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Seasonal Movements of Radio-Implanted Burbot in the Tanana River Drainage

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ABSTRACT

Radio telemetry was used to study the movements of burbot in the Tanana River drainage. Fifty-five burbot were surgically implanted with high frequency (148-149 MHz) transmitters. Forty burbot were large (greater than 650 mm total length) and considered sexually mature, while 15 were small (less than 450 mm total length) and considered sexually immature. All burbot were released in the Tanana and Chena rivers near Fairbanks. Tracking was conducted from a fixed-wing aircraft on 13 occasions between September, 1992 and July, 1993. Forty-one of the 55 burbot were found on 10 or more occasions, and 53 burbot were found during at least one occasion. Small burbot moved shorter distances than did large burbot between all consecutive tracking periods. Total ranges, measured as the linear distance between the most downstream and upstream points, of small burbot averaged 17 km, and were all less than 40 km. Total ranges of large burbot averaged 57 km and ranged between 5 and 255 km. Movements of small burbot did not vary between tracking periods, but movements of large burbot did. Mean movements of large burbot were greatest during periods coinciding with river freeze-up and river ice-out, and were smallest during periods coinciding with spawning. All 14 small burbot located during the study remained in the area of the mid-river fishery. However, the proportion of large burbot remaining in the area of the fishery varied between 0.66 and 0.93. There was substantial interchange of burbot between the Tanana and Chena rivers, but no movements into any other tributaries were documented. Fourteen general spawning locations were identified in the Tanana and Chena rivers. No more than six implanted burbot were located in any one of these areas. Results of this study are at odds with information obtained from tag returns in that a high frequency of downstream movements were documented in this study, whereas tag returns indicated that movements tended to be upstream. Possible explanations for this discrepancy are discussed.

KEY WORDS: burbot, *Lota lota*, radio telemetry, seasonal movements, Tanana River, Chena River, spawning locations.

INTRODUCTION

Burbot *Lota lota* are a sought-after sport fish by anglers in Alaska. Conservation concerns brought on by increasing harvests during the mid 1980's prompted the Alaska Board of Fisheries to implement more restrictive regulations governing seasons, daily bag and possession limits, and methods and means for many fisheries. The largest fishery for burbot in recent years has been in the Tanana River and its tributaries. Harvests from this fishery have been between 3,000 and 5,000 fish annually since 1981, and have averaged between 18 and 46% of the total state-wide harvest during these same years (Mills 1992). Approximately 70% of the harvest in the Tanana River system occurs in the middle river section in a relatively concentrated area in the vicinity of Fairbanks (Evenson and Hansen 1991).

In response to increasing harvests, and because of the limited information available regarding life history and population dynamics of riverine burbot, an ongoing stock assessment program of Tanana River populations was initiated by the Alaska Department of Fish and Game in 1983. The goals of this research program were to determine biological characteristics such as size, age, and density distributions, identify migratory behavior, examine reproductive characteristics, and to monitor the sport fishery.

Migratory information has been generated by subsequent tag recoveries from sampling efforts and from returns by anglers (Evenson 1989, 1990a). However, due to the seasonal nature of the sampling efforts, most tag recoveries have come from those burbot at-large one year or more. Thus, little information regarding seasonal movements has been acquired.

Investigations of reproductive characteristics have yielded information regarding age and length at maturity, time of spawning, duration of the spawning period, and fecundity (Evenson 1990b; Clark et al. 1991; Roach and Evenson *In prep*). However, information regarding spawning locations and movements associated with spawning was not obtained through these investigations.

The objectives of this investigation were to obtain information regarding distribution, migratory, and reproductive characteristics of burbot implanted with radio transmitters throughout the area of the fishery primarily during periods of ice-cover (October through April). The study focused on those burbot residing in the Tanana and Chena rivers near Fairbanks. The study will be ongoing through March, 1994, and a final comprehensive report will subsequently be prepared. The specific project objectives for this study in 1992 and 1993 were to:

1. test the hypothesis that there are at least six aggregations of spawning burbot within the area of the fishery;

2. estimate the proportion of burbot which remain within the area of the fishery between time of implant and time of relocation for all relocation periods;

3. test the hypothesis that the mean distance travelled by burbot is the same for all periods; and,

4. test the hypothesis that there is no relationship between maturity status and distance travelled by burbot.

METHODS

Equipment

Burbot were implanted with Telonics (Telonics Inc., Mesa, AZ) CHP-4P polymerically sealed transmitters. Transmitters were 4.8 x 1.5 cm, and weighed between 17 and 19 g. Transmitting frequencies ranged between 148 and 150 MHz. Operational life is approximately 16 months with a pulse rate of 60 per minute. Transmitter antennas were multi-stranded stainless steel, 1.02 mm diameter, and 45.5 cm long. Antennas were Teflon coated and covered with shrink wrap tubing to increase rigidity. Receivers used were Telonics TR-2 models equipped with model TS-1 scanners. Signals were received with a directional, 5-element Yagi antenna, with 9 dBd gain (mounted on fixed-wing aircraft) and with a directional, 8 element Yagi antenna with 11.8 dBd gain (mounted on boats and snowmachines). The intercom system on the aircraft (Cessna 185) was designed such that telemetry monitoring by two receivers could be accommodated. Isolation switches were installed for the pilot and each of the two monitoring passengers. This switching system allowed for selective isolation of the pilot from the transmitter signals, as well as selective isolation of the two monitors from air traffic control signals.

Implantation Procedures

Burbot were captured using baited hoop traps, which are described in detail by Bernard et al. (1991). Upon capture, burbot were placed into an aerated tub (approximately 50 gallons) until such time that between one and five burbot of appropriate size were obtained. Transmitters were surgically implanted using similar procedures as those described by Breeser et al. (1988) and Ross (1982). Burbot were anesthetized in water with tricaine (MS-222, about 100 mg/L). A 3 cm incision was made along the center line at the largest part (mid-section) of the abdomen. The antenna of the transmitter was threaded through a hollow tagging needle approximately 25 cm long an 0.3 cm in diameter. The needle and antenna were then threaded through the incision and pushed through the skin approximately 4 cm posterior to the incision. The incised area was then sprayed with Furazin, a topical antibacterial powder, and the transmitter was placed into the body cavity. The incision was then closed with four to five sutures. During the surgical procedure, fresh water was periodically poured over the gills to prevent suffocation. Upon completion of surgery, burbot were placed into the aerated tub until they had gained equilibrium (approximately 5 to 10 minutes), at which time they were released.

Location of Releases

Fifty-five burbot were implanted with transmitters. Of these, 40 were "large" (greater than 650 mm total length TL) and were considered predominantly sexually mature, while the remaining 15 were "small" (less than 450 mm TL) and considered predominantly sexually immature (Evenson 1990b). All implanted burbot were released in the Tanana and Chena rivers in the vicinity of Fairbanks. Forty-two burbot were released at four different locations in the

Tanana River, of which 32 were large fish and 10 were small fish. Thirteen burbot (eight large and five small) were released at three locations in the Chena River (Figure 1). All fish were released between 24 August and 4 September, 1992.

Tracking Procedures

Burbot were tracked almost exclusively with fixed-wing aircraft, but on a few occasions with river boats and snowmachines. Transmitters were located quicker and with greater frequency with aircraft and with greater accuracy with boats or snowmachines. A "tracking period" was defined as one or more excursions (generally four to eight hours flying time) conducted within at least a two-week period. There were 13 tracking periods between 28 September, 1992 and 13 July, 1993. Typically, two personnel each manning a receiver accompanied the pilot on an excursion. Tracking generally covered the mainstream Tanana River between Old Minto Village (river kilometer 217) upstream to the confluence of the Salcha River (river kilometer 430), and the Chena River from its confluence with the Tanana River to a point approximately 75 km upstream. Tracking was extended on a couple of occasions beyond these boundaries, and during the mid-July tracking period two burbot were located in the Tanana River downstream from the previous tracking boundary (river kilometers 124 and 140). The farthest tracking excursion downstream in the Tanana River extended to the confluence of Manley Hot Springs Slough (river kilometer 97), and the farthest upstream excursion extended to the outlet of Healy Lake (river kilometer 587). No burbot were located in the Tanana River downstream of river kilometer 124 or upstream of river kilometer 409. In addition the lower reaches (approximately 10 to 30 km) of many tributaries (Tolovana, Nenana, Wood, Salcha, and Goodpaster rivers as well as Little Delta, and Shaw creeks) were searched, however no transmitters were located in these systems.

