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Is the Presence of Broad Whitefish in an Upland Lake an Indication of a Lake Resident Life History Form?

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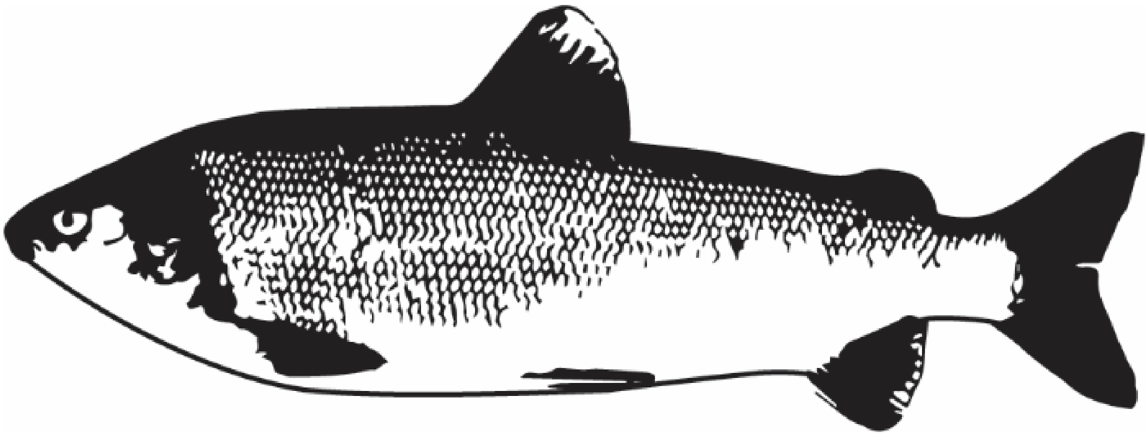

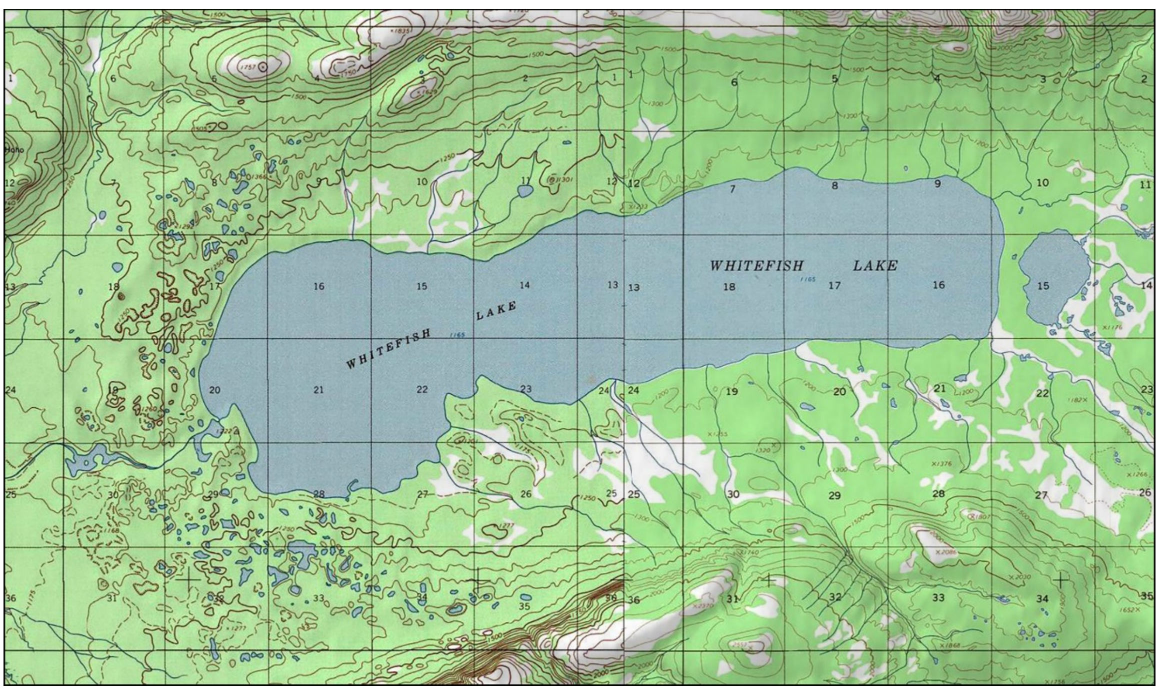

Fairbanks Fish and Wildlife Field Office
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Cover: Broad Whitefish graphic by Jesse Coleman, University of Alaska Fairbanks
A section of a USGS topographic map featuring Whitefish Lake.

Is the Presence of Broad Whitefish in an Upland Lake an Indication of a Lake Resident Life History Form?

