Spawning Distribution and Migratory Timing of Kuskokwim River sheefish using radiotelemetry

2007 Annual Report

Study 06-305

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TABLE OF CONTENTS

Page

LIST OF TABLES iii

LIST OF FIGURES iii

LIST OF APPENDICES iii

ABSTRACT 1

INTRODUCTION 1

OBJECTIVES 2

METHODS 5

Capture and Tagging 5
Radio-Tracking Equipment and Tracking Procedures 6

RESULTS 7

DISCUSSION 10

Conclusions 11
Project Recommendations for 2008 11

ACKNOWLEDGMENTS 12

LITERATURE CITED 13

APPENDIX A: MAPS SHOWING APPROXIMATE UPRIVER AND DOWNRIVER MOVEMENTS OF RADIO-TAGGED SHEEFISH THAT WERE LOCATED DURING THE FALL AERIAL SURVEYS OF 2007 15

LIST OF TABLES

Table **Page**

1. Tagging date, location, gear type, length, gender, and fall aerial survey locations for the 9 sheefish that were captured and tagged in the Upper Kuskokwim River, 2007. 9

LIST OF FIGURES

Figure **Page**

1. Map of the Kuskokwim River showing approximate overwintering, feeding, and spawning locations for sheefish that were recorded by Alt (1987). Map includes the locations of stationary tracking stations that recorded the radio-tagged fish in 2007..... 3

2. Upper Kuskokwim River drainage showing capture area, stationary tracking station locations, and approximate area where the September and October aerial surveys were conducted for 2007. 4

LIST OF APPENDICES

Appendix **Page**

A1. Map showing the approximate upper and lowermost extents of sheefish that were captured and radio-tagged in the Upper Kuskokwim River and located during the September-October 2007 aerial surveys. .....

A2. Map showing the approximate upper and lowermost extents of sheefish that were captured and radio-tagged in the Kuskokwim River and located during the September-October 2007 aerial surveys. .....

ABSTRACT

During August and September 2007, 9 sheefish (*Stenodus leucichthys)* were captured and surgically implanted with radio transmitters in the upper portion of the Kuskokwim River drainage, with the primary objective to document spawning locations. Seven of the 9 tagged fish were judged to have survived tagging and handling. Movements were recorded by a series of 9 stationary tracking stations located throughout the drainage. Three aerial surveys were conducted between late September and mid-October, the typical spawning period of sheefish. One gravid female travelled to a 3-km section within a previously described spawning area in the Big River and was presumed to have spawned. No other spawning areas could be identified with certainty. Five radio-tagged sheefish were detected near Bethel during late October and early November. These fish began their 600 plus kilometer migration from the Upper Kuskokwim River to their overwintering areas in the Lower Kuskokwim River in mid-October. This project is ongoing through 2009, with additional radio tags to be deployed in 2008. Aerial surveys will be conducted throughout the Kuskokwim River drainage to locate those fish tagged in 2007 and 2008 during summer and fall of 2008 and 2009.

INTRODUCTION

The Kuskokwim River is the second largest drainage in Alaska. From its headwaters in the Alaska Range, the Kuskokwim River drains approximately 130,000 km^2 along its 1,130-km course to the Bering Sea. This drainage supports five species of Pacific salmon as well as numerous resident species, including the inconnu, *Stenodus leucichthys*, commonly called sheefish in Alaska.

Sheefish are a highly migratory whitefish found in large northern rivers and associated lakes of northwestern North America and northern Eurasia (McPhail and Lindsey 1970). Sheefish, like other whitefish, are known for their high phenotypic plasticity (Behnke 1972). Most sheefish in Alaska are estuarine anadromous while much smaller numbers belong to local non-anadromous stocks. Sheefish undertake movements and/or migrations related to feeding, spawning, and overwintering, with estuarine anadromous sheefish undertaking the longest migrations (Howland *et al*. 2000). Knowledge of sheefish on the Kuskokwim River is based almost entirely on work by Alt (1987) in the 1970s and early 1980s, and on information from other systems.

Currently and historically the greatest use of sheefish on the Kuskokwim River has been for subsistence. Between 2002 and 2004, sheefish constituted between 2% and 2.8% of the total non-salmon subsistence harvest in the Bethel area, or between 346 and 900 fish (Fall *et al*. 2003; ADF&G 2005, ADF&G *in prep.*). In the Aniak area, sheefish are harvested throughout the year and have constituted between 21% and 23% of the total non-salmon harvest for 2001-2003 (Krauthoefer *et al*. 2005).

Most sheefish harvested by sport fishers have been taken from tributaries of the Kuskokwim River, with the largest fishery occurring in the Holitna River (Chythlook 2006). Between 2003 and 2005, estimated sport harvest of sheefish within the Kuskokwim River drainage has varied

from 45 in 2003, 156 in 2004 to 997 in 2005. Sport harvest estimates in the Holitna River drainage were 15 in 2003, 156 in 2004, and 349 in 2005; approximately 33% to 100% of the total estimated sport harvest within the entire Kuskokwim River drainage (Jennings 2006, 2007, *in prep*.).

This three-year study was initiated to extend our understanding of sheefish in the Kuskokwim River drainage. Management of the Kuskokwim sheefish population for long-term sustainability requires a greater understanding of their life history. The study will be conducted over 3 years (2007-2009) and will focus on identifying spawning aggregations (stocks). Secondarily, the study will provide information on migration timing and seasonal distribution of sheefish in the Kuskokwim River. Information gathered can be used to design future studies to investigate the population dynamics of specific spawning stocks, stock abundance, and stock compositions of harvests. Due to the migratory nature of sheefish, this study will encompass virtually the entire drainage of the Kuskokwim River (Figure 1).

