates among river sections and seasons. Burbot abundance was estimated as an index of burbot caught per net-night. Burbot size and age data were examined using Gabelhouse categories. Selectivity of large and small hoop traps was tested.

Movements:

Burbot movements within the Tanana River based on recaptured burbot obtained through sampling efforts and from anglers prior to 1988 revealed that burbot had migrated extensively within the Tanana River, but none had moved into or through a section near the Tolovana River (river kilometers 112 through 246) or a section above the George Lake Outlet (river kilometers 611 through 714; Evenson 1988). Although extensive tagging has been conducted above and below both of these sections, none had been conducted within either two. Using information concerning movements of burbot in other sections of the river, the

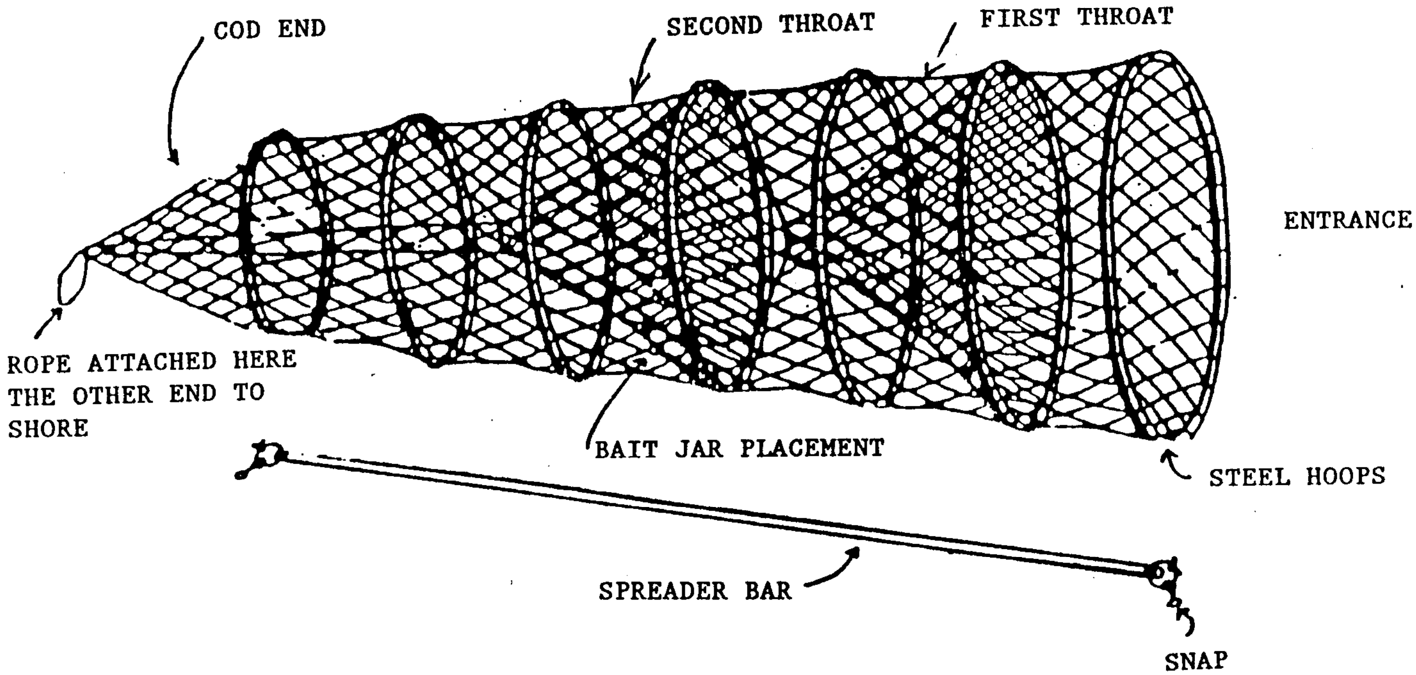

Figure 3. Diagram of hoop trap gear used to sample burbot.

hypothesis that these two sections define boundaries for three separate stocks of burbot (lower river, middle river, and upper river) was tested.

To test the hypothesis of fish passage between lower and middle river and between middle and upper river sections, two sub-sections were sampled. The first sub-section (Tolovana) was a 64 km section located between lower and middle river sections (river kilometer 160 through 216), while the second sub-section (Cathedral Bluffs) was a 64 km section located between the middle and upper river sections (river kilometer 656 through 720). Because the frequency and range of downstream movements are relatively low, the possibility of burbot moving into the sample sections from upstream areas is unlikely. Therefore, the hypothesis considers only: 1) fish moving from lower river upstream to the Tolovana sample section and; 2) fish moving from middle river upstream into the Cathedral sample section. The assumptions of this hypothesis are: 1) the behavior of tagged burbot (frequencies of upstream movements) is consistent throughout the entire river and; 2) the density of burbot (based on mean catch-per-unit-effort) in the two sample sections is consistent with other sections of the river.

To test these hypotheses, burbot tagged during 1987 in sections immediately downstream from the Tolovana and Cathedral Bluffs sample sections were considered. An annual survival rate of 75% was considered for these tests[1]. A 10% interchange was considered to be a significant threshold of stock delineation for both tests. A probability of capture was calculated to be 0.00033[2], with the assumption that the probability of capture is a binomial process. The number of burbot expected to move from lower river into the Tolovana section and from middle river into the Cathedral Bluffs section was calculated as:

$$(1) \quad \hat{y}_j = M_i(\hat{S})(T)$$

where:

$\hat{y}_j$ = the number of burbot expected to move into sample section j;

M_i = the number of burbot marked in section i (immediately downstream from section j) during 1988;

$\hat{S}$ = the estimated annual survival rate; and,

T = the threshold of significant interchange.

The number of burbot needed to be captured in each sample section j to be 95% confident of recapturing at least one tagged burbot which had migrated from downstream sections was calculated as:

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[1] Based on data from Parker et al. (1988) concerning annual survival rates of burbot in lakes in interior Alaska.

[2] Based on data from Evenson (1988) concerning a mark-recapture abundance estimate of burbot in a 16 km sample section of the Tanana River near Fairbanks (mean CPUE = 0.85 burbot per net-night).

(2) $0.05 = (1-\hat{p}x_j)^{y_j}$

where:

$\hat{p}$ = the estimated probability of recapture of one tagged burbot; and,

x_j = the number of burbot needed to be captured in each sample section j.

The number of burbot needed to be captured in the Tolovana section was 550, while the number of burbot needed to be captured in the Cathedral Bluffs section was 70 to produce a precise test. This test considers only migration of burbot tagged in sample sections immediately downstream from the Tolovana and Cathedral Bluffs sections during 1987. However, any tagged burbot recaptured in either of these two sections from other sample sections of the river would also negate the hypothesis that burbot do not migrate through these two sections.

Data from recaptured burbot obtained during 1988 were pooled with data collected from previous years. Information from the hypothesis of fish passage (described above), as well as from recaptures obtained in the other sample sections and from anglers was used to identify boundaries of major stocks of burbot throughout the river. After these boundaries were identified, movement characteristics (frequency and magnitude of movements) were examined.

Relative mixing rates of burbot between river sections were then determined using multinomial proportions based on all burbot recaptured since 1983. These proportions are based on the assumption that there is an equal probability of capture of tagged burbot among river sections in the same year. Because effort was in general spread throughout the river, and traps were in general set at equal densities along the river in all sections, this assumption was satisfied. The marginal proportions in this multinomial distribution were:

(3) $$\hat{Q}_{ij} = \frac{m_{ij}}{R_i};$$

(4) $$V[\hat{Q}_{ij}] = \frac{\hat{Q}_{ij}(1-\hat{Q}_{ij})}{R_i-1}$$

where:

R_i = the number of burbot recaptured in section i;

m_{ij} = the number of burbot marked in section i and recaptured in section j; and,

Q_{ij} = the relative mixing rate of burbot marked in section i and recaptured in sample section j;

Seasonal movements were interpreted by examining all recaptures obtained within one year of tagging. Seasons were described as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November). All fish were tagged during summer or fall. A movement was described as upstream (10 km or more), downstream (10 km or more), or stationary (-10 to 10 km). Proportions of burbot moving upstream, downstream, or remaining stationary during each season were calculated using equations 3 and 4 for burbot tagged during summer and fall.

Catch-per-Unit-of-Effort:

Mean catch-per-unit-of-effort (CPUE is defined as burbot per net-night) for each river section and its associated variance were calculated from the number of burbot caught per net-night for each sampling period (five days and four nights) based upon the following equations from Wolter (1984):

(5) $$\overline{CPUE} = \bar{X} = n^{-1} \sum_{s=1}^{t} X_{ch};$$

(6) $$V[\overline{CPUE}] = \frac{\sum_{s=2}^{t} [X_{ch} - X_{ch-1}]^2}{2t[t-1]};$$

where:

X_{ch} = catch of burbot of a size class c in hoop trap h;

t = the total number of effectively fishing hoop traps in a river section; and,

s = the set number such that s = 1 to t in order with i = 1 the most downstream set and i = t the most upstream.

A mark-recapture experiment conducted in 1987 showed that burbot in the Tanana River are fully recruited to large hoop traps after they have grown beyond 450 mm TL (Evenson 1988). A similar study concerning burbot in interior Alaska lakes showed that in most cases burbot also become fully recruited to small hoop traps at 450 mm TL (in six out of eight lakes full recruitment began at 450 mm TL, in one lake full recruitment began at 500 mm TL, while another lake full recruitment began at 550 mm TL; Parker et al. 1988). Because only small hoop traps were used during 1988 and because no specific mark-recapture experiments were conducted to determine at what length full recruitment began, an assumption based on the above findings was made that full recruitment to small traps in the Tanana River, Tolovana River, Chena River, and Yukon River also began at 450 mm TL. For these reasons estimates of mean CPUE were made for those burbot smaller than 450 mm TL and those 450 mm TL and longer.

In some cases, a trap was considered not to be fishing effectively. This occurred when water levels rose or fell causing the trap to become silted into the river bottom or washed ashore, when the bait container drifted out of the trap, or when a beaver or otter chewed large holes in the trap. In these cases, the trap was not included in the calculation of mean CPUE.

