FISHERY RESOURCES STATUS AND TRENDS GLOBAL CLIMATE CHANGE COMPONENT

MOUNTAIN WHITEFISH MONITORING PROJECT IN THE LOCHSA RIVER DRAINAGE OF NORTHERN IDAHO

COMPREHENSIVE REPORT: 1992-1994
April 1995

U.S. Fish and Wildlife Service
Idaho Fishery Resource Office
Ahsahka, Idaho

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ABSTRACT

This study was intended to be a long-term project to predict and document the effects of climate change on mountain whitefish *Prosopium williamsoni* populations in the upper Lochsa River drainage, Northern Idaho. This report describes our efforts over a three year period, 1992-1994, with the understanding that more research is necessary in order to document any response to climatic change. The study has three components: 1) monitoring densities, distribution, migration timing, age structure and growth, and spawn timing patterns of mountain whitefish, 2) documenting changes in water temperature over time; and describing the relation between changes in whitefish population attributes and changes in environmental variables, and 3) modeling water temperature scenarios for the drainage to predict the responses of mountain whitefish to potential shifts in water temperature regimes caused by climate change. Study sites in White Sand and Crooked Fork creeks (within the Lochsa drainage) were monitored. Shifts in mountain whitefish densities, distribution, and migration timing were seen during snorkel surveys and tagging efforts at these sites from July to November, 1992-1994. Densities of mountain whitefish were reduced in 1994 as compared to previous years. In 1993, their distribution moved further upstream than in 1992. Age structure and growth was not fully investigated due to time and personnel constraints. Water temperatures in both creeks were slightly warmer in 1994 than 1993 or 1992. Homing to specific creeks was documented in 1993 and 1994. Observations of tagged whitefish provided information on mountain whitefish distribution patterns over time. Pre-spawning and postspawning migration were documented in White Sand and Crooked

Fork creeks. Thermographs at six locations recorded year-round water temperatures for calibration of the SNTEMP water temperature model and to determine correlations with timing of spawning and migration.

INTRODUCTION

A Fishery Resources Status and Trends (FRST) program was implemented to assess and monitor trends in North American fish populations and their habitats. The U.S. Fish and Wildlife Service began monitoring mountain whitefish *Prosopium williamsoni* populations and water temperature in the Lochsa River drainage in 1991 as part of a climate change component of the FRST program.

We chose to study mountain whitefish in the Lochsa River drainage due to: a) their narrow range of temperature tolerance (Sigler 1951); b) their widespread distribution throughout the western United States (Daily 1971); c) the abundance of whitefish in the Lochsa River drainage, and; d) water temperatures recorded in the Lochsa River that approach the upper tolerance limits of mountain whitefish (Espinosa 1990).

Sigler (1951) believed that mountain whitefish require cool water, and that high water temperatures limit their distribution. They feed primarily on aquatic insect larvae. Diet varies seasonally and with age. McHugh (1941) listed food and temperature as two important factors which affect the growth rate of mountain whitefish. Mountain whitefish reach a maximum size of 60 centimeters and a maximum age of 18 years. Age and growth depend upon productivity of the environment (Daily 1971).

Mountain whitefish annually demonstrate distinct migration patterns before and after spawning. In late summer they migrate out of the upper stream reaches to congregate in large deep pools at lower elevations. They use these pools and nearby run/riffle habitats as their spawning grounds (Brown 1952). Initial investigations found that most sexually mature mountain whitefish in the Lochsa River drainage also migrate upstream in the spring and summer, and downstream to spawn in the fall and winter (Berg and Garcia 1992). Changes in climate could potentially affect the distribution, migration, and spawn timing patterns of mountain whitefish due to their close links with water temperature (Brown 1952; Davies and Thompson 1976; Erickson 1966; Liebelt 1970; Pettit and Wallace 1975; Thompson 1974).

By monitoring mountain whitefish densities, distribution, migration timing, and age structure, we hope to document any shifts that may occur in these drainages. Subtle changes in water temperatures within the Lochsa River drainage could lead to changes in the population abundance, distribution, migration timing, age structure, or growth.

Specific objectives of this study follow:

Objective 1. Document annual changes in mountain whitefish population density (in each site), distribution in streams, migration timing, age structure and growth, and spawn timing patterns over time.

Objective 2. Document changes in water temperature over time; and describe the relation between changes in mountain whitefish population attributes and changes in environmental variables.

Objective 3. Assess the potential effects of climate change (meteorology, hydrology, and water temperature) on mountain whitefish by modeling water temperature scenarios for the upper Lochsa River drainage.

Our report covers work accomplished during our 1992-1994 field seasons (June-November). We monitored mountain whitefish populations during migration periods from 1992 through 1994 to document annual changes in population density, distribution, movement, and spawn timing patterns.

STUDY AREA

The Lochsa River drainage is located in the Clearwater National Forest in North Central Idaho, and begins in the Bitterroot Mountain Range. It covers 3,056 km^2 of primarily coniferous forest, with a limited mixture of deciduous forest, alpine vegetation, and rocky outcrops at higher elevations. The Lochsa River is formed by the confluence of White Sand and Crooked Fork creeks near the U.S. Forest Service's Powell Ranger Station (Figure 1). The study area is focused on White Sand and Crooked Fork creeks.

These two streams, similar in size, are characterized by widely variable flow regimes displaying average peak discharges of 85 m^3/sec (3,036 cfs) and 4.5 m^3/sec (161 cfs) during base flows (Espinosa 1990).

