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The Resources Agency
DEPARTMENT OF FISH AND GAME

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RECONNAISSANCE OF THE STEELHEAD RESOURCE OF THE CARMEL RIVER DRAINAGE, MONTEREY COUNTY

by

William M. Snider
Environmental Services Branch
Stream Evaluation Program

ENVIRONMENTAL SERVICES BRANCH
Administrative Report No. 83-3

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RECONNAISSANCE OF THE STEELHEAD RESOURCE OF THE CARMEL RIVER DRAINAGE, MONTEREY COUNTY [1/]

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William M. Snider [2/]

ABSTRACT

The Carmel River steelhead resource was studied from 1964 through 1975. The mean production of sea-run steelhead was estimated to be 3,177 fish, the maximum number was 3,602 fish. This level of production is only about 25% of the historic level. Water development, offstream diversions and flood plain encroachment have drastically reduced steelhead habitat.

Essentially all juvenile steelhead production occurred in the drainage between San Clemente Dam, at river mile 18.5, and Los Padres Dam, at river mile 24.8. The uppermost 14.75 miles of spawning and rearing habitats above Los Padres Dam were inaccessible due to an inefficient fishway; the 18.5 stream miles downstream of San Clemente Dam are annually dewatered from summer through fall. Juvenile steelhead reared upstream of San Clemente Dam migrated to the lower 18.5 miles in late winter, then doubled or tripled in size before smolting and emmigrating in mid-spring.

Development may have already committed the steelhead resource to perpetual decline. Habitat downstream of San Clemente Dam is unstable and rapidly degrading. Riparian vegetation has been destroyed, yielding extensive bank erosion and concomitant stream channel widening. Pool and riffle habitats have been buried. Migration to and from the spawning and perennial rearing habitats upstream of San Clemente Dam, and smolt production downstream of the dam are in jeopardy.

Immediate implementation of a stabilization program in the lower river is recommended; relocation of offstream diversion could stabilize the lower river stream channel and induce rehabilitation of essential steelhead habitats, increasing sea-run steelhead production 177%. Optimization of migration over Los Padres Dam is recommended; sea-run steelhead production would be increased 44%.

1/ Environmental Services Branch Administrative Report No. 83- September 1983. This report was prepared as part of the Stream Evaluation Program.

2/ Environmental Services Branch, Sacramento, California.

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FOREWORD

The steelhead, <u>Salmo gairdneri gairdneri</u>, is an important, indigenous resource in California, sustaining one of the state's largest, most popular anadromous sport fisheries. It is also a dwindling resource, diminishing in its historic range and size and in its capacity for natural propagation.

The California Fish and Game Commission recognizes steelhead as a valuable resource with strict environmental requirements. It is the Commission's policy to provide a vigorous, healthy steelhead resource by maintaining an adequate breeding stock and suitable spawning areas and by providing for natural rearing of young fish to migratory size. The policy emphasizes management programs which inventory and protect and, wherever possible, restore or improve the habitat of natural steelhead stocks. It mandates the Department of Fish and Game to develop and implement such programs by measuring and, wherever possible, by increasing steelhead abundance. Protection is to be provided by assessing habitat status and adverse impacts and by alleviating those aspects of projects, development or activities which would or already do adversely impact steelhead habitat or steelhead populations.

Nowhere in the state is the implementation of this mandate more critical than in the steelhead's southernmost range, south of San Francisco Bay. Steelhead, once abundantly distributed as far south as Baja California, are now rarely found south of San Luis Opispo County. Water development and urbanization have drastically depleted the resource, eliminating steelhead production from over 60% of the area's major watersheds and substantially reducing natural production in most of the remaining waters. Steelhead runs collectively totalling well over 100,000 fish have been lost as a result. The Santa Ynez River, for example, once sustained runs of over 10,000 adult steelhead, but water development and urbanization have left the stream barren. The Santa Ynez River is not a solitary example, the steelhead resources of the San Diego, Santa Ana, Los Angeles, Santa Clara and Cuyama rivers, to name others, have similarly yielded to development.

The destruction of steelhead resources is continuing northward. The Pajaro and Salinas rivers located near Monterey, well north of the southern limit of the steelhead's present range, have also been affected by development. These rivers once produced thousands of steelhead, as well as chinook, <u>Oncorhynchus tshawytscha</u> and silver salmon, <u>O. kisutch</u>. Poor water and flood plain management have eliminated the salmon and reduced the steelhead resources to remnant runs. Similarly, the steelhead resources of the San Luis Obispo Creek drainage, the San Lorenzo River drainage and numerous other coastal streams adjacent to the urban areas of the central coast are being rendered unproductive by poor water and land use planning and management. Collectively, thousands of adult steelhead and hundreds of thousands of recreational hours are being jeopardized.

The Carmel River is a major steelhead resource at the southern limit of the present range of steelhead. Its existance, like most of its neighboring steelhead resources, is in immediate jeopardy, pending development and implementation of a watershed management program.

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INTRODUCTION

The Carmel River has the largest, self-sustained steelhead resource south of San Francisco. It supports a popular sea-run steelhead fishery of over 10,000 angling hours per year, the second largest steelhead fishery in that region next to the San Lorenzo River. The resource is diminishing, however, as essential habitat has been and continues to be degraded and destroyed by water development, especially offstream diversion, and by flood plain encroachment, watershed development and erosion. Sea-run adult production has declined an estimated 75% in the past 60 years, and the rate of decline has accelerated with the demands of urban growth. Natural steelhead production in the Carmel River basin will probably cease in the next decade if the present rate of habitat destruction continues. The existing problems must be abated and future problems prevented if this valuable resource is to be saved. The goal is to sustain or restore the Carmel River steelhead resource.

Most of the habitat degradation in the Carmel River basin is the result of water development, and offstream diversion to the Monterey Peninsula. Two dams, and several well fields, which divert the underflow, annually divert up to 14,500 acre-ft of water (about 20% of the mean, annual runoff). The demand for offstream uses of water is growing, increasing the threat to steelhead habitat. In the mid-1970's, for example, the Army Corps of Engineers proposed construction of a water supply-flood control dam on the river which would have essentially eliminated natural production of steelhead from the Carmel River (U. S. Fish and Wildlife Service 1978, Nakaji 1980). More recently, the California American Water Company (Cal-Am), which operates the dams and well fields, has proposed to expand the well field and substantially increase annual diversion of the underflow (an additional 5,000 acre-ft). The existing operation has already demonstrably caused substantial changes in the lower river stream channel and steelhead habitat (Kelley and Dettman 1981, Kelley, Dettman and Turner 1982, Kondolf 1983), and these changes may already have resulted in a perpetual decline of the steelhead resource. Additional offstream diversion should not be allowed without first rectifying the existing problems by restoring the Carmel River's steelhead habitat and resource.

The Monterey Peninsula Water Management District and the Department of Fish and Game (DFG) are involved in developing a management plan which will integrate steelhead habitat requirements with the demands of water and flood plain development. This report provides input to the planning process relative to the state's steelhead policy. The extent of the steelhead population and means of increasing its size are identified. An inventory of steelhead habitat, including problems affecting the steelhead resource, is provided and means of alleviating those problems are recommended. The results of the DFG investigation of steelhead habitat requirements relative to the Army Corps of Engineers project are presented and discussed along with subsequent investigations of the Carmel River steelhead resource.

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DESCRIPTION

General Setting

The Carmel River basin is located in the central coast region of California in the Coast Range mountains about 10 miles south of Monterey (Figure 1). The pear-shaped basin is 27 miles long, 17 miles wide, and encompasses 255 square miles. Its headwaters originate from 4,500 to 5,000 ft above sea level, as far as 36 stream-miles above the river's mouth at Carmel Bay. The river system includes 7 major tributaries and over 60 miles of stream, including 35 miles of mainstem river (Figure 2).

The basin is comprised of two geomorphically distinct regions which are separated by Tularcitos Creek at river-mile 15 (RM 15). The upper drainage encompasses the upper 65% of the basin. Here the river flows in a northwesterly direction, through a steep, V-shaped canyon following the fault block structure of the Coast Range mountains. The stream gradient is steep (320 ft/mile) with several major waterfalls up to 90 ft high in the uppermost reach. A 45-ft high waterfall located near Ventana Mesa Creek (RM 30) represents the upstream limit to steelhead migration. The river substrate is predominantly bedrock, boulder and cobble, with some gravel. Pools are abundant (40-50%, by area) and dense riparian vegetation and steep canyon walls shade the river. The tributaries resemble the mainstem but are narrower and possess more gravel.

In the lower drainage, the river flows in a westerly direction through Carmel Valley. The valley has a maximum width of about 2 miles, with a maximum flood plain width of 4,000 ft. The river gradient is 40 ft/mile. Substrate is generally alluvial, progressively changing from cobble to gravel beween RM 15 and RM 7, from gravel to sand between RM 7 and RM 2.5 and consisting entirely of sand between RM 2.5 and Carmel Bay. A sandbar forms across the mouth as flow declines in the spring creating a lagoon with no access to the ocean until fall and winter rains increase flows enough to remove the bar.

Water Development and Flow

Water has been exported from the Carmel River to the Monterey Peninsula since 1882, when C. P. Huntington organized a water system primarily to supply the Del Monte Hotel (Williams 1983). Since then two dams and a large well field have been developed to export water to the Peninsula (Table 1, Figure 3). San Clemente Dam (RM 18.5), built in 1921, was the Peninsula's only source of Carmel River water until 1940, when wells at the upper end of the Carmel Valley alluvium (RM 11) began producing water to augment summer supplies. As demand continued to grow, Los Padres Dam was built in 1949 followed by increased pumping from the well fields in the mid-1950's (Williams 1983). The combined yield of these sources (1940-1982) has increased from 4,600 acre-ft to over 14,500 acre-ft (Table 2).

Flow, at least upstream of San Clemente Dam is normally perennial. Generally, only Cachauga Creek is intermittent and even it flows perennially in its upper reach. Water released from Los Padres Dam

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FIGURE I. Location of Carmel River Basin, Monterey County.

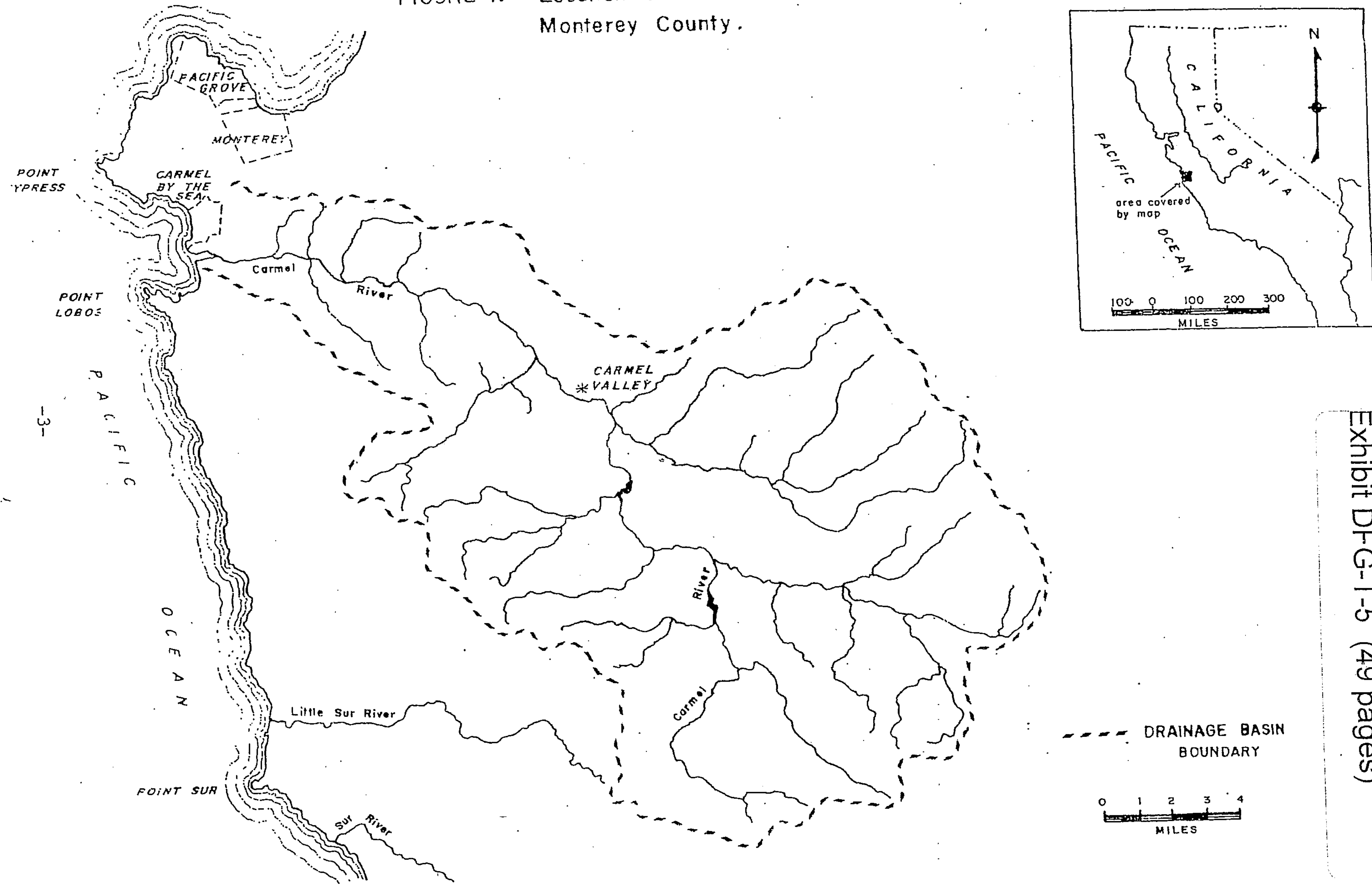


Figure 2. Carmel River Drainage.