Alt (1987) documented only two likely spawning areas within the Kuskokwim River drainage; the first located in the lower 200 m of Highpower Creek near Telida, and the second located in a 3-km section of the Lower Big River northwest of Lone Mountain at approximately 64-67 rkm (Figure 1). Although Alt did not actually observe fish spawning in these areas because the water was too turbid, the fish he collected and examined during late September/early October (the likely spawning period) were freely running milt and eggs could be expressed with little pressure. He had to suspend sampling due to river ice and was therefore unable to determine the post-spawning timing of downriver migrations to overwintering locations.

The focus for the 2007 tagging effort was on sheefish in the upper portion of the Kuskokwim River drainage (Figure 2). The main purpose for the first year of the project was to document spawning locations in the upper portion of the drainage (Takotna River drainage and all waters upstream). Based on Alt's previous work in this river, and feasibility work conducted by the Alaska Department of Fish and Game (ADF&G) in 2004, it was assumed that most of the fish passing through this area at the time of sampling would be mature and would spawn that fall in the upper portion of the drainage (John Burr, Sport Fish Division, Fairbanks, Personal Communication).

OBJECTIVES

The main objective of this study in 2007 was to document spawning stocks and spawning locations of sheefish in the Upper Kuskokwim River drainage.

Secondary objectives of the project were to:

1. determine the migratory timing of mature sheefish to their spawning areas and post-spawning migratory timing out of these areas to their overwintering areas; and,
2. collect tissue samples from all radio-tagged sheefish for future genetic stock identification analysis.

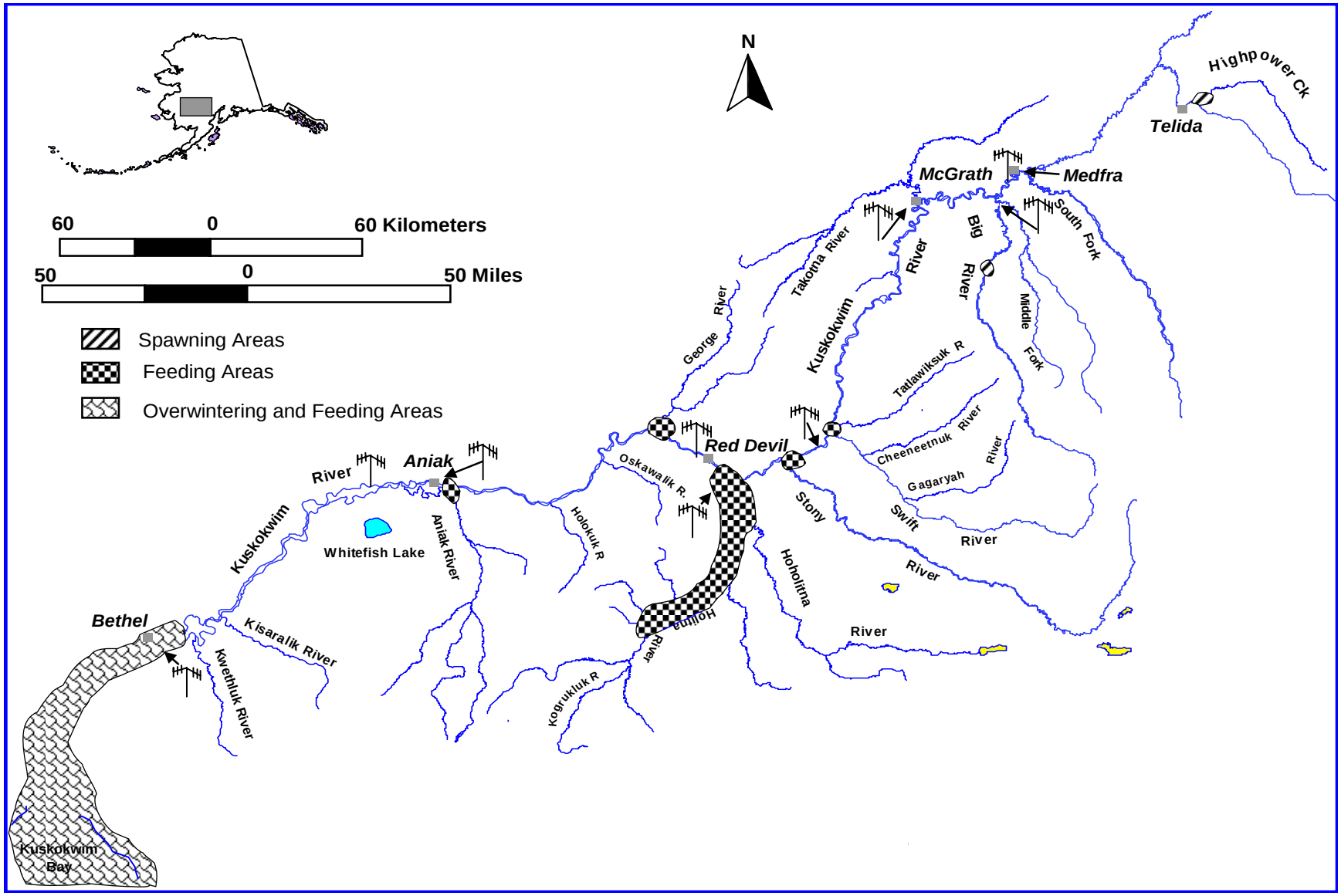

Figure 1.–Map of the Kuskokwim River showing approximate overwintering, feeding, and spawning locations for sheefish that were recorded by Alt (1987). Map includes the locations of stationary tracking stations that recorded the radio-tagged fish in 2007.