Randy J. Brown and Daniel B. Young

Abstract

Broad Whitefish *Coregonus nasus* is a large species in the subfamily Coregoninae. It occurs in a number of Arctic and subarctic rivers in North America and Asia. The species spawns in October or November. Juveniles emerge the following spring and are transported downstream with high flows to rear in estuaries and floodplain lakes for a few years until maturity is attained. Mature fish then migrate back upstream to their natal origins to spawn. Post-spawning individuals typically overwinter in large river environments or estuaries and migrate into floodplain lakes during summer to feed. In the 1970s two different fisheries biologists captured Broad Whitefish in Whitefish Lake, a large upland lake in the headwaters of the Hoholitna River, a tributary of the Kuskokwim River in western Alaska. It is very unusual for the species to occupy upland lakes so its occurrence there could potentially represent an undescribed lake resident life history form. We conducted a 3-day sampling program in Whitefish Lake in late August, 2012, to determine if Broad Whitefish were present in the lake in late summer, and if so, whether individuals were preparing to spawn or not. We captured six species in the lake but no Broad Whitefish were captured or observed. We conclude that the species occupies Whitefish Lake during early summer to feed, similar to its seasonal pattern with floodplain lakes, and therefore, its presence does not represent a lake resident life history form.

Introduction

At least six lakes in Alaska are named Whitefish Lake (Orth 1971). The Whitefish Lake discussed here is an upland lake at the source of the Hoholitna River in the Kuskokwim River drainage in Alaska (Figure 1). It has apparently borne the name since at least the early 1900s (Smith 1917; Orth 1971). It is located at latitude 60.94868º and longitude -154.95604º (WGS84 datum) at an elevation of 355 m. The lake has a surface area of about 34 km^2 and a maximum depth of at least 33 m. Whitefish Lake is approximately 822 river km (rkm) from the sea, and 284 km upstream from the mouth of the Hoholitna River. The Hoholitna River has a relatively low gradient, averaging 1m/km throughout its length. By contrast, other south bank tributaries of the Kuskokwim River such as the South Fork and the Big River have gradients in their upper reaches that exceed 3m/km and decline to 1m/km or less only in their lower reaches (Ireland and Collazzi 1985a, b).

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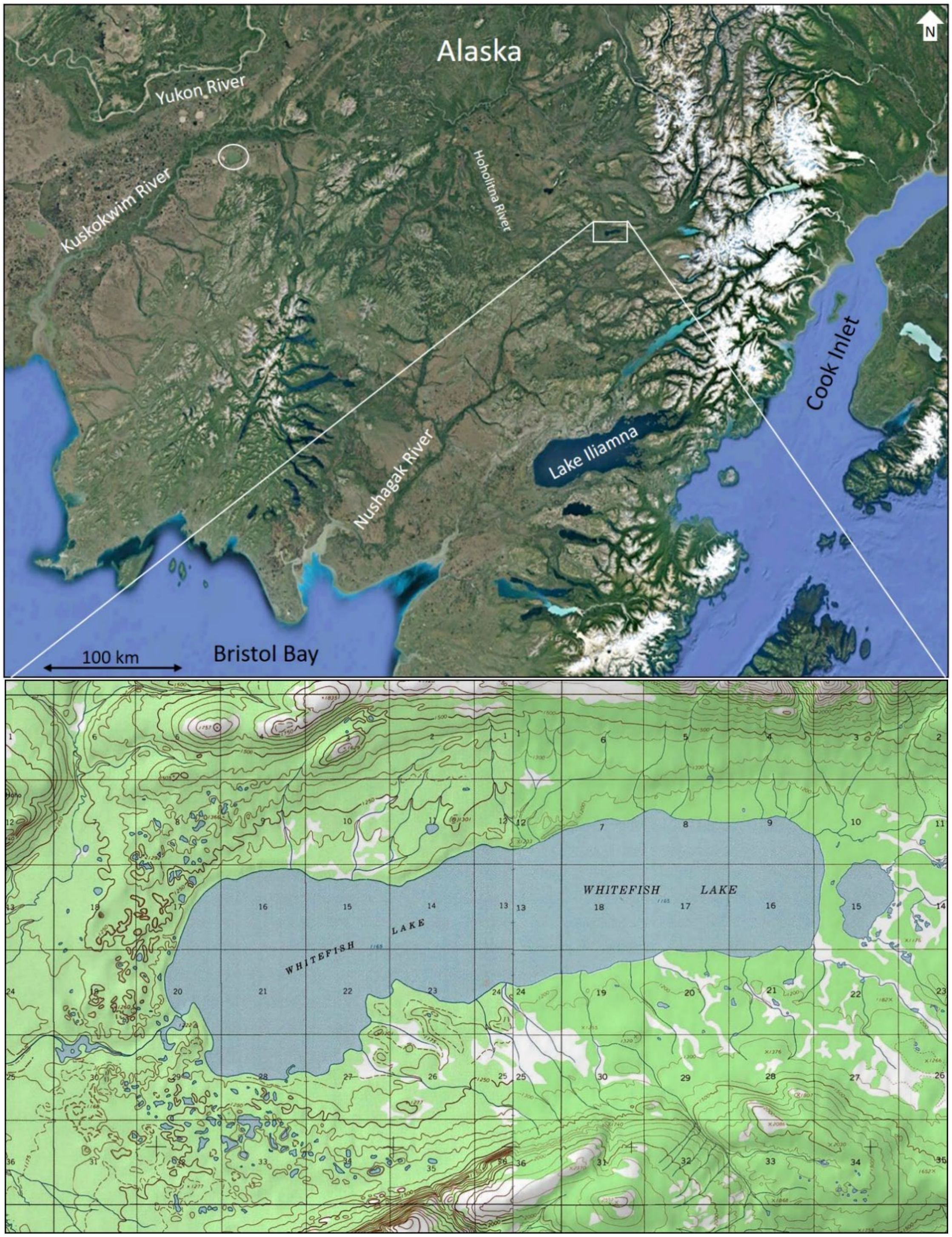

Figure 1. The Whitefish Lake of interest here is an upland lake in the upper Hoholitna River drainage in Alaska. At its longest the lake is 12.6 km east to west and 4.0 km south to north, with a surface area of about 34 km^2. The lake is the source of the Hoholitna River, which drains out the west side of the lake. The white circle near the Kuskokwim River in the upper regional map indicates the location of a second Whitefish Lake that is in the floodplain of the lower Kuskokwim River. Upper image courtesy of Google Earth, lower image is a USGS topographic map.