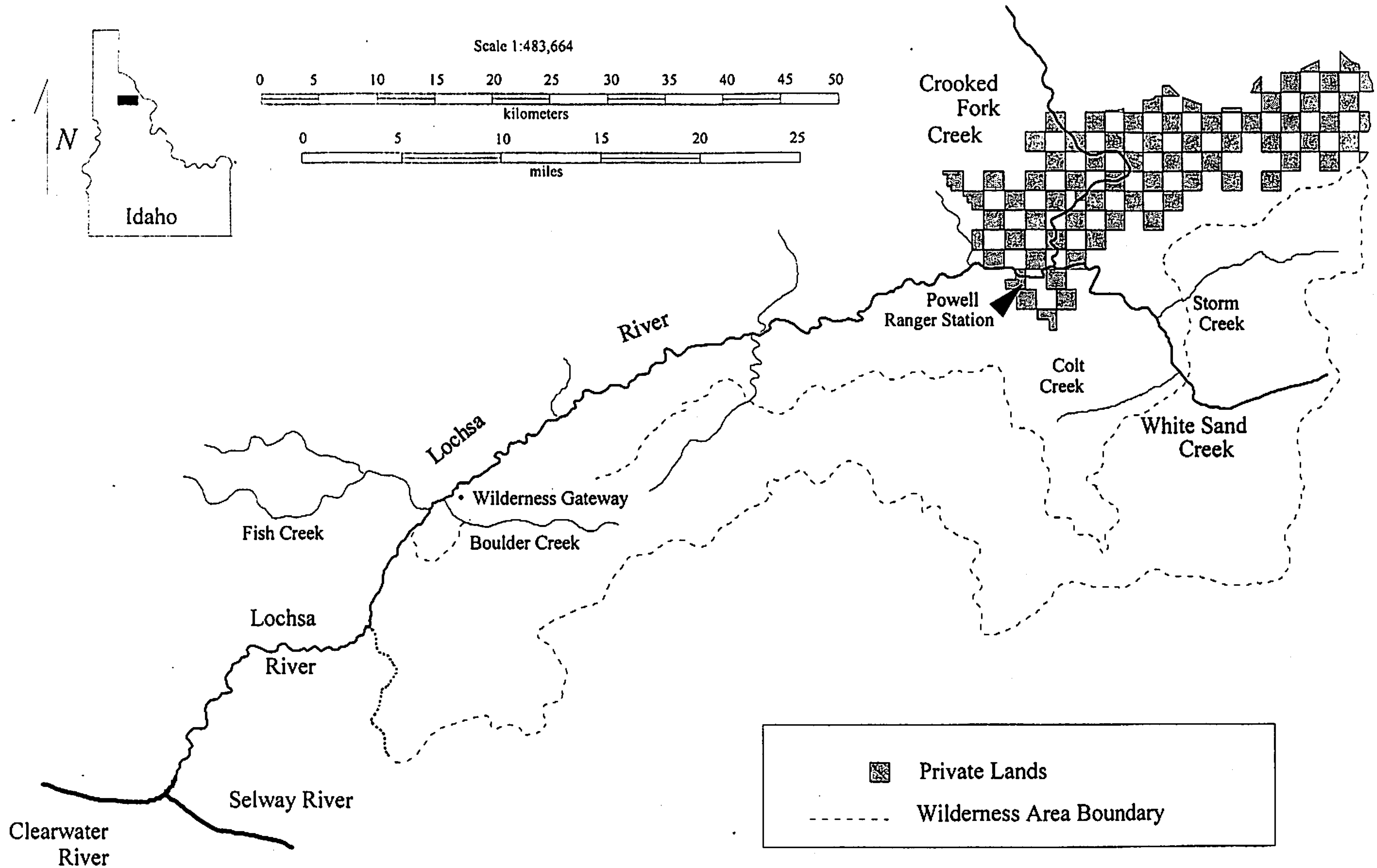

Figure 1. Lochsa River drainage features showing White Sand and Crooked Fork creeks, Lochsa River tributaries, and land ownership.

White Sand Creek drainage covers 860 km^2 and is essentially an undisturbed roadless wilderness area with over half of the drainage falling within the Selway-Bitterroot Wilderness. Roughly 13 km^2 of lower White Sand Creek drainage is privately owned (Figure 1). The study area in White Sand Creek begins approximately 2.4 km upstream of its confluence with Crooked Fork Creek and extends 24 km upstream.

Crooked Fork Creek drains 628 km^2 and contains a combination of Forest Service land, private inholdings, and areas impacted by timber harvest activities. A state highway parallels about 11 km of the lower part of Crooked Fork Creek (Figure 1). The study sites on this creek are approximately 6 km upstream of its confluence with White Sand Creek.

We chose 16 sites on White Sand Creek and 2 sites on Crooked Fork Creek as permanent study sites (Table 1, Figure 2). Sites were chosen based on various factors including: stream width, stream depth, water velocity, and presence of whitefish in some pools (Berg and Garcia 1992). Some pools were chosen without the presence of whitefish at that time. Originally, 18 sites on White Sand Creek were considered. However, two sites were eliminated due to low water conditions in 1994.
All 18 are included in Table 1 for reference.

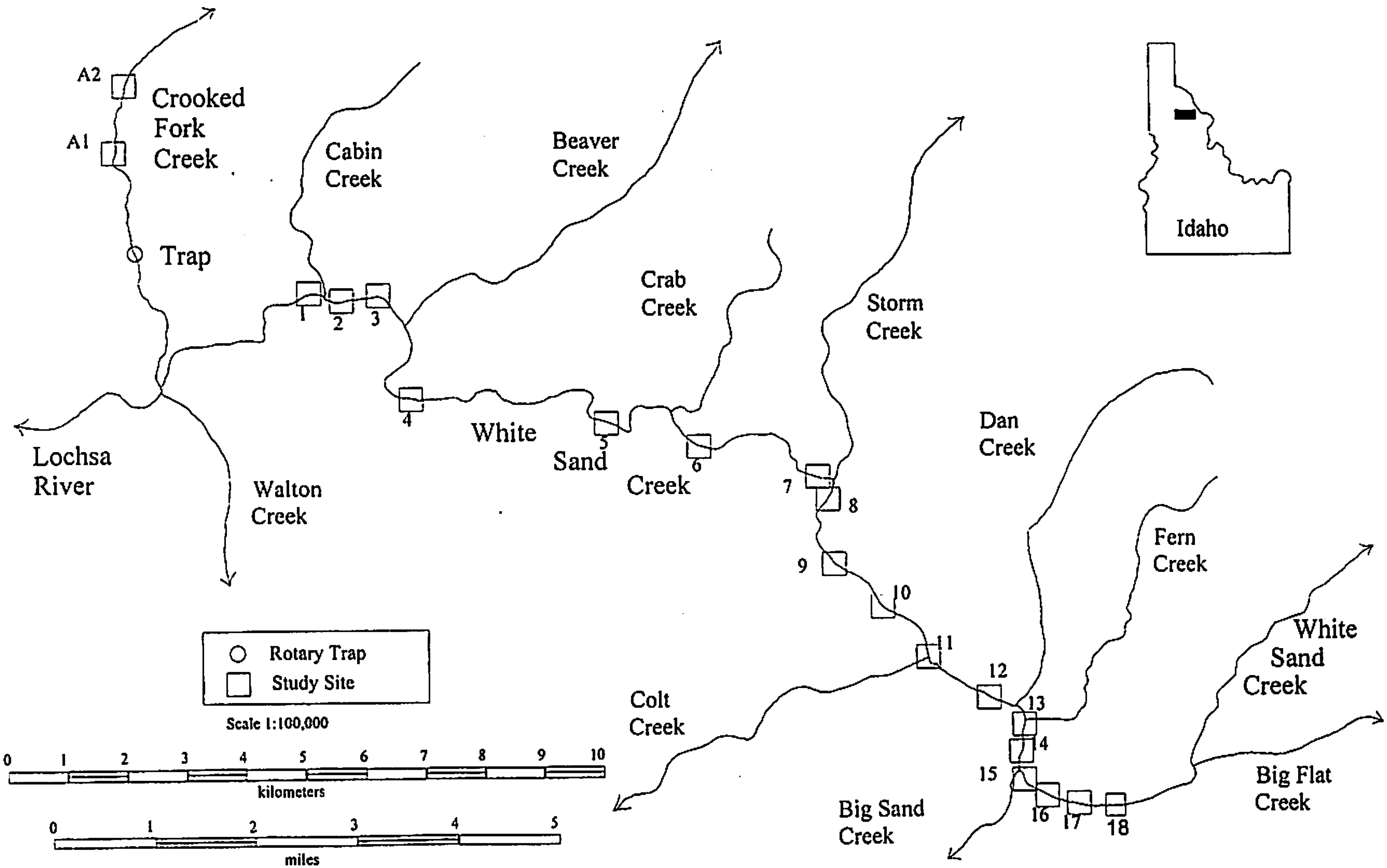

Figure 2. Area map of White Sand and Crooked Fork creeks.

TABLE 1.- White Sand and Crooked Fork creeks- site descriptions.
* Sites 3 and 17 were eliminated in 1994 due to low water conditions.

Site Number	Site Name	Location	Site Length(m)
1	Below Cabin Hole	White Sand Creek	113
2	Above Cabin Hole	"	75
3*	Rock Ledge Hole	"	25
4	Tallus Hole	"	22
5	Big Cutt	"	19
6	Big Flat	"	23
7	Below Storm	"	16
8	Above Storm	"	16
9	Pika Hole	"	29
10	Pillar Hole	"	41
11	Bridge Hole	"	48
12	Tamarack Hole	"	37
13	Fern Creek	"	47
14	Rock Hole	"	9
15	Big Sand Confluence	"	17
16	Plunge Pool	"	12
17*	Hidden Hole	"	16
18	Log Jam	"	16
A1	Moe Foe Hole	Crooked Fork Creek	39
A2	Below Russian Creek	"	33

METHODS

Mountain whitefish density

We used snorkeling to estimate density of mountain whitefish throughout our study sites. One or two people snorkeled downstream through each site. Two snorkelers were required when it was not possible for one person to view the full width of a site and when large numbers (greater than 50) of mountain whitefish were present. Sites with large numbers of fish required multiple passes (maximum of 3) to verify the count. When multiple counts were made, the highest count was used for that site. Densities were calculated using the number of mountain whitefish per 100 meters for each site.