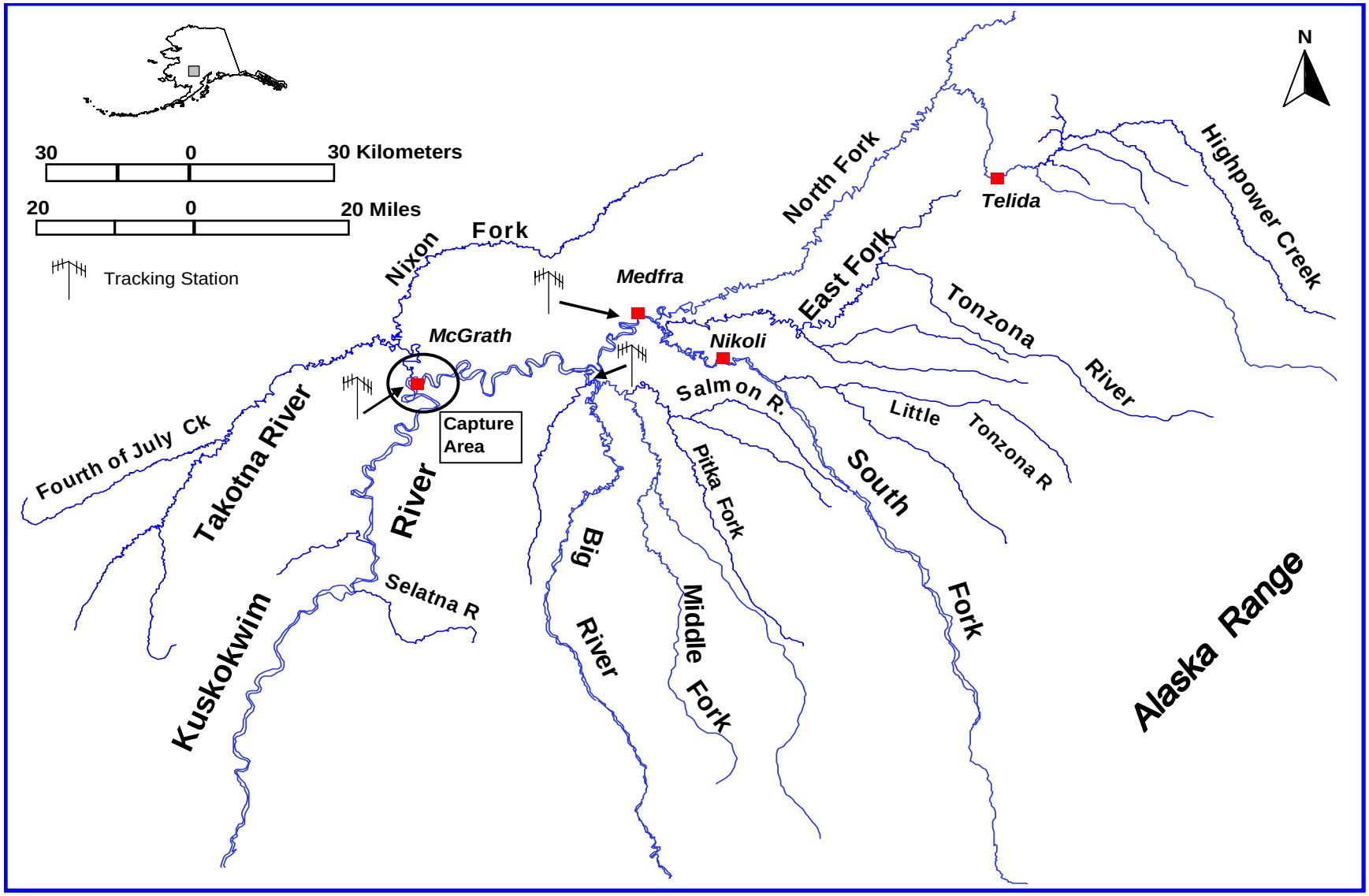

Figure 2.–Upper Kuskokwim River drainage showing capture area, stationary tracking station locations, and approximate area where the September and October aerial surveys were conducted for 2007.

METHODS

During 2007, the main tasks were to capture and mark sheefish in spawning condition and track them to upriver spawning areas. Capture and tagging took place mainly within the vicinity of McGrath and a few miles downriver (Figure 2). A series of 9 stationary tracking stations, owned and operated by the United States Fish and Wildlife Service (USFWS) and located between Bethel and Medfra on the Kuskokwim River, were used to track movements of the radio-tagged sheefish. In late September and early October, aerial flights were conducted in the Upper Kuskokwim River in an attempt to locate the radio-tagged sheefish and to garner insight into probable spawning areas.

The initial plan was to capture enough mature sheefish evenly over a 20-day period to surgically implant 30 radio transmitters. Internally implanted radio transmitters were used, as results from previous studies showed that this style of transmitter was less likely to adversely influence normal behavior than externally attached transmitters (Fleming 1996; Brown 2000). Nine transmitters were deployed between August 14 and September 6.

A sheefish that moves upstream after tagging was presumed to be on a spawning area based on one or more of the following criteria: 1) it was located during the likely time of spawning; 2) it was located in habitat consistent with spawning areas described by observations from past research; 3) it was located in close proximity to one or more other radio-tagged sheefish; or, 4) it was located among a large aggregation of fish sighted from the air.