Our interest in sampling the fish community in Whitefish Lake originated with observations of Broad Whitefish *Coregonus nasus* in the lake by two Alaska Department of Fish and Game (ADF&G) biologists in the 1970s. Both biologists took notes (see Appendices 1 and 2), but neither conveyed their findings in any subsequent publication. Rae Baxter visited Whitefish Lake for five days in mid-June 1974. He set experimental gillnets with a range of stretch mesh sizes from small (25 mm) to large (150 mm) and did some angling for species that can be captured in that way as well. He captured Lake Trout *Salvelinus namaycush*, Arctic Grayling *Thymallus arcticus*, Round Whitefish *Prosopium cylindraceum*, Northern Pike *Esox lucius*, and Broad Whitefish. A few years later Ken Alt sampled fish in Whitefish Lake on July 12 and 13 in 1979. He angled and set three experimental gillnets, each 38 m long; two were sinking nets that were tied one after the other and set offshore perpendicular to the north shore of the lake at a depth of about 10 m, and one was a floating net set in a shallower part of the lake off a point near the outlet. Alt captured the same five species as Baxter noted earlier and also observed juvenile Sockeye Salmon *Oncorhynchus nerka* foraging among boulders in shallow water along the northern edge of the lake. While there is always some uncertainty about a species observed in the water but not captured, results from a radiotelemetry study of the spawning distribution of adult Sockeye Salmon in Kuskokwim River (Gilk et al. 2011) support this observation. Although no radio-tagged Sockeye Salmon were located in Whitefish Lake, during both years of the investigation tagged fish migrated to within 1 km of the lake outlet and presumably spawned there in the river. Alt's observation of juveniles foraging in the lake suggests that at least some of the fry from that population migrate upstream into the lake to rear after emergence, a strategy that has been documented in other Sockeye Salmon systems (Brannon 1972; Burgner 1991; Quinn 2018).

The occurrence of Broad Whitefish in Whitefish Lake, presumably its namesake, is intriguing primarily because it is unusual for the species to be found in upland lakes, which are located near the headwaters of rivers in foothills or mountains (Glesne et al. 2011). Most upland lakes have adequate depth (≥3 m) to avoid freezing and still maintain an aquatic environment with sufficient oxygen to support overwintering fish. By contrast, lowland lakes, common in floodplains of rivers and areas with minimal geographic relief, tend to be much shallower and either freeze to the bottom or become anoxic over the course of the winter. Broad Whitefish are commonly encountered during summer in lowland lakes such as the Whitefish Lake in the Kuskokwim River floodplain (Figure 1), as detailed by Harper et al. (2007), but must return to large river environments in the late summer or fall to spawn and overwinter.

It is not unusual for populations of other whitefish species to spawn, rear, feed, overwinter, and live their entire lives in upland lakes without migrating elsewhere, a life history pattern referred to as lake resident or lacustrine non-migratory (Tallman et al. 2002; Harris et al. 2012a). Examples in the Yukon River drainage of isolated populations in lakes without passable outlets include Humpback Whitefish *C. pidschian* and Round Whitefish in Old John Lake in the Sheenjek River basin (Craig and Wells 1975), Least Cisco *C. sardinella* native to Harding Lake in the Tanana River basin (Doxey 1991), and Humpback Whitefish and Least Cisco in Sithylemenkat Lake in the Kanuti River basin (Pearse 1978). Broad Whitefish in the Traviallant Lake system in the lower Mackenzie River drainage in northwest Canada appear to have an intermediate life history between the big river migrants and the lake resident forms (Tallman et al. 2002; Harris et al. 2012a, b; Millar et al. 2013). To our knowledge, Broad Whitefish have never been documented with a lake resident life history pattern (Brown et al. 2012a).

If Whitefish Lake in the upper Kuskokwim River drainage supports a population of Broad Whitefish that remain in the lake through the year, it would represent a unique life history form that has not been documented. Our primary sampling objective was to test the hypothesis that Broad Whitefish were present in the lake in late August, which was later than the lake had been sampled by Rae Baxter in 1974 and Ken Alt in 1979 (see Appendix 1 and Appendix 2). Our secondary sampling objective, contingent on successfully capturing Broad Whitefish in the lake, was to calculate a gonadosomatic index (GSI = [egg wt/whole body wt]*100) for females to determine if they were preparing to spawn that fall. Broad Whitefish preparing to spawn in the fall would be expected to have GSI values ≥ 10 in late August, versus non-spawners that would have GSI values < 3 (Harper et al. 2007; Brown et al. 2012a; Brown et al. 2012b). If Broad Whitefish were captured in the lake in late August, it would not necessarily indicate that they remain there through the winter. For example, Harper et al. (2007) documented Broad Whitefish leaving the lowland Whitefish Lake in the Kuskokwim River floodplain in early October. However, if we failed to capture Broad Whitefish after a concerted sampling effort it would be an indication that the species occupies the lake seasonally as feeding habitat, similar to their occupancy of the lowland Whitefish Lake.