In order to verify our snorkel counts, three validation counts were made in 1993 using an underwater video camera in White Sand and Crooked Fork creeks. After making snorkel counts, we used the same snorkel technique through the study site, filming the school of mountain whitefish with a hand held video camera. Snorkelers would then use the film for validation counts on a TV screen in the office. Validation counts were compared to snorkel counts to check accuracy.

Distribution

Pilot surveys were conducted in the spring of each year to document extent of mountain whitefish distribution downstream within the Lochsa River. Sites in the Lochsa River were previously established by Idaho Department of Fish and Game, and the Idaho Research Coop Unit's. The sites in Appendix 1 were chosen as the April survey sites, and were surveyed only once each spring. Three snorkelers were required, and the same technique was used as previously described.

We monitored all study sites on White Sand and Crooked Fork creeks between July and November, 1992-1994. At the start of each field season, we snorkeled all 18 sites to document mountain whitefish summer distribution patterns and to establish the current upstream limit of mountain whitefish distribution. In the following surveys, we monitored upper White Sand Creek (sites 11-18) to document the beginning of their downstream migration. Once the mountain whitefish began their migration to the lower sections of White Sand Creek we focused our efforts there. Surveys were done between two and four times a month until no mountain whitefish were seen in any of the sites. We did not continue to snorkel the upper sites after zero counts were obtained for those sites, signalling the migration had begun.

Movement

In order to determine baseline seasonal movement and distribution patterns of mountain whitefish, a tagging component was included in October of each year. Tagging efforts were concentrated in areas with high densities of mountain whitefish. A different tag color was used for each site and year (Table 2).

TABLE 2.- Mountain whitefish tagging locations, color and year tagged. Note that some tag colors do fade, so tag colors observed may document unexpected results.

Creek	Year	Site	Color
White Sand			
	1992	1,2,3	red
	1992	4	blue
	1992	5	orange
	1993	1,2	white
Crooked Fork			
	1992	A1	yellow
	1993	A2	pink
	1994	A1	bright orange

Mountain whitefish in White Sand and Crooked Fork creeks were captured with hook and line. In addition, mountain whitefish in Crooked Fork Creek were captured in a screw trap that was operated by Idaho Department of Fish and Game between June and November. Once captured, fork length (mm) and weight (kg) were taken. Three-inch Floy T-bar anchor tags were inserted through the base of the dorsal fin. Fish were released after holding for 10 minutes. An experiment to assess tag retention and mortality was conducted in 1993. Six tagged whitefish were held in a net pen for 13 days and observed for tag retention and abnormalities related to handling.
In 1993, a lift net was also tried to capture mountain whitefish for tagging.

Age and growth

Once captured, a scale sample was taken (4-5 scales from the area between the dorsal fin and the lateral line) prior to tagging. These scales were placed in scale envelopes for each fish and kept for later analysis.

In 1992, tricaine methanesulfonate (MS-222) buffered with sodium bicarbonate was used to anesthetize fish captured in White Sand Creek during scale sampling and tagging. However, due to slow fish recovery rates, all fish subsequently captured in both creeks were handled without the use of an anesthetic.

Spawning

Reproductive maturation was assessed by indicators such as an extended abdomen (swollen vs. slender), a swollen cloaca (approximately 0.5 cm), and the presence of extruding eggs or milt. Additional spawn timing movement data were obtained by monitoring numbers of mountain whitefish captured in the Idaho Department of Fish and Game's screw trap on Crooked Fork Creek.

Temperature Monitoring

Water temperature was recorded every two hours year-round at six locations within the Lochsa River drainage (Figure 3). Ryan Temp-Mentors were deployed to record the temperatures. The data was downloaded once or twice a year for use in the temperature modeling work.

Temperature Modeling

We used the Stream Network Water Temperature (SNTEMP) model (Bartholow 1989) to simulate water temperature scenarios for the Lochsa River drainage. The model uses actual meterological, hydrological, stream geometry and solar data to simulate possible

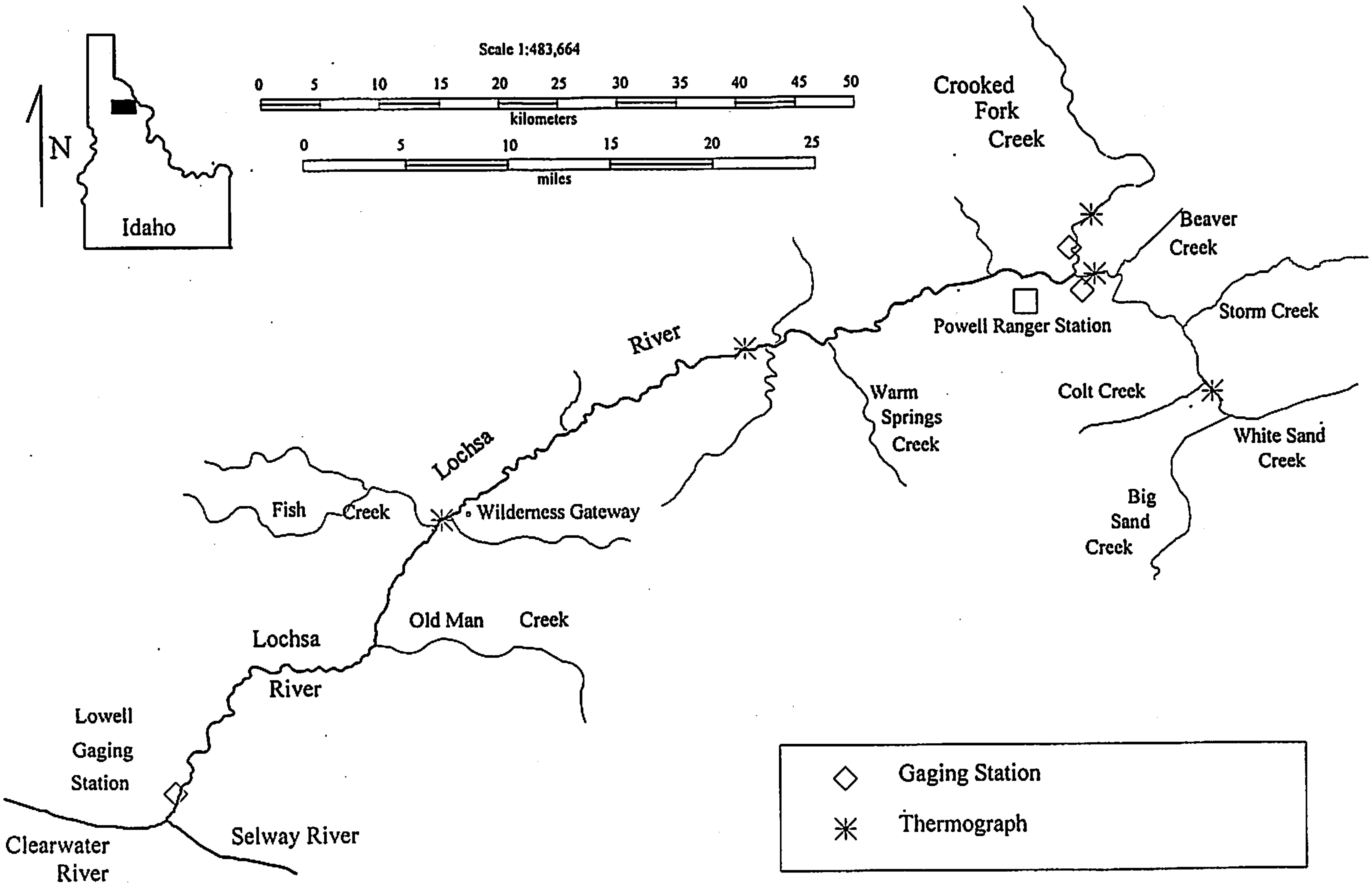

Figure 3. Lochsa River drainage hydrology monitoring sites.

future climate conditions. The scenarios chosen reflect possible future climate conditions. These were based on global warming projections made by Hengeveld (1990) in Canada.