This three-year study is performed in cooperation with the Tanana Chiefs Council (TCC) and the Kuskokwim Native Association (KNA). Local resident(s) were/will be hired to assist with fishing and tagging operations. The local hire experience is intended to teach new skills, expose the individual to the field of fisheries biology, and encourage local participation in fisheries research projects. This study is also intended to be a cooperative project with the OSM-funded Project No. 06-303, by the USFWS, telemetry of humpback and broad whitefish in the lower Kuskokwim River. This sheefish study utilizes the USFWS stationary tracking stations, mentioned above, and the two projects share aerial survey costs.

CAPTURE AND TAGGING

A crew consisting of two ADF&G technicians and the project biologist captured and tagged sheefish during 14 August-6 September 2007. From 14-31 August, the crew fished primarily at the mouth of the Katlitna River, located approximately 36 rkm downriver from McGrath; at the mouth of the Takotna River, located directly across from McGrath; and at the mouth of Nixon Fork, at 23 rkm of the Takotna River. The crew also fished for two days at the mouth of Grayling Creek, located at 43 rkm upriver from McGrath. Following a poorer than expected catches during August, the crew captured and tagged fish at the mouth of the Big River 2 and 3 September in an attempt to deploy more tags.

The sheefish were captured primarily with hook and line. The lures used had single, barbless hooks in order to minimize injury. Fish were retrieved into the boat with a rubber landing net designed to minimize damage to fish during catch-and-release. The crew also set gillnets with 6-

inch or less mesh sizes, as an additional means of capture. All attempts were made to inflict the least amount of stress and injury to each captured fish. Fish that showed signs of stress and/or injury due to capture (bleeding from hooks, ripped fins, lethargy, etc.) were released without receiving a radio tag. Radio tags were implanted into sheefish with lengths greater than 750 mm FL, as fish of this size were more likely to be mature (Brown 2000, Taube and Wuttig 1998). Sheefish less than 750 mm FL were released. After being anesthetized, each sheefish was measured to the nearest mm FL. Gender was noted if eggs or testes were clearly evident.

Each anesthetized sheefish was placed in a restraining cradle. A 15-mm incision was made anterior to the pelvic girdle, along the left ventral side, about 10 mm from the center line. A grooved director was then placed into the coelomic cavity and directed towards the rear where it directed a needle (16G horse catheter) inserted from the posterior of the pelvic girdle towards the incision in the anterior (Brown et al. 2002). The transmitter antenna wire was then routed from the incision past the pelvic girdle by threading the wire through the needle. Upon exit, the needle and grooved director were then removed and the radio tag fully inserted into the coelomic cavity. The incision was sutured with 3–4 simple, interrupted stitches of monofilament suture material (Wagner et al. 2000), and treated with an adhesive (vet bond™). On completion of surgery, the fish was placed into a tub of fresh river water to recover. The fish was released back into the river once it regained equilibrium and maintained an upright position.

A small pelvic fin clip was collected from each radio-tagged sheefish. Each tissue sample was cleaned and immediately placed in an individually labeled vial filled with 100% ethanol. Care was taken to make sure that the fin was approximately 50% or less of the vial length (Bill Templin, Commercial Fisheries Division Geneticist, ADF&G, Anchorage; personal communication). Later the vials were stored in a cool, dark place. In the future, the samples can be added to future collections and used to establish a genetic baseline for sheefish from the Kuskokwim River and allow for identification of different stocks, which will aid in future conservation and management efforts.

RADIO-TRACKING EQUIPMENT AND TRACKING PROCEDURES

Internally implanted radio transmitters are 3V Micro Coded Fish Transmitters, 1.5 cm in diameter, 7 cm long, with a wire whip antenna about 43 cm long (Lotek[1] model MCFT-3L), and programmed with a 3 s burst rate. The transmitters have been programmed to operate for 7.5 months and then shut off for 4.5 months in order to guarantee the tags will last at least three years. Each radio tag is distinguishable by a unique frequency and encoded pulse pattern. For 2007, all tags were programmed with one frequency in the 149.200 MHz range with 30 encoded pulse patterns for a total of 30 uniquely identifiable tags.

The stationary tracking stations recorded the time and date of movement of the radio-tagged sheefish, post-spawning outmigration to overwintering areas, and will record early spring migration upriver in 2008 and 2009. The stationary tacking stations are operated similar to that described by Eiler et al. (2004). Each station consists of a Lotek SRX_400 receiver powered by two, 12 V deep cycle batteries or a series of 6 V batteries charged with a solar array. The

[1] Loteck Wireless, Inc., Ontario, Canada.

components are housed in a water-resistant steel box covered with a fitted rain-proof tarp. Two 4-element Yagi antennas are used to receive the radio signals from the fish. Each antenna is mounted on a mast elevated 2-10 m above the ground depending on the elevation of the site above the river with one antenna aimed upstream and the other downstream. The receivers are programmed to scan through the frequencies at 6 s intervals, and receive from both antennas simultaneously. When a signal of sufficient strength is encountered, the receiver pauses for 6 s on each antenna, and then tag frequency, tag code, signal strength, date, time, and antenna number are recorded on the data logger. The relatively short cycle period helps minimize the chance that a radio-tagged fish would swim past the receiver site without being detected.