Methods

We sampled fish in Whitefish Lake for three days, August 28–30, 2012, using variable mesh gillnets, both floating and sinking. Floating nets were identical to those used by Russell (1980): monofilament mesh, 38.1 m long, 1.8 m deep, and consisting of five 7.6 m panels with mesh sizes 1.3, 1.9, 2.5, 3.8 and 5.0 cm. The sinking nets were a little shorter than the floating nets at 30.5 m long, the same depth (1.8 m), and had fewer panels but a greater maximum mesh size (four 7.6 m monofilament panels with mesh sizes 1.3, 2.5, 5.1 and 10.2 cm). Gillnets were set perpendicular from shore in numerous locations in various habitats around the lake, from near the outlet on the western side of the lake, both north and south shores, and on the eastern side of the lake. Additionally, two nets were tied together and set offshore near the geographic center of the lake at about 18 m depth using anchors on each side of the lead line and a float to the surface.

We collected a range of biological data including date of capture, species, fork length (FL; mm), whole weight (g), and sex if it could be determined. The weight of egg skeins (g) was collected from females of the larger species that died during capture. The presence or absence of food in the stomach was recorded from mortalities of the larger species, and if present and identifiable, the prey species were also recorded. We collected sagittal otoliths for age analysis from the larger Round Whitefish and Lake Trout mortalities. Otoliths were ground into thin transverse sections in preparation for aging (Secor et al. 1992). Sectioned otoliths were viewed with transmitted light on a compound microscope. Annuli were identified and counted as described and illustrated by Chilton and Beamish (1982). Age data are summarized in text but no further analyses were conducted.

Results

Sampling was conducted August 28–30, 2012, totaling approximately 75 gillnet hours. Six species of fish were captured or observed (Table 1; Figure 2; Appendix 3). Lake Trout, Round Whitefish, and Northern Pike were captured in gillnets. Several Northern Pike were also observed in a shallow area with emergent vegetation on the south side of the lake. Arctic

Grayling were captured in a beach seine. A Ninespine Stickleback *Pungitius pungitius* was found dead in emergent vegetation near the outlet of the lake. Species that could be identified as prey of Northern Pike included Arctic Grayling, Round Whitefish, and Ninespine Stickleback. Species that could be identified as prey of Lake Trout included Northern Pike and Slimy Sculpin *Cottus cognatus*. No Broad Whitefish were captured or observed.

Table 1. Common and Latin names of fish species that have been identified in Whitefish Lake during three sampling periods, by Rae Baxter in 1974 (Appendix 1), by Ken Alt in 1979 (Appendix 2), and in the current 2012 study (Appendix 3). Included are the number (*n*) of each species sampled in the 2012 study, the mean FL and range, and whether a species was identified in each of the three sampling projects (Y) or not (left blank).

Species	Latin name	*n*	Mean FL (range)	1974	1979	2012
Lake Trout	*Salvelinus namaycush*	12	492 (423–600)	Y	Y	Y
Sockeye Salmon	*Oncorhynchus nerka*	0			Y	
Round Whitefish	*Prosopium cylindraceum*	17	327 (207–493)	Y	Y	Y
Broad Whitefish	*Coregonus nasus*	0		Y	Y	
Arctic Grayling	*Thymallus arcticus*	3		Y	Y	Y
Northern Pike	*Esox lucius*	2	359 (350–368)	Y	Y	Y
Slimy Sculpin	*Cottus cognatus*	2				Y
Ninespine Stickleback	*Pungitius pungitius*	2				Y

Otoliths were collected for aging from five Round Whitefish and eight Lake Trout. Mean FLs of these aged samples were 473 mm (range = 440–493 mm) for Round Whitefish and 492 mm (range = 423–600 mm) for Lake Trout. Mean ages from these samples were 16.2 years (range = 11–25 years) for Round Whitefish and 15.3 years (range = 10–28 years) for Lake Trout.

Discussion

Broad Whitefish populations most commonly follow a life history pattern as summarized in reviews by Reist and Bond (1988) and Shestakov (2001) for the lower Mackenzie River in northwest Canada and the Anadyr River in eastern Russia, respectively. Spawning takes place in flowing water over a gravel substrate, usually in late October or early November (Chang-Kue and Jessop 1997; VanGerwen-Toyne et al. 2008; Carter 2010; Harper et al. 2012); eggs incubate through the winter, hatch the next spring, and larvae emerge into the river and disperse downstream as flow increases with the spring snow melt (Shestakov 1991; Bogdanov et al. 1992; Næsje et al. 1986, 1995); young fish rear in habitats far downstream from spawning areas that typically include estuaries at river mouths and accessible floodplain lakes (Shestakov 1992, 2001; Bond and Erickson 1985; Martin et al. 1987); and once maturity is achieved in 5–8 years (Reist and Bond 1988; Tallman et al. 2002; Brown 2004; Carter 2010), fish migrate back upstream to their natal spawning areas and start the cycle all over again (Reist and Bond 1988; Brown et al. 2012b; Harper et al. 2012). Like other coregonid fishes, Broad Whitefish survive spawning and are capable of spawning multiple times during their lives, which can extend for 20–30 years or more (Bond and Erikson 1985; Tallman et al. 2002; Brown 2004). However, it is generally assumed that they rest for a year or more between spawning events (Reist and Bond 1988; Lambert and Dodson 1990; Brown 2004).

