Thermal Refugia Use by Adult Salmonids in the Klamath River Basin

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Project Description

This collaborative project uses temperature sensitive radio transmitters to track the movements and monitor the internal body temperatures of adult spring chinook during upriver migration in the Klamath River Basin, California. Salmon are tagged throughout the run in or near the Klamath River estuary and tracked to their respective holding areas or natal tributaries. Combined with data from automated listening stations, external archival temperature tags, river temperature monitoring, and snorkel surveys of thermal refugia the results of this study will provide valuable information on thermal refugia use, thermal experience, migration behavior, and stock specific run timing for adult spring chinook. This project is a critical step towards understanding the role of
thermal refugia in mitigating stress and mortality from elevated temperatures during upriver migration.
Background

The negative effects of altered thermal regimes on salmonids, primarily in the form of elevated water temperatures, are well documented. Mortality is the most obvious negative effect of increased stream temperatures; however, non-lethal effects can be highly detrimental as well. Potential negative effects include decreased growth and survival of juveniles (Brett 1979; NRC 1996), pre-spawning mortality of adults (Gilhousen, 1990; Schreck and Li 1991; Bartholow 1995), delays in upstream migration (Berman & Quinn 1991), decreased egg size and viability (Smith et al. 1983; Berman 1990), and numerous other consequences.

Severe Columnaris infection of Salmon River spring chinook, Bluff Creek Refuge 2002
Use of cold water areas, or thermal refugia, is one way that salmonids accomplish thermoregulation in the face of sub-lethal or lethal temperatures (Beschta et al. 1987; Berman and Quinn 1991; Nielsen et al., 1994; Belchik 1997; Torgersen et al. 1999; Ebersole et al., 2001). The presence of sufficient thermal refugia can allow populations of salmonids to exist in otherwise inhospitable habitats (Torgersen et al. 1999), and may increase the carrying capacity of thermally marginal stream systems (Burns 1971).

Water temperature in the Klamath and lower Trinity Rivers typically exceeds stressful (15°C), sub-lethal (20°C), and even upper incipient lethal (25°C) temperature thresholds (Armour 1991; Bjornn and Reiser, 1991; Bartholow, 1995) for extended periods during summer months (Belchik 1997; McIntosh and Li 1997; Yurok Tribal Fisheries, unpublished data). During these periods, adults and juveniles of all fish species in both rivers have been observed using thermal refugia in the form of cool-water tributary confluences and seeps (Belchik 1997; Yurok Tribal Fisheries, unpublished data).

The Yurok Tribe, the Karuk Tribe, the Hoopa Tribe, and the U.S. Fish and Wildlife Service (USFWS) conducted snorkel surveys of tributary confluences in the summers of 1998, 2001, and 2002 to evaluate the extent of thermal refugia use by juvenile salmonids in the Klamath River. Certain tributary confluences consistently contained the highest numbers of salmonids among available thermal refugia habitat. In the lower Klamath River, the area near the mouth of Blue Creek was notable among these high-use tributary confluences due to its exceptionally large volume, cold temperature, and high proportion of adults to juveniles. During the summers of 2001 and 2002, several thousand adult chinook salmon and summer steelhead were observed holding there (Yurok Tribal Fisheries, unpublished data). Within the Trinity River, adult salmon were consistently observed holding during the summer at the mouths of Mill, Tish Tang, Horse Linto, and Willow Creeks. These observations led to many important questions regarding the use of thermal refugia by adult salmonids during upstream migration.

Recent fish kills dramatically illustrate the severity of thermal (and other) imbalances in the Klamath/Trinity Basin. In the summer of 2000, hundreds of thousands of juvenile
salmonids (primarily chinook) died during downstream migration. Low flows and high ambient temperatures appeared to have induced a fatal outbreak of indigenous and normally non-fatal bacterial pathogens. Schreck and Li (1991) have documented the increased susceptibility of thermally stressed coldwater fishes to infection and disease. A repeat of the 2000 fish kill was expected for the summer of 2001. The expected fish kill did not materialize, but several hundred adult spring chinook and an unknown number of summer steelhead died during upriver migration, again apparently due to temperature induced diseases. Last season an even greater numbers of adult spring chinook died during migration in the Klamath and Trinity Rivers, followed by the tragic and now infamous loss of over 30,000 adult fall run chinook, in addition to significant numbers of steelhead and coho. These recent fish kills are especially alarming due to the extremely low escapement of wild spring chinook and summer steelhead in the basin (Moyle et al. 1989; Nehlsen et al. 1991).
The restoration of spring chinook throughout the Klamath basin will require an understanding of limiting factors and the protection of potential broodstock such as the wild populations of the Salmon River. In turn this will require a comprehensive understanding of temperature effects, thermal refugia, and fishing regulations that will minimize impacts on the precarious remaining populations of wild spring chinook.

The author during a tagging session at the Blue Creek refugia complex, July 2002

Project Objectives
1. Determine the extent of thermal refugia use by adult spring chinook during upriver migration.
2. Determine the thermal experience of adult spring chinook during upriver migration.
3. Gather data on migration behavior, travel rates, and stock specific run timing.