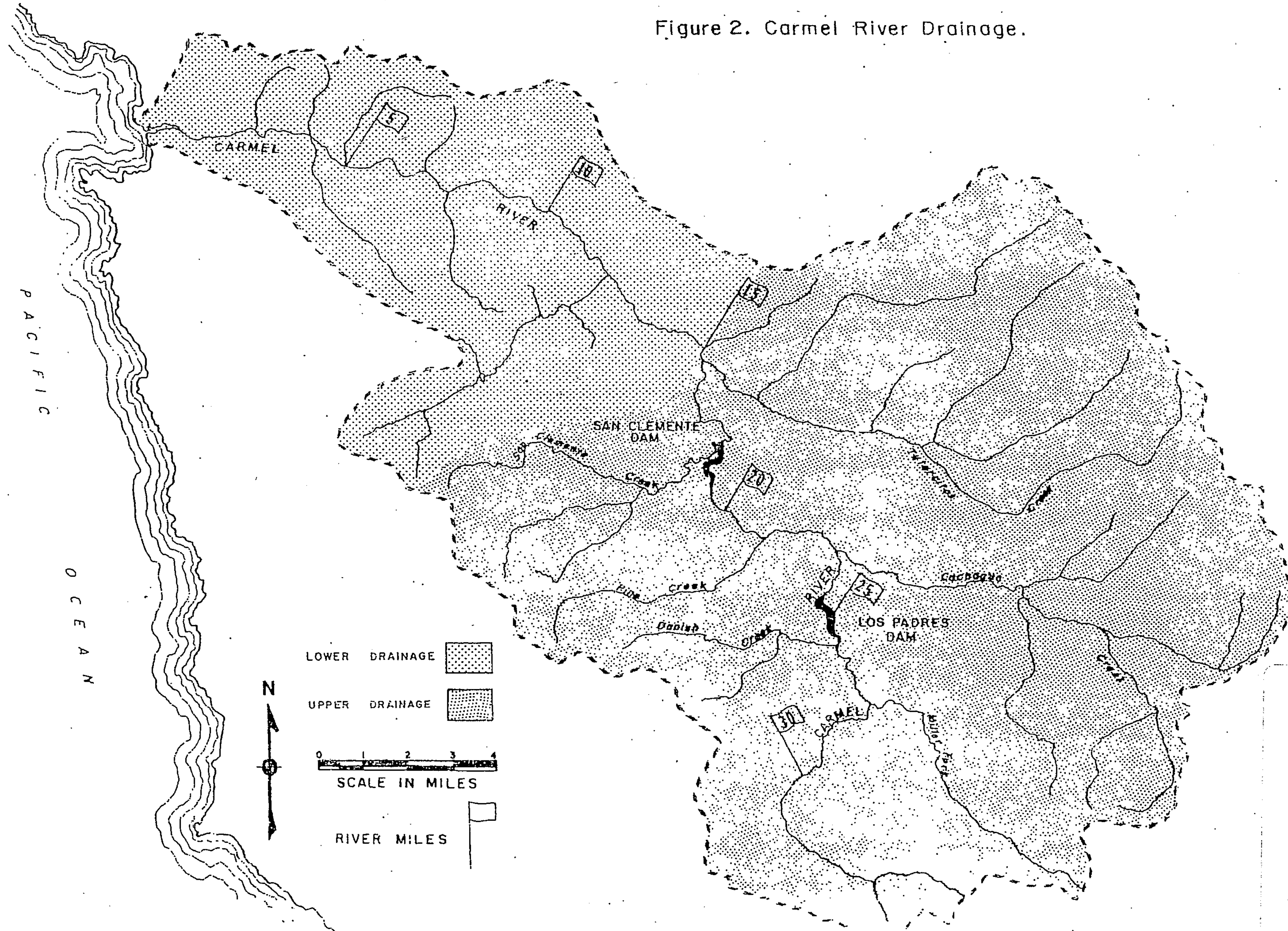


Figure 3. Location of water development facilities, Carmel River.

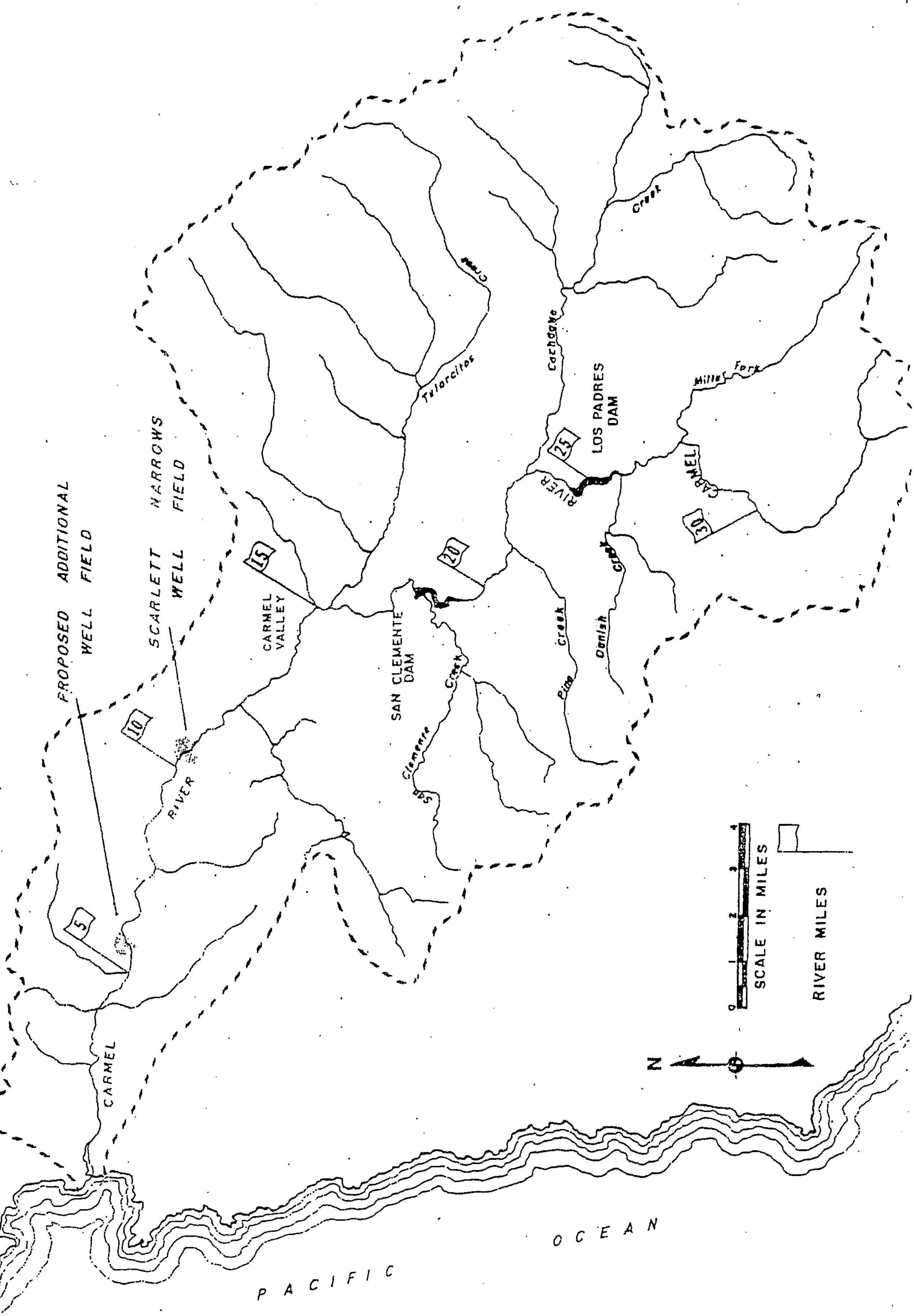


TABLE 1. Specifications of San Clemente and Los Padres Dams, Carmel River Basin[1/]

Specifications	San Clemente Dam	Los Padres Dam
Date of completion	1921	1949
River mile	18.5	24.8
Drainage area (square miles)	250	125
Height of dam (ft)	85	148
Top of dam elevation (ft, m.s.l.)	537	1,058
Spillway crest elevation (ft, m.s.l.)	525	1,040
Reservoir surface area at spillway crest (acres)	33	67
Reservoir capacity at spillway crest (acre-ft)	790	2,050
Reservoir capacity w/flash boards (acre-ft)	1,300	—
Type of dam	Variable-radius concrete arch	Earth
Type of spillway	Overflow (plus flashboards)	Board crested (ungated)
Outlet works:		
Diameter (in)	24	30
Type	Concrete-lined steel	Reinforced concrete pipe
Fish passage facility	Fish ladder	Steep-pass and trap

1/From Williams 1983.

TABLE 2. Annual Water Production of California-American Water Company in the Carmel River Basin, 1940-1982 (Williams 1983).

Water year	Source: Groundwater 1/ (acre-ft)	Source: Surface water (acre-ft)	Total (acre-ft)
1940		4,600	4,600
1941		5,200	5,200
1942		4,500	4,500
1943		5,100	5,100
1944		5,200	5,200
1945	100	5,400	5,500
1946	400	5,400	5,800
1947	800	5,200	6,000
1948	1,000	5,300	6,300
1949	100	6,600	6,700
1950	100	6,900	7,000
1951	50	7,000	7,050
1952	0	7,000	7,000
1953	0	7,700	7,700
1954	0	8,000	8,000
1955	0	7,900	7,900
1956	0	8,300	8,300
1957	0	8,600	8,600
1958	0	8,500	8,500
1959	800	9,500	10,300
1960	1,000	8,600	7,600
1961	2,400	7,800	10,200
1962	1,000	8,600	9,600
1963	600	8,800	9,400
1964	1,100	9,700	10,800
1965	1,400	9,700	11,100
1966	2,800	10,200	13,000
1967	900	8,900	9,800
1968	3,200	9,500	12,700
1969	2,800	7,600	10,400
1970	3,100	9,300	12,400
1971	4,000	7,800	11,800
1972	4,500	7,700	12,200
1973	3,000	8,100	11,100
1974	2,700	8,800	11,500
1975	2,800	9,100	11,900
1976	5,600	6,200	11,800
1977	3,100	2,700	5,800
1978	3,200	7,000	10,200
1979	4,760	7,760	12,520
1980	4,110	9,600	13,710
1982	4,718	9,799	14,517

1/ Private diversion of up to an additional 2000 acre-ft presently occurs.

(minimum required by permit is 5 cfs) maintains perennial flow in the 5.5 mile section between the two dams. Seepage from San Clemente Dam (~1 cfs) maintains several large pools located immediately downstream.

Flow would be permanent from the headwaters to the lagoon during normal and wet years (79% of the years) if stream flow were not diverted by surface or subsurface diversions (Figure 4). Flow would generally increase with the first storms of the season, usually in November, then fluctuate with storm intensity and frequency. It would taper off in late spring, as the rainy season subsides, eventually reaching low flow in late September.

With surface diversions, flow below San Clemente Dam is drastically reduced in late May, when it is shut-off at San Clemente Dam with the installation of 12-foot tall flashboards. Flow does not reach all the way to the lagoon until sufficient rainfall has recharged the aquifer near Scarlett Narrows. As a result, the only flowing surface water generally occurring in the lower river in late summer originates from Tularcitos Creek (1-2 cfs) and flows to near Esquiline Road bridge, about 1 mile, before disappearing into the alluvium. A few perennial pools occur near RM 4.

Development and Environmental Alteration

Urban and agriculture development in the upper drainage is scattered, but increasing. Currently it consists of the two dams, the communities of Cachauga and Prince's Camp and numerous, isolated residences. A large vineyard is being developed near Los Padres Dam and application has been made to the State Water Resources Control Board to divert up to 8 cfs from the Carmel River.