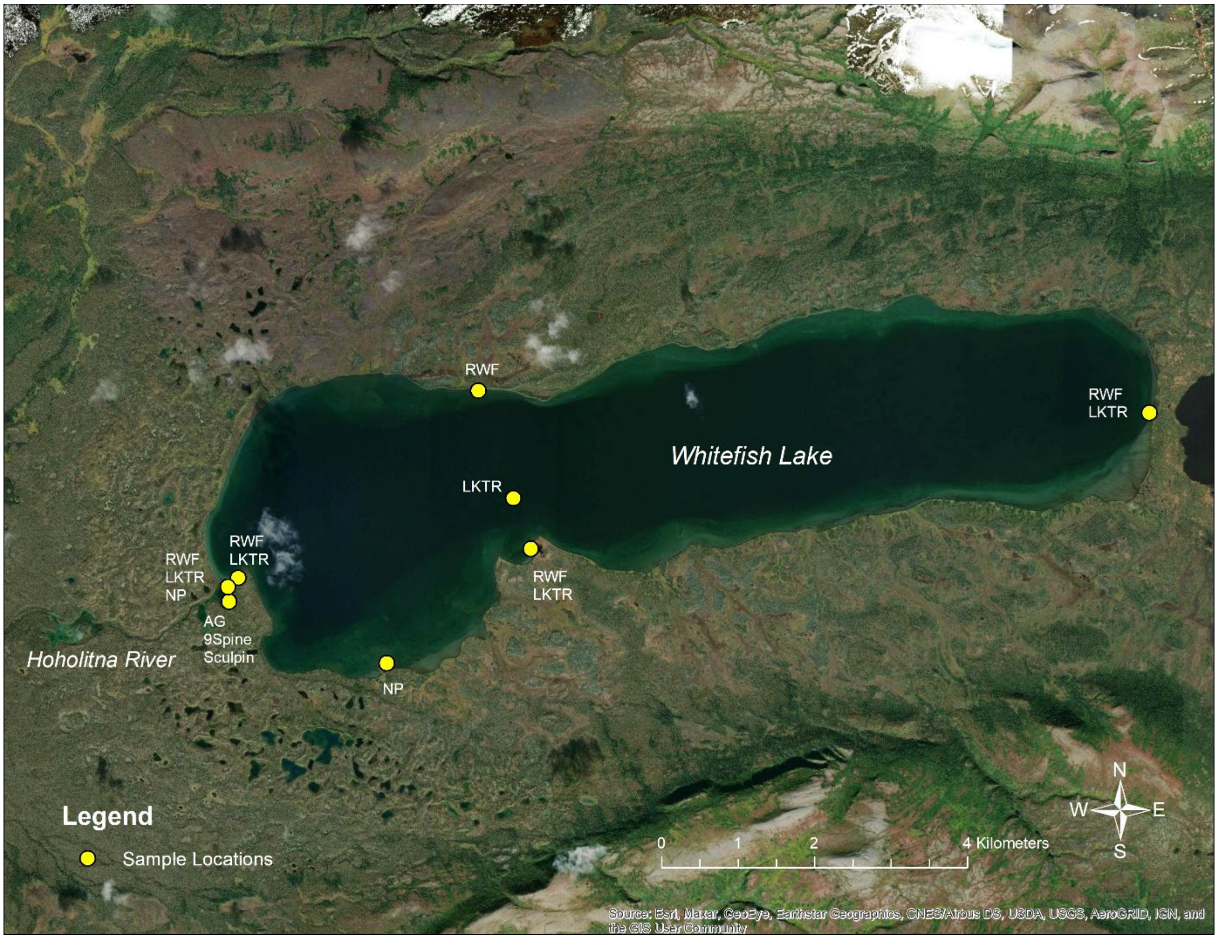

Figure 2 Sampling locations and species captured during the August 2012 sampling project on Whitefish Lake. Species acronyms are as follows: Round Whitefish (RWF); Lake Trout (LKTR); Northern Pike (NP); Arctic Grayling (AG); Ninespine Stickleback (9Spine); and Slimy Sculpin (Sculpin).

Broad Whitefish found in the Travaillant Lake system in the lower Mackenzie River drainage come closer to living a lake resident life than any other populations that we are aware of. None-the-less, Travaillant Lake is one of a series of lakes that the Travaillant River flows through and the fish occupy a number of lakes in the drainage as well as in the river between lakes (Millar et al. 2013). Similar to their conspecifics in larger river systems, they spawn in flowing water over gravel. Additionally, there are several lines of evidence indicating that Broad Whitefish in the Travaillant Lake system are not isolated from the larger Mackenzie River population and there is at least some interchange among individuals from the two environments (Hesslein et al. 1991; Harris et al. 2012a, b).