**Methods**

Temperature sensitive radio transmitters (Advanced Telemetry Systems - ATS F1845 Internal Esophageal Tags with external trailing whip antennae at 150 MHz) will be used to track the movements and internal body temperatures of 30 to 45 adult spring chinook salmon during the spring and summers of 2002 and 2003. Each fish will also be outfitted with an external temperature archival tag (Alpha Mach - iB4 modified iButton). Archival tags alone will be used on an additional 45 adult spring chinook in 2003.

Approximately 6 salmon (3 with radio transmitters, 3 without) will be tagged each week from mid-April to the end of July (~14 weeks) in order to sample fish throughout the continuum of the run in terms of timing of river entry and river temperature. No adipose fin clipped salmon will be tagged in an effort to maximize the chances of tagging wild chinook from the Salmon River or South Fork Trinity populations, although statistically speaking the majority of tagged fish will probably be natural spawners or hatchery fish from the Trinity River.

Fish will be captured in or near the Klamath River estuary using a gill, seine, or soft-mesh dip net depending on the conditions. Each salmon will be held and immobilized using a live tank and cradle, measured (fork length), tagged (using standard procedures), and allowed to recover before release. Care will be taken to minimize capture stress and handling time. Colored, numbered, and labeled Petersen disc tags will be attached to all radio tagged fish to allow for easy visual identification during any snorkel surveys that will be conducted throughout the Basin during the study period and to facilitate tag recovery. An iB4 archival temperature tag will be attached (with epoxy) to one side of each pair of Petersen disc which will record external temperature for the
duration of the season. The same procedure will be used for all fish, unless conditions dictate adjusting the capture method or location.

Mobile radio receivers will be used to track radio tagged fish and record their internal body temperature by the various tracking teams (typically one biologist and technician). The location of all observed tagged fish will be determined using a handheld GPS unit, or if necessary by the nearest mile marker and/or associated landmarks. For each tagged fish observation the date, time, meso-habitat type, river temperature, DO level, and fish behavior will be recorded along with any observations of cold water sources. Transportation during tracking will be by truck along Highways 96, 169, and 299 or by jet boat or inflatable rafts depending on the reach. Tracking reaches are the following:

Klamath estuary to the Glen, the Glen to Coon Creek Falls, Coon Creek Fall to Weitchpec, Weitchpec to Bluff Creek, Bluff Creek to the Salmon River at Wooley Creek, Wooley Creek and above, Weitchpec to Red Rocks, Red Rocks to Tish Tang, Tish Tang to Willow Creek, Willow Creek to Cedar Flat, Cedar Flat to Junction City, Junction City to Douglas City, and Douglas City to Lewiston. The South Fork of the Trinity will be covered via aerial telemetry flights provided by the CA Department of Fish and Game and by the annual spring chinook snorkel survey. Hatchery personnel, snorkel count and carcass survey participants within the study areas will be notified to look out for tagged fish. Efforts will be made to assign reaches to tracking teams in an adaptive manner in order to maximize efficiency and data collection. An attempt will be made to track tagged salmon until they reach their respective holding areas or natal tributaries. Knowing the location (i.e. Salmon River, South Fork Trinity, Trinity River mainstem, or Trinity River Hatchery) where individual fish hold before spawning and the date when they were tagged will allow an examination of stock specific run timing.

A concealed receiver and automated data logger will be placed near the mouth of Blue Creek to continuously monitor fish presence and internal body temperatures in the refuge pool. This station will be equipped with two directional antennas allowing for a determination of whether tagged fish are moving upriver or downriver (as does happen!). Additional listening stations will be placed at: Bluff Creek on the Klamath River, Horse
Linto Creek on the Trinity River, and on the Trinity upriver of its confluence with the South Fork Trinity. Currently negotiations are under way for in-kind support for a fifth listening station on the Salmon River at Wooley Creek, and if funding allows, additional listening stations will be placed at other significant thermal refugia and/or near major migration path junctions.

Throughout the duration of the study, weekly snorkel surveys will be conducted at the Blue Creek refuge pool to monitor the abundance and condition of salmonids. Water quality data and salmonid abundance for other refuge areas will be obtained from the results of monitoring conducted by Yurok Tribal Fisheries, the Karuk Tribe, and the USFWS.

Two thermisters (Onset Optic Stowaways and iB4s) will be used at each listening station to record the temperature of the cold water tributary (or source) and the river above the tributary. In addition, efforts will be made to collaborate and cooperate with the appropriate entities to ensure that thermisters are in place at each significant cold water tributary from Blue Creek to the Salmon River (Klamath) and Weitchpec to Willow Creek (Trinity) to monitor potential thermal refugia temperatures and their corresponding upstream river temperatures. An effort will also be made to obtain copies of any other pertinent temperature data. River flows will be obtained from USGS gauges and weather data (air temperatures) will be obtained from NOAA weather stations located throughout the Basin.

An outreach and reward program will be used to assist in the recovery of tags. Outreach will consist of distribution and posting of informational flyers in pertinent location throughout the study area, plus general PR via newspapers, radio programs, fisher resources, and contacts with the public in the field. The Yurok Tribal Fisheries Harvest Monitoring Program will assist with this effort in the field among Tribal and sport fishers in the Klamath River. Rewards will be commensurate with the completeness of the return of tags and information regarding each fish. If more funding becomes available reward amounts will be increased.
The mouth of the Klamath River, 2002

Literature Cited


Burns, J.W. 1971. The carrying capacity for juvenile salmonids in some northern California streams. California Fish & Game 57: 44-57.


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