The USFWS and KNA personnel set up most of the 9 stationary tracking stations in mid-April of 2007. Upriver, one tracking station is located near McGrath, another near Medfra, and one was placed on the Middle Fork of the Kuskokwim River at the mouth of Blackwater Creek a few bends below the confluence with the Big River (Figures 1 and 2). In addition, a tracking station is located on the mainstem of the Kuskokwim River at Sinka's Landing, which is located just downriver from the mouths of the Swift and Tatlawiksuk rivers. Other mainstem tracking stations are located just downriver from Red Devil, just upriver from Aniak, and across from Bethel. A tracking station is also located a few kilometers upriver on the Holitna River. Lastly, a tracking station is located at the entrance to Whitefish Lake (Figure 1). All 9 tracking stations were programmed with the one sheefish frequency prior to tagging efforts in August. It was expected that the tracking stations would operate until late October, and possibly until late November. Given that spawning activities are concluded by late October, it was anticipated that the tracking stations would operate long enough to detect outmigrating sheefish before the cold and dark of winter drains their batteries and/or the radio tags switch off for the winter.

In addition to the stationary tracking stations, radio-tagged sheefish were located by aerial-tracking from small aircraft on 27 September and 8 October 2007. The USFWS also conducted an aerial survey during 15-18 October throughout the Kuskokwim River drainage and located several tagged sheefish. Tracking excursions were conducted with one aircraft, one person (in addition to the pilot), and utilized one Lotek SRX_600 receiver/scanner and a Lotek SRX 400 receiver/scanner that was passively scanning and recording without the project biologist/pilot listening. For the "active" receiver, whenever a fish was detected, the pilot was instructed to circle in order to ensure the fish and GPS coordinates were exactly recorded. All frequencies (including those from the USFWS whitefish study) were loaded into the receiver prior to each flight. Flight altitude ranged from 100-300 m above ground. Two H-antennas, one on each wing strut, were mounted such that the antennas received signals perpendicular to the direction of travel. During each survey, the fish were tracked along the mainstem Kuskokwim River downriver from the capture site, upstream past McGrath, and covered the upper drainage.

RESULTS

In 2007, 9 sheefish were implanted with radio transmitters. Six sheefish were captured with hook and line and 3 with a gillnet. Four sheefish were captured and tagged at the mouth of the Katlitna River, 1 at the mouth of the Takotna River, 1 at the mouth of Nixon Fork, and 3 near the mouth of Big River (Table 1). Of the tagged fish, 3 were indentified as gravid females, 1 as a gravid male, and the gender designation of the remaining 5 was uncertain. For the 4 sheefish where gender was positively identified, testes or eggs were easily seen through the incision. The body cavities of the three females were swollen with eggs.

Seven of the 9 radio-tagged sheefish were judged to have survived tagging and handling (Table 1). The 2 fish presumed to have died either did not move from their tagging location between the tagging dates and the dates of the three fall aerial surveys, or were not detected by any of the downriver stationary tracking stations. The 1 fish captured and tagged at the mouth of Nixon Fork initially was assumed to have died, because it had not moved between the date of tagging and the 8 October aerial survey. In addition, during the aerial surveys, the tag signal was loud enough to make us suspicious that the fish was out of water. However, during the mid-October flight conducted by USFWS personnel, this fish was located below McGrath and it eventually travelled past the tracking station near Bethel on 5 November 2007.

With the exception of 1 fish located in a previously described spawning area in the Big River, no other spawning areas were documented with certainty. This fish, a gravid female, was tagged near the mouth of the Big River, travelled downriver for 14 days, then swam up the Big River and was located below Lone Mountain within the 3 km section of this drainage (55 rkm from the mouth), noted as a probable spawning area by Alt (1987). The second fish tagged at this location, also a gravid female, travelled past the tracking station located a few bends downriver near the mouth of Blackwater Creek approximately 3 days after release. She then travelled past this station on her way back upriver 1 day later, then downriver approximately 6 days later, and was last detected near McGrath during the 8 October aerial survey. This fish may also have spawned in the area described by Alt (1987), but was never located there.

The post-tagging travel distances that were recorded during the three aerial surveys by the surviving sheefish varied (Appendix A), but only the one described above appeared to be a directed movement toward a spawning area. The 4 sheefish that were captured and tagged near the mouth of the Katlitna River were all relocated within a few hundred meters from the tagging site during the aerial tracking surveys, and all were detected by the stationary tracking station near Bethel during late October and early November. One of these fish was a gravid female; however, it is not certain whether she spawned in that area. During the late September and early October aerial surveys in the Big River, the project biologist attempted to fly close to where fish were detected in hopes of seeing other spawning fish, but was unable to fly close enough to make these observations on both occasions due to wind. Even though the river did appear to get clearer by early October, no sheefish were detected, mainly due to flying altitude. Unlike salmon, sheefish, with their grayish coloring, tend to “blend in” better with the river and stream substrates.

During the 27 September and 8 October aerial surveys, most of the fish that had survived tagging and handling were detected either near or upriver of where they had been tagged; however, during the USFWS aerial survey the following week, most of these fish were observed travelling

Table 1.-Tagging date, location, gear type, length, gender, and fall aerial survey locations for the 9 sheefish that were captured and tagged in the Upper Kuskokwim River, 2007.

