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Migratory Behavior of Broad and Humpback Whitefish in the Kuskokwim River, 2006

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Ken Harper, Frank Harris, Steve J. Miller and David Orabutt

Abstract

Radio telemetry was used to monitor the seasonal migrations of broad whitefish *Coregonus nasus* and humpback whitefish *C. pidschian* in the Kuskokwim River drainage during 2006. Thirty-four broad and 39 humpback whitefish were surgically implanted with radio transmitters between June 12 and August 24, in the lower reaches of the Kuskokwim River. Surgeries were suspended June 24, due to high water temperatures and resumed August 13, after water temperatures cooled. Whitefish movements were monitored with fixed telemetry stations placed at key locations between 106 and 863 rkm and with aerial and boat surveys. Humpback whitefish migrated distances up to 680 rkm. One humpback whitefish was relocated at a possible spawning location in the Swift River. A broad whitefish implanted at ADF&G fish wheels, migrated approximately 543 rkm to a location between McGrath and Medfra, Alaska . Broad whitefish were tracked in the Kuskokwim River between McGrath and Medfra. Subsistence users returned the radio transmitters from three (9%) broad and one (2%) humpback whitefish implanted in 2006.

Introduction

Starting in 2001, an assessment of abundance, length at age and maturity, and migratory patterns of broad whitefish *Coregonus nasus*, humpback whitefish *C. pidschian* and least cisco *C. clupeaformi* in Whitefish Lake (Harper et al. 2007) was initiated through the use of a flexible picket weir, otolith microchemistry, and Floy® tags. Multi year returns of Floy® tagged whitefish indicated fidelity to Whitefish Lake. Otolith chemical analysis indicated broad and humpback whitefish sampled in Whitefish Lake are primarily amphidromous, spending time in brackish or marine waters before migrating up river to feeding and spawning areas. Extensive migrations were indicated through the return of Floy® tagged whitefish harvested by subsistence fishers between the villages of Tuluksak and Medfra, Alaska, a distance of 671 river kilometers (rkm) (Harper et al. 2007). Radio telemetry began in 2004 in an effort to identify migratory patterns and to locate spawning grounds and summer feeding areas. In 2006, the study's focus was narrowed to broad and humpback whitefish.

Broad and humpback whitefish are considered very important non-salmon subsistence species in the lower Kuskokwim River (Baxter, Alaska Department of Fish and Game (ADF&G), unpublished data) and contribute substantially to overall subsistence fish harvests in the drainage. Fishers harvest whitefish throughout the year, utilizing gill nets under the ice during the winter and in open water during the spring, summer, and fall, or by jigging using rod and reel, or stick. Some spearing occurs through the ice in the early winter in Ophir Creek, a tributary of Whitefish Lake. Baxter noted that broad whitefish were considered the most desirable by subsistence users because they had fewer parasites and had a superior flesh. Baxter also reported that the majority of the broad whitefish entering the commercial markets between 1967 and 1970 were taken as bycatch during the August commercial coho salmon

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(*Oncorhynchus kitsuch*) fishery. The ADF&G area management biologist noted in the 1983 annual management report that only a few commercial permits to harvest whitefish had been issued and commercial fishers primarily targeted broad whitefish (Jonrowe et al. 1984). Jonrowe (1984) also noted that the majority of the commercial whitefish catch was taken incidentally in the lower Kuskokwim River during the fall coho salmon fishery.

Despite a heavy dependency of the subsistence users on whitefish and the issuance of commercial fishery permits these species have received little research attention over the past 30 years. Fisheries enumeration projects and annual subsistence harvest surveys have primarily focused on salmon (Ward et al. 2003). Harvest surveys conducted in the village of Akiachak in 1998 (Coffing, ADF&G personal communications) showed that of the total number of non-salmon harvested; blackfish *Dallia pectoralis* constituted 27.0%, whitefish 24% (broad whitefish 12.8%, and humpback whitefish 11.1%), burbot *Lota lota* 17.8%, northern pike *Esox lucius* 15.2%, smelt *Osmerus mordax* 11.3% and inconnu *Stenodus leucichthys* 1.0%. In another subsistence harvest study residents of Kwethluk harvested an estimated 164,501 kg of fish, comprised of 101,903 kg of salmon and 62,598 kg of freshwater fish of which 13,535 kg were whitefish (Coffing 1991). During times of reduced salmon abundance (e.g. 1999-2002), non-salmon species may be an even more important subsistence resource throughout the Kuskokwim drainage.

Regulations, as a management tool, have dealt mainly with prohibiting commercial fishing for whitefish in specific rivers or smaller drainages. For example, the State of Alaska's commercial fishing regulations (5 AAC 39.780), implemented in the 1970s for the Kuskokwim drainage, prohibit commercial fishing for whitefish and northern pike in Whitefish Lake and Johnson River, a tributary to the Kuskokwim River. Over exploitation was mentioned as the probable cause of decreased numbers of whitefish in these systems (Baxter, ADF&G, unpublished data). In 1983 regulations limited commercial nets to 12.7 cm stretched mesh and larger to protect the younger faster growing ages that had possibly spawned once. Jonrowe (1984) also noted at that time there were no indications of declining whitefish populations. In 1992, time and gear regulations were implemented on Whitefish Lake after concerns were expressed by local subsistence users from Aniak and Kalskag, Alaska. These subsistence users expressed concern over the decline in size and numbers of broad whitefish in Whitefish Lake and pointed to previous times when large numbers of whitefish were removed from there and possibly taken to commercial markets in Bethel. Surveys of Whitefish Lake between 2001 and 2003 indicated only a small population of broad whitefish utilized the lake as a feeding area (Harper et al. 2007).

