

SUMMER "COLD POOLS" IN REDWOOD CREEK NEAR ORICK, CALIFORNIA AND THEIR IMPORTANCE AS HABITAT FOR ANADROMOUS SALMONIDS

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ABSTRACT

"Cold pools" maintain summer water temperatures several Celsius degrees cooler than mainstream temperatures. Cold pools do not develop at all locations where cool groundwater flows into the stream. Conditions favorable to the development of a cold pool are: first, a source of cool groundwater that is initially physically separated from the main flow of the stream; and second, a favorable pool morphology must cause slow mixing of the cold and warm water. Many fish occupy the cold pools compared to very few in adjacent pools with warmer temperatures. Cold pools appear to represent refugia for fish from the warm summertime temperatures of the mainstem which may reach 25° C. Enhancement to produce new cold pools would increase summer low flow habitat for anadromous fish such as salmon and steelhead trout.

INTRODUCTION

As with many streams of the Pacific Northwest, the fishery resources of the Redwood Creek basin have been adversely impacted by intensive land use (USDI 1981). Increased sedimentation has reduced both the quality and quantity of spawning and rearing habitat of anadromous salmonids. In addition, land surface activities have resulted in an increased frequency of extremely low summertime streamflows as well as increased instream temperatures (Janda et al. 1975).

A factor limiting anadromous fish productivity in many streams in Northern California is the summer pool environment (Denton 1974). After hatching, silver (coho) salmon *Oncorhynchus kisutch* and steelhead trout *Salmo gairdneri* remain in upstream areas for 1 and up to 4 yrs, respectively, before entering the ocean. Summer low flow conditions and the quantity and quality of the pools where these fish reside during this period represent a significant factor limiting fisheries productivity. Many streams and pools often have water temperatures too warm to maintain a healthy fish population. High quality pool environments are essential if a watershed is to realize its full fisheries potential, especially with regard to silver salmon and steelhead trout.

PRELIMINARY FINDINGS

"Cold pools" with summer water temperatures several degrees Celsius cooler than mainstem temperatures were discovered in Redwood Creek, Redwood National Park, California, during the summer of 1981. A cold pool was located at the confluence of Hayes Creek with Redwood Creek approximately 4 km upstream from the town of Orick (Fig. 1). Another cold pool was located several km further upstream near the Tall Trees Grove.

Cold pools form where cold groundwater seeping into the main channel is not rapidly mixed with the warmer mainstream water; however, cold pools do not develop at all locations where cold groundwater seeps into the stream. Numerous areas were observed where cold groundwater entered Redwood Creek, but did not produce a cold pool. In Redwood Creek, conditions favorable to development of a cold pool appear to be: 1) a source of cold groundwater that is physically separated from the main flow of the stream; and 2) pool morphology that slows mixing of the cold and warm water. Large organic debris is believed to be important in retarding mixing of the cold and warm water.