Sedimentation in portions of the upper drainage is a major problem. An airport constructed above San Clemente Dam annually generates tons of silt into the Carmel River. The Central Coast Regional Water Quality Control Board is attempting to resolve that problem. Also, silt sluiced from Los Padres Dam in 1981 resulted in significant loss of steelhead. Fortunately the silt was greatly reduced in the river with the unusually high flows occurring in the past two rainy seasons (1982 and 1983). Restitution for the loss of steelhead is being sought through litigation.

Land use in the lower drainage is rapidly changing from semi-rural to urban. Flood plain development is extensive, extending from the lagoon to Tularcitos Creek. With the development, large amounts of riparian vegetation have been replaced with rip-rap and other mechanical forms of bank stabilization. Water demand has increased and more sources of erosion and urban runoff have occurred. For example, construction of a golf course and condominums along 0.5 miles of river bank near RM 10, has eliminated all riparian vegetation and replaced it with mechanical bank stabilizers. Irrigation and domestic water demand are estimated to be 2,000-plus acre-feet per year. Storm drains, leading into the river, and the irrigation runoff from the golf course are definite sources of urban runoff (i.e. pollution).

Loss of the riparian vegetation through water and flood plain development, primarily surface and underflow diversion, has increased water temperatures

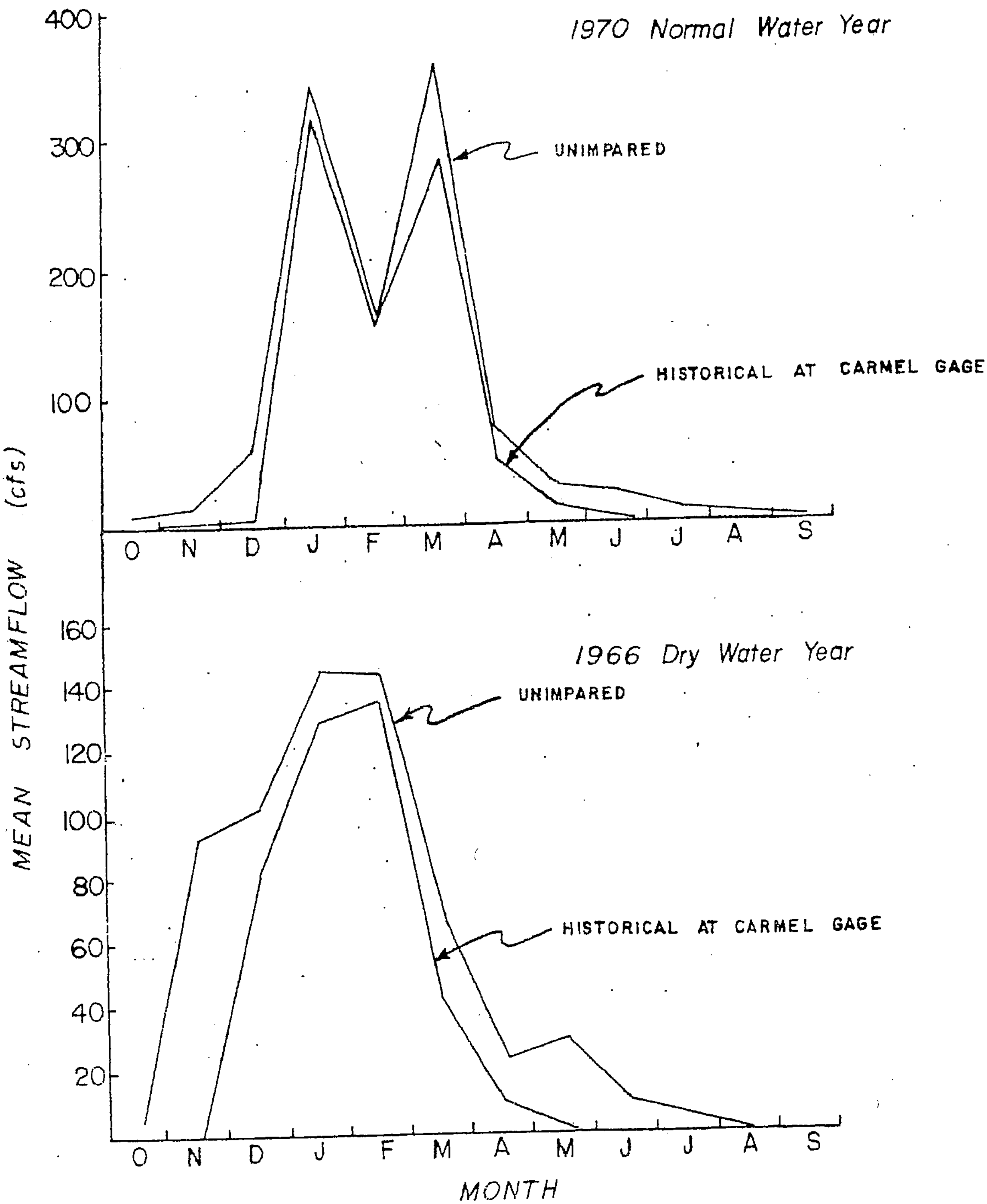
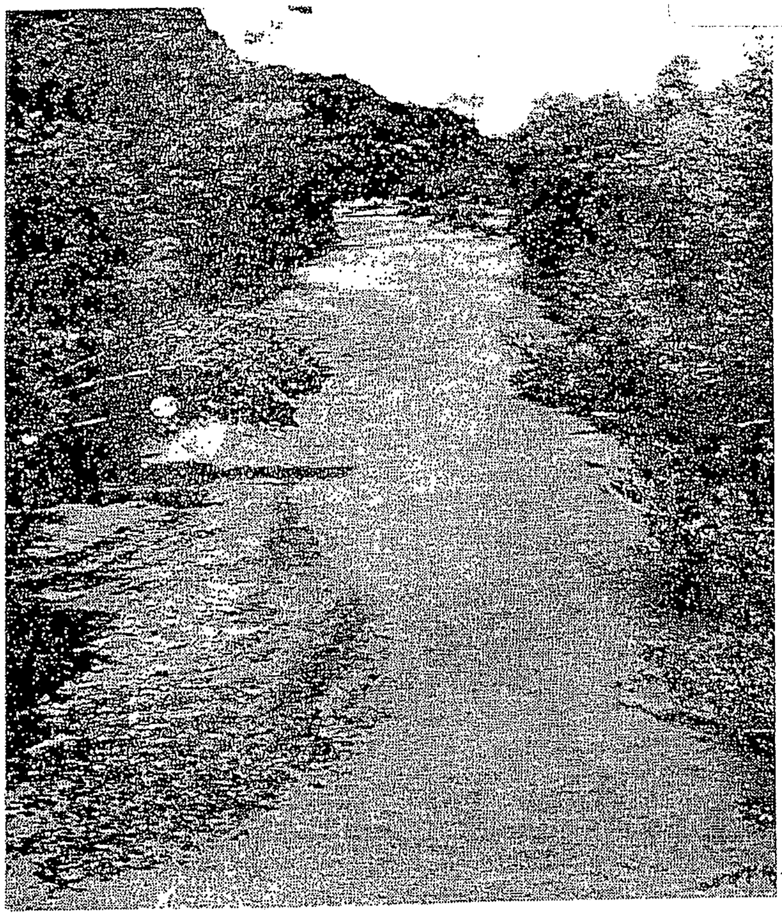


FIGURE 4. Historical Outflow Carmel River in 1970 (normal water year) and in 1966 (dry water year) and Outflows that Would have Occurred if Stream Flow had been Unimpaired by any Surface Diversion or Pumping (U. S. Corps of Engineers Model).



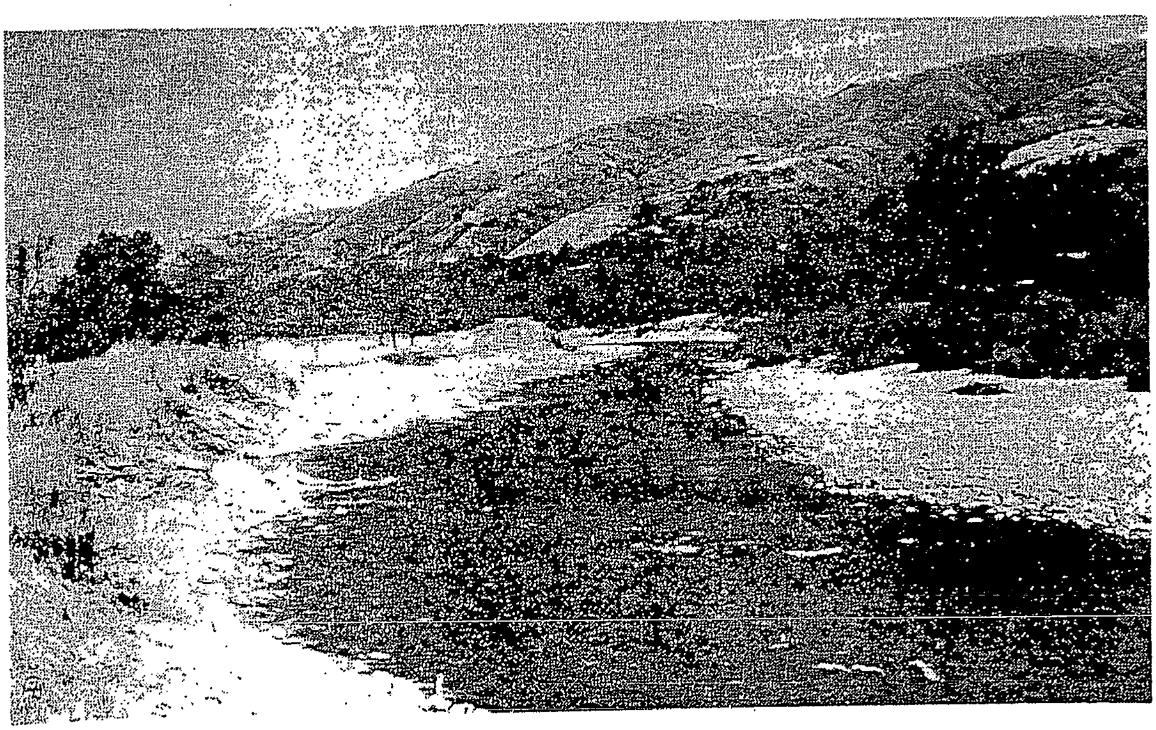


Plate 1 (a) Perennial flow supports dense riparian vegetation immediately downstream from Tularcitos Creek.
(b) Riparian vegetation is lacking along the lower river (in the vicinity of the well fields) where flow normally ceases during summer and fall (photos by author).

in the few remaining surface waters of the lower river (Kelley 1982) and rendered the banks highly erodable (Kondolf 1982). In 1978 and 1980, moderate flows resulted in extensive bank erosion which silted gravel, filled pools, including the lagoon, and caused substantial change in the stream channel configuration. The impact upon steelhead habitat will be discussed later.

METHODS

Data were collected from 1964 through 1975 to assess the impact of the proposed Army Corps of Engineers dam (RM 18.5) upon the Carmel River steelhead resource. Data collected subsequent to 1975 have been used to update our results to further define the steelhead resource and to identify any changes which may require further investigation.

Upstream Migration

An estimate was made of the number of adult steelhead returning to spawn in the drainage above San Clemente Dam by counting the fish moving through the fishway. Between 1964 and 1974, visual counts were made twice a day by reducing the flow through the ladder and counting the fish in each step. An electronic fish counter was placed in the fishway in 1974 and 1975. Adult fish count data were compared with flow at the dam site and near Carmel to identify possible trends in the impetus to stimulate upstream migration and thus, determine requirements for attraction and migration flows.

Spawning

Riffle habitat was measured in the upper drainage, upstream of San Clemente Dam, during low flow conditions (July-October, 1975). Spawning habitat was conservatively estimated to include 1/2 of the riffle area available to steelhead adult during winter flow conditions. Spawning habitat potentially available from Tularcitos Creek to San Clemente Dam was estimated using the findings of Nakaji (1980) who measured spawning, nursery and migration flow using the Fish and Wildlife Service Instream Flow Group method (Bovee 1978).

Spawning habitat in the lower drainage was measured in a 0.5-mile long study section downstream from Esquiline Road bridge (RM 15). The section was considered to be representative of the river between RM 15 and RM 10, where the majority of suitable spawning substrate occurred. The section was divided into a series of stream units consisting of a pool-riffle combination (Mundie 1974). Five representative units were evaluated along transects set at 25 ft intervals. Depth, velocity and substrate were measured along each transect at flows of 50 cfs and 80 cfs, and then compared with spawning criteria developed by Hooper (1973) (Table 3) to estimate total spawning habitat available at each flow. The data were then expanded to obtain an estimate of the total spawning area available in the lower drainage at each flow.

TABLE 3. Steelhead Spawning and Nursery Habitat Criteria (Hooper 1973).