Length Frequency:

For the same reasons described above concerning full recruitment to the gear, estimates of mean length for each sample section were made for only those burbot 450 mm TL and longer. Estimates of mean length and its associated variance for all captured burbot 450 mm TL and larger for six sections of the Tanana River, one section of the Tolovana River, one section of the Chena River, and one section of the Yukon River were:

(7) $$\bar{l} = \sum_{b=1}^{n} \frac{l_b}{n};$$

(8) $$V[\bar{l}] = \sum_{b=1}^{n} \frac{(l_b - \bar{l})^2}{n\,(n-1)};$$

where:

l_b = length of burbot b; and,

n = number of samples.

Lengths of burbot fully recruited to the gear (> 449 mm TL) were compared between river sections using a Kruskal-Wallis test. Multiple comparisons test (Conover 1980) were used to evaluate differences in length distribution between pairs of river sections.

Minimum length categories for Relative Stock Density were defined after review of Gabelhouse (1984). Relative Stock Densities were calculated for all sample sections as the percent of all burbot 300 mm TL and longer within a defined category. Variances for these estimates were calculated as:

(9) $$V[\hat{F}_i] = \frac{\hat{F}_i(1-\hat{F}_i)}{n-1};$$

where: $\hat{F}_i$ = Fraction of sampled fish b within a defined length class.

During the winters of 1987/88 and 1988/89, 214 samples were collected from anglers. All samples were collected in the vicinity of Fairbanks (Fairbanks sample section) between 15 October and 15 February. Eighty samples were collected in 1987, while 134 were collected in 1988. Relative Stock Densities were calculated for each year as described above.

Gear Selectivity:

Selectivity of large and small hoop traps were tested by: 1) comparing length frequency distributions of those burbot caught in hoop traps in the Fairbanks section during August 1987 (large hoop traps) with those burbot caught by anglers during 15 October 1987 through 15 February 1988, and 2) those burbot caught during July, 1988 (small hoop traps) with those burbot caught by anglers during 15 October 1988 through 15 February 1989. Kolmogorov-Smirnov Two sample tests were used to determine any significant (α = .05) differences between length frequency distributions. If these tests proved significant, then RxC contingency tables were used to determine if any length categories were similarly selected for by both gear types.

Mean Length-at-Age of Yukon River Burbot:

During 1984, set-lines were used to collect 57 pairs of otoliths (sagitta) from burbot in the vicinity of the Dalton Highway Bridge (length range 550 mm to 1,005 mm TL). During 1988, an additional 21 samples were obtained from which otoliths were also taken. Otoliths were surface read with aid of a Nikon bifocal microscope (12 to 60 power). Mean lengths for each age group were calculated as described above for burbot in the Tanana River. Mean lengths of Yukon River burbot were plotted and compared to Tanana River burbot.

RESULTS

Movements

During 1988, 2,305 burbot were captured through sampling efforts throughout the Tanana, Chena, and Tolovana Rivers. Of these, 68 were recaptured fish tagged during previous years, and six were recaptured fish tagged during that summer. In addition, 25 recaptured fish were collected from anglers. Between 1983 and 1988, a total of 526 burbot were recaptured throughout the Tanana River and its tributaries.

During sampling efforts in the Tolovana section 292 burbot were captured, but no recaptured fish were collected. This number is below the minimum limit (550) needed to attain 95% confidence of recapturing one fish from the lower river section. Mean CPUE in this section was 1.35 (burbot per net-night; SE = 0.1). This density is higher than was estimated (CPUE = 1.26) which further reduces the confidence of capturing one burbot. For these reasons, the hypothesis that burbot do not migrate from lower to middle river sections as designed in this study could not be rejected. However, one burbot tagged in the lower river section (river kilometer 106) was recaptured by an angler in the middle river section upstream from the Tolovana section (river kilometer 355; 692 days between tagging and recapture). In addition, one fish tagged in the Tolovana River (located on the boundary of lower and middle river) 16 September 1988 was recaptured 186 km upstream 15 December 1988, and one burbot tagged in the Tolovana section 20 August 1988 was recaptured 138 km upstream 4 January 1989. Although these three tag recoveries indicate that burbot in the lower and middle river are not completely isolated stocks, too few recaptures of burbot tagged in lower river have been obtained to determine what degree of interchange exists between fish in these two areas.

During sampling in the Cathedral Bluffs section 274 burbot were captured with 249 net-nights of effort (CPUE = 1.05; SE = 0.09). No recaptured burbot tagged in the middle river section were collected during sampling efforts or from anglers. Because this density of burbot is lower than was anticipated, and because more burbot were collected than were needed to attain 95% confidence of recapturing one tagged fish, the hypothesis that burbot do not migrate from middle river to upper river was not rejected. This information indicates that there are at least two isolated stocks of burbot in the Tanana River, with the boundary lying near the mouth of George Creek (river kilometer 594).

These results indicate that movement behavior (frequency and magnitude of upstream movements) is not consistent throughout the river. Examination of burbot movements throughout the river revealed that differential movement occurred within five river sections. Burbot in Sections I, IV, and V tended to be less mobile than did burbot in Sections II and III (Table 1). Downstream movements were minimal in all Sections. They were in general short-ranging (< 90 km), and were less frequent after a period of 1.5 years. No downstream movements were documented in Sections I and V. Upstream movements were more common, but were also for the most part short-ranging (90 km or less). Movements greater than 90 km were most common in Section II. The frequency of upstream movements was generally higher after a period of 1.5 years. The greatest recorded upstream movement was 264 km, the greatest recorded downstream movement was 168 km and the greatest net movement was 266 km.

Ten burbot were documented as moving out of the mainstem Tanana River into tributary systems (Table 1). These tributaries included the Tolovana, Chena, and Goodpaster Rivers. One burbot was documented as moving out of a tributary stream (Tolovana River) into the mainstem Tanana River. Four burbot moving from the Tanana River into the Tolovana River did so between August and September, 1988 (net movements 45, 59, 88, and 234 km). One burbot moving from the Tolovana River into the Tanana River (net movement 266 km) did so between September and December 1988. All three burbot recaptured in the Goodpaster River were tagged in the Tanana River during August and were recaptured within one year during January, February, and March (net movements 67, 25, and 61 km, respectively). Three burbot tagged in the Tanana River during July and August were recaptured within one year in the Chena River

Table 1. Summary of movements of 526 recaptured burbot tagged in one of five sections[1] of the Tanana River over periods of zero to 1.5 years and 1.5 years and longer.

Distance	I		II		III		IV		V		ALL	
Travelled	<	>	<	>	<	>	<	>	<	>	<	>
(km)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
-151 to -170	-	-	1[3]	-	-	-	-	-	-	-	1	-
-51 to -90	-	-	-	-	1[8]	-	2[11]	-	-	-	4	-
-11 to -50	-	-	6[4]	-	1[9]	2	6	-	-	-	14	2
-10 to 10	6[2]	-	91[5]	14[7]	6[10]	6	182	9	55	8	342	35
11 to 50	-	-	14	4	13	8	20	1	9	1	59	14
51 to 90	-	-	10	2	10	7	-	-	-	1	20	10
91 to 130	-	-	3	2	1	-	-	-	1	-	5	2
131 to 170	-	-	1	2	-	1	-	-	-	-	1	3
171 to 210	-	-	4	1	-	-	-	-	2	-	6	1
211 to 250	-	1	-	1	-	-	-	-	-	-	-	2
251 to 290	-	-	2[6]	2	-	-	-	-	-	-	1	2
Total	6	1	132	28	32	24	210	10	67	10	453	71
% Downstream	0	0	5	0	6	8	4	0	0	0	4	3
% Stationary	100	0	69	50	19	25	87	90	82	80	76	48
% Upstream	0	100	26	50	75	67	9	10	18	20	20	49
Max Upstream	2	250	256	264	112	152	34	18	189	93	256	264
Max Downstream	-3	-	168	-	70	26	54	-	-	-	168	26

[1] Section I: Mouth of Tanana River upstream to confluence of Tolovana River (0 - 170 km);
Section II: Confluence of Tolovana River upstream to confluence of Salcha River (171 - 429 km);
Section III: Confluence of Salcha River upstream to confluence of Volkmar River (430 -568 km);
Section IV: Confluence of Volkmar River upstream to confluence of George Creek (569 - 620 km); and,
Section V: Confluence of George Creek upstream to headwaters (621 - 912 km).

[2] One burbot moved 8 km upstream in Tanana River and 50 km upstream in Tolovana River.

[3] One burbot moved 168 km downstream in Tanana River and 66 km upstream in Tolovana River.

[4] One burbot moved 34 km downstream in Tanana River and 54 km upstream in Tolovana River.

[5] One burbot moved 3 km downstream in Tanana River and 2 km upstream in Chena River; and, one burbot moved 0 km in Tanana River and 3 km upstream in Chena River.

[6] One burbot moved 80 km downstream in Tolovana River and 186 km upstream in Tanana River.

[7] One burbot moved 8 km downstream in Tanana River and 37 km upstream in Tolovana River.

[8] One burbot moved 70 km downstream in Tanana River and 2 km upstream in Chena River.

[9] One burbot moved 21 km downstream in Tanana River and 40 km upstream in Goodpaster River.

[10] One burbot moved 0 km in Tanana River and 24 km upstream in Goodpaster River.

[11] One burbot moved 54 km downstream in Tanana River and 13 km upstream in Goodpaster River.

during September, February, and May (net movements 5, 72, and 136 km, respectively).

Examination of relative mixing rates between these same five river sections and three tributary systems revealed that all recaptured burbot obtained within 3.5 years of original marking date are 100% resident to area V, 97% resident to area IV, 88% resident to area II, 72% resident to area I, only 34% resident to area III, and 75% resident to the Tolovana River (Table 2). Mixing rates between river sections generally increased with time (Tables 3, 4, and 5).

Of the 526 burbot recaptured throughout the river, 306 were recaptured in large traps, 74 in small traps, and 146 were collected from anglers. Length distributions of fish from each of these three capture methods differed slightly. The mean length of burbot recaptured in large traps was 570 mm TL (SE = 5), 588 mm TL (SE = 12) for burbot recaptured in small traps, and 629 mm TL (SE = 23) for recaptured burbot caught by anglers. Because anglers often returned tags without obtaining a length measurement, only 41 of the 146 angler returns included length data. Kolmogorov-Smirnov two sample tests comparing each of the three collecting methods to one another revealed the only significant difference in length distributions was between those burbot caught in large traps and those caught by anglers ($p < .01$).