						Location of ADFG and USFWS fall aerial surveys			Date/Time Detected at Tracking Station near Bethel	
Sheefish Code	**Tagging Date/Time**	**Tagging Location**	**Capture Gear**	**Length (mm)**	**Gender**	**27 Sept**	**8 October**	**USFWS Location and Date**		**Comments**
37	8/18 16:55	Takotna River mouth	Gillnet	730	Unknown	Takotna River mouth	Takotna River mouth	--	--	Presumed dead
36	8/25 15:37	Katlitna River mouth	H&L	700	Male	above Katlitna R.	below Katlitna R.	--	11/8/2007 0:29	--
34	8/28 15:11	Nixon Fork mouth	H&L	720	Unknown	Nixon Fork mouth	Nixon Fork mouth	below McGrath (10/18)	11/5/2007 9:06	Initially presumed dead, but moved downriver
35	8/29 11:12	Katlitna River mouth	H&L	710	Unknown	near mouth Katlitna R.	downriver of Katlitna R.	--	11/1/2007 19:26	--
38	8/30 9:53	Katlitna River mouth	H&L	785	Unknown	up Katlitna R 2+ miles	--	near Kalskag, old channel (10/16)	10/21/2007 4:20	--
39	9/2 13:52	Blackwater Ck mouth	H&L	735	Unknown	few bends upstream in Blackwater Ck	few bends upstream in Blackwater Ck	Blackwater Ck (10/19)	--	Presumed dead
40	9/2 16:56	Middle Fk/Big River mouth	Gillnet	820	Female	Kuskokwim R. above McGrath	Kuskokwim R. above McGrath	--	--	--
31	9/2 17:20	Middle Fk/Big River mouth	Gillnet	755	Female	Big River	Big River below Lone Mtn.	near mouth Middle Fk Kuskokwim R. (10/19)	--	Located in previously described spawning area
32	9/4 10:37	Katlitna River mouth	H&L	810	Female	--	--	below Tulusak (10/15)	10/19/2007 6:24	--

downriver (Table 1), including the gravid female that had travelled up to the 3-km assumed spawning area (Alt 1987). Between 19 October and 8 November, five of the radio-tagged sheefish were recorded by the stationary tracking station located near Bethel. Therefore, these fish travelled approximately 600 and 650 rkm (370 to 400 miles) in approximately 1 to 2 weeks.

DISCUSSION

Despite a month of fishing effort, the crew was unable to capture enough sheefish to reach the goal of deploying 30 radio transmitters in 2007. Unusually high water in August was one of the factors that hampered fishing success. Additionally, the abundance of sheefish was thought to be less than in 2004 when feasibility work was conducted. For example, in addition to the crew's sampling efforts, sampling was also conducted by ADF&G during August 2007 as part of the Alaska Freshwater Fish Inventory program, and their crews did not observe or capture sheefish in any appreciable numbers. Crews in this study floated and surveyed most of the Kuskokwim River tributaries between the Stony River and the South Fork of the Kuskokwim River. Fish were observed and collected using electrofishing techniques during the float trips. Two juvenile sheefish were observed on August 14 at the mouth of the Nunsatuk River (420 and 620-mm fork length); 1 adult sheefish was observed on August 22 in the Lower Big River approximately 35 to 40 rkm below the spawning area documented by Alt (1987); and, on August 24, eleven sheefish were observed at the mouth of Windy Fork, and 4 were likely spawners (630-752 mm FL; Joe Buckwalter, Habitat Biologist, Alaska Department of Fish and Game Sport Fish Division, Personal Communication).

Two of the 9 sheefish captured and tagged were assumed to have died because they did not move from their tagging locations. The remaining 7 tagged fish moved varying distances between tagging and the fall aerial surveys (Appendix A). Underwood (2000) noticed that radio-tagged sheefish in the Selawik River in a 1993-1996 study moved short distances every few days. However, during 1995 he noticed some fish stayed in very close proximity to the tagging areas for up to 1 month after tagging. These fish, similar to the one in this study that was tagged at the mouth of Nixon Fork, were initially assumed to be dead, but eventually made long movements verifying that they were alive. Therefore, we will not be certain that the two fish in this study that did not move between tagging and October aerial flights are dead until after the aerial survey flights in summer 2008 are conducted.

Of the 7 surviving sheefish, only one was thought to be located on a known or suspected spawning area. This was a gravid female that was located within the 3km section where Alt (1987) had previously identified as a probable spawning area. The remaining fish did not move significantly after tagging and, therefore, assumed that they did not spawn in 2007. The three gravid females that were captured and tagged appeared to have recovered from the surgeries; however a probable spawning location was only documented for one of the three. The female that was captured at the mouth of the Katlitna River was not detected in either Big River or Highpower Creek (the two known spawning areas in the upper drainage). Sheefish generally migrate within the vicinity of their spawning grounds 1-2 months before spawning takes place (Howland *et al*. 2000). Similar to other Arctic whitefish species, sexual maturation in sheefish takes place during upstream migration (Dodson et al. (1985), and the warmer water temperatures

within a tributary may be necessary for gonadal development completion (Hokanson *et al*. 1973). Because sheefish are broadcast spawners, it can be assumed that spawning should take place in a small area within a short time frame. Alt (1987) assumed that spawning may occur sometime during late September/early October. The female located in the previously described spawning area left in mid-September, a few weeks earlier than when actual spawning would be assumed to take place, it remains unknown whether or not she spawned. Winter (1996) cautioned that gravid female fish are not ideal candidates for surgically implanted transmitters due to the lengthy recovery period before their behavior returns to normal. Despite difficulty in tagging gravid females, the three females appear to have survived their ordeal; however, the amount of time needed for full recovery from the surgeries was unknown and any effect this may have had on spawning success was unknown.

The late fall migration of sheefish from the upper portion of the Kuskokwim River drainage to their lower river overwintering areas occurred between mid-October and early November. Similarly, Tallman *et al*. (1996) observed that post-spawning, downstream migration of radio-tagged sheefish in the Slave River of Canada occurred between October 15 and 30. Howland *et al*. (2000) observed that the postspawning run out of the Arctic Red River in Canada was fairly synchronous and abrupt, lasting 1-2 weeks, with the majority having moved downriver by October 15. Likewise, Underwood (2000) noted that post-spawning migration on the Selawik River occurred between September 27 and October 19, with the peak on October 14.