By contrast, Whitefish Lake is a terminal lake with the uppermost reach of the Hoholitna River flowing out but no river flowing in. Broad Whitefish are capable of accessing the lake from downstream but must retreat back downstream to exit the lake. Sampling data on the seasonal presence of Broad Whitefish in Whitefish Lake, albeit many years between sampling events, suggests that the species occupies the lake early in the summer and exits the lake to migrate down the Hoholitna River to spawn and overwinter in large river or estuary habitats similar to

Broad Whitefish occupying other feeding habitats (Harper et al. 2012). It appears the only real difference between the life histories of Broad Whitefish that frequent the Whitefish Lake in the upper Hoholitna River and the Whitefish Lake in the floodplain of the lower Kuskokwim River is the distances they must migrate from the larger river environment to their respective lakes, 331 km and 15 km respectively (Harper et al. 2007). In both cases the lake appears to be used as productive feeding habitat during summer.

There was some indication before our 2012 sampling expedition that people had historically utilized the fishery resources at Whitefish Lake. For example, Kari (1983), in her report on the land use and economy of Lime Village, a nearby community in the Stony River drainage, briefly mentioned Whitefish Lake in text and identified it in a resource use map of the region as a historic fishing site for non-salmon species. An old village site was also identified near the outlet of the lake. Similarly, Ellanna and Balluta (1992), did not speak directly about Whitefish Lake in text, but identified the outlet of the lake in a generalized map depicting important locations for hunting, trapping, and fishing activities in the spring. However, it was not until after our 2012 sampling expedition that we came across an oral history book with stories about life in the region compiled by Evanoff (2010). In this book there was a detailed and compelling oral history account by a Native elder named Gilly Jacko about fishing in the spring at Whitefish Lake (Appendix 4). According to Gilly Jacko, a migration of big fat whitefish with big humps migrate into the lake in the spring and people would go there and build a fish trap to catch them. They could then catch thousands of these “really good fish” and smoke them and dry them. Clearly this tremendous resource was the origin of the lake name.

All of these sources of data considered together support a life history model for Broad Whitefish as seasonal visitors to Whitefish Lake. Because the basic patterns of river flow and landscape in this remote region have not changed significantly over time, we expect that this great seasonal migration of Broad Whitefish will continue into the future, into and out of Whitefish Lake every summer.

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Appendix 1: Rae Baxter 1974, Whitefish Lake sample data notes, June 14–18.

FISHERY INVENTORY SURVEY FORM — 20 March 197

System: Whitefish Lake, Hoholitna Date: 14-18 VI 74

Latitude: 6[illegible] N, Longitude: 159° 52′ W. Altitude: 1165 ft

Size: Length ____ Width ____ Hectares ____

Depth, maximum ____ mean ____ Kiloliters (Cubic meters) ____

Land characteristics: Watershed: Tundra - Stunted Spruce

Shore: boulder & Sand

Lake bottom: Soft & Sandy + Bouldery

Water characteristics: Lake type: Glacial moraine

Color: Clear. Secchi disk visibility: 5.52 m

Water chemistry: Oxygen: 12. pH: 7.4. Hardness: 26

Nitrogen ____. Phosphate ____. Iron ____

CO_2 ____. Tannin & lignin ____. Others ____

Fish:	Gill net mesh size. 25	37	50	75	100	114	125	150	1
Coregonus nasus			1/1	1	9	23		2	36
Coregonus nidschian									
Coregonus sardinella									
Stenodus leucichthys									
Esox lucius			/5	19	5	2			
Others									
Prosopium cylindraceum	2	5	/3	3					
Lota lota									
Salvelinus namaycush			/2	9	13	1		1	
Thymallus arcticus			/1						
Hours net fished.	60:30	60:30	60:30 42:30	62:40	42:30	62:30		62:40	11