Broad and humpback whitefish exhibit similar life history traits and different life history types. Both species enter freshwater tundra ponds and lakes in early spring after oxygen increases to tolerable levels as amphidromous, lacustrine, or riverine types (Reist 1997, Harper et al. 2007) and feed during the spring and summer before migrating to spawning areas (Alt 1979, Baxter, ADF&G, unpublished data, Brown 2006, Harper et al. 2007). Brown (2006) also showed that humpback whitefish taken from the Tanana River drainage, Alaska, were nonamphidromous. Chemical analysis of otoliths from whitefish sampled from Whitefish Lake indicated two types; amphidromous, and a group that reared in freshwater Harper et al. (2007). This later type is thought to spawn in Ophir Creek, a tributary to Whitefish Lake with some juveniles rearing in the lake. Brown (2004) found similar characteristics in Selawik River whitefish. Similar traits also exist in the Mackenzie River, where whitefish feed and rear in fresh water lakes and over-winter in brackish coastal waters until they are sexually mature around 8 years of age (Bond and Erickson 1985). Morrow (1980) reported maturity occurs between 4 and 8 years. Mature whitefish in some northern populations may not be consecutive year spawners (Bond and Erikson, 1985, 1993). Mature males generally leave the tundra lakes first, followed by mature females, and migrate upstream to river sections or tributaries with shallow, fast flowing waters and clean gravel to spawn (Chang-Kue and Jessop 1997, Brown 2006). Broad and humpback whitefish are fall spawners and broadcast eggs that settle into the gravel interstices. The eggs develop under the ice and, in the spring, fry wash downstream during flooding and opportunistically move into feeding and rearing habitats. Immature and mature fish are sometimes found in different lakes, as well as the same lake. For instance, lakes on the Tuktoyaktuk Peninsula on the Beaufort Sea, Canada, contained a larger portion of immature rearing whitefish than adults (Chang Kue and Jessop 1992).

Juvenile whitefish rearing areas in the Kuskokwim River are unknown and the few documented whitefish spawning areas are limited to the upper river (Alt 1972). Alt (1972) located spawning inconnu, least cisco, round whitefish *Prosopium cylindracium*, and broad and humpback whitefish in Highpower Creek, a headwater tributary of the North Fork of the Kuskokwim River near Telida, Alaska. In Big River, a tributary of the Kuskokwim River near McGrath, only spawning inconnu and humpback whitefish were found by Alt (1972).

Addressing local community concerns about declines in abundance and a decrease in size of broad whitefish and possibly humpback whitefish requires additional research. Spawning, over wintering, and juvenile rearing areas need to be identified, as well as stock specific run timing and migration patterns. Knowledge of important rearing, feeding and spawning habitats, and seasonal and annual movement patterns is required before harvest implications can be identified with any confidence. Only after an understanding of whitefish biology in the Kuskokwim River drainage is gained can an assessment and status of each species be made and management actions taken to address local concerns and prevent future problems. The specific objectives of this study were to:

1. Locate spawning aggregates of humpback and broad whitefish.
2. Determine migratory timing to spawning, over wintering, and feeding areas of mature broad and humpback whitefish.
3. Map at least one spawning area (aggregates of one species identified in objective 1) by determining the reach of river for which 90% of the spawning occurs for that aggregate of fish.
4. Estimate the youngest age and age of full recruitment to a spawning population identified for one species in objective 1.
5. Estimate the size at which all fish are mature.
6. Determine multiple year PIT tag retention and efficiency of the PIT tag receiver and antenna system at the outlet of Whitefish Lake.
7. Conduct spawning ground surveys to evaluate physical river conditions and habitat for the possible use of a PIT tag interrogator system on a spawning area identified in objective 1.

Study Area

The Kuskokwim River is the second largest drainage in Alaska. The glacially turbid mainstem originates in the Kuskokwim Mountains and the Alaska Range on the northwest side of Mt. McKinley and courses approximately 1,498 rkm in a southwest direction to the Bering Sea. The lower Kuskokwim River flows through a complex area of interconnected tundra lakes, sloughs, and oxbows. Large portions of this lowland delta area are less than 5 meters in elevation with substantial areas less than one meter above sea level. The Kialik River (rkm 50) is a tributary southwest of Bethel (rkm 106) on the lower Kuskokwim River. The majority of the river is below 1 meter in elevation and is tidally influenced for extended distances inland. Lakes in the Kialik River drainage are 5-100 ha in size, connected to the main Kialik River with numerous small tributaries, and interspersed in the low-lying tundra. High water during the spring melt swells the surface area of many tundra lakes. Caunaq Lake is a clear water, oxbow lake 5.9 km long by .3 km wide with a maximum depth of 9 meters, located near the confluence of Discovery Creek and the Kuskokwim River near the village of Kalskag at river km (rkm 263). Approximately 1/3 of the lake is covered with emergent aquatic vegetation. The ADF&G fish wheels are located at rkm 270 on the mainstem of the Kuskokwim River.

Methods

Capture Techniques

The Kialik River drainage, Caunaq Lake and ADF&G fish wheels were the focal areas for capturing whitefish in 2006. Whitefish were captured using gill nets, trap nets and fish wheels (Figure 1). Gill nets (10 cm stretch mesh) were set and fished for $\leq$ 30 minutes, and captured fish were cut from the netting to avoid loss of scales and physical injury. Merwin trap nets were used for live capture and set for varying time periods including overnight sets. Fish wheels were operated by ADF&G (Pawluk et al. 2006). Each fish wheel contained a live box where captured fish were deposited. Captured whitefish were removed from the live boxes and transported in water-filled totes to the surgery site.

Biological Data

A sample size of 45 was set for each of the targeted species in 2006. Each fish selected for a radio implant was measured and weighed. Length at sexual maturity from previous studies (Brown et al. 2002, Harper et al. 2007) was used to select the candidate fish for implants. Fish needed to be a minimum of 350 mm for humpback whitefish and 450 mm for broad whitefish. A fin clip was taken for genetic analysis and sent to the U.S. Fish and Wildlife Service (USFWS) Conservation Genetics Laboratory in Anchorage, Alaska. Fish were also tagged with a numbered Floy tag ® inscribed with a toll free number to call if the fish were captured and labeled with the phrase, “Study Fish Do Not Eat”. The first ray of the right pectoral fin was clipped as a secondary mark and collected for future age analysis.

