Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River

Iron Gate Dam to Seiad Creek, 1996

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Abstract

High water temperatures in the Klamath River are thought to be a major contributor to the decline of anadromous fish stocks in the drainage (Bartholow 1995), and over-summering salmonids may have to rely on pockets of cool water during high temperature episodes in the mainstem Klamath River. However, little was known about the location of these areas or their use by juvenile salmonids. In July and August 1996, the Klamath River from Iron Gate Dam to Seiad Creek (approximately 60 miles) was surveyed for areas of cool water. Klamath mainstem temperatures ranged from 21.3 to 26.2” C during the study period, and 32 areas of relatively cool water (10.O-21.5°C) were found, ranging in size from 0.25 to 6,000 ft^2. Snorkel observations revealed that the number of juvenile salmonids present in these areas varied widely between locations, ranging fi-om 0 to 72 fish. Significant relationships were found between the numbers of fish found and (a) the distance below Iron Gate Dam, (b) proximity of nearest other cool water area, (c) the minimum temperature of the cool water area, and (d) the difference in temperature between the river and the cool water area. No significant relationship was observed between the numbers of Salmonid juveniles present in cool water areas and (a) the size of cool water areas and observed, or (b) the ambient river temperature.

Introduction

Anadromous fish runs of the Klamath River once numbered in the millions and sustained the native peoples of the Klamath watershed. Chinook, coho, steelhead, lamprey, green sturgeon, eulachon, and coastal cutthroat trout formed an integral part of the ecosystem that sustained these people. Although there may be many causes for the decline of these fish, high water temperatures in the mainstem river are commonly cited as being a major contributor to this decline (Bartholow 1995). The Klamath River exhibits temperatures high enough to affect Salmonid health, and at times can reach acute and possibly lethal levels (Bartholow 1995). It has been widely assumed by biologists familiar with the Klamath River that over-summering juvenile salmonids must rely on pockets of cool water during high temperature episodes.

Field investigations in other systems have shown that salmonids use cool water areas (Kubicek 1977, Bilby 1984, Berman and Quinn 1991, Nielsen 1991, Nielsen et al 1994, Torgersen et al 1995), but this issue had not been examined in the Klamath River. Hence, in 1996 Yurok Tribal Fisheries Program inventoried cool water areas in the mainstem river from Iron Gate Dam (IGD) to Seiad Creek. The objectives of this pilot study were to: (1) document areas of cool water with the potential to provide thermal refugia in the river, and (2) gather preliminary information on the presence or absence of salmonids in these areas.

Methods

This study was conducted during the two hottest months of the year, July and August, when acute and chronic high temperature episodes are most common (Bartholow 1995). In addition, because mainstem temperatures fluctuate hour to hour, we searched for cool water areas only during the hottest part of the day, 1200 to 1800. During that time span, we were usually able to cover between two to five river miles. One reach (Iron Gate to Copco-Ager bridge) was surveyed twice.

We used a cataraft equipped with a temperature sensor (Ryan TempMentor which has a precision of $\pm$ 0.1 °C), along with two swimmers in snorkel gear, to locate cool water areas. All thermometers used in the study were calibrated twice for accuracy using an ASTM certified mercury thermometer. Areas of cool water were located by feeling for cooler water, probing with hand-held thermometers (LaMotte model 545 $\pm$ 0.5°C), lowering the temperature sensor to the bottom of deeper pools, and by visually searching for springs, undergravel seeps near point bars (such as noted by Nielsen et al 1994) areas of extensive riparian shading, and tributaries. With one exception (the Scott River confluence), only areas at least 2°C cooler than well mixed ambient Klamath River temperature are reported.

Locations of cool water areas were determined using a Garmin model 45 Personal Navigator Global Positioning Satellite receiver (GPS unit). The length, width and depth of each cool water area encountered was estimated because of the difficulty and time involved in actually measuring the extent of cool water. Also noted were the time of day, ambient river temperature immediately upstream of the cool water input, the minimum temperature of the of cool water area, and the approximate flow of the cool water source.