Habitat	Water depth ft (m)	Water velocity ft (m)	Water temp F (C)	Substrate Composition (% volume) 6-12 in (15-30 mm)	3-6 in (7.5-15 mm)	1-3 in (2.5-7.5 mm)	1/2-1 in (1.3-2.5 mm)	5/32-1/2 in (.4-1.3 m)	<5/32 in (<.4 m)
Spawning	0.7 to 6.0 (0.2 to 1.8)	1.27 to 2.98 (0.4 to 0.9)	<60 (<15)	≤30	≥10	≤50	≤20	≤20	≤20
Nursery	≥0.5 (≥0.15)	--	70 (21)	--	--	--	--	--	--

Nursery Habitat

Pool and riffle habitats were measured throughout the drainage during low flow conditions (July-October 1975). All of the wetted habitat in the upper drainage was considered nursery habitat. The amount of nursery habitat that would be available below San Clemente Dam at 50 and 80 cfs was estimated by applying the nursery criteria listed in Table 3 to the data collected during the spawning habitat evaluation described above.

Juvenile and Adult Populations

The drainage was divided into eight study areas (Figure 5) to facilitate estimation of steelhead populations. Each area contained at least one representative 1 mile long study section. Six 100-ft long sample stations were randomly selected within each study section, and each station was sampled with electrofishers in the late summer and early fall of 1973 and 1974 to determine juvenile steelhead distribution and abundance. Block nets were used to isolate each station from the rest of the stream during electrofishing. Population estimates were made using the two-pass, catch-removal method (Seber and LeCren 1967).

The steelhead collected during electrofishing were measured to the nearest 0.1 inch fork length (FL) and then divided into age classes based on length (Shapovalov and Taft 1954). Mean population estimates (fish/mile) for each age class were made for each section by multiplying the mean population, by age class, for the six stations of each section by 52.8 (i.e., the number of 100-ft stations per mile). The total population for each age class for the entire basin was estimated by summing the products of the total mileage of useable habitat represented by each study section and the mean age class population per mile for each section.

An estimate of adult production was made by applying an average return rate of 2.4% for fish <5 inches FL, 5.8% for fish 5 to 8 inches FL, and 18.1% for fish >8 inches FL (Shapovalov and Taft 1954) to the estimated total number of each age class surviving to spring migration. A 50% survival rate was assumed for each age class.

Juvenile Migration

Two traps were constructed in the lower river in May 1975 to monitor the downstream movement of juvenile steelhead. One was located at RM 16 and the other at RM 6. Migration patterns were assessed by observing movement of juvenile steelhead at San Clemente Dam and at other points during the 1974 and 1975 winter-spring periods. Scales collected from adults caught by anglers in 1982 and 1983 were analyzed to determine the average time juvenile steelhead spent in the stream prior to entering the ocean.

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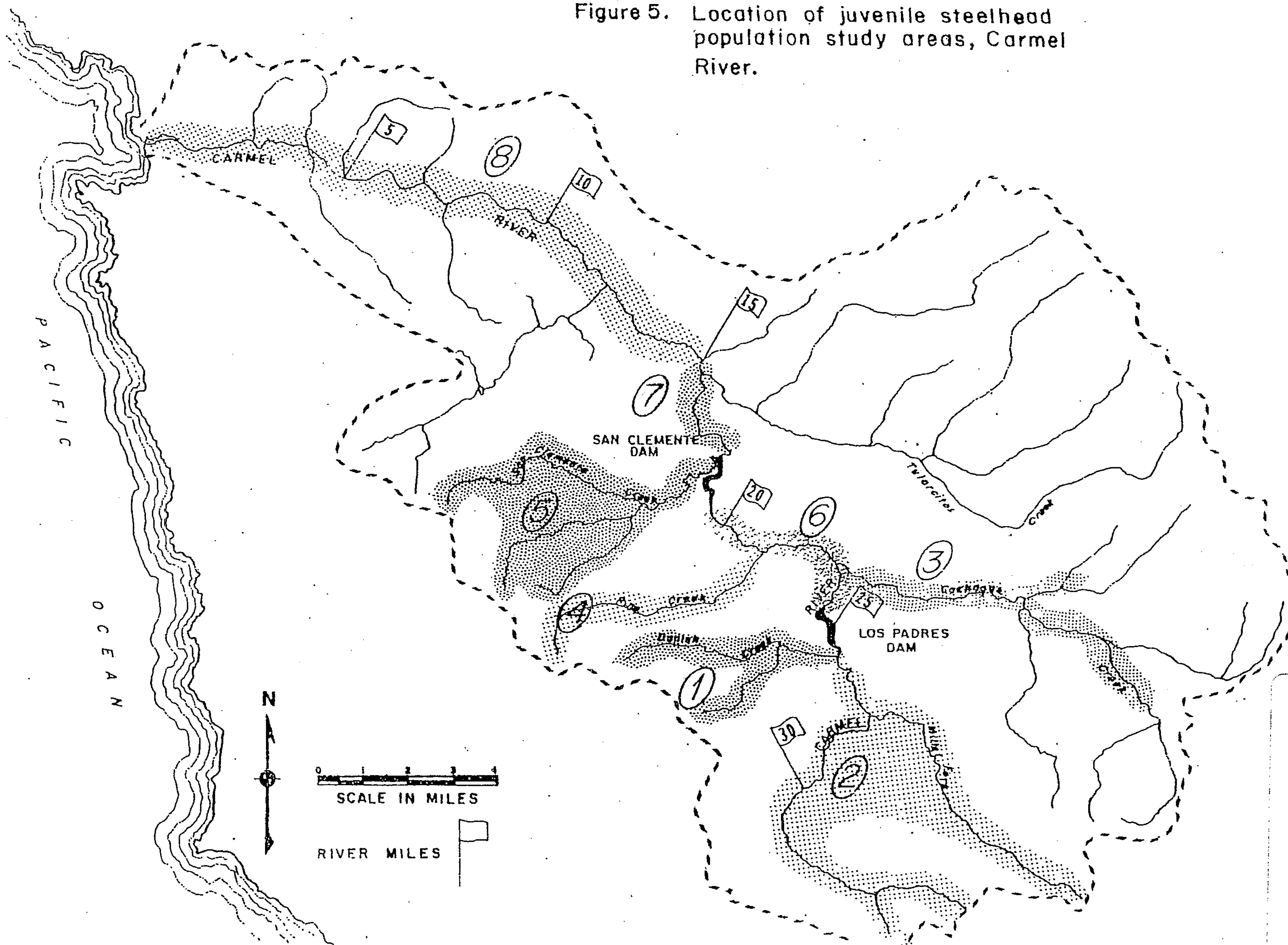
Figure 5. Location of juvenile steelhead population study areas, Carmel River.



RESULTS OF THE CARMEL RIVER STEELHEAD RESOURCE INVESTIGATION, 1964-1975

Upstream Migration

The steelhead counts at San Clemente Dam between 1964 and 1973 are considered conservative. All of the counts were made during the day while the electronic fish counter showed a significant number of fish to move through the ladder at night. However, the comparison of annual trends and relative numbers of adults moving over the fishway are valid as the counts were made in a consistent manner.

Upstream or spawning migration generally occurred between January and April (Table 4). Upstream migrations rarely occurred before flow at Carmel reached at least 200 cfs. Arrival of the year's first group of adult steelhead at the San Clemente Dam fishway between 1964 and 1975 was nearly always preceded by flows of at least 200 cfs near Carmel (Table 5). An exception to this trend occurred in 1968. However, flows never reached 200 cfs that year. Furthermore, fish counts were the lowest recorded in both 1968 (246 fish) and 1972 (94 fish) when peak flows were generally less than 100 cfs. The mean count for those 2 years was only 170 while the overall mean (1964 through 1975) was 821. In 1972, steelhead did not reach the fishway until February and the run was confined to a short period following a flow of 200 cfs (Figure 6).

The number of adults counted at the fishway was also compared with total runoff (Table 6). Between 1964 and 1975, the mean adult counts at low annual runoff (less than 20,000 acre-ft) was shown to be significantly less than the mean adult counts at high annual runoff (170 fish versus 961 fish). Low daily flows and low maximum flows associated with low annual runoff most likely accounted for the small counts of adult fish.

San Clemente Dam did not impede spawning migration. The average number of adult steelhead moving over San Clemente Dam fishway was 821, ranging from 94 in 1972 to 1,350 in 1965. Los Padres Dam, however, did impede access to the river upstream of Los Padres Dam due to an inefficient fishway. For example in 1975 only nine steelhead adults were captured and moved around the dam, while 1,287 steelhead adults had migrated over San Clemente Dam. Fish were observed milling around the base of the dam, apparently unable to locate the entrance to the fishway.

Spawning Habitat

Spawning habitat was present throughout the drainage (Figure 7). In the upper drainage, 28 acres of riffle measured at low flow (Table 7) were estimated to yield about 16 acres of spawning habitat during winter flows (>50 cfs).

Spawning habitat was plentiful in the lower river in 1975 at flows of 200 cfs. However, spawning at such high flows and subsequent flow reduction resulted in some redds being stranded. Instream flow measurements made below Tularcitos Creek indicated that 0.04 acres of spawning habitat would

TABLE 4. Adult Steelhead Counts at San Clemente Dam, Carmel River, 1964 through 1975.

Water year	December	January	February	March	April	Total
1964	0	113	118	327	201	759
1965	203	814	152	181	0	1,350
1966	76	319	451	69	0	915
1967	0	546	275	493	0	1,314
1968	0	153	93	0	0	246
1969	0	205	818	313	0	1,336
1970	0	206	51	105	0	362
1971	0	244	168	265	92	769
1972	0	0	77	17	0	94
1973	0	390	444	188	0	1,022
1974	16	69	39	224	47	395
1975	0	0	285	1,002	0	1,287
Summary	295	3,059	2,971	3,184	340	9,849
Mean	25	255	248	265	28	821

TABLE 5. Occurrence of Initial Adult Steelhead Migrant Recorded at San Clemente Dam, Carmel River, Relative to Flow near Carmel.

Month-year	High flow preceding arrival (cfs)	Flow at fish arrival (cfs)
Feb 1975	2,420	877
Dec 1974	407	39
Jan 1973	188	606
Feb 1972	196	98
Jan 1971	198	129
Jan 1970	407	243
Jan 1969	1,370	1,050
Feb 1968	93	75
Jan 1967	570	270
Jan 1966	725	278
Dec 1965	322	245
Jan 1964	676	263

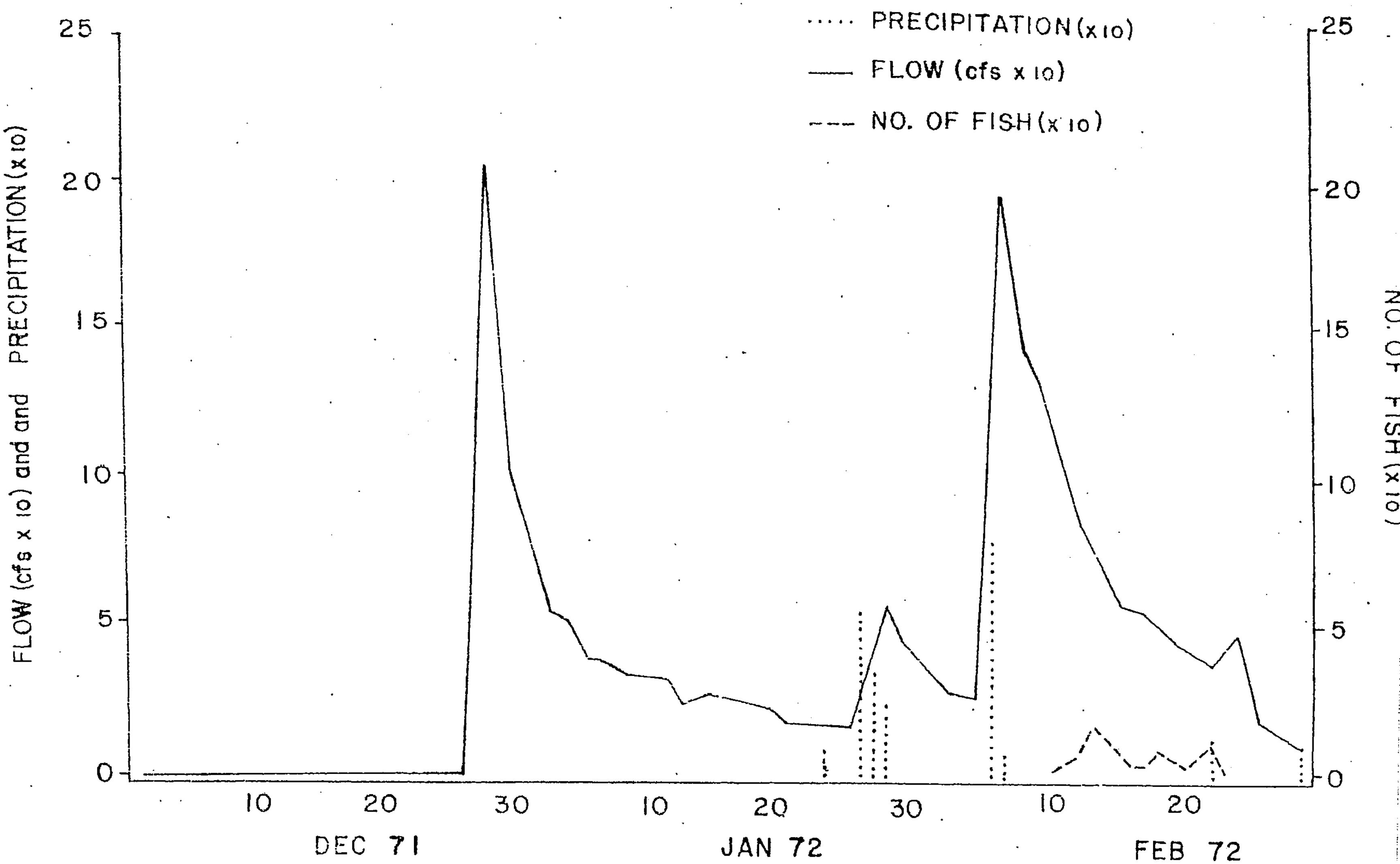


FIGURE 6. Comparison of adult steelhead counts at the San Clemente Dam fishway, flow recorded near Carmel, and precipitation 1972. Carmel River.