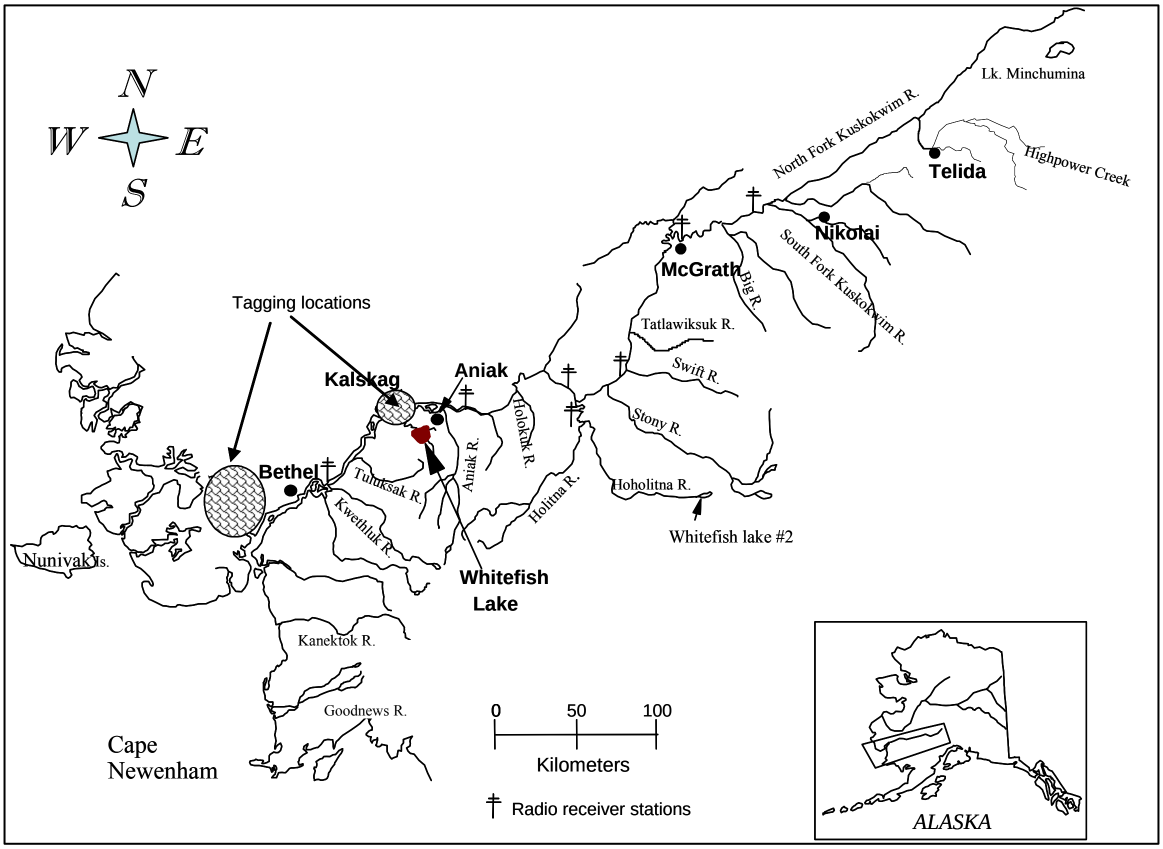

FIGURE 1.—Tagging and fixed receiver station locations in the Kuskokwim River drainage, Alaska, 2006.

Implanting Transmitters

Whitefish were anesthetized with a 40-mg/L solution of Aqui-s®. Sedated fish were placed ventral side up in a neoprene-lined cradle, and their gills were irrigated using a combination of anesthesia and oxygenated water during the procedure. A 2-3 cm incision, large enough to accommodate the transmitter (11 X 47 mm), was made anterior to the pelvic girdle approximately 1 cm from the mid-ventral axis. The transmitter antenna was routed under the pelvic girdle and through the body wall slightly off the mid-ventral axis and anterior to the vent using a hypodermic needle and grooved director (Brown et al. 2002). While the body cavity was open, a Texas Instruments ® 23mm passive integrated transponder (PIT) tag was inserted anterior to the radio tag. The incision was closed with three or four individual stitches of absorbable suture and Vetbond® adhesive. Surgical instruments and transmitters were soaked in a cold sterilant and rinsed in saline solution before each use. Surgeries ranged from 4-10 minutes. Each fish was released near the surgery site.

Radio transmitters used for tracking were programmable Grant Engineering Pices tags. Each tag provided a unique coded radio signal, allowing multiple transmitters on a single frequency. Battery life of each radio tag was maximized by unique programming. Tags were programmed to transmit May 1 to November 20, 2006, May 1 to July 1, 2007 and October 1 to November 20,

2007. Each radio transmitter was programmed to emit a radio signal every 3.5 seconds between 0800 and 1800 hours before switching to a signal every 16 seconds the remaining hours.

Radio Tracking Procedures

Whitefish movements were documented using a combination of fixed stations, aircraft, and boats. Receivers used for tracking were the SRX-400 receiver/data logger (Lotek Engineering Incorporated®). A portable GPS system was used to determine the latitude and longitude coordinates of each located fish.

Boat tracking was conducted using two antennas, one on each side of the boat facing 45º to the forward centerline of the boat. Aerial surveys during 2006 were conducted out of McGrath and Bethel, Alaska, using a Cessna 185 or 206 aircraft equipped with two 4-element Yagi antennas, mounted on the left and right struts of the aircraft. Surveys were flown from 400 to 600 meters above the ground. Fixed receiver stations were set up in purported migration corridors and consisted of a Lotek radio receiver powered with battery banks charged by solar panels and two elevated antennas facing up and down river to pick up transmission signals (Figures 1 and 2). Receivers were set up in early April 2006, and were removed or shut down after December.

In 2006 a solar powered single PIT tag recorder was operated at the outlet of Whitefish Lake at approximately rkm 263. The PIT tag recorder was first operated at the lake in 2005 to determine the feasibility of using PIT tag technology with whitefish (Harper and Harris 2006). Operations during 2006 recorded passage of fish, PIT tagged in 2005 and 2006, moving into or out of, Whitefish Lake, to confirm long term PIT tag retention. Data downloads were completed at this site on an opportunistic basis.