None of the radio-tagged sheefish were detected by the tracking station located at Medfra. Thus, no tagged fish were documented travelling up Highpower Creek, the other previously described spawning area within the Kuskokwim River drainage. A greater sample size is needed to allow for a higher percentage of sheefish to be observed migrating to this and other potential spawning areas.

CONCLUSIONS

Although the sample size objective was not achieved in 2007, some information was gleaned from the 7 radio-tagged sheefish that survived tagging and handling. Locating the one female in the 3-km section below Lone Mountain on Big River added credence to Alt's (1987) assumption of this as a sheefish spawning area. Also, timing of movement of this fish to its probable spawning area was similar to what Howland *et al*. (2000), Tallman *et al*. (1996), Brown (2000), and Underwood (2000) have noted. In addition, the timing of downriver migration occurred fairly consistently in mid-October, similar to what the aforementioned authors also noted.

This project is on-going and the movements of the 7 sheefish that survived tagging and handling will be followed in the summer and fall of 2008 and 2009. Data from the stationary tracking stations were not downloaded in mid-October 2007 due to the inception of river ice, although the data from the station near Bethel were downloaded in mid-February 2008. Data from the remaining stationary tracking stations will be downloaded in April and May 2008. These data may give further insight into fall migration timing of these fish to their overwintering areas.

PROJECT RECOMMENDATIONS FOR 2008

Below are project recommendations for 2008:

- Concentrate tagging efforts lower in the drainage (between Bethel and Stony River) and earlier in the summer (late May to early July) to ensure all remaining radio tags are deployed and to guard against potential negative affects of tagging gravid fish.
- During the aerial surveys in late September and early October in the Big River attempt to fly low over the purported 3km sheefish spawning area reported by Alt (1987) to visually account for, and possibly count, congregating sheefish. This procedure will also be attempted at all potential spawning areas.
- Deploy a temperature data logger within the 3-km sheefish spawning area in the Big River during the late June aerial survey, and collect it during the October aerial survey for comparison with temperature data collected from past work in both this river and other northern systems.

ACKNOWLEDGEMENTS

The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $201,013 in funding support in 2006 for the duration of this project through the Fisheries Resource Monitoring Program, under agreement number 701816J637 for Project 06-305 . ADF&G personnel that assisted with field sampling and field camp maintenance included Loren St. Amand, Virgil Davis, and Heather Scannell. Dan Reed provided biometric support. Matt Evenson, Klaus Wuttig, and John Chythlook worked up the original investigation plan and assisted with the project planning and implementation. Rachael Kvapil prepared the final report. Ken Harper, Frank Harris (USFWS), and David Orabutt (KNA) included the frequencies from the radio-tagged sheefish in their aerial surveys and forwarded stationary tracking station data with these fish.