In order to run the SNTEMP model, climatological data (mean daily air temperature, wind speed, relative humidity, and cloud cover) have been obtained from the Western Regional Climate Center, the Natural Resources Conservation Service, the U.S. Forest Service, and the National Weather Service. These data have been compiled to enter into the meterology section of the SNTEMP model to run multiple temperature scenarios for mountain whitefish areas in White Sand Creek. We also recorded daily water temperatures and obtained flows to enter into the hydrology section of the model. The flow data was recorded by the U.S. Forest Service year-round at three locations in the drainage (Figure 3).

RESULTS

Mountain whitefish densities and distribution

Mountain whitefish were observed in White Sand Creek between site 16 (near Big Sand Creek) and site 1 in two out of three years (Figure 2). Overall densities of mountain whitefish were highest in the years when water temperatures were lowest. Total densities of mountain whitefish in most sites on White Sand Creek were lower in 1994 than in the previous two years (Figures 4 and 5). Estimates of mountain whitefish densities in White Sand Creek (from August through November each year) indicated

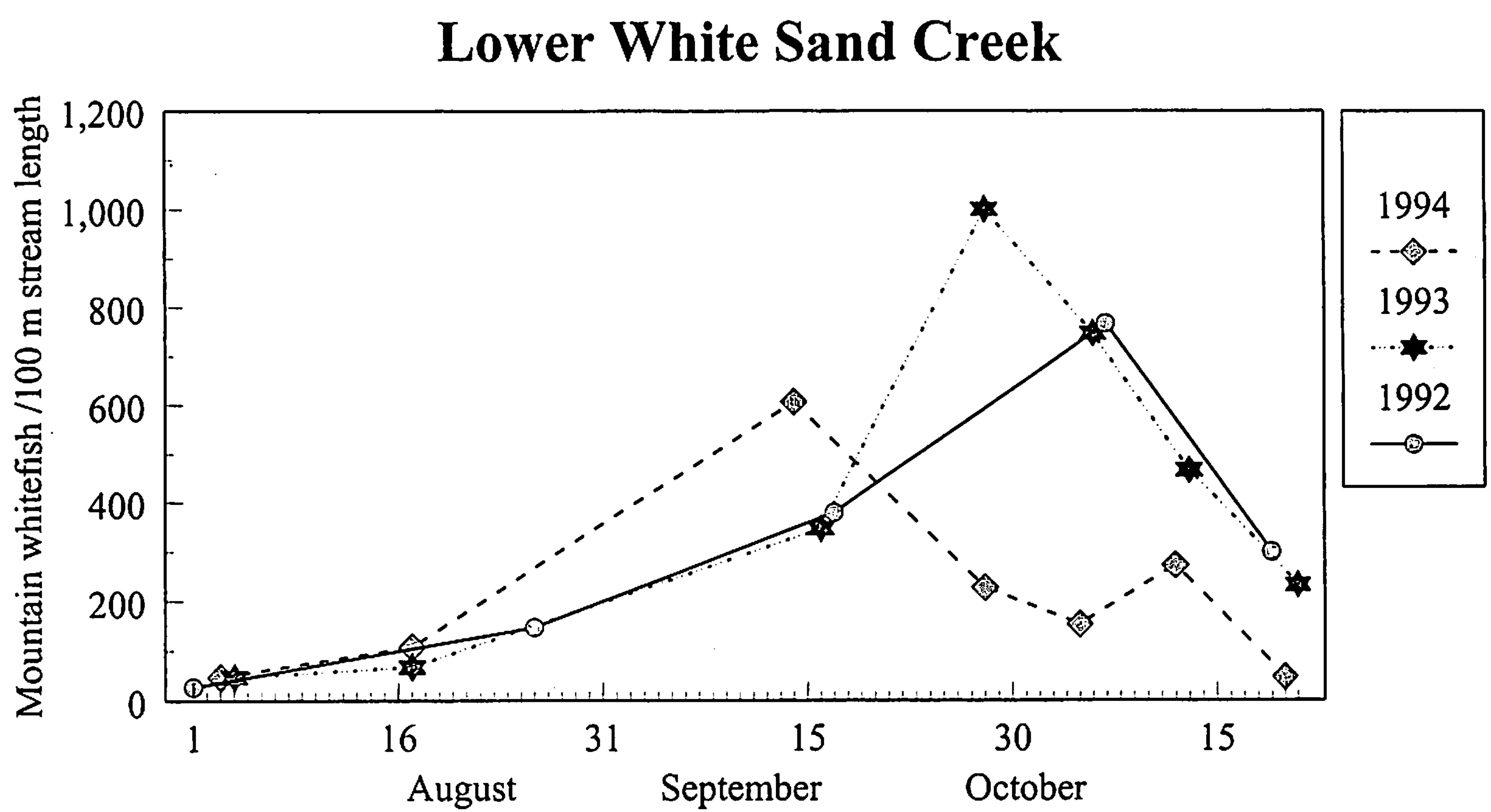

Figure 4. The density of mountain whitefish observed during weekly snorkel counts at site 2 (White Sand Creek) over a three year period (1992-1994).