Tracking radio transmitters from boats or planes was done on an opportunistic basis and as close to a monthly schedule as possible. Weather often hampered set schedules for flying or traveling by boat. Fixed stations were downloaded monthly or as crews passed by them while tracking from water or air.

Data Analysis

Information collected with boat and aerial surveys and from fixed stations was integrated into one database that archived the dates and locations of each radio-tagged whitefish. Fish locations were assigned latitude and longitude coordinates for display on a background map using Arc-Map® software.

Results

Thirty-four broad whitefish and 39 humpback whitefish were radio tagged during 2006 (Table 1). All humpback whitefish were above the minimum size of maturity found at Whitefish Lake (350mm), although six of the 34 broad whitefish selected for implants were less than the minimal size of maturity (450mm) (Harper et al. 2007). The selection of fish less than 450 mm was due to the difficulty in capturing larger broad whitefish in the Kialik River drainage in June. Sex was not determined for the majority of the broad or humpback whitefish at the time of capture due to undeveloped gonads. Nine broad and 14 humpback whitefish were tagged in the Kialik River, between June 12 and 24. Difficulty in obtaining samples in the Kialik River, and the increase in water temperatures past the maximum set for surgeries (15°C), curtailed operations before all tags could be deployed that spring. Water temperatures cooled down in August and tagging operations were moved up river in an attempt to locate migrating whitefish. The ADF&G fish wheels near Kalskag were selected at that time due to reported whitefish catches. Seven humpback and four broad whitefish were tagged between August 13 and 15, the final days of the fish wheel operations. A search was initiated to obtain additional whitefish for radio transmitter implantation. Between August 17 and 24, an additional 21 broad whitefish and 18 humpback whitefish were captured in Caunaq Lake, using gill and trap nets, and implanted with radio tags (Table 1). Additional time was spent netting in the Gweek River (rkm 135) and several sloughs and small tundra lakes downstream of Bethel (rkm 106) between August 24 and September 5. This was done in an attempt to tag the remaining 11 broad and six humpback whitefish to reach the target sample size of 45 for each species. No whitefish were captured during this period due to high water conditions.

TABLE 1.—Comparison of length and weight distributions of broad and humpback whitefish from multiple samples sites on the lower Kuskokwim River, 2006 and from the Yukon River drainage (Brown 2002 and Fleming 1996).

			Length (mm)		Weight (kg)	
Humpback Whitefish	Dates	Sample (N)	Mean	Range	Mean	Range
Kialik River*	6/13 - 19	17	412	355-460	1.0	.74-1.45
Caunaq	8/17 - 24	19	430	385-485	1.0	.7-1.31
ADFG Fish Wheels	8/13 - 15	7	413	365-470	0.97	.67-1.29
		43				
			Median	Range	Median	Range
Chatanika River [a]		1,513	430[c]	360-560	-	-
Tanana River[b]		95	440[c]	390-510	1.13	.84-1.79

			Length (mm)		Weight (kg)	
Broad Whitefish	Dates	Sample (N)	Mean	Range	Mean	Range
Kialik River*	6/13 - 19	9	447	425-460	1.42	1.15-1.58
Caunaq	8/17 - 24	21	486	430-555	1.7	1.21-2.65
ADFG Fish Wheels	8/13 - 15	4	485	475-500	1.80	1.68-1.97
		34				

*Weights collected on 6 humpback whitefish and 4 broad whitefish.
[a] Flemming 1996
[b] Brown 2006
[c] median lengh

Aerial surveys were flown on September 11 and 26-28, October 10-12 and 18-19, and November 18, 2006, to locate radio tagged whitefish during the expected spawning time (Brown et al. 2002; Alt 1979; Reist and Chang-Kue 1997). Upper river aerial surveys covered approximately 637 rkm of the Kuskokwim River, from the confluence of the Holitna River (rkm 491) to Telida (rkm 1128). Tributaries surveyed included the Holitna, Hoholitna, Swift, Stony, lower Tatlawiksuk, Gagaryah, Cheenetnuk, Big, Middle and Windy Forks, South Fork Kuskokwim and Big Salmon rivers, and several other tributaries to the Big and the South Fork Kuskokwim rivers near Nikolai, Alaska (rkm 941) (Figure 2).

Aerial surveys covering the lower river were flown from Bethel on July 7, September 14, October 17 and 24, and November 19. Surveys originating from Bethel covered the area from the Kialik River (rkm 50) to the Aniak (rkm 307) and Holitna (rkm 491) rivers (Figure 2).