Once a cool water area was located, divers snorkeled the site to determine fish presence by visual observation. The raft was kept at a distance to help minimize scaring the fish until observations were complete. Two divers would swim side by side and both would count all fishes present. Due to the small nature of most cool water areas and the sometimes poor visibility, the higher count was used, although the numbers of fish reported by each crew member were usually similar.

Results

During the course of this study, the ambient temperature of the Klamath mainstem ranged from 21.3 to 26.2°C.

Locations of Cool Water Areas

A total of 32 areas of cool water were located, mostly at the mouths of tributaries and mostly in the downstream portion of the study area. (Fig. 1, Table 1). Few areas of cool water were found in the reach of the river immediately below IGD. Bogus Creek (0.6 mi. below IGD) was cooler than the Klamath River on only one of the two occasions that it was measured during the study period. The next area of cool water found below that was at Humbug Creek (19.0 mi. below IGD).

Nine tributaries did not provide cool water to the mainstem either because they were dry, or not cooler than the river (Table 2). For example, the Shasta River flowed into the Klamath River at 29.1°C (84°F), compared to 25.5°C in the mainstem Klamath River at that time. In addition, the presence or absence of cool water areas at four small tributary confluences is not known because the streams were missed or they emptied into rapids where it was difficult to stop the cataraft or swimmers (Table 2).

The approximate aerial extent of the cool water areas ranged from 0.25 to 6000 ft^2. For convenience, the cool water areas were categorized into four broad categories as shown in Figure 1: large (>1000 ft^2), medium (50- 1000 ft^2), occasional (not cooler than the Klamath River for the entire duration of study period) and small (<50 ft^2). There were 4 large, 16 medium, 1 occasional, and 11 small cool water sites (Fig. 1, Table 1). Although there were more cool water sites in the lower part of the study reach (particularly from Horse Creek downstream; Fig. 1), most of those sites were small.

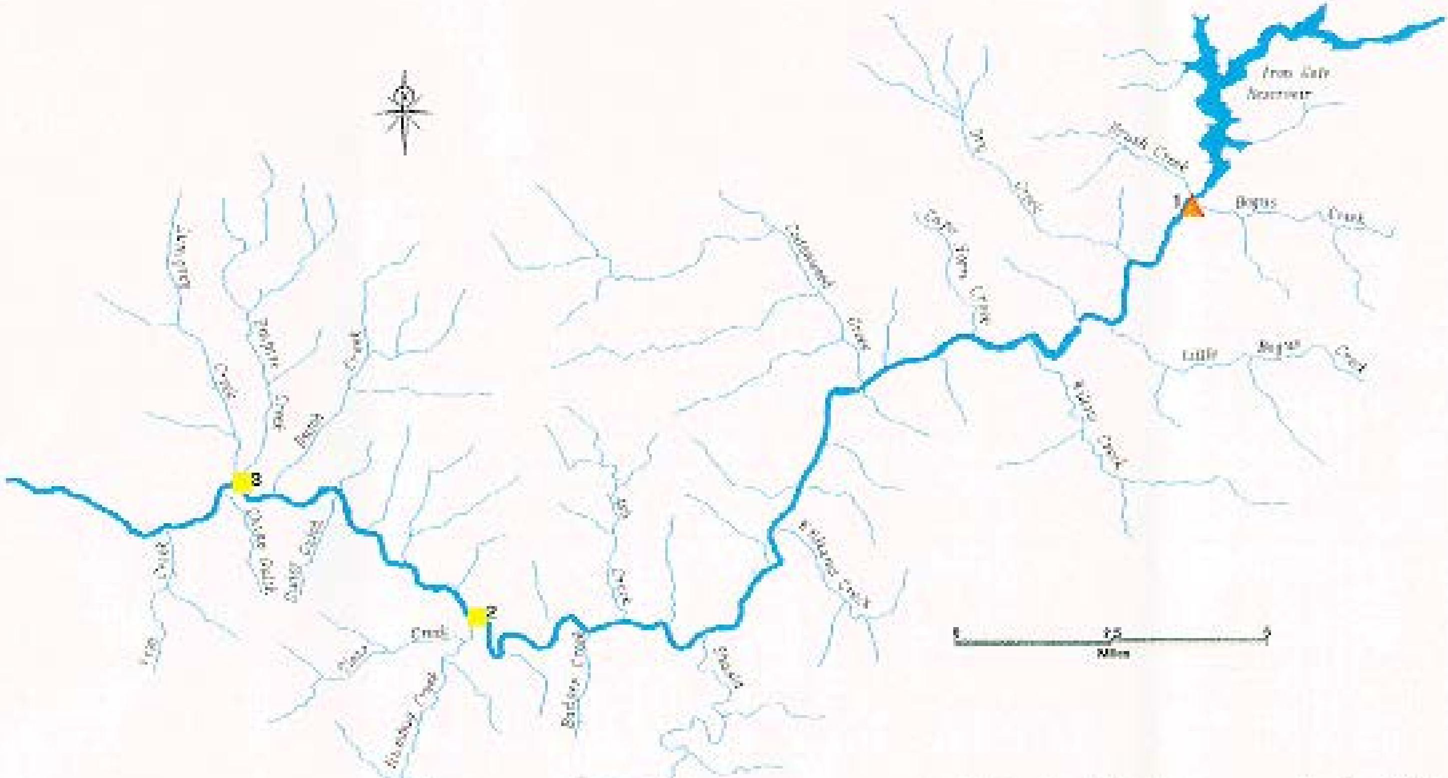
Tributary confluences accounted for 28 out of the 32 sites found. Although four spring/seep cool water areas were located, all of them discharged their water outside the river bed itself (see Table 1 for specifics).