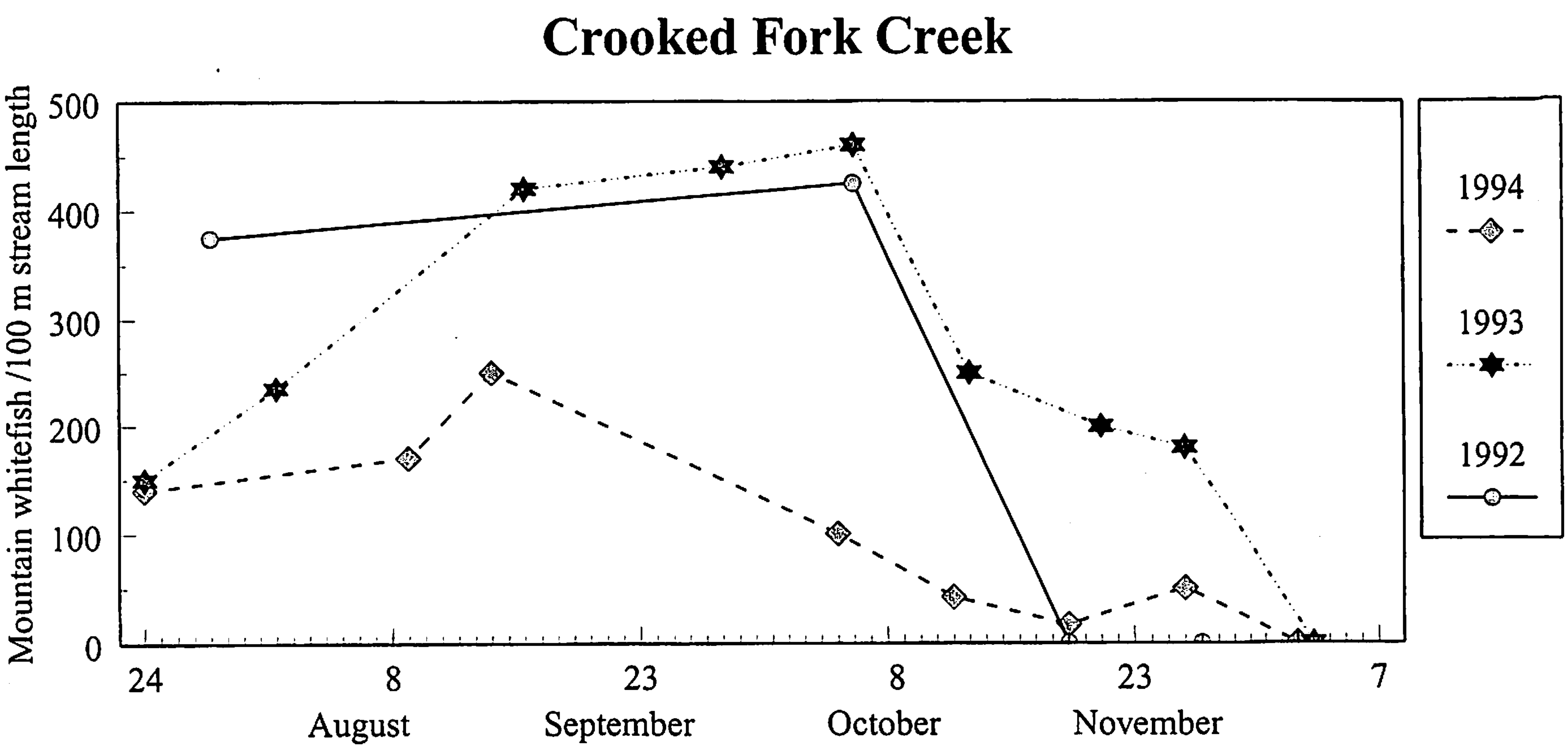

Figure 5. The density of mountain whitefish observed during weekly snorkel counts at site A1 over a three year period (1992-1994).

that most of the mountain whitefish moved out of all sites above site 8 by mid-September at the latest (Appendices 2-4). By late-September or early October, larger schools of mountain whitefish were observed congregating downstream, particularly at sites 4 and 2. By November, mountain whitefish had moved downstream from these sites into the Lochsa River.

In Crooked Fork Creek, overall annual densities of mountain whitefish were also highest in low water temperature years. Total densities of mountain whitefish were lower in 1994 than in previous years. Estimates of mountain whitefish densities from August through November indicated a downstream mountain whitefish concentration in our sites by mid-September in most years (Appendices 2-4). By mid-October our snorkel estimates usually indicated dwindling numbers of mountain whitefish and the beginning of a downstream migration of mountain whitefish out of Crooked Fork Creek into the Lochsa River. By November 2 every year, no more mountain whitefish were observed at our sites in Crooked Fork Creek.

To verify our snorkel counts, three video validation counts were done in 1993. Our video validation counts of numbers of mountain whitefish were within 1% of actual field snorkel counts. Only videos taken with optimal conditions (good light and low turbidity) were usable. On October 21, 1993, site 2 on White Sand Creek had a field count of 175 mountain whitefish and a video validation count of 170 mountain whitefish. One exception was noted on August 25, 1993, at site A2 in Crooked Fork

Creek when field counts (42) were 11% higher than video validation counts (37) due to poor afternoon light conditions.

Movement

Observations during each year of the study in White Sand and Crooked Fork creeks showed a prespawning migration. Small schools of mountain whitefish were widely dispersed in White Sand Creek in early August. By mid-August to mid-September, mountain whitefish had vacated the upper sites and moved downstream in their prespawning migration. This timing was different between years, with the migration beginning earlier in 1994 than in other years (Appendices 2-4). The water temperatures were 2-4^{0}C higher in 1994 than in 1993 or 1992 (Figures 6 and 7).

Annual spring snorkel surveys in the Lochsa River showed the presence of mountain whitefish as far downstream as Deadman Creek at river mile 106.7. Additionally, one tag was returned by a fisherman from a tagged mountain whitefish he caught around river mile 90 near Lowell, Idaho. This is 50 miles downstream from where the fish was originally tagged in Crooked Fork Creek. No other tagged mountain whitefish were observed during 1993 on our spring snorkel surveys on the Lochsa River.

In addition to the movement data presented, we noted whitefish movement by observing tagged mountain whitefish. A total of 273 mountain whitefish were tagged in Crooked Fork Creek and 287 mountain whitefish in White Sand Creek from 1992 to 1994.

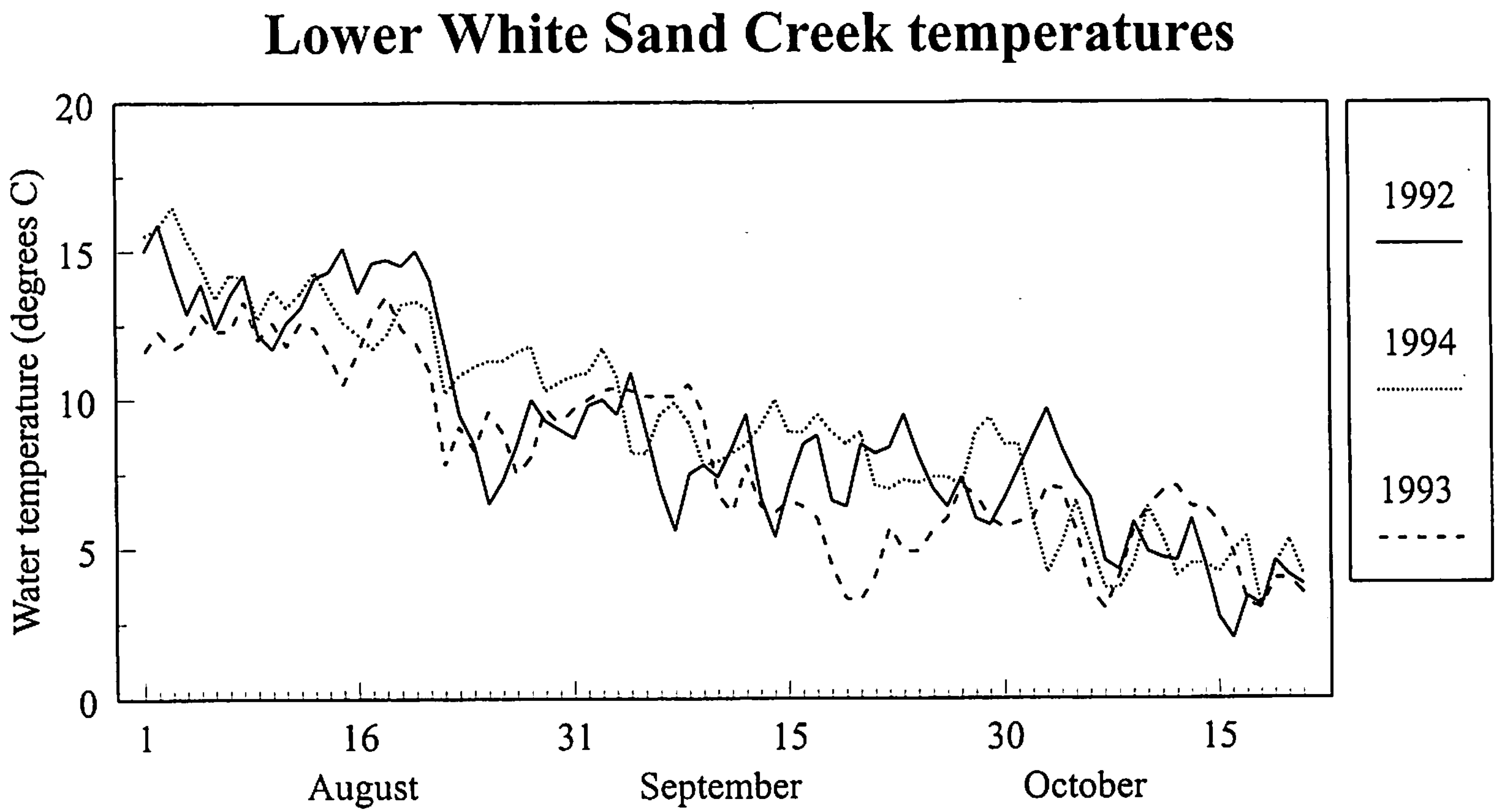

Figure 6. The minimum daily water temperatures on lower White Sand Creek over the years 1992-1994.