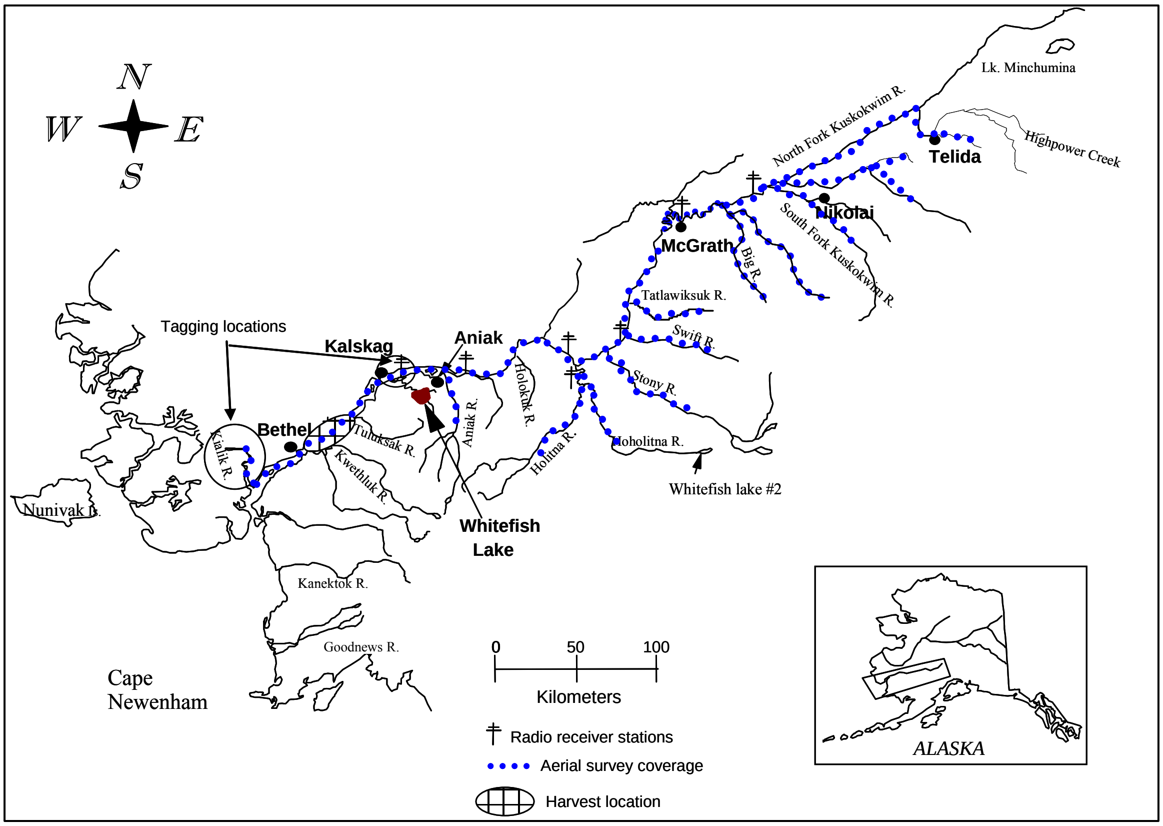

FIGURE 2.–Areas surveyed, and tagging and harvest locations on the Kuskokwim River drainage, 2006.

Boat surveys, conducted on June 24, July 16 and 18, and August 6 and 25, covered portions of the lower Kuskokwim River between tagging locations (Figure 2). Fixed receiver stations were located at Bethel (rkm 106), the confluence of Lewis Creek and the Kuskokwim River (rkm 263), one km above Aniak (rkm 308) , Red Devil (rkm 472), Holitna (rkm 491), Senka's Landing 5 kilometers below the Swift River (rkm 560), McGrath (rkm 753), and Medfra (rkm 863), Alaska (Figure 2).

Fourteen (16%) of the radio tags were returned to the manufacturer because the tags would not start in August. Approximately 60% of the radio transmitters were relocated after a short period of time following implantation, with an increased failure rate as time progressed. The 14 transmitters returned to the manufacturer were determined to have defective processing boards with a high resistance that caused battery life to be truncated.

Broad whitefish.—Five of the nine fish tagged in the Kialik River were relocated during an aerial survey on July 7. One had moved out of this tributary at rkm 50 and was relocated by boat downstream of Aniak at approximately rkm 307 on July 18. Other broad whitefish tagged in the Kialik River were not found in 2006 (Figure 3).

Broad whitefish catches at the ADF&G fish wheels near Kalskag increased in August. Fish tagged at that location moved both up and down stream. One of the four fish tagged at the fish wheels was relocated within several days of surgery upstream from the tagging site, only to head downstream where it was recorded passing the Bethel fixed station a few days later (Figure 1).

By August 30, only four of the 21 broad whitefish tagged a couple of weeks earlier remained in Caunaq Lake, dropping to two by September 14, and one remained on October 24. In September, three of these fish had migrated downriver and were relocated upriver from Bethel. Three more broad whitefish had migrated upriver of Senka's Landing (rkm 560) (Figure 4). Between October 12 and 24, broad whitefish tagged in Caunaq Lake were located between Bethel (rkm 106) and McGrath (rkm 753), with the majority between the Holitna River (rkm 491) and McGrath (Figure 4). During November, five of these fish were relocated between Aniak (rkm 307) and McGrath. One fish found at McGrath in October was relocated between the Swift (rkm 560) and Stony (rkm 536) rivers on November 18 (Figure 4).

Humpback whitefish.—Most humpback whitefish implanted with radio transmitters in the Kialik River drainage remained near their tagging location through July. One early migrant had moved out of the Kialik River system and was relocated near Kalskag (rkm 263) in the mainstem Kuskokwim River on July 8. Tagging efforts and aircraft availability curtailed aerial surveys of the lower river in August, so locations of tagged whitefish below Bethel during that time period were not collected. By late August, one humpback whitefish tagged in the Kialik River had migrated upstream near McGrath. This humpback whitefish was relocated traveling downstream in late September. Other humpback whitefish tagged in the Kialik River continued to migrate up the Kuskokwim River through September, with one being relocated between the Swift River and McGrath (Figure 5). None of these humpback whitefish were relocated after late September.

One of the seven humpback whitefish tagged at the fish wheels in August was relocated in September downriver near the confluence of the Tuluksak River (rkm 192). It was found in this location for the remainder of the survey period.

Humpback whitefish tagged in Caunaq Lake in August began moving upriver from the tagging site in early September. By September 14, only three of the 18 humpback whitefish tagged at this site remained in the lake. One fish had moved out of the lake and was relocated downstream near the Tuluksak River confluence. Aerial surveys in October relocated one humpback whitefish in the suspected Swift River spawning site. No tagged humpback whitefish were relocated near McGrath after late September (Figures 4 and 5).

Radio tags were programmed to shut off by late November to extend transmitter battery life. The last aerial survey was completed on November 19.

Spawning areas and age at maturity.—The first year of the study was used to locate suspected spawning areas. Objectives 3, 4 and 5 associated with spawning populations, age and maturity, and estimates of size at maturity will be conducted in 2007 and 2008.

PIT tag detection.—The PIT tag antenna installed in 2005 (Harper and Harris 2006) was operational between June 6 and October 26, 2006. Eight fish were detected: five humpback whitefish and three least cisco (Table 2). Three of the eight detected fish were radio tagged when the PIT tags were implanted in 2005 at Whitefish Lake. Fish were implanted with PIT tags in both 2005 and 2006 but only fish implanted with PIT tags in 2005 in Whitefish Lake were detected.