Fish Presence in Cool Water Areas

Fish presence in cool water areas varied widely, ranging from 0 to 72 juvenile salmonids per area (Table 1). Only 324 juvenile salmonids were observed in the entire study area during this inventory, and no juvenile salmonids were observed in locations other than cool water areas. However, low visibilities, strong currents and abundant instream cover made fish observations problematic in certain cool water areas at times. Visibilities in the mainstem Klamath away from the influence of clearer tributaries was poor (two to six feet), most often averaging about three

Cool Water Areas in the Klamath River Mainstem, 1996

Iron Gate Dam to Seiad Creek - Map 1 of 2

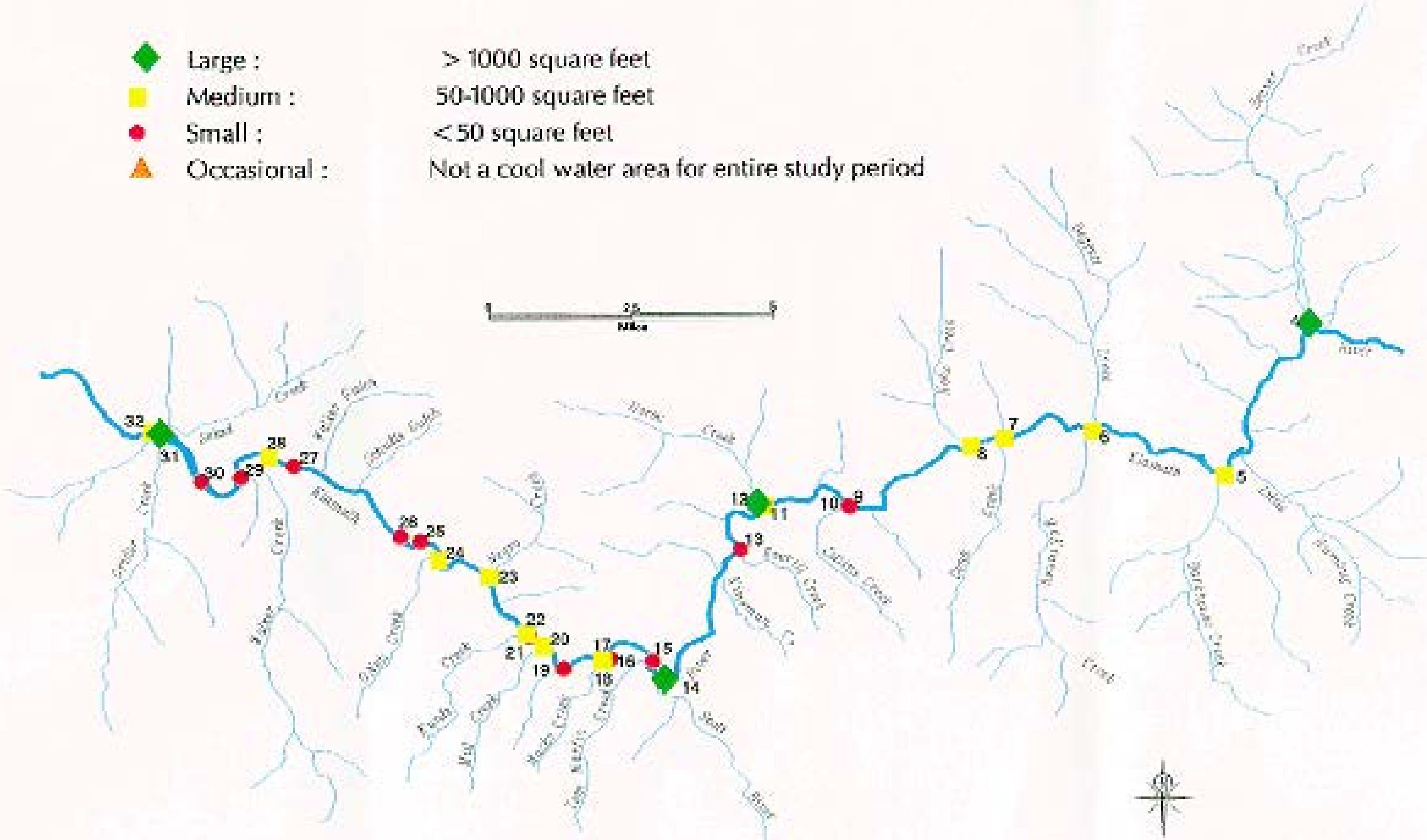


Source: Mike Belchik, Yurok Tribal Fisheries Program, Klamath, California.
Compiled by: Kelly A. Duncan. Klamath Bioregional Assessment Project. Humboldt State University, Arcata, California. March 1997.

Large :	> 1000 square feet
Medium :	50-1000 square feet
Small :	< 50 square feet
Occasional :	Not a cool water area for entire study period

Cool Water Areas in the Klamath River Mainstem, 1996

Iron Gate Dam to Seiad Creek - Map 2 of 2



Source: Mike Belchik, Yurok Tribal Fisheries Program, Klamath, California.

Compiled by: Kelly A. Duncan, Klamath Bioregional Assessment Project, Humboldt State University, Arcata, California, March 1997.

Table 1: Cool water areas found in the mainstem Klamath River from Iron Gate Dam to Seiad Creek, listed from upstream to downstream. The site # corresponds with the numbers in Fig. 1. "Discharge" refers to the estimated volume of cold water input per unit of time.