Crooked Fork Creek temperatures

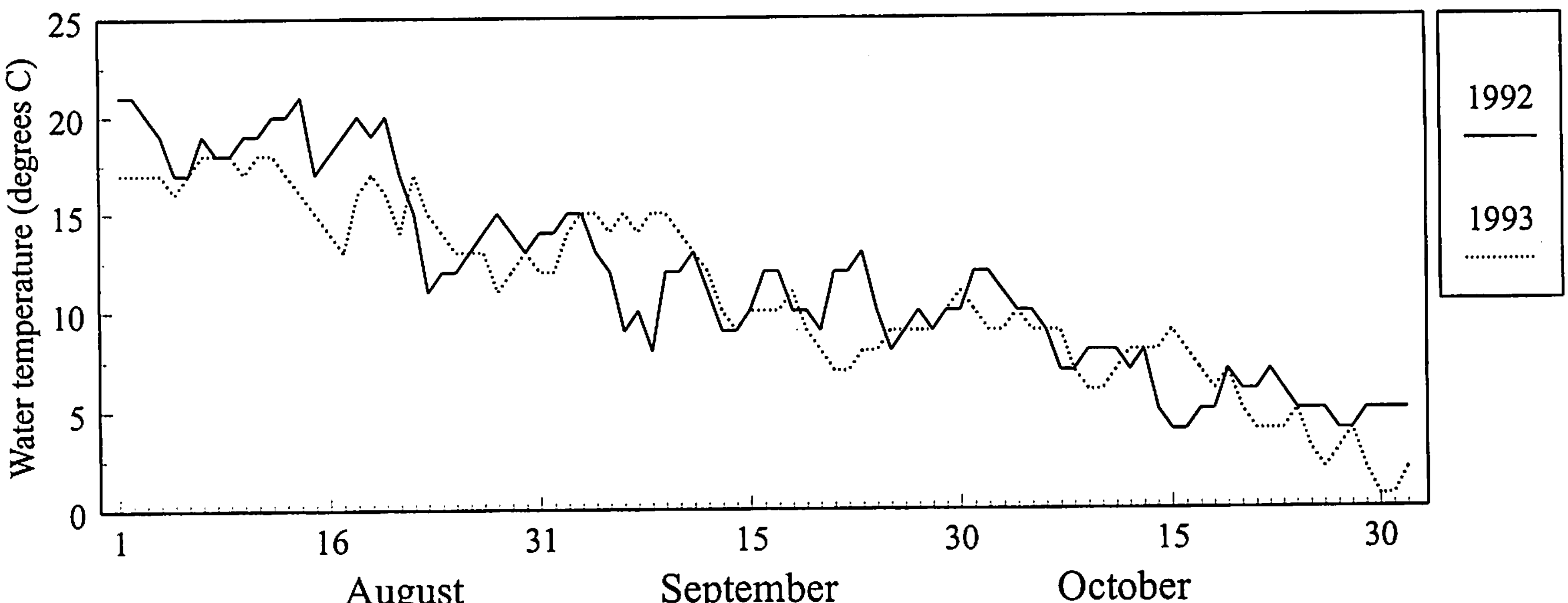

Figure 7. The maximum water temperatures on Crooked Fork Creek for the years 1992 and 1993 (1994 temperature information unavailable).

Later, through 917 observations of tagged fish (often the same fish seen on different dates), we documented homing to specific creeks but not to specific sites. During this time, we observed tagged mountain whitefish migrating upstream as far as site 15 in White Sand Creek, with distribution downstream throughout our snorkel sites (Appendix 7).

Age structure and growth

Scales were taken from 560 mountain whitefish. Age analysis has not been completed at the writing of this report.

Spawning

Observations of fish captured for tagging indicate that the majority of mountain whitefish spawning occurred during October. First observations of ripe mountain whitefish in White Sand and Crooked Fork creeks usually coincided with water temperatures of 3°C in early October. Fish may have been ripe earlier than these dates. By late-October each year, most of the mountain whitefish were already spent but a few were still ripe.

Use of the net suspension system to capture mountain whitefish was abandoned after a few days. Ninety-five mountain whitefish were captured in it during its use in 1993, but this was not enough fish to justify the intensive effort necessary to set up the system and run it.

Temperature Monitoring

The Ryan Temp-Mentors were downloaded one or two times annually. Temperatures recorded showed slight variations between streams and between years (Figures 6 and 7).

Spawning and movement exhibited a seasonal curvilinear-relation between time of year and fish density each year. This would indicate some relation between temperature and fish density (although flow, photoperiod, or turbidity would also have some effect). Fish did appear to begin their downstream migration and start congregating around temperatures between 4-8^{0}C. This relation changed slightly from year to year and from site to site (Figures 4 through 7, Appendices 2-4).

Temperature Modelling

Hengeveld (1990) predicts a global climate warming of 1.5 to 4.5^{0}C during the next century. We simulated this scenario using the SNTEMP model. The SNTEMP calibrated model was built using hydrological and climatological data from July 15 to November 15, 1993. The calibrated model reaches the hypothesized range of mountain whitefish spawning temperatures of 4-6^{0}C (Brown 1952) in lower White Sand Creek by about October 6 (Figure 8). A model simulation of warming air temperatures by 1.5^{0}C, 3.0^{0}C, and 4.5^{0}C only slightly shifted the dates at which specific temperatures were reached.