TABLE 2.—Detection of PIT tags at the outlet of Whitefish Lake, 2006.

Date	PIT tag	Species	Length at tagging	Date Tagged	Radio tag	Channel	Code
07/01/06	113729450	HW	420	6/24/2005	no		
07/12/06	113729455	HW	470	6/21/2005	no		
08/02/06	113727661	HW	460	5/29/2005	yes	60	129
08/06/06	113727584	HW	430	6/8/2005	yes	58	117
08/12/06	113729491	HW	430	6/11/2005	no		
08/21/06	113729446	LC	300	6/24/2005	no		
09/08/06	113729462	LC	305	6/18/2005	no		
10/01/06	113727607	LC	330	5/23/2005	yes	62	167

Harvest of Tagged Whitefish

Two of the nine broad whitefish tagged in the Kialik River drainage, and one of the 21 broad whitefish tagged in Caunaq Lake, were harvested in August 2006 between Bethel and Akiachak (Figure 2). One humpback whitefish tagged in Caunaq Lake was harvested in February 2007 near Bethel during the winter subsistence fishery. Radio transmitters from the three (9%) broad and the one (2%) humpback whitefish tagged in 2006 were returned by subsistence users.

Discussion

Whitefish migration patterns are complicated (Harper et al. 2007). However, much has been learned from this study. Their locations during surveys and capturing for implanting vary with water and other environmental conditions. Late ice break up on the lower Kuskokwim River in 2006 delayed radio implantation until June, by which time the majority of fish had already moved out of the main river and into their feeding areas. Water temperatures in the tundra lakes of the Kialik River drainage increased rapidly to the maximum surgery temperature of 15 ^{o}C. Only 9 broad and 17 humpback whitefish were tagged between June 12 and 24. If whitefish in this system had been as plentiful as previously noted by Baxter (Baxter, ADF&G, unpublished data), the target of implanting 45 transmitters in each of the species should have been accomplished. Regardless, efforts to deploy the remaining 68 tags (31 humpback whitefish and 37 broad whitefish) resumed in August, when water temperatures decreased. Water levels increased nearly two meters during the Caunaq Lake operations and had water levels remained static perhaps more whitefish would have been tagged at that location. Several small lakes in the lower 10 km of the Gweek River, and lakes adjacent to the Kuskokwim River below Bethel and between Bethel and Kwethluk were sampled during late August with no captures, suggesting that the majority of whitefish had emigrated or were still in those systems. High water was also believed to have reduced our catch.

During 2006, migration and timing patterns may have been influenced by warm water, surgeries or radio transmitter failures. For example, one humpback whitefish was relocated several times in the same location near Tuluksak over a period of eight months. Also, two other whitefish migrated short distances upstream post surgery only to be relocated downstream of the capture location a few days later and, subsequently, not relocated. Relocation of individual tags decreased as the season progressed and tag failure is suspected. Total tag failure was undetermined, however it is suspected to be high, as only 120 validated radio hits were recorded during tracking operations or at fixed stations in 2006.

Broad Whitefish.—Broad whitefish tagged in 2006 were only relocated in the main stem Kuskokwim River between McGrath and the confluence of Big River, and not in any tributaries. However, Alt (1972) found spawning broad, humpback, and round whitefish, and least cisco mixed in with spawning inconnu in Highpower Creek, a headwater tributary to the North Fork Kuskokwim River, in early October, 1971. Our findings may be a product of capturing immature or non spawners in 2006, or we missed fish that moved quickly into and out of tributaries between aerial surveys. Another explanation may be different life history types. More tagging may confirm or disprove either or both findings.

Humpback whitefish.–In October 2006, humpback whitefish radio tagged in both 2005 and 2006 were relocated in a suspected spawning area in the lower Swift River. Several humpback whitefish tagged in 2006 migrated past Senka's Landing and were relocated in the mainstream of the Kuskokwim River downstream of McGrath in October. A spawning site may exist above Medfra and is supported by the subsistence harvest of a humpback whitefish on September 15, 2004 at Medfra that was Floy® tagged in Whitefish Lake, May 2003 (Harper et al. 2007). However, no radio tagged whitefish have been tracked to or past this site. Migration of humpback whitefish into the Swift River is similar to spawning migrations described by Alt (1972) and Brown (2006).

PIT tags.—The PIT tag detector continued to operate in 2006 at the outlet of Whitefish Lake. It was not surprising that PIT tags implanted in 2006 were not detected. Several fish tagged in 2005 in Whitefish Lake were picked up by the PIT tag recorder, confirming their fidelity to the lake and the operation of the PIT tag recorder. The fish tagged in the current study were tagged in lakes downstream of Bethel and in Caugnuq Lake upriver of Whitefish Lake and it is suspected that they would behave similarly and exhibit a fidelity to those lakes. The continued operation and detection of PIT tags at Whitefish Lake confirms the value of this type of equipment for evaluating long-term movement patterns using a relatively inexpensive technology.

Harvest areas.—Broad and humpback whitefish tagged in the Kialik River drainage were harvested in the subsistence fishery. Two of the nine broad whitefish tagged in the Kialik system were harvested in the Kuskokwim River near Bethel. This harvest of a large percentage of the small number of broad whitefish tagged may suggest a high harvest rate for this Kialik River aggregate. Subsistence fishers have commented on the lack of broad whitefish in their subsistence and commercial catches in recent years. This is in contrast with Jonrowe (1984) who noted whitefish harvests were not a concern of subsistence fishers at that time. Interestingly, none of the 17 humpback whitefish implanted in the same system as the broad whitefish were harvested. This information provides some insight into run timing differences between the species, migratory corridors used by the species, and, perhaps, harvest methods used to capture the different species.