Most recaptured burbot collected by anglers were captured within Section II (river kilometers 171 - 429). Through examination of all recaptured burbot (hoop traps and anglers) collected in Section II, it appeared that those burbot captured by anglers tended to move more frequently than did those captured in hoop traps. To test this hypothesis, burbot recaptured in small and large hoop traps were pooled and compared to burbot recaptured by anglers across four ranges of movement using a contingency test (Table 6). This test revealed that recaptured burbot obtained from anglers did exhibit a higher proportion of moderate upstream movement than did burbot collected through sampling. However, when this same test was performed considering only recaptured fish obtained during open water periods (all hoop trap recaptures; 32 angler recaptures), no significant difference was noted (Table 7).

A separate contingency test considering all recaptured fish captured during open water periods compared these same four movement characteristics to burbot of four length categories (Table 8). There was no significant difference between length and degree of movement.

This information supports a hypothesis that burbot in Section II tend to move more frequently during periods of ice cover than during open water periods. This hypothesis was further supported by varying proportions of movement during summer, fall, winter, and spring of burbot recaptured within one year of tagging (Table 9). These proportions indicate that the highest frequencies of movement occur during the fall and winter. These proportions seem to be similar in Sections III and IV, although very few recaptures were obtained during fall, winter and spring (Tables 10 and 11). Burbot in Section V tend to move most during the summer and little during the fall and spring. No recaptures were obtained during the winter within one year of tagging date in

Table 2. Relative mixing rates[2] (Q_{ij} and SE [Q_{ij}]) of burbot between river sections[1] of the Tanana River (all recaptures).

	SECTION RECAPTURED (Q_j)								
SECTION TAGGED (Q_i)	TAN I	TOLOV RIVER	TAN II	CHENA RIVER	TAN III	GOODP RIVER	TAN IV	TAN V	TOTAL RECAPS
TAN I	0.72 0.03	0.14 0.02	0.14 0.02	0 0	0 0	0 0	0 0	0 0	7
TOLOV RIV	0 0	0.75 0.06	0.25 0.06	0 0	0 0	0 0	0 0	0 0	4
TAN II	0 0	0.02 0.0001	0.88 0.0007	0.02 0.0001	0.04 0.0002	0 0	0.04 0.0002	0 0	159
TAN III	0 0	0 0	0 0	0.02 0.0003	0.34 0.004	0.03 0.0005	0.61 0.004	0 0	59
TAN IV	0 0	0 0	0 0	0 0	0.02 0.0001	0.01 0.0001	0.97 0.0001	0 0	220
TAN V	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1.0 -	77
TOTAL	5	7	141	4	32	3	257	77	526

1 The five Tanana River sections were defined as follows:
Section I: Mouth of Tanana River upstream to confluence of Tolovana River (0 - 170 km);
Section II: Confluence of Tolovana River upstream to confluence of Salcha River (171 - 429 km);
Section III: Confluence of Salcha River upstream to confluence of Volkmar River (430 - 568 km);
Section IV: Confluence of Volkmar River upstream to confluence of George Creek (569 - 620 km); and,
Section V: Confluence of George Creek upstream to headwaters.
The mouth of the Tolovana River is located on the boundary of Section I and Section II at river kilometer 170, the mouth of the Chena River is located within Section II at river kilometer 358, and the mouth of the Goodpaster River is located within section III at river kilometer 528.

2 The probability that a recaptured burbot collected in section j was originally tagged in section i.

Table 3. Relative mixing rates[2] (Q_{ij} and SE [Q_{ij}]) of burbot between river sections[1] of the Tanana River (recaptures obtained between zero and 0.5 years from tagging date).

	SECTION RECAPTURED (Q_j)								
SECTION TAGGED (Q_i)	TAN I	TOLOV RIVER	TAN II	CHENA RIVER	TAN III	GOODP RIVER	TAN IV	TAN V	TOTAL RECAPS
TAN I	0	1.0	0	0	0	0	0	0	1
	0	-	0	0	0	0	0	0	
TOLOV RIV	0	0.75	0.25	0	0	0	0	0	4
	0	0.06	0.06	0	0	0	0	0	
TAN II	0	0.04	0.94	0.02	0	0	0	0	46
	0	0.001	0.001	0.001	0	0	0	0	
TAN III	0	0	0	0	0.31	0	0.69	0	13
	0	0	0	0	0.018	0	0.018	0	
TAN IV	0	0	0	0	0.06	0.06	0.88	0	16
	0	0	0	0	0.004	0.004	0.007	0	
TAN V	0	0	0	0	0	0	0	1.0	20
	0	0	0	0	0	0	0	-	
TOTAL	0	6	44	1	5	1	23	20	100

[1] The five Tanana River sections were defined as follows:
Section I Mouth of Tanana River upstream to confluence of Tolovana River (0 - 170 km);
Section II: Confluence of Tolovana River upstream to confluence of Salcha River (171 - 429 km);
Section III: Confluence of Salcha River upstream to confluence of Volkmar River (430 - 568 km);
Section IV: Confluence of Volkmar River upstream to confluence of George Creek (569 - 620 km); and,
Section V: Confluence of George Creek upstream to headwaters.
The mouth of the Tolovana River is located on the boundary of Section I and Section II at river kilometer 170, the mouth of the Chena River is located within Section II at river kilometer 358, and the mouth of the Goodpaster River is located within section III at river kilometer 528.

[2] The probability that a recaptured burbot collected in section j was originally tagged in section i.

Table 4. Relative mixing rates[2] (Q_{ij} and SE [Q_{ij}]) of burbot between river sections[1] of the Tanana River (recaptures obtained between 0.5 and 1.5 years from tagging date).

	SECTION RECAPTURED (Q_j)								
SECTION TAGGED (Q_i)	TAN I	TOLOV RIVER	TAN II	CHENA RIVER	TAN III	GOODP RIVER	TAN IV	TAN V	TOTAL RECAPS
TAN I	1.0 -	0 0	0 0	0 0	0 0	0 0	0 0	0 0	5
TOLOV RIV	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0
TAN II	0 0	0.01 0.0001	0.88 0.001	0.01 0.0001	0.05 0.0006	0 0	0.05 0.0006	0 0	85
TAN III	0 0	0 0	0 0	0.05 0.002	0.31 0.01	0.05 0.002	0.59 0.01	0 0	22
TAN IV	0 0	0 0	0 0	0 0	0.02 0.0001	0 0	0.98 0.0001	0 0	194
TAN V	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1.0 -	47
TOTAL	5	1	75	2	14	1	208	47	353

[1] The five Tanana River sections were defined as follows:
Section I: Mouth of Tanana River upstream to confluence of Tolovana River (0 - 170 km);
Section II: Confluence of Tolovana River upstream to confluence of Salcha River (171 - 429 km);
Section III: Confluence of Salcha River upstream to confluence of Volkmar River (430 - 568 km);
Section IV: Confluence of Volkmar River upstream to confluence of George Creek (569 - 620 km); and,
Section V: Confluence of George Creek upstream to headwaters.
The mouth of the Tolovana River is located on the boundary of Section I and Section II at river kilometer 170, the mouth of the Chena River is located within Section II at river kilometer 358, and the mouth of the Goodpaster River is located within section III at river kilometer 528.

[2] The probability that a recaptured burbot collected in section j was originally tagged in section i.

Table 5. Relative mixing rates[2] (Q_{ij} and SE [Q_{ij}]) of burbot between river sections[1] of the Tanana River (recaptures obtained between 1.5 and 3.5 years from tagging date).

	SECTION RECAPTURED (P_j)								
SECTION TAGGED (Q_i)	TAN I	TOLOV RIVER	TAN II	CHENA RIVER	TAN III	GOODP RIVER	TAN IV	TAN V	TOTAL RECAPS
TAN I	0 0	0 0	1.0 -	0 0	0 0	0 0	0 0	0 0	1
TOLOV RIV	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0
TAN II	0 0	0 0	0.71 0.008	0.07 0.002	0.11 0.004	0 0	0.11 0.004	0 0	28
TAN III	0 0	0 0	0 0	0 0	0.42 0.01	0 0	0.48 0.01	0 0	24
TAN IV	0 0	0 0	0 0	0 0	0.10 0.01	0 0	0.90 0.01	0 0	10
TAN V	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1.0 -	10
TOTAL	0	0	22	2	10	0	26	10	70

[1] The five Tanana River sections were defined as follows:
Section I: Mouth of Tanana River upstream to confluence of Tolovana River (0 - 170 km);
Section II: Confluence of Tolovana River upstream to confluence of Salcha River (171 - 429 km);
Section III: Confluence of Salcha River upstream to confluence of Volkmar River (430 - 568 km);
Section IV: Confluence of Volkmar River upstream to confluence of George Creek (569 - 620 km); and,
Section V: Confluence of George Creek upstream to headwaters.
The mouth of the Tolovana River is located on the boundary of Section I and Section II at river kilometer 170, the mouth of the Chena River is located within Section II at river kilometer 358, and the mouth of the Goodpaster River is located within section III at river kilometer 528.

[2] The probability that a recaptured burbot collected in section j was originally tagged in section i.

Table 6. Contingency table analyses of recaptured burbot obtained by anglers during all seasons and from hoop traps during open water periods by four ranges of movement.

	Downstream (> 10 km)	Stationary (-10 to 10 km)	Intermediate Upstream (10 to 99 km)	Extreme Upstream (≥ 100 km)
Anglers	2	53	27	5
Hoop Traps	2	54	3	0

Test Breaks[2]					Significance[1] Tests
1.	|———|	|———|	|———|	|———|	P<.001
2.		|———|	|———|	|———|	P<.001
3.		|———|	|———|		P<.001
4.	|———|	|———|			P<.001
5.		|———|		|———|	.05<P<.025
6.	|——————	——————|		|———|	.05<P<.025

[1] Tests are RxC contingency tables and χ^2 statistics for $H_o: p_i = p$ where p_i = probability of capturing a burbot in the ith movement category.

[2] Each group of lines corresponds to specific categories which were entered into the chi-square test. The symbols "—| |—" correspond to boundaries between adjacent categories in a test.

Table 7. Contingency table analyses of recaptured burbot obtained by anglers during open water periods and from hoop traps during open water periods by four ranges of movement.