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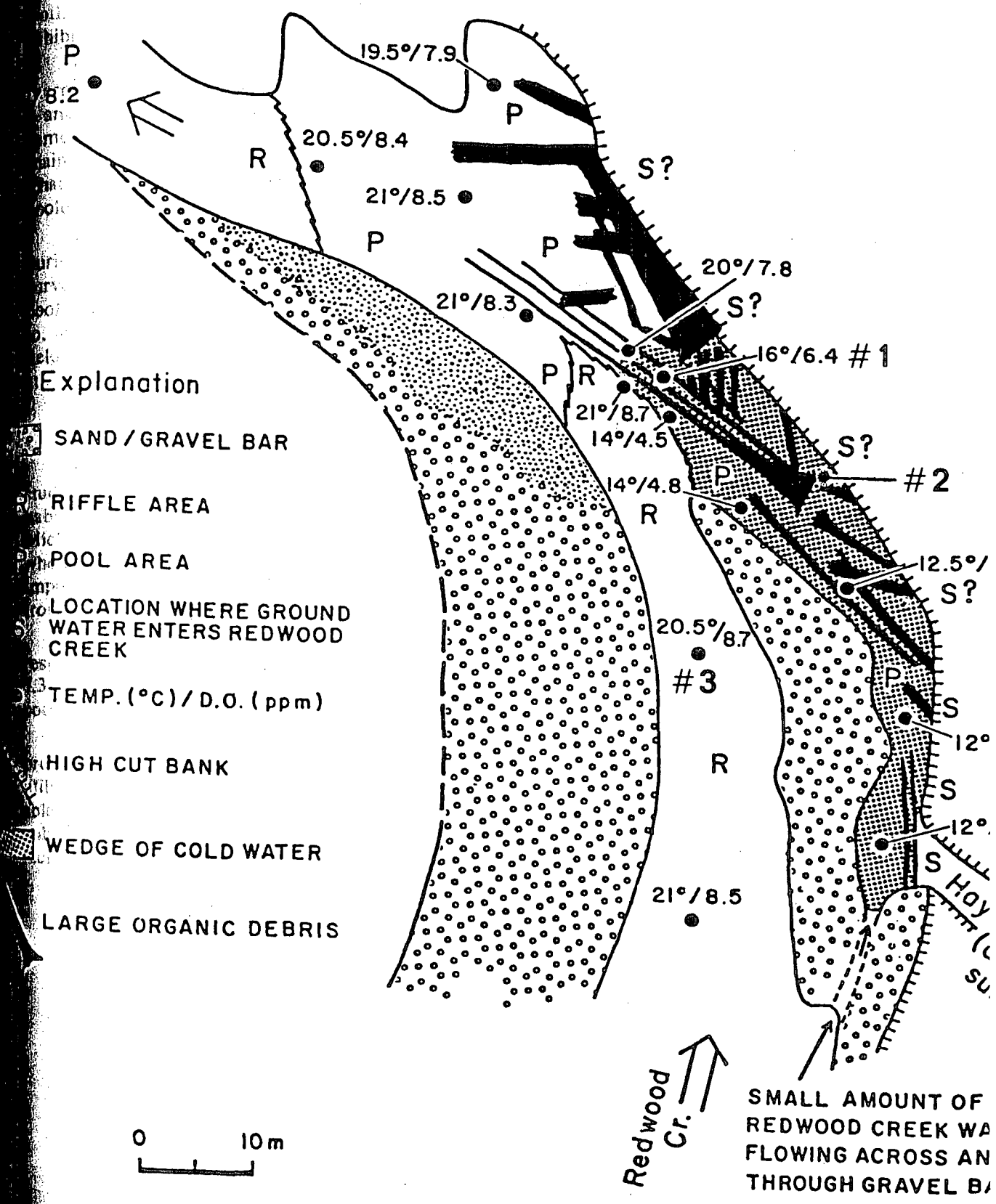


Figure 1

Map of cold pool in Redwood Creek near Orick, California. Data collected on September 1, 1981. Locations where continuous temperature data (#1 and #2) and maximum-minimum temperatures (#3) were obtained are indicated.

Both cold pools found in Redwood Creek contained a substantial amount of large organic debris that inhibits rapid mixing of the cold and warm water.

Cold pools apparently persist during the summer low flow period. Two continuously recording thermographs were placed near the bottom of the Hayes Creek cold pool at the locations shown in Fig. 1 and a maximum-minimum thermometer was placed in the mainstem of Redwood Creek during the same period. At no time during the period of measurement was the cold pool as warm as that in the mainstem, and temperatures varied with the distance from the source of cold water entering the pool. That is, Station 2 always exhibited cooler water temperatures than Station 1, and both stations were cooler than the mainstem temperatures throughout the observation period (Fig. 2).

In Redwood Creek, cold pools apparently account for much of the diversity of the fish population during the summer low flow period. During August, 1981, the lower 40 km of Redwood Creek was surveyed with snorkel and mask. The survey revealed a spotty distribution of juvenile fish. Some deep pools were devoid of fish while others contained many. The first cold pool was discovered subsequent to, and independent of this survey. However, the second cold pool was located by referring to survey field notes. Hundreds of fish were observed to occupy the cold pools compared to tens of fish, or none at all, in the adjacent pools with warmer water temperatures.

RELEVANCE AND MANAGEMENT IMPLICATIONS

The distribution, origin, and significance of cold pools to anadromous fish has not previously been studied. However, limited research is available concerning the interactions of groundwater and fish habitat. Benson (1953) discusses the importance of groundwater to trout in the Pigeon River, Michigan. Reid (1961) was perhaps the first to mention the possible existence of cold pools produced where springs discharged cold water into a pool, and Webster and Eiriksdottir (1976) discuss the importance of upwelling groundwater as a factor influencing the choice of spawning sites by brook trout.

From our preliminary data it was concluded that cold pools represent refugia where young fish reside when mainstem water temperatures rise. The preferred temperature range for chinook salmon is 7.3 - 14.6° C for silver salmon and, 7.3 - 14.6° C for steelhead (Reiser and Bjornn 1979). The cold pools provide permanent summertime habitats with optimum temperatures for rearing salmonids.