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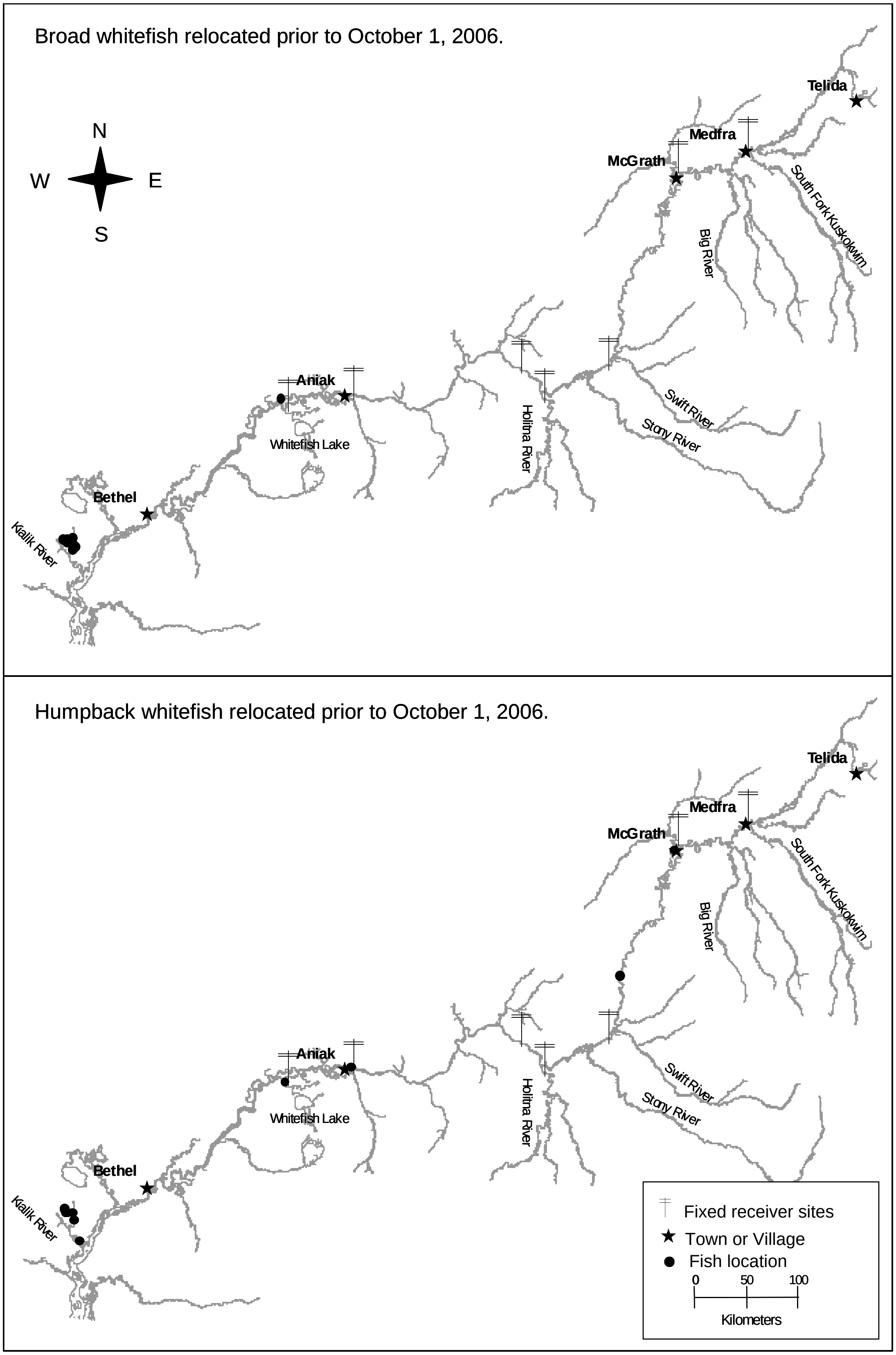

FIGURE 3.–Distribution of broad and humpback whitefish radio tagged in the Kialik River drainage, 2006. No radio tagged whitefish were relocated after October 1, 2006.