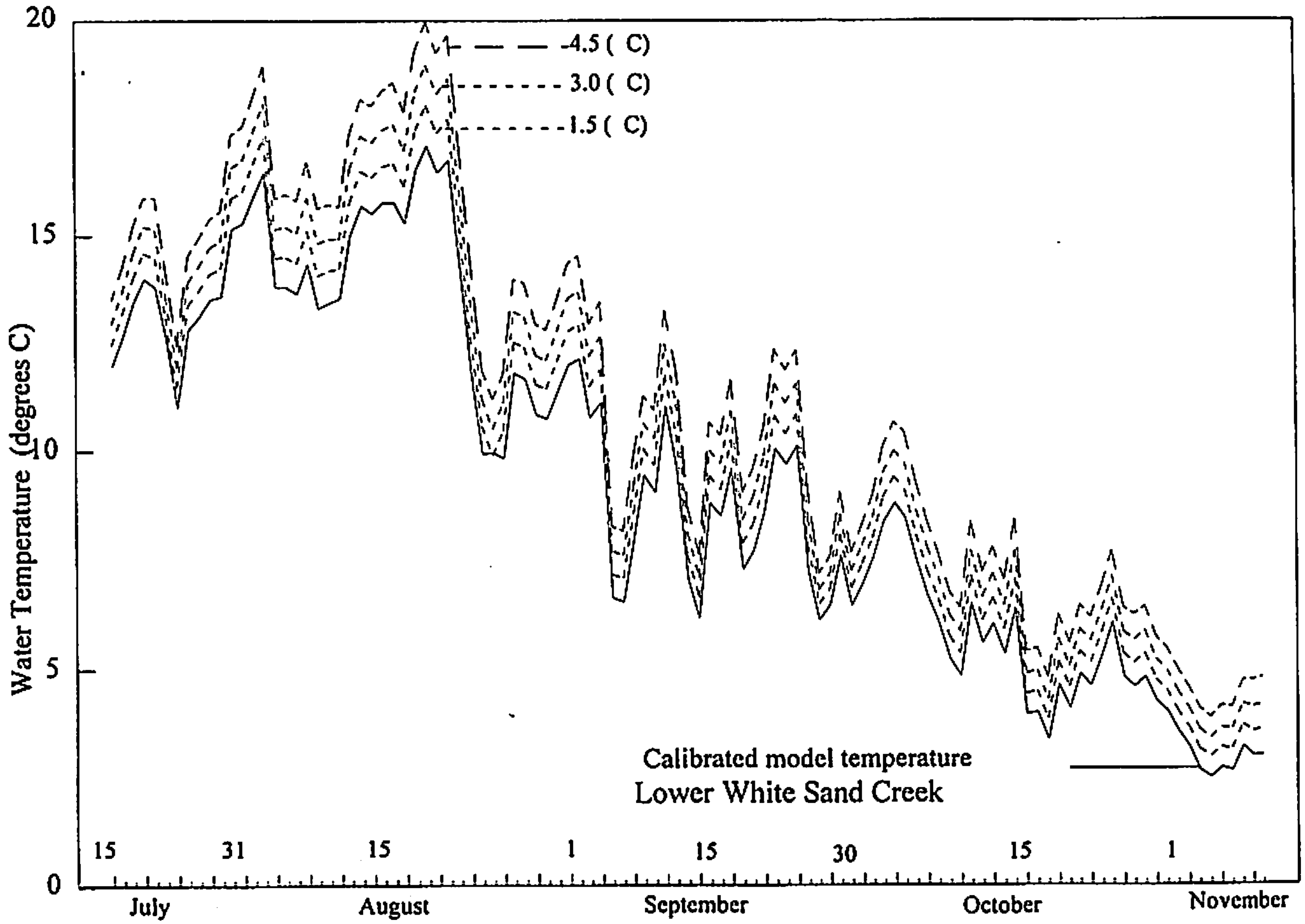

Figure 8. Water temperatures from the calibrated SNTEMP model with three simulated scenarios for lower White Sand Creek (site 2).

DISCUSSION

Density

The overall pattern of densities each year in both White Sand and Crooked Fork creeks fluctated as the season changed. This was a part of the mountain whitefish's standard natural history, with summer low densities in each site and fall congregating of fish for spawning. Our study documented these patterns, with one additional observation. During 1994, mountain whitefish were seen in reduced densities at most sites in both creeks (Figures 4 through 6, Appendices 2-4). 1994 was also a low flow year. Sigler (1951) found in Logan, Utah, that streams which measured less than 16 ft. maximum width and 4 ft. maximum depth at minimum flows lacked whitefish. He believed that low water does not provide acceptable cover. This may have been part of the reason for our observations of reduced densities of mountain whitefish.

Movement, distribution and spawn timing

Early seasonal mountain whitefish movement, referred to as a prespawning migration, has been documented by Davies and Thompson (1976) in the Sheep River in Canada. We verified a similar prespawning migration in White Sand and Crooked Fork creeks. As documented by Pettit and Wallace (1975) mountain whitefish also demonstrate a downstream postspawning migration to overwintering sites where winter conditions are less severe. Our data on downstream migration timing was in agreement with Petit and Wallace (1975). Our observations indicate this movement coincided with spawning documented during our tagging efforts. Other investigators reported similar mountain whitefish spawning, usually near 6°C (Breder and Rosen 1966; Brown 1952; Brown 1972; Thompson and Davies 1976).

Most mountain whitefish floy tagged in the fall of 1992 and 1993 returned to their respective streams in the spring and summer of 1994, exhibiting a strong homing behavior. There were a few anomalies to this situation but were associated to tags that had faded. We have verified that the pink tags do fade to white, and we suspect that some yellow tags observed may have been faded orange tags. In spite of these few anomalies, we did observe homing to specific streams by the majority of tagged mountain whitefish in White Sand and Crooked Fork creeks.

Temperature Monitoring

As mentioned earlier, the prespawning migration in Lower White Sand and Crooked Fork creeks occurred earlier in 1994 than in previous years (Appendix 2 through 4). Low flows and high water temperatures (near lethal) may be part of the cause for these events. Sigler (1951) and LaRivers (1962) believed that high water temperatures limit mountain whitefish to elevations above 4,500 ft. in California, Nevada, and Utah. Mountain whitefish in Idaho have been shown to be sensitive to temperatures exceeding 20°C (personal communication, Jody Brostrom, Lewiston, Idaho-IDFG). In 1994, the temperatures in the Clearwater River (downstream from White Sand and Crooked Fork creeks) reached 22°C. After this event, dead mountain whitefish were seen floating in the river. We have noted temperatures as high as 17.4°C in upper White Sand Creek, but have not directly tested the temperature tolerances of mountain whitefish.

Temperature Modeling

A shift in the global climate could result in one of many different scenarios for mountain whitefish populations in the Lochsa River drainage. Although our model predicts the date a particular temperature would occur or how much water temperature would change, the reaction of aquatic organisms to their environment can only be hypotheisized without additional data. Mountain whitefish spawning may occur later in the year with warmer temperatures; earlier with cooler temperatures; or they may choose different, perhaps less suitable spawning grounds further upstream or downstream at the same time of year. Continued annual monitoring would provide us with data to more accurately confirm mountain whitefish population changes by correlation to water temperature.

SUMMARY

Since this project is designed to be a long-term monitoring project, we preface our observations with the reminder that the conclusions here are made with a short-term data-set. After three years of monitoring mountain whitefish in White Sand and Crooked Fork creeks, we observed several events occuring: Fluctuations were seen in densities of mountain whitefish (generally, lower fish densities with high water temperatures); mountain whitefish distributions changed seasonally, with migrations upstream in the summer and downstream in the fall; minor shifts in mountain whitefish migration timing were observed (earlier in 1994); fluctuations in water temperature were seen within and between years; it appears that mountain whitefish migration may be associated with spawning, and finally; there may be a relation between water temperature and migration/spawning timing.

In addition, we developed a site-specific temperature model which can predict some possible outcomes of climate change. However, we cannot draw firm conclusions from a three-year data set. For a global warming study, we need to continue with consistent monitoring protocol that we established. Long-term data sets are needed in order to make conclusions.

ACKNOWLEDGEMENTS

We thank the U.S. Forest Service's Powell Ranger Station for providing housing on many of our survey trips. We also thank Idaho Department of Fish and Game for providing information on mountain whitefish captured in their screw trap, and for their assistance in fishing and tagging. Additional help in snorkeling and tagging was provided by Dworshak National Fish Hatchery personnel and their time and effort is appreciated.

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Appendices

Appendix 1.- Location and physical descriptions of monitoring sites in the Lochsa River.

General Location	River Mile	Hwy.Mile	Section Length (m)	Section Description
Above Fish Ck.	25.5	120.1	95.6	run, pocket water
Above Sherman Ck.	27.0	123.0	---	pool,run
Above Five Island	31.0	127.1	137.0	pool
Below Castle Creek	35.5	131.5	48.7	pocket water
Below Skookum	39.0	134.7	100.0	pool
Above Indian Creek	45.0	139.6	180.0	pool,run
Below Colgate Lick Creek	53.0	147.2	103.0	pocket water
Below Jerry Johnson C.G.	56.0	150.3	66.0	pool
Below Badger Creek	62.0	156.0	80.3	pool
Below Papoose Creek	65.5	159.2	84.5	run

Appendix 2.- Densities of mountain whitefish (fish per 100 m. stream length) at snorkel sites in White Sand and Crooked Fork creeks, 1994.