Other gear fished: Sport Gear

Catch: 550, 602,

History: Habitation: Old Trapping Camp at outlet

Sportfishery: Great Potential - very little pressure

Other ____

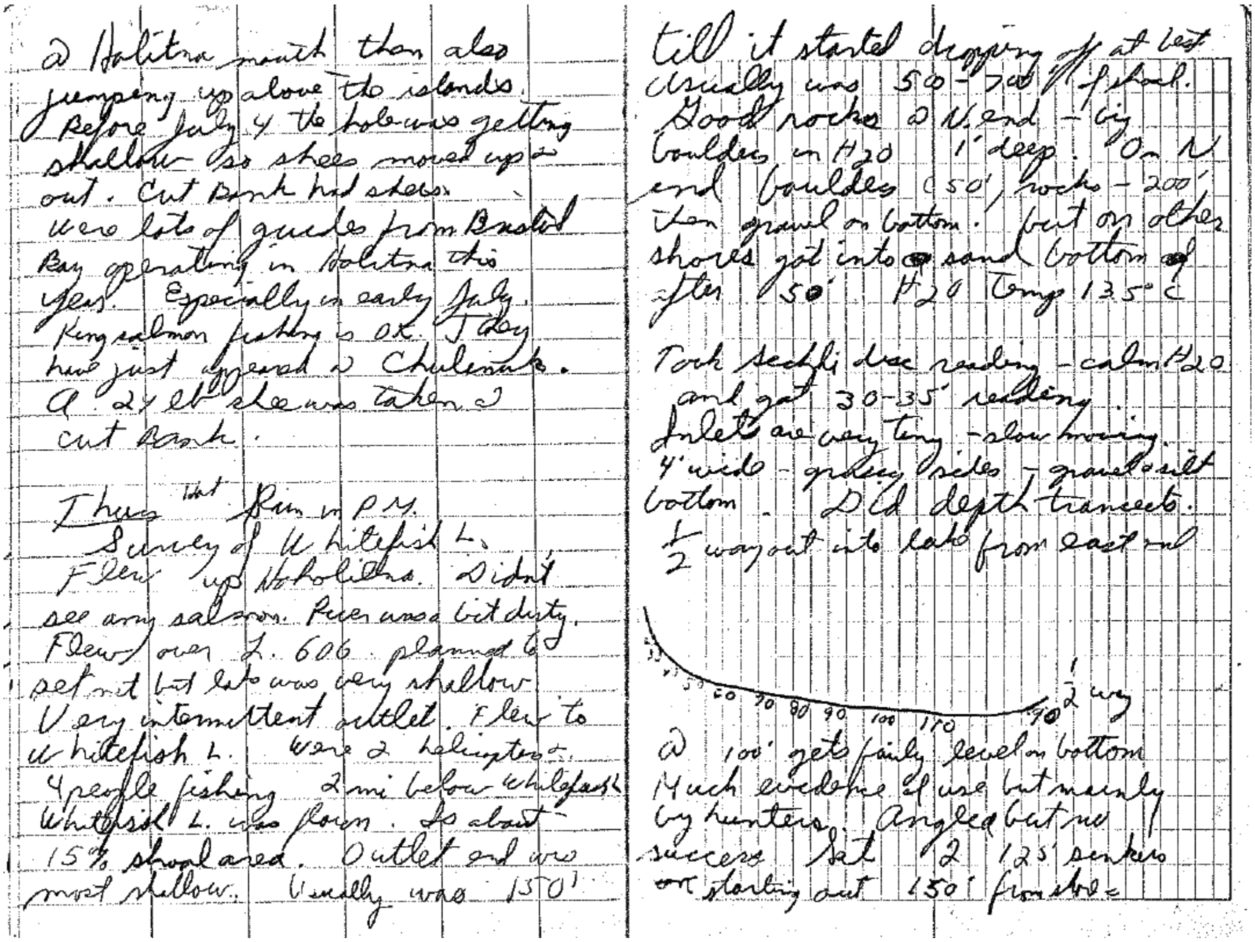
Spawning areas. –

Commercial potentials: Good for a Sport fishery

Remarks

581	525	550	560	602
355 2382	469-1722	195-8151	371-7664	355-457

Appendix 2: Ken Alt 1979, Whitefish Lake sample data notes, July 12–13.



@ Holitna mouth than also
jumping up above the islands.
Before July 4 the hole was getting
shallow so shees moved up &
out. Cut Bank had shees.
Were lots of guides from Bristol
Bay operating in Holitna this
year. Especially in early July.
King salmon fishing is OK. They
have just appeared @ Chulenak.
A 24 lb shee was taken @
Cut Bank.

Thurs 12th Rain in P.M.
Survey of Whitefish L.
Flew up Hoholitna. Didn't
see any salmon. River was a bit dirty.
Flew over L. 606 planned to
set net but lake was very shallow
Very intermittent outlet. Flew to
Whitefish L. Were 2 helicopters &
4 people fishing 2 mi below Whitefish
Whitefish L. was flown. Is about
15% shoal area. Outlet end was
most shallow. Usually was 150'

till it started dropping off at last
Usually was 50-70' of shoal.
Good rocks @ W. end - big
boulders in H_2O 1' deep. On W
end boulders (50', rocks - 200'
then gravel on bottom. but on other
shores got into sand bottom after 50'. H_2O Temp 13.5°C

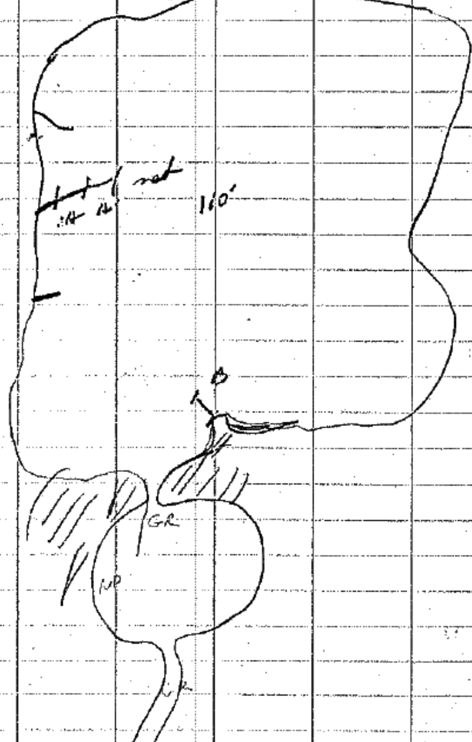
Took secchi disc reading - calm H_2O
and got 30-35' reading
Inlets are very tiny - slow moving.
4' wide - grassy sides - gravel & silt
bottom. Did depth transects.
1/2 way out into lake from east end

@ 100' gets fairly level on bottom
Much evidence of use but mainly
by hunters. Angled but no
success. Set 2 125' sinkers
on starting out 150' from shore

Pages 1 and 2.