	Downstream (> 10 km)	Stationary (-10 to 10 km)	Intermediate Upstream (10 to 99 km)	Extreme Upstream (≥ 100 km)
Anglers	1	27	4	0
Hoop Traps	2	54	3	0

Test Breaks[2]	Downstream	Stationary	Intermediate Upstream	Extreme Upstream	Significance[1] Tests
1.	|———|	|———|	|———|		.25<P<.10
2.	|———————	———————|	|———|		.25<p<.10
3.	|———|	|———————	———————|		P>.99

[1] Tests are RxC contingency tables and χ^2 statistics for $H_o: p_i = p$ where p_i = probability of capturing a burbot in the ith movement category.

[2] Each group of lines corresponds to specific categories which were entered into the chi-square test. The symbols "—| |—" correspond to boundaries between adjacent categories in a test.

Table 8. Contingency table analysis of ranges of movement of recaptured burbot by length[1].

	Test Breaks[2] (mm TL)			
	300 - 449	450 - 599	600 - 749	750 - 1000
Downstream (> 10 km)	0	12	3	1
Stationary (-10 to 10 km)	21	175	75	10
Intermediate Upstream (11 to 99 km)	5	75	26	2
Extreme Upstream (≥ 100 km)	1	22	5	0

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<tr><th></th><th></th><th></th><th></th><th>Significance Tests[3]</th></tr>
<tr><td colspan="2">|————————————|</td><td colspan="2">|————————————|</td><td>.50<P<.25</td></tr>
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[1] Only burbot collected during periods of open water were considered in these tests.

[2] Each group of lines corresponds to specific categories which were entered into the chi-square test. The symbols "—| |—" correspond to the boundaries between adjacent categories in a test.

[3] Tests are RxC contingency tables and χ^2 statistics for H_o: $p_i = p$ where p_i = probability of catching a burbot in the ith length group. All recaptured burbot collected during open water periods (approximately 15 May through 15 Oct) were used for the test.

Table 9. Proportions of seasonal movements of burbot in the Tanana River based on recaptures obtained within one year of tagging (Section II; river kilometer 171 - 429).

TAGGED IN SUMMER					TAGGED IN FALL				
Season of Recapture[1]	Type of Movement[2]	Number Recaptured	Relative Proportion	SE	Season of Recapture	Type of Movement	Number Recaptured	Relative Proportion	SE
Same Summer	Upstream	2	0.07	0.002	Same Fall	Upstream	2	0.67	0.11
	Stationary	30	0.93	0.002		Stationary	1	0.33	0.11
	Downstream	0	-	-		Downstream	0	-	-
Fall	Upstream	3	0.19	0.01	Winter	Upstream	2	0.50	0.08
	Stationary	11	0.69	0.01		Stationary	2	0.50	0.08
	Downstream	2	0.12	0.007		Downstream	0	-	-
Winter	Upstream	7	0.58	0.02	Spring	Upstream	1	0.14	0.02
	Stationary	5	0.42	0.02		Stationary	6	0.86	0.02
	Downstream	0	-	-		Downstream	0	-	-
Spring	Upstream	2	0.40	0.06	Summer	Upstream	2	0.15	0.01
	Stationary	3	0.60	0.06		Stationary	11	0.85	0.01
	Downstream	0	-	-		Downstream	0	-	-
Next Summer	Upstream	5	0.14	0.004	Next Fall	Upstream	3	0.43	0.04
	Stationary	26	0.74	0.006		Stationary	4	0.57	0.04
	Downstream	4	0.12	0.003		Downstream	0	-	-

[1] Seasons were defined as: Summer = June, July, and August; Fall = September, October, and November; Winter = December, January, and February; and, Spring = March, April, and May.

[2] Movements were defined as: Upstream = 10 km or more; Stationary = less than 10 km upstream or downstream; and Downstream = 10 km or more.

Table 10. Proportions of seasonal movements of burbot in the Tanana River based on recaptures obtained within one year of tagging (Section III; river kilometer 430 - 568).

TAGGED IN SUMMER					TAGGED IN FALL				
Season of Recapture[1]	Type of Movement[2]	Number Recaptured	Relative Proportion	SE	Season of Recapture	Type of Movement	Number Recaptured	Relative Proportion	SE
Same	Upstream	10	1.00	-	Same	Upstream	-	-	-
Summer	Stationary	0	-	-	Fall	Stationary	-	-	-
	Downstream	0	-	-		Downstream	-	-	-
	Upstream	1	1.00	-		Upstream	-	-	-
Fall	Stationary	0	-	-	Winter	Stationary	-	-	-
	Downstream	0	-	-		Downstream	-	-	-
	Upstream	0	-	-		Upstream	-	-	-
Winter	Stationary	0	-	-	Spring	Stationary	-	-	-
	Downstream	1	1.00	-		Downstream	-	-	-
	Upstream	0	-	-		Upstream	1	1.00	-
Spring	Stationary	1	1.00	-	Summer	Stationary	-	-	-
	Downstream	0	-	-		Downstream	-	-	-
Next	Upstream	13	0.77	0.01	Next	Upstream	-	-	-
Summer	Stationary	4	0.23	0.01	Fall	Stationary	-	-	-
	Downstream	0	-	-		Downstream	-	-	-

1 Seasons were defined as: Summer = June, July, and August; Fall = September, October, and November; Winter = December, January, and February; and, Spring = March, April, and May.

2 Movements were defined as: Upstream = 10 km or more; Stationary = less than 10 km upstream or downstream; and Downstream = 10 km or more.

Table 11. Proportions of seasonal movements of burbot in the Tanana River based on recaptures obtained within one year of tagging (Section IV; river kilometer 569 - 620).

TAGGED IN SUMMER					TAGGED IN FALL				
Season of Recapture[1]	Type of Movement[2]	Number Recaptured	Relative Proportion	SE	Season of Recapture	Type of Movement	Number Recaptured	Relative Proportion	SE
Same	Upstream	3	0.02	0.0001	Same	Upstream	0	-	-
Summer	Stationary	130	0.97	0.02	Fall	Stationary	0	-	-
	Downstream	2	0.01	0.0001		Downstream	0	-	-
	Upstream	1	0.13	0.01		Upstream	0	-	-
Fall	Stationary	8	0.87	0.01	Winter	Stationary	0	-	-
	Downstream	0	-	-		Downstream	0	-	-
	Upstream	0	-	-		Upstream	0	-	-
Winter	Stationary	0	-	-	Spring	Stationary	0	-	-
	Downstream	1	1.00	-		Downstream	0	-	-
	Upstream	0	-	-		Upstream	0	-	-
Spring	Stationary	6	1.00	-	Summer	Stationary	0	-	-
	Downstream	0	-	-		Downstream	0	-	-
Next	Upstream	15	0.08	0.0004	Next	Upstream	0	-	-
Summer	Stationary	169	0.90	0.0005	Fall	Stationary	0	-	-
	Downstream	3	0.02	0.0002		Downstream	0	-	-

[1] Seasons were defined as: Summer = June, July, and August; Fall = September, October, and November; Winter = December, January, and February; and, Spring = March, April, and May.

[2] Movements were defined as: Upstream = 10 km or more; Stationary = less than 10 km upstream or downstream; and Downstream = 10 km or more.

Section V (Table 12). Too few recaptures were obtained in Section I to determine seasonal movements.

Catch-per-Unit-of-Effort

The CPUE estimates for small burbot (< 450 mm TL) in the mainstem Tanana River ranged from 0.18 (SE = 0.03) in the Tolovana section to 0.65 (SE = 0.06 and 0.07) in the Delta and Cathedral Bluffs sections. The CPUE estimates of small burbot in the Yukon and Tolovana Rivers were both 0.03 (SE = 0.02 and 0.01), while CPUE of small burbot in the Chena River was 0.32 (SE = 0.01). Ranges of CPUE estimates for large burbot (≥ 450 mm TL) in sample sections of the Tanana River were from 0.54 (SE = .05) in the Fairbanks section to 1.26 (SE = 0.14) in the Delta section. The CPUE estimates of large burbot sampled in the Yukon, Chena, and Tolovana Rivers were 0.59, 0.90, and 1.11 respectively (SE = 0.06, 0.13, and 0.1). Sample sections of the Tanana River with the highest ratio of large to small burbot were in the lower and upper river (Manley, Tolovana, and Tok sections: 4.0, 6.6, and 2.2 respectively), while sample sections with the lowest ratios were in the middle river (Fairbanks, Delta, and Cathedral Bluffs sections: 0.9, 1.9, and 0.6 respectively). Ratios of large to small burbot in the Yukon and Tolovana Rivers were extremely high (19.7 and 37.0), while large-to-small ratio in the Chena River was moderate (2.8; Table 13). Mean CPUE estimates for large burbot collected in five sample sections of the Tanana River in 1988 using small hoop traps were generally lower than estimates obtained in 1986 and 1987 using large hoop traps. Catches of small burbot in these same sections were similar (Table 14).

Plots of mean CPUE of large burbot in 8 km subsections of each 64 km section of the Tanana River sampled in 1988 showed that catch rates were consistent (within 1 burbot per net-night) throughout the Manley, Fairbanks, Cathedral Bluffs, and Tok sections, but were varied in the Tolovana and Delta sections (Figure 4). Catch rates in the Delta section were consistent from river kilometer 523 through 571, but dramatically increased in the upstream three subsections (Healy Lake Outlet area). CPUE estimates of all 8 km subsections varied from a low of 0.08 in the Cathedral Bluffs section to a high of 6.88 in the Delta section.

Length Frequency

Mean lengths of large burbot (larger than 449 mm TL) captured in six sections of the Tanana River varied from 523 mm TL in the Fairbanks section (river kilometer 312 to 376) to 610 mm TL in the Tolovana section (river kilometer 526 to 592). Mean lengths of large burbot sampled in the Chena and Tolovana Rivers were 557 and 660 mm TL respectively, while the mean length of large burbot sampled in the Yukon River was 651 mm TL. Length ranges varied from 235 to 1000 mm TL (Table 15). Mean lengths of 8 km subsections within each 64 km sample section were consistent throughout the Manley, Tolovana, and Fairbanks sections but were variable within the Delta, Cathedral Bluffs, and Tok sections (Figure 5). Mean lengths of all 8 km subsections in the Tanana River varied from 487 mm TL (river kilometer 336 to 344 of Fairbanks sample section) to 695 mm TL (river kilometer 672 to 680 of the Cathedral Bluffs section).