Description of Movements

The antenna was mounted on the aircraft such that it "listened" forward to facilitate location of transmitters by flying up the center of the river. Successively louder signals were heard followed by a null signal (a distorted, raspy pulse) when directly over a transmitter, and then a sharp decline in signal strength after passing over a transmitter. Upon detection of the null signal, location was marked on 1:63,360 USGS maps. Flying at an altitude of 300 m above the ground, it was difficult to determine from which portion of the river channel the signal was originating. However, because of the sensitive directionality of the antenna, slight manipulation of the aircraft bearing enabled more precise location of the transmitter. Because of the close proximity of many of the transmitters to Fairbanks, and the final approach path of the Fairbanks International Airport, flying in circular patterns and flying below 300 m was often ill-advised. Thus, usually only one pass over each transmitter was made. On one occasion, four transmitters located from the aircraft were also located from the ground by snowmachine the following day. All four were within 0.5 km of the locations noted from the air.

Approximate locations of spawning aggregations of burbot were determined by noting locations of large burbot during the spawning period. Based upon the samples collected during this investigation, and those from Evenson (1990b)

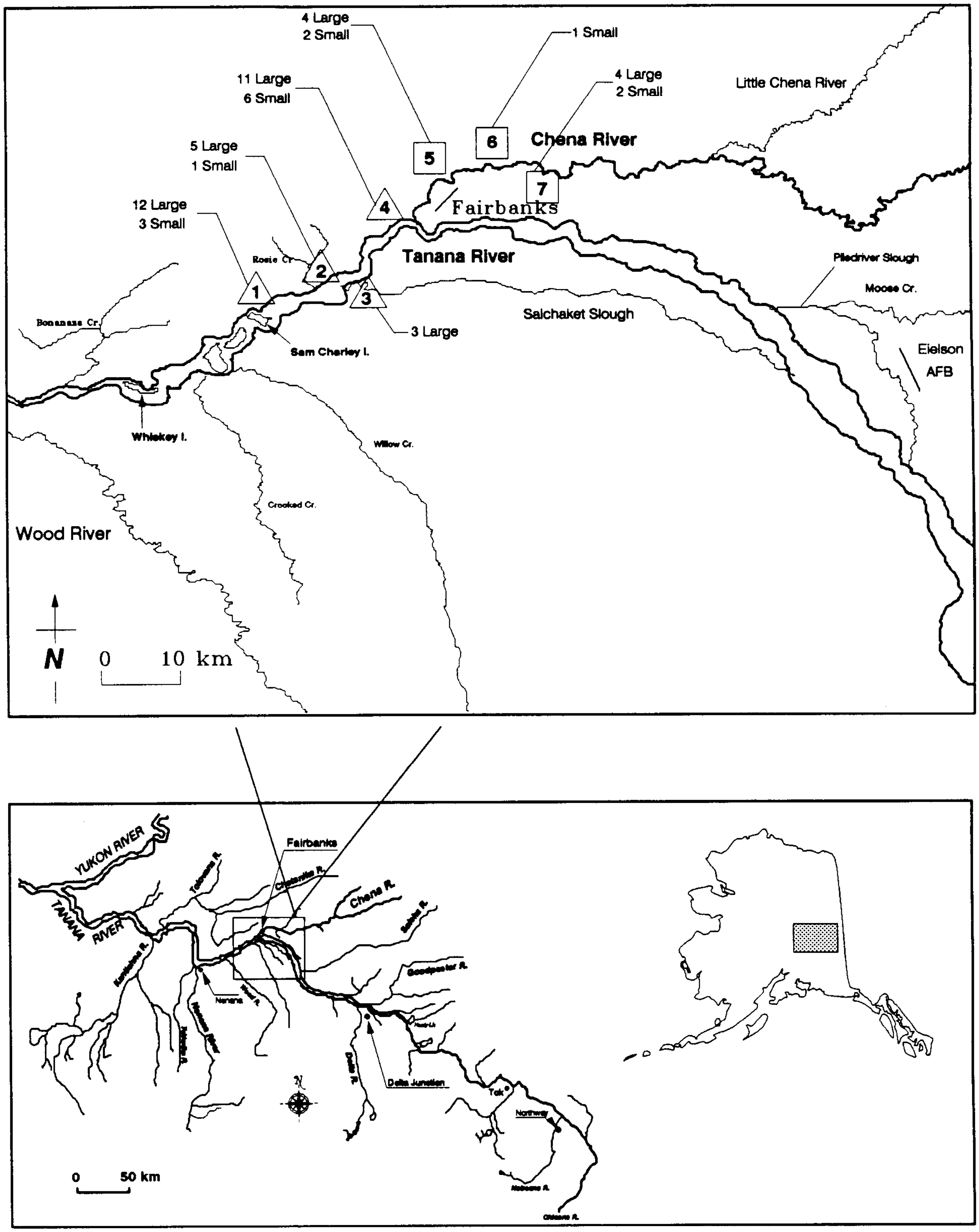

Figure 1. Release locations of large and small burbot implanted with radio transmitters in the Tanana and Chena rivers.

and Clark et al. (1991), the spawning period within the study area begins during mid-January and is predominantly completed by mid-February. Tracking periods were conducted every two weeks from mid-December through mid-March to determine the extent of movement during this period.

Although the fishery occurs throughout the Tanana drainage, much of the harvest occurs in the vicinity of Fairbanks (Evenson and Hansen 1991; Mills 1992). Therefore, burbot residing in this area are more vulnerable to harvest than other burbot. Because drainage-wide abundance of burbot is large relative to total harvest (Evenson 1993), of most concern are localized depletions. For purposes of this report, the boundaries of the fishery are described as follows: Tanana River beginning downstream at the confluence of Bonanza Creek (river kilometer 314), and extending upstream to the confluence of Moose Creek (river kilometer 394). The Chena River beginning at its confluence with the Tanana River upstream to the Moose Creek Dam (river kilometer 64). As an indicator of the risk of localized depletions in the mid-river fishery, the proportion of burbot remaining within the immediate Fairbanks area was estimated during each tracking period.

Many burbot move in excess of 50 km in a year or more (Evenson 1990a). To determine whether these movements are abrupt or gradual, and to determine during which periods of the year movements are most frequent, distances travelled between each tracking period for both large and small burbot were estimated to the nearest 1 km from topographical maps.

A two-way analysis of variance (ANOVA) was used to test for differences in movement between size groups and tracking periods. When size groups were compared, a rank transformation was used to eliminate problems of unequal variance. No transformation for comparisons between tracking periods within a size group was warranted.

RESULTS

Between 34 and 46 of the 55 implanted burbot were located during each tracking period. A higher proportion of small burbot (between 11 and 14 of the 15 released) were located during each tracking period than were large burbot (between 25 and 32 of the 40 released were located during each period). One implanted large burbot was killed and returned by an angler on 8 November, 1992 (Table 1, Appendix A). Forty-one of the 55 burbot released were located during 10 or more tracking periods. Two burbot (one large and one small) were never relocated after initial implant (Figure 2, Appendix A).

Movements of Small Burbot

Small burbot moved shorter distances than did large burbot between all consecutive tracking periods (ANOVA; rank transformation; $F=122$, $df=1, 450$, $p<0.001$). There was no difference in movement between time periods among small burbot (ANOVA; $F=1.45$, $df=12, 133$, $p=0.15$). Mean distance travelled between periods was 2.6 km for small burbot compared to 5.8 km for large burbot. The longest movement of any small burbot was substantially less (34 km downstream) than the longest movement of any large burbot (105 km downstream). Observed total ranges (linear distance between farthest downstream and upstream points) of small burbot averaged 17 km and were all

Table 1. Number of large and small burbot found during each tracking period, October 1992 - July 1993.

		Tracking Period												
	Number Released	Oct 6 1	Nov 18 2	Dec 8 3	Dec 24 4	Jan 11 5	Jan 27 6	Feb 5 7	Feb 22 8	Mar 10 9	Mar 22 10	May 1 11	Jun 1 12	Jul 13 13
Large Burbot	40	29	25	31	29	31	32	32	31	29	32	27	25	23
Small Burbot	15	12	11	12	12	14	14	13	13	12	11	13	12	11
All	55[a]	41	36	43	41	45	46	45	44	41	42	40	37	34

[a] One implanted burbot was killed and returned by an angler on 8 November 1992.