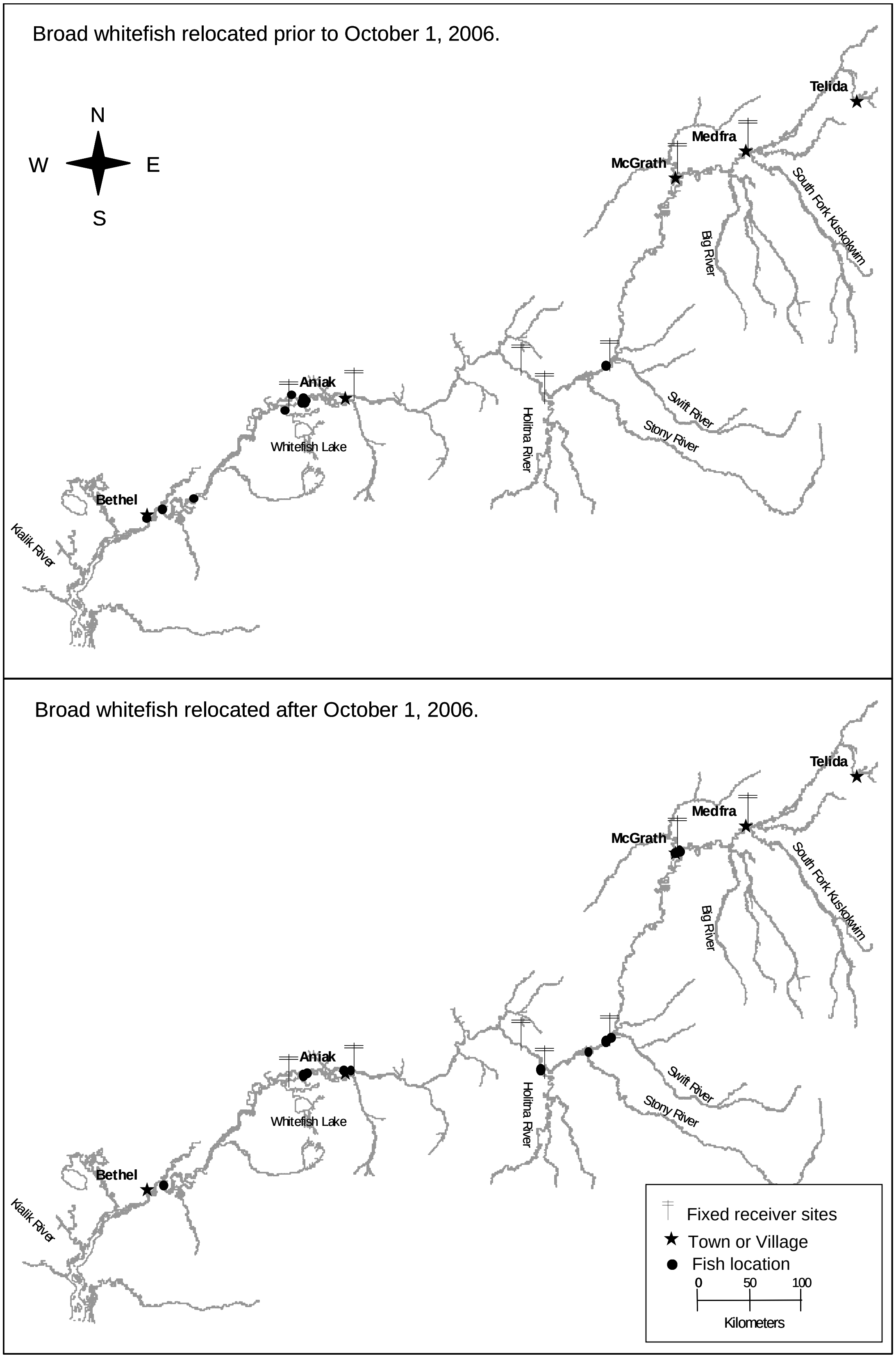

FIGURE 4.─Distribution of Broad whitefish tagged in Caunaq Lake and ADF&G fish wheels, 2006.

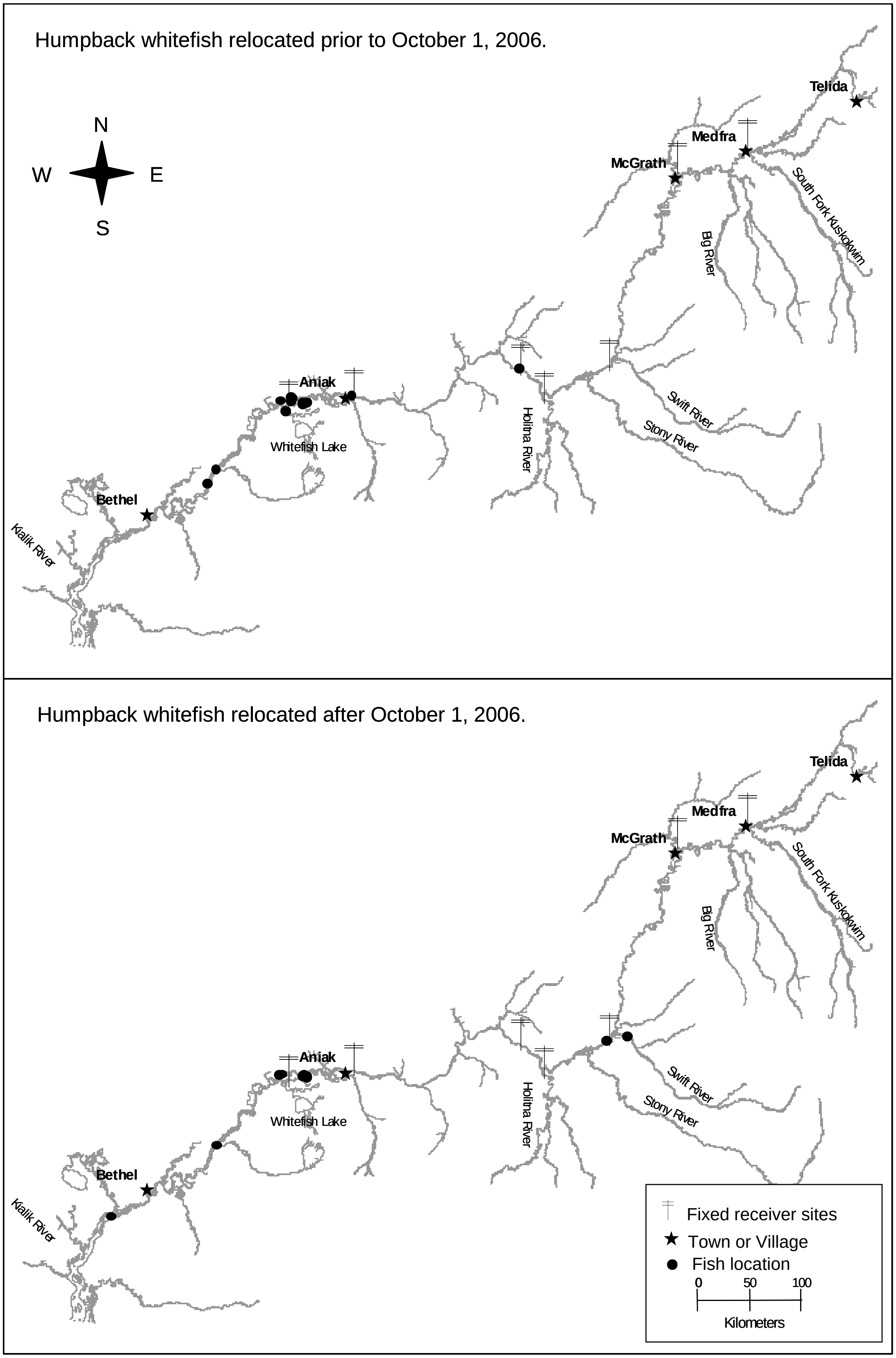

FIGURE 5.─Distribution of humpback whitefish tagged in Caunaq Lake and ADF&G fish wheels, 2006.