											Salmonid juveniles observed			
Site #	Location	Miles below IGD	Date	Type	River temp	Min. temp	Temp. Difference	Estimated Discharge	Estimated Area (sq. ft)	Category	chinook	coho	steelhead	total
1	Bogus Cr.	0.56	08/07/96	tributary confluence	21.6	19.7	1.9	I-10 cfs	1000	occasional	2	0	10	12
2	Humbug Cr.	16.96	07/25/96	tributary confluence	25.0	19.3	5.7	<1 cfs	120	medium	6	0	46	52
3	Empire/Lumgrey Cr.	24.22	08/02/96	tributary confluence	20.1	16.1	4.0	I-10 cfs	250	medium	1	0	15	16
4	Beaver Cr.	29.10	07/31/96	tributary confluence	24.1	20.9	3.2	>10 cfs	6000	large	16	0	21	39
5	Barkhouse Creek	32.67	08/01/96	tributary confluence	23.4	16.7	4.7	I-10 cfs	160	medium	30	2	40	72
6	McKinney Cr.	35.49	08/01/96	tributary confluence	23.9	20.4	3.5	I-10 cfs	75	medium	5	2	5	12
7	Dona Cr.	36.04	08/06/96	tributary confluence	22.2	14.6	7.6	I-10 cfs	174	medium	6	0	1	7
6	Kohl Cr.	36.67	08/01/96	tributary confluence	24.1	17.2	6.9	I-10 cfs	250	medium	6	0	10	16
9	Near Collins Cr.	40.73	08/07/96	spring/seep	22.2	15.2	7.0	<1 cfs	36	small	0	0	0	0
10	Collins Cr.	40.75	08/07/96	tributary confluence	22.5	13.7	6.6	<1 cfs	37.5	small	0	0	0	0
11	120yds above mouth of Horse Cr.	42.61	08/07/96	spring/seep	23.1	15.2	7.9	I-10 cfs	225	medium	20	0	0	20
12	Horse Cr.	42.62	08/07/96	tributary confluence	23.2	17.7	5.5	>10 cfs	4000	large	1	0	1	2
13	Everill Cr.	44.78	08/07/96	tributary confluence	23.7	15.2	8.5	<1 cfs	100	medium	0	0	1	1
14	Scott River	47.13	08/07/96	tributary confluence	23.9	22.8	1.1	>10 cfs	1800	large	1	0	16	17
15	Tom Martin Cr.	47.88	08/07/96	tributary confluence	24.1	15.8	8.3	1-10 cfs	40	small	0	0	11	11
16	below Sarah Totten campground	49.34	08/08/96	spring/seep	22.0	12.2	9.8	<1 cfs	4	small	0	0	1	1
17	gulch above Mack Cr.	49.36	08/08/96	tributary confluence	22.1	12.7	9.4	<1 cfs	14	small	0	0	0	0
18	Mack Cr.	49.38	08/08/96	tributary confluence	22.1	10.2	11.9	<1 cfs	600	medium	0	0	0	0
19	Jim Cr.	50.32	08/08/96	tributary confluence	23.1	14.2	8.9	<1 cfs	40	small	0	0	0	0
20	Mill Cr.	50.88	08/08/96	tributary confluence	23.3	10.9	12.4	<1 cfs	91	medium	0	0	0	0
21	near Kuntz Cr.	51.06	08/08/96	spring/seep	23.3	15.2	8.1	<1 cfs	50	medium	0	0	0	0
22	Kuntz Cr.	51.07	08/08/96	tributary confluence	23.3	15.5	7.8	1-10 cfs	96	medium	0	0	1	1
23	Negro Cr.	52.57	08/08/96	tributary confluence	23.8	17.7	6.1	1-10 cfs	64	medium	2	0	21	23
24	O'Neill Cr.	53.14	08/08/96	tributary confluence	24.0	15.7	8.3	<1 cfs	100	medium	0	0	0	0
25	Unnamed trib	54.17	08/08/96	tributary confluence	24.1	15.2	8.9	<1 cfs	8	small	0	0	0	0
26	Louie Cr.	54.59	08/14/96	tributary confluence	23.6	14.4	9.2	<1 cfs	18	small	0	0	0	0
27	Unnamed gulch	56.50	08/14/96	tributary confluence	23.7	16.7	7.0	<1 cfs	12	small	0	0	1	1
28	Walker Cr.	57.08	08/14/96	tributary confluence	23.8	16.4	7.4	1-10 cfs	80	medium	0	0	11	11
29	Gard Cr.	57.93	08/14/96	tributary confluence	24.1	16.2	7.9	<1 cfs	0.25	small	0	0	0	0
30	Caroline Cr.	58.11	08/14/96	tributary confluence	24.2	16.7	7.5	<1 cfs	4	small	0	0	0	0
31	Grider Cr.	60.09	08/14/96	tributary confluence	24.3	17	7.3	>10 cfs	2250	large	0	0	10	10
32	Seiad Cr.	60.27	08/14/96	tributary confluence	24.4	21.7	2.7	<1 cfs	360	medium	0	0	0	0

Table 2: List of tributaries that (1) did not have cool water areas at their confluences with the Klamath River during the 1996 survey or (2) were not located or assessed.