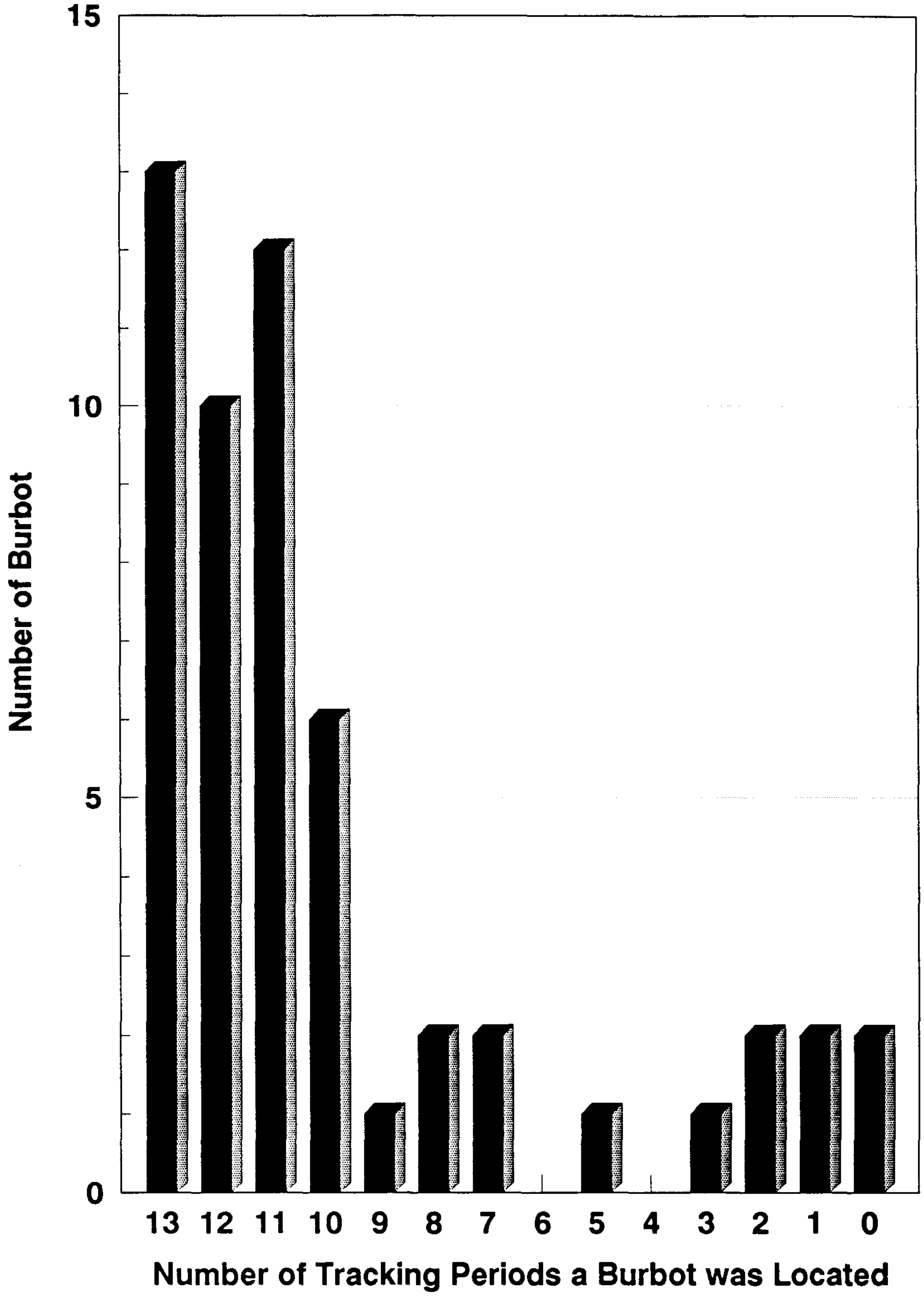

Figure 2. Number of locations obtained for each of 55 radio-implanted burbot.

less than 40 km (Figure 3). All 14 small burbot located during the study remained in the area of the fishery throughout all periods.

Movements of Large Burbot

Total ranges of individual burbot ranged between 5 km and 255 km (Figure 3). Fifteen of the 39 large burbot located throughout the study had total ranges exceeding 50 km. Large burbot were located in the Tanana River as far downstream as river kilometer 123 (237 km below the confluence of the Chena River) to as far upstream as river kilometer 411 (48 km above the confluence of the Chena River), and were located throughout the Chena River upstream to river kilometer 84. Proportions of large burbot remaining in the area of the mid-river fishery ranged from 0.66 (SE = 0.09) during period 7 (5 February) to 0.93 (SE = 0.05) immediately after release (6 October; Table 2).

Movements of large burbot differed significantly among periods (ANOVA; $F=3.9$, $df=12, 317$, $P<0.001$). Movements were most prevalent (based on Duncan's multiple range test described by Duncan 1955) during the two months following initial release (periods 1 and 2), which coincides with river freeze-up, and during periods 11 and 12, which coincides with river ice break-up. Movements were least prevalent during periods 6 and 7, which coincide with the spawning period (Table 3, Figures 4 and 5).

Movements exceeding 50 km (either upstream or downstream) were uncommon, and only three burbot moved a distance of 100 km or more between any two consecutive periods (Figures 4 and 5). Although long-ranging abrupt movements were uncommon, movements of 50 km or greater were more common over longer time periods (Figures 6 and 7). The largest downstream movement from the point of release was 224 km, while the largest upstream movement was 85 km. Movements were predominantly downstream following initial release. During other periods, mean net movements between periods were both upstream and downstream (Figure 8). However, mean net movement for all burbot since original release was downstream (Figure 9).

Movements Between River Systems

There was a moderate amount of interchange between the Chena and Tanana rivers. One small burbot moved from the Tanana River into the Chena River (between periods 12 and 13), and one small burbot moved from the Chena River into the Tanana River (between release and period 1). A third small burbot moved from the Tanana River into the Chena River (period 9) and back into the Tanana River (period 11). The remaining 12 small burbot remained in the river in which they were released. Of the eight large burbot released in the Chena River, four moved out of the Chena River into the Tanana River (two at river freeze-up and two at river ice-out) and remained there through period 13, and four remained in the Chena River during all periods. Of the 31 large burbot released in the Tanana River and located during at least one period, 28 were located only in the Tanana River, one burbot moved into (between periods one and three), and remained in the Chena River, and two burbot moved from the Tanana River into the Chena River prior to spawning and moved back after ice-out.

Although other tributaries were searched (see Methods section), no burbot were located in any waters other than the Tanana and Chena rivers.

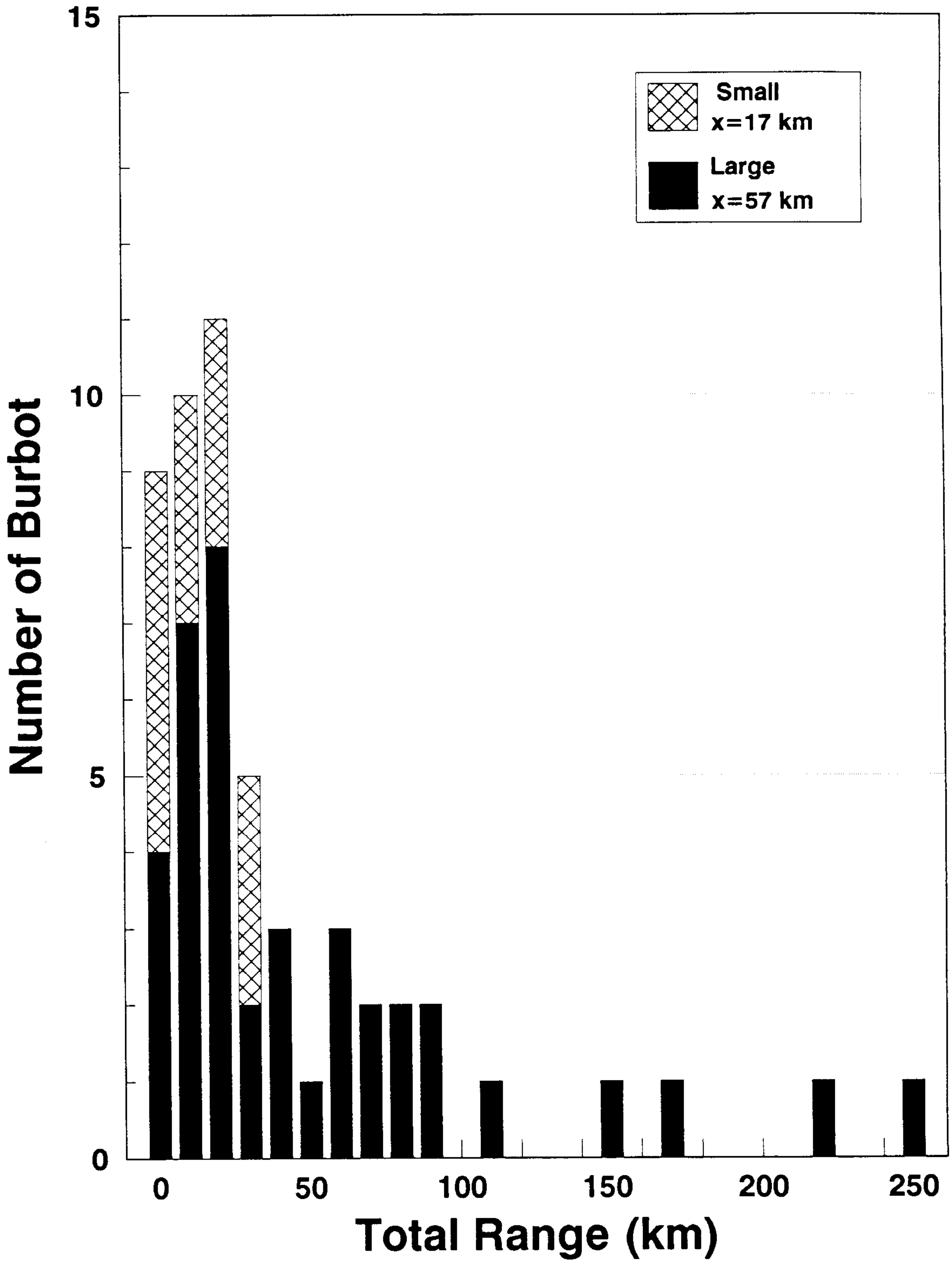

Figure 3. Total ranges, measured as the linear distance between the most upstream and downstream locations, for large and small burbot.