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TABLE 6. Annual Carmel River Basin Runoff and Sea-run Steelhead Counts at San Clemente Dam Fishway for Water Years 1964 through 1975.

Water year	Annual runoff (acre feet)	Sea-run steelhead counts
1964	21,270	759
1965	49,480	1,350
1966	23,700	915
1967	128,800	1,314
1968	7,430	246
1969	226,300	1,336
1970	50,410	362
1971	30,320	769
1972	7,000	94
1973	150,400	1,022
1974	NA	395
1975	NA	1,287
Mean	69,511	821

Exhibit DFG-T-5 (49 pages)

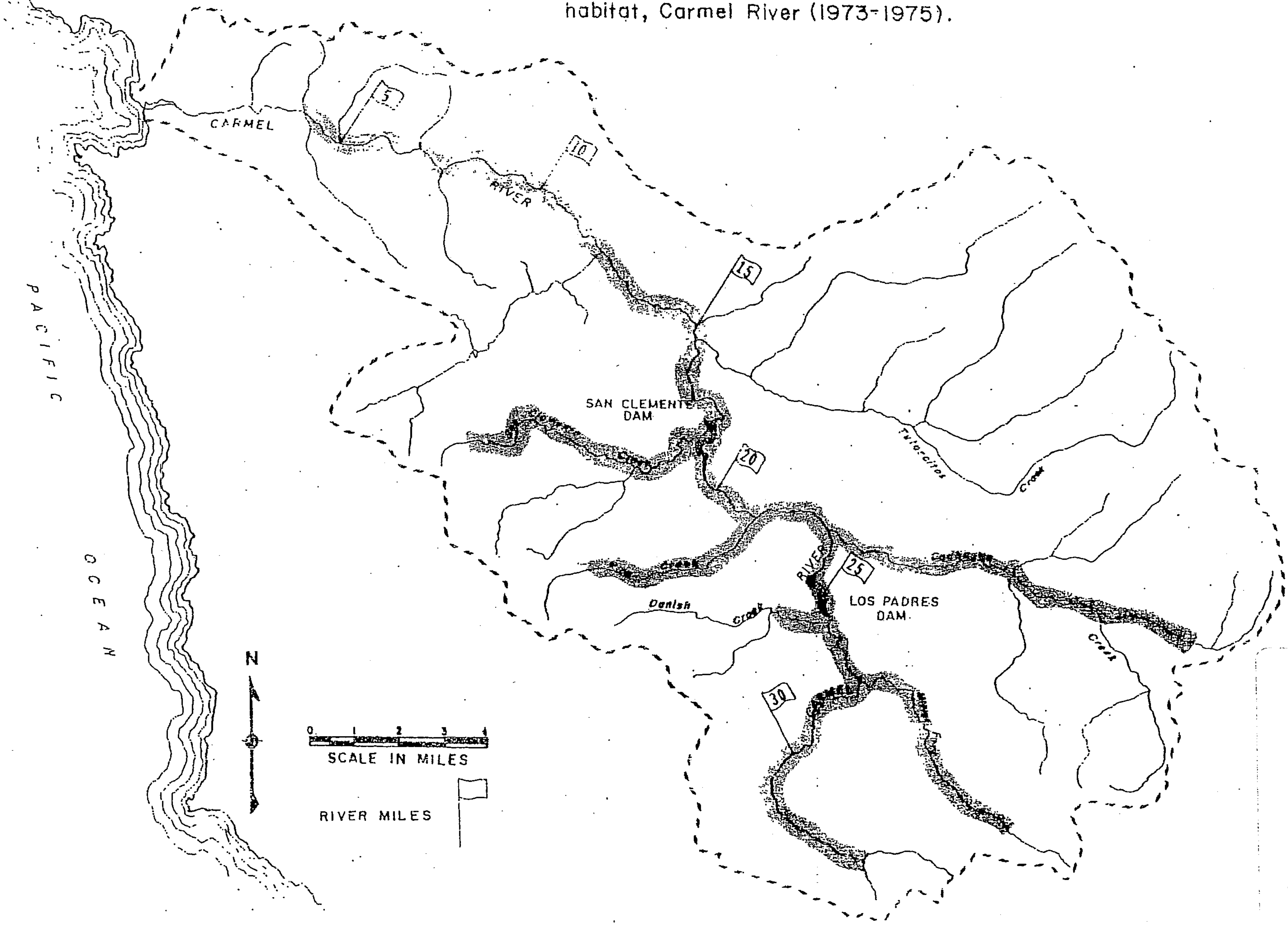

Figure 7. Location of suitable steelhead spawning habitat, Carmel River (1973-1975).

TABLE 7. Steelhead Habitat Available in the Carmel River Basin during Low Flow Period (July - October).[1]

Study Area	Flow at time of measurement (cfs)	Stream miles	Surface area (acres)	Riffle area (acres	Pool area	Spawning[2] habitat (acres)	Nursery habitat (acres)
Danish Creek	1-2	0.75	0.36	0.36	0.14	0.22	0.36
Carmel River, upstream of Los Padres Dam	5-10	14.00	17.57	15.26	10.19	7.66	17.57
Cachauga Creek	1	2.0	1.21	0.73	0.48	0.36	1.21
Pine Creek	1-2	5.50	4.00	2.00	2.00	2.00	4.00
San Clemente Creek	2-3	4.50	2.73	1.37	1.37	1.37	2.73
Carmel River, between San Clemente and Los Padres dams	10-20	5.50	16.67	8.34	8.34	4.25	16.67
Carmel River, downstream of San Clemente Dam							
Flowing section	1-2	1.25	3.03	1.82	1.21	--	3.03
Non-flowing section	0	0.75	2.27	0	2.27	--	2.27

1/Measured July-October 1975.

2/Area estimated to meet spawning criteria during January-April spawning period.

be available in the lower river at 50 cfs and 0.40 acres would be available at 80 cfs (Table 8). The wetted area at 50 cfs and 80 cfs were essentially the same, but depths and velocities were different at the two flows. Habitat suitable for spawning at 80 cfs would still be covered with water and potentially suitable for egg incubation at 50 cfs.

Nursery Habitat and Juvenile Steelhead Production

Steelhead production occurred predominantly in the upper drainage, between Tularcitos Creek and Los Padres Dam (Figure 8). High quality nursery habitat occurred upstream of Los Padres Dam, but the inoperative fishway at Los Padres Dam has precluded steelhead production from this section of the stream. A resident rainbow trout population occurred there during the study period (Table 9). Mean juvenile steelhead populations found in the remainder of the upper drainage ranged from 2,082 fish/mile in San Clemente Creek to 5,201 fish/mile in Pine Creek (Table 9). Mean juvenile density ranged from 1,594 fish/acre in the river between the two dams, to 7,152 fish/acre in Pine Creek. The proportion of age 1+ and older trout was greatest in the river above Los Padres Dam, averaging 14% of the population in that area (Table 10). The composition of age 1+ and older steelhead in the remainder of the upper drainage ranged from 1% in Danish and Cachauga creeks to 7% in Pine Creek.

Nursery habitat in the lower drainage, below Tularcitos Creek, was lacking both in quality and quantity. Following termination of releases from San Clemente Dam in June 1975, flow receded rapidly leaving only 1 mile of perennial flowing river in the lower drainage (RM 15 to RM 14). The stream in this section was generally less than 6 inches deep, the result of 1-2 cfs spreading across a wide, low gradient streambed. Mean population estimates in late summer were high, however (5,120 fish/mile). The few large pools located downstream of RM 14 stopped receiving flow soon after releases from San Clemente Dam were stopped. Water temperatures soon rose to 70-80 F and dissolved oxygen levels soon fell to below 5 ppm, providing marginal steelhead habitat. Mean population estimates in late summer were low, 396 fish/mile (Table 9), but composition of age 1+ and older fish was very high, averaging 46% of the population (Table 10). No population estimates were made in the lagoon, but juveniles were observed, indicating that the quality of the area was suitable for steelhead.

Instream flow data collected in the lower river during spring of 1975 indicated that over 23 acres of good quality nursery habitat would be provided between Tularictos Creek and Garland Park by 50 cfs flows (Table 8), compared with the 5 acres of fair to poor habitat provided by 1-2 cfs in 1975. An additional 42 acres of nursery habitat could be provided from Garland Park to the mouth if habitat were rehabilitated.

Juvenile Migration

Specific flow requirements for downstream movement were not measured. However, steelhead were observed migrating downstream until flow near Robles del Rio (RM 14)dropped from near 80 cfs to less than 10 cfs in June 1975. Thus, high spring flows lasting at least through June appeared necessary to allow downstream migration of smolts and pre-smolts to the

TABLE 8. Estimated Steelhead Spawning and Nursery Habitat Potentially Available in the Carmel River Downstream of San Clemente Dam at 50 cfs and 80 cfs, 1975

Flow at time of measurement	Above Tularcitos Creek[1/] (3.5 stream miles)		Garland Park to Tularcitos Creek (5 stream miles)		Carmel Bay to Garland Park[2/] (10 stream miles)	
	Spawning ft^2 (acres)	Nursery ft^2 (acres)	Spawning habitat ft^2 (acres)	Nursery habitat ft^2 (acres)	Spawning habitat ft^2 (acres)	Nursery habitat ft^2 (acres)
50 cfs	1,743 (0.04)	583,972 (13.4)	47,938 (1.1)	998,000 (22.9)	0 (0)	1,829,520 (41.9)
80 cfs	17,432 (0.40)	583,972 (13.4)	589,330 (13.5)	998,000 (22.9)	0 (0)	-- --

1/ Estimate based upon instream flow studies conducted in 1980 (Nakaji 1980).

2/ Estimate based upon instream flow studies conducted in 1980 (Nakaji 1980) using criteria in Table 1.