Location	Date Surveyed	Reason why no cool water area was found
Brushy Gulch	07 August 1996	not cooler than river
Willow Creek	23 Julv 1996	drv
Cottonwood Creek	24 July 1996	not cooler than river
Williams Creek	24 July 1996	dry
Shasta River	24 Julv 1996	not cooler than river
Ash Creek	24 July 1996	empties into rapid, could not check
Badger Creek	25 July 1996	not located
Dutch Creek	31 July 1996	empties into rapid, could not check
Vesa Creek	31 July 1996	not located
Dogget Creek	01 August 1996	not cooler than river
Kinsman Creek	07 August 1996	not located
Sambo Gulch	07 August 1996	not cooler than river
Schutt's Gulch	14 August 1996	not located

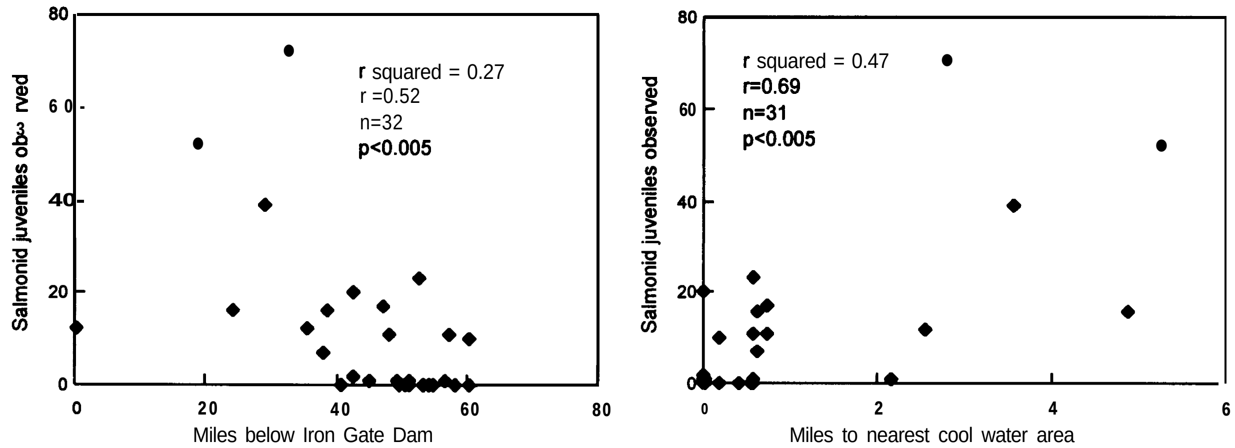
feet. Within cool water areas though, visibilities were considerably higher, and identification of juvenile salmonids was possible.

Analyses of potential relationships between juvenile Salmonid use of cool water areas and the physical characteristics of the cold water areas are limited because of the small sample sizes and the unequal distribution of equivalent cold waters in the study area. Additionally, juvenile Salmonid usage is probably affected by unmeasured factors such as cover and predator access.

Preliminary analyses indicate that numbers of fish per cool water area decreased as distance below Iron Gate Dam increased (Fig. 2). There was no significant relationship between numbers of juvenile salmonids present and the size of cool water areas, but a significant relationship occurred between numbers of juvenile salmonids present and distance to the next available cool water area (Fig. 2).

Two additional relationships seem spurious: juvenile Salmonid abundances were highest in the warmest cool water areas and in the cool water areas with the least temperature difference compared to ambient river temperature (Fig. 3). These relationships are driven in large part by the relatively large numbers of fish at three upstream locations (Humbug, Beaver, and Barkhouse Creeks).

No adult anadromous fish were seen in any of the cool water areas.



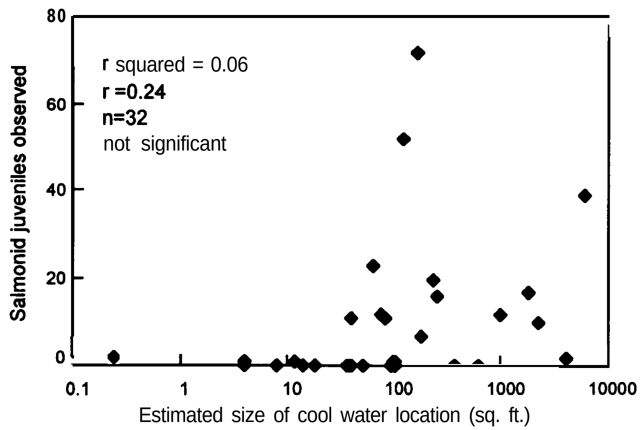


Figure 2: Relationship between the total numbers of salmonids observed in cool water locations and 1) distance below Iron Gate Dam, 2) estimated size of cool water locations, and 3) distance to nearest other cool water area. Bogus Creek was not included in (3) because cooler mainstem temperatures probably negated the need for cool water areas near that location.