Table 2. Proportion of large burbot remaining in the area of the mid-river fishery during each tracking period.

		Tracking Period												
Location	Number Released	Oct 6 1	Nov 18 2	Dec 8 3	Dec 24 4	Jan 11 5	Jan 27 6	Feb 5 7	Feb 22 8	Mar 10 9	Mar 22 10	May 1 11	Jun 1 12	Jul 13 13
Number Remaining Within the Fishery	40[a]	27	22	25	21	22	22	21	22	20	22	23	20	16
Number Moving Outside the Fishery	0	2	3	6	8	9	10	11	9	9	10	4	5	7
Total Located		29	25	31	29	31	32	32	31	29	32	27	25	23
Proportion Remaining in the Area of the Fishery		0.93	0.88	0.81	0.72	0.71	0.69	0.66	0.71	0.69	0.69	0.85	0.80	0.70
Standard Error		0.05	0.07	0.07	0.08	0.08	0.08	0.09	0.08	0.09	0.08	0.07	0.08	0.10

[a] One implanted burbot was killed and returned by an angler on 8 November 1992.

Table 3. Analysis of differential movements of large burbot between consecutive tracking periods using Duncan's multiple range test.

Tracking Period/Date	Mean Movement (km)	Number of Burbot Located	Duncan Grouping[a]
2 (18 Nov, 1992)	14.6	22	A
12 (1 Jun, 1993)	13.5	21	A
1 (6 Oct, 1992)	13.3	28	A
11 (1 May, 1993)	9.5	26	A B
9 (10 Mar, 1993)	5.1	28	B C
5 (11 Jan, 1993)	4.7	27	B C
3 (8 Dec, 1992)	4.2	22	B C
4 (24 Dec, 1992)	4.2	26	B C
8 (22 Feb, 1993)	2.6	28	B C
13 (13 Jul, 1993)	2.1	20	B C
10 (22 Mar, 1993)	1.9	28	B C
7 (5 Feb, 1993)	1.3	28	C
6 (27 Jan, 1993)	0.9	26	C

[a] Means with the same letter are not significantly different.

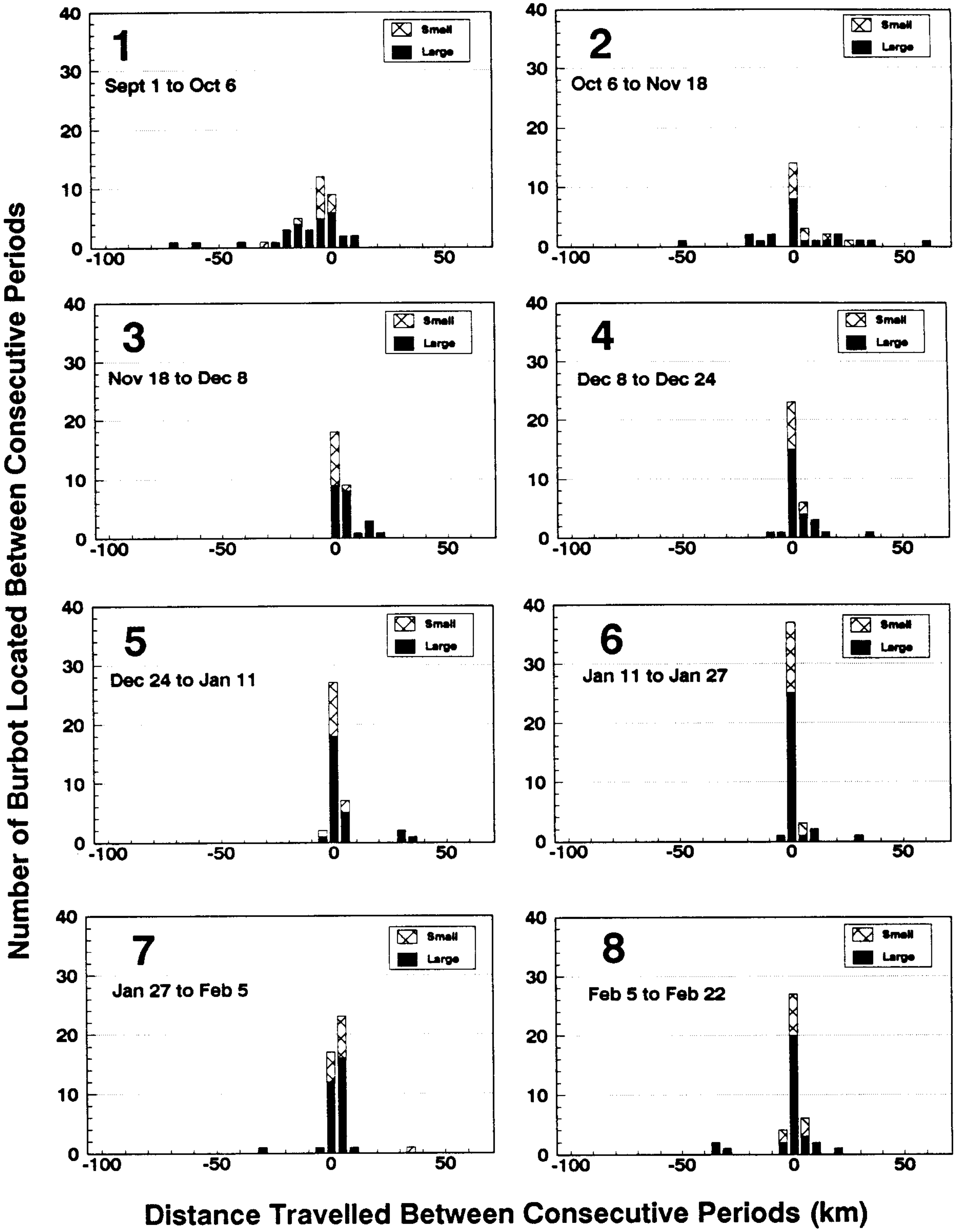

Figure 4. Net distance travelled between consecutive tracking periods (one through eight) for large and small burbot.