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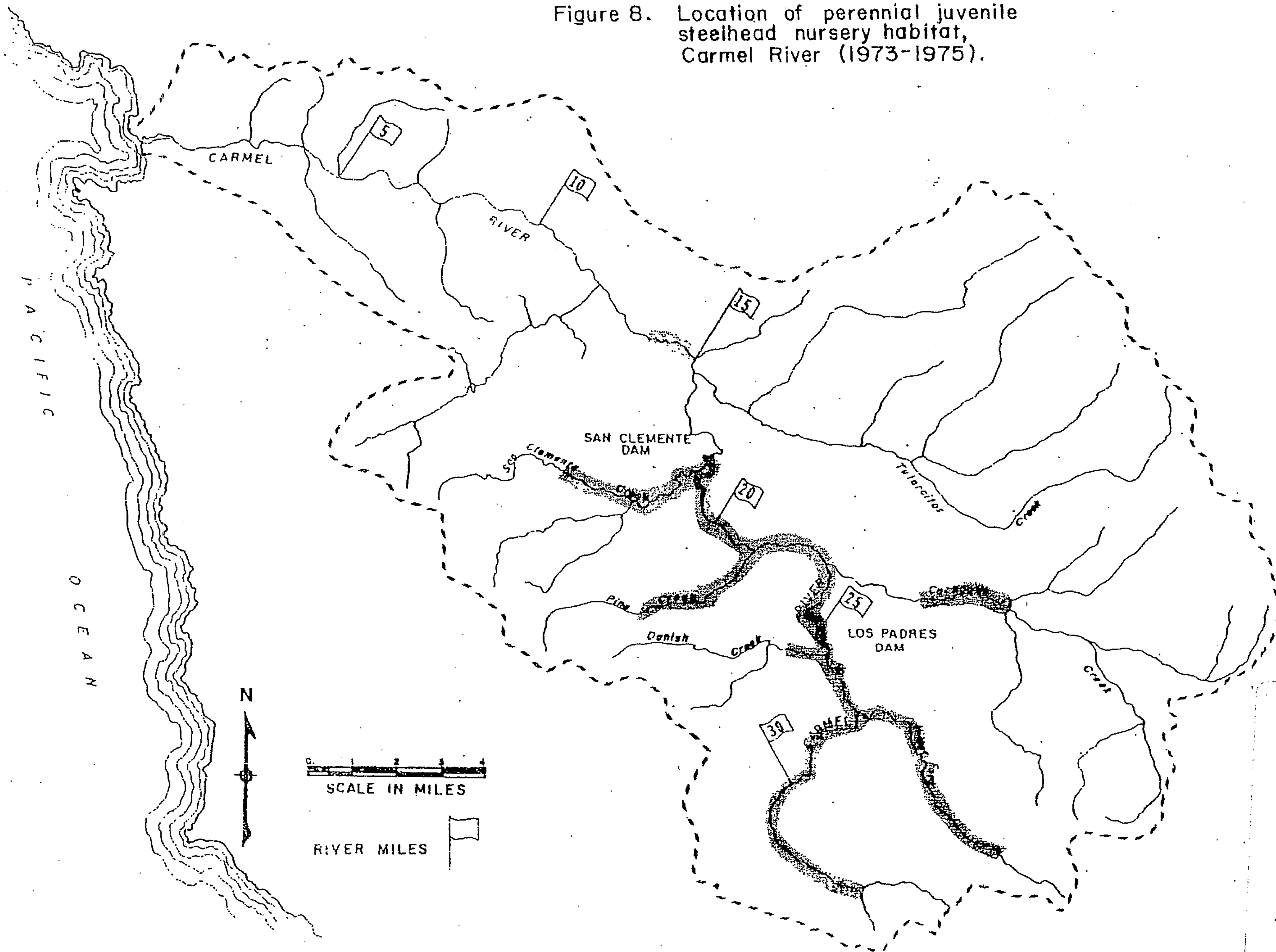


Figure 8. Location of perennial juvenile steelhead nursery habitat, Carmel River (1973-1975).

TABLE 9. Juvenile Steelhead and Resident Rainbow Trout Population Estimate in the Carmel River Basin, 1973 and 1974.

Study area	Year	No./mile	No./acre	Total/study area
1. Danish Creek[1/]	1973	2,323	4,840	1.742
	1974	1,637	3,411	1,228
	Mean	1,980	4,136	1,485
2. Carmel River, upstream of Los Padres Dam[1/]	1973	1,475	1,175	20,650
	1974	1,267	1,010	17,738
	Mean	1,371	1,092	19,194
3. Cachauga Creek	1973	Not sampled		
	1974	2,165	3,579	4,330
4. Pine Creek	1973	6,389	8,785	35,140
	1974	4,013	5,518	22,072
	Mean	5,201	7,152	28,606
5. San Clemente Creek	1973	2,633	4,340	11,849
	1974	1,531	2,524	6,890
	Mean	2,082	3,432	9,370
6. Carmel River, between San Clemente and Los Padres dams	1973	6,072	2,003	33,396
	1974	3,590	1,184	19,745
	Mean	4,831	1,594	26,571
Carmel River, downstream of San Clemente Dam				
7. Flowing section	1973	6,336	2,613	7,920
	1974	3,904	1,610	4,880
	Mean	5,120	2,112	6,400
8. Non-flowing section	1973	211	70	158
	1974	581	192	436
	Mean	396	131	297
Entire River	1973	---	----	110,855
	1974	---	----	78,319
	Mean	---	----	94,587

1/ Rainbow trout found upstream of Los Padres Dam were not considered anadromous.

Exhibit DFG-T-5 (49 pages)

TABLE 10. Juvenile Steelhead and Resident Rainbow Trout Age Class Distribution in the Carmel River Basin, 1973 and 1974.

Study area	Year	Age 0+ No.	Age 0+ %	Age 1+ and older No.	Age 1+ and older %
1. Danish Creek 1/	1973	1,724	99	18	1
	1974	1,216	99	12	1
	Mean	1,470	99	15	1
2. Carmel River upstream of Los Padres Dam 1/	1973	17,965	87	2,685	13
	1974	15,077	85	2,661	15
	Mean	16,506	86	2,688	14
3. Pine Creek	1973	34,086	97	1,054	3
	1974	19,644	89	3,428	11
	Mean	26,865	93	1,741	7
4. Cachauga Creek	1973		Not sampled		
	1974	4,287	99	43	1
5. San Clemente Creek	1973	11,731	99	118	1
	1974	6,821	94	69	6
	Mean	9,276	96	94	4
6. Carmel River, between San Clemente and Los Padres dams	1973	33,129	99	267	1
	1974	18,560	92	1,185	8
	Mean	25,845	96	727	4
Carmel River, downstream of San Clemente Dam					
7. Flowing section	1973	7,841	99	79	1
	1974	4,490	92	390	8
	Mean	6,166	96	235	4
8. Non-flowing Section	1973	119	75	39	25
	1974	144	33	292	67
	Mean	132	54	166	46
All areas	1973	106,595	96	4,260	4
	1974	70,239	90	8,080	10
	Mean	88,417	93.5	6,170	6.5

1/ Rainbow trout found upstream of Los Padres Dam were not considered anadromous.

ocean or at least to perennial waters in the lower river. A sudden reduction in flow in the lower river in June 1975 resulted in the stranding and eventual loss of numerous downstream migrants, demonstrating that migrants were in the lower river at that time and that abrupt reductions in flow during June are harmful.

Scales taken from adult steelhead indicated that juvenile steelhead spend their first year in the upper drainage where growth is moderate (3-4 inches FL). They then move into the lower drainage after forming their first annulus, probably in mid-winter, and grow rapidly until entering the ocean as age 1+ fish, probably in late spring.

Downstream migration over Los Padres Dam involves a rapid, abrasive, drop down a steep, long concrete apron terminating on a rocky outcrop at the foot of the dam. Survival of such a descent is probably low. Migration over San Clemente Dam did not generally appear to be a problem. However, immediately after the flashboards are installed, the pool at the foot of the dam recedes drastically. Survival of migrants passing over the dam is reduced when sufficient pool size and depth is not maintained.

Sea-run Adult Steelhead Production

Sea-run adult steelhead production estimated from age-class distribution data (Table 10) were 2,708 in 1973 and 2,043 in 1974 (Table 11). The majority of the potential sea-run adults were produced in the nursery areas upstream of San Clemente Dam - 91% in 1973 and 90% in 1974.

DISCUSSION

Upstream Migration

Shapovalov and Taft (1954) found upstream migration of steelhead to occur in Waddell Creek on rising and falling stream levels after any physical barrier, such as the sandbar across the mouth, was removed. They also found the number of fish ascending the stream to vary substantially depending upon the proportion of the run that had already ascended during the storm and during the season, upon preceding flows, climatic conditions and upon factors such as sexual ripeness of the fish and turbidity of the water. They found that steelhead may "hole up" in the lower river with a sudden cessation in a storm and lowering of flow only to subsequently ascend the river in large numbers during a light rain and corresponding small rise in the river level. Their findings indicate that four factors are essential for optimum upstream migration: breaching of the sandbar at the mouth of the river, impetus to movement (e.g., attraction flow, climatic condition, etc.), transportation flow and suitable or holding areas.

Lower River

The sandbar across the mouth of the Carmel River is usually breached mechanically early in the rainy season to prevent flooding of adjacent residences. During the 1973 to 1975 study period, the emptying of the lagoon after mechanical breaching provided sufficient flow to attract

TABLE 11. Summary of Estimated Sea-run Steelhead Production in the Carmel River Basin, 1973 and 1974.

Study area	Adult steelhead production, 1973		Adult steelhead production, 1974		Mean	
	No.	%	No.	%	No.	%
1. Danish Creek[1]	0	0	0	0	0	0
2. Carmel River, above Los Padres Dam [1]	0	0	0	0	0	0
3. Pine Creek	1083	38.8	872	42.7	978	40.5
4. Cachauga Creek	128[2]	4.6	128	6.3	128	5.3
5. San Clemente Creek	351	12.6	204	10.0	278	11.5
6. Carmel River, between dams	985	35.3	645	31.6	815	33.7
Carmel River, below San Clemente Dam						
7. Flowing section	234	8.4	165	8.0	200	8.3
8. Nonflowing section	7	<1.0	29	1.4	18	<1.0
Total drainage	2,788		2,043		2,415	

[1] Rainbow trout found upstream of Los Padres Dam were not considered anadromous.

[2] Cachauga Creek was not sampled in 1973, however, production was considered to have been at least as much as that in 1974.

steelhead into the lagoon, only to be trapped by the ebbing tide when sufficient transportation flows were not present to enable their upstream migration. This left steelhead in the lagoon vulnerable to angling and poaching until suitable attraction and transporation flow occurred.

Between 1964 and 1975, the first migration to San Clemente Dam appeared to require an attraction flow of at least 200 cfs at Carmel, although navigation upstream appeared possible at lesser flows. Nakaji (1980) identified 75 cfs as a minimum transportation flow and Kelley and Dettman (1981) identified 50 cfs as a minimum transportation flow. However, the 1972 fish movement data suggest the need for attraction flows which are greater than minimum transportation flow. Although sufficient transportation flow were available several times between December and February, no fish movement occurred until late (February) and after a flow of 200 cfs occurred. Kelley and Dettman (1981) note that fish movement subsequent to the initial counts occured at flows substantially less than 200 cfs. However, as discussed above, fish movement may occur at abnormally low flow following holing up and that a variety of factors can provide impetus to movement as long as at least marginal transportation flow is present.

Suitable holding areas were lacking during the study. Only the lagoon and several large pools near Highway 1 and in the vicinity of RM 4 provided adequate holding areas. Kelley and Dettman (1981) noted that the lagoon is no longer a suitable holding area since it has been filled with sediment generated by bank erosion. The other holding areas have disappeared as well. Furthermore, the stream channel has become wider, requiring increased flows for upstream attraction and transportation. Changes in channel configuration will continue to occur as long as the unstable character of the banks persists.

A further complication to upstream migration is associated with Cal-Am's proposal to develop a second well field near RM 6. According to Lee (1980), the probable draw-down of the water table in the lower river would result in an increase in the occurrence of rapid flow cessation during upstream spawning migration, leaving fish stranded with no holding areas. He predicted that the stream bed would have gone dry during the peak upstream migration period at least once in 11 of the 12 study period years (1964 to 1975), and that the dry periods would have lasted from 9 to 140 days if the proposed well diversions had been operated. A substantial decrease in the steelhead resource would have occurred.

Based upon the data collected through 1975, the complex nature of upstream attraction and the observations made by Kelley and Dettman regarding the changes in channel configuration after 1975, it appears that further investigation of upstream migration through the lower river is required. The required magnitude and duration of transportation flows will probably increase as the stream channel continues to degrade.

Upper Drainage

The narrow canyon and a healthy riparian canopy maintains a relatively narrow, stable stream channel in the upper drainage. As a result, it takes less flow to provide adequate transportation in the upper river than in the lower river. The major problem to upstream migration in the upper drainage has been the fishway at Los Padres Dam. It was reconstructed in 1981 and appears to be more efficient now. Over 100 fish were captured in both 1982 and 1983 (Paul Chappell, Fishery Biologist, Department of Fish and Game, Morro Bay pers. comm.). This number could increase substantially when progeny of these fish begin to return.

Spawning Habitat

Steelhead spawning occurs in the Carmel River after upstream migration, predominantly from January through March. Cool (<60 F), relatively swift (1.5-3.0 ft/s.), deep (>0.7 ft) flow through clean (silt free) gravel and cobble is required for redd site selection, incubation (50-60 days) and sustenance of alevins prior to emergence (30-60 days). Steelhead rarely select redd sites which will be exposed by receding flow (Shapovalov and Taft 1954); however, several exposed redds were observed in the Carmel River during the study. The redd must be provided with adequate flow for at least 80 days in the late season, when temperatures are warm and incubation and alevin development is fast, which means at least until late June.