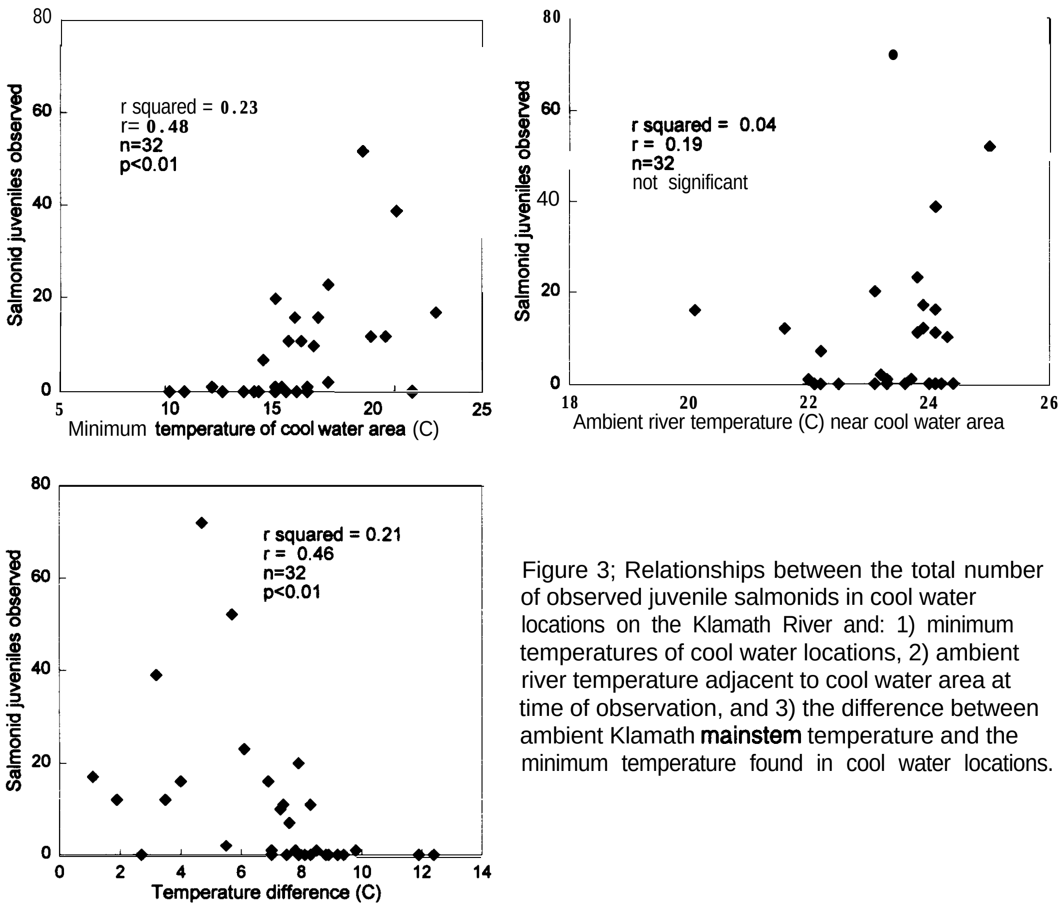


Figure 3; Relationships between the total number of observed juvenile salmonids in cool water locations on the Klamath River and: 1) minimum temperatures of cool water locations, 2) ambient river temperature adjacent to cool water area at time of observation, and 3) the difference between ambient Klamath mainstem temperature and the minimum temperature found in cool water locations.

Discussion

The temperature of the mainstem Klamath River in the study area regularly exceeds optimum or even lethal levels for rearing salmonids (Bartholow 1995). Bartholow suggests that temperatures over a daily average of 20°C will cause acute stress to salmonids, and that temperatures over a weekly average of 15°C will cause chronic stress to salmonids. Other investigators state that acute problems for salmonids may be expected when mean weekly water temperatures reach 21°C (Zedonis 1996) or if instantaneous temperatures reach 24°C (Rich 1987) or 25°C (Brett, 1952). Given that average daily Klamath mainstem temperatures ranged from 19.9°C to 25.4°C during the study period (Michael Deas, UC Davis Department of Civil Engineering, pers. comm.), it is highly likely that juvenile salmonids experience thermal stress and would utilize areas of cool water given the opportunity.