Table 12. Proportions of seasonal movements of burbot in the Tanana River based on recaptures obtained within one year of tagging (Section V; river kilometer 621 - 912).

TAGGED IN SUMMER					TAGGED IN FALL				
Season of Recapture[1]	Type of Movement[2]	Number Recaptured	Relative Proportion	SE	Season of Recapture	Type of Movement	Number Recaptured	Relative Proportion	SE
Same	Upstream	4	1.00	-	Same	Upstream	0	-	-
Summer	Stationary	0	-	-	Fall	Stationary	5	1.00	-
	Downstream	0	-	-		Downstream	0	-	-
	Upstream	0	-	-		Upstream	0	-	-
Fall	Stationary	8	1.00	-	Winter	Stationary	0	-	-
	Downstream	0	-	-		Downstream	0	-	-
	Upstream	0	-	-		Upstream	0	-	-
Winter	Stationary	0	-	-	Spring	Stationary	1	1.00	-
	Downstream	0	-	-		Downstream	0	-	-
	Upstream	0	-	-		Upstream	3	0.20	0.01
Spring	Stationary	4	1.00	-	Summer	Stationary	12	0.80	0.01
	Downstream	0	-	-		Downstream	0	-	-
Next	Upstream	4	0.17	0.006	Next	Upstream	2	0.50	0.08
Summer	Stationary	19	0.83	0.006	Fall	Stationary	2	0.50	0.08
	Downstream	0	-	-		Downstream	0	-	-

[1] Seasons were defined as: Summer = June, July, and August; Fall = September, October, and November; Winter = December, January, and February; and, Spring = March, April, and May.

[2] Movements were defined as: Upstream = 10 km or more; Stationary = less than 10 km upstream or downstream; and Downstream = 10 km or more.

Table 13. Mean catch-per-unit of effort[1] of large and small[2] burbot in sample sections during 1988.

River Section (km)	Total Net-Nights	Large Burbot Catch	Large Burbot $\overline{CPUE}$	Large Burbot $SE(\overline{CPUE})$	Small Burbot Catch	Small Burbot $\overline{CPUE}$	Small Burbot $SE(\overline{CPUE})$	Ratio $\frac{CPUE\ large}{CPUE\ small}$
Tanana River								
Manley (48-112)	254	247	0.97	0.08	60	0.24	0.03	4.0
Tolovana (160-216)	215	254	1.18	0.09	38	0.18	0.03	6.6
Fairbanks (312-376)	268	145	0.54	0.05	170	0.63	0.05	0.9
Delta (526-592)	256	323	1.26	0.14	166	0.65	0.06	1.9
Cathedral Bluffs (656-720)	262	103	0.39	0.05	171	0.65	0.07	0.6
Tok (784-848)	248	209	0.84	0.06	97	0.39	0.05	2.2
Other Sections								
Tolovana River (37-78)	192	214	1.11	0.10	5	0.03	0.01	37.0
Chena River (0-24)	88	65	0.90	0.13	23	0.32	0.08	2.8
Yukon River (-22-56)	239	141	0.59	0.06	6	0.03	0.02	19.7

1 Mean CPUE and SE (CPUE) for each section were calculated according to equations 9 and 10.
2 Small burbot are less than 450 mm (TL), while large burbot are 450 mm (TL) and larger.

Table 14. Comparison of mean catch-per-unit of effort estimates for five sample sections of the Tanana River obtained during 1988 using small hoop traps with estimates obtained in 1986[1] and 1987[2] using large hoop traps.

River Section (km)	Year of Sampling	Total Net-Nights	Large Burbot[3]			Small Burbot			Total Burbot		
			Catch	CPUE	SE(CPUE)	Catch	CPUE	SE(CPUE)	Catch	CPUE	SE(CPUE)
Manley											
(99-117)	1986	23	-	-	-	-	-	-	61	2.65	0.48
(102-112)	1987	89	196	2.20	0.25	20	0.22	0.07	216	2.42	0.27
(48-112)	1988	254	247	0.97	0.08	60	0.24	0.03	307	1.21	0.10
Fairbanks											
(334-352)	1986	25	-	-	-	-	-	-	47	1.88	0.09
(356-377)	1986	19							23	1.21	0.16
(339-352)	1987	446	381	0.85	0.05	181	0.41	0.04	562	1.26	0.07
(356-378)	1987	79	60	0.76	0.11	58	0.73	0.12	118	1.49	0.18
(312-376)	1988	268	145	0.54	0.05	170	0.63	0.05	315	1.18	0.07
Delta											
(523-532)	1986	27	-	-	-	-	-	-	138	5.11	0.76
(553-564)	1986	21	-	-	-	-	-	-	430	20.00	3.3
(578-584)	1986	24	-	-	-	-	-	-	70	2.92	0.98
(520-536)	1987	97	145	1.49	0.18	107	1.11	0.13	252	2.60	0.23
(553-571)	1987	101	179	1.77	0.21	58	0.58	0.10	237	2.35	0.23
(578-594)	1987	269	1,680	6.25	0.42	233	0.87	0.08	1,913	7.12	0.45
(526-592)	1988	256	323	1.26	0.14	166	0.65	0.06	489	1.90	0.18
Cathedral Bluffs											
(712-728)	1986	27	-	-	-	-	-	-	72	2.67	0.42
(656-720)	1988	262	103	0.39	0.05	171	0.65	0.07	274	1.05	0.08
Tok											
(800-816)	1986	25	-	-	-	-	-	-	124	4.96	0.49
(806-829)	1987	97	136	1.40	0.15	91	0.94	0.12	227	2.34	0.19
(842-853)	1987	77	198	2.57	0.27	48	0.62	0.10	246	3.19	0.30
(784-848)	1988	248	209	0.84	0.06	97	0.39	0.05	306	1.22	0.08

[1] Data taken from Hallberg et al. (1987) is not differentiated into large and small burbot.
[2] Data taken from Evenson (1988).
[3] Large burbot are 450 mm TL and longer.

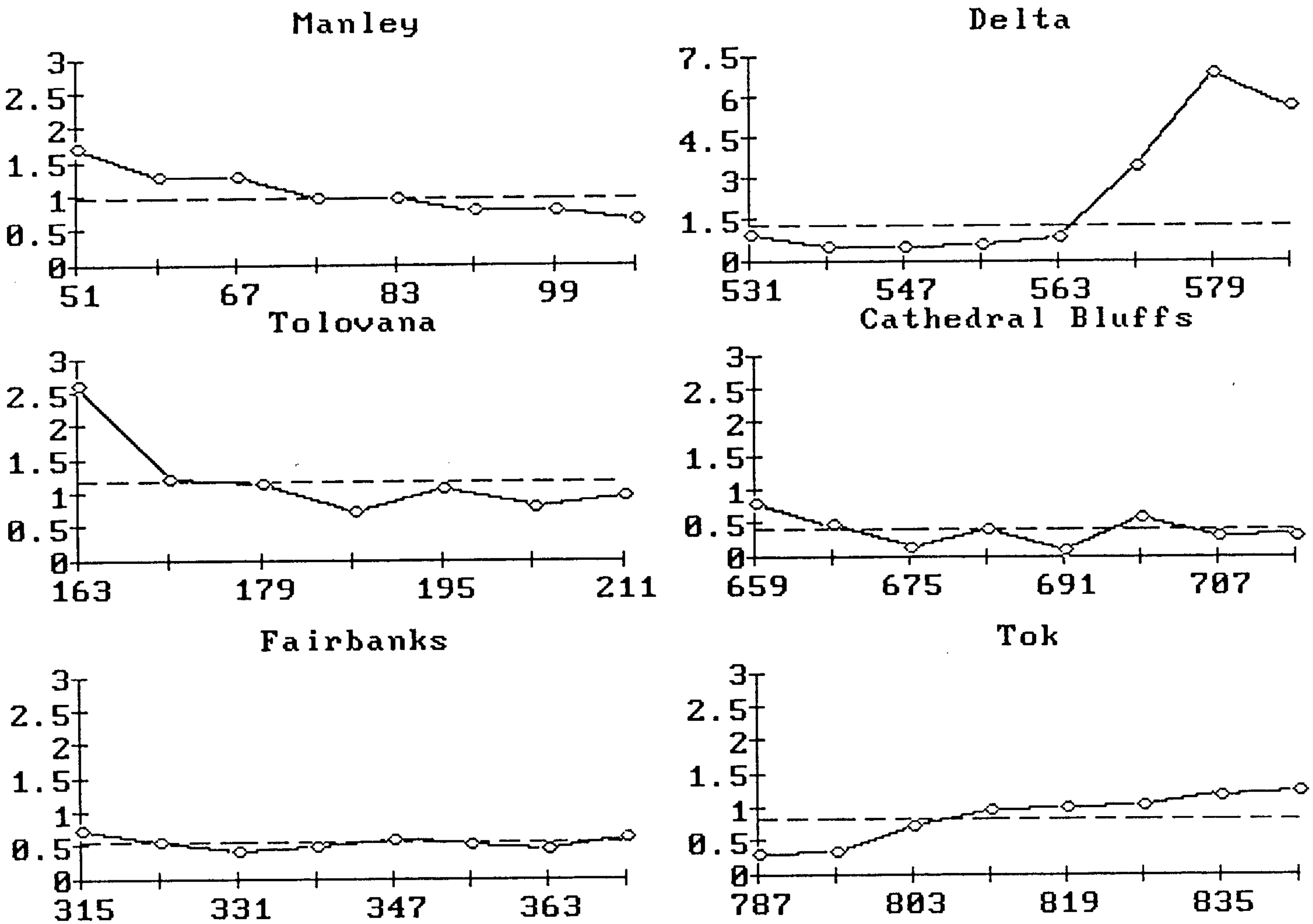

Figure 4. Mean catch-per-unit of effort for 8 km subsections within each 64 km sample section of the Tanana River obtained in 1988.

Table 15. Mean lengths and length ranges of burbot captured in sample sections during 1988.