Appendix 2, continued.

The edge of outer net (400') was in 30' of H2O. Set another net off point before outlet (B)



The lake on S. end of ~~Goodnews~~ whitefish L. was only 4' deep. The lake like area on other end was fairly deep. Fished and caught 10 grayling 8"-14"

Friday — rain, white then clear + warm — Continued survey of whitefish L. Checked for small LT in big boulders — saw only red salmon fry. Pulled floater net (B). Had 6 BWF, 5 RWF, 4 NP. Broads were all prespawners. Pike had spawned already. Worked up fish. Carried net back to camp. Took measurements at outlet. Was 30' wide gravel to med. gravel bottom. Took 25 seconds to float block 100'. Was shallow

0 1' 2' 2' 3' 1' 0

Was nice hole below this stream. Then lakelet got large. Pike came at 11 a.m. Pulled other 2 nets A + A'. Had 7 RWF, 4 LT (2-9 lbs), 2 BWF, 1 NP. Were no char although saw them. Are red salmon in the lake.

Pages 3 and 4.

Appendix 3: Brown and Young (2012), Whitefish Lake sample data notes, August 28–30.

– 2012 –

Sample Site: WHITEFISH LAKE **Samplers:** BROWN / YOUNG / ZIMMERMAN

Sample	Date	Species	Fork length (cm)	Weight (g)	Feeding?	Sex	Egg weight	Comments
100	8/28	LKTR	57.5	2.2 kg	NO	F	293 g	
101		RWF	301 mm		Y	IMM		M?
102		RWF	296 mm		Y	M		IMMATURE
103		RWF	270 mm		Y	F		IMM
104		RWF	290 mm		Y	IMM		
105		RWF	296 mm		Y	F		IMM
106		RWF	209 mm		Y	IMM		
107	8/28	RWF	226 mm		Y	IMM		
108	ALSO OBSERVED NORTHERN PIKE IN GRASSY AREAS							
109	ONE DECOMPOSING NINESPINE STICKLEBACK							
110	RELEASED TWO LIVE LAKE TROUT							
111	APPROX 18 NET HOURS — 3 NETS 6 HOURS							
112								
113	8/29	RWF	207 mm	73 g				
114		RWF	228 mm	100 g				
115		RWF	265 mm	182 g				
116		RWF	277 mm	188 g				
117		NO. PIKE	368 mm	395 g	Y			JUV RWF IN STOMACH
118		LKTR	432 mm	930 g	N	M		MATURING
119		LKTR	423 mm	900 g	N	M		MATURING
120		LKTR	547 mm	1700 g	Y	M		RESTING
121			SCULPINS AND SMALL PIKE IN STOMACH					
122		RWF	493 mm	1560 g	Y	F	134 g	SNAILS
123		RWF	489 mm	1340 g	Y	M		MATURING
124		RWF	481 mm	1100 g	Y	M		MATURING
125	8/29	RWF	440 mm	860 g	N	F	12 g	RESTING
126								
127	APPROX 16 HOUR SOAK – 3 NETS							
128	RELEASED TWO LIVE LAKE TROUT + ONE ROUND WHITEFISH							
129	CAUGHT 3 GRAYLING ~ 150 mm. IN BEACH SEINE							
130								
131	8/29	LKTR	600 mm	1800 g	Y	F		resting
132								
133								
134	8/30	LKTR	464 mm	1150 g	N	M		MATURING
135		LKTR	455 mm	1060 g	N	F	21.1 g	NON-SPAWNING
136		LKTR	436 mm	925 g	N	F	111 g	
137	8/30	NO PIKE	350 mm	390 g	Y	I		GRAYLING 9SPINE + ODON
138	8/30	RWF	462 mm	1150 g	Y	F	81 g	MATURE
139								
140		LAKE TROUT FROM NET SET AT Z ~ 60'						
141								

Appendix 4: Evanoff (2010). Dena'ina Ełnena, a Celebration. Page 74.

Łih Vena: Whitefish Lake

By Gilly Jacko

Some certain creeks
  like White Fish Lake [**Łih Vena**].
My grandpa owned the place and nobody come around.
But if anybody ask him
  for permission [to use the place].
In spring time like this,
  they used to move in there
  and there's a creek like that.
They put the fence across,
  fence right across together, they put it like that
  and there's a big pin right here—
  a little wide stick in the bottom,
  then they got a door.
And that place there,
  there's so many whitefish,
  them big whitefish got a big hump about that big.
You can get about five to six thousand fish.
Oh, maybe from here to there [referring to area], you know.
There was this little stick,
  the fish go over it at night time.
So they had little fence there,
  so there was this height under there.
The fish all goes in there
  and fill everything and start jumping.
They put this door back in and there's two racks over it.
They tie it up and block 'em.
They put that over it and block it.
Just like to keep it all in there.
Then take a scoop,
  another big fence in the beach,
  then scoop them out.
They get so much,
  take some out and keep some in there.
You can get oh, four, five, six thousand of them
  big, fat fish.
Yeah, they smoke and dry 'em; they're really good fish,
  Whitefish Lake.
Lot of 'em used to be.

Gilly Jacko, 1973
Interviewed by Joan Townsend
LACL File 310