Because most areas of cool water were only inventoried once, the results presented in this study represent a "snapshot" of summer conditions in 1996. In order for these areas to be considered thermal refugial areas for rearing juvenile salmonids, two conditions must be satisfied: (1) mainstem temperatures must be high enough to necessitate usage of these areas, and (2) cool water areas must be cool enough and large enough to safely harbor the rearing salmonids. The high temperatures measured in the Klamath indicate strongly that juvenile salmonids would utilize cool water areas if available. In the study area, minimum temperatures of cool water areas ranged from 10 to 21.5°C, and they were measured during the afternoon when their temperatures would be at or near maximum.

Although this pilot study was not intended to be a thorough investigation of overall juvenile Salmonid distribution in the study area, we spent considerable time looking for juvenile salmonids in areas of the river not affected by cool water areas. However, poor visibility in the mainstem precluded a valid documentation of fish presence except in cool water areas. So, although we found that juvenile salmonids are hard to find anywhere in the mainstem Klamath River except at areas of cool water, we could not confirm that these were the only places where juveniles are found during the summer rearing period.

Preliminary indications are that cool water areas provide key habitat areas for over-summering juvenile salmonids in the mainstem Klamath. It would then follow that emphasis should be placed on management of these sensitive areas.

Recommendations for further study

Further research on this topic is needed to determine what overall role cool water areas play in the life histories of summer-rearing salmonids in the Klamath system. The specific characteristics of these areas which are important to fish should be identified. Finally, the ability of different flow releases from Iron Gate dam to change specific characteristics of cool water areas should be investigated. These ideas are presented in more detail below:

1. Importance of cool water areas to salmonids utilizing the Klamath mainstem:

   a. Do salmonids utilize cool water areas in the mainstem Klamath River preferentially over other habitats during any part of the year? This question needs to be addressed more critically before assuming the significance of these areas to rearing salmonids.

   b. How does fish use of cool water areas vary with time and space? Variations in juvenile Salmonid use of these areas needs to be addressed on a seasonal and a daily basis. In addition, usage of cool water areas needs to be documented both on a system-wide scale, and within individual cool water areas (i.e. which parts of the cool water area are utilized).

   c. What characteristics determine the usability of cool water areas for salmonids? Given that fish use varies widely at these areas, can we determine the important factors that affect fish abundance at these areas? Variables that could be associated with Salmonid abundance in cool water areas include: surface area of cool water, depth, velocity, cover, and access to the tributary itself This information will assist our understanding of the effects that different flow releases from Iron Gate Dam will have upon Salmonid populations utilizing these cool water areas.

   d. What effect do different thermal regimes of the Klamath River (i.e., die1 temperature variation, daytime maximum temperature, etc.) have on the role of these cool water areas in the rearing of salmonids in the Klamath mainstem? Are juvenile salmonids “trapped” in cool water areas, and if so, are fish able to move between cool water areas at night when water temperatures drop?

   e. Do the same fish rear for some time at the same cool water area? If so, does residence in a small cool water area increase predation rates or disease transmission? What are the food resources of cool water areas?

   f Do juvenile salmonids move up into tributaries to escape warm water temperatures in the mainstem Klamath? If so, what affect does this have on anadromous and tributary resident Salmonid populations?

2. Physical aspects of cool water areas:

   a. What is the distribution and availability of cool water areas downstream of the study area to the mouth of the river?

b. What are the physical characteristics of cool water areas (e.g., hourly and seasonal temperature fluctuations and discharge variation).

c. What effects do releases from Iron Gate Dam have on the physical characteristics of cool water areas such as surface area, cover, depth, and velocity? If releases from IGD influence die1 temperature regimes as a function of distance from Iron Gate Dam, how would that affect the need for cool water areas by rearing juvenile salmonids?

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