Sample Section	Catch		Length (mm TL)				
	Large[1]	Total	Range	Large burbot		All burbot	
				Mean	SE	Mean	SE
Tanana River							
Manley	247	307	304 - 845	566	5	531	5
Tolovana	256	292	275 - 952	610	8	583	9
Fairbanks	143	312	235 - 855	523	6	447	5
Delta	334	494	268 - 865	563	5	505	4
Cathedral Bluffs	105	274	290 - 966	584	10	454	8
Tok	210	304	288 - 980	604	7	534	8
Other Sections							
Chena River	65	88	306 - 754	557	8	515	10
Tolovana River	239	244	364 - 910	660	8	655	8
Yukon River	102	104	311 - 1,000	656	11	651	11

[1] Large burbot are 450 mm TL and longer.

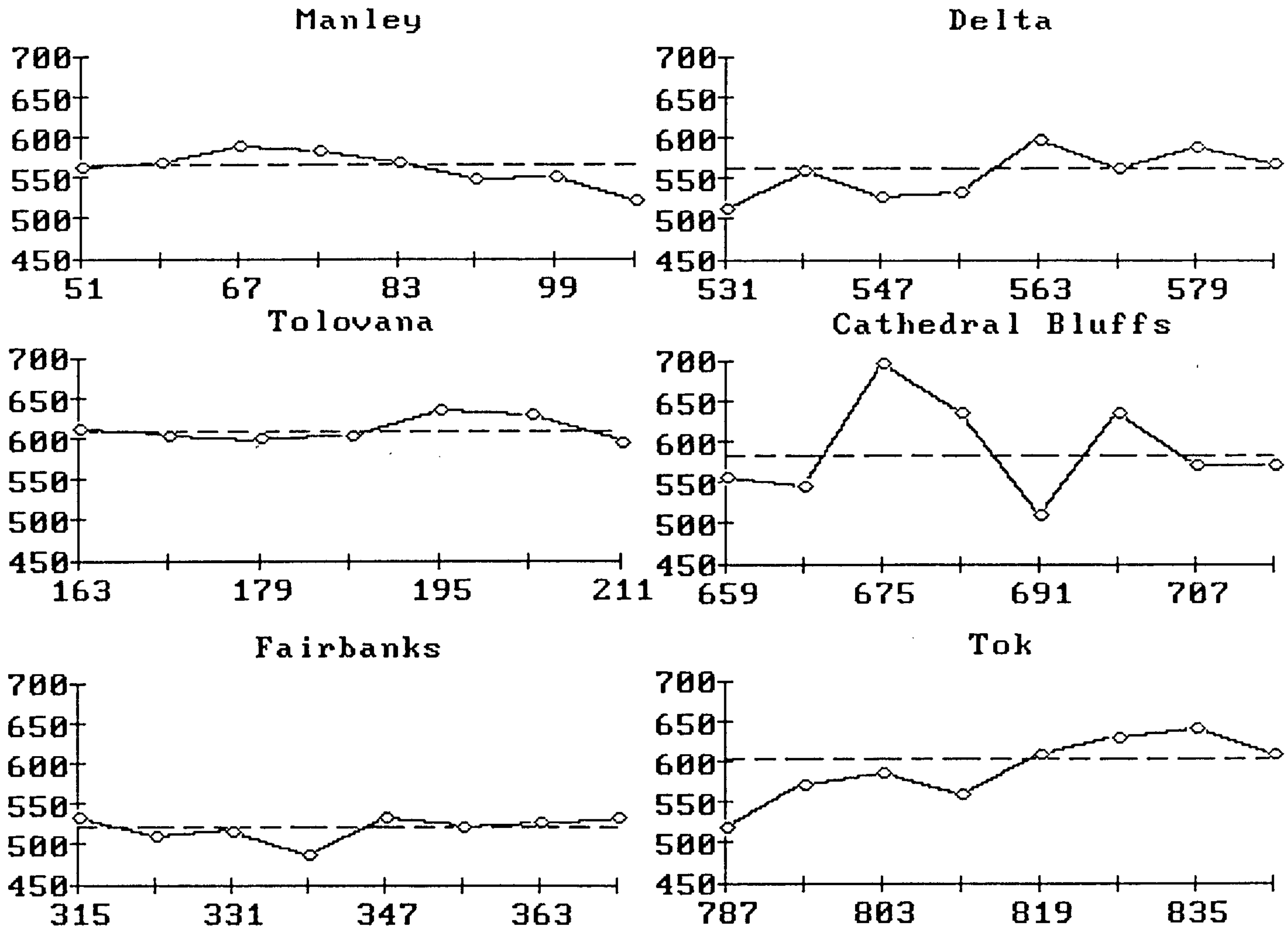

Figure 5. Mean lengths of burbot in 8 km subsections within each 64 km sample section of the Tanana River obtained in 1988.

A non parametric analysis of variance (Kruskal-Wallis Test) on fully recruited burbot (> 449 mm TL by 10 mm increments) indicated that the size of burbot varied by river section ($p < .001$). A multiple comparison test from Conover (1980) with $p = 0.05$ for each two section comparison showed the largest fish in the Tolovana and Yukon Rivers. The smallest fish were from samples taken in the Fairbanks section. Samples from the Tolovana and Tok sections were similar and contained the largest fish in the mainstem Tanana River. Samples from the Manley, Delta, Cathedral Bluffs, and Chena River sections were of similar, intermediate sizes.

Examination of Relative Stock Densities further supported these findings. Proportions within each category varied between river sections (Table 16). Most burbot captured in the Tanana River were of "stock" and "quality" lengths. The Fairbanks and Cathedral Bluffs sections had the highest proportions of stock and quality length burbot. The Manley and Tolovana sections had the lowest proportions of stock and quality length fish. The Fairbanks and Delta sections had the lowest proportions of "memorable" and "trophy" length fish. The Tolovana and Tok sections had the highest proportion of memorable and trophy length fish. Preferred, memorable, and trophy length fish were more prevalent in sample sections of the Tolovana and Yukon Rivers than in any Tanana River sample sections. The section sampled in the Yukon River contained the highest proportion of trophy length burbot.

Mean lengths of burbot captured in sample sections during 1988 using small hoop traps tended to be smaller than mean lengths of burbot sampled in similar sections during 1986 and 1987 using large hoop traps (Table 17). With the exception of the Fairbanks section, these sections receive little fishing pressure, and these differences in mean length are most likely due to different selectivities of the gears.

Mean length of burbot captured by anglers in 1988 (712 mm TL; SE = 10) in the Fairbanks section was slightly larger than mean length of burbot captured by anglers in 1987 (699 mm TL; SE = 17). A Kolmogorov-Smirnov two sample test revealed that length frequencies of burbot captured by anglers in 1988 were significantly different than those of burbot captured in 1987 ($p < .05$). Examination of Relative Stock Densities revealed that during 1988, a higher proportion of preferred and memorable length fish were captured, but that lower proportions of stock, quality, and trophy length burbot were caught (Table 18).

Gear Selectivity

Kolmogorov-Smirnov two sample tests comparing length frequency distributions of: 1) those burbot captured in large hoop traps in the Fairbanks section during August 1987 with those burbot caught by anglers in the Fairbanks section between 15 October 1987 and 15 February 1988, and 2) those burbot caught in small hoop traps in the Fairbanks section during July 1988 with those burbot caught by anglers between 15 October 1988 and 15 February 1989 showed significant differences in both cases ($p < .001$). Calculated Relative Stock Densities revealed that both large and small hoop traps caught higher proportions of stock and quality length burbot and lower proportions of

Table 16. Relative Stock Density[1] estimates of burbot sampled in six sections of the Tanana River, one section of the Chena River, one section of the Tolovana River, and one section of the Yukon River during 1988.

Sample Section		Category / Gabelhouse Minimum Length (mm TL)[2]				
		Stock 300	Quality 450	Preferred 625	Memorable 725	Trophy 900
Manley	RSD	19.6	61.8	14.0	4.6	0
	SE[RSD]	2.3	2.8	2.0	1.2	0
Tolovana (Tanana)	RSD	12.0	54.3	17.5	14.8	1.4
	SE[RSD]	1.9	2.9	2.2	2.1	0.7
Fairbanks	RSD	52.7	44.4	2.3	0.6	0
	SE[RSD]	2.9	2.9	0.9	0.5	0
Delta	RSD	31.6	53.6	11.5	3.3	0
	SE[RSD]	2.1	2.3	1.5	0.8	0
Cathedral Bluffs	RSD	61.3	25.4	8.1	4.8	0.4
	SE[RSD]	3.0	2.6	1.7	1.3	0.4
Tok	RSD	29.5	43.0	17.8	9.4	0.3
	SE[RSD]	2.6	2.9	2.2	1.7	0.3
Tolovana River	RSD	2.1	39.7	31.2	25.4	1.6
	SE[RSD]	0.9	3.1	3.0	2.8	0.8
Chena River	RSD	26.1	63.6	9.1	1.2	0
	SE[RSD]	4.7	5.2	3.1	1.1	0
Yukon River	RSD	4.1	41.1	30.8	20.6	3.4
	SE[RSD]	1.6	4.1	3.8	3.4	1.5

1 Relative Stock Density expressed as a percentage.
2 Minimum lengths for each category derived from Gabelhouse (1984).

Table 17. Comparisons of mean length estimates for five sample sections of the Tanana River obtained during 1988 using small hoop traps with estimates obtained in 1986[1] and 1987[2] using large hoop traps.

River Section (km)	Year of Sampling	Catch		Length (mm TL)				
					Large burbot		All Burbot	
		Large[3]	Total	Range	Mean	SE	Mean	SE
Manley								
(99-117)	1986	261	336	270 - 990	569	5	527	6
(102-112)	1987	195	215	302 - 866	607	2	587	7
(48-112)	1988	247	307	304 - 845	566	5	531	5
Fairbanks								
(334-352)	1986	287	430	258 - 922	577	6	511	6
(356-377)	1986	74	121	294 - 954	566	14	493	12
(339-352)	1987	365	527	304 - 1,079	588	6	530	6
(356-378)	1987	60	117	312 - 937	557	15	477	11
(312-376)	1988	143	312	235 - 855	523	6	447	5
Delta								
(523-532)	1986	148	251	279 - 921	541	6	477	6
(553-564)	1986	932	1,030	295 - 962	584	3	568	3
(578-584)	1986	32	160	235 - 742	528	13	381	7
(520-536)	1987	144	255	308 - 750	525	5	469	6
(553-571)	1987	168	237	300 - 933	557	7	514	7
(578-594)	1987	1,653	1,923	312 - 962	577	2	555	3
(526-592)	1988	334	494	268 - 865	563	5	505	4
Cathedral Bluffs								
(712-728)	1986	125	220	285 - 940	593	9	493	9
(656-720)	1988	105	274	290 - 966	584	10	454	8
Tok								
(800-816)	1986	263	338	270 - 1,147	613	9	561	9
(806-829)	1987	134	227	305 - 1,000	572	9	497	9
(842-853)	1987	201	246	326 - 985	600	7	564	8
(784-848)	1988	210	304	288 - 980	604	7	534	8

[1] Data taken from Hallberg et al. (1987).