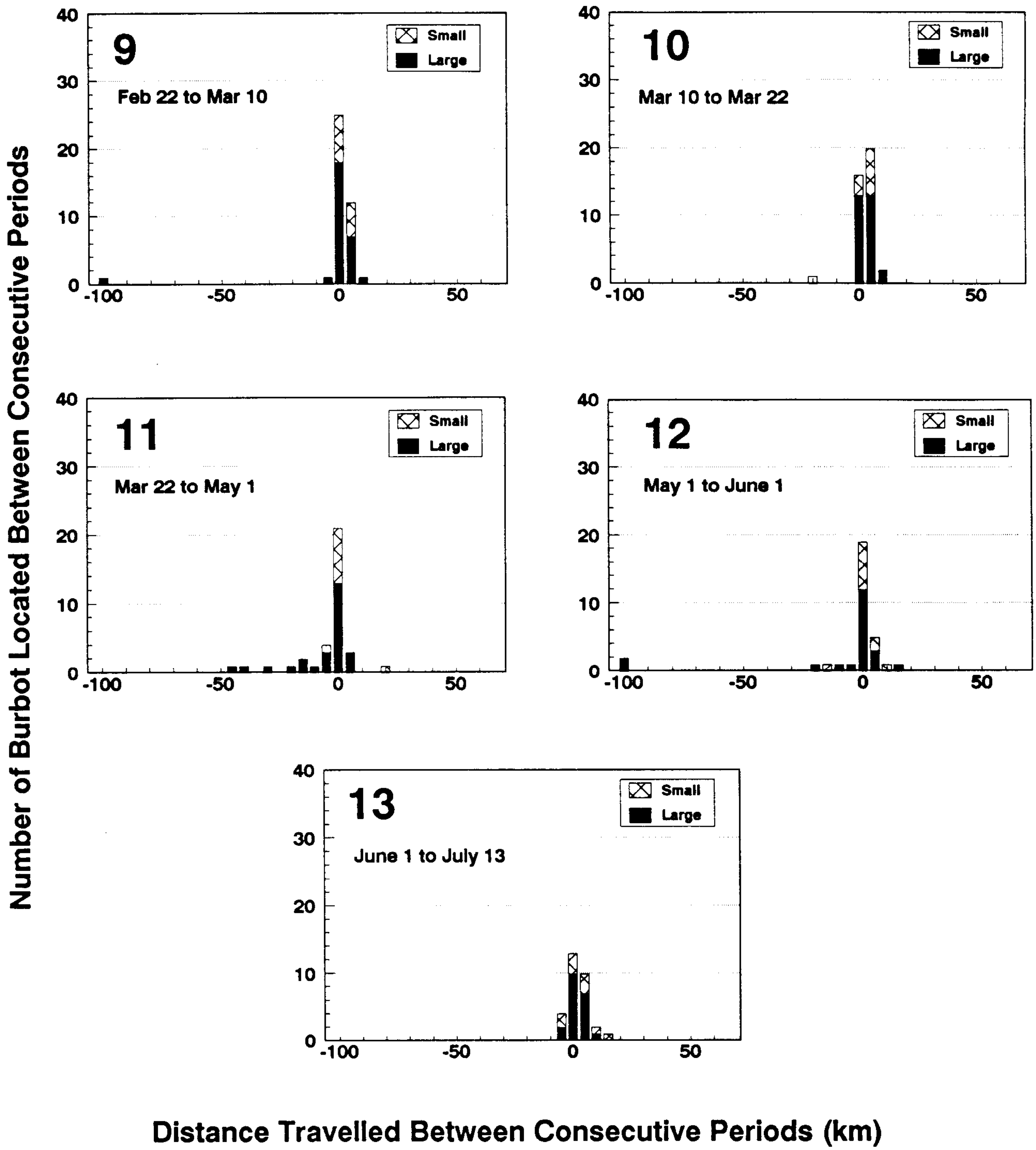

Figure 5. Net distance travelled between consecutive tracking periods (nine through 13) for large and small burbot.

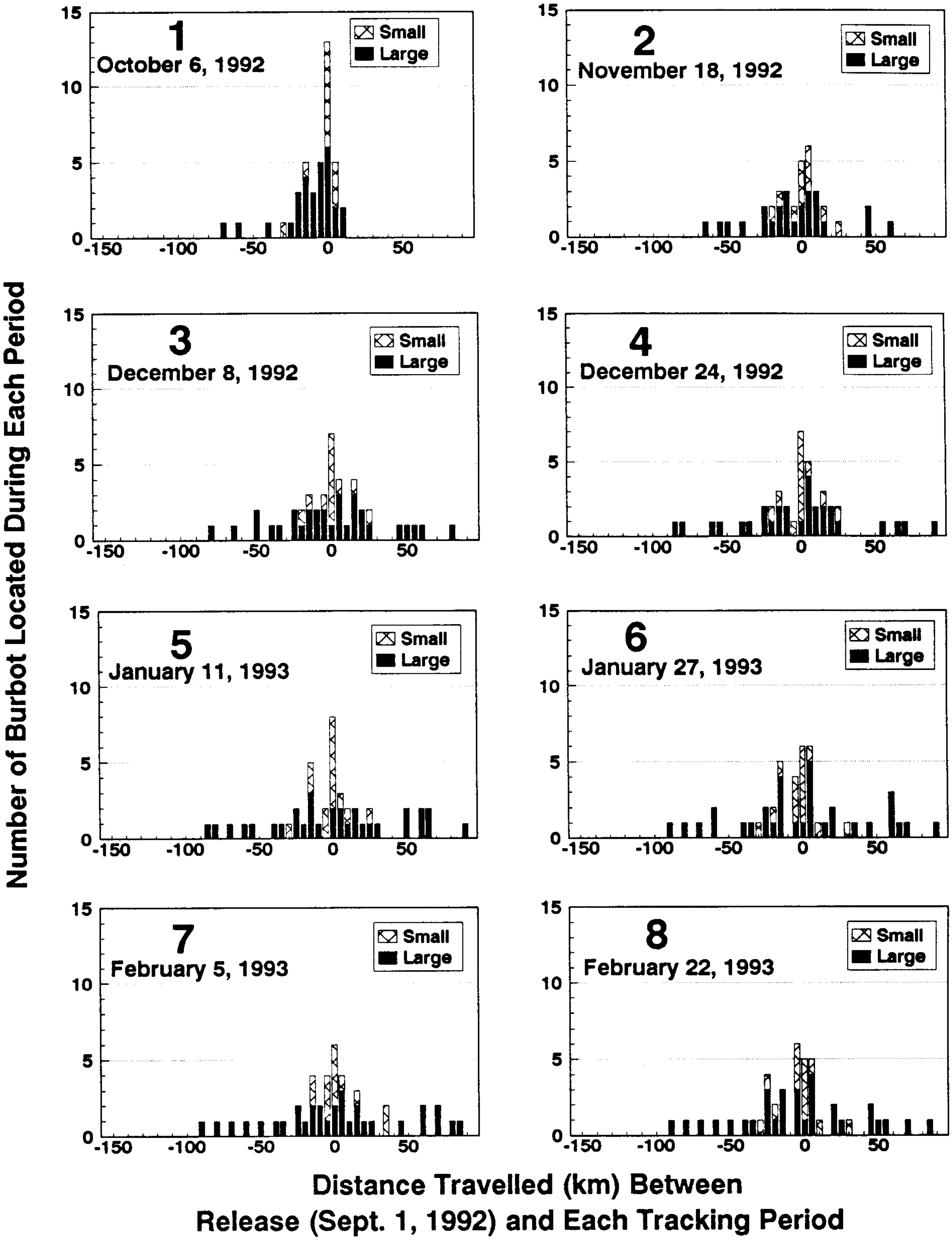

Figure 6. Net distance travelled between original release and each tracking period (one through eight) for large and small burbot.

