TASK 5. THERMAL REFUGIA

5.1 OBJECTIVE

The purpose of this task was to identify coldwater refugia in the Mokelumne River between Camanche Dam and Lake Lodi (Camanche reach) and below Woodbridge Dam to DeVries Road.

5.2 METHODS

BioSystems biologists conducted temperature surveys to investigate if coldwater refugia were present in Camanche reach and below Woodbridge Dam to De Vries Road. Coldwater refugia were defined as pockets of water in the river or in backwaters that exhibit temperatures 2° C cooler than the average temperature found in the main channel. Because temperature differences (due to stratification or springs) are likely to be observed during warm months, surveys were conducted during the summer.

5.2.1 Camanche Reach

Camanche reach was sampled from 5-7 July 1990 during the first survey period and 23-24 August 1990 during the second survey period. In general, temperature gradient data were collected in backwaters, pools, and deep runs; no riffles were sampled. On both sampling occasions, biologists floated in a canoe over the entire river from Camanche Dam to Lake Lodi and measured water temperatures between the hours of 1000 and 2100. Measurements were recorded with a Yellow Springs Instrument (YSI) temperature and dissolved oxygen meter. Depending on habitat type, the sampling strategies identified below were used to determine if coldwater refugia were present in the Camanche reach.

All pools were sampled with the exception of one small shallow (< 1.2 m) pool and one pool located immediately below Camanche Dam. As biologists floated down the river in a canoe, they spot checked all pools for temperature differences. Regardless of whether temperature differences were noted during spot checks, transects were taken once for pools less than 100 m in length and once every 100 m for pools greater than 100 m. Across each transect (placed perpendicular to river flow) temperature profiles (3) were taken in the right, middle, and left channel. Each profile consisted of taking temperatures at three depths: 0.3 m above the bottom, mid-water, and 0.3 m below the surface.

Depth (visually estimated) determined whether runs were sampled. In general, shallow runs (< 1 m deep) were not sampled and deeper runs (> 1 m deep) were spot checked. Transects were taken if differences were observed between surface and bottom temperatures. Transects were taken once on runs less than 300 m long and every 150 to 300 m on runs greater than 300 m, regardless of whether temperature differences were noted during spot checks. The methods used for conducting transects in runs were similar to those described for pools.

During the first survey period, all backwater habitats (with the exception of five) were preliminarily assessed for potential refugia by comparing temperatures taken in the backwater to temperatures in the main river. First, instream temperatures were recorded upstream, downstream, and at the mouth of each of the backwaters to see if these habitats were contributing to cooler temperatures in the main river. Secondly, bottom temperatures were spot checked in the backwater and compared to temperatures in the river. If no differences were observed in river and backwater temperatures, further studies were not conducted; if backwater temperatures were cooler, temperature profile transects were then conducted. Transects were placed longitudinally to the mouth of the backwater and temperature profiles (bottom, midwater, and surface) were taken at right bank, center, and left bank locations along each transect.

Similar methods were used during the second survey period; however, only backwaters that exhibited cooler temperatures during the first survey period were investigated.

Temperature profile data collected in the pools, runs, and backwaters were used to confirm the presence of stratification and, therefore, potential coldwater refugia in each of these habitats. If coldwater refugia were present, several temperature and dissolved oxygen profiles were taken within the habitat to delineate the boundaries of the refugia. Once the boundaries of the refugia were determined, the length and width of the refugia were measured and recorded.

Temperatures in habitats in the main river were assessed in two ways. First, the bottom and surface temperatures from each profile were compared to obtain an average difference in temperature. Secondly, average temperatures taken in consecutive habitats were compared to determine variation.

5.2.2 Woodbridge Reach

Coldwater refugia in Woodbridge reach were investigated on 23-24 August 1990. Surface temperatures were recorded in the main river every 300 m starting below Woodbridge Dam and continuing to DeVries Road. In addition, temperatures were recorded upstream, downstream, and at the mouth of each backwater. A standard thermometer was used to record temperature. All habitat types sampled were recorded.