It is apparent that more cold pools would result in more summer habitat and perhaps better fish production. As more is learned about the nature and extent of cold pools, information gained could be utilized to favorably manage anadromous fish in streams of the Pacific northwest. Managers may be able to utilize locations where cold water enters the stream to create cold pools for anadromous fish enhancement. This could be particularly important where rearing habitat for juvenile fish is a limiting factor of fish production.

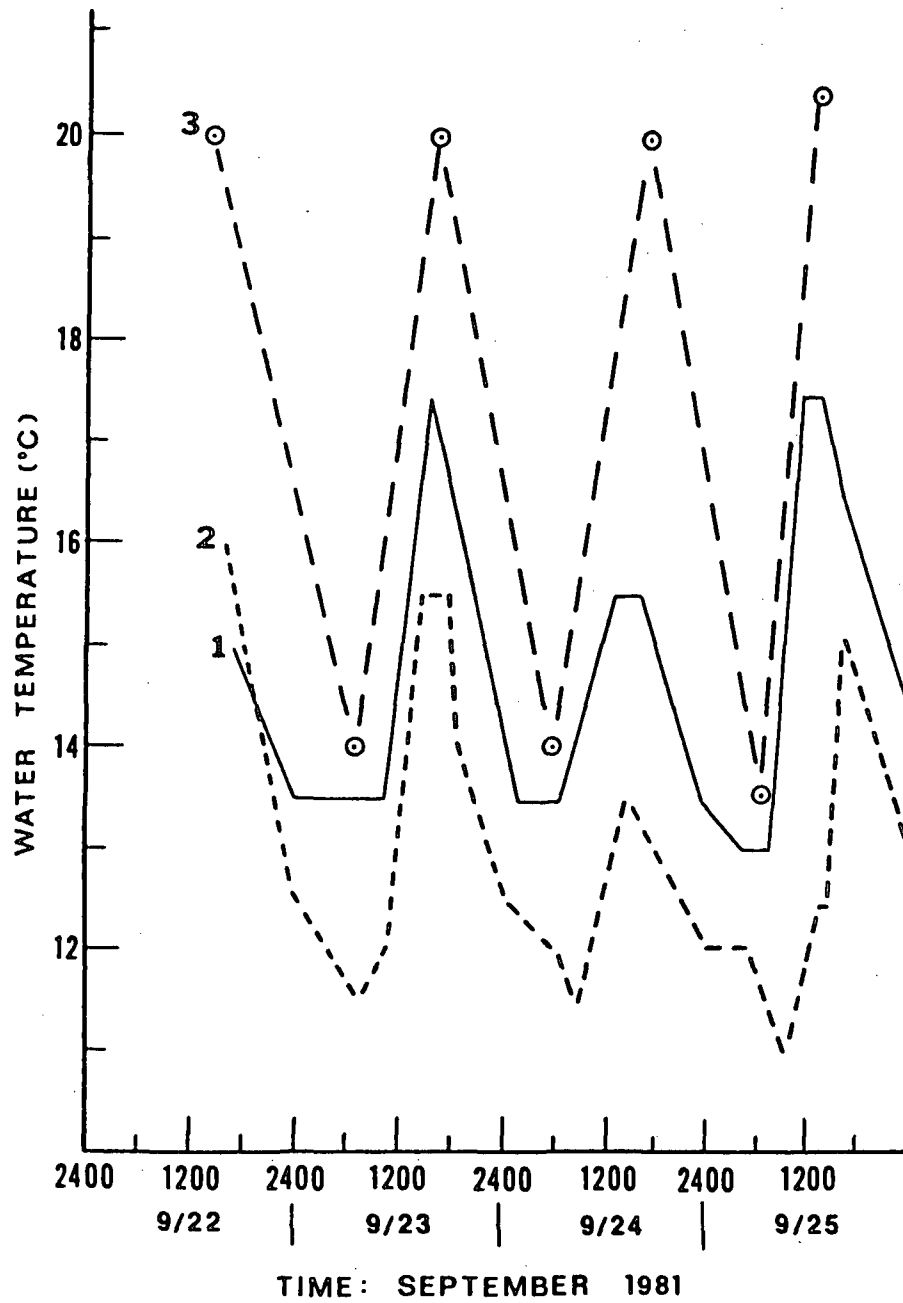


Figure 2

Water temperatures in cold pool from continuous recording thermographs (#1 and #2) and in mainstem from maximum-minimum thermometer (3). See Figure 1 for locations.