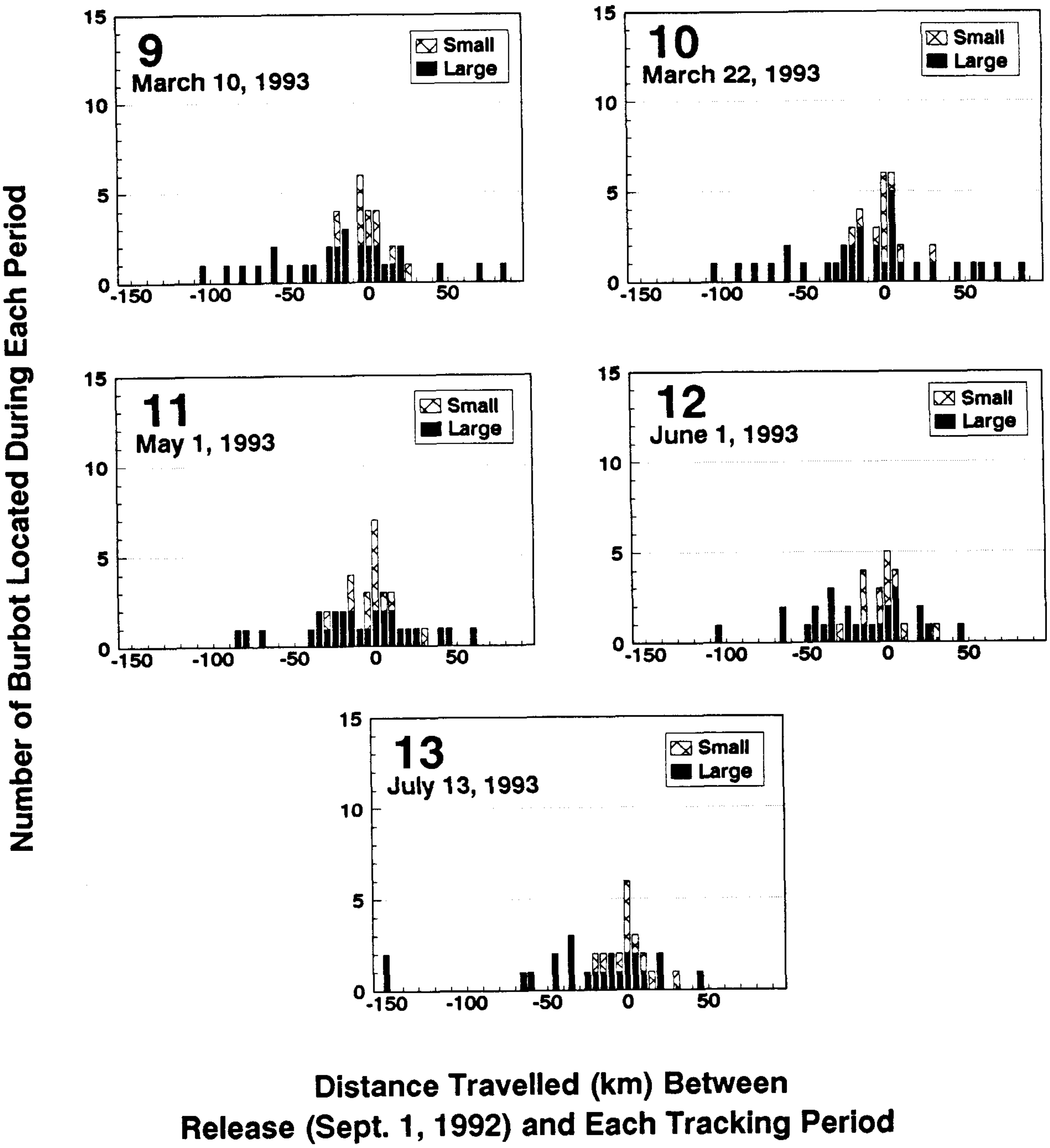

Figure 7. Net distance travelled between original release and each tracking period (nine through 13) for large and small burbot.

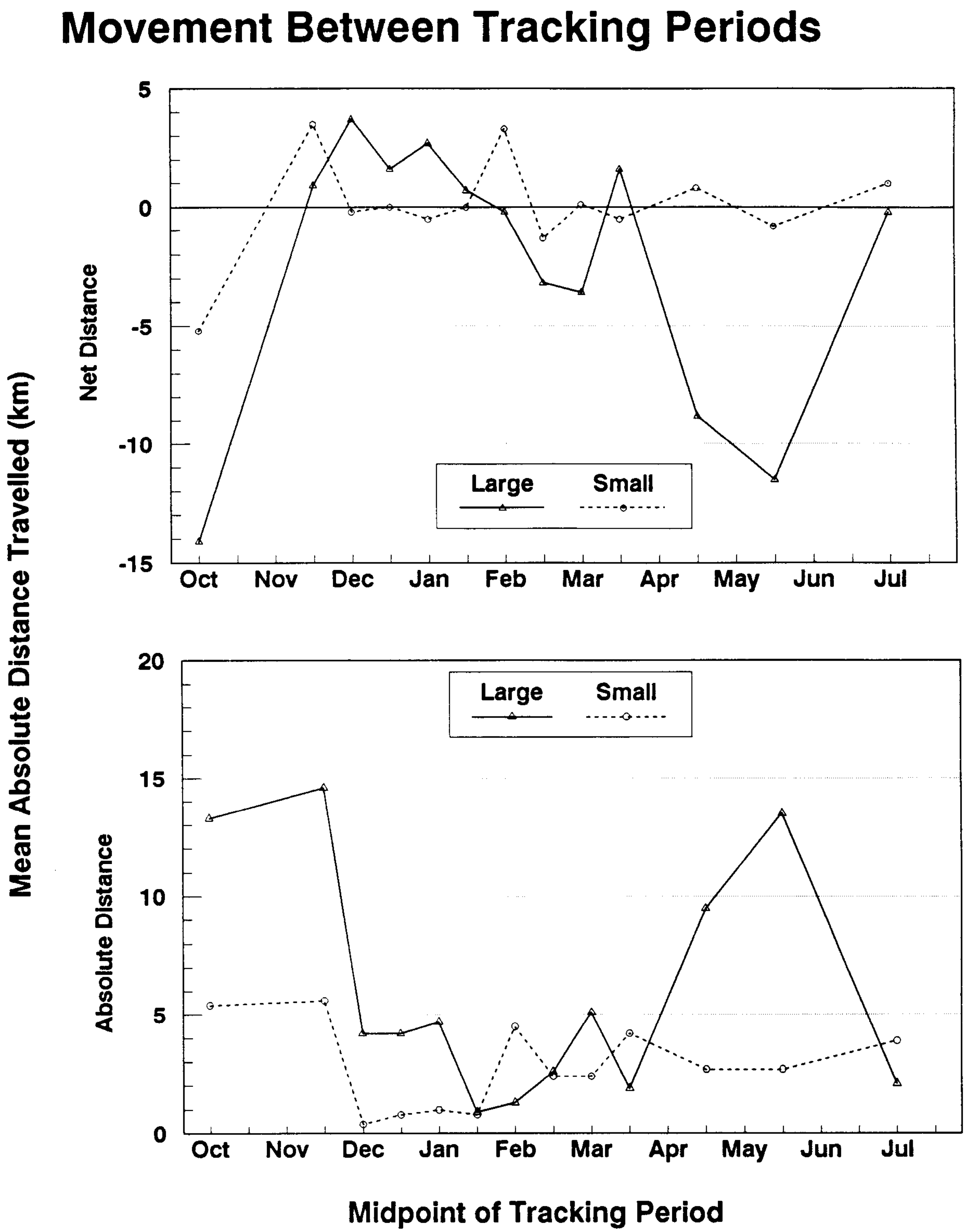

Figure 8. Mean net and absolute distance travelled between each tracking period for large and small burbot.

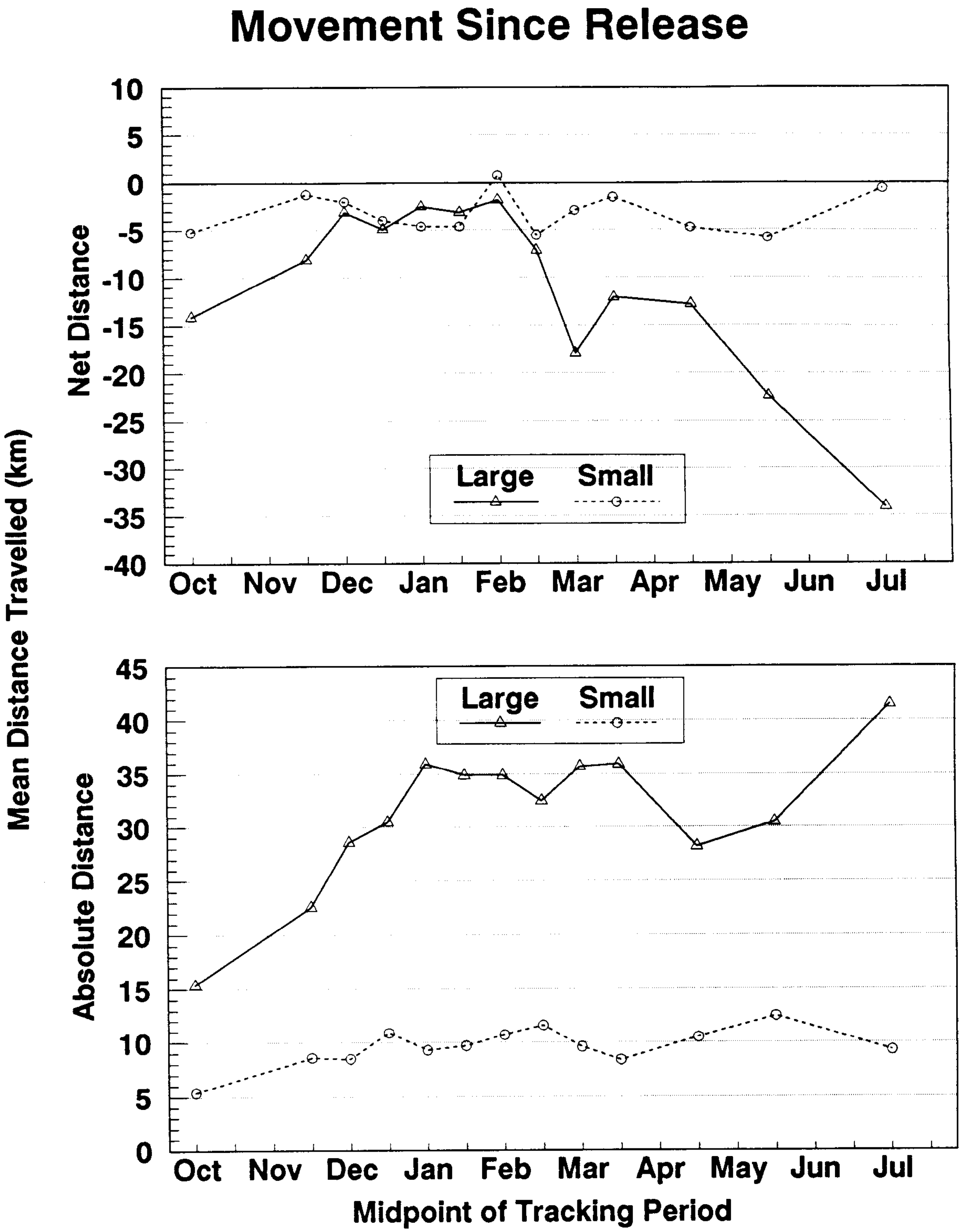

Figure 9. Mean net and absolute distance travelled between original release and each tracking period for large and small burbot.