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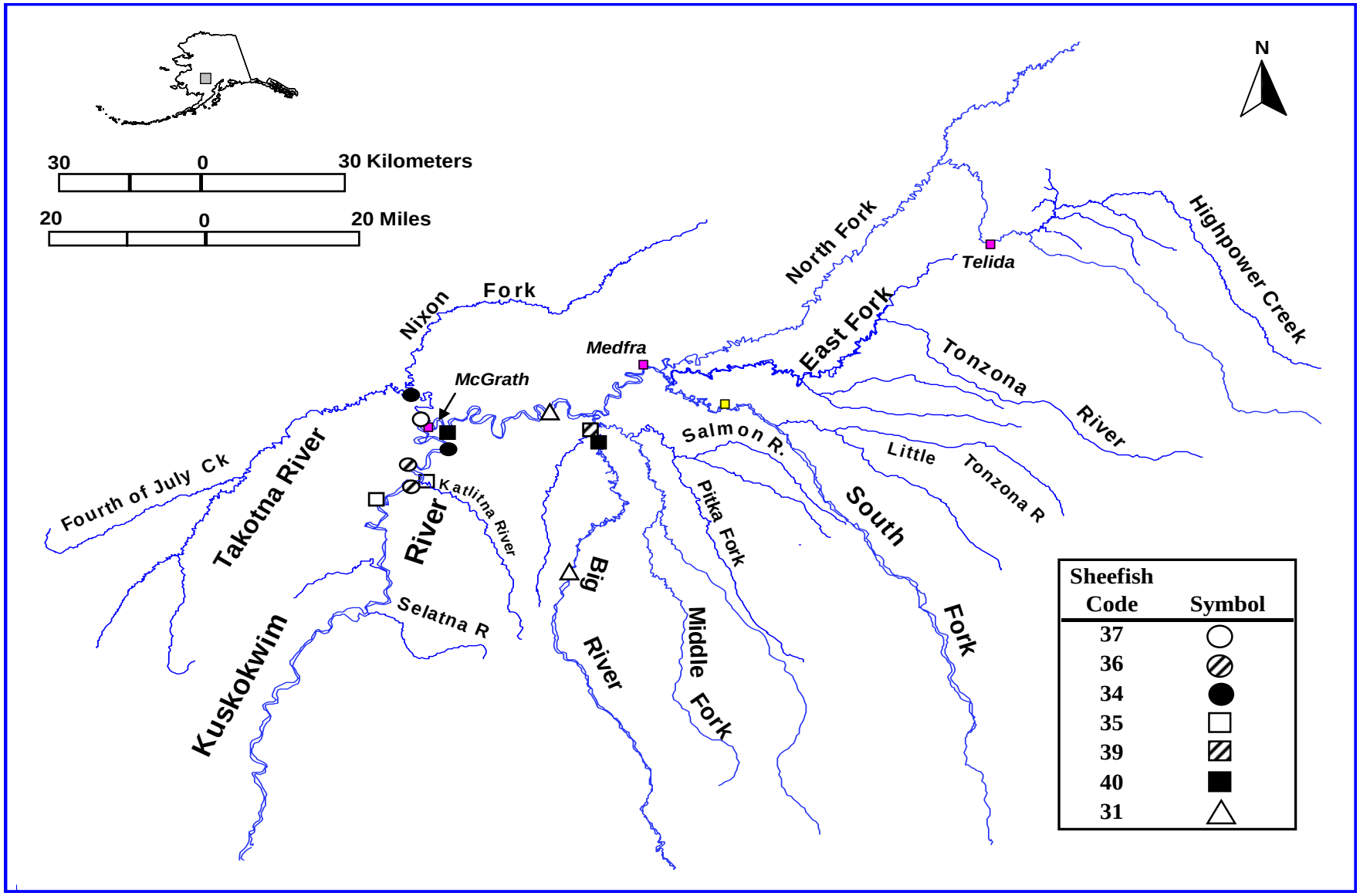
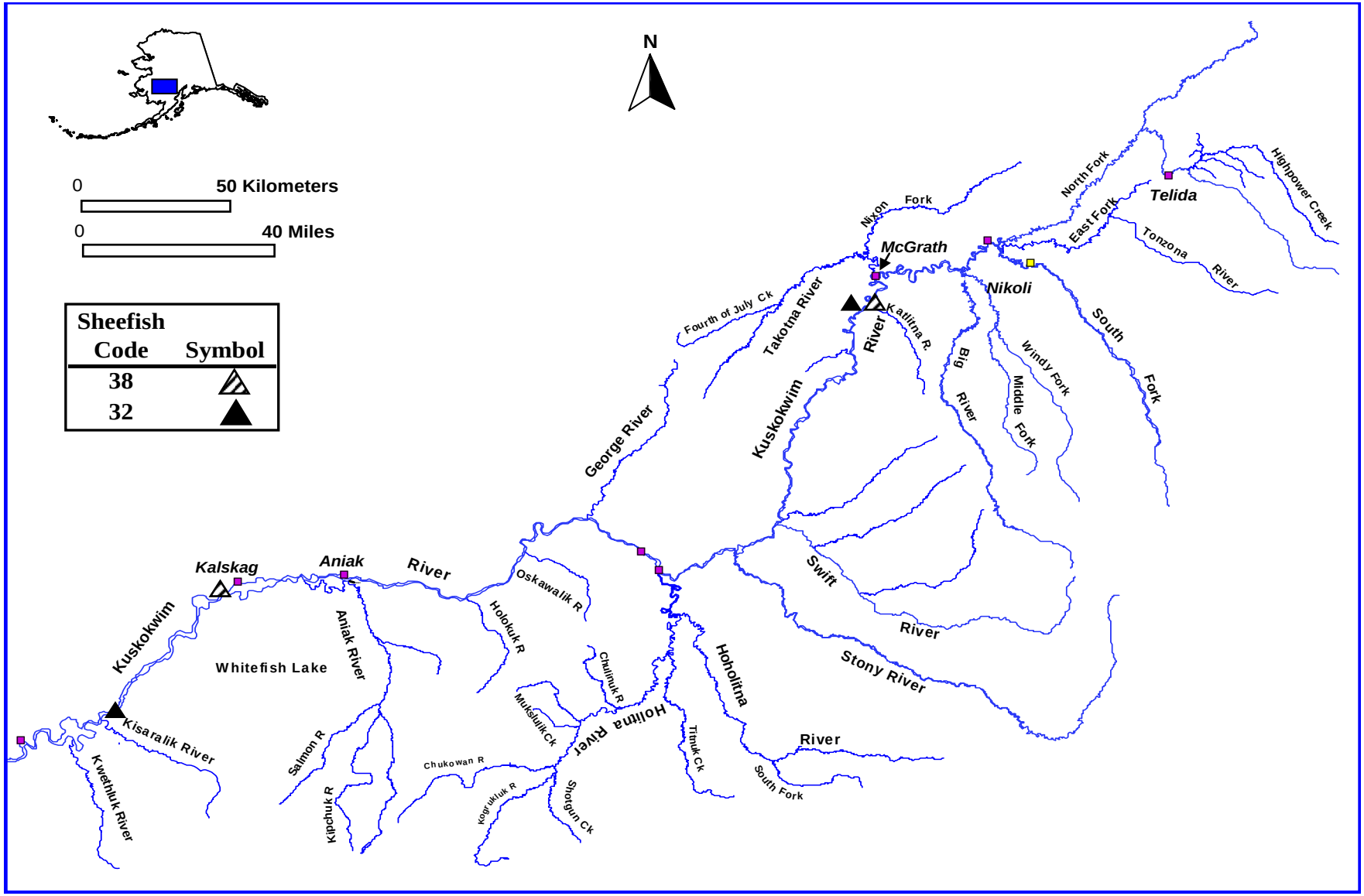
APPENDIX A

MAPS SHOWING APPROXIMATE UPRIVER AND DOWNRIVER MOVEMENTS OF RADIO-TAGGED SHEEFISH THAT WERE LOCATED DURING THE FALL AERIAL SURVEYS IN 2007



Appendix A1.-Map showing the approximate upper and lowermost extents of sheefish that were captured and radio-tagged in the upper Kuskokwim River and located during the September-October 2007 aerial surveys.



Appendix A2.-Map showing the approximate upper and lowermost extents of sheefish that were captured and radio-tagged in the Kuskokwim River and located during the September-October 2007 aerial surveys.

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