[2] Data taken from Evenson (1988).

[3] Large burbot are 450 mm TL and longer.

Table 18. Relative Stock Density[1] estimates of Tanana River burbot captured by anglers in the Fairbanks section during 1987 and 1988.

		1987		1988	
Category	Gabelhouse Minimum Length[2]	Relative Stock Density	S.E.	Relative Stock Density	S.E.
Stock	300	2.5	1.8	0	0
Quality	450	38.8	5.5	29.1	3.9
Preferred	625	15.0	4.0	23.1	3.7
Memorable	725	31.2	5.2	44.0	4.3
Trophy	900	12.5	3.7	3.7	1.6

[1] Relative Stock Density expressed as a percentage.
[2] Minimum lengths for each category derived from Gabelhouse (1984).

preferred, memorable, and trophy length burbot than did anglers (Table 19). Burbot caught in large traps compared with burbot caught by anglers, and burbot caught in small hoop traps compared with burbot caught by anglers across varying length ranges showed that burbot ≥ 550 mm TL and < 850 mm TL were caught in similar proportions by large hoop traps and anglers. Burbot < 550 mm TL were caught in higher proportions in large hoop traps than anglers, while burbot ≤ 850 mm TL were caught in lower proportions (Table 20). Similar proportions of burbot were caught between 600 and 799 mm TL inclusive by small hoop traps and anglers. Burbot < 600 mm TL were caught in higher proportions in small hoop traps than by anglers, while burbot ≤ 800 mm TL were caught in lower proportions (Table 21).

Mean Length-at-Age of Yukon River Burbot

A total of 82 length-at-age samples were collected in the Yukon River during 1984 and 1988. Of these, 36 were male, 45 were female, and one was of unidentified sex. Ages of males ranged from six to 17 years, while females ranged from four to 18 years (Table 22). Although length-at-age seemed to be similar for males and females, too few samples were collected to estimate parameters of the Von Bertalanffy equation for male and female segments of the population. Length-at-age data for male and female burbot collected in the Yukon River were pooled and compared to similar data of Tanana River burbot (Figure 6). Growth rates for burbot in both systems are similar with Yukon River burbot being slightly smaller at a given age than Tanana River burbot.

DISCUSSION

One of the major goals of this ongoing research is to identify existing stocks of burbot throughout the Tanana River drainage. These stocks are not reproductively isolated, since the possibility exists for the transfer between areas of burbot that are too small to capture with hoop-traps or set-lines. This movement is especially likely in a downstream direction since burbot larvae are pelagic. Thus, stock definition arises from examination of movement characteristics, length and age compositions, and relative densities of catchable size burbot throughout the river. Changes in length compositions and relative densities of burbot in sample sections from one year to the next may be influenced significantly by immigration or emigration of burbot, and therefore accurate information regarding seasonal and long term movements of burbot is needed to assess stock status in a given area. Predictions of movements of burbot throughout the Tanana River and its tributaries in this study are based on behavior of tagged burbot. Although the effects of tagging on burbot migrations are uncertain, it is assumed that tagged burbot behave the same as untagged burbot.

Information concerning movements of burbot in the Tanana River (n = 437) prior to 1988 has shown that 72% of all burbot remain resident (within 8 km) to a given area, 25% move upstream (8 km or more) and only 3% move downstream (8 km or more). The maximum distance any burbot traveled upstream was 262 km, while the maximum distance any burbot traveled downstream was 58 km. The mean distance traveled for all burbot recaptured prior to 1988 (1983 through 1987) was 14 km upstream (SE = 1.8; Evenson 1988).

Table 19. Relative Stock Density[1] estimates of Tanana River burbot captured by small hoop traps, large hoop traps, and anglers in the Fairbanks section (during 1987 and 1988).

		1987				1988			
		Anglers		Lg. Hoop Traps		Anglers		Sm. Hoop Traps	
Category	Gabelhouse Minimum Length[2]	Relative Stock Density	S.E.	Relative Stock Density	S.E.	Relative Stock Density	S.E.	Relative Stock Density	S.E.
Stock	300	2.5	1.8	40.1	2.9	0	0	52.6	4.2
Quality	450	38.8	5.5	46.0	2.9	29.1	3.9	44.4	4.2
Preferred	625	15.0	4.0	5.5	1.3	23.1	3.7	2.3	1.3
Memorable	725	31.2	5.2	6.6	1.5	44.0	4.3	0.7	0.7
Trophy	900	12.5	3.7	1.7	0.8	3.7	1.6	0	0

1 Relative Stock Density expressed as a percentage.
2 Minimum lengths for each category derived from Gabelhouse (1984).

Table 20. Contingency table analyses comparing burbot of various length ranges caught in large hoop traps with burbot caught by anglers during 1987[1].

	Test Breaks[2] (mm TL)					
	450-549	550-649	650-749	750-849	850 +	
Anglers	10	31	10	13	18	
Hoop Traps	89	50	15	13	6	Significance Tests[3]
	├──┤	├──┤	├──┤	├──┤	├──┤	(p>.005)
		├──┤	├──┤	├──┤	├──┤	(.025<p<.005)
			├──┤	├──┤	├──┤	(.05<p<.025)
		├──┤	├──┤	├──┤		(.5<p<.25)

[1] Burbot were captured in large hoop traps during August 1987, while burbot caught by anglers were captured during 15 October 1987 through 15 February 1988.

[2] Each group of lines corresponds to specific categories which were entered into the chi-square test. The symbols "—| |—" correspond to the boundaries between adjacent categories in a test.

[3] Tests are RxC contingency tables and χ^2 statistics for H_o: $p_i = p$ where p_i = probability of catching a burbot in the ith length group.

Table 21. Contingency table analyses comparing burbot of various length ranges caught in small hoop traps with burbot caught by anglers during 1988[1].

<table>
<tr><th></th><th colspan="12">Test Breaks[2] (minimum length of category mm TL)</th><th></th></tr>
<tr><th></th><th>550</th><th>575</th><th>600</th><th>625</th><th>650</th><th>675</th><th>700</th><th>725</th><th>750</th><th>775</th><th>800</th><th>825+</th><th></th></tr>
<tr><td>Anglers</td><td>4</td><td>11</td><td>13</td><td>9</td><td>11</td><td>8</td><td>3</td><td>9</td><td>9</td><td>12</td><td>6</td><td>28</td><td></td></tr>
<tr><td>Hoop Traps</td><td>10</td><td>14</td><td>5</td><td>2</td><td>3</td><td>0</td><td>2</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>Significance Tests[3]</td></tr>
<tr><td></td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>(p<.001)</td></tr>
<tr><td></td><td></td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td colspan="3">|——————|</td><td colspan="3">|——————|</td><td>(p<.001)</td></tr>
<tr><td></td><td></td><td></td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td colspan="3">|——————|</td><td colspan="3">|——————|</td><td>(.05<p<.025)</td></tr>
<tr><td></td><td></td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td></td><td></td><td></td><td>(.025<p<.01)</td></tr>
<tr><td></td><td></td><td></td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td>|-|</td><td></td><td></td><td></td><td>(.25<p<.10)</td></tr>
</table>

1 Burbot were captured in small hoop traps during July 1988, while burbot caught by anglers were captured during 15 October 1988 through 15 February 1989.

2 Each group of lines corresponds to specific categories which were entered into the chi-square test. The symbols "—| |—" correspond to the boundaries between adjacent categories in a test.

3 Tests are RxC contingency tables and χ^2 statistics for H_o: $p_i = p$ where p_i = probability of catching a burbot in the ith length group.

Table 22. Mean length-at-age of Yukon River burbot sampled during 1984[1] and 1988[2].

	Sample Size			Length (mm TL)								
				Mean			Range			S.E.		
Age	Male	Fem.	All	Male	Fem.	All	Male	Fem.	All	Male	Fem.	All
4	0	1	2[3]	-	312	335	-	-312-	312-358	-	-	23
5	0	2	2	-	436	436	-	413-459	413-459	-	23	23
6	3	1	4	469	424	458	464-477	-424-	424-477	4	-	12
7	0	1	1	-	514	514	-	-514-	-514-	-	-	-
8	4	7	11	574	591	585	550-585	531-674	531-674	8	3	11
9	4	1	5	628	619	626	579-690	-619-	579-690	23	-	18
10	2	2	4	728	712	720	712-743	700-723	700-743	16	12	9
11	4	5	9	697	725	713	665-725	625-798	625-798	13	35	20
12	4	3	7	745	717	733	709-831	667-775	667-831	29	31	20
13	2	4	6	735	774	761	719-750	708-868	708-868	16	35	24
14	3	3	6	785	831	808	730-895	740-894	730-895	55	47	34
15	6	4	10	817	814	816	752-950	764-905	752-950	28	31	20
16	3	5	8	863	845	852	790-909	767-1005	767-1005	37	15	29
17	1	4	5	775	937	904	-775-	869-988	775-988	-	27	38
18	0	2	2	-	933	933	-	915-950	915-950	-	18	18

[1] All burbot were collected 4 October 1984 near the Dalton Highway Bridge using set-lines.

[2] Burbot were collected between 25 August and 29 August 1988 near the Dalton Highway Bridge using small hoop traps and set-lines.

[3] Includes one burbot that sex could not be identified.