Lower River

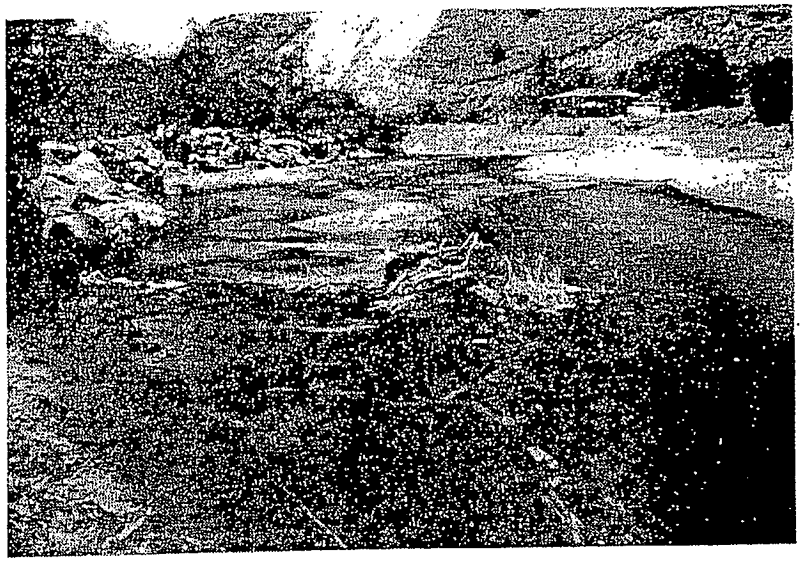
Spawning did not limit steelhead production in the lower river as evidenced by the large number of young-of-the-year fish present during early summer. Successful spawning still appears to be common as the rescue of young-of-the-year fish is still an annual event in the lower river.

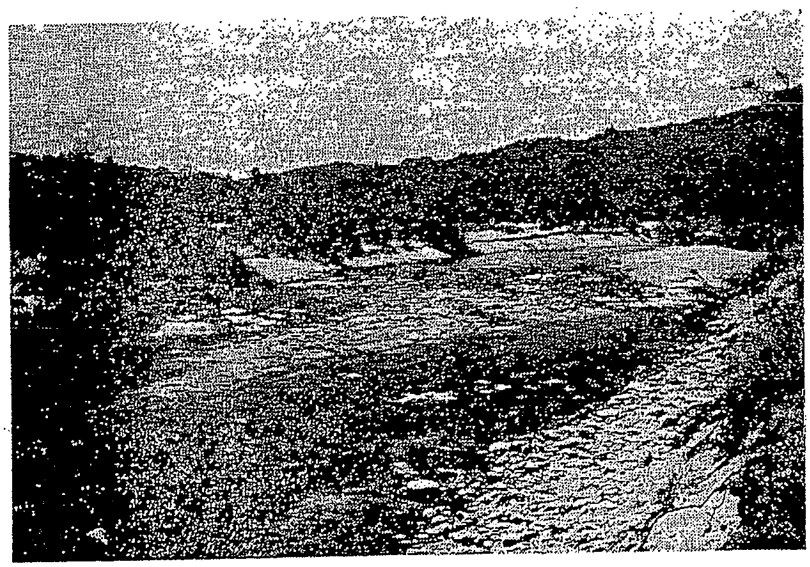
Most of the spawning habitat in the lower river was above Garland Park (RM 10). At 50 cfs, 1.1 + acres (49,681 ft) of suitable spawning habitat were present between Garland Park and San Clemente Dam potentially accommodating 400 pair of spawning adults (120 ft /redd, Orcutt, Pulliam and Arp 1968). Over 5,000 pair of spawning adults would be accommodated at flows of 80 cfs. Nakaji (1980) found maximum spawning habitat available at 250 cfs.

Spawning habitat available at 80 cfs would not be exposed at 50 cfs. However, some spawning habitat available at 200 cfs (attraction flow) or even 75 cfs (minimum transportation flow) may be exposed or rendered unsuitable for incubation at 20 cfs. The minimum flow required to maintain a viable redd built at 75 cfs needs to be determined.

Spawning habitat quality and quantity may have changed since 1975 with the changes in stream channel configuration described earlier. Substrate composition has likely changed too. As the channel widens, flow must increase to maintain the depths and velocities required for spawning. As such, spawning habitat requirements should be reevaluated. It should be recognized, however, that the stream channel will continue to change as long as the present bank instability exists.

Exhibit DFG-T-5 (49 pages)





Plage 2 (a) High flows during 1983 caused drastic changes in the stream channel of the lower river. Denuded banks were severely eroded, forcing the use of riprap. The debris in the center of the photograph represents the previous location of the left bank.

(b) The widened stream channel of the lower river possesses many wide, shallow riffles which pose as barriers to upstream migration at low flows. Flow was about 100 cfs when this picture was taken (photos by author).

Upper Drainage

Spawning did not limit steelhead production between the two dams, as evidenced by the density of young-of-the-year fish found in early summer. However, the low number of spawning adults ascending upstream of Los Padres Dam apparently has limited production above the dam to essentially zero.

Rearing Habitat and Juvenile Steelhead Production

Juvenile steelhead rearing habitat requirements include cool (<70 F), well oxygenated (>5 ppm) water, suitable cover and food producing areas. Young-of-the-year generally inhabit the bank areas immediately after emergence, then move to the riffle areas (where more food occurs) as they grow and food intake demands increase. Eventually, as the fish reach smolt size (>3.0 inches FL), the habitat demands increase to include deeper water or pools, and more substantial cover such as undercut banks, surface turbulence, cobble, boulder and submerged or overhead vegetation.

Lower River

Under historic, natural conditions (i.e., no diversions and no development) the lower river provided abundant nursery habitat. Flow occurred throughout the lower river in 6 out of 10 years, and in the lower 3 to 6 miles 8 out of 10 years (Kelley et al. 1982). The riparian canopy maintained amenable temperatures; pool habitat was present; and even during years of no September flow, perennial surface water most likely sustained juvenile steelhead. A few perennial pools occurred in the lower river as late as 1975. Many of the 100,000+ young-of-the-year and yearling steelhead which are annually stranded and perish with the cessation of flow in late spring would survive to sea-run adults given natural flow.

A minimum 50 cfs flow would provide 65 acres of rearing habitat between Tularcitos Creek and the mouth. This habitat would support about 170,000 juvenile steelhead, assuming the density of trout to be the same as occurred in the 1-mile long section of flowing water below Tularcitos Creek in 1973 (2,613 fish/acre). This estimate may be considered liberal, in as much as the number of juvenile present in the Tularcitos Creek area during the study probably resulted from fish being forced into the only surface water available as flow receded in late spring. Regardless, changes in channel configuration in the lower river, the loss of riparian vegetation which provides shade needed to provide food and maintain amenable temperatures and the changes in substrate composition have probably voided these findings. The entire lower river should be reeavaluated to determine the extent of the changes in potential nursery habitat as well as the possiblity of restoring conditions required to sustain juvenile steelhead.

Upper Drainage

The upper drainage provides an abundance of juvenile habitat. Over 90% of the river's production occurred upstream of San Clemente Dam. Production could be increased substantially if the drainage upstream of Los Padres Dam were freely available to spawning adults. The uppermost 14 + stream miles should be able to support at least the same density of juveniles as the river between the dams (2,002 fish/acre). This would increase the number of juveniles in the river by about 35,200.

The lowermost portion of the upper drainage, from San Clemente Dam downstream to Tularcitos Creek, presently supports few juvenile steelhead in the few, large, perennial pools immediately downstream of the dam. The few young-of-the-year that are able to reach these pools when flow ceases in late spring are probably consumed by resident brown trout, Salmo trutta. Based upon Nakaji's (1980) instream flow study, year-round flow of about 50 cfs would maintain abundant, good quality juvenile habitat here (about 13.4 acres). The juvenile population density would probably be equivalent to that observed between the two dams in 1973 (2,002 fish/acre) which would have increased juvenile steelhead population in 1973 30% (88,463 fish to 115,290 fish). A minimum annual flow of 25 cfs would provide 10.6 acres of juvenile habitat and would have increased total juvenile production 24% in 1973 (88,463 to 109,684).

Juvenile Migration

Both fish size and environmental conditions caused juvenile steelhead in Waddell Creek to start downstream migration (Shapovalov and Taft 1954). If the fish had reached the appropriate size but the environmental conditions were not right (principally photoperiod), migration did not occur. Similarly, if the environmental conditions were right but the fish were too small, migration did not occur. If size and photoperiod were right, the migration could be retarded or advanced by local environmental conditions, principally flow. If flow was unusually low, migration was early; if it was high, migration was late. Fish in the lower drainage moved earliest, as the growing conditions were more favorable there than in the upper drainage and fish were larger earlier. Most fish migrated between April and June.

It appears that juvenile steelhead in the Carmel River initiate downstream migration during the early rainy season, from late fall to early winter, moving to the lower river where growth conditions are more favorable. They then grow rapidly from late winter through early spring, then move into the ocean as age 1+ fish sometime before flow is cut off at San Clemente Dam. Fish were still moving downstream when the flow was cut from near 80 cfs to essentially zero in June 1975. These fish perished with the receding flow. A more gradual reduction in flow might have encouraged most of the remaining migrants to move out earlier if the mouth of the river remained open. The minimum flow required for downstream migration has not been determined.

Sea-run Adult Production

Production of sea-run fish is the critical component of a steelhead fishery. Since survival of smolts to returning adults increases exponentially with smolt size (Shapovalov and Taft 1954), the better the habitat for producing large smolts, the more productive the steelhead fishery.

The juvenile steelhead in the Carmel River system grew to 3-4 inches (FL) in their first year, mainly within the upper drainage. They then grew to 5-8 inches (FL) by the spring of their second growing season, generally after migrating to the lower drainage when high winter-spring flow conditions provided large fish habitat. Large fish habitat (i.e., habitat for age 1+ and older fish) was scarce in the drainage during the rest of the year as evidenced by the few yearling and older fish found during the investigation. Age 1+ fish either smolted in the spring or perished in the summer.

It can be argued that most age 1+ fish would smolt in the spring regardless of the abundance of large fish habitat since the fish were 5-8 inches (FL) by then - a good sized smolt. However, Shapovalov and Taft (1954) found that most of the sea-run fish migrated at age 1+ into the lower creek, where large fish habitat occurred, then smolted and migrated to sea as age 2+ fish. Similarly, fish in Arroyo de la Cruz, in Little Sur River and numerous streams in Santa Cruz County move from small fish habitat in the upper drainage to spend one more year in the large fish habitat of the lower river before smolting. Large fish habitat areas are assuredly very important in sustaining large numbers of potential sea-run fish. The lagoon on Little Sur River, for example, supports an estimated 25% of the potential sea-run fish production in that very expansive drainage (Jerry Smith, San Jose State University, pers. commun.).

Fish would likely stay over another year in the Carmel River given large fish habitat in the lower river. Some fish migrated into the pool environs of the lower river and stayed over another season during the investigation as evidenced by the higher proportion of age 1+ fish found in the marginal pool habitat present in the lower river in 1974 and 1975. The lagoon was not sampled, but it was deep and large with abundant cover. There is reason to suspect that it held many fish. The large fish habitat has essentially disappeared from the lower river, however, with the filling of the pools and lagoon since 1975. Kelley and Dettman (1981) suggest that the lower river contained abundant rearing habitat before water development and flood plain encroachment changed it.

Adult steelhead production, at least relative escapement to the San Clemente Dam fishway, was also influenced by flow conditions during upstream and downstream migration. There was a direct correlation between the flow conditions in April and May, the apparent downstream migration period, and the number of adults counted at the San Clemente Dam fishway two years hence (Figure 9); the greater the runoff during the April-May period, the greater the number of smolts reaching the ocean, thus the greater escapement two years later. For example, high April-May flow conditions in 1962 and 1964 yielded relatively high counts of adult steelhead in 1964 and 1966 despite relatively low flow during the upstream migration period (January through March). Conversely, the low April-May flow conditions in 1968 and 1972 resulted in relatively low counts of adult steelhead in 1970 and 1974 even though relatively high runoff occurred during the upstream migration period.