Spawning Aggregations

Although exact spawning locations were never identified, movements of large burbot throughout the spawning period were infrequent and short-ranging. Based on locations of large burbot during tracking periods six through eight (11 January through 22 February), 14 loose concentrations in the Tanana and Chena rivers were identified for 33 large burbot (Figure 10). The largest concentration of large burbot was in the vicinity of Whiskey Island (area 4 of Figure 10), where six fish were located throughout the spawning period. Six large burbot were not located during the spawning period. Only one of these was found during subsequent tracking periods.

DISCUSSION

The results of this study are at odds with information obtained from tag returns (Evenson 1989, 1990a), which has indicated burbot infrequently move downstream, and that when downstream movements do occur, they are short-ranging. In this study downstream movements were common and ranged to as much as 224 km from the release site. The net movement of all burbot was slightly downstream. Much of the initial downstream movement noted between release and the first tracking period may have been associated with recovery from implantation. Breeser et al. (1988) reported that 12 of the 21 burbot they implanted with transmitters also moved downstream following implantation. However, in this study, numerous downstream movements occurred after the first tracking period. Tag return data may have been biased due to unequal distribution of sampling effort among river areas. Many of the tag returns were obtained from anglers fishing in, and from sampling conducted in, the Fairbanks area and areas upstream from Fairbanks. A relatively small proportion of the tagging effort has occurred in areas downstream from Fairbanks. Thus, it is likely that the probability of capturing a burbot which moved downstream is less than that of capturing one which moved upstream or one which remained in the area it was tagged.

The high proportion of downstream movement observed may be attributed in part to mortality and/or expulsion of the transmitters. The transmitters were not equipped with mortality sensors (a small mercury switch sensitive to movement commercially available on some transmitters), thus it was not possible to determine whether tags had been expelled or the fish had perished. Because of the margin of error associated with determining locations from the aircraft (approximately ±1 km), detection of slight upstream movements were not possible. Fifteen of the 53 burbot (28%) located in this study either did not move (at least 2 km), or moved downstream only from their release site. Breeser et al. (1988) observed that only 4 of the 21 burbot (19%) radio-implanted in their study did not move upstream, and for this reason were presumed dead. Rates of trans-intestinal expulsion (engulfment of the transmitter by the intestine and expulsion of it through the anus), and/or expulsion through the incision of surgically implanted transmitters have been documented at 52% for channel catfish *Ictalurus punctatus* (Marty and Summerfelt 1986), and at 59% for rainbow trout *Oncorhynchus mykiss* (Chisholm and Hubert 1985). Based on these studies, it is reasonable to assume that at least some proportion of these 15 burbot either expelled their transmitters or perished. Before completion of this study, tracking of these fish should be

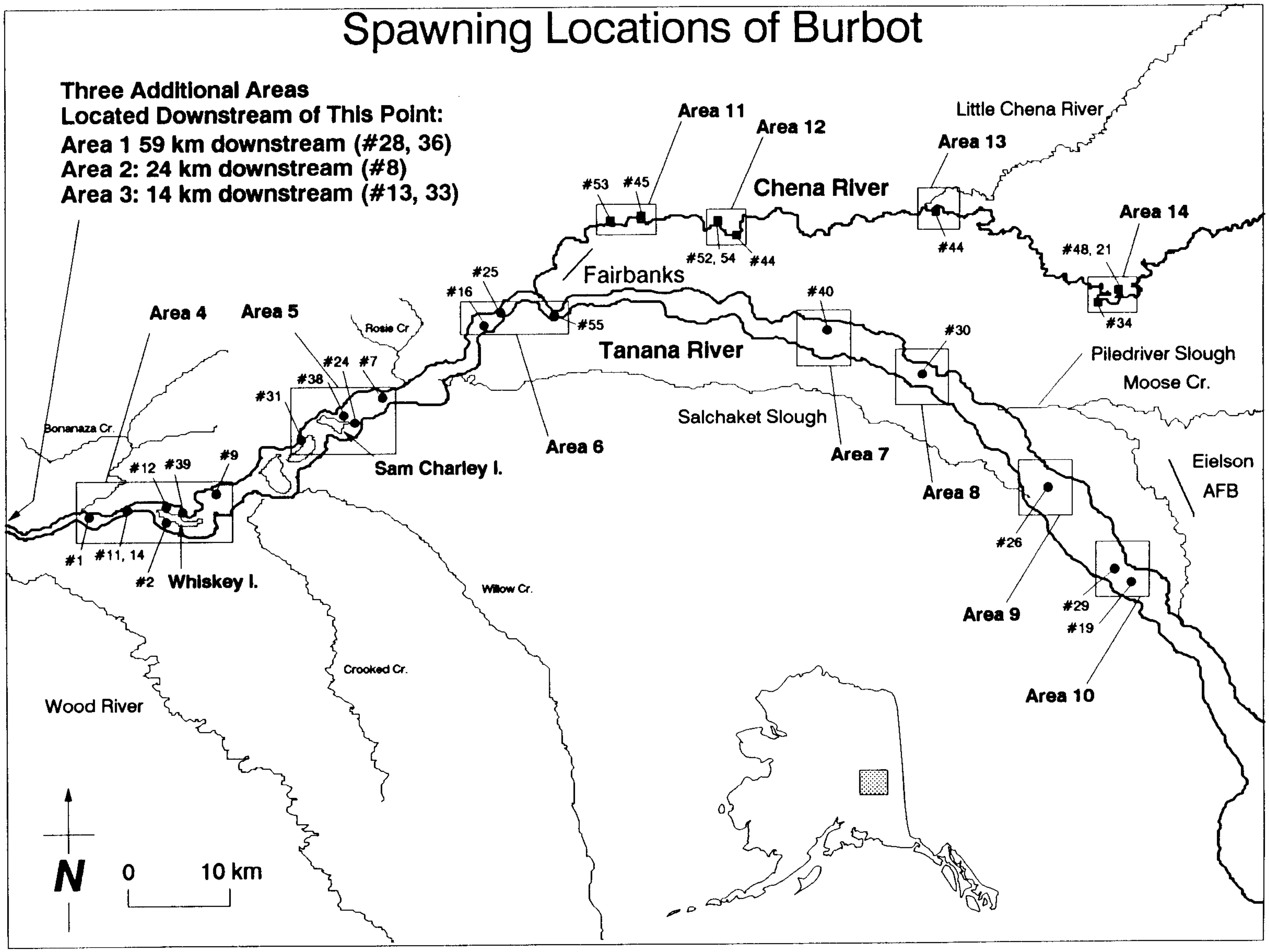

Figure 10. Spawning locations of 33 large burbot in the Tanana and Chena rivers.

conducted on a daily basis from a riverboat (provides a more accurate location than from aircraft) until it is determined whether the fish are alive.

Two burbot were never located, and three burbot were not located at any time after the third period (Appendix A). Three possibilities exist which would explain this. First, the transmitters may have failed. The transmitters, although polymerically sealed, are not designed for long term moisture proofing as are hermetically sealed transmitters, and the manufacturer states that they "may be subject to moisture related problems". These transmitters have been successfully used in the past however (Roach 1993; Pearse and Clark 1992) with minimal transmitter failures.

Second, the transmitters may have been operational and the fish may have been located within the areas searched, but the signal was not received. Eiler (1990) reported poor reception of high-frequency transmitters (150-151 MHz) at depths of 4.5 m and no reception at depths greater than 6 m. This is a likely explanation for the periodic locations of some transmitters, but it is unlikely that burbot remained in water exceeding 6 m for the duration of the study. With either of these two scenarios, it is reasonable to assume that the behavior of the fish which were not found is similar to that of those which were located regularly.

The third possibility is that these fish moved out of the areas which were searched. The longest documented movement from 828 tag returns is 369 km, but less than 5% moved greater than 150 km from release site (Evenson Unpublished). The greatest recorded movement of 21 implanted burbot monitored by Breeser et al. (1988) was 119 km. Tracking in the mainstream Tanana River extended downstream 250 km from the most downstream release site and upstream 237 km from the most upstream release site. Tracking in the Chena River extended 120 km upstream in the Chena River. It is unlikely that burbot moved beyond the ranges searched in these two systems. However, there are numerous small order tributaries within this range that were not searched beyond the lower few kilometers. Thus, movement beyond the range searched in these trackings is possible, and if so, interpretation of movement data could change substantially. Time and cost constraints have prohibited searching beyond these ranges thus far. However, before this study is completed, searching beyond the current ranges should be conducted to eliminate this as a reasonable possibility.