5.3 RESULTS

5.3.1 Camanche Reach

During the first survey period, mean daily flows in the Camanche reach ranged from 295 to 310 cfs (USGS Station #11323500) and temperatures (BioSystems YSI) ranged from 12.9° to 17.4° C. During the second survey period, mean daily flows ranged from 267-268 cfs and temperatures were 15.9°-20.9° C.

No coldwater refugia were found in the main river during the first survey period. Water temperatures measured between consecutive habitats did not differ more than 0.6° C on any of the survey dates (N = 125, mean = 0.1° C, SD = 0.1° C).

Three coldwater refugia were identified in backwaters (Table 5.1). These refugia exhibited temperatures 2.2° to 2.4° C cooler than those found in the main river. A total of 207 temperatures (23 transects) were taken in 20 backwaters. Although some additional backwaters exhibited stratification, temperatures were warmer than those found in the river in all but the three identified in Table 5.1. Temperatures in the main river immediately downstream of the mouth of these backwaters were similar to other river temperatures, indicating that these refugia are small and localized and do not alter the temperatures in the main channel.

Table 5.1. Summary of coldwater refugia identified in backwaters of the Mokelumne River, July 1990.

HAB. NO.	APPROXIMATE LOCATION	SIZE (m)		RANGE OF DO (mg/L)	MINIMUM BOTTOM TEMPERATURE	RIVER TEMP. (°C)	DIFF. (°C)
		LENGTH	WIDTH				
29B	40 m upstream of Hwy. 88; left side	14	11	10.5-12.6	13.1° @ 2.7 m	15.5°	2.4°
34A	0.5 km downstream of Hwy. 88; right side	46	12	5.4-12.2	13.1° @ 2.1 m	15.5°	2.4°
41A	1.1 km downstream of Hwy. 88; left side	31	15	9.3-13.6	13.4° @ 2.7 m	15.6°	2.2°

A total of 92 temperatures (11 transects) were recorded in seven pools. Almost all (97%) bottom temperatures were within 0.5° C of the surface temperature (mean = 0.1° C, SD = 0.3° C). The maximum temperature difference observed between surface and bottom water was 1.5° C in a relatively deep (3 m) pool.

A total of 918 temperatures (114 transects) were measured in runs. The average difference between bottom and surface temperatures was 0.1° C (SD = 0.1). The maximum temperature difference observed was 0.4° C in a 0.9 m deep run.

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No refugia were found in either the main river or backwaters during the second survey period (23-24 August). As with the first period, river temperatures were uniform between consecutive habitats and never differed by more than 0.7° C (N = 141, mean = 0.1° C, SD = 0.2° C).

A total of 114 temperatures were taken in 12 backwaters. Although some of these backwaters exhibited stratification, temperatures were warmer than those found in the river and no other refugia were found.

A total of 72 temperatures (9 transects) were recorded in six pools. All bottom temperatures were within 0.5° C of surface temperatures (mean = 0.1° C, SD = 0.2° C).

A total of 632 temperatures (134 transects) were measured in 52 runs. Almost no difference was observed between bottom and surface temperatures (mean = 0.02° C, SD = 0.1). The maximum temperature difference was 0.5° C in a 0.9 m deep run.

5.3.2 Woodbridge Reach

At Woodbridge reach, the mean daily flow (USGS Station #11325500) was 28 cfs and BioSystems temperature readings were 18.5°-25° C.

Water temperatures in the river increased noticeably downstream, accounting for a high average temperature difference (N = 19, mean = 0.6° C, SD = 0.6° C) between consecutive habitats. A total of 34 temperatures were measured in six pools. A total of 51 temperatures were recorded in 15 runs.

A total of 14 backwaters were examined. Temperatures in the main river immediately downstream of the mouth of these backwaters were generally similar to upstream river temperatures. Surface temperatures in six of these backwaters also were similar to those in the river, except for two backwaters where temperatures were 1° C cooler than those observed in the river.