Escapement was also affected by flow conditions during the upstream migration period. In 1972, when the January through March runoff was the

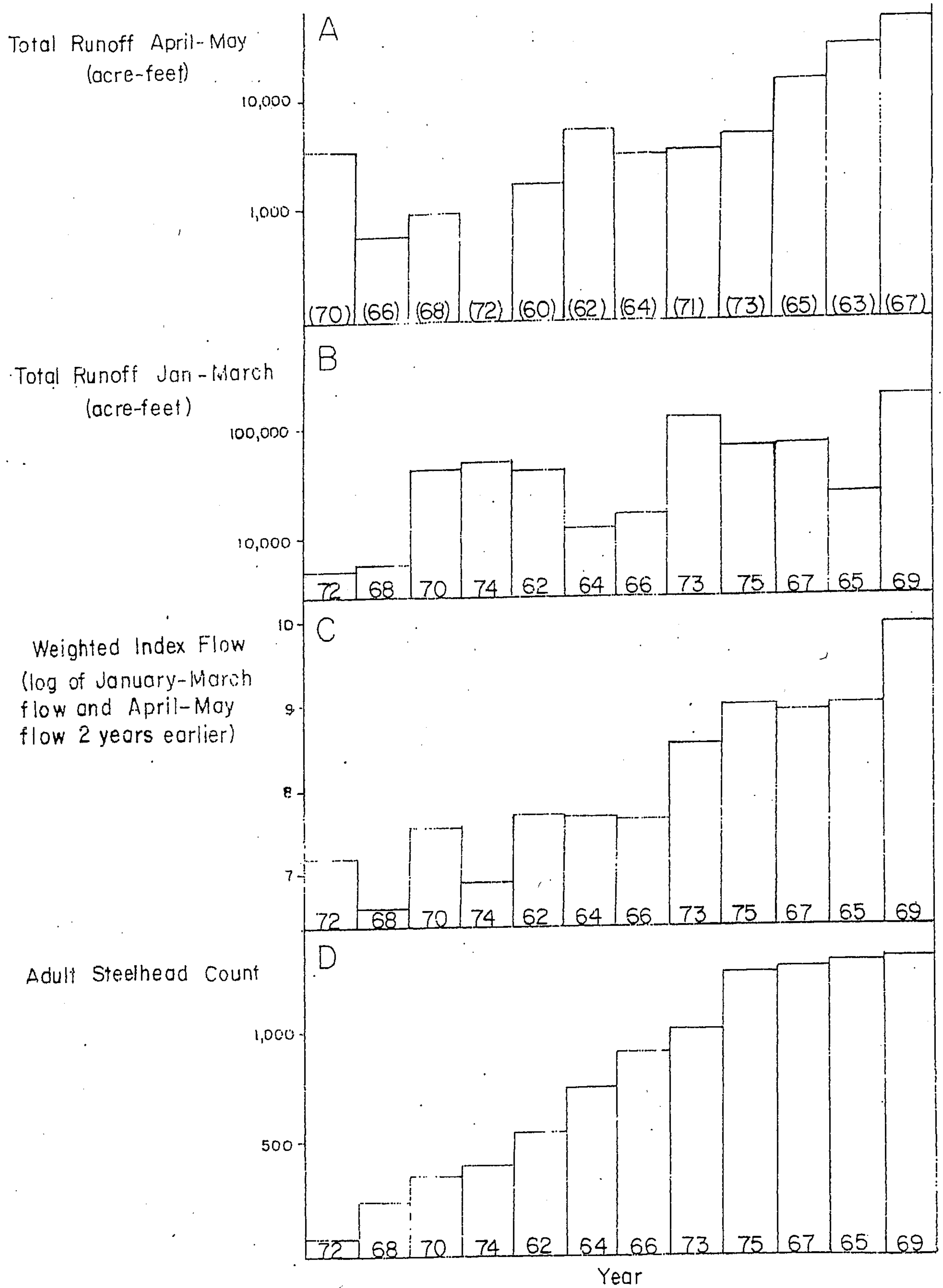


Figure 9. (A) Acre-feet flow during downstream migration of steelhead smolts (year in brackets), (B) acre-feet flow two years later during upstream migration of adult steelhead, (C) an index of (A) plus (B), to compare with (D) the annual number of adult steelhead counted at San Clemente fish ladder. From D.W. Kelley; (unpublished data).

lowest, the number of adults counted at the San Clemente Dam fishway was also the lowest, even though good flow conditions occurred during the downstream migration period 2 years prior (1970). The combination of poor flow conditons during April and May, and January through March 2 years hence resulted in relatively low escapement as evidenced in 1968.

Sea-run steelhead production could be increased in the Carmel River by increasing the number of juvenile steelhead produced above Los Padres Dam (by improving passage by the dam as discussed earlier), and by restoring juvenile rearing habitat in the lower river. Restoration would require perennial surface water, the reestablishment of the riparian canopy to provide shade, food production, cover and channel stability. It would also require the removal of sediment presently burying the large fish habitat of the lower river, including the lagoon, and rehabilitation of the streambed including purging of fine material from the gravel and cobble, and possibly the replacement of gravels intercepted by the dams.

Lower River

A minimum 50 cfs flow to Highway 1 would increase total sea-run steelhead production approximately 177% (Table 12). This would have increased production in 1973 from 2,788 fish to over 7,700 fish.

The increases discussed above are based only upon increasing production of age 1+ smolts in the juvenile rearing habitat potentially available from San Clemente Dam to the mouth. It does not consider the increase in large fish habitat and the potential increase in growth rate in this area, which would increase the number of larger smolts and thus sea-run adult production. The information to predict the increase due to these factors is not available. Furthermore, as stated repeatedly above, the conditions in the lower river today are very different from those measured prior to 1976. The lower river needs to be reassessed once the system has been relatively stabilized, to determine spawning, rearing and migration habitat availability in order to identify potential sea-run adult production.

Upper Drainage

A minimum 25 cfs flow from San Clemente Dam to Tularcitos Creek would have increased total sea-run production approximately 29% (from 2,788 fish to about 3,600 fish) in 1973. A minimum 50 cfs flow would have increased production about 36% (to ~3,800 fish) in 1973.

Efficient operation of the fish trap at Los Padres Dam and modification of the dam spillway to maximize survival of downstream migrants would allow full sea-run steelhead production in the drainage upstream of the dam. An increase of 44% in sea-run steelhead production (from 2,788 fish to about 4,000 fish) would have occurred in 1973. Approximately 440 spawning steelhead pairs would be required to achieve full stocking (i.e., the production of 35,200 juvenile fish). This number is based upon an average fecundity of 4,000 eggs and a mean survival to age 0+ of 2% (Shapovalov and Taft 1954).

Exhibit DFG-T-5 (49 pages)

TABLE 12. Summary of Estimated Increases in Total Sea-run Steelhead Production Associated with Various Changes in the Carmel River Drainage.[1]

Condition change	Increase in total sea-run production (%)	Increase in total sea-run production (nos.)
1. Maintain perennial flow from San Clemente Dam to Hwy. 1 (50 cfs min.)	177	2,788[2] to 7,736
2. Maintain perennial flow from San Clemente Dam to Tularcitos Creek of:		
a. 25 cfs (min.)	29	2,788 to 3,587
b. 50 cfs (min.)	36	2,788 to 3,801
3. Provide unhampered, migration by Los Padres Dam (upstream and downstream)	44	2,788 to 4,126
4. Perennial flow from San Clemente Dam to Hwy. 1 (50 cfs min.) and unhampered access by Los Padres Dam	221	2,788 to 8,974

1/ Based upon 1975 habitat conditioning.

2/ The 1973 sea-run steelhead production estimate is used as a base production level.

CONCLUSION

The Carmel River is a valuable steelhead resource, quite possibly the most valuable, self-sustained steelhead resource in the southern portion of the steelhead's present range. The Department of Fish and Game's management goals for the Carmel River are to maintain it as a self-sustained, naturally produced steelhead resource and to restore it as much as possible to its historic level of productivity. Water development, offstream diversion and flood plain development have already destroyed steelhead habitat reducing productivity by 75%.

The lower river is a critical component of the steelhead resource. It provides access to and from the only perennial rearing habitats (in the upper drainage) and it sustains critical smolt production of the juveniles reared in the upper drainage. The loss of riparian vegetation along the lower river and concomitant bank erosion continue to be extensive, resulting in a wider stream channel, and thus shallower flow conditions during the upstream and downstream migration periods, filled pools as well as the lagoon, and silted gravel and cobble habitats. The loss of the riparian corridor has reduced shading, increased water temperatures, and has reduced food production. Resting and holding areas for upstream migrants have also been eliminated; suitable spawning and smolt producing habitats have been reduced.

As the lower river becomes incapable of sustaining rapid juvenile steelhead growth, the average size of smolting fish will decrease, thus, decreasing sea-run steelhead production. It is imperative that the unstable condition of the lower river be abated and steelhead habitat restored. Additional development, which would increase riparian vegetation removal and, thus, aggravate an already serious condition, should not be allowed.

The lower river was also a major perennial rearing area before offstream diversion eliminated summer and fall flow. Reestablishment of perennial flow could alleviate if not eliminate the unstable conditions in the lower river as well as increase juvenile steelhead production. Sea-run adult production could be increased 177%.

Steelhead production can be partially restored by rehabilitating the lower river as discussed above, and by improving upstream and downstream migration over Los Padres Dam. The reconstructed fish trap at the base of Los Padres Dam should allow full stocking above the dam and potentially increase sea-run steelhead production by 35%. However, the spillway needs to be modified to increase survival of downstream migrants to fully realize increased production upstream of the dam.

The magnitude of upstream and downstream migration flow needs to be reassessed. The potential juvenile, and thus sea-run adult production potentially derivable at specific flows, also needs to be reassessed. Regardless, the relocation of the offstream diversion point from San Clemente Dam downstream to RM 6 would encourage reestablishment of the riparian corridor and stabilize the stream channel and induce restoration of steelhead habitat. Efficiency of flow for upstream and downstream migration would improve as the channel narrows and the lag time in aquifer recharge is shortened. Sea-run steelhead production would be increased substantially.

RECOMMENDATIONS

The following tasks are recommended to alleviate resource destruction and potentially restore the naturally propagated steelhead resource of the Carmel River.

1. Develop and implement a stabilization program in the lower river to halt the perpetual degradation of the banks and stream channel. Reestablish a riparian vegetation corridor to both stabilize the channel and to improve steelhead habitat. Attain sufficient flows to maintain riparian vegetation. Prohibit all development which would aggrevate the problem.

2. Restore steelhead habitat in the lower river once the channel is stabilized and excessive erosion and sedimentation are abated. Provide for purging of sediment from gravel and cobble habitats and from pools and the lagoon. Provide sufficient water to sustain upstream and downstream migration, spawning, incubation and juvenile and smolt rearing habitats. The minimum required flows will need to be altered to accommodate both water supply and steelhead resource demands.

3. Develop and implement a plan to provide perennial flow downstream of San Clemente Dam. Identify a diversion point downstream of the dam which would allow maximum beneficial use of the water for both water supply and steelhead production.

4. Optimize the number of spawning steelhead migrating over Los Padres Dam. A minimum 440 pair of spawning steelhead should be placed upstream of the dam to achieve juvenile carrying capacity. The trap should be made fully functional. Attraction to the trap should be monitored and improved if necesary.

5. Maximize survival of steelhead migrating down the spillway over Los Padres Dam. The spillway surface should be smoother, and its tail end should be redeesigned to lift the fish out and into the pool downstream. The pool should be excavated so that fish are not impinged against rock when they leave the spillway.

6. Abate sedimentation in the drainage. Identify chronic sources of excessive sediment and work with state and local agencies to implement corrective action.

Exhibit DFG-T-5 (49 pages)

REFERENCES

Bovee, K.D. 1978. Hydraulic simulation in instream flow studies; Theory and techniques. Instream Flow Information Paper No. 5. U. S. Fish and Wildl. Ser., Coop. Instream Flow Group. 131 p.

Hooper, Douglas R. 1973. Evaluation of the effects of flows on trout ecology. Pacific Gas and Electric Company Rept. January 1973. 97 p.

Kelley, D. W. and D. H. Dettman. 1981. Reconnaisance of water deveopment alternatives for the Carmel River, Monterey County, California. Unpbl. rept. to Monterey Peninsula Water Management District. 50 p.

Kelley, D. W., D. H. Dettman, and J. L. Turner. 1982. The probable effect of Carmel River water supply alternatives on steelhead resources. Unpbl. Rept. to Monterey Peninsula Water Management District. 32 p.

Kondolf, G. M. 1982. Recent channel instability and historic channel changes of the Carmel River, Monterey County, California. M. S. Thesis. Univ. Calif., Santa Cruz. 129 p.

Lee, E. 1980. Unpubl. Rept. to Monterey Peninsula Water Management District. 2 p.

Mundie, J. H. 1974. Optimization of the salmonid nursery stream. J. Fish. Res. Bd. Can. 31:1827-1837.

Nakaji, Fred T. 1980. Carmel River instream flow study final. U. S. Fish and Wildl. Serv. Sacramento, Calif. 18 p.

Orcutt, D. R., B. R. Pulliam, and A. Arp. 1968. Characteristics of steelhead trout redds in Idaho streams. Trans.Amer Fish. Soc., 97(1): 42-45.

Seber, G. A. F. and E. D. LeCren. 1967. Estimating population parameters from catches large relative to the population. J. Ani. Ecol. 36(3): 631-643.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon

(*Oncorphynchus kisutch*). Calif. Fish Game, Fish Bull. No. 98. 375 p.

U. S. Fish and Wildlife Service. 1978. Untitled, environmental statement from area manager for unauthorized project for flood control and allied purposes in the Carmel River Basin, Monterey County, 17 p.

Williams, J. 1983. Habitat change in the Carmel River Basin. Unpubl. Rept. to Calif. Dept. Fish and Game. 30 p.