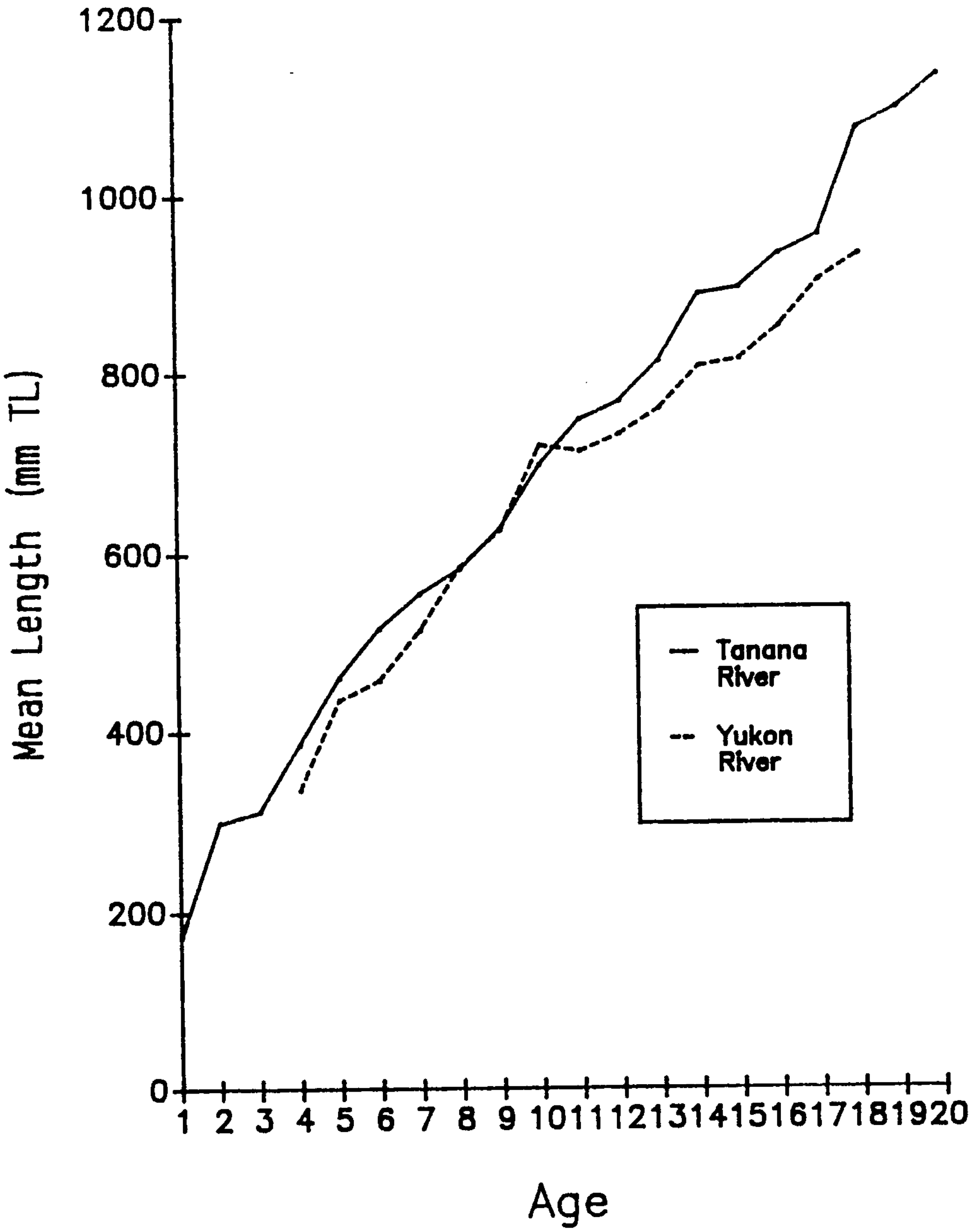

Figure 6. Comparison of mean length-at-age of Tanana River and Yukon River burbot.

The high proportions of burbot documented as being resident may have been artificially high as a result of sampling design. Because sampling typically was conducted in the same or similar areas from one year to the next, the probability of recapturing a burbot which was tagged in that section was higher than the probability of recapturing a burbot which had moved in from another section. The proportions of burbot remaining resident to an area tended to decrease with time, indicating that burbot are not completely resident to an area throughout their lifetime. Extensive movements by burbot throughout the river were documented. These movements were predominantly upstream. Most upstream movements were 100 km or less, although 19 (4%) recaptures were obtained showing movement of greater than 100 km. Downstream movements were short-ranging and infrequent. When they did occur they were generally observed within one year of tagging date and were often associated with movements into a tributary stream. Movements of 10 to 100 km have been documented by Smith and Van Oosten (1940); Keleher (1963); Stein et al. (1973); Bendock and Burr (1984, 1985); Breeser et al. (1988); and, Sundet and Wenger (1984). However, none of these studies documented a tendency for movements to be upstream. Preferential upstream movement was noted by Malinin (1971) who reported that burbot transplanted downstream tended to return to upstream capture sites.

Movements were most frequent during the fall and winter. These movements are most likely feeding (movements during the fall) migrations in response to out-migrations of prey fish from tributary systems, and spawning (movements during the winter) migrations. Sorokin (1971) reported an out-migration of burbot from Lake Baikal into tributary streams during the fall initially for feeding, then further upstream migration in the winter for spawning, and then downstream migration back into the lake following spawning. This scenario may be true for burbot in the Tanana River as evidenced by high frequencies of movements during the fall and winter and low frequencies of movements during the summer months and from one summer to the next.

Information from tag returns also indicated that at least two isolated stocks of burbot exist in the mainstem Tanana River with the boundary lying near the mouth of George Creek (river kilometer 594). This boundary area is characterized by swift current velocities and relatively low burbot densities, which may act as a barrier for burbot migration. Additionally, the upstream end of the lower section (near the outlet of Healy Lake) is an area with the highest documented density of burbot in the river. Suitable habitat and abundant food supply in this area may influence burbot to remain in this area.

Movement behavior was not consistent throughout the mainstem Tanana River. Burbot in lower and upper river areas tend to be less mobile than burbot in middle river areas. However, only six burbot tagged in lower river areas, (one percent of all recaptures) and only 77 (15% of all recaptures) burbot tagged in upper river areas have been recaptured to date. I recommend sampling activities during 1989 be continued in lower and upper river areas to further define movement characteristics of burbot in these areas.

Interchange of burbot between the mainstem Tanana River and three tributary streams (Tolovana, Chena, and Goodpaster Rivers) were documented indicating stocks of burbot in these systems are not isolated. Few small burbot (Gabelhouse stock category 300 - 449 mm TL; RSD = 2.9%) were captured in the Tolovana River, indicating that spawning and rearing of young fish may not occur in this system. One burbot tagged in the Tolovana River during the fall was recaptured in the mainstem Tanana River during winter (spawning period) of the same year indicating that movement of burbot from the Tanana River into this system may be for feeding. A much higher proportion of stock length fish (RSD = 26.1%) was captured in the Chena River. Chen (1969) reported capturing young-of-the-year burbot in the lower stretches of this river. This information indicates spawning most likely occurs in the Chena River and migrations of burbot from the Tanana River into the Chena River during the fall may be feeding migrations, spawning migrations, or both. The three tag returns from the Goodpaster River were obtained during winter and spring indicating that this system may also support spawning stocks of burbot. I recommend more sampling be conducted in tributary systems of the Tanana River to further define degrees of interchange between burbot in these systems.

Tests for gear selectivity indicated that hoop trap gear did not accurately assess the true abundance of very large burbot (> 800 mm TL). These tests may have been biased, however, due to the fact that sampling with hoop traps and sampling by anglers were not conducted during the same time of year. Growth recruitment, immigration, and emigration between summer and winter may have influenced these results. Sample sections during 1987 and 1988 included areas up to 50 km downstream and up to 20 km upstream of the main fishery. Movement information revealed that in a period of one year or less at least 70% of burbot tagged in this area would not migrate out, and 15% would move a distance of 50 km or less. There was no differential movement behavior between large and small fish. This information indicates that the winter set-line fishery most likely harvested the same stock as was sampled during the summer months. Large burbot are available for capture during both sampling periods, but anglers tend to capture a higher proportion than do hoop traps. Burbot greater than 300 mm TL are predominantly piscivorous (Beeton 1956). Hoop traps were baited exclusively with herring (non-native), while set lines were typically baited with native species of whitefish (*Coregonus pidschian* and *Coregonus sardinella*). Thus, there may be some preference for whitefish by larger burbot. Bait in hoop traps is used as an attractant and burbot are physically captured by the trap, while set lines require the ingestion of the bait and hook to be captured. The large hooks and bait used in the set-line fishery (regulations require hooks to be 0.75 inches from barb to shank) may prohibit the capture of small burbot. Hoop traps are fished almost exclusively near shore in relatively shallow water out of the main channel. Set-lines tend to target more for areas along the edge of the main channel. Burbot prefer areas in the main river channel and main channel border areas (Malinin 1971, Mecum 1984). Swift current velocities prevent hoop traps from fishing effectively within the river channel. This information suggests that determination of relative stock densities of burbot harvested in the Tanana River should come from catch sampling from the fishery and not from length compositions of burbot collected using hoop traps.

Relative densities and length compositions of burbot varied throughout sample sections in the mainstem Tanana River. Ryan (1980) reported that burbot catches tended to increase with greater distance upstream. Robins and Deubler

(1955) noted an absence of smaller burbot in headwater creeks. The fluctuations of relative densities and length compositions observed in this study were not consistent with these findings. However, because the hoop traps used in this study are size selective for burbot greater than 450 mm TL, the distribution of smaller burbot (primarily non-spawning fish) throughout the river is not known.

Relative densities of large burbot (≥ 450 mm TL) based on mean CPUE as well as mean lengths of large burbot throughout the river sampled with small hoop traps were generally lower than those burbot sampled in past years using large hoop traps. Bernard et al. (in press) reported that large hoop traps were more effective at catching large burbot than were small traps. With the exception of the Fairbanks area, most sample sections receive little fishing pressure, and differences in relative densities and mean lengths are most likely due to different selectivities of the two gears.

Information to date does not suggest that burbot stocks in the Tanana River are overexploited. Harvest levels, although significantly higher than thirteen years ago, have remained stable over the last eight years. Catch sampling of the winter set-line fishery near Fairbanks, although limited, has not indicated a decline in angler catch rates or size composition. Information from tag recoveries has shown that extensive movements of burbot occur throughout the drainage. These movements minimize the impacts of concentrated local fisheries such as occurs in the Fairbanks area. For these reasons I recommend that no new management actions be proposed to the Alaska Board of Fisheries during 1989.

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