TASK 11. QUALITY AND QUANTITY OF CHINOOK SALMON SPAWNING HABITAT

11.1 OBJECTIVE

The purpose of this task was to determine the maximum number of female spawners that can be supported in the Lower Mokelumne River using information on chinook salmon habitat preference and aquatic habitat quality and quantity.

11.2 METHODS

For analysis, a literature search on salmonid spawning habitat preference was conducted using information gathered during recent field surveys on the Lower Mokelumne River. This information included results from an Instream Flow Incremental Methodology (IFIM) study conducted on the Mokelumne River in 1987 (Envirosphere 1988), aquatic habitat quantification (Task 4), and EBMUD's redd surveys during both the 1990-1991 and 1991-1992 spawning seasons (Task 10).

Three types of spawning habitat (potential, weighted usable area [WUA], and preferred) were considered in the analysis. Potential habitat encompasses all spawning habitat identified and measured during mapping surveys on the Mokelumne River in spring 1990 (Task 4). Classification of spawning habitat was qualitative and based on habitat type, substrate composition, and water depth. During the mapping of spawning habitat, flows averaged 254 cfs.

Chinook salmon spawning WUA was determined from the 1987 IFIM studies (Envirosphere 1988). Estimated spawning habitats for three study sites in the Camanche reach (fish screen, spillway, and pasture) were averaged to produce a mean spawning WUA. Mean WUA (ft^2/1000 ft) at flows equal to 250 cfs was then multiplied by the total length (ft/1,000) of spawning habitat measured during BioSystems' field surveys (Task 4) to produce total WUA spawning area (ft^2). All measurements were converted to metric following determination of WUA.

In addition to potential and WUA spawning habitat, a third category was evaluated: preferred spawning habitat. Preferred habitat is more narrowly defined than potential spawning habitat and is based on spawning habitat selection as described in the scientific literature and actually observed during redd surveys (Task 10).

Information on redd size was obtained from chinook salmon redd surveys (Task 10). Only data from the 1991-1992 spawning season was used since the field sampling program during this time was more comprehensive.

Synthesizing the various data sources, it was estimated that the number of female spawners the Lower Mokelumne River can support by dividing the amount of potential, WUA, and preferred spawning habitat by the mean redd size.

11.3 RESULTS

The estimated area of potential spawning habitat was 87,382 m^2, the WUA was 28,665 m^2, and the estimated area of preferred habitat was 12,549 m^2. Based on results from literature surveys and field observations, preferred spawning habitat was defined as encompassing only the area found in the upper 10 m of each of the spawning habitats identified above. This definition of preferred habitat was based on the assumption that spawning females select the transition area between non-spawning and spawning habitat types (i.e., top of a riffle or end of a pool leading into a riffle). This transition area typically occurs at the head of a riffle or the lower end of a pool, close to where smooth surface water breaks into a riffle and gathers velocity.

This phenomena has been observed in the Mokelumne River as well as described or alluded to in the literature. During the 1991-1992 redd surveys, most redds (98%) occurred in the upper 10 m of the top of the habitat (Task 10). Shapovalov and Taft (1954) noted that female silver salmon typically select spawning sites at the head of a riffle. Briggs (1953), in a study of a coastal stream in Northern California, noted that redds of salmonids (silver salmon, chinook salmon, and steelhead trout) were most often located at the ends of pools where water was beginning to gather momentum. This is also mentioned in the USFWS' habitat suitability models (Raleigh et al. 1986), but it is not incorporated into any of the models. Vronskiy (1972) reported that 95 percent of chinook salmon redds are in the gravel transition areas between pools and riffles.

The average area of redds measured on the Mokelumne River during the 1991-1992 spawning season was 5.5 m^2 (range 0.5-35.1 m^2) (Task 10). This size corresponds with those observed for chinook salmon in other systems. Mean redd sizes determined for two study areas in the Nechako River (British Columbia) were 10.0 m^2 and 9.1 m^2 (range 0.5-27.5 m^2) (Neilson and Banford 1983). Burner (1951) reports an average redd size of 5.1 m^2 for fall-run chinook salmon in the Columbia River.

The total area of spawning habitat (potential, WUA, and preferred) was divided by Mokelumne River mean redd area to predict the maximum number of spawning females the river could support at flows of around 250 cfs. Using our estimates of preferred and WUA habitat, it is predicted that from 2,282 to 5,212 spawning females, respectively, could construct redds without superimposition in the Mokelumne River. Using this estimate of potential habitat, the maximum predicted number of potential female spawners could be 15,888.

The estimates of all three types of spawning habitat are probably too high, especially since the classification of spawning habitat was qualitative and does not take into account microhabitat features such as embeddedness or armoring that would further lessen spawning

quality. During 1991-1992 surveys on the Mokelumne River, the majority of redds (86 percent) were found on naturally formed gravel ridges or "berms." Placement of redds on berms has been documented in other studies. Tutty (1986) found that chinook salmon spawning areas were directly associated with what he called "dune" formations, or berms, in the Nechako River. This study documented that spawning activity actually resulted in the formation of new berms which would be used later in the spawning season. In the Deschutes River in Oregon, berms, specifically the leading edge of berms, were also associated with redd placement (Huntington 1985). Huntington suggested that berms are originally formed by spawning salmonids and are typically found in regulated rivers lacking significant flows that would otherwise destroy these structures. In an investigation of spawning activities in the Tehama-Colusa Canal, it was discovered that 93 percent of chinook salmon selected gravel ridges or berms created by routine cleaning operations (Vogel 1982).

The reason salmon select berms for redd construction has not been well studied. Although they did not refer to these areas as berms, Crisp and Carling (1989) noted that brown trout, Atlantic salmon, and rainbow trout constructed redds most often in areas where "water velocity was appreciable and upwelling or downwelling flow was likely to occur." Elevated stream bottoms are subjected to the highest underflow currents (Stuart 1953); as a result of these water circulation conditions, the leading edge of berms may be ideal for intra-gravel egg incubation and survival (Vronskiy 1972; Huntington 1985; Tutty 1986). These conditions would help explain why redds are often observed in the transitional area between pool/run and riffle habitats since elevated ridges are normally found there.

Interest is growing in berm utilization by spawning salmonids. Shirvell (1989) concluded that PHABSIM, part of IFIM, erroneously predicts chinook spawning habitat because it fails to consider spawning on berms. IFIM studies conducted on the Mokelumne River failed to take into account redd placement on berms, thereby overestimating the amount of available spawning habitat.