Movements of large burbot were most prevalent in the fall and spring during the periods of river freeze-up and ice-out. Catch rates using hoop traps are higher during these periods than during mid-summer months (Evenson 1993), and it is likely that angler catch rates are higher during these periods as well. Muller (1973) reports three peaks in daily activity patterns of burbot in northern latitudes (Messaure, Sweedish-Lapland, 66°42'N) during late February, late June, and late September. These results are, in part, consistent with this study, except that little or no movement was noted during February. Breeser et al. (1988) indicated that the longest movements of burbot in the upper Tanana River occurred during the period November-March, and attributed them to movements to spawning areas.

Movements of large burbot were significantly different from those of small burbot. This differential movement may be attributed to either spawning or feeding activities. Less than 10% of burbot smaller than 450 mm TL (size of small burbot in this study) in the Tanana River drainage are sexually mature, whereas over 90% burbot larger than 650 mm TL (size of the large burbot in this study) are sexually mature (Evenson *In prep*). This is roughly the size at which burbot switch from a diet of primarily invertebrates to one of primarily fish (Beeton 1956; Bjorn 1940; Hewson 1955).

Ranges of movement of burbot indicated that relatively few burbot travelled extensive distances (greater than 100 km), at least within the 11 month period of this study. Tag return information (Evenson 1989, 1990a), however, has shown mixing occurs through all stretches of the mainstream Tanana River, and that dispersal from the release site increases with time. Tag returns have also documented movement between many tributary rivers and the mainstream Tanana River. For these reasons burbot throughout the drainage are managed as a single stock. Information from this study supports this approach, however localized depletions resulting from spatially concentrated fishing effort should still be of concern. The Alaska Statewide Harvest Survey provides estimates of harvest for three Tanana River sections (upper, middle, and lower), and for all major tributaries, and is thus a good indicator of excessive harvest in localized areas.

Little is known of spawning behavior of riverine burbot, and prior to this study little was known of spawning areas in the Tanana River near Fairbanks. Burbot are known to spawn in large aggregations, with no apparent pairing of males and females (Cahn 1936; McCrimmon 1959). Breeser et al. (1988) identified two possible spawning locations in the upper Tanana River, and both were in tributaries (Chisana and Tetlin rivers). Of management concern was the number and location of spawning areas in the Fairbanks vicinity. This study identified many potential spawning aggregations throughout the mainstream Tanana River and in the Chena River in the vicinity of Fairbanks. No more than six burbot (18% of total) were located in any one aggregation. Given the fairly uniform distribution of fish, it is unlikely that anglers can target on only a few, very large spawning aggregations.

The intent of this study was to determine if spawning aggregations of burbot occur in the Tanana River drainage, for purposes of managing the fishery based on area or season closures. Because transmitters were located from an aircraft at biweekly intervals during spawning, the precise time and site of spawning could not be identified. Determining exact locations of spawning sites would require daily tracking of transmitters from the ground, and visual observation of the spawning act under the ice. By measuring and categorizing the micro-habitat of burbot spawning sites, the location and frequency of occurrence of spawning sites throughout the Tanana River drainage could be predicted. However, obtaining information on the micro-habitat of burbot spawning sites would be costly, and is not necessary to the management of the fishery.

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APPENDIX A

Appendix A. Relocation histories of all burbot implanted with radio transmitters in the Tanana and Chena rivers for each of 13 tracking periods.

					Tracking Period												
Fish No.	Frequency (MHz)	Length (mm TL)	Length Class	Release Site[a]	Oct 6 1	Nov 18 2	Dec 8 3	Dec 24 4	Jan 11 5	Jan 27 6	Feb 5 7	Feb 22 8	Mar 10 9	Mar 22 10	May 1 11	Jun 1 12	July 13 13
1	149.100	754	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	X
2	149.090	700	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	X
3	148.970	838	Large	1													
4	149.020	709	Large	1	X	X	X										
5	149.000	439	Small	1	X	X	X		X	X	X	X	X	X	X	X	X
6	148.940	428	Small	2													
7	148.960	932	Large	2	X	X	X	X	X	X	X	X	X	X	X	X	
8	149.110	695	Large	2	X		X	X	X	X	X	X	X	X	X		
9	149.010	874	Large	4	X												
10	148.900	677	Large	4	X	X	X	X	X	X	X	X	X	X	X	X	X
11	149.030	725	Large	4	X	X	X	X	X	X	X	X	X	X	X	X	X
12	148.770	1,040	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	X
13	148.990	729	Large	4	X	X	X	X	X	X	X	X	X	X		X	
14	148.950	709	Large	4	X	X	X	X	X	X	X	X	X	X	X	X	X
15	148.980	445	Small	4	X		X	X	X	X	X	X	X	X	X	X	X
16	148.930	820	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	
17	148.410	441	Small	1			X	X	X	X	X	X	X	X	X	X	X
18	148.680	759	Large	2													X
19	149.060	922	Large	4	X	X	X	X	X	X	X		X	X		X	X
20	148.920	655	Large	4	X		X										
21	149.080	655	Large	4	X		X		X	X	X	X	X	X	X	X	X
22	149.070	439	Small	4	X	X	X	X	X	X	X	X	X	X	X	X	X
23	148.450	704	Large	4	X	X								X		X	X
24	149.050	890	Large	4	X	X	X	X	X	X	X	X	X	X	X		
25	148.660	765	Large	1			X	X	X	X	X	X	X	X	X	X	X
26	148.670	451	Small	1	X	X	X	X	X	X	X	X	X	X	X	X	X
27	148.570	680	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	X

(continued)

Appendix A. (Page 2 of 2).

Fish No.	Frequency (MHz)	Length (mm TL)	Length Class	Release Site[a]	Tracking Period Oct 6 1	Nov 18 2	Dec 8 3	Dec 24 4	Jan 11 5	Jan 27 6	Feb 5 7	Feb 22 8	Mar 10 9	Mar 22 10	May 1 11	Jun 1 12	July 13 13
28	148.570	680	Large	2	X	X	X		X	X	X	X	X	X	X		
29	148.850	755	Large	3	X	X	X	X	X	X	X	X		X			X
30	148.840	807	Large	3	X	X		X	X	X	X			X	X	X	X
31	148.510	748	Large	3	X	X	X	X	X	X	X	X	X	X	X		
32	148.430	450	Small	4	X	X	X	X	X	X	X	X	X	X	X		
33	148.710	694	Large	4	X	X	X	X	X	X	X	X	X	X		X	X
34	148.750	702	Large	4	X		X	X	X	X	X	X	X	X	X	X	X
35	148.810	428	Small	4	X		X	X	X	X	X	X	X	X		X	X
36	148.600	832	Large	1				X	X	X	X	X	X	X			
37	148.420	844	Large	1			X	X	X	X	X	X	X	X	X	X	
38	148.520	724	Large	1				X	X	X	X	X	X	X	X	X	X
39	148.730	742	Large	1	X	X	X	X	X	X	X	X	X	X	X	X	X
40	148.590	800	Large	2					X	X							
41	148.690	446	Small	4		X	X	X	X	X	X	X	X		X	X	X
42	148.740	441	Small	4	X	X	X	X	X	X	X	X	X	X	X	X	X
43	148.640	456	Small	6	X			X	X	X		X			X	X	
44	148.780	655	Large	7		X	X	X	X	X	X	X	X	X	X	X	
45	148.440	655	Large	7		X	X	X	X	X	X	X		X	X	X	X
46	148.530	457	Small	7	X	X	X	X	X	X	X	X	X	X	X	X	X
47	148.540	441	Small	7	X	X	X		X	X	X	X	X	X	X	X	X
48	148.650	655	Large	7		X	X	X	X	X	X	X	X	X	X	X	X
49	148.240	710	Large	5	X	X	(Returned dead by angler)										
50	148.830	456	Small	5	X	X		X	X	X	X				X		X
51	148.720	457	Small	5	X	X	X	X	X	X	X	X	X	X	X	X	
52	148.550	678	Large	5	X	X	X	X	X	X	X	X	X		X		
53	148.820	753	Large	5	X	X	X	X	X	X	X	X	X	X	X	X	X
54	148.760	712	Large	7		X	X		X	X	X	X	X	X	X	X	
55	148.700	730	Large	5	X		X	X	X	X	X	X	X	X	X	X	X

[a] Refer to Figure 1 for locations of releases.