Site No.	Site Name	Jul 20	Aug 3	Aug 17	Sep 14	Sep 28	Oct 5	Oct 12	Oct 20	Oct 26	Nov 2
1	Below Cabin	103	81	72	68	80	89	53	38	0	--
2	Above Cabin	--	47	107	607	228	153	273	47	0	--
3	Rock Ledge	--	--	--	--	--	--	--	--	--	--
4	Tallus	--	80	129	0	--	--	--	--	--	--
5	Big Cutt	--	50	77	12	0	--	--	--	--	--
6	Big Flat	7	6	3	0	--	--	--	--	--	--
7	Below Storm	17	70	33	0	--	--	--	--	--	--
8	Above Storm	5	15	10	0	--	--	--	--	--	--
9	Pika	10	35	45	0	--	--	--	--	--	--
10	Pillar	0	15	22	0	--	--	--	--	--	--
11	Bridge	38	27	27	0	--	--	--	--	--	--
12	Tama-rack	68	22	16	0	--	--	--	--	--	--
13	Fern	9	0	--	0	--	--	--	--	--	--
14	Rock	0	11	22	0	--	--	--	--	--	--
15	B.Sand	12	6	24	0	--	--	--	--	--	--
16	Plunge	8	0	0	--	--	--	--	--	--	--
17	Hidden	--	--	--	--	--	--	--	--	--	--
18	Log Jam	0	0	0	--	--	--	--	--	--	--
A1	Moe	318	323	359	641	--	256	108	44	128	0
A2	Russian	106	109	167	73	--	36	0	--	--	--

-- = Not Snorkeled

Appendix 3.- *Densities of mountain whitefish (fish per 100 m. stream length) at snorkel sites in White Sand and Crooked Fork creeks, 1993.*

Site No.	Site Name	Aug 4	Aug 18	Sep 16	Sep 28	Oct 6	Oct 13	Oct 21	Oct 26	Nov 3
1	Below Cabin	35	66	142	531	372	243	150	75	11
2	Above Cabin	47	67	347	1000	747	467	233	160	0
3	Rock Ledge	26	41	7	4	0	--	--	--	--
4	Tallus	40	47	743	0	--	--	--	--	--
5	Big Cutt	31	46	31	46	212	0	--	--	--
6	Big Flat	11	15	0	--	--	--	--	--	--
7	Below Storm	13	20	7	0	--	--	--	--	--
8	Above Storm	10	0	0	0	--	--	--	--	--
9	Pika	7	10	7	3	3	--	--	--	--
10	Pillar	12	5	2	0	0	--	--	--	--
11	Bridge	36	32	32	2	2	--	--	--	--
12	Tama-rack	32	54	19	5	5	0	--	--	--
13	Fern	17	9	6	0	--	--	--	--	--
14	Rock	0	0	--	--	--	--	--	--	--
15	B.Sand	6	0	--	--	--	--	--	--	--
16	Plunge	8	0	--	--	--	--	--	--	--
17	Hidden	0	0	0	--	--	--	--	--	--
18	Log Jam	--	0	0	--	--	--	--	--	--
A1	Moe	256	385	603	1077	1179	641	513	462	0
A2	Russian	76	127	127	197	158	30	0	--	--

-- = Not Snorkeled

Appendix 4.- Densities of mountain whitefish (fish per 100 m.stream length) at snorkel sites in White Sand and Crooked Fork creeks, 1992.

Site No.	Site Name	Jul 13	Aug 25	Sep 17	Oct 6	Oct 19	Oct 26	Nov 2
1	Below Cabin	46	75	40	310	6	28	0
2	Above Cabin	27	147	380	767	300	60	0
3	Rock Ledge	23	75	79	56	548	100	0
4	Tallus	35	183	569	421	2	0	0
5	Big Cutt	58	365	0	0	--	--	--
6	Big Flat	--	132	0	0	--	--	--
7	Below Storm	13	10	0	0	--	--	--
8	Above Storm	0	0	0	0	--	--	--
9	Pika	7	0	0	0	--	--	--
10	Pillar	7	0	0	0	--	--	--
11	Bridge	4	0	0	0	--	--	--
12	Tama-rack	19	3	0	0	--	--	--
13	Fern	11	0	0	0	--	--	--
14	Rock	33	0	0	0	--	--	--
15	B.Sand	0	0	0	--	--	--	--
16	Plunge	0	0	0	--	--	--	--
17	Hidden	0	0	0	--	--	--	--
A1	Moe	1282	962	--	1090	0	0	--
A2	Russian	--	348	--	91	0	0	--

-- = Not Snorkeled

Appendix 5.- Spawning condition of mountain whitefish on White Sand (WSC) and Crooked Fork (CFC) creeks, 1993-1994.*

Site	Date	Sex	Total	Ripe	%
WSC	10/7/93	M	24	18	75
		F	57	11	19
	10/14/93	M	4	4	100
		F	25	5	20
	10/21/94	M	5	5	100
		F	3	3	100
	10/25/94	M	15	15	100
		F	1	1	100
	10/26/93	M	0	0	0
		F	8	8	100
CFC	9/29/93	M	29	14	100
		F	9	0	0
	10/7/93	M	11	9	82
		F	15	12	80
	10/22/93	M	1	1	100
		F	10	8	80
	10/26/93	M	8	8	100
		F	9	7	78

* Insufficient data for 1992 ripeness results

Appendix 6. -Schedule of Work Activities
The following schedule of activities was used as a guide.

January: Put out fisherman survey forms in local sports shops. This is to document mountain whitefish lower-most distribution in the Lochsa River.

March: Conduct snorkel survey in the Lochsa River to look for floy tagged fish. Begin work on collecting climatological data from outside sources (i.e. Western Regional Climate Center-Reno) for the temperature model. Begin work on reading mountain whitefish scales from previous field seasons.

April: Continue to collect data for temperature modeling. Complete scale age-length analysis.

May: Continue to collect data for temperature modeling.

July: Conduct first snorkel survey of the season to establish summer distribution during the second or third week of the month depending on flows. Check with USFS Powell Ranger Station for flow information. Snorkel all sites in both creeks. Download all thermographs in White Sand Creek, Crooked Fork Creek, and the Lochsa River.

August: Conduct second snorkel survey during the second week of the month. Make a third survey in the last week of August. Note: Mountain whitefish had vacated all our upper sites between July 15 and August 29 during the year 1993. This added trip should better define that movement. In addition, the most likely time to document bull trout in White Sand Creek is mid to late August.

September: Based on our findings in August, the next survey trip should be the first or second week of the month. All succeeding survey trips will then be made bi-weekly in conjunction with length and scale collection. While collecting length data (using rod and reel methods) we will be monitoring for spawning ripeness. Set up a tag retention test. Coordinate with IDFG to get information from their screw trap on Crooked Fork Creek. Peak timing of mountain whitefish prespawning activity (i.e. migrating downstream and congregating in large schools) appears to be around late September to early October.

October: Continue snorkel surveys bi-weekly until spawning appears to be very close. Then begin the weekly snorkel surveys with emphasis on observing some actual spawning activity (egg deposition,etc.). Continue to capture fish for length and scale collection and spawning ripeness information.

November: Continue to monitor mountain whitefish movement until all sites on both creeks are vacated. Then download thermographs at all 6 Temp-mentor sites. Send temperature data to USFS (Powell), and bull trout data to USFWS-ES (Spokane). Begin to write up annual report.

December: Write annual report. Send copies to appropriate offices.

Appendix 8. - Lochsa River snorkel survey results, 1992 and 1993. (No survey was conducted in 1994.)

Location	Date	No.Mountain Whitefish Observed	No. Tags Observed
Above Fish Creek	11/24/92	30	0
	4/8/93	0	0
Above Sherman Ck.	2/10/92	0	0
Above Five Island	2/10/92	300	0
	11/24/92	6	0
	4/8/93	0	0
Above Indian Grave Creek	2/10/92	1	0
	11/24/92	90	0
Below Colgate Lick Creek	--	--	--
Below Jerry Johnson Creek	--	--	--
Below Badger Creek	--	--	--
Below Papoose Creek	--	--	--

-- = Not Snorkeled

Appendix 9.- Photographs of sites and activities.